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Biological Resources

Biological Opinions

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-2025-01881

July 28, 2025

Kandice Krull
Environmental Protection Specialist
U.S. Department of Transportation, Federal Aviation Administration
2200 S. 216th Street
Des Moines, Washington 98198

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Seattle-Tacoma International Airport Sustainable Airport Master Plan Near-Term Projects

Dear Ms. Krull:

This letter responds to your June, 30, 2025, request for initiation of consultation with the National Marine Fisheries Service (NMFS) pursuant to Section 7 of the Endangered Species Act (ESA) for the subject action.

We reviewed the Federal Aviation Administration's (FAA's) consultation request and related initiation package. Where relevant, we have adopted the information and analyses you have provided and/or referenced but only after our independent, science-based evaluation confirmed they meet our regulatory and scientific standards. In our biological opinion below, we indicate what parts of your document(s) we have incorporated by reference and where that information is being incorporated. We incorporate by reference the following sections of the Seattle-Tacoma International Airport Sustainable Airport Master Plan Near Term Projects (NTPs) Final Biological Evaluation (BE; Krull 2025):

- Sections 1.0 and 2.0 for the Proposed Action;
- Section 3.0 for the Action Area;
- Section 4.0 for the Status of Species and Status of Critical Habitat;
- Section 4.0 for the Environmental Baseline; and
- Sections 5.0 and 6.0 for the Analysis of Effects on Critical habitat and the Analysis of Effects on Species.

The BE will be included in the administrative record for this consultation and we will send it to readers of the biological opinion as an email reply attachment to requests sent to samuel.bankston@noaa.gov.

INTRODUCTION

Consultation History

On October 2, 2024, NMFS received a request from FAA for written concurrence that the proposed action is not likely to adversely affect (NLAA) the following ESA-listed species and critical habitats under NMFS' purview:

- Chinook salmon (*Oncorhynchus tshawytscha*, Puget Sound Evolutionarily Significant Unit [ESU]) and their critical habitat
- Steelhead (*O. mykiss*, Puget Sound Distinct Population Segment [DPS])
- Bocaccio rockfish (*Sebastes paucispinus*, Puget Sound/Georgia Basin DPS) and their critical habitat
- Yelloweye rockfish (*S. ruberrimus*, Puget Sound/Georgia Basin DPS) and their critical habitat
- Killer whale (*Orcinus orca*, Southern Resident DPS) and their critical habitat

On November 12, 2024, NMFS provided FAA with a letter responding to their request stating the biological assessment and information provided as part of FAA's request did not demonstrate that the effects of the proposed action were either wholly beneficial, discountable, or insignificant and, consequently, that NMFS could not concur with the NLAA determination.

On March 13, 2025, NMFS and FAA engaged in a coordination call regarding the ESA consultation pathway for the proposed action. During this call NMFS requested additional information.

On April 10, 2025, FAA transmitted the additional information requested by NMFS and reaffirmed their request for informal consultation. FAA followed up to confirm NMFS' receipt of their transmittal on April 22, 2025.

On April 28, 2025, NMFS informed FAA that the additional information transmitted on April 10, 2025, did not change NMFS' conclusion provided in the non-concurrence letter sent to FAA on November 12, 2024.

On May 19, 2025, NMFS contacted FAA to clarify the process for initiating formal consultation for the proposed action.

On June 30, 2025, FAA resubmitted their request for informal consultation and provided the final BE for the proposed action.

NMFS determined the proposed action is likely to adversely affect ESA-listed species and designated critical habitat based on the best available scientific and commercial information, the ESA, and section 7 regulations. NMFS initiated formal consultation on July 1, 2025.

Updates to the regulations governing interagency consultation (50 CFR part 402) were effective on May 6, 2024 (89 Fed. Reg. 24268). We are applying the updated regulations to this consultation. The 2024 regulatory changes, like those from 2019, were intended to improve and

clarify the consultation process, and, with one exception from 2024 (offsetting reasonable and prudent measures), were not intended to result in changes to the Services' existing practice in implementing section 7(a)(2) of the Act. 89 Fed. Reg. at 24268; 84 Fed. Reg. at 45015. We have considered the prior rules and affirm that the substantive analysis and conclusions articulated in this biological opinion and incidental take statement would not have been any different under the 2019 regulations or pre-2019 regulations.

Proposed Action

As described in Section 1.0 of the BE (Krull 2025), the proposed action includes 29 NTPs subject to FAA approval and/or funding identified by the Port of Seattle (Port) in their Sustainable Airport Master Plan for the Seattle-Tacoma International Airport (SEA) to meet forecasted rising passenger and cargo demand by improving efficiency, safety, access, and support facilities. The proposed action would be located entirely on Port-owned property within and adjacent to SEA. As described in Section 2.0 of the BE (Krull 2025), the proposed action comprises the following elements:

- NTPs: Airfield, terminal, cargo, landside, and airport/airline support projects designed to increase airport capacity and operational efficiency to meet projected future needs
- Program Support Projects: Infrastructure improvements needed to support NTP development, as identified in the Port Utilities Master Plan:
    - Operational infrastructure improvements (electrical, fuel, gas, water, sewer, and information and telecommunications technology)
    - Stormwater drainage system and industrial wastewater system improvements
- Mitigation for anticipated wetland and buffer impacts
- Best management practices (BMPs) used by the Port to avoid and minimize environmental impacts from the construction and operation of the NTPs and Port Utilities Master Plan program support projects

Project construction would occur in stages beginning in 2025 and continuing through 2032. The proposed action would result in the net addition of approximately 72 acres of impervious surfaces at SEA, which includes approximately 50 acres of pollution-generating impervious surfaces (PGIS). The proposed action includes improvements to the structural stormwater drainage system, improvements to the industrial wastewater system, and operational-source-control BMPs to service these new impervious surfaces. The proposed mitigation for the up to 0.58 acre of anticipated permanent impacts to Category II and III wetlands would include 2.65 acres of mitigation for wetland buffer impacts and at least 1.17 acres, and up to 4.68 acres, of compensatory wetland mitigation. BMPs are described in Section 2.7 of the BE (Krull 2025) and include construction and operational source control BMPs. Additional conservation measures are described in Section 2.8 of the BE (Krull 2025) and include ongoing participation in the Washington Department of Ecology (Ecology) Stormwater Working Group and 6PPD-Q subgroup as well as funding an independent stormwater media treatment study to determine how technologies can effectively remove 6PPD-Q from SEA stormwater discharge.

BIOLOGICAL OPINION

We examined the status of each species that would be adversely affected by the proposed action to inform the description of the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. We also examined the condition of critical habitat throughout the designated area and discuss the function of the physical or biological features essential to the conservation of the species that create the conservation value of that habitat.

Table 1 summarizes NMFS' determinations for the listed species, critical habitat, and species proposed for listing considered in this biological opinion. We made these determinations based on the analyses presented in the BE in conjunction with our own analyses informed by the best available information and policy guidance. Species included in our analyses, but absent from the BE, consist of the sunflower sea star, which is proposed for listing.

Table 1. NMFS Species and Designated Critical Habitat Determinations

ESA-Listed Species	Determination of Effect to Listed Species	Determination of Effect to Critical Habitat	Pathway for Potential Effects
Chinook salmon Puget Sound ESU* 70 FR 37160, 70 FR 52630, NMFS 2017	LAA†	LAA	Water quality degradation from stormwater runoff
Steelhead Puget Sound DPS‡ 72 FR 26722, 76 FR 20558, 73 FR 55451, NMFS 2017	LAA	LAA	
Bocaccio Puget Sound/Georgia Basin DPS 75 FR 22276, 80 FR 7977	LAA	LAA	Water quality degradation from stormwater runoff
Yelloweye rockfish Puget Sound/Georgia Basin DPS 75 FR 22276, 80 FR 7977	LAA	LAA	
Killer Whale Southern Resident DPS 70 FR 69903, 80 FR 7380, 71 FR 69054, 86 FR 41668	LAA	LAA	Potential reduction in prey base
Sunflower Sea Star (Proposed) 88 FR 16212	LAA	--	Water quality degradation from stormwater runoff

*Evolutionarily Significant Unit (ESU); ‡ Distinct Population Segment (DPS); †Likely to Adversely Affect

We incorporate by reference Section 4.4 of the BE (Krull 2025) for the status of species and critical habitat within the action area and supplement this section of the BE with the following information.

One factor affecting the status of species considered in this opinion, and aquatic habitat at large, is environmental variation. Environmental variation is systemic, influencing freshwater, estuarine, and marine conditions. Other systems are also being influenced by changing environmental conditions. Here we adapt information from Siegel and Crozer (2020) to describe habitat changes relevant to the species considered in this opinion, prior to describing how these changes result in the varied specific mechanisms impacting these species in subsequent sections.

Marine and Estuarine Environments

A recent study projects a nearly complete loss of existing tidal wetlands along the U.S. West Coast because of sea-level rise (Thorne et al. 2018). California and Oregon showed the greatest threat to tidal wetlands (100 percent), while 68 percent of Washington tidal wetlands are expected to be submerged. Coastal development and steep topography prevent horizontal migration of most wetlands, causing the net contraction of this crucial habitat. Rising ocean temperatures, stratification, ocean acidity, hypoxia, algal toxins, and other oceanographic processes will alter the composition and abundance of a vast array of oceanic species. In particular, there will be dramatic changes in both predators and prey of Pacific salmon, salmon life history traits, and relative abundance. For example, in a study of small planktivorous fish, Gliwicz et al. (2018) found that higher ambient temperatures increased the distance at which fish reacted to prey. Perhaps the most dramatic change in physical ocean conditions will occur through ocean acidification and deoxygenation. It is unclear how sensitive salmon and steelhead might be to the direct effects of ocean acidification because of their tolerance of a wide pH range in freshwater (although see Ou et al. 2015 and Williams et al. 2019); however, impacts of ocean acidification and hypoxia on sensitive species (e.g., plankton, crabs, rockfish, groundfish) will likely affect salmon and steelhead indirectly through their interactions as predators and prey.

Environmental Variation Effects on Salmon and Steelhead

In freshwater, year-round increases in stream temperature and changes in flow will affect physiological, behavioral, and demographic processes in salmon and steelhead and change the species with which they interact. Changing freshwater temperatures are likely to affect incubation and emergence timing for eggs, and in locations where the greatest warming occurs, may affect egg survival, although several factors impact intergravel temperature and oxygen (e.g., groundwater influence) as well as sensitivity of eggs to thermal stress (Crozier et al. 2021). Changes in temperature and flow regimes may alter the amount of habitat and food available for juvenile rearing, and this, in turn, could lead to a restriction in the distribution of juveniles, further decreasing productivity through density dependence. For migrating adults, predicted changes in freshwater flows and temperatures will likely increase exposure to stressful temperatures, alter migration travel times, and increase thermal stress accumulation for ESUs or DPSs with early-returning (i.e. spring- and summer-run) phenotypes associated with longer freshwater holding times (Crozier et al. 2025, FitzGerald et al. 2020). Rising river temperatures increase the energetic cost of migration and the risk of en route or pre-spawning mortality of adults with long freshwater migrations, although populations of some ESA-listed salmon and steelhead may be able to make use of cool-water refuges and run-timing plasticity to reduce thermal exposure (Keefer et al. 2018, Barnett et al. 2020).

Changes in winter precipitation will likely affect incubation and/or rearing stages of most populations. Changes in the intensity of cool season precipitation, snow accumulation, and runoff could influence migration cues for fall, winter, and spring adult migrants, including Chinook salmon and steelhead. Egg survival rates may suffer from more intense flooding that scours or buries redds. Changes in hydrological regime, such as a shift from mostly snow to more rain, could drive changes in life history, potentially threatening diversity within an ESU (Beechie et al. 2006). Changes in summer temperature and flow will affect both juvenile and

adult stages in some populations, especially those with yearling life histories and summer migration patterns (Crozier and Zabel 2006; Crozier et al. 2010; Crozier et al. 2019).

Status of the Species

Table 2 provides a summary of listing and recovery plan information, status summaries, and limiting factors for the species addressed in this opinion. More information can be found in recovery plans and status reviews for these species. Acronyms appearing in the table include ICTRT (Interior Columbia Technical Recovery Team), MPG (Multiple Population Grouping), NWFSC (Northwest Fisheries Science Center), TRT (Technical Recovery Team), and VSP (Viable Salmonid Population).

Table 2. Listing classification and date, recovery plan reference, most recent status review, status summary, and limiting factors for each species considered in this opinion.

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Puget Sound Chinook salmon	Threatened 6/28/05 (70 FR 37159)	Shared Strategy for Puget Sound 2007 NMFS 2006	NMFS 2017a; Ford 2022	This ESU comprises 22 populations distributed over five geographic areas. 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. Productivity remains low in most populations. Overall, the Puget Sound Chinook salmon ESU remains at "moderate" risk of extinction.	● Degraded floodplain and in-river channel structure ● Degraded estuarine conditions and loss of estuarine habitat ● Degraded riparian areas 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 steelhead	Threatened 5/11/07	NMFS 2019	NMFS 2017a; Ford 2022	This DPS comprises 32 populations. Viability of 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). Increases in spawner abundance were observed in a number of populations over the last five years within the Central & South Puget Sound and the Hood Canal & Strait of Juan de Fuca MPGs, primarily among smaller populations. There were also declines for summer- and winter-run populations in the Snohomish River basin. In fact, all summer-run steelhead populations in the Northern Cascades MPG are likely at a very high demographic risk.	● Continued destruction and modification of habitat ● Widespread declines in adult abundance despite significant reductions in harvest ● Threats to diversity posed by use of two hatchery steelhead stocks ● Declining diversity in the DPS, including the uncertain but weak status of summer-run fish ● A reduction in spatial structure ● Reduced habitat quality ● Urbanization ● Dikes, hardening of banks with riprap, and channelization
Puget Sound/ Georgia Basin DPS of yelloweye Rockfish	Threatened 04/28/10	NMFS 2017b	Lowry et al. 2024	Yelloweye rockfish within the Puget Sound/Georgia Basin (in U.S. waters) are very likely the most abundant within the San Juan Basin of the DPS. Yelloweye rockfish spatial structure and connectivity is threatened by	● Over harvest ● Water pollution ● Climate-induced changes to rockfish habitat ● Small population dynamics

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				the apparent reduction of fish within each of the basins of the DPS. This reduction is probably most acute within the basins of Puget Sound proper. The severe reduction of fish in these basins may eventually result in a contraction of the DPS' range.	
Puget Sound/ Georgia Basin DPS of Bocaccio	Endangered 04/28/10	NMFS 2017b	Lowry et al. 2024	Though bocaccio were never a predominant segment of the multi-species rockfish population within the Puget Sound/Georgia Basin, their present-day abundance is likely a fraction of their pre-contemporary fishery abundance. Most bocaccio within the DPS may have been historically spatially limited to several basins within the DPS. They were apparently historically most abundant in the Central and South Sound with no documented occurrences in the San Juan Basin until 2008. The apparent reduction of populations of bocaccio in the Main Basin and South Sound represents a further reduction in the historically spatially limited distribution of bocaccio, and adds significant risk to DPS viability.	● Over harvest ● Water pollution ● Climate-induced changes to rockfish habitat ● Small population dynamics
Southern resident killer whale	Endangered 11/18/05	NMFS 2008	NMFS 2022	The Southern Resident killer whale (SRKW) DPS is composed of a single population that ranges as far south as central California and as far north as southeast Alaska. While some of the downlisting and delisting criteria have been met, the biological downlisting and delisting 63 criteria, including sustained growth over 14 and 28 years, respectively, have not been met. The SRKW DPS has not grown; the overall status of the population is not consistent with a healthy, recovered population. Considering the status and continuing threats, the Southern Resident killer whales remain in danger of extinction.	● Quantity and quality of prey ● Exposure to toxic chemicals ● Disturbance from sound and vessels ● Risk from oil spills

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Sunflower Sea Star	Proposed Rule to List as Threatened 3/16/2023	NA	Lowry et al. 2022	From 2013-17 sea star wasting syndrome (SSWS) reached pandemic levels, killing an estimated 90%+ of the population. Impacts varied by region across the range of the species and generally progressed from south to north. By 2017, *P. helianthoides* was rare south of Cape Flattery, WA, where it had been conspicuous and ecologically important in the benthic marine ecosystems. Declines in coastal British Columbia and the Aleutian Islands exceeded at least 60%, and more likely 80%. Environmental factors (e.g. temperature, dissolved oxygen) likely contributed to the pandemic and continue to interact with the disease to suppress recovery. The species is facing a moderate risk of extinction over the foreseeable future.	● Disease – Sea Star Wasting Disease SSWD ● Elevated Ocean Temperatures and other Environmental Variation related effects (correlated with SSWD) ● Lack of Regulation on Environmental Variation ● Lack of direct species protection

Status of the Critical Habitat

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

For most salmon and steelhead, NMFS' critical habitat analytical review teams (CHARTs) ranked watersheds within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC5) in terms of the conservation value they provide to each ESA-listed species that they support (NOAA Fisheries 2005). The conservation rankings were high, medium, or low. To determine the conservation value of each watershed to species viability, the CHARTs evaluated the quantity and quality of habitat features, the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area. Even if a location had poor habitat quality, it could be ranked with a high conservation value if it were essential because of factors such as limited availability, a unique contribution of the population it served, or is serving another important role. A summary of the status of critical habitats, considered in this opinion, is provided in Table 3.

Table 3. Critical habitat, designation date, federal register citation, and status summary for critical habitat considered in this opinion

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Puget Sound Chinook salmon	9/02/05 70 FR 52630	Critical habitat for Puget Sound Chinook salmon includes 1,683 miles of streams, 41 square mile of lakes, and 2,182 miles of nearshore marine habitat in Puget Sounds. The Puget Sound Chinook salmon ESU has 61 freshwater and 19 marine areas within its range. Of the freshwater watersheds, 41 are rated high conservation value, 12 low conservation value, and eight received a medium rating. Of the marine areas, all 19 are ranked with high conservation value.
Puget Sound/Georgia Basin DPS of yelloweye rockfish	11/13/2014 79 FR68042	Critical habitat for yelloweye rockfish includes 414.1 square miles of deepwater marine habitat in Puget Sound, all of which overlaps with areas designated for canary rockfish and bocaccio. No nearshore component was included in the CH listing for juvenile yelloweye rockfish as they, different from bocaccio and canary rockfish, typically are not found in intertidal waters (Love et al. 1991). Yelloweye rockfish are most frequently observed in waters deeper than 30 meters (98 ft) near the upper depth range of adults (Yamanaka et al. 2006). Habitat threats include degradation of rocky habitat, loss of eelgrass and kelp, introduction of non-native species that modify habitat, and degradation of water quality as specific threats to rockfish habitat in the Georgia Basin.
Puget Sound/Georgia Basin DPS of bocaccio	11/13/2014 79 FR68042	Critical habitat for bocaccio includes 590.4 square miles of nearshore habitat and 414.1 square miles of deepwater habitat. Critical habitat is not designated in areas outside of United States jurisdiction; therefore, although waters in Canada are part of the DPSs' ranges for all three species, critical habitat was not designated in that area. Based on the natural history of bocaccio and their habitat needs, NMFS identified two physical or biological features, essential for their conservation: 1) Deepwater sites (>30 meters) that support growth, survival, reproduction, and feeding opportunities; 2) Nearshore juvenile rearing sites with sand, rock and/or cobbles to support forage and refuge. Habitat threats include degradation of rocky habitat, loss of eelgrass and kelp, introduction of non-native species that modify habitat, and degradation of water quality as specific threats to rockfish habitat in the Georgia Basin.
Southern resident killer whale	08/02/21 86 FR 41668	Critical habitat includes approximately 2,560 square miles of marine inland waters of Washington: 1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; 2) Puget Sound; and 3) the Strait of Juan de Fuca. Six additional areas include 15,910 square miles of marine waters between the 20-feet (ft) (6.1-meter (m)) depth contour and the 656.2-ft (200-m) depth contour from the U.S. international border with Canada south to Point Sur, California. We have excluded the Quinault Range Site. Based on the natural history of the Southern Residents and their habitat needs, NMFS identified three PCEs, or physical or biological features, essential for the conservation of Southern Residents: 1) Water quality to support growth and development; 2) prey species of sufficient quantity, quality, and

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		availability to support individual growth, reproduction and development, as well as overall population growth; and 3) passage conditions to allow for migration, resting, and foraging Water quality in Puget Sound, in general, is degraded. Some pollutants in Puget Sound persist and build up in marine organisms including Southern Residents and their prey resources, despite bans in the 1970s of some harmful substances and cleanup efforts. The primary concern for direct effects on whales from water quality is oil spills, although oil spills can also have long-lasting impacts on other habitat features In regards to passage, human activities can interfere with movements of the whales and impact their passage. In particular, vessels may present obstacles to whales' passage, causing the whales to swim further and change direction more often, which can increase energy expenditure for whales and impacts foraging behavior. Reduced prey abundance, particularly Chinook salmon, is also a concern for critical habitat.

Our conclusions regarding the effects of the proposed action on species and critical habitats for which we have made NLAA determinations—the Central American DPS of Humpback Whales (*Megaptera novaeangliae*) and the Mexico DPS of Humpback Whales—are presented below under the heading: NLAA determinations. The BE concludes that the proposed action would have no effect on these species; however, we disagree with this finding and provide the basis for our differing conclusions in the "NLAA determinations" section of this document.

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). We adopt by reference Section 3.0 of the BE (Krull 2025) for description of the action area, which comprises:

- A 4.76-mile segment of Miller Creek extending from the upstream limit of measurable construction effects and stormwater discharge to the confluence with Puget Sound
- 2.42 miles of Walker Creek from its headwaters to the confluence with Puget Sound
- 3.66 miles of Des Moines Creek and tributaries from the upstream limit of measurable construction and stormwater effects to the confluence with Puget Sound
- Nearshore and marine areas of Puget Sound in proximity to action area tributary confluences and within a 1.2-mile (2-kilometer) radius of the Port's permitted Industrial Wastewater Treatment Plant outfalls
- All wetlands impacted by construction and receiving stormwater runoff from the proposed action.

We modify the action area described in the BE by extending it 2 kilometers outward from the confluences of Miller Creek, Walker Creek, and Des Moines Creek with the Puget Sound to account for the transport of stormwater contaminants and related effects on water quality.

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 that are contemporaneous with the consultation in process. The impacts to listed species or designated critical habitat from federal agency activities or existing federal agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02). We incorporate and adopt by reference Section 4.0 of the BE (Krull 2025) for the environmental baseline, which includes a detailed discussion of anticipated ESA-listed species occurrence and habitat use within the action area, and supplement it with the following.

<u>Species in the Action Area</u>

The status of each species considered in this opinion varies from moderate to high risk of extinction. The environmental baseline is such that ESA-listed species inhabiting the marine

portions of the action area are exposed to reduced water quality, lack of suitable habitat, and reduced prey abundance. Many conditions in the baseline are understood to limit productivity and specified as factors limiting productivity in a manner that impedes species recovery. These stressors, as well as those from environmental variation, already exist, and we consider these factors with the addition of any adverse effects produced by the proposed action.

Puget Sound Chinook Salmon and Puget Sound Steelhead

Although portions of Miller Creek, Walker Creek, and Des Moines Creek are accessible to Puget Sound Chinook salmon and Puget Sound steelhead, neither species is known to inhabit these creeks, and none of these creeks include critical habitat for either species. However, both species are known to occur in the marine portions of the action area within the Puget Sound. The marine portions of the action area also overlap nearshore marine areas that have been designated as critical habitat for Puget Sound Chinook salmon.

For Puget Sound Chinook Salmon, individuals occurring in the marine portions of the action area most likely belong to the Puyallup River, White River, Nisqually River, or Green River populations (Shared Strategy for Puget Sound 2007; NMFS 2017a). The Puget Sound Salmon Recovery Plan (Shared Strategy for Puget Sound 2007) identifies ESU- and population-level viability criteria (Ruckelshaus et al. 2002). All populations of Puget Sound Chinook salmon likely to be affected by the proposed action play an important role in meeting these viability criteria, and, at this time, each of these populations remain well below the TRT planning ranges for recovery escapement levels (Ford 2022).

For Puget Sound steelhead, individuals occurring in the marine portions of the action area are most likely from the Cedar River, Green River, Nisqually River, Puyallup River/Carbon River, South Puget Sound Tributaries, and White River populations (Ford 2022). As outlined in the Recovery Plan for Puget Sound Steelhead (NMFS 2019), viability criteria for the DPS require that all three of the DPS' major population groups be viable for the DPS to be delisted under the ESA. The six populations of Puget Sound steelhead likely to be affected by the proposed action belong to the Central and South Puget Sound major population group. While some of the populations considered in this opinion have exhibited recent positive increases in abundance, all remain well below their productivity recovery targets (Ford 2022).

Puget Sound/Georgia Basin DPS Bocaccio and Puget Sound/Georgia Basin DPS Yelloweye Rockfish

For Puget Sound/Georgia Basin bocaccio, the DPS is currently managed as a single population. Therefore, individuals occurring in the marine portion of the action area play a role in achieving the quantitative, biological-based DPS-level delisting criteria described in the species' recovery plan (NMFS 2017). However, because encounters within this DPS have been exceptionally rare in recent years, current progress toward meeting biological recovery criteria cannot currently be assessed (Lowry et al. 2024).

For and Puget Sound/Georgia Basin yelloweye rockfish, individuals occurring in the marine portion of the action area are considered part of the non-Hood Canal population. Therefore, individuals with potential to be affected by the proposed action play a role in fulfilling the

quantitative biological-based recovery criteria outlined for the non-Hood Canal population in the species' recovery plan (NMFS 2017b). Recent modeling suggests that this population has made progress toward but has not yet met biological recovery criteria (Lowry et al. 2024).

Southern Resident Killer Whale

The SRKW DPS is composed of a single population and component individuals may occur in the marine portions of the action area. Every individual SRKW is critically important to the species' recovery because of the population's small size and the specific demographic goals required for delisting of the species (NMFS 2008).

Sunflower Seastar

The sunflower sea star (*Pycnopodia helianthoides*) occupies nearshore subtidal marine waters shallower than 450 m (~1400 ft) deep from Adak Island, AK, to Bahia Asunción, Baja California Sur, MX (see map below). They are occasionally found in the deep parts of tide pools. Areas with substantial freshwater input, e.g., river mouths, are known to have a lower likelihood of sunflower sea star occurrence. The species is a habitat generalist that consumes a wide variety of invertebrate prey, and also opportunistically scavenges on vertebrates.

Critical Habitat in the Action Area

Section 4.4 of the BE (Krull 2025) includes a detailed description of the PBFs of critical habitat for Puget Sound Chinook salmon, Puget Sound/Georgia Basin bocaccio, Puget Sound/ Georgia Basin yelloweye rockfish, and SRKW present in marine portions of the action area and is adopted here by reference. These PBFs have been degraded by anthropogenic sources within Puget Sound (e.g. pollutants from vessels) as well as upstream sources (municipal, industrial, and nonpoint sources). Nonetheless, the PBFs of critical habitat present in the action area continue to provide a wide range of important habitat functions for the ESA-listed species considered in this opinion and are of high conservation value.

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.

Effects on Species

Sections 5 and 6 of the BE (Krull 2025) provide a detailed discussion and assessment of likely effects of the proposed action on ESA-listed species and are adopted here (50 CFR 402.14(h)(3)). NMFS has evaluated these sections and after our independent, science-based evaluation determined they meet our regulatory and scientific standards with the addition of our

supplemental analyses concerning stormwater- and wastewater-related effects on ESA-listed species and their critical habitat provided below.

Short-term effects of the proposed action are expected to be limited to those associated with construction activities that would largely occur in upland areas characterized by extensive development, and to a lesser extent within and along wetlands and streams. Effects may include increased turbidity in nearby surface waters and construction noise and vibration, and contaminant leaks from equipment use and storage. Such effects are expected to be negligible because of the distance between construction areas and habitats occupied by ESA-listed species and the expected implementation of appropriate BMPs during construction work, as described in Section 2.8.1 of the BE (Krull 2025).

The proposed action's long-term effects on ESA-listed species and designated critical habitat are primarily associated with decreased water quality in areas of Puget Sound from stormwater runoff and wastewater discharge. The BE's analysis of potential stormwater-related effects concludes that ESA-listed fish, "could be directly exposed to degraded water quality and habitat quality could be degraded due to reduced water quality from proposed action stormwater pollutants" but that the extent and severity of adverse effects on ESA-listed species from degraded water quality would not reach the scale where take occurs. NMFS recognizes that the stormwater drainage and industrial wastewater systems included as part of the proposed action comprise a robust combination of structural controls and operational-source-control BMPs designed to intercept pollutants before they enter stormwater runoff and provide treatment to reduce contaminant concentrations to the greatest extent practicable. However, as noted in the BE, "While the Port's existing and proposed structural and operational pollution controls are robust, [stormwater drainage system] and [industrial wastewater system] treated discharges unavoidably contain low levels of contaminants even after treatment". Additionally, when flows exceed the 50-year storm event, the stormwater drainage system will cease to function as intended, and untreated runoff will be discharged to surrounding waters. These discharges will enter adjacent waterways and flow downstream, ultimately introducing chronic low levels of contamination to Puget Sound to which ESA-listed species will be directly and indirectly exposed. Repeated and chronic exposures, even of very low levels of toxins, are still likely to injure or kill individuals of the species considered in this opinion, 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).

The BE notes that the proposed action will lead to an increase in aircraft operations, and we expect a corresponding increase in vehicular traffic to and from the airport proportional to the resulting increase in air passenger capacity, which will likely contribute to a regional increase in greenhouse gas (GHG) emissions. However, it is not possible to separate this project's contribution to overall increases in GHG emissions from the contributions of all other sources of GHG emissions. Continued global environmental variation, and resultant impacts on listed species within the action area are expected to occur whether or not the proposed action is implemented. Therefore, all relevant future climate-related environmental conditions in the action area are considered part of the environmental baseline.

Puget Sound Chinook Salmon and Puget Sound Steelhead

Stormwater and wastewater have the potential to deliver a wide variety of pollutants to aquatic ecosystems, and many of which are unregulated and unevaluated. Table 4 summarizes potential contaminants that may be present in stormwater and wastewater originating throughout the action area, including their likely sources and corresponding effects on ESA-listed species.

Table 4. Potential Pollutants in Stormwater and Wastewater, Their Likely Sources, and Their Potential Effects on Salmonids.

Pollutant Class	Examples	Sources	Effects from Exposure
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	Accumulation of these persistent highly toxic compounds varies depending on a multitude of factors, but can affect health of adult individuals, their reproductive success, and survival of their offspring. Exposure during smolting ranges from delayed entry to saltwater and reduced osmoregulatory capacity, depending on exposure concentrations. Larvae with the yolk-sac still attached show no immediate effects but do exhibit a decreased preference for saltwater a year after exposure (Lerner et al. 2007).
Petroleum hydrocarbons	PAHs (poly aromatic hydrocarbons)	Roads (vehicles, tires), industrial, consumer products	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. 2016); can cause chronic sub-lethal effects to aquatic organisms at very low levels (Meador et al. 2006; Neff 1982), and are classified as carcinogens (Collier et al. 2013).
Microplastics	6PPD/6PPD-quinone	Vehicle tires	6ppd-quinone induces mortality, likely through cardiorespiratory disruption, and disrupts vascular permeability pathways primarily in developing coho salmon, but in Chinook salmon and steelhead as well (French et al. 2022; Greer et al. 2023).
Metals	Mercury, copper, chromium, nickel, titanium, zinc, arsenic, lead	Roads, electronics, pesticides, paint, waste treatment	Effects from heavy metals are primarily physical (leading to behavioral changes), including: effects to the gill epithelium, which leads to internal tissue hypoxia, reduced immunity, include osmoregulatory failure, hindering predator avoidance, acidosis, and low oxygen tensions in arterial blood (Eisler 1993; Sandahl et al. 2007).
Common use pesticides, surfactants	Herbicides (glyphosate, diquat), insecticides, fungicides, adjuvants, surfactants (detergents, soaps)	Roads, railways, lawns, levees	Long-term exposure leads to behavioral changes as fish to seek suboptimal water temperatures, and less polluted waters, inhibiting their normal migration patterns to the sea. Physically, low doses of exposure may mimic or block sex hormones, and interfere with thyroid function and bone development and increase stress, increasing predation risk by reducing fitness (Ewing 1999).
Nutrients and sediment	Nitrogen, phosphorus fertilizers, fine-grained inorganic sediment	Fertilizer, soil erosion	Nutrient loading and increased sediment lead to eutrophication or excessive plant growth. Dense algae growth limits light penetration, reducing the effectiveness of predation and predator avoidance, and can favor some plankton and other prey species over others, changing available prey for salmonids. At the chemical level, decreased dissolved oxygen creates a hypoxic or anoxic ‘dead zone' lacking sufficient oxygen to support most organisms, some algae produce noxious toxins (Chislock et al. 2013).

Injury or death from exposure to contaminants in stormwater and wastewater may occur through a variety of behavioral, endocrine disrupting, and immunotoxic effects, either by themselves or through additive and synergistic interactions with other contaminants (Baldwin et al. 2009; Feist et al. 2011; Hicken et al. 2011; Spromberg and Meador 2006; Spromberg and Scholz 2011). Even at very low levels, chronic exposures to contaminants are known to have a wide range of adverse effects on the ESA-listed salmonid species considered in this opinion (Carls et al. 2008; Comeleo et al. 1996; Feist et al. 2011; Hecht et al. 2007; Sandahl et al. 2007; Spromberg and Meador 2006).

We expect that every year following implementation of the proposed action, some individuals of all life stages of Puget Sound Chinook salmon and Puget Sound steelhead will experience sublethal effects such as stress and reduced prey consumption as a result of stormwater runoff pollutants. Not all exposed individuals would experience immediate adverse effects, and latent health effects are difficult to discern and document. We cannot estimate the number of individuals that would experience adverse effects from exposure to stormwater with any meaningful level of accuracy. Some individuals would respond with avoidance behaviors that disrupt feeding and migratory behavior. Others would 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 an indeterminate number of individuals in all exposed cohorts for the foreseeable future.

Puget Sound/Georgia Basin DPS Bocaccio and Puget Sound/Georgia Basin DPS Yelloweye Rockfish

As noted in the BE (Krull 2025), "Eggs, larva, post-settlement juvenile, and adult bocaccio and yelloweye rockfish that occur in the aquatic component of the action area (Puget Sound) could be directly exposed to pollutants in treated operational stormwater discharge and indirectly exposed to pollutants through the consumption of contaminated prey organisms." The level of exposure attributable to the proposed action cannot be reliably estimated, but given the chronic and pervasive nature of expected water quality pollution resulting from the proposed action, it is likely that individual rockfish at larval, juvenile, or adult life stages will encounter some deleterious chemical components of stormwater/wastewater discharge from the proposed action. Greene and Godersky (2012) report that "contaminants such as polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers, and chlorinated pesticides appear in rockfish collected in urban areas (Palsson et al. 2009). While the highest levels of contamination occur in urban areas, toxins can be found in the tissues of fish occurring throughout Puget Sound (West et al. 2017). Although few studies have investigated the effects of stormwater contaminants on rockfish ecology or physiology, other fish species in the Puget Sound region have demonstrated metabolic dysfunction from exposure to contaminants that may occur in stormwater and wastewater generated as a result of the proposed action (Meador et al. 2018). Recent studies conducted in the San Francisco Bay also document injury to similar species from stormwater-derived pollutants (Overdahl et al. 2021; Peter et al. 2024). Therefore, given that bocaccio and yelloweye rockfish would be exposed to stormwater and wastewater pollutants in the Puget Sound, we expect that individuals at various life stages will experience adverse effects, such as metabolic dysfunction, similar to what has been observed in other fish species. These effects will

the reduce fitness and likelihood of survival among an indeterminate number of individuals in all exposed cohorts for the foreseeable future.

Southern Resident Killer Whale

The submitted BE provides an assessment of the effects of the proposed action on SRKW and their critical habitat, concluding that the proposed action is NLAA affect SRKW or their critical habitat. NMFS has evaluated the analyses presented in the BE and concluded these determinations do not meet our regulatory and scientific standards. We have supplemented the BE's analysis of likely project effects to the species and their critical habitat for populations using the marine waters within Puget Sound and determined that the proposed action is likely to adversely affect individuals and their designated critical habitat. These determinations align with NMFS' current scientific research and policy. The basis for these determinations is provided below.

Water quality supports SRKW's ability to forage, grow, and reproduce free from disease and impairment. Water quality is essential to the whales' conservation, given the whales' present contamination levels, small population numbers, increased extinction risk caused by any additional mortalities, and geographic range (and range of their primary prey) that includes highly populated and industrialized areas. Water quality is especially important in high-use areas where foraging behaviors occur and contaminants can enter the food chain. Water quality impaired by contaminants can inhibit reproduction, impair immune function, result in mortalities, or otherwise impede the growth and the species' recovery. The proposed action would expose SRKW to contaminants delivered to Puget Sound via stormwater and wastewater.

SRKW can be exposed to contaminants directly, or indirectly when their prey are contaminated through their own exposure to reduced water quality. For example, Chinook salmon contain higher levels of some persistent pollutants than other salmon species, but only limited information is available for pollutant levels in Chinook salmon (Krahn et al. 2007; O'Neill and West 2009; Veldhoen et al. 2010; Mongillo et al. 2016). These harmful pollutants, through consumption of prey species that contain these pollutants, are stored in the killer whale's blubber and can later be released; when the pollutants are released, they are redistributed to other tissues when the whales metabolize the blubber in response to food shortages or reduced acquisition of food energy that could occur for a variety of other reasons. The release of pollutants can also occur during gestation or lactation. Once the pollutants mobilize into circulation, they have the potential to cause a toxic response. Therefore, nutritional stress from reduced Chinook salmon populations may act synergistically with high pollutant levels in SRKW and result in adverse health effects.

Various adverse health effects in multiple species have been associated with exposures to persistent pollutants. These pollutants have the ability to cause endocrine disruption, reproductive disruption or failure, immunotoxicity, neurotoxicity, neurobehavioral disruption, and cancer (Reijnders 1986, de Swart et al. 1996, Subramanian et al. 1987, de Boer et al. 2000; Reddy et al. 2001, Schwacke et al. 2002; Darnerud 2003; Legler and Brouwer 2003; Viberg et al. 2003; Ylitalo et al. 2005; Fonnum et al. 2006; Viberg et al. 2006; Darnerud 2008; Legler 2008; Bonefeld-Jørgensen et al. 2011). Southern Residents are exposed to a mixture of pollutants, some of which may interact synergistically and enhance toxicity, influencing their health. High levels

of these pollutants have been measured in blubber biopsy samples from Southern Residents (Ross et al. 2000; Krahn et al. 2007; Krahn et al. 2009), and more recently, these pollutants were measured in fecal samples collected from Southern Residents (Lundin et al. 2016a; Lundin et al. 2016b).

It is expected that SRKW prey species in the action area (i.e., Puget Sound Chinook salmon) will be exposed to and bio-accumulate contaminants through the proposed actions stormwater and wastewater discharge (a pathway for exposure of persistent pollutants such as PCBs). The majority of SRKWs have high levels of PCBs (Ross et al. 2000; Krahn et al. 2007, 2009) that exceed a health-effects threshold (17,000 ng/g lipid) derived by Kannan et al. (2000) and Ross et al. (1996) for PCBs in marine mammal blubber. The PCB health-effects threshold is associated with reduced immune function and reproductive failure in harbor seals (Reijnders 1986; de Swart et al. 1996; Ross et al. 1996; Kannan et al. 2000). Moreover, juvenile SRKWs have blubber concentrations that are currently 2 to 3.6 times higher than the established health- effects threshold (Krahn et al. 2009).

Since the contaminant exposure resulting from the proposed action is considered to be chronic and on-going, it is also expected a SRKW will consume at least some of the exposed and contaminated fish, adversely impacting SRKW health and fitness. The proposed action, therefore, reduces the time until persistent pollutants (e.g. PCBs from stormwater) will surpass a health-effects threshold (i.e., PCB accumulation over the lifetime of a killer whale will occur more rapidly with the action than without it). Increasing persistent pollutant levels in the whales only further exacerbates their current susceptibility to adverse health effects.

Sunflower Sea Star

Little is known about specific effects of toxic contaminants on sunflower sea stars or how stress from exposure to such chemicals affects susceptibility to sea star wasting syndrome. Laboratory challenge tests have exposed larval stages of various marine invertebrates to hydrocarbons, heavy metals, pesticides, and other contaminants commonly found in stormwater runoff. Documented impacts range from developmental abnormalities to behavioral augmentation, and mortality is common at concentrations as low as several parts per million (e.g., Hudspith et al. 2017, de Almeida Rodrigues et al. 2022). For juvenile and adult marine invertebrates, including sea stars and other echinoderms, a variety of sublethal behavioral and physiological effects from these toxic contaminants have been documented, but mortality is also possible. Suspended sediment in stormwater may also be a concern as sea stars that become covered by sediment may experience greater risk of wasting disease. Absent species-specific data for the sunflower sea star, ecologically and physiologically similar species can be used as proxies to state that stormwater runoff is likely to harm, injure, or kill sunflower sea stars, having the greatest effects during the larval life history stage.

Effects on Critical Habitat

Water quality is a feature of critical habitat for all species considered in this opinion. Runoff from runways, roadways, parking lots, and other hardscaped elements that would be created as part of the proposed action is expected to represent an extraordinarily complex chemical mixture, consisting of thousands of distinct compounds, the vast majority of which have not been

identified or characterized in terms of adverse environmental effects (Du et al. 2017, Peter et al. 2018). The proposed action intends to capture and treat stormwater and wastewater prior to discharge into Puget Sound. However, we expect that, despite the robust treatment methodologies to be performed as part of the proposed action, treated stormwater and wastewater will still contain some residual contaminants that will ultimately be introduced to Puget Sound, thereby degrading the water quality PBF of critical habitat for Puget Sound Chinook salmon, Puget Sound/Georgia Basin bocaccio, Puget Sound/Georgia Basin yelloweye rockfish, and SRKW. The species considered in this opinion may also take up contaminants through ingestion of contaminated prey. Consequently, the prey PBFs of critical habitat for Puget Sound/Georgia Basin bocaccio and yelloweye rockfish and SRKW will also be adversely affected by the proposed action. However, we expect the magnitude and extent of degradation from the proposed action to be such that affected PBFs of critical habitat within the actions area would continue to support the conservation role for each of the corresponding listed species.

Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. The BE describes cumulative effects in section 5.4, which is incorporated by reference here with the exception of the following conclusory statement, with which we do not concur, "There is not enough information available to meaningfully quantify or evaluate the cumulative impacts of the proposed action but they are not expected to reach the scale where take would occur." Therefore, we supplement the information presented in section 5.4 of the BE (Krull 2025) with the following.

Some continuing non-federal activities are reasonably certain to contribute to environmental variation within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global environmental variation that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future environmental conditions relating to environmental variation in the action area are assumed to be part of the environmental baseline.

We expect most non-federal activities that impact the listed species and critical habitats considered in this opinion to continue for the foreseeable future, contributing to cumulative effects driven by economic conditions that characterize traditional natural-resource-based industries, resource demands associated with settlement of local and regional population centers, and efforts by social groups dedicated to the river restoration and use of natural amenities, such as cultural inspiration and recreational experiences.

The economic and environmental significance of the natural-resource-based economy is currently declining in absolute terms and relative to a newer economy based on mixed manufacturing and marketing with an emphasis on high technology (Brown 2011). However, resource-based industries are likely to continue to have an influence on environmental conditions within the action area for the indefinite future. Because resource-based industries have adopted management practices that avoid or minimize many of their most harmful impacts, the level of

cumulative effects anticipated from these activities is likely to be less intense than would have been anticipated even a few years ago.

While natural-resource extraction within Washington may be declining, general resource demands are increasing with growth in the size and standard of living of the local and regional human population. The percentage increase in population growth may provide the best estimate of general resource demands because as local human populations grow, so does the overall consumption of local and regional natural resources. Per Washington's Office of Financial Management, Washington's population growth had been below 1.0 percent from 2009 to 2013 but has increased recently to 1.6 percent. Population growth remains concentrated in the five largest metropolitan counties—Clark, King, Pierce, Snohomish, and Spokane. The state added 45,300 housing units in 2019, compared to 42,200 in 2018, an increase of 7.3 percent. Fifty-five percent of all new units built in the past year were multi-family units. The state's housing stock has grown by an average of 31,700 units per year since 2010, 27 percent below the prior decade average of 43,500 units per year. More than 71 percent of all new housing units this decade were built in one of the state's five largest metropolitan counties. King County leads all counties with 104,500 new housing units or 37 percent of the state total since 2010.

Demand for cultural and aesthetic amenities also continues to grow with human population and is reflected in decades of concentrated effort by tribes, states, and local communities to restore an environment that supports flourishing wildlife populations, including populations of species that are now ESA-listed. Reduced economic dependence on traditional resource-based industries has been associated with growing public appreciation for the economic benefits of river restoration and growing demand for the cultural amenities that river restoration provides. Thus, many non-federal actions have become more responsive to the recovery needs of ESA-listed species. Those actions included efforts to ensure that resource-based industries adopt improved practices to avoid, minimize, or offset their adverse impacts.

Elsewhere, many actions have focused on completion of river restoration projects specifically designed to counter the major factors now limiting the survival of ESA-listed species at all stages of their life cycle. Those actions have improved the availability and quality of estuarine and nearshore habitats, floodplain connectivity, channel structure and complexity, riparian areas and large wood recruitment, stream substrates, stream flow, water quality, and fish passage. In this way, the goal of ESA-listed species recovery has become a common and accepted part of the state's economic and environmental culture. We expect this trend to continue into the future as public awareness of environmental and at-risk species issues. However, funding for restoration activities from governmental and non-governmental sources is uncertain, while development demands are largely consistent or growing over time, and, therefore, more certain to occur.

The EPA, via the states, regulates stormwater effluent through a National Pollution Discharge Elimination System Municipal Separate Storm Sewer System permit. The Washington Department of Ecology, under EPA's delegated authority, issues permits for the operation of the stormwater system, requiring municipalities to maintain publicly owned storm and surface water facilities for water quality. Municipal Separate Storm Sewer System permits have "anti-backsliding" provisions, which require stormwater management plans to control pollutant discharges to the maximum extent practicable. Renewal permits require the permittees to ensure

that all new development and redevelopment follow local construction and post-construction stormwater regulations.

NMFS also expects that state, tribal, local, or private parties will continue taking actions to reduce toxic pollution and stormwater runoff to the Puget Sound from all sources (EPA 2012). While there are reasons to expect continued reduction in pollutant deliveries to the river and sound from existing sources, increasing human population growth and corollary upland development are likely to result in new sources of both point and non-point load. Therefore, we expect the concentration of contaminants in Puget Sound are unlikely to show improvements in habitat conditions or lead to improvement in population viability of ESA-listed species.

In summary, resource-based activities (e.g., timber harvest, agriculture, mining, shipping, energy development) are likely to continue to exert an influence on the quality of freshwater, estuarine, nearshore marine, and marine habitats in the action area. The intensity of this influence is difficult to predict and is dependent on many social and economic factors. However, the adoption of industry-wide standards to reduce environmental impacts and the shift away from resource extraction to a mixed manufacturing and technology-based economy should result in a gradual decrease in influence over time. In contrast, the population of Washington is likely to increase in the next several decades with a corresponding increase in natural resource consumption. Additional residential and commercial development, and a general increase in human activities, are likely to cause localized degradation of freshwater, estuarine, and marine habitats. Interest in restoration activities is growing along with greater environmental awareness among the public. At best, this will lead to localized improvements to these habitat types. Otherwise, it is likely that cumulative effects will not have a strong positive or negative effect on population abundance trends of ESA-listed species or the quality and function of critical habitat physical and biological features.

Integration and Synthesis

ESA-Listed Species

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 to the environmental baseline and the cumulative effects, taking into account the status of the species and critical habitat, 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.

The species considered in this opinion are listed as threatened or endangered with extinction because of declines in abundance, poor productivity, reduced spatial structure, and diminished diversity. This depressed condition is a function of many factors, including reductions in the amount or quality of habitat throughout their range and overharvest in previous years. Systemic anthropogenic detriments to estuarine and marine habitats are impairing populations of the species considered in this opinion, and these are often described as limiting factors. Baseline

conditions in the marine portions of the action area reflect habitat degradation typical in the near-marine environment throughout Puget Sound.

To this status, we add the effects of the proposed action. As described above, individuals exposed to contaminants in stormwater and wastewater discharges either directly or through trophic interactions are most likely to have sublethal responses that could ultimately result in earlier mortality than would occur in more fit individuals. However, the proposed action's increment of take, when added to the baseline and considering the status of the species and their component populations that would be subject to take, is not large enough to discernibly alter current population-level abundance and productivity; therefore, it is unlikely to reduce the survival and recovery the listed species considered in this opinion.

The sunflower sea star is proposed for listing throughout its range, and no data exist to suggest that the species consists of anything other than a single, panmictic population. We are not currently aware of any specific habitat types or locations used by sunflower sea stars for mating or spawning, larvae are planktonic, and newly settled juveniles appear in a variety of habitats. Therefore, to reach a determination of jeopardy, a proposed action would have to impact rangewide population dynamics. Because effects of the proposed action would be limited to a small fraction of the sunflower sea star's range, it is not likely to appreciably reduce the likelihood of survival and recovery of the species, even when combined with a degraded environmental baseline and additional pressure from cumulative effects and environmental variation.

Critical Habitat

We also consider the effects on critical habitat from the proposed action in the context of the current status of critical habitat and existing baseline conditions. The PBFs of critical habitat for listed species, as a baseline condition throughout the action area, are degraded by multiple anthropogenic changes, including reduced habitat quality and complexity, decreased prey availability, and diminished water quality. Federal, tribal, state, and local entities are actively carrying out habitat improvement projects, but at the same time, human population growth and development pressures on aquatic systems are increasing throughout many areas in Washington. The long-term consequences of human population growth trends may further degrade the quality and function of critical habitat within the action area. Environmental variation will have a range of effects on habitat contemporaneous with the design life of the proposed action, which could also exert additional downward pressure on habitat functions.

For critical habitat of all listed species considered in this document, the proposed action is expected to have an adverse effect on the physical and biological features related to freshwater, estuarine, nearshore marine, and marine conditions when contaminants in stormwater and wastewater discharges from the proposed action reach Puget Sound. These discharges will incrementally reduce water quality and forage PBFs of critical habitat for listed species throughout the design life of the proposed action. We anticipate that the effects of the proposed action, when added to the baseline, and in consideration of the status of PBFs of critical habitat within the action area, will be slightly negative but insufficient to appreciably reduce the conservation value of the critical habitat.

Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat considered in this opinion, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of, or to destroy or adversely modify designated critical habitat for:

- Puget Sound Chinook salmon
- Puget Sound steelhead
- Puget Sound/Georgia Basin bocaccio
- Puget Sound/Georgia Basin yelloweye rockfish
- Southern Resident killer whale

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 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 ITS.

Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take is reasonably certain to occur in the form of harm from direct exposure and trophic links to contaminants in stormwater and wastewater discharges.

Take in the form of harm is often impossible to quantify as a number of individuals because the presence of the individuals (exposure to the harmful conditions) is highly variable over time, and is influenced by factors that cannot be easily predicted. Additionally, the duration of exposure is highly variable based on species behavior patterns, and the wide variability in numbers exposed and duration of exposure creates a range of responses, many of which cannot be observed without research and rigorous monitoring. In these circumstances, we described an "extent" of take which is a measure of the harming condition spatially, temporally, or both. The extent of take is causally related to the amount of harm that would result from the proposed action and provides observable metrics for monitoring, compliance, and re-initiation purposes.

In this case, the extent of take is 51 acres of PGIS. This take indicator is causal and proportional to the take identified in this biological opinion as it directly affects the amount of stormwater/wastewater pollution that would be generated. Take would be exceeded if the amount of additional PGIS created as a result of the proposed action is more than 51 acres and/or any area that is not currently pollution-generating is converted to PGIS, without coordination with NMFS' West Coast Region.

The amount and extent of take in this ITS serves two functions: 1) it identifies the quantity of incidental take exempted for the action agency and applicant. In the case of a species without 4(d) protective regulations, such as the sunflower sea star, the exemption is not needed because incidental take is not prohibited; and 2) it serves as a check on NMFS's jeopardy analysis. The amount or extent of take identifies the anticipated level of take NMFS considered in reaching its conclusion that the proposed action will not jeopardize the continued existence of a listed species. If this level of take is exceeded, reinitiation of consultation is triggered to ensure that NMFS's no-jeopardy conclusion remains valid.

Effect of the Take

In the biological opinion, 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.

Reasonable and Prudent Measures

"Reasonable and prudent measures" refer to those actions the Director considers necessary or appropriate to minimize the impact of the incidental take on the species (50 CFR 402.02).

FAA shall require the Port to:

1. Minimize take associated with water quality degradation in Puget Sound from stormwater and wastewater discharges as described in the proposed action.

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 FAA or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. The following terms and conditions implement reasonable and prudent measure 1:
    a. Ensure the project does not exceed the design specifications and creates no more than 51 acres of PGIS, unless otherwise coordinated with NMFS West Coast Region. The FAA shall provide an as-built report including the total area of PGIS to NMFS within 90 days following project completion. This report should be sent

to projectreports.wcr@noaa.gov including "Attn: WCRO-2025-01881" within the subject line.

b. The Port shall carry out the operation and maintenance plans described in the *Seattle-Tacoma International Airport Stormwater Pollution Prevention Plan* (Port of Seattle 2022 or most recent) to ensure that facilities or systems that are used to manage stormwater and wastewater at SEA are properly operated and maintained.
    i. The Port shall maintain records of inspection and maintenance to document compliance with the standards provided in the *Seattle-Tacoma International Airport Stormwater Pollution Prevention Plan* (Port of Seattle 2022 or most recent). Records do not need to be provided to NMFS unless requested.

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). No conservation recommendations are included with this biological opinion.

Reinitiation of Consultation

Under 50 CFR 402.16(a): "Reinitiation of consultation is required and shall be requested by the federal agency where discretionary federal 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."

NLAA DETERMINATIONS

We reviewed FAA's consultation request document and related materials. Based on the information provided by FAA, and supplemented by our knowledge and expertise informed by the best available science, we find that the proposed action is NLAA the following ESA-listed species and designated critical habitats under NMFS' purview:

- Central American DPS Humpback Whales
- Mexico DPS Humpback Whales

Central American and Mexico DPS Humpback Whales

Humpback whales were listed as endangered under the Endangered Species Conservation Act in June, 1970 (35 FR 18319), and remained listed after the passage of the ESA in 1973 (35 FR

8491). Humpbacks are divided globally by NMFS into 14 DPSs and place four DPSs (Western North Pacific, Arabian Sea, Cape Verde/Northwest Africa, and Central America) as endangered and one (Mexico DPS) as threatened (81 FR 62259). Photo-identification and modeling efforts indicate that a large proportion of humpback whales feeding along the coasts of northern Washington and southern British Columbia are from the Hawaii DPS (63.5 percent), with fewer animals from the Mexico (27.9 percent) and Central America (8.7 percent) DPSs (Wade 2017).

Numbers of humpback whales have been growing annually at a rate of 6-7.5 percent off the U.S. West Coast (Carretta et al. 2020; Calambokidis and Barlow 2020). Humpback whale sightings in the Salish Sea have also been increasing since the early 2000s (Calambokidis et al. 2018). Humpbacks may be entering the Salish Sea as a foraging or rearing opportunity along their migration from summer feeding grounds to winter breeding grounds. Alternatively, there are indications that some humpbacks may overwinter entirely within the Salish Sea. Existing sighting data in the Puget Sound proper is not reliable distribution data and may be skewed to warm weather, when more people are likely to be whale watching. Sightings in recent years have most mostly occurred from May through October, which overlaps with project construction windows. Despite increases in sightings of humpback whales in the Puget Sound, scientific survey data indicate that the highest densities of humpback whales occur within the Strait of Juan de Fuca up to Port Angeles with only intermittent use of the Puget Sound (pers. comm., John Calambokidis, Cascadia Research Collective, February 26, 2020 cited in 86 FR 21082). While the likelihood of exposure of humpbacks to effects of the proposed action is low because of low whale density outside the Strait, it remains a possibility, and we have, therefore, examined possible effects related to contamination from pollutants.

Humpback whales are generalist feeders, and may show regional prey preferences. The whales are known to shift prey between krill and fish along the US West Coast and these shifts seem to match the relative abundance of prey and are reflected in changes in stable isotope concentrations from skin samples taken in biopsies of whales (Fleming et al. 2016). No studies have yet been conducted on the feeding preferences of humpback whales within the Salish Sea. Humpbacks forage and switch between target prey depending on what is most abundant or of highest quality in the system (Fleming et al. 2016) and it is possible that humpbacks enter the Salish Sea in search of dense congregations of prey such as krill and other forage fish like sand lance, and herring. Because humpbacks are opportunistic foragers, however, any decrease in the number of forage fish available in the entire Salish Sea due to the proposed action is unlikely to adversely affect their overall food supply. Krill are planktonic, and do not rely on the nearshore environment in a substantial way for their life cycle, therefore will not be affected by the proposed action. We expect that the whales will proportionally shift food sources in response to any decrease in forage fish, but any decrease in forage fish within the marine portions of the action area is not expected to have a detectible effect on humpback food availability. Therefore, effects on humpbacks due to any decrease in forage fish related to water quality degradation resulting from the proposed action are expected to be insignificant.

Humpback whales can bioaccumulate lipophilic compounds (e.g., halogenated hydrocarbons) and pesticides (e.g., DDT) in their blubber, by feeding on contaminated prey (bioaccumulation) or inhalation in areas of high contaminant concentrations (Barrie et al. 1992; Wania and Mackay 1993). Herring in the Puget Sound and Georgia Basin, a known humpback food source, have

elevated pollutant levels in their bodies. And PCBs in herring in two Central/South Puget Sound locations were significantly greater than three northern locations (O'Neill and West 2001).

Although there has been substantial research on the identification and quantification of such contaminants on individual whales, including humpbacks, no detectable effect from contaminants has been identified in baleen whales. There may be chronic, sub-lethal impacts, but these are currently unknown. In the 2015 NMFS status review of humpback whales, contaminants were currently not considered an important threat to the Central America, Mexico, and Hawaii DPSs (Bettridge et al. 2015). Because no detectable effects of contaminants have been identified in humpback whales, the response is considered insignificant.

ESSENTIAL FISH HABITAT RESPONSE

NMFS also reviewed the proposed action for potential effects on EFH designated under the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1855(b)). This review was pursuant to section 305(b) of the MSA, implementing regulations at 50 CFR 600.920, and agency guidance for use of the ESA consultation process to complete EFH consultation. We have concluded that the action would adversely affect EFH designated under the following fisheries management plans:

- Pacific Coast Salmon Fishery Management Plan (PFMC 2024a)
- Coastal Pelagic Species Fishery Management Plan (PFMC 2024b)
- Pacific Coast Groundfish Fishery Management Plan (PFMC 2024c)

EFH conservation recommendations are provided below.

Magnuson-Stevens Fishery Conservation and Management Act

Section 305(b) of the MSA directs federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species' contribution to a healthy ecosystem. For the purposes of the MSA, EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity", and includes the associated physical, chemical, and biological 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 may result from actions occurring within EFH or outside of it and may include direct, indirect, site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) of the MSA also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH (50 CFR 600.905(b)).

EFH Affected by the Proposed Action

The marine portions of the action area overlap with identified EFH for Pacific Coast Salmon (PFMC 2024a), coastal pelagic species (PFMC 2024b), and Pacific Coast groundfish (PFMC 2024c).

We evaluated the effects of the proposed actions on EFH, as regulated by the Magnuson-Stevens Fisheries Conservation and Management Act. We incorporate by reference the analyses and findings of effects submitted in section 7 of the BE (Krull 2025). Based on the information provided by FAA, supplemented by our knowledge and expertise informed by the best available science, we make the following determinations for EFH within the proposed action area.

Table 5. Project-related Effects on Essential Fish Habitat

Essential Fish Habitat	Determination of Effect to EFH	Pathway for Potential Effects
Pacific Salmonids PFMC 2024a	Would Adversely Affect	Water quality degradation from stormwater/wastewater discharge
Coastal Pelagic Species PFMC 2024b	Would Adversely Affect	Water quality degradation from stormwater/wastewater discharge
Pacific Coast Groundfish PFMC 2024c	Would Adversely Affect	Water quality degradation from stormwater/wastewater discharge

Adverse Effects on EFH

The effects of the proposed action on ESA-listed species are described in the "Effects of the Action" section of the ESA analysis above. The same mechanisms of effect are likely to affect EFH for Pacific Coast groundfish, coastal pelagic species, and Pacific Coast salmon to varying degrees. Based upon the analysis presented in the "Effects of the Action" section of this document, NMFS has determined that the proposed action would adversely affect EFH for various federally-managed fish species under the Pacific Coast groundfish species, coastal pelagic species, and Pacific Coast salmon species FMPs.

EFH Conservation Recommendations

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

- The FAA should implement RPM 1 to minimize the delivery of stormwater/wastewater pollutants to waters containing EFH for Pacific Coast salmon, Pacific Coast groundfish, and coastal pelagic species. Implementation of RPM 1, including the required Terms and Conditions, will serve as EFH conservation measures.

Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, FAA must provide a detailed response in writing to NMFS within 30 days after receiving an EFH conservation recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH conservation recommendations unless NMFS and the

federal agency have agreed to use alternative time frames for the federal agency response. The response must include a description of the measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the conservation recommendations, the federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

Supplemental Consultation

FAA must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations (50 CFR 600. 920(l)).the basis for NMFS' EFH conservation recommendations (50 CFR 600. 920(l)).

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

Please direct questions regarding this letter to Sam Bankston, ESA Consultation Biologist in the Oregon Washington Coastal Office, at 503 454-6761 or samuel.bankston@noaa.gov.

Sincerely,



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United States Department of the Interior

FISH AND WILDLIFE SERVICE

Washington Ecological Services
1009 College Street SE, Suite 215
Lacey, Washington 98503

In Reply Refer to:
FWS/R1/2024-0081720

September 23, 2025

Kandice Krull, Environmental Protection Specialist
U.S. Department of Transportation
Federal Aviation Administration
2200 South 216th Street
Des Moines, Washington 98198

Dear Ms. Krull:

Subject: Biological Opinion, Seattle-Tacoma International Airport Sustainable Airport Master Plan, Near-Term Projects

This letter transmits the U.S. Fish and Wildlife Service's (Service) Biological Opinion (Opinion) addressing the proposed Seattle-Tacoma International Airport, Sustainable Airport Master Plan Near-Term Projects, located in King County, Washington, and the action's foreseeable effects on the bull trout (*Salvelinus confluentus*) and designated critical habitat for the bull trout. Consultation was initially requested by the Federal Aviation Administration (FAA) on October 2, 2024. A second submittal of information in support of consultation was received on June 30, 2025. The FAA provided information in support of "may affect, not likely to adversely affect" determinations. On August 8, 2025, the Service communicated that we do not concur with this finding, and that formal consultation and preparation of an Opinion are advisable. This formal consultation was conducted in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (ESA).

We were able to expedite our review and evaluation because the FAA provided key information and analyses in the June 30, 2025, Biological Evaluation (BE) and consultation initiation package. Where relevant, we adopted the information and analyses you provided after our independent, science-based evaluation confirmed they meet our regulatory and scientific standards. The enclosed Opinion indicates where we incorporate this information by reference.

The FAA made several "no effect" determinations for additional species that are known to occur in King County, including the North American wolverine (*Gulo gulo luscus*), yellow-billed cuckoo (*Coccyzus americanus*), marbled murrelet (*Brachyramphus marmoratus*), northwestern pond turtle (*Actinemys marmorata*), monarch butterfly (*Danaus plexippus*), and Suckley's cuckoo bumble bee (*Bombus suckleyi*).

The Service has no authority or responsibility under the ESA to concur with "no effect" determinations. These determinations rest with the FAA, and no consultation with the Service is required. We recommend that the FAA retain a copy of your "no effect" determinations with your administrative records.

A record of this consultation is on file at the Service's Washington Ecological Services Office in Lacey, Washington. An electronic copy of this Opinion will be available to the public approximately 14 days after it is finalized and signed. A list of Opinions completed by the Service since October 1, 2017, can be found on the Service's Environmental Conservation Online System (ECOS) website at https://ecos.fws.gov/ecp/report/biological-opinion.html.

If you have any questions regarding the enclosed Opinion or our shared responsibilities under the ESA, please contact Logan Kent (logan_kent@fws.gov) or Ryan McReynolds (ryan_mcreynolds@fws.gov), and please copy the Ecological Services Office Inbox (washingtonfwo@fws.gov).

Sincerely,

MOLLY GOOD

Digitally signed by MOLLY GOOD
Date: 2025.09.23 18:21:00 -07'00'

for Brad Thompson, State Supervisor
Washington Ecological Services

cc:
Port of Seattle, Seattle, WA (S. Rybolt)

Endangered Species Act - Section 7 Consultation

BIOLOGICAL OPINION

U.S. Fish and Wildlife Service Reference:
2024-0081720

Seattle-Tacoma International Airport, Sustainable Airport Master Plan, Near-Term Projects

King County, Washington

Federal Action Agency:

US Department of Transportation
Federal Aviation Administration
Northwest Mountain Region – Seattle Airports District Office

Consultation Conducted By:

U.S. Fish and Wildlife Service
Washington Ecological Services Office
Lacey, Washington

MOLLY GOOD

Digitally signed by MOLLY GOOD
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for Brad Thompson, State Supervisor
Washington Ecological Services Office

September 23, 2025
Date

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1 CONSULTATION HISTORY

The following is a summary of important events associated with this consultation:

- The Federal Aviation Administration (FAA) submitted a request for informal consultation on October 2, 2024.
- A revised, final Biological Evaluation (BE) and additional information necessary to initiate consultation were submitted by the FAA on June 30, 2025.
- In e-mail correspondence dated August 8, 2025, the U.S. Fish and Wildlife Service (Service) communicated that we do not concur with the FAA's effects determinations, and that formal consultation and preparation of an Opinion are advisable. We also indicated that we have sufficient information (i.e., from the BE and other sources) to initiate consultation.

2 BIOLOGICAL OPINION

3 DESCRIPTION OF THE PROPOSED ACTION

A federal action means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies in the United States or upon the high seas (50 CFR 402.02).

The FAA's Seattle-Tacoma International Airport Sustainable Airport Master Plan Near Term Projects Final BE (Krull 2025 pp. 15-49) includes a complete description of the proposed action. The FAA proposes to approve and/or provide funding to the Port of Seattle (Port) for implementation of the Seattle-Tacoma International Airport (SEA or Airport) Sustainable Airport Master Plan (SAMP) and approximately 29 associated Near-Term Projects (NTPs) (Krull 2025, p. vii). The NTPs include plans for new facilities and improvements to existing facilities that will address identified safety, operational, and capacity (passenger, freight, and cargo) needs on a 20-year planning horizon.

Section 1.0 of the BE (Krull 2025 pp. 9-14), which is incorporated here by reference and included in Appendix A, describes purpose and need, location, 'key issues' (e.g., stormwater and wastewater discharges), and species.

The proposed action is located entirely on Port-owned property within and adjacent to the existing SEA footprint. As described in Sections 2.0 through 2.9 of the BE (Krull 2025, pp. 15-49; Appendix A), the proposed action comprises the following elements:

- NTPs – airfield, terminal, cargo, landside, and airport/airline support projects designed to increase airport capacity and operational efficiency to meet projected future needs.
- Program Support Projects (PSPs) – additional infrastructure improvement projects needed to support NTPs, as identified in the Port Utilities Master Plan (UMP, Port 2022), including:
    - Operational infrastructure improvements (electrical, fuel, gas, water, sewer, and information and telecommunications technology).

    - Stormwater drainage system (SDS) and industrial wastewater system (IWS) improvements.
- Mitigation for anticipated wetland and buffer impacts.
- Best management practices (BMPs) implemented by the Port to avoid and minimize environmental impacts from construction and operations.

Figure 2 and Table 2 from the BE (Krull 2025, pp. 18-20; Appendix A) identify and describe the location, configuration, and 'footprint' of the NTPs and PSPs. Additional details are provided in the BE and incorporated here by reference (Krull 2025, pp. 21-29).

Construction of projects (NTPs and PSPs) would begin as soon as 2025 and continue in stages through 2032. The proposed action, inclusive of the approximately 29 associated NTPs and PSPs, will result in the construction and net addition of approximately 72 acres of impervious surfaces at SEA, including approximately 51 acres of pollution-generating impervious surfaces (PGIS). The proposed action includes improvements to the existing SDS, improvements to the existing IWS, and operational source control BMPs for new and existing impervious surfaces.

The proposed action includes improvements to, and expansion of, the SDS and IWS to provide the additional detention and treatment capacity needed to support NTP development. The SDS comprises 12 stormwater drainage basins and a network of conveyance pipes, detention vaults, and ponds used to capture and treat stormwater runoff from approximately 1,284 acres of SEA property. Half of this area is impervious and primarily associated with airport runways, taxiways, parking lots, roads, and roof tops. The remainder is pervious and consists of landscaped or fallow open spaces and areas associated with stormwater treatment Best Management Practices (BMPs) such as runway filter strips. The Airport's SDS is segregated into separate stormwater subbasins that each drain to individual outfall locations. The IWS comprises two drainage basins covering a combined 325.1 acres that service the aircraft operations area and a 26.5-acre drainage basin servicing the airport parking garage. The IWS services portions of the Port, where aircraft de-icing and handling of fuel, paint, lubricants, degreasers, and other hazardous materials routinely occur. Improvements and expansions to the SDS and IWS systems are described in Table 4 of the BE (Krull 2025, pp. 37-38).

The FAA and Port will provide mitigation for unavoidable impacts (permanent and temporary) to wetlands and wetland buffers (i.e., approximately 0.58 acre of Category II and Category III wetlands); this will include approximately 2.65 acres of mitigation for wetland buffer impacts, and between 1.17 acres and 4.68 acres of mitigation for wetland impacts (Krull 2025, pp. 41-43).

The BMPs are described in Section 2.8 of the BE (Krull 2025, pp. 43-45) and include construction and operational source control BMPs. The Port's Seattle-Tacoma International Airport Stormwater Pollution Prevention Plan (SWPPP) defines compliance requirements and expectations for all construction activities that occur on Port property, including state and federal guidance and regulatory requirements for avoiding and minimizing impacts to the environment (SWPPP, Port 2021). Additionally, the Port will require every construction project to develop a site-specific construction SWPPP.

The FAA and Port participate in, and contribute to, additional collaborative multi-party/multi-agency efforts directed at stormwater science and monitoring; see Section 2.8 of the BE (Krull 2025, pp. 49). This includes ongoing participation in the Washington Department of Ecology (Ecology) Stormwater Working Group and 6PPD-Q subgroup, and a proposal to independently fund and implement a stormwater media treatment study to evaluate technologies for the effective removal of 6PPD-quinone from stormwater discharge.

In summary, the action agency's description of the proposed action includes infrastructure improvements and developments (construction) spanning a timeline of 2025 – 2032. This includes 29 NTPs, PSPs, wetland mitigation and the implementation of BMPs and other conservation measures to minimize environmental impacts. The description of the proposed action, including BMPs/conservation measures and action area, are hereby incorporated by reference from the following sources:

- Description of the proposed action – BE (Krull 2025, pp. 15-43).
- BMPs/conservation measures – BE (Krull, pp. 43-49); and,
- Action area – BE (Krull, pp. 50-52).

4 ANALYTICAL FRAMEWORK FOR THE JEOPARDY AND ADVERSE MODIFICATION DETERMINATIONS

4.1 Jeopardy Determination

In accordance with our regulations (50 CFR 402.02, 402.14(g)), the jeopardy determination in this Opinion relies on the following four components:

1. The *Status of the Species* evaluates the species' current range-wide condition relative to its reproduction, numbers, and distribution; the factors responsible for that condition; its survival and recovery needs; and explains if the species' current range-wide population retains sufficient abundance, distribution, and diversity to persist and retains the potential for recovery (see Endangered Species Consultation Handbook, March 1998).

2. The *Environmental Baseline* section of this Opinion evaluates the past and current condition of the species in the action area relative to its reproduction, numbers, and distribution absent the effects of the proposed action; including the anticipated condition of the species contemporaneous to the term of the proposed action; the factors responsible for that condition; and the relationship of the action area to the survival and recovery of the species.

3. The *Effects of the Action* section of this Opinion evaluates all consequences to the species that are reasonably certain to be caused by the proposed action (i.e., the consequences would not occur but for the proposed action and are reasonably certain to occur) and how those consequences are likely to influence the survival and recovery of the species.

4. The *Cumulative Effects* section of this Opinion evaluates the 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, on the species and its habitat, and how those effects are likely to influence the survival and recovery of the species.

In accordance with policy and regulation, the jeopardy determination is made by formulating the Service's opinion as to whether the proposed Federal action, including its consequences, taken together with the status of the species, environmental baseline, and cumulative effects, reasonably would be expected to reduce appreciably the likelihood of both the survival and recovery of the species in the wild by reducing the reproduction, numbers, or distribution of that species.

4.2 Destruction or Adverse Modification Determination

In accordance with regulations and regional implementing guidance, the destruction or adverse modification determination in this Opinion relies on the following four components:

1. The *Status of Critical Habitat* section evaluates the range-wide condition of the critical habitat in terms of essential habitat features, primary constituent elements (PCEs), or physical and biological features (PBFs) that provide for the conservation of the listed species; the factors responsible for that condition; and the intended value of the critical habitat for the conservation of the listed species.

2. The *Environmental Baseline* section of this Opinion evaluates the past and current condition of the critical habitat in the action area absent the effects of the proposed action; including the anticipated condition of the species and its critical habitat contemporaneous to the term of the proposed action; the factors responsible for that condition; and the conservation value of critical habitat in the action area for the conservation of the listed species.

3. The *Effects of the Action* section of this Opinion evaluates all consequences to critical habitat that are reasonably certain to be caused by the proposed action (i.e., the consequences would not occur but for the proposed action and are reasonably certain to occur) and how those consequences are likely to influence the conservation value of the affected critical habitat for the species in the action area.

4. *Cumulative Effects* section of this Opinion evaluates the effects on critical habitat 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, and how those effects are likely to influence the conservation value of the affected critical habitat for the species in the action area.

In accordance with regulation, the destruction or adverse modification determination is made by formulating the Service's Opinion as to whether the effects of the proposed Federal action, taken together with the status of the critical habitat, environmental baseline, and cumulative effects, reasonably would be expected to result in a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of the species.

5 STATUS OF THE SPECIES: Bull Trout

For a detailed account of bull trout biology, life history, threats, demography, and conservation needs, refer to the Service's *Species Status Assessment (SSA) for the Coterminous Distinct Population Segment of Bull Trout* (USFWS 2024a), the *5-Year Status Review: Summary and Evaluation* (USFWS 2024b), and the BE (Krull 2025; Appendix D, Section 4.0, Coastal-Puget Sound Bull Trout, pp. D5-D7).

6 STATUS OF CRITICAL HABITAT: Bull Trout

The action area includes designated bull trout critical habitat, which the Service quantifies conservatively as approximately 100 acres (i.e., extending along approximately 15,000 linear feet [ft] of shoreline and waterward approximately 300 ft offshore). This designated critical habitat is essential to the conservation and recovery of bull trout from the Coastal Recovery Unit (CRU) and includes important nearshore marine foraging, migratory, and overwintering (FMO) habitat. This FMO habitat supports anadromous bull trout originating from the Skagit, Stillaguamish, Snohomish/Skykomish, and Puyallup River Core Areas. For a detailed account of the status of designated bull trout critical habitat, refer to Appendix B: Status of Designated Critical Habitat: Bull Trout.

7 ENVIRONMENTAL BASELINE: Bull Trout and Designated Bull Trout Critical Habitat

Regulations implementing the ESA (50 CFR 402.02) define the environmental baseline as 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 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. The impacts to listed species or designated critical habitat from Federal agency activities or existing Federal agency facilities that are not within the agency's discretion to modify are part of the environmental baseline.

7.1 Current Condition of the Species in the Action Area and Factors Responsible for the Condition of the Species

The current condition of bull trout in the action area is described in the BE and incorporated here by reference (Krull 2025, pp. 53-58, 61-63). We have supplemented the BE with the following additional information.

Puget Sound nearshore marine FMO habitat is degraded as a result of impaired water quality, decreased forage and prey availability and diversity, altered nearshore and estuarine conditions and habitat quality, and disruptions to the natural functions of migration habitat resulting from elevated in-air and underwater sound, altered shoreline conditions, and human activities.

Shoreline modifications fragment habitat, reduce productivity, and diminish resiliency compared to historical conditions.

Complex nearshore marine habitats used by bull trout include those provided by or that include eelgrass (*Zostera* spp.), macroalgae, sand, mud, and mixed fine substrates. Bull trout prey on juvenile salmonids and marine forage fish, including surf smelt (*Hypomesus pretiosus*), Pacific herring (*Clupea pallasii*), Pacific sand lance (*Ammodytes hexapterus*), and other small schooling fish, often with a specific focus on spawning beaches (Kraemer 1994) and the locations where out-migrating salmonids concentrate (Lowery and Beauchamp 2015). Within the action area, the Washington Department of Fish and Wildlife (WDFW) documents surf smelt spawning grounds (WDFW Forage Fish Spawning Map).

We expect that bull trout in the action area originate from four Puget Sound bull trout core areas: the Lower Skagit River, Stillaguamish River, Snohomish/Skykomish River, and the Puyallup River Core Areas. These four core areas are within the range we expect bull trout would typically travel (Goetz 2016). For the four bull trout core areas named above, we include a summary of the status and trends information, population estimates, redd counts or other demographic data, and a description of existing threats and conservation needs (Appendix C: Bull Trout Core Area Summaries). We expect that a low density of adult and sub-adult bull trout from these four core areas use the action area for FMO purposes.

7.2 Current Condition of the Critical Habitat in the Action Area and Factors Responsible for the Condition of the Critical Habitat

The current condition of designated bull trout critical habitat in the action area is described in the BE and incorporated here by reference (Krull 2025, pp. 61-63; Appendix A). We supplement the BE with the following additional information.

The action area contains and provides the PCEs of designated bull trout critical habitat, including PCEs 2, 3, 4, and 8. Within and across the CRU, the current condition of designated bull trout critical habitat reflects natural variability, patterns of disturbance and recovery from both natural and man-made events, and the effects of earlier and concurrent, unrelated activities occurring in the same nearshore environments and watersheds. Within the action area, natural forms of nearshore habitat complexity are moderately to severely impaired. The same can be said regarding the condition of the bull trout prey base.

PCE 2: *Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.*

The action area provides nearshore marine FMO and serves as an important migratory corridor for bull trout. However, this habitat is degraded and there are several physical, biological, and water quality impediments to migration. Within the action area, the nearshore marine waters of Puget Sound include both developed and undeveloped shorelines, large man-made in-water and overwater structures (residential and commercial), and bulkheads and breakwaters (including those associated with the City of Des Moines Marina). Within the action area, the nearshore

marine waters of Puget Sound are listed as impaired, polluted, or a water of concern for several water and sediment quality parameters, including bacteria, hydrocarbons (benzo-a-pyrene, benzo-b-fluoranthene), and polychlorinated biphenyls (PCBs) (Krull 2025, pp. 57-58, Table 14). The Service considers this PCE to be moderately impaired and functioning at risk.

PCE 3: *An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.*

The action area provides nearshore marine FMO and supports bull trout prey, including marine forage fish and salmonids. The action area includes patchy eelgrass and other forms of complex natural habitat. Marine forage fish spawn in the action area. The Service considers this PCE to be moderately impaired and functioning at risk.

PCE 4: *Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure*.

Within the action area, the nearshore marine waters of Puget Sound include both developed and undeveloped shorelines, large man-made in-water and overwater structures (residential and commercial), and bulkheads and breakwaters (including those associated with the City of Des Moines Marina). "Virtually the entire shoreline … has been armored to protect development" (Krull 2025, p. 56). Natural shoreline processes are interrupted, degraded, and/or impaired. The action area includes patchy eelgrass and other limited forms of complex natural habitat. The Service considers this PCE to be moderately impaired and functioning at risk.

PCE 8: *Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.*

Puget Sound provides water quality and quantity conditions that support bull trout foraging, migration, and overwintering. Within the action area, the nearshore marine waters of Puget Sound are listed as impaired, polluted, or a water of concern for several water and sediment quality parameters, including bacteria, hydrocarbons (benzo-a-pyrene, benzo-b-fluoranthene, etc.), and PCBs (Krull 2025, pp. 57-58, Table 14). The Service considers this PCE to be moderately impaired and functioning at risk.

7.3 Climate Change

Consistent with Service policy, our analyses under the ESA include consideration of ongoing and projected changes in climate. The term "climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2014a, pp. 119-120). The term "climate change" thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2014a, p. 119).

Various types of changes in climate can have direct or indirect effects on species and critical habitats. These effects may be positive, neutral, or negative, and they may change over time. The nature of the effect depends on the species' life history, the magnitude and speed of climate change, and other relevant considerations, such as the effects of interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2014b, pp. 64, 67-69, 94, 299). In our analyses, we use our expert judgment to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change and its effects on species and their critical habitats. We focus in particular on how climate change affects the capability of species to successfully complete their life cycles, and the capability of critical habitats to support that outcome.

The ongoing and future effects of climate change on bull trout and designated critical habitat for the bull trout are extensively described in the Service's SSA (USFWS 2024a, entire). Climate change will continue to challenge the resiliency of some recovery units, core areas, and local populations. Bull trout are vulnerable to the effects of warming climates and changing precipitation and hydrologic regimes.

Climate change in the Pacific Northwest will include rising air temperatures, changes in the timing and volume of flow in rivers and streams, increases in extreme precipitation events, and other changes that are likely to degrade bull trout habitat and increase competition with non-native warmwater fish (Mote et al. 2014). However, the impacts of climate change in the Puget Sound, and in the action area specifically, are much less certain.

According to the National Oceanic and Atmospheric Administration (NOAA), changing environmental conditions are likely to include the following: sea-level rise; loss of tidal wetlands; rising ocean temperatures, stratification, ocean acidity, and hypoxia; dramatic shifts in physical ocean conditions, including ocean acidification and deoxygenation; altered species distributions; altered predator-prey relationships; thermal stress; altered fish and salmonid physiological, behavioral, and demographic processes; altered patterns and timing of migration; and altered and reduced productivity and survival (NMFS 2025, pp. 4-6).

According to the BE (Krull 2025, p. 76), the proposed action will lead to an increase in airport operations and passenger activity. It is reasonable to conclude this increase may correspond with an increase in greenhouse gas (GHG) emissions. However, it is not possible to separate this action's contributions to overall increases in GHG emissions from the contributions of all other sources of GHG emissions. Climate change and resulting impacts to listed species are expected to occur whether or not the proposed action is implemented.

8 EFFECTS OF THE ACTION: Bull Trout and Designated Bull Trout Critical Habitat

The effects of the action are all consequences to listed species and designated critical habitat that are caused by the proposed action, including consequences that are caused by but not part of the 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 (50 CFR 402.02).

We describe the effects of the action on bull trout and designated critical habitat for the bull trout in Appendix A (Krull 2025, pp. 67-83) and incorporate them by reference.

The BE finds and concludes the following (Krull 2025):

- "Regulated priority pollutants represent a fraction of the compounds found in stormwater and industrial wastewater. Some of these compounds are emerging contaminants of concern, for which the effectiveness of currently available treatment methods is not fully understood. It is unknown if treatment effectively removes non-regulated pollutants because neither testing methods nor thresholds have been established" (p. 72);
- "There is insufficient information to quantify potential significant effects on listed species from exposure to chronic surface water pollutants generated by the proposed action" (p. 72);
- "The Port's existing and proposed structural and operational pollution controls are robust [but] SDS and IWS discharges unavoidably contain low levels of [pollutants and] contaminants even after treatment. These residual[s] could harm ESA-listed fish and their habitats through direct and indirect exposure[s]" (p. 73);
- "Bull trout could be directly exposed to degraded water quality and habitat quality could be degraded. [However,] the extent and severity of those effects cannot be meaningfully quantified or evaluated" (p. 82); and,
- "Stormwater [pollutants and] contaminants remain in treated discharge and degrade water quality within designated critical habitat [However,] the extent and severity of those effects cannot be meaningfully quantified or evaluated. There is not enough information to reasonably conclude that treated stormwater and wastewater discharges produced by the action could adversely affect [designated] bull trout critical habitat" (p. 82).

The Service does not agree with or concur with some of these conclusions. We, instead, find that the best available scientific information supports the following (i.e., the following are likely and foreseeable consequences of the proposed action):

- Pollutants present in SEA-treated and -untreated discharges are sources of, and contribute to, degraded water and sediment quality in the action area;
- SEA discharges contain measurable quantities (loadings and concentrations) of solids, bacteria, persistent organic compounds (including hydrocarbons), metals, toxic and endocrine-disrupting compounds, microplastics, and contaminants that accumulate in media and prey; and,
- Discharges originating from SEA act as a stressor, they contribute to bull trout and bull trout prey exposures in the action area, and they degrade and impair habitat, long-term habitat functions, and critical habitat functions (i.e., PCEs and PCE functions).

We do not discuss further in this Opinion the effects of stressors that have only insignificant or discountable effects where we concur with and have incorporated those conclusions by reference, (Section 5.1.1 Noise, 5.1.2 Habitat Modification, Krull 2025, pp. 68-69). We confirmed effect determinations based on analyses presented in the BE, in conjunction with our own independent analyses informed by the best available information, science, and policy guidance.

8.1 SEA Airport Operations and Discharges

SEA operations include industrial activities; aircraft, vehicle, and equipment maintenance, cleaning, and storage; outdoor handling, storage, and disposal of wastes and materials; fuel storage and delivery; vehicle and equipment painting; aircraft deicing and anti-icing; waste servicing and system flushing; ramp and runway maintenance and cleaning; fire suppression; spill response and cleanup; and additional activities (Krull 2025, pp. 46-48, Tables 10 and 11). These operations and activities are recognizable sources for a wide variety of stormwater and industrial stormwater pollutants and contaminants (U.S. EPA 1991, pp. 2-3).

The SEA operates with a NPDES permit(s) issued by Ecology (Permit WA-002465-1). SEA occupies more than 2,500 acres of land (p. 8). The SEA IWS collects and treats wastewater containing vehicle and aircraft wash water; stormwater contaminated with fuel, lubricants, fire-fighting foam, cleaning agents, and aircraft and ground surface deicing and anti-icing agents; contaminated construction dewatering or water; excess water from ground water well construction and monitoring; and, leachate from solid waste facilities (p. 8). The conveyance system includes approximately 21 miles of pipe/conveyance, 510 manholes and catch basins, 2 below-grade vaults (in the parking garage), 10 pump stations, and 3 lagoons (pp. 10, 11). The hydraulic capacity of the treatment plant is 8.3 million gallons per day (mgd); the maximum flow that can be accepted by the trunk line is 4,900 gallons per minute (gpm) (or 7.1 mgd) (p. 13).

Ecology (Permit WA-002465-1) has provided a wastewater effluent characterization (p. 24); SEA IWS effluent and SEA stormwater runoff contains measurable quantities (including quantities warranting or requiring permit limits) for pH, oil and grease, total suspended solids (TSS), biological oxygen demand (BOD), ammonia, glycol, benzene, toluene, additional hydrocarbons, phenols, and metals (including copper (Cu), lead (Pb), and zinc (Zn)) (pp. 24, 53-55).

8.2 Exposures to SEA Discharges and Resulting Effects

In light of the Service's prior Opinions addressing actions that produce and/or discharge treated and untreated stormwater runoff, and treated and untreated wastewater, we have commonly used and applied best available science, including the science syntheses included here in Appendices D (Stormwater and Stormwater Effects) and D (Wastewater Pollutants as Environmental Stressors). The science and body of literature summarized in these appendices is multi-faceted, detailed, and (to some extent) still evolving. Nevertheless, these are important themes to highlight:

- Stormwater runoff contains a variety of pollutants that impair water quality and pose a risk to aquatic organisms. Data obtained from a variety of sources indicate that pollutant concentrations are highly variable. Heavy metals, polycyclic aromatic hydrocarbons

(PAHs), and other non-polar organic contaminants are generally bound in greatest concentration to the smallest particles and colloids.

- Treatment efficiency and effectiveness depend both on the specific treatment systems and technologies employed, and on how well these systems are designed, operated, and maintained. Studies indicate significant variation among different treatment technologies and facilities.
- Stormwater pollutants can affect the physiology and/or behavior of exposed bull trout and other salmonids in ways that disrupt normal behaviors (i.e., movement, feeding, and sheltering), reduce growth, migratory success, and reproduction. In sufficient concentrations, stormwater pollutants can also result in acute toxicity and death. Effects on aquatic life are influenced by the size and dilution capacity of the receiving waterbody, background water quality conditions, concurrent discharges and/or background levels of other pollutants or contaminants, frequency and duration of exposure, concentration and relative toxicity of the pollutant(s), biological uptake and availability, and life history stage of the organism.
- Stormwater runoff is a complex chemical mixture. Even during the course of a single discharge event, physical and chemical properties (including pollutant concentrations) can vary by orders of magnitude. Additional sources of uncertainty include the effect of intermittent, episodic, or transient exposures; variations in tolerance among exposed individuals and/or populations; and, the potential for synergistic or additive effects among pollutants with similar, or the same, modes of toxic action.
- Pollutant loads bound or complexed with the particulate-phase or fraction of stormwater runoff represent a persistent, long-term source of potential chronic exposures and effects. Heavy metals do not degrade in the environment, and organic contaminants easily persist for durations that exceed the life history stages of individual fish or multiple generations of fish. Chronic effects on individuals stem from repeated exposures over time, through multiple exposure pathways, and from multiple stressors and combinations of stressors. Solids act as both ‘sinks’ and sources for metals and non-polar organic contaminants; contaminants are reversibly bound to particles and these particles can act as a source of toxicity.
- Even at low concentrations, copper (Cu) is acutely toxic to fish. Effects of exposure to Cu include 1) weakened immune function and impaired disease resistance; 2) impaired respiration; 3) disruptions to osmoregulation; 4) impaired function of olfactory organs and brain; 5) altered blood chemistry; 6) altered enzyme activity and function; and, 7) pathology of the kidneys, liver, and gills.
- In addition to the physiological effects of zinc (Zn) exposure, studies document a variety of behavioral responses including altered avoidance behavior, decreased swimming ability, and hyperactivity.
- Unconventional wastewater contaminants are a focus of intense study (Pederson et al. 2022). Natural and synthetic steroids and hormones, pharmaceuticals, disinfectant and detergent metabolites, plasticizers, and fire retardants are ubiquitous in United States waters. Many of these are biologically active and relevant at exceedingly low

concentrations, and some share a common mode of action or affect related biochemical pathways.

- For many chemical compounds, there is incomplete information to describe their presence in treated and untreated wastewaters, the efficacy of treatment processes (i.e., the ability of treatment to achieve removal from the waste stream), their fate and transport in the environment, and their potential for independent, additive, antagonistic, and/or synergistic effects in exposed aquatic life.

According to the National Marine Fisheries Service (NMFS) (2025, p. 18), microplastics present in treated and untreated stormwater runoff include sources of 6PPD and 6PPD-quinone; "6PPD-quinone induces mortality, likely through cardiorespiratory disruption, and disrupts vascular permeability pathways primarily in developing coho salmon (*Oncorhynchus kisutch*), but [also] in Chinook salmon (*O. tshawytscha*) and steelhead (*O. mykiss*) (French et al. 2022, Greer et al. 2023)."

Airport operations introduce, or release to the environment, a wide array of pollutants and toxicants from fuel combustion, fuel spillage, the washing and cleaning of aircraft and airport service equipment, and the use of deicing or anti-icing agents. These include heavy metals, detergents, formaldehyde, phenols, PAHs, and PCBs (Sulej et al. 2012).

When samples from San Francisco Bay were analyzed, results identified the presence of 154 organic contaminants, including organophosphate esters, bisphenols, per- and polyfluoroalkyl substances (PFASs), and a suite of novel urban stormwater tracers (including vehicle-derived chemicals, pesticides, pharmaceuticals/personal care products, and benzothiazoles/benzotriazoles) (Peter et al. 2024).

Stormwater can be a significant contributor to overall pollutant loads in receiving waterbodies (Wheeler et al. 2005). Pollutants that are dissolved in, or mobilized by stormwater runoff, are easily transported to wetlands, streams, and rivers.

There is a variety of engineered stormwater treatment systems and technologies. These systems and technologies vary with regard to which pollutants or pollutant categories they are best capable of treating, and the effectiveness with which they treat specific pollutants. Treatment efficiency and effectiveness depend both on the specific treatment systems and technologies employed, and on how well these systems are designed, operated, and maintained. Studies indicate significant variation among different treatment technologies and facilities (Schueler 1987; WSDOT 2006).

The Service concludes that adverse exposures to, and effects on, bull trout are foreseeable and likely to occur as a result of the proposed action.

Elevated pollutant concentrations in water and media will result in direct exposures; most or all of these exposures will be episodic, transient, and sub-lethal; nevertheless, exposures will cause and contribute to avoidance response, stress response, adverse physiological response, and significant disruptions to normal behavior.

Elevated pollutant concentrations in water, media, and prey will result in indirect exposures, including cumulative and chronic exposures; indirect, cumulative, and chronic exposures will cause and contribute to sub-lethal stress response and physiological response; impaired cardiorespiratory, osmoregulatory, immunological, reproductive, and other physiological function; reduced fitness, reduced reproductive success, and survival; and, significant disruptions to normal behavior, with a likelihood of physical injury.

Elevated pollutant and contaminant concentrations in water, media, and prey will measurably degrade water and sediment quality at the scale of the action area; these will degrade and impair habitat, long-term habitat functions, and critical habitat functions (i.e., PCEs and PCE functions).

These adverse exposures and effects are a foreseeable consequence of the proposed action and SEA discharges, including pollutants and sources of pollutants from approximately 51 acres of new PGIS, and resulting increases in stormwater and wastewater pollutant loads to Puget Sound and nearshore marine bull trout FMO habitat. Low or very low numbers of adult and sub-adult bull trout are likely to be exposed and adversely affected; these bull trout are most likely to originate from the Lower Skagit, Stillaguamish, Snohomish/Skykomish, and Puyallup River Core Areas and associated local populations.

The BE refers to "first flush events," when heavy stormwater pollutant loading results after a period without significant rainfall (Krull 2025 pp. 74). "First flush" events may typically overlap with bull trout use of nearshore marine FMO in the fall (Goetz 2021).

The Service acknowledges that SEA stormwater runoff receives treatment prior to discharge, and runoff is managed with robust operational source controls and BMPs to remove and reduce pollutants and contaminants. However, when flows exceed the 50-year storm event, the SDS and IWS will cease to function as intended, and untreated (or incompletely treated) runoff will discharge to Puget Sound. It is possible and likely that individual bull trout will be present during these events.

The Service was not provided site-specific sample data for metal concentrations, total Cu or total Zn (micrograms per liter [µg/L]). Thus, we use the following example to show or demonstrate how low levels of pollutants or contaminants will be introduced to the environment, with adverse consequences for bull trout:

- Even at low or very low concentrations (an increase of 2 µg/L over background), Cu is acutely toxic to fish. At sufficient concentrations and when bioavailable for uptake (concentrations exceeding 5.6 µg/L over background), Zn is also toxic or disruptive to fish;
- The Service expects that adult and sub-adult bull trout will be exposed to dissolved Cu and at concentrations that cause adverse sub-lethal effects (e.g., avoidance and olfactory responses), and significant disruptions to normal bull trout behaviors (i.e., the ability to successfully feed, move, and shelter). Both Eisler (1998) and Playle (2004) found that dissolved metal mixtures exhibit synergistic effects; and,
- We expect these exposures will be episodic, occurring whenever bull trout are present near the outfall(s) to Puget Sound.

We agree that treated discharges will "unavoidably contain low levels of contaminants even after treatment" (Krull 2025 pp. 74). Furthermore, large discharge volumes at low concentrations, combine over time and represent significant pollutant and contaminant loads. These loads cause and contribute to repeated and chronic exposures in water, media, and prey, and are likely to measurably and adversely affect individual bull trout (Hicken et al. 2011; Spromberg and Meador 2006).

In conclusion, the Service expects that individual adult and sub-adult bull trout will be exposed to elevated stormwater pollutant concentrations. Not all individuals exposed to treated and untreated SEA stormwater runoff will experience immediate adverse effects, and delayed indirect or cumulative effects on fitness, reproduction, and survival will be difficult or impossible to discern and document. Some individuals will respond with avoidance that disrupts feeding and migratory behaviors. Others will experience reduced growth, impairment of essential behaviors related to successful spawning and rearing, and/or reduced reproductive success. Adverse exposures will affect an uncertain number of individuals, for the foreseeable future.

8.1.2 Summary of Adverse Effects on Bull Trout

Error! Reference source not found. identifies and summarizes exposure pathways, anticipated responses, and adverse effects of bull trout.

Table 1. Summary of adverse exposures and effects on bull trout.

Stressor	Exposure	Response
Measurable quantities of pollutants present in SEA-treated and -untreated discharges; elevated pollutant concentrations in water and media.	Sub-lethal direct exposures; episodic and transient exposures.	Avoidance response; sub-lethal stress response and physiological response; disruptions to normal behavior.
Measurable quantities of pollutants present in SEA-treated and -untreated discharges; elevated pollutant concentrations in water, media, and prey.	Sub-lethal indirect exposures; episodic and transient exposures; cumulative and chronic exposures.	Sub-lethal stress response and physiological response; impaired cardiorespiratory, osmoregulatory, immunological, reproductive, and other physiological function; reduced fitness, reproductive success, and survival; disruptions to normal behavior, with a likelihood of physical injury.
Elevated pollutant and contaminant concentrations in water, media, and prey.	Elevated and increasing concentrations at the scale of the action area; degraded long-term water and sediment quality.	Degraded and impaired habitat and long-term habitat function; degraded and impaired critical habitat function (i.e., PCEs and PCE functions).

8.2.2 Summary of Adverse Effects on Critical Habitat

The Service expects that long-term operational discharges of SEA-treated and -untreated stormwater runoff will further impair water and sediment quality in the receiving waters. Pollutant loads associated with the post-project condition will worsen the overall trajectory of water and sediment quality impairment in the action area. These pollutant loads will have measurable adverse effects on bull trout, their habitat and prey base, and the current functions of designated bull trout critical habitat.

Water quality and quantity are essential features of designated bull trout critical habitat. Additional features or functions of designated bull trout critical habitat are present and will be measurably and adversely affected.

The action area includes approximately 100 acres of designated bull trout critical habitat (i.e., extending along approximately 15,000 linear ft of shoreline and waterward approximately 300 ft offshore). The action area contains and provides the PCEs of designated bull trout critical habitat, including PCEs 2 (migration habitat), 3 (food base), 4 (marine shoreline and 8 (water quality and quantity).

Pollutants present in SEA-treated and -untreated discharges are a source of degraded, and will contribute to degrade, water and sediment quality. Discharges contain measurable quantities (loadings and concentrations) of solids, bacteria, persistent organic compounds (including hydrocarbons), metals, toxic and endocrine disrupting compounds, microplastics, and contaminants that accumulate in media and prey. Discharges originating from SEA act as stressors; they contribute to bull trout and bull trout prey exposures in the action area, and they degrade and impair habitat, long-term habitat functions, and critical habitat functions.

PCE 2 (*Migration Habitat*): The current function of this PCE is moderately impaired and functioning at risk. Discharges of SEA-treated and -untreated stormwater runoff will result in elevated pollutant and contaminant concentrations in water and media. Resulting exposures will further degrade and impair the current function of nearshore marine FMO habitats. The proposed action will have measurable adverse effects on approximately 100 acres of designated bull trout critical habitat. Migration habitat will not be permanently removed or destroyed.

PCE 3 (*Food Base*): The current function of this PCE is moderately impaired and functioning at risk. Discharges of SEA-treated and -untreated stormwater runoff will further impair water and sediment quality in the receiving waters. Elevated pollutant and contaminant concentrations will result in water, media, and prey. The proposed action will have measurable adverse effects on approximately 100 acres of designated bull trout critical habitat.

PCE 4: (*Marine Shoreline*): The current function of this PCE is moderately impaired and functioning at risk. Discharges of SEA-treated and -untreated stormwater runoff will result in elevated pollutant and contaminant concentrations in water and media. Resulting exposures will further degrade and impair the current function of nearshore marine FMO habitat and shoreline. The proposed action will have measurable adverse effects on approximately 100 acres of

designated bull trout critical habitat. Marine shoreline and processes will not be permanently removed or destroyed.

PCE 8 (*Water Quality and Quantity*): The current function of this PCE is moderately impaired and functioning at risk. Discharges of SEA-treated and -untreated stormwater runoff will further impair water and sediment quality in the receiving waters. Elevated pollutant and contaminant concentrations will result in water, media, and prey. The proposed action will have measurable adverse effects on approximately 100 acres of designated bull trout critical habitat.

Low or very low numbers of adult and sub-adult bull trout use the action area, and the Service expects that the affected bull trout critical habitat will continue to serve its assigned conservation role for the species. However, bull trout that use the action area may have or experience adverse behavioral, health, fitness, and survival outcomes.

9 CUMULATIVE EFFECTS: Bull Trout and Designated Bull Trout Critical Habitat

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion. 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.

The BE describes anticipated cumulative effects on the species and designated critical habitat, which are hereby incorporated by reference (Krull 2025, p. 79). These cumulative effects include local jurisdiction stormwater runoff and permitted wastewater discharges.

In addition to the cumulative effects incorporated by reference, the Service has identified the following additional cumulative effects, which we conclude are reasonably certain to occur:

- Expansion of maritime industry infrastructure, residential and commercial development, shoreline modifications, road construction and maintenance, and agricultural development.

These actions or activities are reasonably certain to result in additional impervious surfaces and increased stormwater runoff, which will introduce more and, potentially, new pollutants and contaminants into the action area. Increased output from wastewater treatment plants will also introduce additional pollutant loads into the marine environment. These cumulative effects will further degrade water quality and increase stress for bull trout and other salmonids that use the action area. This, in turn, may compromise growth, long-term survival, and reproductive potential of bull trout.

10 INTEGRATION AND SYNTHESIS OF EFFECTS: Bull Trout and Designated Bull Trout Critical Habitat

The Integration and Synthesis Section is the final step in assessing the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, the Service adds the effects of the action and the cumulative effects on the status of the species and critical

habitat, and the environmental baseline, to formulate our opinion as to whether the proposed action is likely to: 1) appreciably reduce the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or, 2) result in the destruction or adverse modification of critical habitat.

10.1 Integration and Synthesis for Bull Trout

The action area provides nearshore marine FMO habitat, serves as an essential migratory corridor, and supports foraging and overwintering bull trout. The action area supports essential native salmonid behaviors (e.g., juvenile outmigration) and productivity, and includes spawning habitats for marine forage fish; accordingly, the action area is an important source of prey for bull trout.

Some of the Puget Sound's bull trout core areas are considered robust and stable; the Lower Skagit River Core Area is generally considered more abundant than any other core area in the CRU. While the action area represents a small portion of marine FMO habitat and the CRU, all marine FMO habitat is integral to the recovery of bull trout. Coastal Washington and the Puget Sound support the anadromous bull trout life history form, and they are essential for maintaining the distribution of this rare life history form, in the CRU and across the species' coterminous range (USFWS 2010, p. 85). Comparatively, large numbers of bull trout from the Lower Skagit River and Snohomish/Skykomish River Core Areas are anadromous and therefore rely on Puget Sound marine FMO for migration, overwintering, extended rearing, and growth to maturity (USFWS 2004, USFWS 2015). Current information suggests that adult and sub-adult bull trout use the action area regularly but in relatively low numbers.

The Service expects the proposed action will result in measurable adverse effects on bull trout. Foraging, migrating, and overwintering adult and sub-adult bull trout will be exposed to pollutants and contaminants originating from SEA-treated and -untreated discharges. Acute exposures will be episodic but may be more frequent and of longer duration during winter months. Some bull trout may be exposed repeatedly as a result of regular movements through the action area.

Exposed adult and sub-adult bull trout will experience adverse sub-lethal effects, including reduced olfactory sensory responsiveness, foraging success, and feeding efficiency. Avoidance behavior may impair free movement and/or cause fish to leave refugia and preferred habitats. The Service does not expect that acute exposures will cause lethal effects.

Pollutant loadings associated with the post-project condition will worsen the overall trajectory of water and sediment quality impairment in the action area. Pollutant loadings will also further diminish habitat suitability and function, and/or result in reduced prey availability and/or quality. However, the Service cannot evaluate or describe exactly how chronic and cumulative exposures resulting incrementally from the proposed action will affect normal bull trout behaviors, growth, survival, and/or reproductive fitness.

The Service expects that pollutant loadings associated with the post-project condition, when added to the environmental baseline, will act as a persistent, long-term source of chronic

exposures and effects throughout the action area. However, because these exposures are likely to be episodic and bull trout use of the action area is infrequent and/or transient, it is not possible to reliably quantify the frequency, duration, or intensity of chronic exposures for individual bull trout. Furthermore, available information does not allow us to predict how exposures within the action area will add incrementally to the cumulative effect of multiple exposures over the lives of individual bull trout.

Based on the preceding information, and because relatively low numbers of adult and sub-adult bull trout will be exposed and adversely affected, the Service expects that the proposed action will not have a measurable effect on the relative size of the anadromous component of any bull trout core area. Furthermore, the action's long-term effects will not measurably reduce the likelihood of persistence at the scales of the local populations or core areas (Lower Skagit, Stillaguamish, Snohomish/Skykomish, and Puyallup River Core Areas). The anticipated direct and indirect effects of the action, combined with the effects of interrelated and interdependent actions, and the cumulative effects associated with future State, Tribal, local, and private actions will not appreciably reduce the likelihood of survival and recovery of the species. The anticipated direct and indirect effects of the action will neither measurably reduce bull trout reproduction, numbers, or distribution at the scale of the core areas or CRU, nor alter the status of bull trout at the scales of the CRU or coterminous range. Table 2 summarizes the effects of the action on bull trout numbers, reproduction, and distribution.

Table 2. Effects on bull trout numbers, reproduction, and distribution.

Bull Trout	Anticipated Effects	Rationale
Numbers	Reductions in bull trout fitness and survival among individuals (adults and sub-adults) foraging, migrating, and overwintering in the action area; a small reduction in bull trout numbers over time, from the Lower Skagit, Stillaguamish, Snohomish/Skykomish, and Puyallup River Core Areas; changes in numbers may be indiscernible from natural variation and/or other causes.	Some bull trout may be exposed repeatedly as a result of regular movements through the action area. Pollutant loadings will further diminish habitat suitability and function, and/or result in reduced prey availability and/or quality. Pollutant loadings associated with the post-project condition will worsen the overall trajectory of water and sediment quality impairment in the action area. Exposed adult and sub-adult bull trout will experience adverse sub-lethal effects, including reduced olfactory sensory responsiveness, foraging success, and feeding efficiency. Avoidance behavior may impair free movement and/or cause fish to leave refugia and preferred habitats. The Service does not expect that acute exposures will cause lethal effects. Exposures are likely to be episodic and bull trout use of the action area is infrequent and/or transient.
Reproduction	Reductions in bull trout reproductive fitness and productivity for individuals (adults and sub-adults) foraging, migrating, and overwintering in the action area; changes may be indiscernible from natural variation and/or other causes.	
Distribution	The proposed action will not affect bull trout distribution.	

10.2 Integration and Synthesis for Designated Critical Habitat

The action area includes approximately 100 acres of designated bull trout critical habitat (i.e., extending along approximately 15,000 linear ft of shoreline and waterward approximately 300 ft offshore). The action area contains and provides the PCEs of designated bull trout critical habitat, including PCEs 2 (migration habitat), 3 (food base), 4 (marine shoreline), and 8 (water quality and quantity).

Pollutants present in SEA-treated and -untreated discharges are a source of degraded, and will contribute to degrade, water and sediment quality. Discharges originating from SEA act as stressors, and they contribute to bull trout and bull trout prey exposures in the action area, and degrade and impair habitat, long-term habitat functions, and critical habitat functions.

Effects on the PCEs of designated bull trout critical habitat will be permanent or long-lasting (i.e., for the foreseeable future), but also limited in physical extent. No designated bull trout critical habitat will be permanently removed or destroyed. Despite foreseeable adverse effects on the PCEs of designated bull trout critical habitat, the Service expects that the action area will

retain much of its current level of function and will continue to support successful bull trout foraging, migration, and overwintering.

The anticipated direct and indirect effects of the action, combined with the effects of interrelated and interdependent actions, and the cumulative effects associated with future State, Tribal, local, and private actions will not prevent the PCEs of designated bull trout critical habitat from being maintained. Within the action area, designated critical habitat will continue to serve the intended conservation role for bull trout, at the scale of the core areas, CRU, and coterminous range.

11 CONCLUSION: Bull Trout and Designated Bull Trout Critical Habitat

After reviewing the status of bull trout, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the Service's biological opinion that the action as proposed, is not likely to jeopardize the continued existence of the bull trout and will not destroy or adversely modify designated bull trout critical habitat.

12 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without 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 defined by the Service as an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering (50 CFR 17.3). *Harass* is defined by the Service as an intentional or negligent act or omission which creates 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 (50 CFR 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement (ITS).

The measures described below are non-discretionary and must be undertaken by the FAA so that they become binding conditions of any grant or permit issued to the Port, as appropriate, for the exemption in section 7(o)(2) to apply. The FAA has a continuing duty to regulate the activity covered by this ITS. If the FAA 1) fails to assume and implement the terms and conditions or 2) fails to require the Port to adhere to the terms and conditions of the ITS through enforceable terms that are added to the permit or grant document, then the protective coverage of section 7(o)(2) may lapse. To monitor the impact of incidental take, the FAA and Port must report the progress of the action and its impacts on the species to the Service as specified in this ITS [50 CFR 402.14(i)(4)].

13 AMOUNT OR EXTENT OF TAKE

The Service anticipates incidental take of bull trout will be difficult to detect for the following reason(s): 1) the low likelihood of finding dead or injured adults, sub-adults, or juveniles; 2) delayed mortality; and, 3) losses may be masked by seasonal fluctuations or natural variation in numbers.

However, pursuant to 50 CFR 402.14(i)(1)(i), a surrogate can be used to express the amount or extent of anticipated take in an ITS, provided that the Opinion or ITS: 1) explains why measuring take impacts to a listed species is not practical; 2) describes the causal link between the effects of the action on the surrogate and take of the listed species; and, 3) sets a clear standard for determining when the level of anticipated take based on the surrogate has been exceeded.

The Service's regulations state that significant habitat modification or degradation caused by an action that results in death or injury to a listed species by significantly impairing its essential behavior patterns constitutes take in the form of harm (50 CFR 17.3). Those regulations further state that an intentional or negligent act or omission that creates the likelihood of injury to a listed species by annoying it to such an extent as to significantly disrupt its normal behavioral patterns constitutes take in the form of harass. Such annoyance can be caused by actions that modify or degrade habitat conditions. In cases where this causal link between effects of a federal action to habitat and take of listed species is established, and the Opinion or ITS explains why it is not practical to express and monitor the level of take in terms of individuals of the listed species, the Service regulations authorize the use of habitat as a surrogate for expressing and monitoring the anticipated level of take, provided a clear standard is established for determining if and when the level of anticipated take has been exceeded.

Table 3 addresses the three regulatory criteria for use of a surrogate to express the anticipated level of take.

Table 3. Habitat or other surrogate for anticipated incidental take of bull trout.

Stressor Causing Take	Life Stage(s)	Duration/Frequency	Surrogate/Extent
Measurable quantities of pollutants and contaminants present in SEA-treated and -untreated discharges; elevated concentrations in water, media, and prey	Adult and sub-adult bull trout	Direct exposures will be episodic and transient; cumulative and chronic exposures are not easily quantified; effects in the environment will be permanent or long-lasting (i.e., for the foreseeable future)	New and replaced PGIS

Incidental take of adult and sub-adult bull trout from the Lower Skagit, Stillaguamish, Snohomish/Skykomish, and Puyallup River Core Areas, resulting from exposures to measurable quantities of pollutants and contaminants present in SEA-treated and -untreated discharges, and elevated concentrations in water, media, and prey:

- All bull trout that forage, migrate, and/or overwinter in the action area and affected nearshore marine FMO habitat; permanently, or for the foreseeable future; and,
- SEA discharges originating from approximately 51 acres of new and replaced PGIS.

14 EFFECT OF THE TAKE

In the accompanying Opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of designated critical habitat.

15 REASONABLE AND PRUDENT MEASURES

The Service finds that the following Reasonable and Prudent Measure (RPM) is necessary and appropriate to minimize the impacts (i.e., the amount or extent) of incidental take of bull trout:

1. Monitor implementation of the proposed action; track, verify, and report the as-built conditions of the approximately 29 NTPs, including improvements to the SDS and IWS; ensure that the level of incidental take provided under this ITS is not exceeded.

16 TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the ESA, the FAA and Port must comply with the following terms and conditions (T&Cs), which implement the RPM described above and outline required monitoring and reporting requirements. This T&C is non-discretionary.

1. Submit reports to the Service each biennium, or as agreed to and documented, for the record. Each report shall document the most recently implemented NTPs (and SDS or IWS improvements) and shall include a quantification of associated new and replaced PGIS. Reports shall be submitted to the Washington Fish and Wildlife Office in Lacey, Washington (WashingtonFWO@fws.gov) and copied to the Assistant Field Supervisor or assigned lead consultation biologist (Attn: ryan_mcreynolds@fws.gov), by December 31 of each year that activities are completed.

The RPMs, with their implementing T&Cs, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, then such incidental take requires reinitiation of consultation and review of the RPMs provided. The federal agency must immediately provide an explanation of the causes of the taking and review with the Service need for possible modification of the RPMs.

The Service is to be notified within three working days upon locating a dead, injured or sick endangered or threatened species specimen. Initial notification must be made to the nearest Service Law Enforcement Office. Notification must include the date, time, precise location of the injured animal or carcass, and any other pertinent information. Care should be taken in handling sick or injured specimens to preserve biological materials in the best possible state for later analysis of cause of death, if that occurs. In conjunction with the care of sick or injured endangered or threatened species or preservation of biological materials from a dead animal, the finder has the responsibility to ensure that evidence associated with the specimen is not unnecessarily disturbed. Contact the Service Law Enforcement Office at (425) 883-8122, or the Service's Washington Ecological Service Office at (360) 753-9440.

17 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or designated critical habitat, to help implement recovery plans, or to develop information.

1. As described in the proposed action, where possible, incorporate low-impact development (LID) stormwater treatment methods into design and implementation of the SAMP NTP program. Document the LID methods used or implemented and include this information in submitted reports.

2. Continue the 6PPD-quinone treatment study and report findings.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects, or otherwise benefitting listed species or their habitats, we request notification of the implementation of any conservation recommendations.

18 REINITIATION NOTICE

This concludes formal consultation on the action outlined in the request for Seattle-Tacoma International Airport Sustainable Master Plan Near Term Projects. As provided in 50 CFR 402.16, reinitiation of formal consultation is required and shall be requested by the Federal agency where discretionary federal agency involvement or control over the action has been retained or is authorized by law and 1) the amount or extent of incidental take is exceeded; 2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Opinion; 3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat not considered in this Opinion; or, 4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

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Appendix A: US Department of Transportation
Federal Aviation Administration
Northwest Mountain Region – Seattle Airports District Office

Seattle-Tacoma International Airport
Sustainable Airport Master Plan Near Term Projects

FINAL BIOLOGICAL EVALUATION

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June 2025

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ACRONYMS AND ABBREVIATIONS

6PPD	N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine
6PPD-Q	6PPD-quinone
ARFF	Aircraft Rescue and Firefighting
BE	Biological evaluation
Biochar	Biochar-Black Owl Stormwater Mix
BMPs	Best management practices
BOD	Biological oxygen demand
CESF	Chitosan enhanced sand filtration
CFR	Code of Federal Regulations
Construction SWPPP	Site-specific construction stormwater pollution prevention plan
CRDC	Centralized receiving and distribution center
dBA	A-weighted decibel
DPS	Distinct population segment
Ecology	Washington State Department of Ecology
EEZ	Exclusive economic zone
EFH	Essential fish habitat
ESA	Endangered Species Act
ESU	Evolutionarily significant unit
FAA	Federal Aviation Administration
FMO	Foraging, migration, and overwintering
FR	Federal Register
GSA	General study area
GSE	Ground service equipment
HS250	Hydrosil HS-250
IWS	Industrial wastewater system
IWTP	Industrial Wastewater Treatment Plant IWTP
km	Kilometer
mg/L	Milligrams per liter
MLLW	Mean lower low water
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NAE	North Airport Expressway
NGT	North Ground Transportation
NMFS	National Marine Fisheries Service
NOS	Natural-origin spawners
NPDES	National Pollutant Discharge Elimination System
NPGIS	Non-pollution-generating impervious surface
NTPs	Near-term project
NWSA	Northwest Seaport Alliance’s
OSC	Operational source control
PAHs	Polyaromatic hydrocarbons
PBF	Physical and biological feature

PCE	Primary constituent element
PFMC	Pacific Fishery Management Council
PGIS	Pollution-generating impervious surface
Port	Port of Seattle
ppb	Parts per billion
PPP	Pollution Prevention Plan
PSP	Program support project
RIM	Runway incursion mitigation
RM	River mile
SAMP	Sustainable Airport Master Plan
SCU	SCU-Evoqua
SDS	Stormwater drainage system
SEA	Seattle-Tacoma International Airport
SEA SWPPP	Seattle-Tacoma International Airport Stormwater Pollution Prevention Plan
Section 404	Section 404 of the Clean Water Act
Services	National Marine Fisheries Service, and U.S. Fish and Wildlife Service
SRKW	Killer whale, Southern Resident Distinct Population Segment
UMP	Utilities Master Plan
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VCC	Virgin coconut carbon
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resources Inventory Area
WSDOT	Washington State Department of Transportation

EXECUTIVE SUMMARY

The Port of Seattle (Port) completed a Sustainable Airport Master Plan for the Seattle-Tacoma International Airport (SEA) that identified a Long-Term Vision to accommodate future needs over the 20-year planning horizon. From this, the Port developed 31 Near-Term Projects (NTPs) to improve safety and meet forecasted passenger and cargo demand. While the NTPs are the Port's intended development at SEA, only some of these development components are subject to federal approval and/or funding. The Federal Aviation Administration (FAA) determined it does not have approval authority for L04 – Northeast Ground Transportation Center and S01 – Fuel Farm Expansion in accordance with of Section 163 of HR 302, the "FAA Reauthorization Act of 2018" (P.L. 115-254) and Section 743 of HR 3935, the "FAA Reauthorization Act of 2024" (P.L. 118-63).

The Proposed Action addressed in this Biological Evaluation (BE) comprises the construction and operation of 29 NTPs funded and/or authorized by FAA, the construction and operation of associated program support projects necessary for implementation of these NTPs, habitat mitigation for unavoidable impacts to wetlands and wetland buffers resulting from project construction, and best management practices used by the Port to avoid and minimize environmental impacts from the construction and operation of the Proposed Action.

The federal actions associated with the Proposed Action constitute a federal nexus necessitating consultation under Section 7 of the Endangered Species Act (ESA). This BE evaluates the Proposed Action's potential effects on ESA-listed species and critical habitats that occur in the action area. The action area includes terrestrial and aquatic habitats in Water Resources Inventory Area 9 (Green/Duwamish and Central Puget Sound Watershed). The aquatic component of the action area is limited to hydrologic unit code 17110019 (Central Puget Sound) while the terrestrial component overlaps the boundary between hydrologic unit codes 17110019 and 17110013 (Duwamish).

Summary of Anticipated Effects to Listed Species

Table ES-1 summarizes the species evaluated in the BE and effects determinations for each species and critical habitat. The Proposed Action would not result in direct construction effects on ESA-listed species or critical habitat. Anticipated effects would result from delayed consequences associated with operational treated stormwater runoff and treated industrial wastewater discharges that would be generated by the Proposed Action. It is important to note that the difference between the Proposed Action and No Action is negligible. The FAA determined these effect determinations using the best available scientific and commercial data, including 14 years of *in-situ* toxicity testing, acute toxicity testing, and sublethal testing conducted on treated stormwater discharges as well as recent 6PPD-Q treatment testing results. The FAA also considered the Port's robust stormwater and industrial wastewater treatment systems and Operational Source Control Best Management Practices.

Table ES-1. Effects determinations for ESA-listed species and designated critical habitat

Species/Habitat	Effects Determination
Chinook salmon (*Oncorhynchus tshawytscha,* Puget Sound ESU)	Not likely to adversely affect
Chinook salmon critical habitat	Not likely to adversely affect
Steelhead (*O. mykiss*, Puget Sound ESU)	Not likely to adversely affect
Steelhead critical habitat	No effect
Bull trout (*Salvelinus confluentus*, Coastal-Puget Sound DPS)	Not likely to adversely affect
Bull trout critical habitat	Not likely to adversely affect
Bocaccio rockfish (*Sebastes paucispinus*, Puget Sound/Georgia Basin DPS)	Not likely to adversely affect
Bocaccio rockfish critical habitat	Not likely to adversely affect
Yelloweye rockfish (*S. ruberrimus,* Puget Sound/Georgia Basin DPS)	Not likely to adversely affect
Yelloweye rockfish critical habitat	Not likely to adversely affect
Killer whale (*Orcinus orca*, Southern Resident DPS)	Not likely to adversely affect
Killer whale critical habitat	Not likely to adversely affect
North American wolverine (Gulo gulo luscus)	No effect
Yellow-billed cuckoo (Coccyzus americanus)	No effect
Marbled murrelet (Brachyramphus mamoratus)	No effect
Northwestern pond turtle (*Actinemys marmorata)*	No effect
Monarch butterfly (Danaus Plexippus)	No effect
Suckley's Cuckoo Bumble Bee (Bombus suckleyi)	No effect
Southern Pacific eulachon (Thaleichthys pacificus)	No effect
Central America/Western North Pacific Humpback Whale (*Megaptera novaeangliae)*	No effect
Southern green sturgeon (*Acipenser medirostris)*	No effect
DPS – Distinct population segment; ESU – Evolutionarily significant unit	

Summary of Anticipated Effects to Essential Fish Habitat

The Proposed Action was also evaluated for its potential effects on essential fish habitat (EFH). It was determined that the Proposed Action is not likely to adversely affect EFH for groundfish, coastal pelagic, and Pacific salmon species in Puget Sound and EFH for Pacific salmon species in tributaries that drain to Puget Sound from SEA. All effects to EFH would result from delayed consequences associated with operational treated stormwater runoff and treated industrial wastewater discharges that are generated by the Proposed Action.

1.0 INTRODUCTION

The Port of Seattle (Port) completed a Sustainable Airport Master Plan (SAMP) for the Seattle-Tacoma International Airport (SEA) that identified a Long-Term Vision to accommodate future needs over the 20-year planning horizon. From this, the Port developed 31 Near-Term Projects (NTPs) to improve safety and meet forecasted passenger and cargo demand. The NTPs include airfield projects, terminal projects, cargo projects, landside projects, and airline/airport support projects.

This biological evaluation (BE) has been developed to initiate consultation between the Federal Aviation Administration (FAA), the lead federal action agency, and the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS), collectively "the Services," under Section 7 of the Endangered Species Act (ESA) of 1973 (16 United States Code 1531-1544). Section 7 requires federal agencies to ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of listed species or species proposed for listing under the ESA or result in the destruction or adverse modification of critical habitat for those species.

Section 163 of H.R. 302, the "FAA Reauthorization Act of 2018" (Public Law 115-254) and Section 743 of H.R. 3935, the "FAA Reauthorization Act of 2024" (Public Law 118-63) limited FAA's authority in certain circumstances. While the Port intends to develop all 31 NTPs, only some of the NTPs are subject to federal approval or funding. The FAA determined it does not have approval authority for L04 – Main Terminal North GT Lot and S01 – Fuel Farm Expansion; therefore, these projects are not considered in this consultation. These projects are considered as part of the future environmental baseline.

The Proposed Action addressed in this BE comprises the construction and operation of 29 NTPs and associated program support projects (PSPs), habitat mitigation for unavoidable impacts to wetlands, and best management practices (BMPs) to avoid and minimize environmental impacts from the construction and operation of the 29 NTPs. The provision of federal funding and/or authorization for these projects constitutes a federal nexus necessitating consultation under Section 7 of the ESA.

The action area comprises terrestrial and aquatic habitats in Water Resources Inventory Area 9 (Green/Duwamish and Central Puget Sound Watershed). The aquatic component of the action area is in hydrologic unit code 17110019 (Central Puget Sound). The terrestrial component of the action area overlaps the boundary between hydrologic unit codes 17110019 and 17110013 (Duwamish).

This BE evaluates the potential direct effects and delayed consequences of the Proposed Action on species that are listed, or proposed to be listed, as endangered or threatened under the ESA. Wherever possible, NMFS utilizes existing interagency coordination processes to fulfill consultation requirements for the Magnuson-Stevens Fishery Conservation and Management Act (MSA) consultations with federal agencies. For this Proposed Action, this goal is being met by incorporating MSA consultation into this ESA Section 7 consultation.

1.1 Biological Evaluation Contents

- Chapter 1.0, Introduction, provides an overview of the project, explains the federal nexus, and introduces the species covered in the BE.
- Chapter 2.0, Project Description, describes the Proposed Action, including specific details of each of the NTPs, PSPs, plans for mitigation, and BMPs to minimize environmental impacts.
- Chapter 3.0, Action Area, defines the project's action area.
- Chapter 4.0, Environmental Setting/Baseline, describes the baseline conditions within the terrestrial and aquatic portions of the action area, and the federal status, occurrence, and critical habitat of listed species that may be affected by the Proposed Action.
- Chapter 5.0, Analysis of Effects, analyzes direct effects and delayed consequences of the Proposed Action, identifies interrelated and interdependent actions, and cumulative effects of the Proposed Action, organizing the discussion by potential mechanism of effect to listed species.
- Chapter 6.0, Conclusions and Effects Determinations, summarizes the conclusions of the effects analysis for each listed species and designated critical habitat.
- Chapter 7.0, Effects to Essential Fish Habitat (EFH), assesses impacts to EFH resulting from the Proposed Action.

1.2 Key Issue and Species Addressed

While all potential direct and indirect effects of the Proposed Action were analyzed (Chapter 5.0), the key issue addressed in this BE is the potential effects that could result from permitted treated stormwater and industrial wastewater discharges. Stormwater is the surface runoff that results from rain and snowmelt. Urban development alters the land's natural infiltration, and human activity generates a host of pollutants that can accumulate on paved surfaces. Current treatment technologies can reliably reduce the concentrations of known, commonly occurring stormwater contaminants like polyaromatic hydrocarbons (PAHs) and metals.

While the list of contaminants prioritized for regulation under the National Pollutant Discharge Elimination System (NPDES) is broad (USEPA 2010), it represents a fraction of the thousands of chemicals that routinely occur in stormwater runoff and wastewater discharges. It is unknown if treatment effectively removes contaminants not included under NPDES because neither testing methods nor thresholds have been established.

There is uncertainty about the effectiveness of current stormwater treatment technology for emerging contaminants of concern. For example, the chemical 6PPD-quinone (6PPD-Q) has been identified as a causal agent of pre-spawn mortality of salmonids (Ecology 2022). Vehicle tires contain the chemical 6PPD (N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine) to prevent tires from degrading. Tires wear down through contact with roads, releasing particles into the environment. When 6PPD in these particles reacts with ozone in the air, it forms 6PPD-Q. When it rains, stormwater from hard surfaces, like parking lots and streets, washes these particles into streams and other water bodies.

The extent of potential downstream transport of treated stormwater and industrial wastewater discharges defines the action area for this BE (Chapter 3.0) and therefore the species addressed. Species lists from USFWS (2024a) and NMFS (2024a) were obtained from the agencies' websites in April

2024 and June 2025 (Appendix A). The following species occur in, have potential to occur in, and/or have designated critical habitat present in the action area (Section 4.4):

- Chinook salmon, Puget Sound Evolutionarily Significant Unit (ESU) (*Oncorhynchus tshawytscha)*
- Steelhead, Puget Sound Distinct Population Segment (DPS) (*O. mykiss)*
- Bull trout, Coastal-Puget Sound DPS (*Salvelinus confluentus)*
- Bocaccio rockfish, Puget Sound/Georgia Basin DPS (*Sebastes paucispinis*)
- Yelloweye rockfish, Puget Sound/Georgia Basin DPS (*S. ruberrimus*)
- Killer whale, Southern Resident DPS (SRKW) (*Orcinus orca*)

1.3 Species Not Addressed

Table 1 shows NMFS and USFWS-listed species that may occur in King County but that are not found in the action area for the reasons described below and the Proposed Action will have no effect on.

Table 1. ESA-listed species and critical habitat with No Effects

Species	Scientific Name	Lead Agency	Federal Status	Critical Habitat in Action Area
North American wolverine	*Gulo gulo luscus*	USFWS	Threatened	No
Yellow-billed cuckoo	*Coccyzus americanus*	USFWS	Threatened	No
Marbled murrelet	*Brachyramphus marmoratus*	USFWS	Threatened	No
Northwestern pond turtle	*Actinemys marmorata*	USFWS	Proposed Threatened	No
Monarch butterfly	*Danaus plexippus*	USFWS	Proposed Threatened	No
Suckley's Cuckoo Bumble Bee	*Bombus suckleyi*	USFWS	Proposed Endangered	No
Southern Pacific eulachon	*Thaleichthys pacificus*	NMFS	Threatened	No
Central America/Western North Pacific Humpback Whale	*Megaptera novaeangliae*	NMFS	Endangered	No
Southern green sturgeon	*Acipenser medirostris*	NMFS	Threatened	No

1.3.1 North American Wolverine

1.3.1.1 *Federal Status*

The North American wolverine is listed as a threatened species (88 Federal Register [FR] 83726). Critical habitat has not been proposed in Washington.

1.3.1.2 *Occurrence*

The North American wolverine is found in the western and northwestern United States, Canada, and Alaska. Wolverines are rare in Washington State and generally occur in alpine and sub-alpine habitats of the Cascades and eastern Washington. The Washington Department of Fish and Wildlife (WDFW) estimates the population within the Cascades to be less than 25 individuals (2024a). Wolverines are very solitary and tend to avoid interactions with humans and areas of human activity.

1.3.1.3 *Rationale for Exclusion*

The Proposed Action would have no effect on the North American wolverine or its habitat because the urbanized environment of the action area does not provide suitable habitat for the species.

1.3.2 Yellow-Billed Cuckoo

1.3.2.1 *Federal Status*

The yellow-billed cuckoo is listed as a threatened species (79 FR 59991). Critical habitat has not been proposed in Washington.

1.3.2.2 *Occurrence*

Yellow-billed cuckoos are migratory birds that arrive in western North America in May, nest from June through August, and leave in September. They have a strong preference for large, continuous riparian zones composed of willows and cottonwoods (at least 50 acres). They were once considered abundant along the Columbia River and occasionally observed in western Washington, but they no longer breed in Washington (Wiles and Kalasz 2017). Recent reports of individual cuckoos in Washington are rare and occur east of the Cascade Mountains (Wiles and Kalasz 2017).

1.3.2.3 *Rationale for Exclusion*

The Proposed Action would have no effect on the yellow-billed cuckoo or its critical habitat because the cuckoo has been functionally extirpated from Washington State and the action area does not provide suitable habitat for this species.

1.3.3 Marbled Murrelet

1.3.3.1 *Federal Status*

The USFWS listed the marbled murrelet as threatened in 1992 (57 FR 45328). Critical habitat was designated in 1996 (61 FR 26256) and revised in 2011 (76 FR 61599), covering 3,698,100 acres in Washington, Oregon, and California.

1.3.3.2 *Occurrence*

Marbled murrelets spend most of their life foraging in shallow, nearshore marine waters across the west coast but migrate inland for nesting in old-growth forests with large trees and multiple canopies (USFWS 2024c). Murrelets live and forage in Puget Sound, and adults and subadults are routinely observed at a long-term monitoring location approximately 2 km west of the IWTP outfall (Falxa et al. 2013; McIver et al. 2021). Designated critical habitat is limited to remaining tracts of old growth and mature late-successional forest that provide suitable habitat conditions for nesting.

1.3.3.3 *Rationale for Exclusion*

Though the marbled murrelet may occur in the action area, the likelihood of effects is insignificant and discountable for this wide-ranging species. Critical habitat does not occur in the action area.

1.3.4 Northwestern Pond Turtle

1.3.4.1 *Federal Status*

The USFWS proposed to list the northwestern pond turtle as threatened in 2023 (88 FR 68370). Critical habitat has not been proposed in Washington.

1.3.4.2 *Occurrence*

The northwestern pond turtle is native to the northwest United States, occurring in Washington, Oregon, Nevada, and California. The northwestern pond turtle is primarily aquatic, leaving the water only to lay eggs, overwinter, or disperse to new water bodies. The species was extirpated from Washington State in 1990. Because of recovery efforts, there are now 6 populations in the state, none of them occurring in King County.

1.3.4.3 *Rationale for Exclusion*

The Proposed Action would have no effect on the northwestern pond turtle or its habitat because this species does not occur in the action area.

1.3.5 Monarch Butterfly

1.3.5.1 *Federal Status*

The USFWS proposed to list the monarch butterfly as threatened in 2024 (89 FR 100662). Critical habitat has not been proposed.

1.3.5.2 *Occurrence*

Monarch butterflies in Washington occur primarily east of the Cascades in weedy fields, sparsely vegetated habitats along large river courses, and in wetland areas where their obligate milkweed host plant (primarily Asclepias spp.) grows. The number of monarchs in Washington is relatively low. Milkweeds are patchily distributed within the Columbia Basin. Migrating monarchs often concentrate along the large river courses of the Columbia and Snake Rivers (WDFW 2024c).

1.3.5.3 *Rationale for Exclusion*

The Proposed Action would have no effect on the monarch butterfly or its habitat because this species does not occur in the action area.

1.3.6 Suckley's Cuckoo Bumble Bee

1.3.6.1 *Federal Status*

The USFWS proposed to list the Suckley's Cuckoo Bumble Bee as endangered in 2024 (89 FR 102074). Critical habitat has not been proposed in Washington.

1.3.6.2 *Occurrence*

Suckley's cuckoo bumble bee species historically occurred throughout the State of Washington. Recent range-wide surveys in Washington detected the species in only six localities, primarily in remote subalpine and montane areas.

1.3.6.3 *Rationale for Exclusion*

The Proposed Action would have no effect on the monarch butterfly or its habitat because this species does not occur in the action area.

1.3.7 Southern Pacific Eulachon

1.3.7.1 *Federal Status*

The Southern DPS of eulachon is listed as threatened (75 FR 13012). Critical habitat for the Southern DPS of eulachon was finalized in 2011 (76 FR 65323). Critical habitat in Washington is limited and has not been designated in any documented spawning tributaries in Puget Sound.

1.3.7.2 *Occurrence*

Eulachon are anadromous; they spawn in fresh water and spend their juvenile and adult lives in marine waters. Although eulachon range from northern California to western Alaska, the Southern DPS consists of populations spawning in rivers south of the Nass River in British Columbia, Canada, to and including the Mad River in California. The major production areas include the Columbia and Fraser rivers (WDFW and ODFW 2023). The species is not known to spawn in Puget Sound streams and has been found infrequently in Puget Sound (Pietsch and Orr 2015).

1.3.7.3 *Rationale for Exclusion*

The Proposed Action would have no effect on the Southern Pacific eulachon or its critical habitat because the eulachon are unlikely to occur in the action area.

1.3.8 Central America and Western North Pacific Humpback Whale

1.3.8.1 *Federal Status*

The Central America DPS and Western North Pacific DPS of humpback whale was listed as endangered in 1970 (35 FR 18319) and revised in 2016 (81 FR 62259)). The NMFS designated critical habitat for the Western North Pacific DPS and Central America DPS on April 21, 2021 (86 FR 21082). Critical habitat for humpback whales is not present in the action area.

1.3.8.2 Occurrence

Humpback whales are found throughout the world, including along Washington's coastline. Puget Sound is not considered a part of their natural habitat, and they are unlikely or infrequent in Puget Sound (City of Seattle 2015). Prior to 1990, humpback whale sightings in Puget Sound were extremely rare (Calambokidis and Steiger 1990). In recent years, incidental sightings have occurred within Puget Sound, including humpbacks visiting Puget Sound during migration and some documented staying through the winter months (Calambokidis et al. 2018; Whale Museum 2023). Humpback whales are unlikely to occur in shallow nearshore habitats in Puget Sound.

1.3.8.3 *Rationale for Exclusion*

The Proposed Action would have no effect on the humpback whale or its critical habitat because critical habitat does not occur in Puget Sound and the humpback whale is unlikely to occur in the action area.

1.3.9 Southern Green Sturgeon

1.3.9.1 *Federal Status*

The Southern DPS of green sturgeon is listed as threatened (50 CFR 223.102). In Washington, critical habitat for this DPS is established in the lower Columbia River, Willapa Bay, and Grays Harbor (50 CFR 226.219). No critical habitat is present in the action area.

1.3.9.2 *Occurrence*

In Washington, green sturgeons are found primarily in the Columbia River basin and coastal waters including Willapa Bay and Grays Harbor. The current spawning range is limited to the Sacramento and Klamath river basins in California and the Rogue River in Oregon. Green sturgeon is migratory and anadromous, spending most of their lifecycle in coastal marine waters and large coastal estuaries of Washington, Oregon, and California. Occurrence in the Puget Sound is rare at best (Moser et al. 2020).

1.3.9.3 *Rationale for Exclusion*

The Proposed Action would have no effect on the Southern DPS of green sturgeon or its critical habitat because critical habitat does not occur in Puget Sound and green sturgeon are unlikely to occur within the action area.

2.0 PROJECT DESCRIPTION

The Proposed Action comprises the following elements:

- NTPs (Section 2.4): Airfield, terminal, cargo, landside, and airport/airline support projects designed to increase airport capacity and operational efficiency to meet projected future needs.
- PSPs (Section 2.5): Infrastructure improvements needed to support NTP development, as identified in the Port of Seattle Utilities Master Plan (UMP; Port 2022a):
  - Operational infrastructure improvements (electrical, fuel, gas, water, sewer, and information and telecommunications technology).
  - Stormwater drainage system (SDS) and industrial wastewater system (IWS) improvements.
- Mitigation (Section 2.7): Planned mitigation for anticipated wetland and buffer impacts.
- BMPs (Section 2.8): BMPs used by the Port to avoid and minimize environmental impacts from the construction and operation of the NTPs and UMP PSPs.

All components of the Proposed Action are currently at planning or conceptual levels of development. NTP and PSP dimensions and construction footprints may change during project design. The Port and FAA anticipate such changes would be small and would not measurably alter the effects to ESA-listed species and critical habitat or effects determinations presented herein.

2.1 Project Location

SEA is located primarily within the City of SeaTac in southern King County, Washington, 12 miles south of downtown Seattle, and 20 miles north of the City of Tacoma. SEA owns approximately 2,800 acres of land generally bound by SR 99 to the east, SR 509 to the west, S. 142nd Place to the north, and S. 200th Street to the south. Additional land owned by the Port and used for runway protection and noise compatibility extends northward to S. 136th Street and southward to S. 216th Street. Land uses adjacent to SEA include industrial, commercial, residential, and park land.

The Proposed Action would be implemented entirely on Port property within and adjacent to SEA in the general study area (GSA) considered in the National Environmental Policy Act analysis for the project. The GSA is shown in Figure 1.

2.2 Consultation History

The FAA submitted an initial BE for the Proposed Action to the Northwest Seaport Alliance's (NWSA's) ESA consultation liaison on March 19, 2024. The ESA liaison conducts ESA Section 7 consultations for NWSA member projects on behalf of the Services, with the intent of streamlining and expediting the consultation process. The liaison provided initial comments and recommendations to the Port and FAA, identifying additional information and analyses needed to initiate consultation. The Port and FAA subsequently met with NMFS staff on April 26, 2024, to discuss BE requirements and obtain guidance on consultation requirements.

The FAA submitted a request for informal consultation on September 26, 2024. NMFS provided a letter of non-concurrence on November 12, 2024. The FAA and NMFS held meetings on January 15, 2025, March 13, 2025, May 14, 2025, and June 17, 2025, to discuss the consultation request.

Figure 1. Project vicinity and GSA



2.3 Purpose for the Project

The Proposed Action addresses five independent needs that affect the future ability of SEA to maintain its essential function as the primary commercial airport in the Pacific Northwest.

- Insufficient passenger processing facilities and gates to accommodate 56 million annual passengers at an optimal level of service.
- Insufficient facilities to accommodate projected cargo demand.
- Airfield infrastructure that does not meet current FAA airport design standards.
- Insufficient/inadequate taxiway layout.
- Lack of fuel storage to meet projected demand and the Port's Sustainable Aviation Fuel initiative.

The purpose of the Proposed Action is to accommodate project passenger and cargo demand; provide airfield infrastructure that meets current FAA airport design standards; enhance the efficiency of the taxiway layout; and to meet projected fuel storage demand including sustainable aviation fuel initiatives. All NTPs are anticipated to be complete or in final construction by 2032.

2.4 Proposed NTPs

The NTPs are grouped into five categories (Figure 2):

- Airfield projects (A): Modification and improvement of runways, taxiways, aircraft holding areas, and related facilities to improve operational efficiency and meet FAA airport design standards.
- Terminal projects (T): Development of new terminal concourses, aircraft loading/unloading aprons, and associated parking facilities to provide increased passenger handling capacity.
- Cargo projects (C): Development of new cargo warehouses and appurtenant loading/unloading, parking, and administrative facilities to meet projected needs for increased cargo capacity.
- Landside projects (L): Improvements to existing and construction of new airport access roads, mass transit infrastructure, holding lots, and parking facilities needed to meet projected future passenger and employee transportation requirements.
- Airport/airline support projects (S): Improvements to airport infrastructure needed to support routine operations and maintenance activities, including aircraft fueling, aircraft maintenance, firefighting and emergency response, and de-icing and snow removal.

The NTPs are identified by their category prefix and project number (e.g., airfield project A01). Recognizing that treated stormwater and wastewater discharges are the primary source of potential impact to ESA-listed species from the Proposed Action, the estimated total and net acres of pollution-generating and non-pollution-generating impervious surface (PGIS and NPGIS, respectively) are included and summarized in Table 2. The Proposed Action would add approximately 72 acres of impervious surface (increase of 7.6% overall), which includes 50.03 acres of PGIS (increase of 5.4% overall) and 21.42 acres of NPGIS.

Certain NTPs require the demolition of existing buildings and infrastructure to make room for construction. Demolished buildings and structures would either be relocated elsewhere on Port property, replaced by new facilities, or incorporated into existing facilities with improvements.

Figure 2. Locations of proposed SAMP NTPs

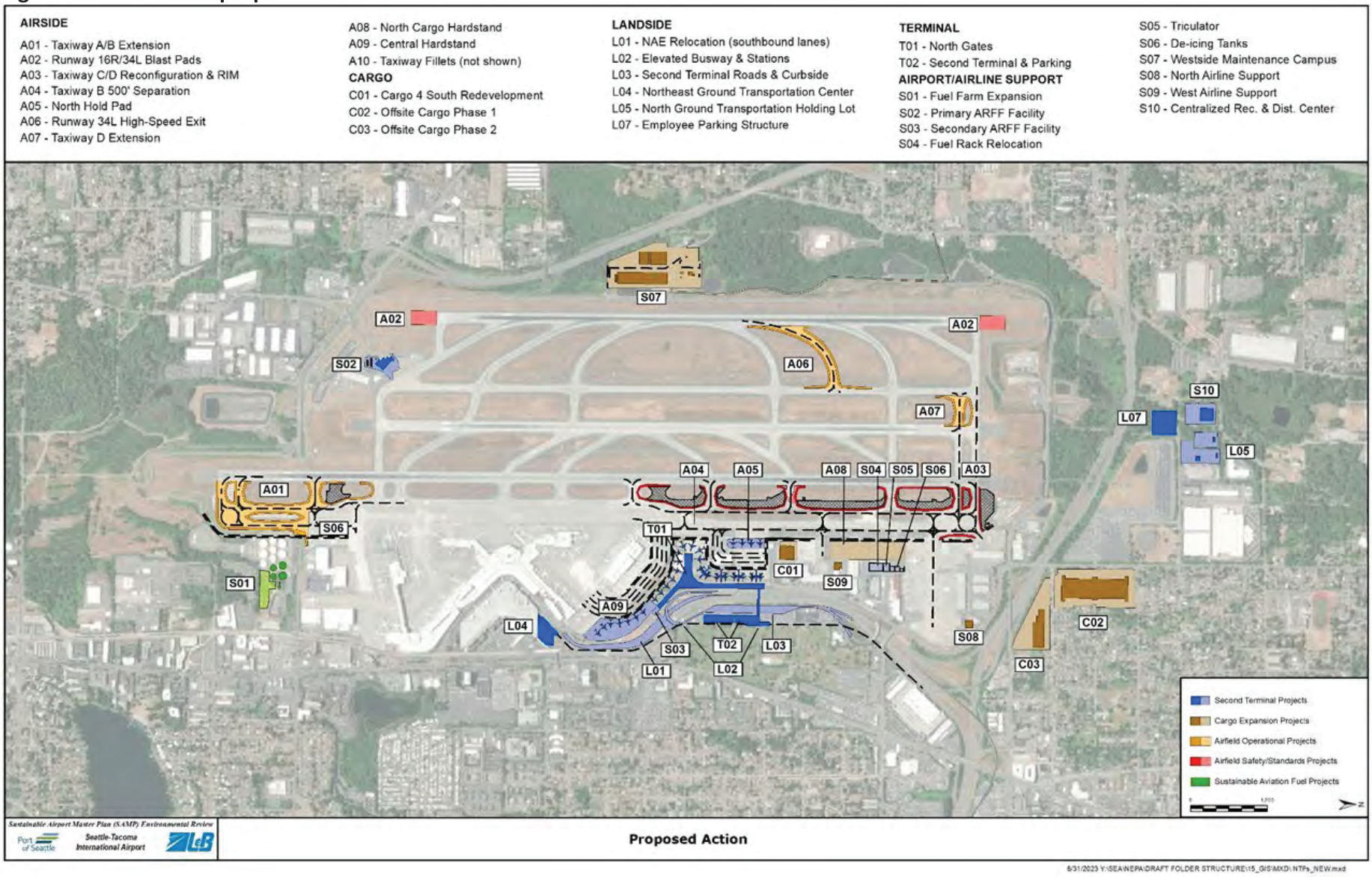


Table 2. Estimated NTP and PSP construction footprints, net change in impervious surface area, and permanent habitat impacts.

Project	Construction Footprint (acres)	Existing Impervious (acres)	Total Impervious Added (acres)	Net Change NPGIS (acres)	Net Change PGIS (acres)	Drainage Basin	Wetland	Wetland Buffer	Stream	Stream Buffer
A01 – Taxiway A/B Extension	33.2	17.83	1.84	0.00	1.84	SDS4; SDS3	--	--	--	--
A02 – Runway 16R/34L Blast Pads	7.2	2.17	1.87	1.87	0.00	SDS6-7 SDN3A	--	--	--	--
A03 – Taxiway C/D Reconfiguration & RIM	17.1	10.52	-0.41	0.00	-0.41	IWS	--	--	--	--
A04 - Taxiway B 500-foot Separation	46.8	51.17	-6.36	0.00	-6.36	SDN2; SDS3; SDE4; IWS	--	--	--	--
A05 – North Hold Pad	3.9	2.06	0.00	0.00	0.00	IWS	--	--	--	--
A06 – Runway 34L High-Speed Exit	13.6	1.53	5.17	0.00	5.17	SDW1B; SDS3A	--	--	--	--
A07 – Taxiway D Extension	6.3	1.38	1.47	0.00	1.47	SDN3	--	--	--	--
A08 – North Cargo Hardstand	11.5	7.87	0.09	-2.40	2.49	IWS	--	--	--	--
A09 – Central Hardstand	10.1	4.13	2.58	0.00	2.58	IWS	--	--	--	--
A10 – Taxiway Fillets	<1	--	<1	--	--	--	--	--	--	--
T01 – North Gates	11.5	11.77	7.31	3.35	3.96	SDE4; IWS	--	--	--	--
T02 – Second Terminal & Parking Garage	4.9	2.37	0.00	2.37	-2.37	SDE4; IWS	--	--	--	--
C01 – Cargo 4 South Redevelopment	3.3	1.84	0.00	0.00	0.00	SDE4	--	--	--	--
C02 – Offsite Cargo Phase 1	21.5	0.64	16.41	7.57	8.84	N of SR 518	--	--	--	--
C03 – Offsite Cargo Phase 2	12.7	0.23	8.85	2.04	6.81	N of SR 518	--	--	--	--
L01 – NAE Relocation	13.0	2.85	2.60	0.00	2.60	SDE4	--	--	--	--
L02 – Elevated Busway and Stations	1.7	0.36	0.15	0.51	-0.36	SDE4	--	--	--	--
L03 – Second Terminal Roads/Curbside	16.7	5.03	1.08	0.00	1.08	SDE4	--	--	--	--
L05 – NGT Holding Lot	8.5	0.00	5.63	0.24	5.39	N of SR 518	--	--	--	--
L07 – Employee Parking Structure	5.2	0.09	3.19	0.00	3.19	N or SR 518	0.02	0.60	--	--
S02 – Primary ARFF Facility	4.9	2.26	0.40	0.00	0.40	IWS	--	--	--	--
S03 – Secondary ARFF Facility	0.9	0.12	0.09	0.21	-0.12	IWS	--	--	--	--
S04 – Fuel Rack Relocation	1.6	0.61	0.02	0.63	-0.61	IWS	--	--	--	--
S05 – Triculator	1.3	0.37	0.04	0.41	-0.37	IWS	--	--	--	--
S06 – De-icing Tanks	1.0	0.21	0.01	0.22	-0.21	IWS	--	--	--	--
S07 – Westside Maintenance Campus	25.5	4.56	15.91	2.88	13.03	SDW2; SDW2A; IWS	<0.01	1.70	0.01	0.07
S08 – North Airline Support	1.0	0.31	0.00	0.31	-0.31	IWS	--	--	--	--
S09 – West Airline Support	1.0	0.29	0.00	0.29	-0.29	SDE3	--	--	--	--
S10-Centralized Receiving and Distribution	5.6	0.00	3.51	0.92	2.59	N of SR 518	--	--	--	--

Project	Construction Footprint (acres)	Existing Impervious (acres)	Total Impervious Added (acres)	Net Change NPGIS (acres)	Net Change PGIS (acres)	Drainage Basin	Wetland	Wetland Buffer	Stream	Stream Buffer
Information/Communications Technology	19.6	12.90	0.00	0.00	0.00	--	--	--	--	--
Power	8.4	4.50	0.00	0.00	0.00	--	--	--	--	--
Water	6.6	5.80	0.00	0.00	0.00	--	--	--	--	--
Sanitary Sewer	9.3	5.80	0.00	0.00	0.00	--	--	0.01	--	--
Aviation Fuel	2.2	2.10	0.00	0.00	0.00	--	--	--	--	--
SDS4 Pond Expansion	0.63	0.10	0.00	0.00	0.00	--	--	<0.01	--	--
Pond M Expansion	1.87	0.80	0.00	0.00	0.00	--	--	0.11	--	--
Miller Creek Detention Pond Construction	1.27	0.30	0.00	0.00	0.00	--	0.55	--	--	--
Pond F Relocation/Replacement	2.56	0.90	0.00	0.00	0.00	--	--	<0.01		
Walker Creek Detention Pond Construction	1.18	1.40	0.00	0.00	0.00	--	--	--	--	--
Stormwater Lines	14.4	9.70	0.00	0.00	0.00	--	0.01	0.23	0.01	0.05
Industrial Wastewater Lines	13.7	8.80	0.00	0.00	0.00	--	--	--	--	--
Grand Total	**373.21**	**185.67**	**71.45**	**21.42**	**50.03**	**--**	**0.58**	**2.65**	**0.02**	**0.12**

2.4.1 Airside Projects

2.4.1.1 *A01 – Taxiway A/B Extension*

Extension of parallel Taxiway A/B by approximately 1,800 feet to provide access to the south end of Runway 16L/34R. This NTP includes:

- Shifting Taxiway A east by approximately 100 feet and Taxiway B west by approximately 100 feet to create two separate taxiways. Existing pavement will be reconfigured, including relocation of Taxiway S 310 feet to the south.
- Relocation of Runway 34R glideslope antenna and associated equipment shed approximately 100 feet east. These features are in the mowed field between Taxiway A/B and Runway 16L/34R.
- Relocation of a service vehicle bridge over S 188th Street approximately 60 feet east of the existing road. This bridge would be approximately 100 feet long by 25 feet wide (0.06 acre).

NTP A01 relocates or retrofits approximately 17.83 acres of PGIS and creates 1.84 acres of new PGIS.

2.4.1.2 *A02 – Runway 16R/34L Blast Pads*

Expansion of Runway 16R/34L blast pads from the existing 200 by 200 feet (0.9 acre) to 220 by 400 feet (2.0 acres) to meet FAA design standards. Blast pads would be poured concrete construction on cleared and compacted ground. Includes relocation of navigational aids to enable construction. Blast pad expansion would retrofit 2.17 acres of existing NPGIS and create 1.87 acres of new NPGIS.

2.4.1.3 *A03 – Taxiway C/D Reconfiguration and Runway Incursion Mitigation*

Modification of existing taxiway geometry of Taxiways C and D to correct non-standard intersection angles and reconfigure non-standard intersections. Includes the extension of Taxiways C and D by approximately 500 feet to intersect with Taxilane A and the removal of 2,670 square feet (0.06 acre) of existing impervious surfaces for runway incursion mitigation. Approximately 100,000 square feet (2.3 acres) of pavement north of Taxiway C would be removed to offset the increase in impervious surfaces. In total, this NTP would result in a net reduction in PGIS of 0.41 acres.

2.4.1.4 *A04 - Taxiway B 500-foot Separation*

Relocation of Taxiways A and B 100 feet east between Taxiways C and L to provide the required 500 ft runway/taxiway separation. This would require extending Taxiways C, D, E, H, and K 100 feet to connect with the relocated Taxiway B. Existing paved surfaces would be removed to offset the increase in impervious area, resulting in a net reduction in PGIS of 6.36 acres.

2.4.1.5 *A05 – North Hold Pad*

Construction of an approximately 90,000-square-foot (2.1-acre) hold pad for up to four aircraft to reduce congestion on the taxiways and at the terminal. This new surface would be constructed entirely on existing PGIS, resulting in no net change in PGIS.

2.4.1.6 *A06 – Runway 34L High-Speed Exit*

Construction of a new high-speed exit for Runway 34L arrivals between Taxiways J and E to allow for more efficient use of the runway by arriving aircraft. Construction would require clearing and grading of the field and relocation of the multilateration remote unit. This NTP would add a total of approximately 5.2 acres of mostly new PGIS. A small percentage (less than 5%) of NTP acreage would be constructed on existing impervious surfaces on the runway and taxiway shoulders.

2.4.1.7 *A07 – Taxiway D Extension*

Extension of Taxiway D by approximately 500 feet from Runway 16C/34C west to Taxiway T. This NTP would add approximately 1.47 acres of new PGIS. Construction would require clearing and grading of approximately 1.6 acres of maintained field between the runway and taxiway. A small percentage (less than 5%) would be constructed on the existing taxiway shoulders.

2.4.1.8 *A08 – North Cargo Hardstand*

Construction of an approximately 360,000-square-foot (8.3-acre) cargo aircraft hardstand in the North Cargo area east of Taxiway A. The hardstand would accommodate five aircraft for loading and unloading cargo freight and parking of cargo aircraft. Construction would require the relocation of the United maintenance hangar and Swissport cargo facility (S08), the Port's aviation maintenance facility (S07), and ground service equipment (GSE) maintenance facility (S09). All construction would occur on existing impervious surfaces. This NTP would increase PGIS by 2.49 acres.

2.4.1.9 *A09 – Central Hardstand*

Construction of an approximately 292,000-square-foot (6.7-acre) hardstand for seven aircraft north of Concourse D and east of the North Satellite to accommodate increased demand for passenger hardstand operations and overnight parking of passenger aircraft. Requires relocating portions of the North Airport Expressway (NAE) (L01). This NTP would add approximately 2.58 acres of PGIS.

2.4.1.10 *A10 – Taxiway Fillets*

Construction of new full strength pavement panels and shoulders to meet FAA standards. This NTP would be constructed entirely on existing impervious surfaces and would result in no net change in impervious area or PGIS. The anticipated project footprint is small (less than 1 acre) and too broadly distributed to be displayed on Figure 2 but would be associated with all taxiways.

2.4.2 Terminal Projects

2.4.2.1 *T01 – North Gates*

Construction of a new multi-level concourse and aircraft apron to accommodate up to 19 gates. The new concourse would have a footprint of approximately 203,000 square feet (4.7 acres), all of which would be NPGIS. The associated aircraft apron would have a footprint of approximately 500,000 square feet (11.5 acres) of existing and new impervious surfaces. The new facility would displace the Aircraft Rescue and Firefighting (ARFF) station (S02), Cargo 6 warehouse (C01), deicing tanks (S06), NAE (L01) and fuel rack (S04). This NTP would increase PGIS by 3.96 acres.

2.4.2.2 *T02 – Second Terminal and Parking Garage*

Construction of a new multi-level passenger terminal on the east side of the NAE from proposed T01, connected via an elevated pedestrian walkway. Includes the construction of a new multi-level parking garage with approximately 1,350 parking spaces. The new terminal and garage would have a combined footprint of approximately 286,000 square feet (6.6 acres). The new facilities would displace the Doug Fox Parking Lot and would reduce existing PGIS by approximately 2.37 acres.

2.4.3 Cargo Projects

2.4.3.1 *C01 – Cargo 4 South Redevelopment*

Construction of an approximately 80,000-square-foot cargo facility (warehouse, office space, truck terminals, and parking) at the Cargo 4 South site in the central cargo area to replace the Cargo 6 warehouse, which will be demolished for T01. The new facility would have a footprint of approximately 1.8 acres. This NTP would result in no net change in NPGIS or PGIS.

2.4.3.2 *C02 – Offsite Cargo Phase 1*

Construction of a new 330,000-square-foot (7.6-acre) cargo warehouse on the Port's L-shaped parcel located north of SR 518. The facility footprint (warehouse, office space, truck terminals, parking, and access roads) would cover approximately 16.0 acres. Approximately 98% of the project footprint is vegetated pervious surface that would be cleared for construction. This NTP would create approximately 7.6 and 8.8 acres of new NPGIS and PGIS, respectively.

2.4.3.3 *C03 – Offsite Cargo Phase 2*

Construction a new 90,000-square-foot (2.1-acre) cargo warehouse on the triangular portion of the Port's L-shaped parcel located north of SR 518. The entire facility footprint (warehouse, office space, truck terminals, parking, and access roads) would cover approximately 8.1 acres. Approximately 98% of the project footprint is vegetated pervious surface that would be cleared for construction. This NTP would create approximately 2.1 and 6.8 acres of new NPGIS and PGIS, respectively.

2.4.4 Landside Projects

2.4.4.1 *L01 – North Airport Expressway Relocation (Southbound Lanes)*

Construction of approximately 7,300-linear-feet of NAE to replace the section displaced by construction of A09 and T01. The relocated portion would be widened from 3 to 4 lanes, provide access to T02, and alleviate congestion. This NTP would create about 2.60 acres of new PGIS.

2.4.4.2 *L02 – Elevated Busway and Stations*

Construction of approximately 6,000-linear-feet of elevated busway and three stations to connect the main terminal, new second terminal, and rental car facility. The busway and stations would be located along the eastern edge of SEA property and would tie into existing bus routes. L02 would displace the existing ground transportation holding lot by cutting off access to SEA, which would be replaced with L05. In total, this NTP would reduce existing PGIS by approximately 0.36 acre.

2.4.4.3 *L03 – Second Terminal Roads and Curbside*

Construction of a new loop ramp connecting the NAE to T02 from the existing S 160th Street Loop, westbound SR 518 on-ramp at S. 160th Street, and northbound lanes of the NAE. Split-level curbsides would be constructed for arriving vehicles, departing vehicles, and commercial vehicles (shuttles, taxis, and ride-share companies). This NTP would increase existing PGIS by 1.08 acres.

2.4.4.4 *L05 – North Ground Transportation (GT) Holding Lot*

Relocation of GT Holding Lot to Port property north of SR 518 and south of S 144th Street to replace the parking lot displaced by L02. Construction would require clearing and grading of existing vegetated upland habitat and would create approximately 0.24 and 5.39 acres of new NPGIS and PGIS, respectively.

2.4.4.5 *L07 – Employee Parking Structure*

Construction of a new 8-story (1 below grade and 7 above grade), 3,500-stall employee parking structure on Port property north of SR 518 and south of S 144th Street. The structure would have a footprint of approximately 3.3 acres. This NTP would create approximately 3.19 acres of new PGIS.

2.4.5 Airport/Airline Support Projects

2.4.5.1 *S02 – Primary Aircraft Rescue and Firefighting Facility*

Relocation of the Primary ARFF station to accommodate construction of T01. The new 50,000-square-foot (1.1-acre) ARFF would be located on the south airfield between Runway 16R/34L and Runway 16C/34C. The ARFF building and associated vehicle pads, access roads, and parking areas would have a combined footprint of approximately 2.7 acres. This NTP would displace an existing building and parking lot. The new facility would increase PGIS by 0.40 acres.

2.4.5.2 *S03 – Secondary Aircraft Rescue and Firefighting Facility*

Construction of an approximately 10,000-square-foot (0.2-acre) secondary ARFF to provide ambulatory and fire response to the terminals and concourses and back-up emergency response to the airfield. The Secondary ARFF facility would be integrated within T01 at the southeast end of the concourse, decreasing existing PGIS by 0.12 acre.

2.4.5.3 *S04 – Fuel Rack Relocation*

Relocation of the fuel rack from its existing location in the Cargo 6 area to the Cargo 3 area to accommodate T01. The fuel rack is part of the airport fuel distribution system where aircraft fuel trucks refill. The replaced facility would have a construction footprint of approximately 1.6 acres and would be constructed entirely on existing impervious surfaces, reducing existing PGIS by 0.61 acre.

2.4.5.4 *S05 – Triculator*

Relocation of the airport triculator building from east of the ARFF to the north cargo area for construction of A09. The triculator transfers aircraft waste to the sewer system. The relocated facility would have a footprint of approximately 12,200 square feet (0.4 acre) of NPGIS and would be constructed entirely on existing impervious surfaces, resulting in a net reduction in PGIS of 0.37 acre.

2.4.5.5 *S06 – De-icing Tanks*

Relocation of the de-icing fluid tanks from Cargo 6 and Cargo 7 to the east of A08 and near A01 service vehicle bridge to accommodate T01. Each site would have a containment system, blending station, and two tanks (Type I de-icing fluid and Type IV de-icing fluid). The two sites would have a combined footprint of approximately 14,000 square feet (0.3 acre) of NPGIS and would be constructed entirely on existing impervious surfaces, reducing existing PGIS by 0.21 acre.

2.4.5.6 *S07 – Westside Maintenance Campus*

Relocation of the Port's Aviation Maintenance Facility to the west side of the airfield for construction of A08. The facility includes a vehicle fuel rack, airfield deicer storage, snow equipment storage, multi-bay buildings, and associated maintenance facilities. The Westside Maintenance Campus would have a combined total footprint of approximately 29.1 acres, comprising approximately 6.0 acres of new buildings/structures and 15.3 acres of access roads, parking areas, hardstands, and retaining walls. In total, this NTP would add approximately 13.03 acres of PGIS.

NTP S07 would be developed on an existing slope on an 11-acre upper and 6-acre lower platform constructed on the hillside, bounded by retaining walls with a footprint. Retaining walls would reach a maximum height of up to 65 feet at the southern end of the site and would most likely be mechanically stabilized earth construction. Facility construction could require up to 1,550,000 cubic yards of combined cut and fill. Construction would permanently displace a fraction (<0.01) of an acre of wetland and 1.7 acres of wetland buffer habitat. Includes the reconstruction of S. 168th St. access and construction of a new access road from S. 157th Place to the new facility. The S 157th Place access road would require improvements to an existing culvert crossing over Miller Creek to support long-term operations. Roadway surfacing and stormwater improvements at this crossing would result in approximately 0.01 and 0.07 acre of permanent impacts to stream and stream buffer, respectively.

2.4.5.7 *S08 – North Airline Support*

Construction of an approximately 15,000-square-foot (0.3-acre) airline support building in the northeast corner of the North Cargo area on existing impervious surface. This enabling project would accommodate aircraft maintenance functions displaced by construction of A08. The new building would replace existing PGIS with NPGIS, resulting in a net reduction in PGIS of 0.31 acre.

2.4.5.8 *S09 – West Airline Support*

Expansion of the existing AMB/AFCO III building by approximately 12,500 square feet (0.3 acre) to replace GSE maintenance functions displaced by construction of A08. The new building would replace existing PGIS with NPGIS, resulting in a net reduction in PGIS of 0.29 acre.

2.4.5.9 *S10 – Centralized Receiving and Distribution Center (CRDC)*

Construction of an approximately 55,000-square-foot (1.3-acre) CRDC on Port property north of SR 518 and south of S. 144th Street. This facility would service the dining and retail concessionaires in passenger terminals and is needed to improve the security and efficiency of food, beverage, and inventory distribution. The new CRDC building would be constructed on vacant ground, requiring clearing and grading of the entire project footprint. This NTP would create 2.59 acres of new PGIS.

2.5 Proposed Program Support Projects

2.5.1 Utilities Projects

The UMP (Port 2022a) identified several water, sewer, electrical, heating and cooling, and information and communications technology projects necessary to support NTP development. In addition, T01 would require the installation of new jet fuel distribution lines. The Proposed Action includes the construction of new underground lines, ducts, and utility tunnels. Table 3 summarizes the planned length and construction footprint acreages for utilities projects by category. Utility line corridors would be installed under existing pervious and impervious surfaces. Corridor segments outside of NTP footprints would be restored to pre-construction conditions and would result in no net change in impervious surface area. Planned utility locations are shown in Figures 3 to 5.

The Proposed Action also includes planned upgrades to the SEA mechanical plant. These upgrades comprise replacement of and improvements to internal equipment and systems within existing infrastructure footprints. No measurable effects on the outside environment are anticipated.

Table 3. UMP projects needed to support NTP development.

Utility Type	Construction Type	Length (miles)	Temporary Construction Footprint (acres)	Impervious Surfaces Construction Footprint (acres)
Water	Buried mainlines	2.74	6.6	5.8
Sanitary sewer	Buried trunk lines	3.82	9.3	5.8
Power	Underground lines/duct banks	3.39	8.4	4.5
Information/Communication Technology	Underground duct banks	7.70	19.6	12.9
Aviation fuel	Buried lines	0.89	2.2	2.1

Figure 3. Proposed UMP projects, northeast section of project area.

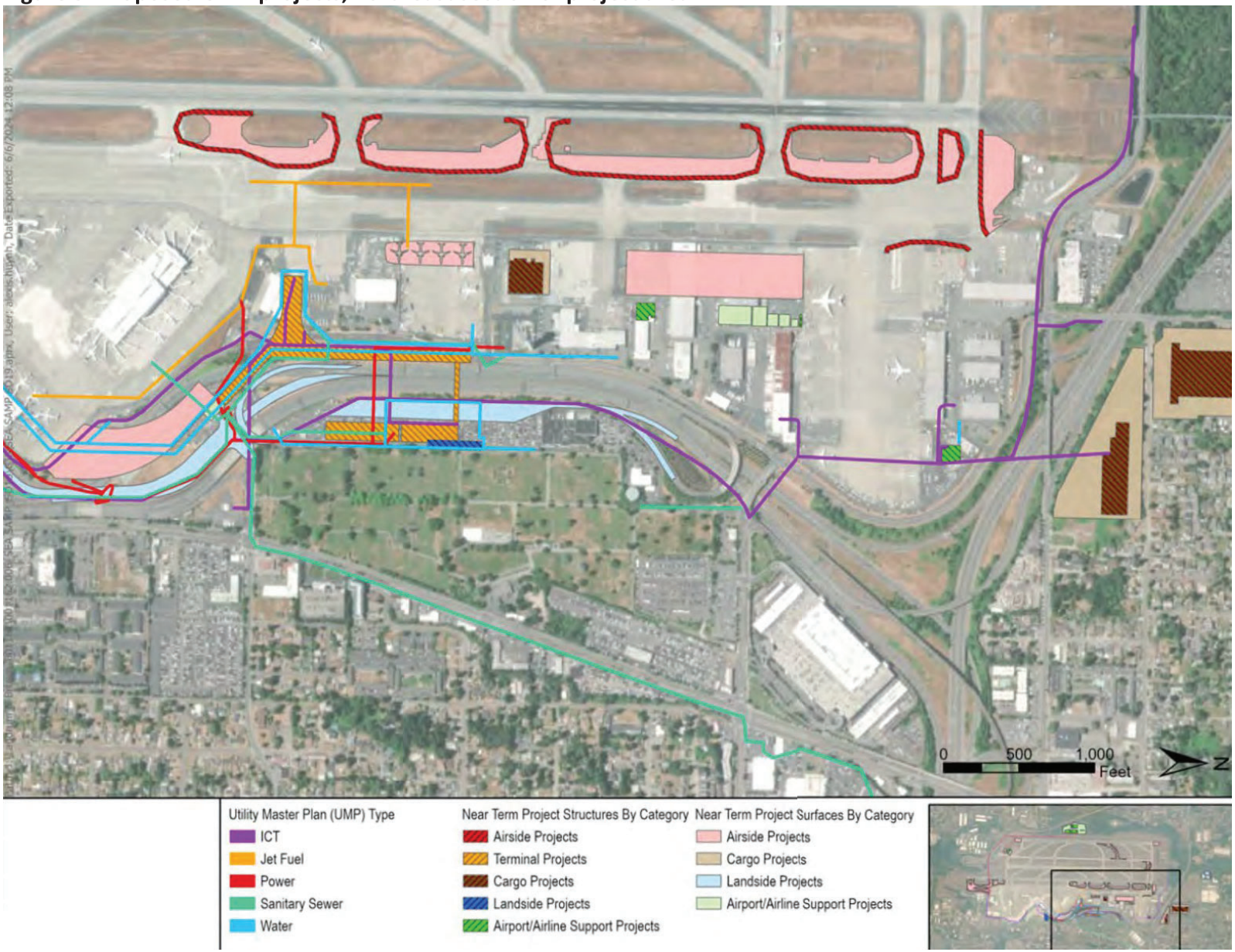


Figure 4. Proposed UMP projects, southeast section of project area.

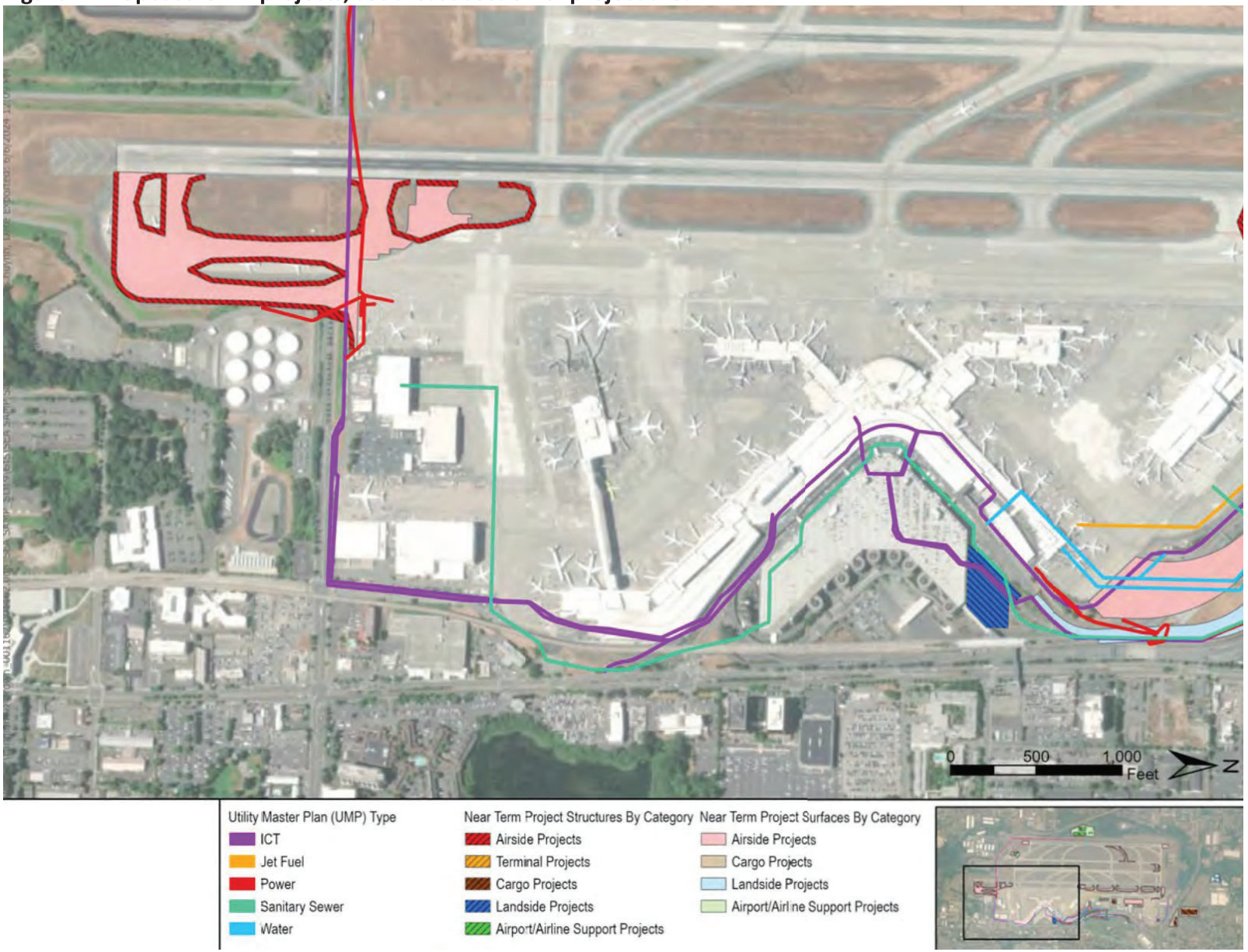
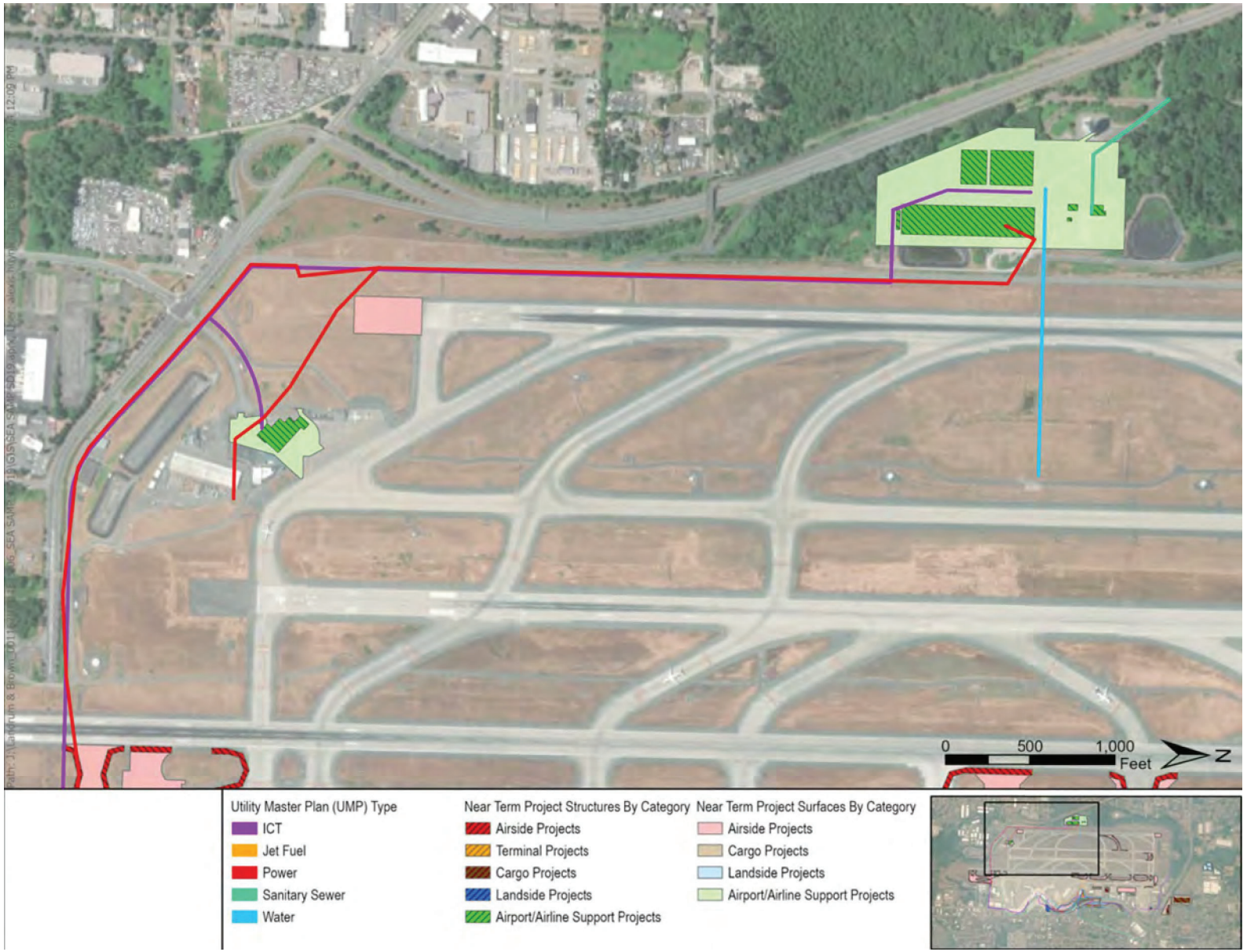


Figure 5. Proposed UMP projects, southwest section of project area.



2.5.2 Stormwater and Wastewater Projects

The Proposed Action includes improvements to and expansion of the SDS and IWS to provide the additional detention and treatment capacity needed to support NTP development. This program, described in detail in the *Seattle-Tacoma International Airport Stormwater Pollution Prevention Plan* (SEA SWPPP) (Port 2022b), comprises 4 primary components:

- The SDS: Structural stormwater detention and treatment infrastructure.
- The IWS: The Port's permitted Industrial Wastewater Treatment Plant (IWTP) system, wastewater drainage basins, and associated detention and conveyance infrastructure.
- Operational source controls (OSCs): BMPs used to avoid and minimize pollutant releases from SEA operations, reducing the quantity of pollutants discharging to the SDS.
- Water quality monitoring: The Port's NPDES permit is broken down into three parts: Part 1: Industrial Wastewater, Part 2: Industrial Stormwater, and Part 3: Construction Stormwater. The NPDES permit establishes conditions, prohibitions, and management practices designed to reduce the discharge of pollutants from the SDS and IWS, to protect water quality, and to comply with appropriate CWA requirements. One of the conditions is compliance monitoring at all points of discharge for the SDS and IWS systems. A summary of the Port's water quality monitoring activities, including priority constituents and monitoring frequency, is provided in Appendix B. The Port has established pollutant monitoring protocols for the sanitary sewer system (Port 2021a), the IWS (Port 2020, 2021b), and the SDS (Port 2021c, 2021d).

Existing SDS and IWS drainage basins and detention infrastructure are shown in Figure 6. The SDS comprises 12 stormwater drainage basins and a network of conveyance pipes, detention vaults, and ponds used to capture and treat stormwater runoff from approximately 1,284 acres of SEA property. Over half of this area is impervious and primarily associated with airport runways, taxiways, parking lots, roads, and roof tops. The remainder is pervious which consists of landscaped or fallow open spaces and areas associated with stormwater treatment BMPs such as runway filter strips. About 25 percent of the area drained by the SDS flows to Miller Creek. This drainage area represents about 7 percent of Miller Creek's watershed. Approximately 71 percent of the total SDS area drains to the Northwest Ponds and Des Moines Creek, which represents about 21 percent of Des Moines Creek's watershed.

The Airport's SDS is segregated into separate stormwater subbasins that each drain to individual outfall locations. The NPDES permit lists a total of thirteen (13) outfalls in two categories: Existing & New Outfalls and Subbasins, and Future Outfalls to be activated during future development. As of June 30, 2023, eleven (11) of the thirteen (13) outfalls are active.

The IWS comprises 2 drainage basins covering a combined 325.1 acres that service the aircraft operations area and a 26.5-acre drainage basin servicing the airport parking garage. The IWS services portions of the Port where aircraft de-icing and handling fuel, paint, lubricants, degreasers, and other hazardous materials routinely occur. The IWS conveyance system includes approximately 35 miles of piping, 1,200 manholes and catch basins, two below-grade vaults in the parking garage, and 11 pump stations. The IWS collects stormwater from flush gutters and catch basins and conveys the stormwater to the IWS storage lagoons. Prior to entering the storage lagoons, the wastewater is automatically analyzed, and flow is directed to specific lagoons based upon biological oxygen demand (BOD)

concentration. The primary purpose of Lagoons #1 and #2 is for collection of the "first flush" of high BOD influent from the South Aviation and North Aviation areas, respectively. Although the primary purpose of Lagoon #3 is for collection of low BOD runoff, high BOD runoff during de-icing periods may also be stored in Lagoon #3 when Lagoons #1 and #2 reach full capacity. Prior to treatment, the wastewater flows from Lagoons #1 and #2 through mechanical screening devices, which are sized to remove large objects. Water stored in Lagoons #1 and #2 drain by gravity to the IWTP. Water is pumped from Lagoon #3 to the IWTP. Some settling of solids occurs in the lagoons. The lagoons are typically cleaned every other year pending summer weather conditions. The IWTP discharges treated effluent to either the Puget Sound or to the sanitary sewer system.[1]

Quantification of existing impervious surface acreage in SDS and IWS drainage basins affected by the Proposed Action are provided in Table 4. Table 4 also summarizes the existing structural source controls and level of treatment provided in each drainage basin, proposed SDS and IWS improvements, and relevant OSC BMPs. Treatment levels are defined in Table 5, which apply Washington State Department of Ecology (Ecology) terminology (Ecology 2019).

As detailed in Table 2, the Proposed Action would increase the total amount of impervious surface by approximately 71 acres and increase PGIS by approximately 50 acres. None of the vegetation that will be removed is located directly adjacent to or near water sources or habitat for aquatic species. All new PGIS would be treated prior to draining to the Puget Sound via Miller, Walker, or Des Moines creeks or the IWTP discharge. The Proposed Action includes construction of new and improvements to existing SDS and IWS infrastructure. The stormwater and wastewater projects included in the Proposed Action are shown in Figures 7 to 10 and are summarized in Table 6.

OSCs comprise an array of operational BMPs designed to prevent avoidable releases of pollutants, minimize unavoidable releases, and reduce the quantity of pollutants discharged to the SDS and IWS. All NTPs would be subject to the OSC BMPs applicable to the functions they provide. OSC BMPs are described in Section 2.7.2. Table 4 identifies 3 specific BMP actions—runway rubber removal, dry sweeping of impervious surfaces, and sediment management—that are relevant for avoiding and minimizing impacts to ESA-listed species from stormwater contaminants. Additional information about the frequency and extent of these activities is provided in Section 2.7.2.

Construction of proposed SDS and IWS improvements would result in permanent impacts to approximately 0.01 acre of streams and 0.05 acre of stream buffer and up to 0.56 acre of wetland and 0.35 acre of wetland buffer habitats. These impacts are described in Section 5.1.2. Anticipated mitigation requirements are summarized in Section 2.6.

[1] The receiving body for IWTP discharge is determined by effluent BOD. Per Individual NPDES Permit WA-0024651 effluents with BOD concentrations below the BOD threshold are permitted for direct discharge to Puget Sound. Effluents exceeding this threshold are diverted to the sanitary sewer per King County Industrial Waste Discharge Permit 7810-05.

Figure 6. Existing SDS and IWS drainage basins and stormwater infrastructure

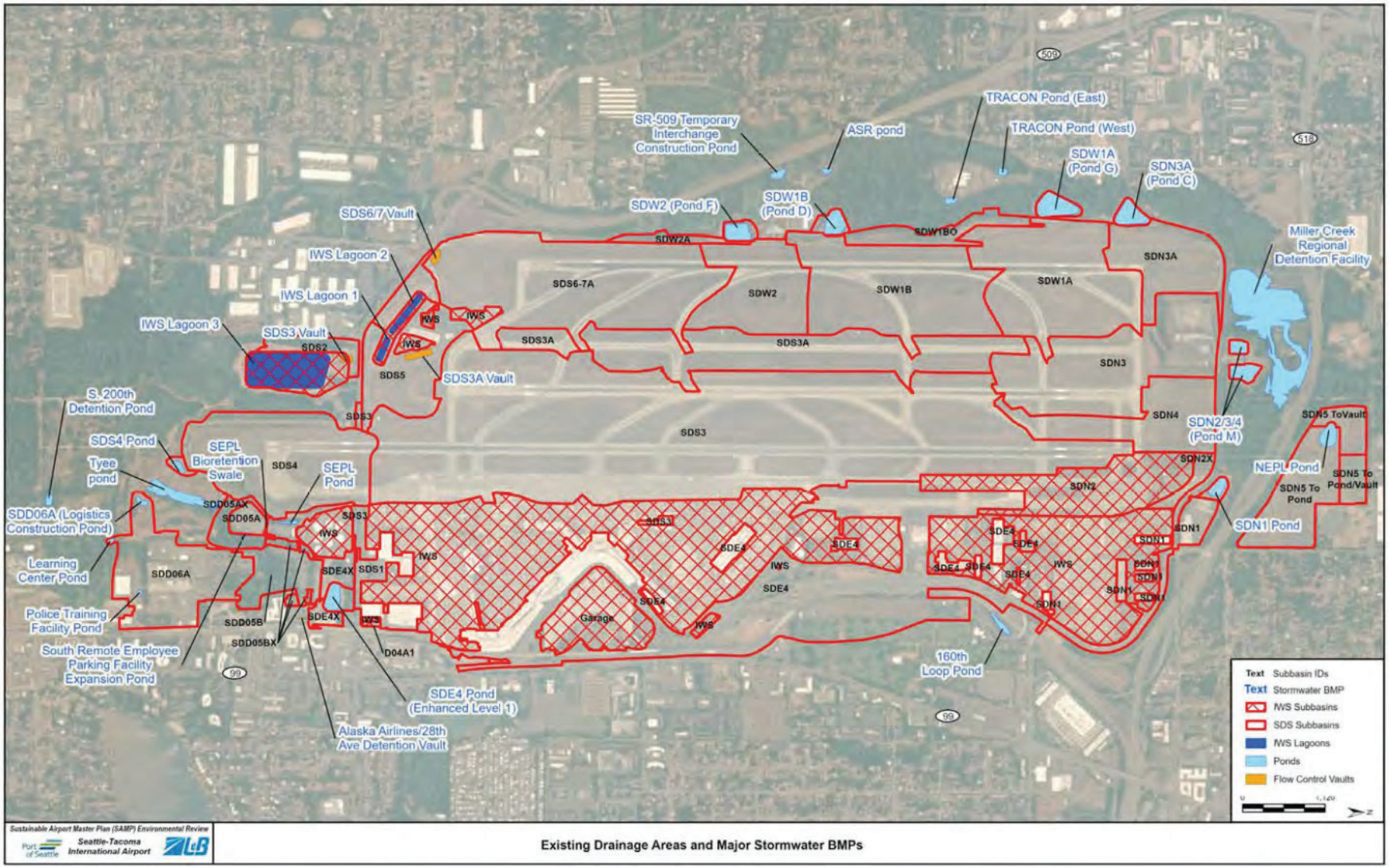


Figure 7. Proposed SDS and IWS projects, northeast section of project area

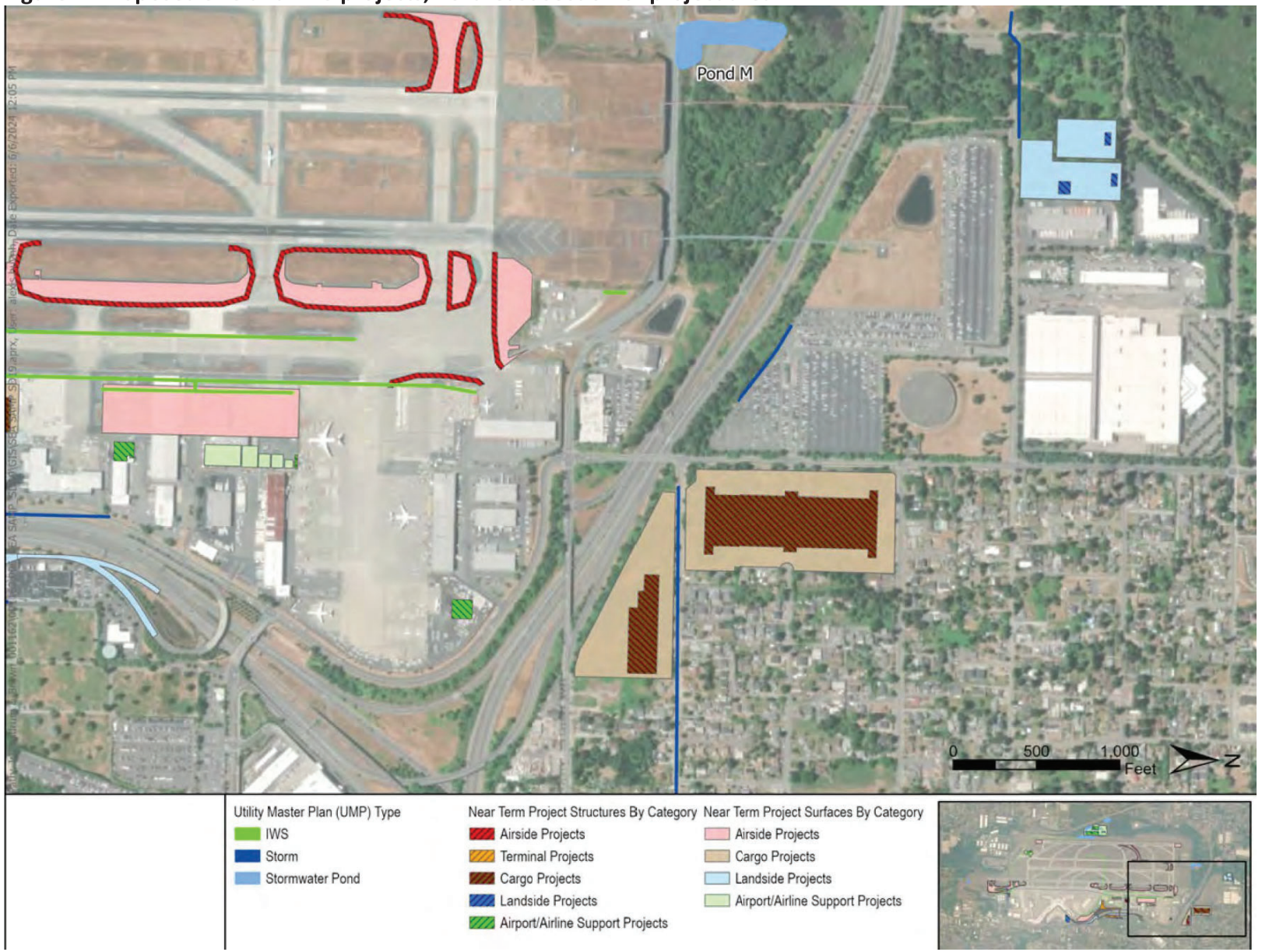


Figure 8. Proposed SDS and IWS projects, east section of project area

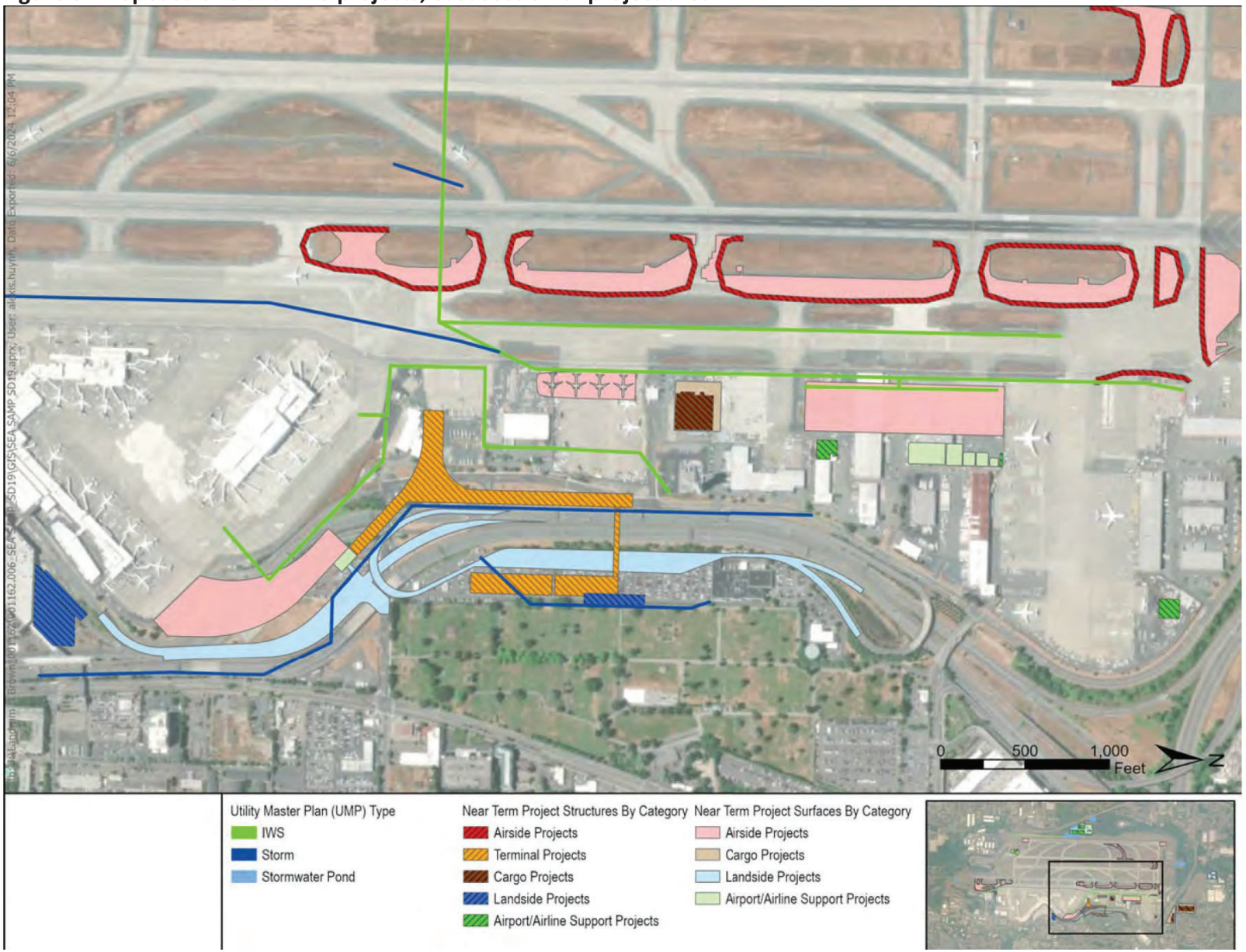


Figure 9. Proposed SDS and IWS projects, southeast section of project area

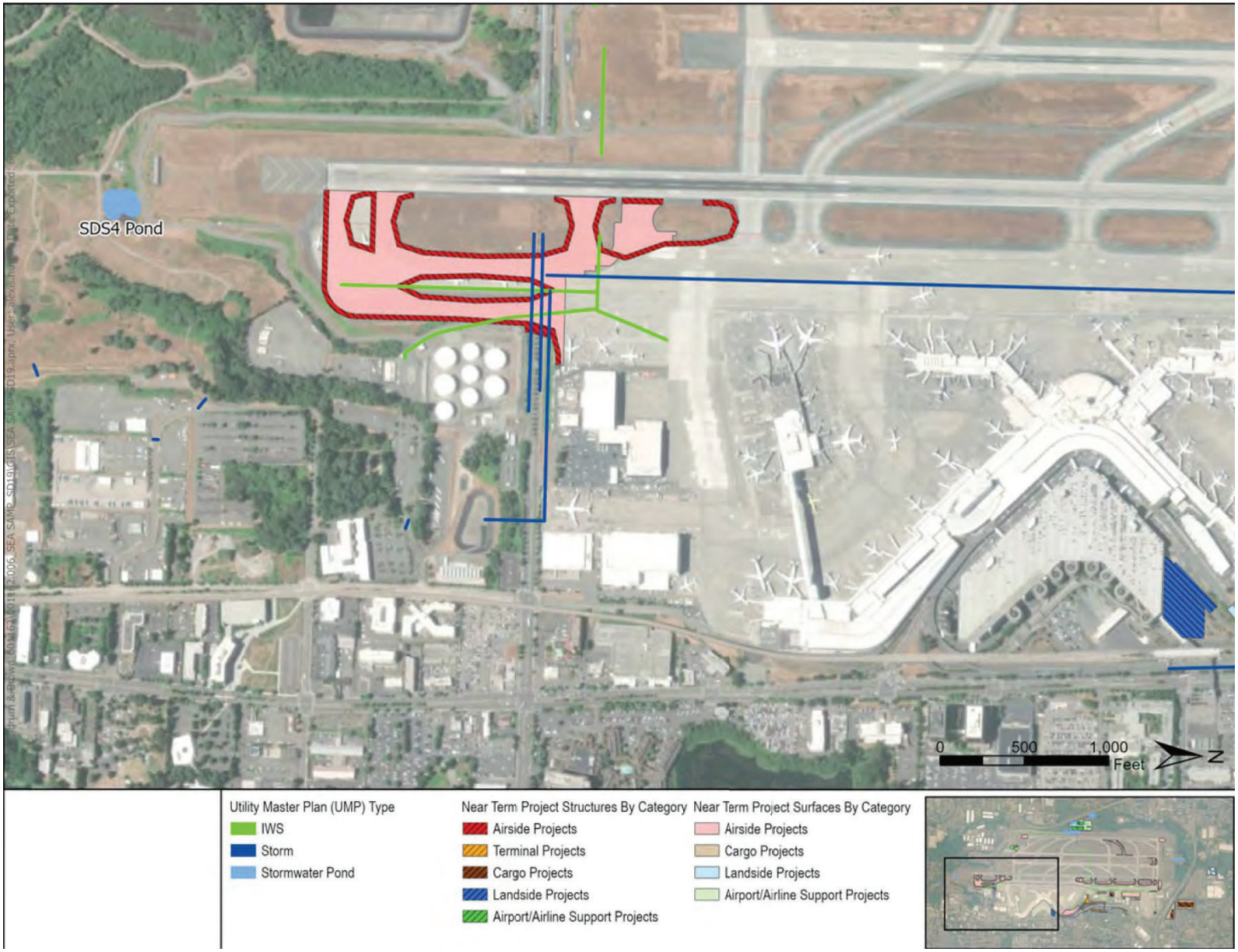


Figure 10. Proposed SDS and IWS projects, southwest section of project area

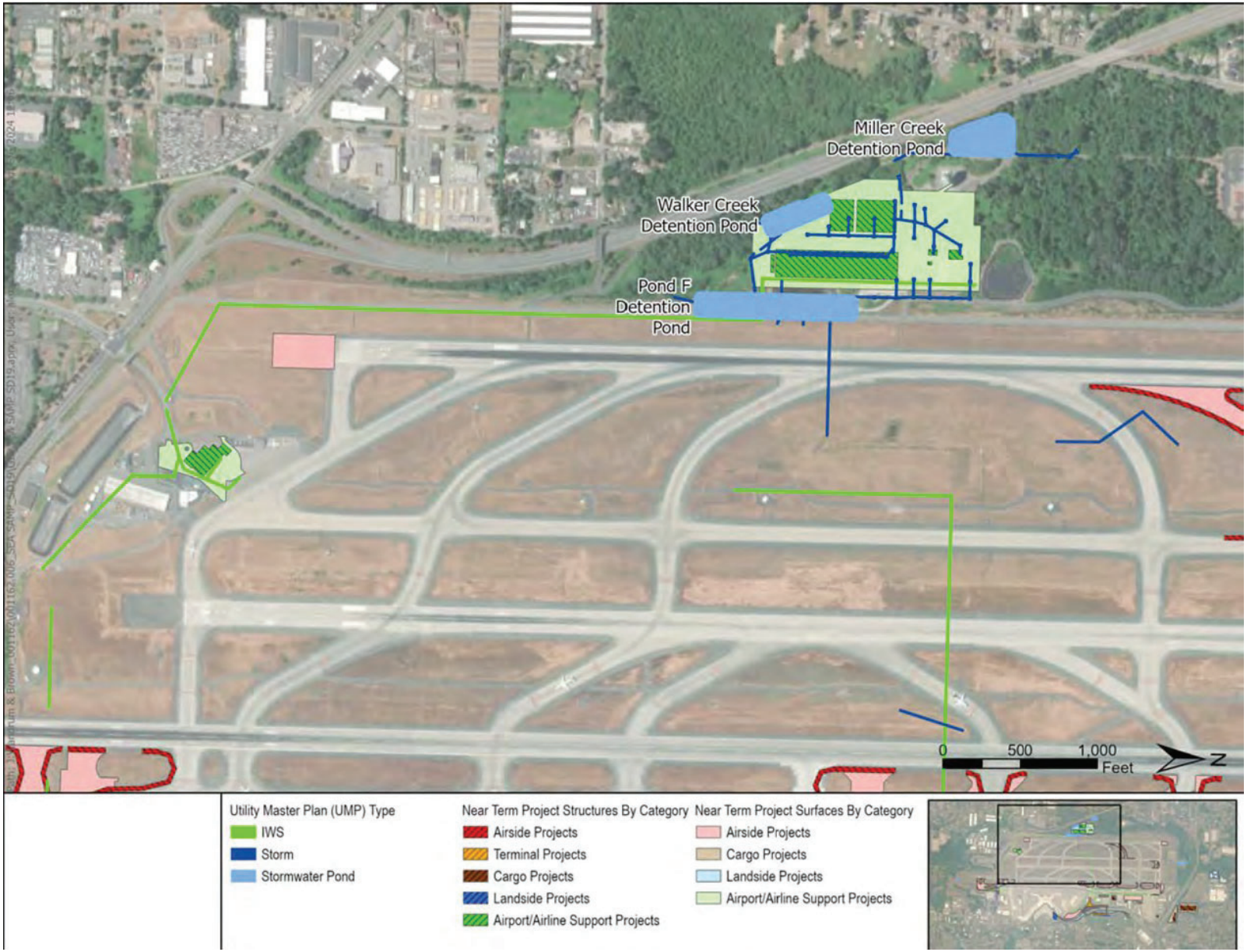


Table 4. Existing and proposed structural and OSC BMPs and net change in impervious areas and PGIS resulting from the Proposed Action by drainage basin and receiving body.

Receiving Water	SDS/IWS Drainage Basin	Existing Drainage Total Area (acres)	Existing Drainage Basin Total Impervious (acres)	Existing Drainage Basin NPGIS (acres)	Existing Drainage Basin PGIS (acres)	Existing Structural Source Control BMPs and Treatment Level[2]	Proposed Structural Source Control BMPs and Treatment Level[2]	OSC BMPs[3]
Des Moines Creek East	SDD05B	22.8	9.6	0.2	9.5	Oil/Enhanced ▪ Vegetated filter strips. ▪ SEPL Bioretention Swale. ▪ SDD05B Pond, enhanced level 1 flow control.	Increase Enhanced treatment capacity: ▪ Expand SDD05B Pond volume by 2.3 acre-feet. ▪ Pursue opportunities for infiltration if practicable. ▪ Integrate on-site LID techniques where practicable.	SM
	SDD06A	45.3	27.2	3.0	24.1	Oil/Enhanced ▪ 4 Biofiltration swales followed by oyster shell media bed. ▪ Oil/water separators. ▪ SDD06A Pond – Level 1 flow control detention pond.	Increase Enhanced treatment capacity: ▪ Expand existing detention pond volume by 6.4 acre-feet. ▪ Pursue opportunities for infiltration if practicable. ▪ Integrate on-site LID techniques where practicable.	SM
	SDE4/SDS1	190.2	141.9	40.4	101.5	Oil/Enhanced ▪ SDS1: Bioswales (SDS1). ▪ SDE4: SE Pond detention and treatment – Enhanced Level 1. ▪ 600-cartridge media filter vault with enhanced treatment. ▪ Media-augmented biotreatment swale. ▪ Oil/water separators.	Increase Oil/Enhanced treatment capacity: ▪ Install two oil/water separators and canister filters. ▪ Additional water quality treatment for runoff from garage and toll booth plaza.	SS, SM
	Receiving water totals	***258.3***	***178.7***	***43.6***	***135.1***			
NW Ponds and Des Moines Creek West	SDS4	67.6	25.9	0.1	25.9	Oil/Enhanced: ▪ Compost amended vegetated filter strips. ▪ SDS4 Pond. ▪ Biotreatment swale with design media. ▪ Oil/water separators.	Add additional Basic treatment capacity: ▪ Expand SDS4 Pond detention volume and bioretention swale footprint at outfall. ▪ Expand detention volume by 0.1 acre-feet to address development within basin only (assuming no diversion from SDS3/5). ▪ Expand bioretention swale footprint by 90 square feet or provide equivalent detention and treatment alternative. ▪ Integrate on-site low-impact development techniques as feasible. ▪ Pursue opportunities for shallow / deep infiltration to offset storage requirements.	R3, SM
	SDS3/5	456.8	250.6	3.2	247.3	Oil/Enhanced: ▪ Compost amended vegetated filter strips. ▪ Two bioswales. ▪ Two enhanced Level 1 flow control detention facilities.	Expand Basic treatment capacity: ▪ Divert runoff to SDS4 outfall to avoid need for additional storage. ▪ Increase detention pond volume.	R3, SM
	SDS6/7	117.1	48.2	0.1	48.1	Enhanced: ▪ 3.5-acre-foot vault for enhanced level 1 flow control. ▪ Compost-amended vegetated filter strips. ▪ Bioswales adjacent to runways and taxiways.	Maintain existing Enhanced treatment capacity	R3, SM
	Receiving water totals	***641.5***	***324.7***	***3.4***	***321.3***			
Miller Creek	SDW1b	87.5	25.3	0.0	25.3	Enhanced: ▪ Compost amended vegetated filter strips. ▪ SDW1B Pond (Pond D) for flow control. ▪ Sedimentation management for water quality.	Increase Enhanced treatment capacity: ▪ Expand SDW1b Pond detention volume by 4.4 acre-feet. ▪ Provide additional source controls, including oil/water separator. ▪ Pursue opportunities for infiltration. ▪ Integrate LID techniques where practicable.	R3, SM
	SDN3A	33.9	8.1	0.1	8.0	Enhanced: ▪ Compost amended vegetated filter strips. ▪ SDN3A Pond (Pond C) – Level 2 flow control. ▪ Sedimentation management for water quality.	Maintain existing Enhanced treatment capacity	R3, SM
	New Development North of SR 518	42.7	0.9	0.0	0.9	N/A	Develop new Enhanced treatment capacity: ▪ Install new on-site detention and water quality treatment.	SM
	Receiving water totals	***164.1***	***34.3***	***0.1***	***34.2***			

2 Oil, Basic, and Enhanced structural treatment levels as defined by Ecology (2019), see Table 5.
3 OSC BMPs applicable to 6PPD-Q and other stormwater contaminants: R3 (runway rubber removal); SS (dry sweeping of PGIS); SM (sedimentation management). See Section 2.7.2 for details.

Receiving Water	SDS/IWS Drainage Basin	Existing Drainage Total Area (acres)	Existing Drainage Basin Total Impervious (acres)	Existing Drainage Basin NPGIS (acres)	Existing Drainage Basin PGIS (acres)	Existing Structural Source Control BMPs and Treatment Level[2]	Proposed Structural Source Control BMPs and Treatment Level[2]	OSC BMPs[3]
Miller Creek via Lake Reba	SDN2/3/4	115.9	44.6	0.4	44.2	Enhanced: ▪ Compost amended vegetated filter strips in airfield. ▪ SDN2/3/4-POND (Pond M) for flow control. ▪ Sedimentation management for water quality.	Increase Enhanced treatment capacity: ▪ Expand SDN2/3/4 Pond detention volume by up to 4.7 acre-feet. ▪ Pursue opportunities for infiltration at SR518 Pond. ▪ Integrate on-site LID techniques where practicable.	R3, SM
	Receiving water total	***115.9***	***44.6***	***0.4***	***44.2***			
Walker Creek	SDW2/SDW2A	44.4	10.8	0.0	10.8	Basic/Enhanced: ▪ Compost amended vegetated filter strips. ▪ SDW2-POND (Pond F) for flow control. Sedimentation management for water quality.	Increase Enhanced treatment capacity, add Oil treatment: ▪ Detention Pond F displaced by NTP S07. Relocate or convert to an underground vault with total storage capacity of 14.3 acre-feet (existing plus 2.4 acre-feet of additional storage). ▪ Expand SDW2 Pond detention volume and relocate basin to accommodate development. ▪ Integrate on-site LID techniques where practicable. ▪ Pursue opportunities for shallow / deep infiltration to offset storage requirements if practicable. ▪ Provide additional treatment including oil/water separator. ▪ Pursue opportunities for infiltration.	R3, SM
	Receiving water totals	**44.4**	**10.8**	**0.0**	**10.8**			
Puget Sound and/or Sanitary Sewer	IWS Combined	372.4	339.1	16.1	323.0	IWTP treatment (oil/basic): ▪ Oil/water separators. ▪ 6 dissolved air flotation units (DAFs) ▪ Settling Lagoons 1, 2, and 3	Increase on-site IWTP treatment and storage capacity: ▪ Convert SDS vaults SDS3 and SDS3A to IWS vaults. ▪ Construct 5.68 miles of new IWS pipe for vault discharge to IWS.	SS, SM
	Receiving water totals	***372.4***	***339.1***	***16.1***	***323.0***			

Table 5. Structural treatment level definitions

Structural Treatment Level	Treatment Objectives
Oil	▪ No ongoing or recurring visible sheen. ▪ Daily average total petroleum hydrocarbon concentration no greater than 10 milligrams per liter (mg/L) with a maximum of 15 mg/L for discrete (grab) samples.
Basic	▪ 80 percent removal of total suspended solids for an influent concentration range of 100 mg/L to 200 mg/L.[1] ▪ For influent concentration less than 100 mg/L the effluent goal is 20 mg/L total suspended solids.[1]
Enhanced	Meet Basic Treatment objectives, and provide: ▪ 30 percent removal of dissolved copper for influent concentration range of 0.005 mg/L to 0.02 mg/L[1] ▪ 60 percent removal of dissolved zinc for influent concentration range of 0.02 mg/L to 0.30 mg/L[1]
Phosphorous	▪ Meet Basic Treatment objectives and provide 50 percent total phosphorus removal for an influent concentration range of 0.1 to 0.5 mg/L.[1]

[1] Samples with influent concentrations that are greater than the range may be included by artificially setting the value at the upper end of the concentration range prior to completing the pollutant removal efficiency calculations. If the applicant opts to include samples with concentrations that are greater than the influent concentration range, they must include all valid samples that are greater than the range.

Table 6. Proposed stormwater and wastewater PSPs

Project Type	PSP	Permanent Footprint (acres)	Temporary Construction Footprint (acres)	Impervious Surface in Construction Footprint (acres)[1, 2]
SDS lines	Construct 5.93 miles of new SDS lines	n/a (buried)	14.4	9.7
IWS lines	Construct 5.68 miles of new IWS lines	n/a (buried)	13.7	8.8
Expand existing detention ponds	Expand SDS4 Pond by 0.1 acre	0.13	0.63	0.1
	Expand Pond M by 0.7 acre	0.76	1.87	0.8
Construct new detention ponds	Miller Creek pond	1.13	1.27	0.3
	Pond F relocation	1.69	2.56	0.9
	Walker Creek pond	0.49	1.18	1.4

[1] SDS and IWS lines are buried construction. A portion of line length routed under existing impervious surfaces (e.g., access roads). All affected surfaces are PGIS as detailed in Table 2. Remaining length would require clearing and excavation of managed fields and existing vegetation. All excavated surfaces would be restored to prior condition on completion of construction and would result in no net change in impervious and PGIS acreage.

[2] Detention pond construction activities would impact impervious surfaces around pond perimeters. The affected acreage is all NPGIS.

2.6 Project Construction

The Proposed Action would be constructed in stages beginning in 2025 and continuing through 2032[4]. The project designs for each NTP and associated PSPs are still in development and project-specific details are not yet available. Each project would be constructed using typical methods and equipment employed in large facility and infrastructure development. The specific types of construction equipment, number of equipment units, and construction scheduling would be determined during the project design process and may be modified to comply with relevant permit requirements.

2.6.1 Construction Equipment

Anticipated equipment types are shown in Table 7. Not all the equipment types shown would be used on every NTP project. For example, the hardstand and blast pad projects would not require cranes or power tools but would likely require excavators, graders, ground compactors, concrete mixers, and haul trucks. In contrast, new terminal development would require a broad range of construction equipment at various stages of construction.

Table 7. Anticipated construction equipment types

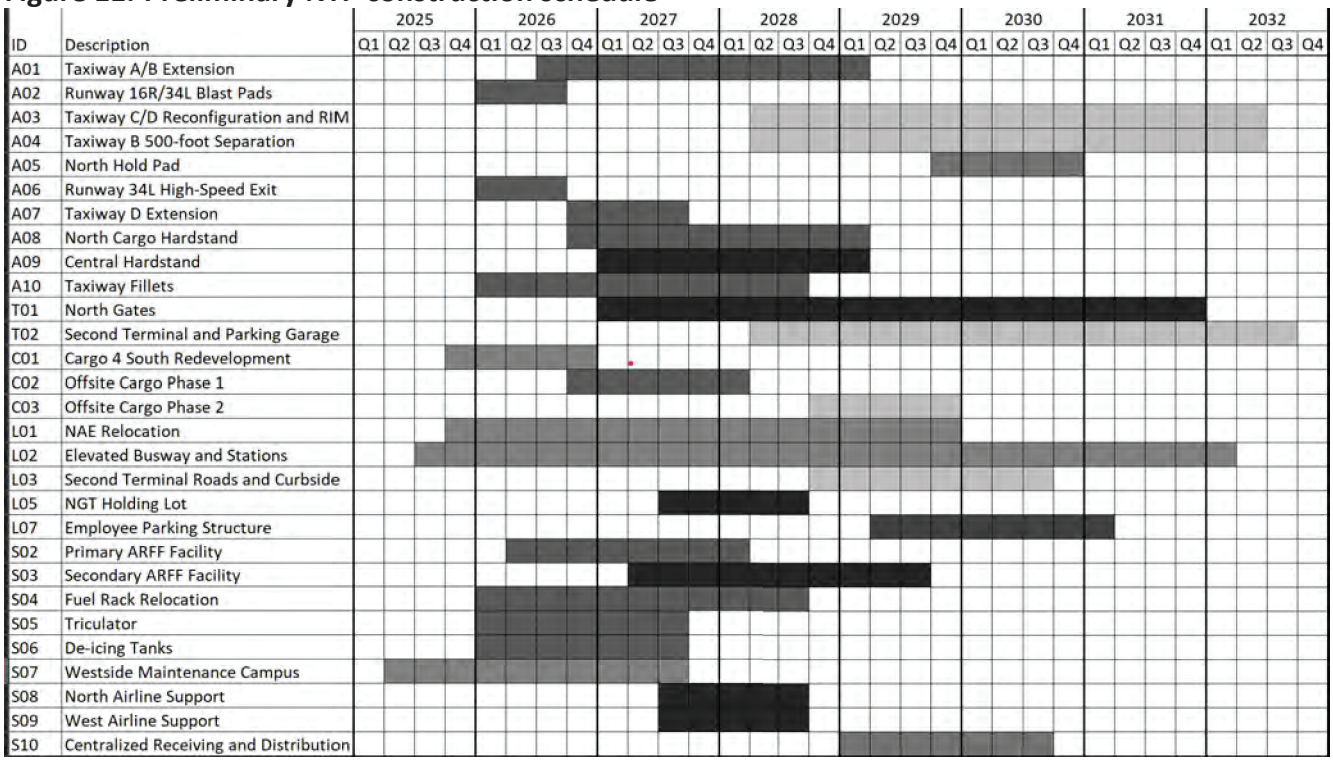
Equipment Category	Equipment Type		
General	Asphalt Truck	Flat Bed Truck	Street Sweeper
	Water Tanker Truck		
Heavy	Auger Drill Rig	Drill Rig Truck	Mounted Impact Hammer (hoe ram)
	Backhoe	Drum Mixer	Rock Drill
	Clam Shovel (dropping)	Dump Truck	Roller
	Compactor (ground)	Excavator	Slurry Plant
	Compressor (air)	Forklift	Slurry Trenching Machine
	Concrete Mixer Truck	Front End Loader	Vacuum Excavator (Vac-Truck)
	Concrete Pump Truck	Grader	Vibrating Hopper
	Crane	Horizontal Boring Hydraulic Jack	Vibratory Pile Driver
	Dozer	Impact Pile Driver	Woodchipper
Light	Boring Jack Power Unit	Jackhammer	Vacuum Street Sweeper
	Generator	Man Lift	Vibratory Concrete Mixer
	Grapple (on backhoe)	Sand Blasting	
Paving	Concrete Saw	Paver	Pavement Scarifier
Misc.	Hot Tar Kettle Trailer	Refrigerator Unit	Ventilation Fan
	Pumps	Scraper	Warning Horn
Power/Hand Tools	Chain Saw	Hammer Drill	Rivet Buster/Chipping Gun
	Grinder	Pneumatic Tools	Welder/Torch

4 Construction will begin once all environmental processes have been completed, all permits are acquired, and the project is ready to move forward.

2.6.2 Preliminary Project Schedule

The preliminary construction schedule for the NTPs and associated PSPs is provided in Figure 11. As shown, NTP construction would commence in 2025[5] and would continue through 2032. The 29 planned NTP projects would be staggered, with four projects commencing construction in 2025, 11 in 2026, six in 2027, five in 2028, and three in 2029. The anticipated duration of construction varies depending on the complexity of the project, ranging from less than one year to over 6 years.

Figure 11. Preliminary NTP construction schedule



2.7 Wetland Mitigation

The Port selected the proposed sites for project development to avoid and minimize impacts to wetlands, streams, and buffers to the extent practicable. The Port will continue to explore opportunities to further reduce impacts during design; however, based on the proposed NTP footprints, some impacts to wetlands, streams, and associated buffers are likely to occur. The anticipated permanent impacts, which are described in Section 5.1.2, are used to estimate mitigation requirements. These impact estimates represent a worst-case scenario based on currently available information. The Port would fully restore all sites temporarily impacted by project construction.

5 Construction will begin once all environmental processes have been completed, all permits are acquired, and the project is ready to move forward.

2.7.1 Anticipated Wetland Mitigation Requirements

The Port anticipates that the Proposed Action could result in up to 0.58 acre of permanent impacts to delineated Category II and III wetlands. Up to 0.55 acre of this total may be avoided if a stormwater vault is constructed in lieu of the proposed Miller Creek detention pond.

Compensatory mitigation requirements are dictated by federal, state, and local guidance. Table 8 identifies the compensatory mitigation ratios for Category II and III wetlands recommended by an interagency review committee representing the U.S. Army Corps of Engineers (USACE) Seattle District, U.S. Environmental Protection Agency (USEPA) Region 10, and Ecology (Ecology et al. 2021).

Table 8. Recommended compensatory wetland impact mitigation ratios by mitigation type.

Wetland Category[1]	Buffer Mitigation	Wetland Mitigation Ratio[2]		
		Creation or Reestablishment	Rehabilitation	Enhancement
Category II	1:1	3:1	6:1	12:1
Category III	1:1	2:1	4:1	8:1

[1] Hruby and Yahnke (2023).

[2] Ecology, USACE Seattle District, and USEPA Region 10 (2021).

Parametrix (2024a) characterized projected impacts to wetlands and wetland buffers resulting from the NTPs and associated PSPs (Appendix C). Projected mitigation requirements for the anticipated acres of impacts from the Proposed Action on Category II and III wetlands are provided in Table 9.

The Proposed Action would include 2.65 acres of mitigation for wetland buffer impacts and at least 1.17 acres and potentially up to 4.68 acres of compensatory mitigation for wetland impacts, depending on the type of mitigation provided. In addition, improvements to an existing culvert crossing on Miller Creek as part of S07 would result in impacts to streams (0.02 acre) and stream buffers (0.13 acre).

Table 9. Anticipated compensatory wetland mitigation acreage requirements.

Project Element	Wetland Category	Impacts Resulting from Proposed Action (acres)		Compensatory Wetland Mitigation Requirement by Type (acres)			
		Wetland	Buffer	Re-establishment	Rehabilitation	Enhancement	Buffer
NTPs	III	0.02	2.30	0.04	0.08	0.16	2.30
PSP – UMP sanitary sewer line	III	0.00	0.01	0.00	0.00	0.00	0.01
PSP – Stormwater conveyance	II	0.01	0.23	0.03	0.06	0.12	0.23
PSP – Stormwater ponds	III	0.55	0.11	1.10	2.75	4.40	0.11
Total Areas		**0.58**	**2.65**	**1.17**	**2.89**	**4.68**	**2.65**

Source: Parametrix (2024a).

2.7.2 Mitigation Plan and Sequencing

The Port would develop a compensatory mitigation plan for unavoidable permanent impacts to wetlands, streams and associated buffers, and temporary impacts to wetlands lasting more than one year during the permitting phase for each project in accordance with applicable state and federal guidance (Ecology et al. 2006, 2021). The mitigation plan would be developed following a mitigation sequencing approach based on a hierarchy of avoiding and minimizing impacts during design, rectifying temporary impacts, and compensating for unavoidable impacts.

The Port has seven sites within its ownership identified as being suitable for compensatory wetland mitigation (Anchor QEA 2019). Six sites are on SEA property and one site is located along the Green River in Auburn. They encompass over 150 acres and include potential for greater than 40 acres of wetland re-establishment, 11 acres of wetland enhancement, almost eight acres of preservation, and 80 acres of buffer enhancement (Anchor QEA 2019). The Port anticipates that these sites have sufficient capacity to accommodate the mitigation requirements for the Proposed Action. However, other mechanisms, such as purchasing mitigation credits from banks or in-lieu fee programs, or a combination of these mechanisms may be used to meet mitigation requirements.

If practicable, all permanent stream and stream buffer impacts would be mitigated by fully restoring the affected habitat functions on site or in proximity to the impacts. Should this approach prove infeasible, SEA is within the service area of several existing mitigation banks and in-lieu fee programs with available mitigation credits sufficient to offset the projected impacts.

To the extent possible, the Port would emphasize in-kind mitigation within the same watershed where the impacts occurred. However, out of watershed mitigation (e.g., at the Green River site) may be considered should state and federal resource agencies determine this would produce the most desirable ecological outcomes. Regardless of mechanism, the Port will commit to providing sufficient mitigation to comply with local, state, and federal requirements at the highest replacement ratios.

2.8 Best Management Practices

The Port would comply with standard specifications, BMPs, and applicable federal and state regulatory requirements during design, construction, and operation of the Proposed Action. BMPs that are designed to protect water and sediment quality with vegetation are expected to be most effective at reducing adverse effects from stormwater discharges over short and long terms.

2.8.1 Construction Best Management Practices

The SEA SWPPP (Port 2021e, or current version) defines compliance requirements and expectations for all construction activities that occur on Port property. This plan is periodically updated to reflect current state and federal guidance and regulatory requirements for avoiding and minimizing impacts to the environment. It comprises the following 13 programmatic elements:

1. Preserving Vegetation and Marking Clearing Limits: Maintain natural vegetation to the extent practicable and clearly mark construction limits to minimize land-disturbing impacts.
2. Establishing Construction Access: Minimize construction activity in unpaved areas, establish stabilize access points, and use vacuum sweeping and wheel washing to limit sediment track out.

3. Control Flow Rates: Stormwater management measures to minimize discharge and runoff from construction sites.
4. Sediment Controls: Filter all stormwater runoff through appropriate sediment removal BMPs and test to verify compliance with turbidity and pH limits before discharge from the site.
5. Soil Stabilization: Stabilize exposed and unworked soil with application of effective BMPs to prevent erosion throughout the life of the project.
6. Slope Protection: Design, construction, and protection of cut and fill slopes to minimize erosion.
7. Drain Inlet Protection: Protect storm drain inlets/culverts using temporary plugs, phasing, and/or inlet protection to prevent untreated water from entering drainage conveyance system.
8. Channel and Outlet Stabilization: Design, construction, and protection of temporary onsite conveyance channels to prevent erosion from the expected peak 10-minute velocity of flow from a 10-year, 24-hour recurrence-interval storm.
9. Pollutant Control: All pollutants, including waste and demolition debris, generated onsite will be handled and disposed of in a manner that does not cause contamination of stormwater.
10. Dewatering Control: Discharge dewatering water from open-cut excavation, tunneling, foundation work, trenches, or underground vaults into a controlled conveyance system prior to discharge to a sediment trap or sediment pond.
11. Construction BMP Maintenance: Inspection, maintenance, and repair of temporary and permanent erosion and sediment control BMPs as needed to ensure continued performance in accordance with intended functions. Visual monitoring of the BMPs should be conducted daily and within 24 hours of any stormwater or non-stormwater discharge from the site.
12. Project Management: Scheduling, phasing, inspecting, maintaining, and managing construction projects to avoid/minimize stormwater impacts. Includes seasonal phasing of ground-disturbance.
13. Protect Low-Impact Development (LID) BMPs: All LID BMPs on and downstream of Port property will be protected by appropriate erosion and sediment control BMPs.

The Port requires every construction project on SEA property to develop a site-specific construction SWPPP that details the methods and procedures used to comply with the programmatic elements listed above, and the Port's standard operating procedures for construction water quality monitoring (Port 2016a). The Port would require each contractor to develop Construction SWPPPs for their respective projects. The typical Construction SWPPP comprises:

- Stormwater BMP implementation and site-specific performance monitoring plan, (required for all sites larger than 1 acre)
- Pollution Prevention Plan (PPP): site-specific hazardous materials management plan
  - Site specific description and drawings
  - Contractor pollution prevention contact personnel
  - Known or potential hazardous materials inventory list
  - Safety data sheets all inventoried hazardous materials
  - Container labeling system
  - Container storage and handling procedures
  - Spill prevention, control, and response procedures

  - Hazardous material cleanup and disposal procedures
  - Reporting procedures
  - Signed acknowledgement of PPP requirements by all subcontractors
- Contractor Erosion and Sediment Control Plan (site-specific)
  - Site description and drawings
  - Contractor-designated erosion and sediment control personnel
  - Construction schedule and sequencing
  - BMP installation, maintenance, and inspection procedures
  - Record keeping requirements
  - BMP removal procedures
  - Emergency response plan
  - Construction dewatering plan
  - Fugitive dust management plan
  - Utility plan
  - Contractor education procedures
- Contract plans and specifications

2.8.2 Operational Source Control Best Management Practices

The Port would continue to implement the 16 OSC BMPs detailed in the SEA SWPPP (Port 2022b) to avoid and minimize adverse impacts to ESA-listed species. These BMPs, outlined in Table 10, would be adapted as needed to address ongoing and new operational activities resulting from the Proposed Action. OSC BMP 1.0 defines a set of 39 management measures grouped into 8 categories. These categorical measures apply to all potential pollutant generating operations that occur on Port property. The remaining 15 OSC BMPs specify the additional categorical measures used to avoid and minimize stormwater impacts from specific operations and maintenance activities.

Table 10. OSC BMP summary

OSC BMP	Purpose	Targeted Pollutant(s)	Measures
1.0 – General Industrial Activities	Established general compliance measures for preventing and reducing discharge of pollutants to the SDS and IWS. This BMP comprises 39 compliance measures that are applicable to all Port and tenant operations with potential to impact stormwater.	All potential pollutants used or generated on Port property.	39 general measures in 8 categories: ▪ *Pollution prevention team:* Establishes responsibilities, points of contact, and communication protocols. ▪ *Good housekeeping practices*: Establish standard practices for pollutant prevention, interception, and IWS and SDS maintenance of treatment systems to limit pollutant releases. ▪ *Minimizing exposure of pollutants to stormwater*: Limits industrial activities and hazardous materials handling to IWS drainage basins. ▪ *Preventative maintenance*: Routine maintenance of SDS and IWS to ensure that system is functioning at maximum pollutant control capacity and efficacy. ▪ *Spill prevention and response planning*: Spill prevention and response planning and compliance procedures. ▪ *Facility inspections*: Routine inspection of Port facilities and Port and tenant activities to ensure proper function and compliance with BMPs. ▪ *Employee/tenant/contractor training*: Training to ensure familiarity and compliance with Port environmental policies and procedures, including BMP implementation. ▪ *Recordkeeping and reporting*: Establishes procedures for compliance with NPDES Permit reporting requirements.
2.0 – Aircraft, Vehicle, and Equipment Maintenance	Preventing and reducing releases of pollutants associated with aircraft, vehicle, and equipment maintenance activities.	▪ Fuel, oil, grease ▪ Solvents/ cleaning solutions ▪ Battery acid ▪ Paint ▪ Anti-freeze ▪ Other vehicle fluids	13 activity-specific pollution control measures in the *good housekeeping practices, minimize exposure of pollutants to stormwater, preventative maintenance, spill prevention and response,* and *routine facility inspections* categories.
3.0 – Aircraft, Vehicle, and Equipment Cleaning	Prevent and reduce releases of pollutants associated with aircraft, vehicle, and equipment washing, and cleaning and degreasing actions.	▪ Oil and grease ▪ Solvents ▪ Vehicle fluids ▪ Cleaning solutions	Nine activity-specific pollution control measures in the *good housekeeping practices, minimize exposure of pollutants to stormwater, preventative maintenance, routine facility inspections,* and *recordkeeping and reporting* categories.
4.0 – Aircraft, Vehicle, and Equipment Storage	Prevent fuel spills/leaks, prevent contact with petroleum products and metals, and reduce their impacts to stormwater.	▪ Oil and grease ▪ Fuel ▪ Vehicle fluids ▪ Metals	Five activity-specific pollution control measures in the g*ood housekeeping practices* and *minimize exposure of pollutants to stormwater* categories.
5.0 – Outdoor Handling, Storage, and Disposal of Wastes and Materials	Prevent or reduce the discharge of pollutants to stormwater from outdoor handling, storage, and disposal of materials and waste.	All potential pollutants used or generated on Port property	24 activity-specific pollution control measures in *good housekeeping, minimize exposure of pollutants to stormwater, preventative maintenance, spill prevention and response, routine facility inspections, employee/contractor training,* and *recordkeeping and reporting* categories. Management of stormwater runoff measures to protect waste material storage areas from stormwater accumulation and runoff (e.g., prioritizing indoor storage, coverage for outdoor storage areas, secondary containment, etc.).

OSC BMP	Purpose	Targeted Pollutant(s)	Measures
6.0 – Fuel Storage and Delivery	Prevent fuel spills and leaks and reduce their impacts to stormwater.	Fuel and petroleum products	21 activity-specific pollution control measures in the *good housekeeping, minimize exposure of pollutants to stormwater, preventative maintenance, spill prevention and response, routine facility inspections, employee/contractor training, and recordkeeping* and *reporting* categories.
7.0 – Building and Grounds Maintenance	Prevent or reduce discharge of pollutants through best practices for building/grounds maintenance, keeping debris from entering storm drains, and routine maintenance of stormwater system.	▪ Pesticides/herbicides /fertilizers ▪ Oil and grease ▪ Zinc ▪ Landscape waste ▪ Washdown waste ▪ Sediment ▪ Particulate matter (paint chips, roofing aggregate, tire dust)	24 activity-specific pollution control measures in the *good housekeeping, minimize exposure of pollutants to stormwater, preventative maintenance, spill prevention and response, routine facility inspections,* and *employee/contractor training* categories. These measures include: ▪ Dry sweeping of aircraft and vehicle operations surfaces. ▪ Runway rubber removal. ▪ Routine maintenance and cleaning of catch basins, vaults, and separators to remove accumulated particulates, including rubber particles.
8.0 – Vehicle and Equipment Painting	Prevent the discharge of pollutants to stormwater from vehicle and equipment painting.	▪ Paint ▪ Metals ▪ Solvents	14 activity-specific pollution control measures in *good housekeeping, minimize exposure of pollutants to stormwater, preventative maintenance, spill prevention and response, management of stormwater runoff,* and *employee/contractor training* categories.
9.0 – Garbage Handling and Disposal	Prevent or reduce discharge of pollutants to stormwater from garbage/municipal solid waste handling/disposal by preventing runoff from trash compactors and dumpsters.	▪ Dumpster waste ▪ Compactor fluids ▪ Trash ▪ Nutrient pollution contributing to biological oxygen demand (BOD)	Nine activity-specific pollution control measures in the *good housekeeping, minimize exposure of pollutants to stormwater, preventative maintenance, routine facility inspections, management of stormwater runoff,* and *employee/contractor training* categories.
10.0 – Aircraft De-icing and Anti-icing	Prevent discharge of pollutants to stormwater from aircraft de-icing and anti-icing procedures.	▪ Ethylene glycol ▪ Propylene glycol ▪ BOD	10 activity-specific pollution control measures in *good housekeeping, minimize exposure of pollutants to stormwater, preventative maintenance, spill prevention and response,* and *routine facility inspections* categories.
11.0 – Aircraft Lavatory Waste Servicing	Prevent the discharge of pollutants to stormwater from aircraft de-icing and anti-icing procedures.	▪ Lavatory chemicals ▪ Lavatory waste ▪ Lavatory truck wash water	10 activity-specific pollution control measures in *good housekeeping, minimize exposure of pollutants to stormwater, preventative maintenance, spill prevention and response, routine facility inspections,* and *management of stormwater runoff* categories.
12.0 – Potable Water System Flushing	Prevent discharges to the storm drain system associated with flushing of aircraft and vehicle potable water systems.	▪ Purine ▪ Chlorine bleach	Two activity-specific pollution control measures in the minimize exposure of pollutants to stormwater category.
13.0 – Roadway, Ramp, and Runway Maintenance and Cleaning	Prevent or reduce the discharge of pollutants to stormwater from maintenance activities, and through routine cleaning of roads, ramps, and runways.	▪ Oil and grease ▪ Fuel ▪ De-icing/anti-icing ▪ Chemicals ▪ Sediments ▪ Foreign object debris ▪ Tire particles ▪ Solvents/cleaning solutions	10 activity-specific pollution control measures in *good housekeeping, minimize exposure of pollutants to stormwater, preventative maintenance, routine facility inspections,* and *management of stormwater runoff* categories.

OSC BMP	Purpose	Targeted Pollutant(s)	Measures
14.0 – Fire Suppression and Aqueous Film Forming Foam Discharge	Prevent discharges to the storm drain system associated with flushing or testing of firefighting foam systems.	Aqueous film-forming foam	Five activity-specific pollution control measures in *good housekeeping, minimize exposure of pollutants to stormwater, preventative maintenance,* and *routine facility inspections* categories.
15.0 – Animal Handling	Prevent discharges to the storm drain system associated with animal handling and cargo.	Fecal coliform	Five activity-specific pollution control measures in *good housekeeping* and *minimize exposure of pollutants to stormwater* categories.
16.0 – Spill Response and Clean-Up	Identify and establish roles and responsibilities for all spills at SEA.	▪ Fuels ▪ Biffy spills ▪ Hydraulic fluids ▪ Oil and grease ▪ Glycols ▪ De-icing/anti-icing chemicals	Establishes standard spill response practices and notification procedures for spills by pollutant category.

Table 4 (Section 2.4.2) identifies 3 OSC activities that are relevant for avoiding and minimizing impacts to ESA-listed species from stormwater contaminants: runway rubber removal, impervious surface sweeping, and detention basin, vault, and separator maintenance. These specific activities, associated OSC BMPs, and typical frequency are described in Table 11.

Table 11. OSC BMP activities to avoid/minimize risks to aquatic habitat from 6PPD-Q and metals.

OSC Activity (code)	Associated OSC BMPs	BMP Activities and Frequency
Runway rubber removal (R3)	1.0, 13.0	▪ Regular testing of runways for rubber accumulation. ▪ Rubber removals are scheduled based on observed accumulation levels. ▪ Typical removal frequencies are every 6 weeks for runway 16R/34L, twice a year on 16C/34C, and four times/year for 16L/34R.
Surface sweeping (SS)	1.0, 7.0, 13.0	▪ Dry sweeping of roads, ramps, and runways to prevent or reduce the discharge of pollutants to stormwater from maintenance and cleaning of PGIS. ▪ Sweeping occurs daily on both landside and airside pavements.
Detention basin, vault, and separator maintenance (SM)	1.0, 7.0	▪ Regular cleaning and maintenance of manhole sumps and oil/water separators. ▪ Regularly clean any catch basins which receive runoff from a maintenance area. Install and maintain catch basin filter inserts in areas prone to high volumes of debris. ▪ Regularly inspect and maintain stormwater control devices. ▪ Remove accumulated sediment from targeted ponds and vaults annually in the summer, prior to fall rains (i.e., first flush).

2.9 Additional Conservation Measures

The Port's Aviation Environmental staff have been proactively reviewing available research and guidance on stormwater management of 6PPD-Q since the University of Washington published their findings on this emerging contaminant in late 2020. The Port is voluntarily conducting research on the fate and transport of 6PPD-Q at SEA, and the effectiveness of available treatment methods.

- Ongoing participation in Ecology's Stormwater Working Group and 6PPD-Q subgroup.
- Funding an independent stormwater media treatment study (Treatability Testing) to determine if available technologies can effectively remove 6PPD-Q from SEA stormwater discharge. Four commercially available filter media are being evaluated individually and in combination with Chitosan Enhanced Sand Filtration (CESF):
  - Chitosan Enhanced Sand Filtration (CESF) - Combines chitosan (shells from crustaceans) with sand filtration to remove pollutants from water.
  - Virgin Coconut Carbon (VCC) - Adsorption media effective at removing most compounds found in both stormwater and process water.
  - Hydrosil HS-250 (HS250) - A 50/50 mix of a pure zeolite based organoclay and 6 x 30 tyler mesh anthracite coal that is effective at removing oil, heavy metals, and organics from water.
  - SCU-Evoqua (SCU) - An Ion exchange media effective at removing trace metals from water.
  - Biochar-Black Owl Stormwater Mix (Biochar) - A biochar-based media effective at removing COD, TSS, metals, and Mercury from stormwater.

The Treatability Testing study is an incredibly proactive approach. The Port is searching for solutions years before regulations are in place. The results of this study will be useful in finding BMPs other than 100% infiltration that are effective at removing 6PPD-Q from stormwater given the limited availability of 100% infiltration. The first year of testing was largely successful with removal rates up to 99.9%. The results demonstrate that the Port would be able to meet proposed state limits. The Port is prepared to share the findings of this study with NMFS and Ecology's Stormwater Working Group when the results are available. The Port is hopeful that this effort will contribute to regional efforts to reduce the adverse effects of 6PPD-Q on the aquatic environment.

3.0 ACTION AREA

The action area for this ESA analysis is defined as "all areas to be affected directly or indirectly by the Proposed Action and not merely the immediate area directly adjacent to the action" (50 CFR 402.02). The action area includes all surrounding areas where project activities could potentially affect the environment. The action area encompasses all areas exposed to direct and indirect effects, as well as any effects of interrelated or interdependent actions.

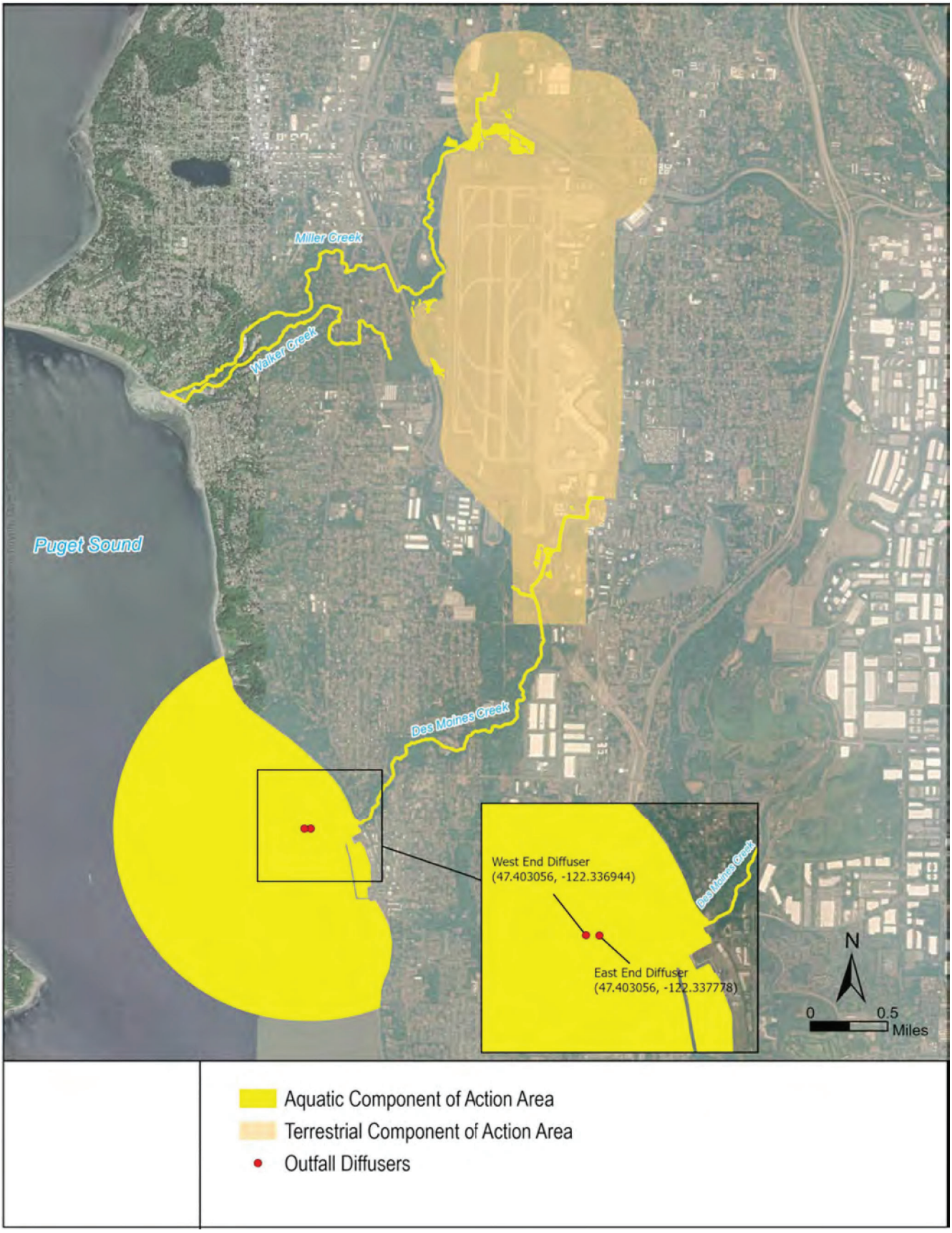
The Proposed Action would result in temporary and permanent modification to existing developed and undeveloped surfaces on Port property. The Proposed Action would retrofit existing and create new impervious surfaces. In addition, project construction would result in temporary and permanent impacts to wetlands, streams, and buffer habitats.

The action area comprises discrete terrestrial and aquatic components, which are summarized in Table 12 and displayed in Figure 12. As described in Section 3.1, the terrestrial component of the action area comprises all habitats directly within the construction footprint of the NTPs, PSPs, and mitigation, areas exposed to construction noise and activity levels that exceed baseline conditions, and project operations. The aquatic component of the action area is described in Section 3.2 and comprises all aquatic habitats exposed to temporary and permanent construction impacts and anticipated operational stormwater and industrial treated wastewater discharges from the NTPs.

Table 12. Action area dimensions

Action Area Component	Location(s)	Impact Producing Activity	Dimensions
Terrestrial	Locations where construction or operations would occur, including wetland buffers and areas exposed to construction noise above ambient levels.	▪ NTP and PSP construction ▪ NTP operations ▪ Wetland mitigation	2,554 acres
Aquatic	Wetlands on SEA property	▪ NTP and PSP construction ▪ Operational stormwater	43.9 acres
	Miller Creek	NTP construction	0.02 acre (stream) 0.12 acre (stream buffer)
		Operational stormwater	4.76 miles
	Walker Creek	Operational stormwater	2.42 miles
	Des Moines Creek	Operational stormwater	3.66 miles
	Puget Sound	Industrial wastewater	1,833 acres
		Operational stormwater	~2 acres

Figure 12. Action area



3.1 Terrestrial Component

The terrestrial component of the action area is defined by the physical extent of measurable effects (both temporary and permanent) resulting from the construction and operation of the Proposed Action. The Proposed Action comprises a range of activities, including the construction and operation of the NTPs and PSPs, habitat mitigation, and the ongoing implementation of operational BMPs. These activities will occur at multiple locations throughout SEA. Therefore, the terrestrial component of the action area is defined by the SEA property boundary.

3.2 Aquatic Component

The aquatic component of the action area includes construction activities proposed within wetland and stream aquatic habitats, areas potentially exposed to treated stormwater pollutants, and the dilution zones around treated stormwater outfalls that serve the Proposed Action. Construction activities would not cause elevated underwater noise levels outside of the temporary impact from project construction anticipated for aquatic habitats.

The Proposed Action would generate stormwater and industrial wastewater that would discharge through new and existing infrastructure after treatment to Miller Creek, Walker Creek, Des Moines Creek, and the Puget Sound. The Proposed Action includes structural SDS and IWS improvements and OSC BMPs to service the new, replaced, and retrofitted PGIS.

Miller Creek and Des Moines Creek flow into Puget Sound, and Walker Creek flows into Miller Creek near its confluence with Puget Sound. As detailed in Section 4.2, the action area includes several wetlands in the headwaters of these tributaries that would receive treated stormwater discharge. SEA's IWTP discharges treated industrial wastewater to Puget Sound from an NPDES-permitted offshore outfall with 2 diffusers located at a mean lower low water (MLLW) depth of 148 feet.

The action area also includes theoretical contaminant exposure zones around the NPDES-permitted outfall for the SEA IWTP, located approximately 1,600 feet offshore of the mouth of Des Moines Creek. Per direction from NMFS, this exposure zone extends up to 6,560 feet (2 kilometers [km]) from each diffuser and extends from the seabed to the top of the water surface. The combined extent of these mixing zones is approximately 1,833 acres, providing a conservative surrogate for potential operational stormwater-related effects in the absence of stormwater pollutant data and a quantitative method to determine the spatial extent of effects.

4.0 ENVIRONMENTAL SETTING/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.

4.1 Terrestrial Habitat

SEA property is a fully developed international airport facility where terrestrial habitats have been substantially altered from historical conditions. Land cover primarily comprises developed airport facilities, fragmented open space including managed fields adjacent to runways and taxiways, open fields and shrublands, forested areas, stormwater ponds, wetlands, and wetland and riparian buffers. These habitats are managed for tree height and wildlife control to maintain aircraft safety. Many vegetated habitats around the outer edge of SEA were previously developed for residential uses. These properties were subsequently purchased, cleared for airport noise mitigation, and have revegetated over time. None of these open spaces provide suitable habitat for ESA-listed species.

4.2 Aquatic Habitat

The aquatic component of the action area comprises a 4.76-mile segment of Miller Creek extending from the upstream limit of measurable construction effects and stormwater discharge to the confluence with Puget Sound; 2.42 miles of Walker Creek from headwaters to the confluence with Puget Sound; 3.66 miles of Des Moines Creek and tributaries from the upstream limit of measurable construction and stormwater effects to the confluence with Puget Sound; nearshore and marine areas of Puget Sound in proximity to action area tributary confluences and within a 1.2-mile (2-km) radius of the IWTP outfall; and all wetlands impacted by construction and receiving stormwater runoff from the Proposed Action. All marine, estuarine, and freshwater aquatic habitats within the action area are listed as 303(d) impaired waters due to exceedances of a variety of parameters (Table 14).

Parametrix (2024b) prepared an aquatic critical areas impact assessment memorandum for the Proposed Action based on wetland, pond, and stream delineations completed in 2019 and 2020 and field verified in 2024. The report identified 31 wetlands covering approximately 74.5 acres (Table 13).

Table 13. Wetlands in action area

Wetland	Area (acres)	USFWS Classification	Hydrogeomorphic Classification	Ecology Rating	Habitat Rating	Buffer Width (feet)
N3	18.97	PFO/PSS/PEM	Depressional	I	7	165
N4	1.22	PFO/PSS	Slope	IV	4	40
1	0.11	PSS	Slope	IV	3	40
2	0.84	PFO/PSS/PEM	Slope	III	5	105
A	0.11	PSS/PEM	Slope	III	4	60
4	4.71	PFO	Depressional	II	6	165
5	5.27	PFO	Depressional	II	6	165
6	0.91	PFO	Depressional	II	6	165
7	6.75	PFO	Depressional	II	6	165
8	4.57	PFO/PSS/PEM	Depressional	I	7	165
9	3.10	PFO/PSS/PEM	Depressional	II	6	165
10	0.41	PFO/PSS/PEM	Depressional	III	6	165
11	0.01	PFO	Depressional	III	4	60
39	2.60	PFO/PSS	Slope	III	6	165
R15	2.21	PFO	Depressional	II	6	165
A20	0.55	PFO/PSS/PEM	Depressional	III	5	105
A14a	0.21	PFO/PSS/PEM	Slope	III	6	165
A14b	0.12	PFO/PEM	Slope	III	6	165
44	3.12	PFO	Depressional	II	6	165
E1	0.21	PFO	Slope	III	4	60
52A	1.72	PFO	Slope	II	6	165
DMC1	<0.01	PSS/PEM	Slope	III	5	105
DMC2	0.05	PSS/PEM	Slope	III	5	105
52B	1.01	PFO/PSS	Slope	III	6	165
52C	0.82	PFO/PEM	Riverine	II	6	165
G12	2.41	PFO/PSS/PEM	Depressional/Slope	II	6	165
G1	<0.01	PFO/PSS	Slope	III	5	105
G4	0.01	PSS	Slope	III	5	105
G5	0.93	PSS/PEM	Slope	III	5	105
H	0.07	PSS/PEM	Slope	III	5	105
D	3.81	PFO/PSS	Riverine	II	6	165

PFO – Palustrine forested; PSS – Palustrine scrub-shrub; PEM – Palustrine emergent

4.2.2 Des Moines Creek

The southern portion of SEA drains into the Des Moines Creek Drainage Basin. The headwaters of Des Moines Creek are located on the south side of SEA. There is an East Branch to the creek near the headwater. Des Moines Creek and the East Branch of the creek are associated with ponds and wetland systems. SEA outfalls drain into Des Moines Creek, the East Branch, and wetland/pond systems. The creek flows south and southwest for about 3.6 miles through wetlands, forested parks, and various developments beneath roads with culverts before flowing into Puget Sound.

WDFW identifies Des Moines Creek as gradient-accessible to fall Chinook salmon and winter steelhead 0.9 miles downstream of SEA property, however, neither species has been documented in the system (WDFW 2024d). Chum salmon (*O. keta*) are documented in the lower 0.2 miles of the creek, and coho salmon (*O. kisutch*) presence is documented from the mouth to 0.2 miles downstream of SEA property (WDFW 2024d). Resident cutthroat trout (*O. clarkii*) presence is documented in the upstream reach of the creek and the East Branch (NWIFC 2024, WDFW 2024d, e).

4.2.3 Miller Creek

The north and western portions of SEA drain into the Miller Creek/Walker Creek Drainage Basin. The headwaters of Miller Creek are located on the north side of SEA and an East Branch to the creek is near the headwater. The Miller Creek main channel originates north of SEA, north of SR 518, and the East Branch flows through wetlands, ponds, and Lake Reba on the north side of SEA. SEA outfalls drain into Miller Creek and Lake Reba. The creek flows for about 4.7 miles through wetlands, forested parks, and various developments beneath roads with culverts before flowing into Puget Sound. Walker Creek flows into Miller Creek a short distance from the creek outlet to Puget Sound.

WDFW (2024d) identifies Miller Creek as potentially accessible to fall Chinook salmon and winter steelhead based on modeled suitable habitat up to an existing barrier culvert at 1st Avenue S, approximately 0.65 mile downstream of SEA property. However, neither species is currently documented (WDFW 2024d). Chum salmon, coho salmon, and resident cutthroat trout are documented as known or potentially occurring in Miller Creek. Documented coho salmon potential presence and resident cutthroat trout presence in the upper reach (NWIFC 2024, WDFW 2024d, e).

The Miller and Walker Creek Executive Committee (2006) state that Chinook salmon did not occur naturally in Miller Creek and are not currently present, but the species has been occasionally observed in the system as recently as 2000 due to a failed attempt to introduce Chinook salmon to the Miller Creek system in the 1980s and 1990s. Chinook salmon do not occur in any independent tributaries adjacent to or in proximity to Miller Creek, despite being equally accessible and providing similar habitat (WDFW 2024d. There are no recent records of Chinook salmon occurrence in Miller Creek and none of the documented observations are less than 20 years old. Therefore, it is reasonable to conclude that the Miller Creek system does not currently support Chinook and is unlikely to do so in the future.

4.2.4 Walker Creek

Walker Creek is within the Miller Creek/Walker Creek Drainage Basin on the north and western portions of SEA. SEA outfalls drain into Walker Creek and associated tributaries and ponds. The approximately 2.4-mile creek flows beneath SR 509 before flowing through wetlands, forested parks, residential areas, and

beneath roads with culverts before flowing into Miller Creek a short distance from the Miller Creek outlet to Puget Sound.

WDFW identifies Walker Creek as gradient-accessible to fall Chinook salmon and winter steelhead up to the South Normandy Road crossing at Airport Park, approximately 0.2 mile downstream of SEA property. However, neither species has been documented in this system. Chum salmon, coho salmon, and resident cutthroat trout are documented in the system (NWIFC 2024, WDFW 2024d, e). As described above for Miller Creek, it is reasonable to conclude that the Walker Creek system does not currently support ESA-listed Chinook and is unlikely to do so in the future.

4.2.5 Puget Sound

The aquatic component of the action area includes nearshore areas of Puget Sound at the mouths of Miller, Walter, and Des Moines creeks, and an offshore area within approximately 6,560 feet (2 km) of paired diffusers at the existing stormwater outfall for the IWS, located approximately 1,600 feet waterward of the mouth of Des Moines Creek at a depth of -148 feet relative to MLLW. The nearshore portions of the action area are located on broad subtidal flats composed of predominantly sand and gravel substrate. Patchy beds of eelgrass (*Zostera marina*) and various species of marine algae are present (Ecology 2023). Kelp beds are absent, likely due to a lack of large-grained substrate material suitable for holdfast anchoring. Virtually the entire shoreline adjacent to the action area has been armored to protect development (Ecology 2023). Sparse clam populations and a sparce array of polychaete species are present. Geoduck clams (*Panopea generosa*) may be present in deeper waters (Dethier 2010). Upper shore areas, as in mixed-fine habitats, tend to be composed of depauperate steep gravel-sand sediments. All ESA-listed species covered in this evaluation may be present within the Puget Sound portion of the action area periodically throughout the year.

4.3 Water Quality

Ecology is responsible for monitoring water quality standards throughout the state of Washington. Ecology's Water Quality Atlas identifies 303(d) listed waterbodies, which are those with impaired water or sediment quality. Marine, estuarine, and freshwater aquatic habitats within the action area are listed as 303(d) impaired waters due to exceedances of a variety of parameters under Categories 1, 2, 4a, and 5 waters (Ecology 2024). Table 14 summarizes the water quality parameters with identified exceedances within the action area per aquatic habitat, as reported by Ecology.

Table 14. Water quality parameters in the action area

Water Quality Parameter	Category	Puget Sound	Des Moines Creek	Miller Creek	Walker Creek
4, 4'-DDD/DDE/DDT	5	No	No	No	No
Alpha-BHC	5	No	No	No	No
Arsenic, Inorganic	5	No	No	No	No
Bacteria – Enterococci	5	Yes	No	No	No
Bacteria – Fecal coliform	5	Yes	Yes	Yes	Yes
Benzo(a)anthracene	5	No	No	No	No
Benzo(a)pyrene	5	No	No	No	No
Benzo(b)flouranthene	5	No	No	No	No
Benzo(k)flouranthene	5	No	No	No	No
Bis(2-ethylhexyl)phthalate	5	No	No	No	No
Chrysene	5	No	No	No	No
Copper	5	No	Yes	No	No
Dibenzo(a,h)anthracene	5	No	No	No	No
Indeno(1,2,3-c,d)pyrene	5	No	No	No	No
Dissolved oxygen	5	No	Yes	Yes	Yes
Mercury	5	No	No	No	No
PCBs*	5	No	No	No	No
pH	5	No	No	No	No
Temperature	5	No	Yes	Yes	Yes
Temperature	4A	No	No	No	No
Bacteria – Escherichia coli	2	No	No	No	No
Bacteria – Fecal coliform	2	Yes	No	No	No
Benzo(a)anthracene	2	Yes	No	No	No
Benzo(a)pyrene	2	Yes	No	No	No
Benzo(b)flouranthene	2	Yes	No	No	No
Bis(2-ethylhexyl)phthalate	2	No	No	No	No
Copper	2	No	No	Yes	No
Dissolved oxygen	2	No	No	No	No
Mercury	2	No	No	No	No
Polychlorinated biphenyls	2	Yes	No	No	No
pH	2	No	No	Yes	Yes
Phosphorus	2	No	Yes	No	No
1,2-Dichlorobenzene	1	No	No	No	No
1,3-Dichlorobenzene	1	No	No	No	No
1,4-Dichlorobenzene	1	No	No	No	No
3,3-Dichlorobenzidine	1	No	No	No	No
2,4-Dichlorophenol	1	No	No	No	No

Water Quality Parameter	Category	Puget Sound	Des Moines Creek	Miller Creek	Walker Creek
2,4-Dinitrophenol	1	No	No	No	No
2,4-Dinitrotoluene	1	No	No	No	No
1,2-Diphenylhydrazine	1	No	No	No	No
2,4,6-Trichlorophenol	1	No	No	No	No
Anthracene	1	No	No	No	No
Antimony	1	No	No	No	No
Arsenic	1	No	No	No	No
Ammonia-N	1	No	Yes	Yes	Yes
Bis(2-chloroethyl) ether	1	No	No	No	No
Bis(2-chloroisopropyl) ether	1	No	No	No	No
Chlordane	1	No	No	No	No
Chloride	1	No	No	No	No
Di-n-butyl phthalate	1	No	No	No	No
Diethyl phthalate	1	No	No	No	No
Dimethyl phthalate	1	No	No	No	No
Fluoranthene	1	No	No	No	No
Fluorene	1	No	No	No	No
Hexachlororobutadiene	1	No	No	No	No
Hexachlororobenzene	1	No	No	No	No
Hexachlororocyclopentadiene	1	No	No	No	No
Hexachlororocyclohexane (Lindane)	1	No	No	No	No
Isophorone	1	No	No	No	No
Hexachloroethane	1	No	No	No	No
Mercury	1	No	No	No	No
N-Nitrosodiphenylamine	1	No	No	No	No
Nickel	1	No	No	No	No
Nitrobenzene	1	No	No	No	No
Pentachlorophenol	1	No	No	No	No
Phenol	1	No	No	No	No
PCBs*	1	No	No	No	No
pH	1	No	No	No	No
Pyrene	1	No	No	No	No
Selenium	1	No	No	No	No
Thalium	1	No	No	No	No
Zinc	1	No	Yes	Yes	No

Category 5 = polluted waters that require a water improvement project
Category 4 = Impaired waters with a USEPA-approved total Maximum Daily Load attainment plan in place
Category 2 = waters of concern
Category 1 = waters that meet tested water quality standards

4.4 ESA-listed Species and Critical Habitat Occurrence in Action Area

The ESA-listed species covered in this BE that could occur within the action area are Chinook salmon, steelhead, bull trout, yelloweye rockfish, bocaccio rockfish, and SRKW. Species status and presence of designated critical habitat in the action area are identified in Table 15. Effects to designated critical habitat physical and biological features (PBFs) are also analyzed in this BE. This BE uses the preferred term PBFs, per 81 FR 7414, which replaces the older term, Primary Constituent Elements (PCEs). The older Federal Register documents identifying critical habitat use the term PCEs. See Appendix D for additional information about species' life histories.

Table 15. ESA-listed species and critical habitat in the action area

Species	Lead Agency	Federal Status	Critical Habitat in Action Area
Chinook salmon (Puget Sound ESU)	NMFS	Threatened	Yes
Steelhead (Puget Sound DPS)	NMFS	Threatened	No
Bull trout (Coastal-Puget Sound DPS)	USFWS	Threatened	Yes
Bocaccio rockfish (Puget Sound/Georgia Basin DPS)	NMFS	Endangered	Yes
Yelloweye rockfish (Puget Sound/Georgia Basin DPS)	NMFS	Threatened	Yes
Killer whale (Southern Resident DPS)	NMFS	Endangered	Yes

4.4.1 Puget Sound Chinook Salmon

4.4.1.1 Federal Status

Puget Sound Chinook salmon were listed as a threatened species on June 28, 2005, and updated on April 14, 2014 (70 FR 37160). A recovery plan is in place for Puget Sound Chinook (SSPS 2007; NMFS 2007). The recovery plan adopts ESU and population-level viability criteria recommended by the Puget Sound Technical Recovery Team (Ruckelshaus et al. 2002).

4.4.1.2 Occurrence

The Puget Sound ESU consists of 22 extant populations. Several Chinook salmon populations could occur in the aquatic component of the action area, specifically the mixing zones for stormwater and industrial wastewater discharge to Puget Sound. WDFW (2024d) identifies Miller Creek, Walker Creek, and Des Moines Creek as potentially suitable habitat based on gradient, but the species is not currently documented in these systems. Chinook salmon are most likely to occur in the marine portion of the action area, specifically in offshore waters of Puget Sound around the IWTP outfall as pre-spawn migratory adults and in offshore and nearshore habitats as outmigrant juveniles. Adults are most likely to be returning migrants from the Puyallup River, White River, Nisqually River, and Green River populations (NMFS 2007; 2017a). Juveniles are also most likely to be members of these populations. However, juvenile Chinook range widely throughout Puget Sound and individuals occurring in the action area could come from any population in the ESU (Hayes et al. 2019).

Juvenile Chinook salmon rely on estuarine and nearshore habitats of Puget Sound for rearing and to make their transition from fresh to saltwater conditions (smoltification) before migrating out to the open ocean. They use these habitats for migration, foraging, refuge, and the osmoregulatory transition to salt water (City of Seattle 2015). Juveniles rely on shallow nearshore habitats such as eelgrass beds, intertidal flats

or marshes, and subtidal channels. The Puget Sound portion of the action area comprises intertidal and subtidal flats with some patchy eelgrass, indicating that the area has limited suitable habitat for and may be used by juvenile Chinook salmon on occasion. The frequency and time in this area is limited by the patchy beds of eelgrass (*Zostera marina*) and armoring of virtually the entire shoreline adjacent to the action area (Ecology 2023).

The Chinook populations likely to occur in the action area are at abundance levels well below recovery objectives (GSRO 2022). According to the 2016 5-year review of the status of the Puget Sound Chinook salmon ESU, the most recent available, all Puget Sound Chinook populations are below the planning ranges identified for recovery. There is concern that recovery to a naturally sustaining harvestable population is hindered by habitat factors as well as competition for habitat and food sources between naturally spawning fish and hatchery fish. Population trends vary depending on whether hatchery fish are combined or analyzed separately from natural-origin fish on the river system. NMFS has identified the effect of hatchery strays on wild Chinook salmon production in river systems such as the Green/Duwamish as a key concern leading to the listing of Chinook salmon (West Coast Salmon Biological Review 2003).

4.4.1.3 *Critical Habitat*

Critical habitat for Puget Sound Chinook salmon was designated on September 2, 2005 (70 FR 52630). The freshwater habitats in Miller Creek, Walker Creek and Des Moines Creek are not mapped as designated critical habitat (NOAA 2024). The mouths of these systems into Puget Sound contain estuarine and nearshore marine areas designated as critical habitat. Puget Sound contains both nearshore and offshore marine areas designated as critical habitat.

The PBFs relevant to the action area are as follows:

(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, and side channels; and

iii. Juvenile and adult forages support 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.

(6) Offshore marine areas with water quality conditions and forage supporting growth and maturation.

4.4.2 Puget Sound Steelhead

4.4.2.1 *Federal Status*

Puget Sound steelhead trout were listed as a threatened species in 2007, and the listing was updated on April 14, 2014 (72 FR 26722). A recovery plan is in place for Puget Sound steelhead, produced through a wide collaboration by the Puget Sound Steelhead Recovery Team (NMFS 2019).

4.4.2.2 *Occurrence*

In Washington, steelhead are present in most coastal streams, the lower Columbia River, and in all the larger drainages of the Salish Sea (Pietsch and Orr 2015). Steelhead spend the first 1 to 2 years of life rearing in freshwater rivers before out-migrating to the ocean. Steelhead then spend about 1 to 2 years at sea before returning to their freshwater streams of origin to spawn. A small percentage of adults, predominantly females, are repeat spawners. These individuals, referred to as kelts, migrate to the ocean to feed and recover and return to freshwater to spawn again the following year.

Steelhead are most likely to occur in the marine portion of the action area, specifically the offshore waters of Puget Sound around the IWTP outfall, as pre-spawn migratory adults and outmigrant juveniles. There are currently 10 extant stocks of ESA-listed winter run steelhead that are likely to occur within this marine migratory corridor, three originating from the Puyallup/ White River system, one from the Nisqually, and five from independent tributaries to the South Puget Sound Basin (Scott and Gill 2008), all of which are part of the Puget Sound DPS (NMFS 2019). Outmigrant juveniles typically migrate rapidly through the offshore waters of Puget Sound, moving from natal rivers to the open ocean within days to weeks (Berejikian 2016; Moore et al. 2015; Moore and Berejikian 2017) and do not make extensive use of the nearshore habitat (Puget Sound Partnership and WDFW 2011).

According to NMFS 5-year review of the Puget Sound steelhead DPS, risks have not changed since the species' listing in 2007 and the DPS is at very low viability. Scott and Gill (2008) considered Puyallup/White and Nisqually winter-run steelhead populations to be at moderate/high risk of extinction by 2100 based on abundance trends through 2005, but abundance of each component stock has increased since 2005. The current abundance of all stocks potentially occurring in the action area remain well below recovery goals (NWFSC 2015; NMFS 2017a, 2019). Insufficient information is available to evaluate the status of south Puget Sound and east Kitsap stocks.

4.4.2.3 *Critical Habitat*

Critical habitat for 12 ESUs of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho was designated on September 2, 2005 (70 FR 52630). The freshwater habitats in Miller Creek, Walker Creek and Des Moines Creek are not included in Puget Sound steelhead critical habitat (NOAA 2024). Critical habitat for Puget Sound steelhead does not include marine habitats. Therefore, no designated critical habitat for Puget Sound steelhead is present in the action area.

4.4.3 Coastal-Puget Sound Bull Trout

4.4.3.1 *Federal Status*

Bull trout were listed as threatened species on November 1, 1999 (64 FR 58910). The listing applies to all bull trout in the coterminous United States, including the Coastal-Puget Sound DPS. A recovery plan is in place (USFWS 2015).

4.4.3.2 *Occurrence*

Most bull trout reside their entire lives in streams, large rivers, and lakes, but the Coastal-Puget Sound DPS is amphidromous, meaning that the species flexibly uses freshwater, estuarine, and nearshore marine waters at various points during its life cycle. Bull trout from Puget Sound rivers are known to migrate and forage in nearshore waters, using the nearshore zone as a migratory corridor between seasonal habitats in natal and non-natal watersheds (Goetz et al. 2004, 2021). These foraging, migrating, and overwintering

(FMO) habitats are crucial to the conservation of the species. Bull trout have more specific habitat requirements than other salmonids. Specifically, they require a narrower range of colder water temperatures for spawning and rearing, and they are more sensitive to passage barriers and fine sediment in spawning substrates.

Puget Sound bull trout populations spend a significant portion of their lifecycle in salt water, moving back and forth between mouths of rivers and streams (Pietsch and Orr 2015). Marine FMO habitat includes portions of Puget Sound, particularly the highly productive nearshore and estuarine areas that provide complex habitat structure and abundant prey, which is not present in the action area. Important prey species include juvenile salmonids, sandlances (*Ammodytes hexapterus*), surf smelts (*Hypomesus pretiosus*), Pacific herring (*Clupea pallasi*), and shiner perch (*Cymatogaster aggregata*).

The final bull trout recovery plan identifies the Puget Sound nearshore zone as FMO habitat (USFWS 2015) for the Skagit, Stillaguamish, Snohomish-Skykomish, and Puyallup River core areas. The action area lies between the Stillaguamish and Snohomish-Skykomish core areas to the north and the Puyallup River core area to the south, the latter being closest based on marine migration distance. Based on observed amphidromous behavior (Goetz et al. 2004, 2021), the nearshore zone of Puget Sound within the action area is well within the maximum migratory range of bull trout from each of these core areas. However, based on observed mean migration ranges reported by Goetz et al. (2021), most bull trout that occur in the action area are likely to originate from the Puyallup River.

Current Coastal-Puget Sound bull trout distribution is like probable historical distribution, but the abundance of contributing subpopulations has decreased over approximately 50 percent of their range (USFWS 2004). Bull trout in the Puget Sound region are stable overall, with the population neither increasing nor decreasing (USFWS 2015). Bull trout may occur in action area as adults or subadults foraging in or migrating through nearshore habitats, though the presence is likely limited by the limited habitat structure and armoring of virtually the entire shoreline adjacent to the action area (Ecology 2023). As stated, bull trout could occur in the action area at any time but are most likely to be present from March through July (Goetz et al. 2021). Bull trout is least likely to occur in the action area from October through February.

4.4.3.3 *Critical Habitat*

Critical habitat for bull trout was designated on October 26, 2005, and then revised on October 18, 2010 (75 FR 63898). Critical habitat comprises the following primary habitat types:

- Spawning and rearing
- FMO (marine nearshore areas used by bull trout for foraging and migration)

The revised critical habitat designation comprises 32 critical habitat units and support PBFs required for spawning, rearing, and FMO between suitable habitats. The Puget Sound critical habitat unit contains 1,144 miles of streams and 443 miles of marine shoreline, as well as lake areas.

The aquatic component of the action area overlaps the Marine Critical Habitat Subunit of Critical Habitat Unit 2: Puget Sound. Unit 2 includes the marine and tidally influenced estuarine shorelines of Puget Sound and contributing river systems from the mean higher high water (MHHW) line to the depth of 10 meters (33 feet) relative to the MLLW line.

The PBFs relevant to the action area (Puget Sound) are as follows (75 FR 63898):

(2) Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

(3) An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

(4) Complex river, stream, lake, reservoir, and marine shoreline aquatic environments and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.

(5) Water temperatures ranging from 2 to 15 °C (36 to 59 °F), with adequate refugia available for temperatures at the upper end of the range.

(8) Sufficient water quality and quantity to support normal reproduction, growth, and survival.

4.4.4 Puget Sound/Georgia Basin Boccacio Rockfish

4.4.4.1 *Federal Status*

Puget Sound/Georgia Basin bocaccio rockfish (bocaccio) were listed as an endangered species in 2010 (75 FR 22276). A recovery plan is in place for Puget Sound/Georgia Basin bocaccio and yelloweye rockfish (NMFS 2017b).

4.4.4.2 *Occurrence*

Bocaccio is a deep-water species of rockfish typically found along steep slopes of sand or rock substrates. They prefer high relief boulder fields and rocks and may school with other rockfish species. They may occasionally wander onto mudflats or be found well off the bottom substrate (Love et al. 2002). Adults are found in waters ranging from 12 to 478 meters (39 to 1,568 feet) deep but are most frequently found at depths ranging from 50 to 250 meters (164 to 820 feet).

Larvae and pelagic juveniles are found near the surface; juveniles prefer shallow, algae-covered rocks or eelgrass, or may shelter under kelp mats (Love et al. 2002; USACE 2012). The juveniles move to deeper waters within 3 to 3.5 months (Love et al. 2002). Larvae of bocaccio can be widely dispersed by surface currents. Offshore of Washington and Oregon, larval release begins in January and may run through April (Drake et al. 2010); little is known of the timing of breeding within Puget Sound.

The bocaccio was once common on steep walls throughout Puget Sound, but this species is now much rarer (Love et al. 2002). Drake et al. (2010) report that in the Puget Sound most bocaccio occur in the southern sound and are rare north of Tacoma. Adult and juvenile bocaccio could potentially occur in the Puget Sound portion of the action area, particularly in the mixing zone of the industrial wastewater outfall in Puget Sound but may be limited due to by the patchy beds of eelgrass (*Zostera marina*) and armoring of virtually the entire shoreline adjacent to the action area (Ecology 2023). Bocaccio eggs and larvae are likely to occur in nearshore marine habitats as well as this mixing zone.

Bocaccio populations have declined severely throughout their range. In Puget Sound, stocks appear to have declined based on the frequency of recreational catches between the 1970s and 1990s and were not identified in dockside surveys of several thousand rockfish caught between 1996 and 2007. This suggests a strong decline in bocaccio in these inland waters (Drake et al. 2010, NMFS 2017b).

4.4.4.3 *Critical Habitat*

The NMFS designated critical habitat for bocaccio and yelloweye rockfish within Puget Sound/Georgia Basin in 2014 (79 FR 68041). This habitat is segmented into nearshore and deepwater rockfish critical habitat (79 FR 68041). Essential habitat features associated with rockfish are separated by life stage (NMFS 2013). The aquatic component of the action area overlaps bocaccio nearshore critical habitat for larval and juvenile bocaccio at the mouths of the Miller, Walker, and Des Moines Creeks, and deepwater critical habitat at the mixing zone of the industrial wastewater outfall.

Critical habitat attributes useful for analyzing project impacts in Section 7 consultations comprise the following (79 FR 68041):

1) Quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities; and
2) Water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities.

4.4.5 Puget Sound/Georgia Basin Yelloweye Rockfish

4.4.5.1 *Federal Status*

Yelloweye rockfish were listed as a threatened species in 2010 (75 FR 22276). A recovery plan is in place for Puget Sound/Georgia Basin bocaccio and yelloweye rockfish (NMFS 2017b).

4.4.5.2 *Occurrence*

Yelloweye rockfish is a deep-water species associated with rocky reefs, kelp canopies, artificial structures, and rocky bottoms, often near steep slopes (Palsson et al. 2009). This species occurs in deeper waters ranging from 80 to 1,560 feet but is most common between 300 and 590 feet. Juveniles and subadults prefer shallower waters, while the adults tend to use deeper waters. Subadults and adults tend to be solitary and prefer staying close to the substrate in rocky areas with high relief and shelter such as overhangs, caves, or boulder piles (Love et al. 2002). Yelloweye rockfish eat a variety of prey, including smaller fish, shrimps, and crabs. Larval release occurs primarily in March to July off British Columbia (Love et al. 2002). Little is known about this species' breeding timing within Puget Sound but may occur in early spring to late summer in the Sound.

Of the two listed species, yelloweye rockfish appear to be more abundant with the widest distribution. Pietsch and Orr (2015) records indicate a range from the south end of Saratoga Passage to Golden Gardens and Elliott Bay, with additional isolated records elsewhere in Puget Sound. Juvenile yelloweye rockfish are not typically found in intertidal waters (Love et al. 1991; Studebaker et al. 2009, NMFS 2017b). Juvenile and larval yelloweye could potentially occur in the Puget Sound portion of the action area, particularly in the mixing zone of the industrial wastewater outfall.

The yelloweye rockfish is slowly recovering from a significant decrease in abundance across its range. This species is rare to uncommon in Puget Sound, and harvested numbers have historically been too small to discern population status and trends (Drake et al. 2010; NMFS 2016).

4.4.5.3 *Critical Habitat*

The NMFS designated critical habitat for yelloweye rockfish within Puget Sound/Georgia Basin in 2014 (79 FR 68041). There is no nearshore critical habitat for yelloweye rockfish (79 FR 68041). Essential habitat

features associated with rockfish are separated by life stage (NMFS 2013). The aquatic component of the action area overlaps yelloweye rockfish deepwater critical habitat at the mixing zone of the industrial wastewater outfall in Puget Sound.

Critical habitat attributes useful for analyzing project impacts in Section 7 consultations comprise the following (79 FR 68041):

1) Quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities; and

2) Water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities.

4.4.6 Southern Resident Killer Whale

4.4.6.1 *Federal Status*

SRKW was listed as endangered on November 18, 2005 (70 FR 57565) and updated on April 14, 2014.

4.4.6.2 *Occurrence*

The SRKW comprises three distinct pods (J, K, and L), totaling 74 individuals (MMC 2024). The three pods are regularly present in the inland waters of Puget Sound, inland waters of southern British Columbia, and the Strait of Juan de Fuca from April through September. During much of this time, they tend to be concentrated around the San Juan Islands. SRKW pods tend to move farther south within Puget Sound in the fall, likely following runs of Chinook and chum salmon. May and June are the months with the fewest sightings in the central Puget Sound region.

These family groups are highly mobile and can travel over 80 miles (160 km) in a single day. From 2020 to 2022, there were 277 SRKW observations submitted to the whale museum in the east passage of Puget Sound from Elliot Bay south the Des Moines, Washington (Whale Museum 2023). Of these, the 43 records identified as SRKW occurred on 28 unique days in the months of July, September, October, November, December, and January.

SRKW have not been recorded within the freshwater portion of the action area and are not expected to enter freshwater. SRKW would likely pass through in the mixing zone of the industrial wastewater outfall discharging into Puget Sound. In addition, SRKWs may be affected via trophic link, as any impacts to Chinook salmon would affect prey availability for SRKWs.

The SRKW population is relatively stagnant at just 0.1 percent rate of increase in size per year, well below the target 2.3 percent increase needed for the species to be delisted (Wiles 2016). From 1995 to 2005, J pod grew, K pod stayed largely the same, and L pod decreased. Reproduction can be heavily affected by prey availability. Wasser et al. (2017) observed that low availability of Chinook salmon was a substantial cause of late pregnancy failure. If Chinook salmon abundance remains constant or increases, J pod has the potential to double in size in the next 25 years (Wiles 2016).

A final recovery plan (NMFS 2008) stated that reduced prey availability and quality, high levels of contaminants, and disturbance from both vessels and sound were among the factors limiting the recovery of the species. NMFS (2011) has informed affected constituents about the importance of Chinook salmon to the diet of SRKWs and the potentially serious implications of the salmon fisheries and other activities affecting Chinook salmon on the survival and recovery of these whales. Mongillo et al. (2016) determined

that the bioaccumulation of toxic and physiologically damaging chemicals through consumption of contaminated prey poses a significant ongoing risk to species recovery.

4.4.6.3 *Critical Habitat*

Critical habitat was originally designated on November 29, 2006 (71 FR 69054) and revised on August 29, 2021, to include coastal marine waters of Washington, Oregon, and California (86 FR 41668). The revised designation includes the following three specific areas in the inland marine waters of Washington State:

- The Summer Core Area in Haro Strait and waters around the San Juan Islands
- The Puget Sound Area
- The Strait of Juan de Fuca Area

Critical habitat for the SRKW includes all marine waters in the Puget Sound area waterward of 20 feet (6.1 meters) below extreme high water (86 FR 41668). The action area overlaps this critical habitat at one location: in the mixing zone of the industrial wastewater outfall discharge in Puget Sound.

PBFs associated with the SRKW are as follows:

- Water quality to support growth and development.
- Prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth.
- Passage conditions to allow for migration, resting, and foraging.

5.0 ANALYSIS OF EFFECTS

Effects of the action are 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 (i.e., interrelated, and interdependent activities). 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 based on clear and substantial information, using the best scientific and commercial data available. In other words, potential or speculative consequences or worst-case scenarios or pessimistic assumptions are not considered a consequence of the action. As noted in the Maine Lobsterman's Association v. National Marine Fisheries Service decision (No. 22-5238 D.C. Cir. 2023), "nothing in Section 7 requires distorting the decision-making process by overemphasizing highly speculative harms whenever data is wanting."

Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (i.e., indirect effects, also referred to as delayed consequences). Examples of delayed consequences are as follows:

- Changes to ecological systems resulting in altered predator/prey relationships.
- Changes to ecological systems resulting in long-term habitat alteration.
- Anticipated changes in human activities, including changes in land use.

Effects are generally categorized as being insignificant, discountable, beneficial, or adverse. Insignificant effects relate to the size of the impact (and should never reach the scale where take occurs), while discountable effects are those that are extremely unlikely to occur. Based on best judgment, one would not be able to meaningfully measure, detect, or evaluate insignificant effects or expect discountable effects to occur. Beneficial effects are those effects of an action that are wholly positive, without any adverse effects, on a listed species or designated critical habitat.

Adverse effects are those that are not discountable or insignificant and are expected to result in take of species or designated critical habitat. "Take," as defined by the ESA, includes such activities that harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct (ESA Section 3[19]). "Harm" is defined to include substantial habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering. "Harass" is further defined as actions that create the likelihood of injury to listed species to such an extent as to substantially disrupt normal behavior patterns that include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3). Adverse effects to designated critical habitat may include significant habitat modification or degradation where it kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. In general, take is assumed when harm or harassment to a species or designated critical habitat is demonstrated. The effects of exposure range in severity from chronic sub-lethal effects to immediate lethality, depending on the type of pollutant or pollutants, exposure mechanisms (i.e., direct or dietary), and concentration, duration, and frequency of exposure (Brette et al. 2014; Feist et al. 2011; Gobel et al. 2007; Incardona et al. 2004, 2005; McIntyre et al. 2012; Meador et al. 2006; Sandahl et al. 2007; Spromberg et al. 2016). Repeated exposure to certain pollutants, even at sublethal concentrations, can lead to prolonged adverse effects on survival and fitness (Feist et al. 2011; Spromberg and Meador 2006; Spromberg and Scholz 2011).

5.1 Direct Effects

Direct effects are defined as direct or immediate effects of the Proposed Action on the species or its habitat. Potential direct effects of the Proposed Action include short-term construction impacts and long-term permanent effects from operation of the Proposed Action.

5.1.1 Noise

Construction-related noise is a function of the types of equipment being used, distance to receptors, and duration of construction activities. Background or ambient sound levels can vary greatly depending on site-specific factors. Ambient sound levels can effectively mask construction noise. While most of the NTPs are located near SEA operation areas with high ambient noise levels, a few of the NTPs are located on the perimeter, such as at the north end of SEA, where background sound levels are more consistent with populated urban areas. The construction noise analysis concluded that most NTPs are in areas with an ambient sound level of 76.5 dBA, while the five NTPs located north of SR 518 (C02, C03, L05, L07, and S10) are in areas with ambient sound levels of 66 dBA (Landrum & Brown 2024). Noise from construction equipment may at times exceed ambient noise levels and be noticeable to nearby receivers for the five NTPs located north of SR 518. These increases in noise would be short-term, temporary increases only occurring during active construction. As described in Section 1.4, no potential suitable habitat for ESA-listed terrestrial species is located within miles of the action area. The Proposed Action does not include any activities that are likely to result in elevated in-air noise levels in potential terrestrial habitat for ESA-listed species during construction or long-term operations. Therefore, in-air noise effects are not considered further in this BE.

The Proposed Action does not include any activities that are likely to result in elevated in-water noise levels during construction or long-term operations. In addition, all in-water construction activities would take place at locations that are not accessible to ESA-listed species. Therefore, underwater noise effects are not considered further in this BE.

5.1.2 Habitat Modification

Construction would occur primarily in paved and developed areas of SEA property where no or limited landscape vegetation exists. Vegetation and tree removal would occur for five projects north of SR 518, in areas that were previously cleared and are currently comprised of trees, low shrubs, maintained and unmaintained fields, and paved residential roads. Construction of S07 would require clearing and regrading of approximately 18.6 acres of maintained grass, shrubs, and deciduous and coniferous trees typical of unmanaged urban green spaces. S07 also includes improvements to an existing culvert crossing that would impact streams (0.01 acre) and stream buffers (0.05 acre).

Construction activities within wetland and wetland buffers include a total of approximately 0.58 acre of wetland impacts and 2.65 acres of wetland buffer impacts. Compensatory mitigation is proposed for all wetland and wetland buffer impacts. As shown on Table 9, the Proposed Action would include 2.65 acres of mitigation for wetland buffer impacts and at least 1.17 acres and potentially up to 4.68 acres of compensatory mitigation for wetland impacts, depending on the type of mitigation provided.

5.1.2.1 *Effects of Habitat Modification on Listed Species*

Proposed wetland impacts would occur in habitats upstream of Miller Creek and Des Moines Creek, where no ESA-listed species occur and more than 2 miles upstream of where the potential presence of ESA-listed species is documented. There are no measurable potential impacts to ESA-listed species associated with wetland and wetland buffer impacts under the Proposed Action.

5.1.2.2 *Effects of Habitat Modification Critical Habitat*

Designated critical habitat is not present in the portion of the action area where impacts to wetlands and stream habitats would occur, nor in downstream habitats in Des Moines Creek, Walker Creek, and Miller Creek where temporary construction-related effects on water quality could occur. Proposed in-water work is limited to wetland fill, buffer impacts, stormwater pond development, and culvert improvements in headwater areas at least 2 miles upstream of Puget Sound. Construction BMPs would ensure that no delivery of suspended sediments and associated contaminants to designated critical habitat in nearshore areas of Puget Sound would occur. Therefore, habitat modifications resulting from the Proposed Action would have no measurable effects on designated critical habitat.

5.1.3 Stormwater

The Proposed Action includes construction of new, replaced, and retrofitted PGIS. As noted in Section 2.4.2, stormwater runoff on SEA property is collected in existing stormwater treatment systems. All stormwater and wastewater from new, replaced, and retrofitted PGIS that drains to the SDS would discharge through existing and proposed SEA stormwater outfalls to Miller Creek, Walker Creek, and Des Moines Creek. This drainage area represents about 7 percent of Miller Creek's and about 21 percent of Des Moines Creek's watersheds. The IWS discharges via the IWTP outfall to Puget Sound. Miller Creek and Des Moines Creek flow directly into Puget Sound, while Walker Creek flows into Miller Creek immediately upstream of its confluence with Puget Sound.

The Port's SDS and IWS comprise a combination of robust structural controls and OSC BMPs designed to intercept pollutants before they enter stormwater runoff and provide treatment to reduce contaminant concentrations to the greatest extent practicable. For example, current OSCs include dry sweeping of PGIS, runway rubber removal, and regular maintenance of vaults, detention basins, and filtration systems. These operational BMPs are consistent with Ecology (2022) recommendations for limiting contamination of surface waters by 6PPD-Q and other emerging contaminants of concern.

The Proposed Action includes improvements to existing and construction of new structural source controls and expansion of OSCs to all new impervious surfaces and PGIS. In combination, these measures are likely to be highly effective at minimizing adverse effects to listed species from stormwater and wastewater pollutants. SEA's SDS and IWS systems represent the currently practicable state-of-the-art treatment options that are fully compliant with state and federal regulations. These regulations protect beneficial uses, including for aquatic life. In addition, SEA implements numerous initiatives, such as low impact development techniques to avoid/reduce stormwater runoff, conservation of potable water through rainwater capture and reuse, ongoing habitat protection and restoration programs, and invasive weed and debris removal. It is important to note that the difference between the Proposed Action and No Action is negligible. Therefore, the Proposed Action is expected to result in insignificant effects to threatened and endangered species in the action area.

5.1.3.1 *NPDES Related Testing*

Under the NPDES permit, SEA is required to conduct *in-situ* toxicity testing biannually and acute and sublethal testing the year prior to permit renewal. Acute toxicity tests are performed on stormwater samples collected from stormwater outfalls. Sublethal toxicity tests are performed on ambient receiving water samples collected downstream of stormwater outfalls. Finally, *in-situ* testing is conducted using a watershed approach.

Acute toxicity tests measure mortality as the significant response to the toxicity of the effluent from seven representative outfalls discharging stormwater from SEA (SDS3/5, SDD06A, SDE4/S1, SDN1, SDN2/3/4, SDW1B, and SDW2). Acute testing is required once during the last winter and last summer prior to the submittal of the NPDES permit renewal application. Acute toxicity testing procedures follow guidelines provided by the USEPA (2002). The last acute toxicity test was completed in 2020. Survival in the 100 percent undiluted samples, and in both the unadjusted and hardness-adjusted samples, was equal to or greater than 90 percent for both species (Daphnia pulex and fathead minnows), indicating that no acute toxicity was demonstrated by any of the samples (Nautilus 2020).

Sublethal testing under the NPDES is part of the Whole Effluent Toxicity (WET) testing. WET tests measure the aggregate toxic effect of an effluent (wastewater discharge) on aquatic organisms and are crucial for ensuring that water quality standards are met, and aquatic life is protected. Sublethal toxicity testing is required once during the last winter and last summer prior to the submittal of the NPDES permit renewal application. Stormwater outfalls at SEA discharge into five local receiving waters identified in the NPDES permit (Miller Creek, Des Moines Creek, Walker Creek, Northwest Ponds, and Lake Reba). Samples from six representative sites were tested for sublethal toxicity using the 7-day rainbow trout embryo test (Environment Canada 1998; modifications from Canaria et al 1999). Receiving water samples consistently showed no evidence of sublethal toxicity in the tests conducted from 2019 to 2020 (Nautilus 2020).

In addition, the NPDES permit requires rainbow trout (RBT) early life stages (ELS) *in situ* monitoring tests be conducted biannually in the fall and spring (Appendix E). The objective of the testing is to use salmonid ELS as an *in-situ* monitoring tool to assess the quality of receiving waters potentially affected by stormwater discharges from SEA, as well as a multitude of the other discharges from the surrounding urban environment. Results from the *in-situ* bioassays and supporting analytical data are intended to provide an indication of attainment of receiving water quality standards and associated beneficial uses related to salmonid spawning and rearing. The program was initiated in Fall 2010.

The exposure sites include Miller Creek, Des Moines Creek Downstream, and Des Moines Creek Upstream, with Walker Creek being added to the study beginning in Spring 2016. Monitoring points are generally located downstream of SEA inputs. However, one site is located upstream of SEA stormwater outfalls to monitor potential impacts originating upstream of SEA (Des Moines Creek basin upstream of SEA is heavily urbanized). Results are compared to a laboratory control conducted concurrently with the *in-situ* tests.

All test data were entered in CETIS (Comprehensive Environmental Toxicity Information System, Tidepool Scientific, McKinleyville, CA). Differences among the exposure sites and laboratory controls were evaluated using pair-wise multiple comparison tests according to the USEPA flow chart (USEPA 2002); significant differences were identified at $p \leq 0.05$.

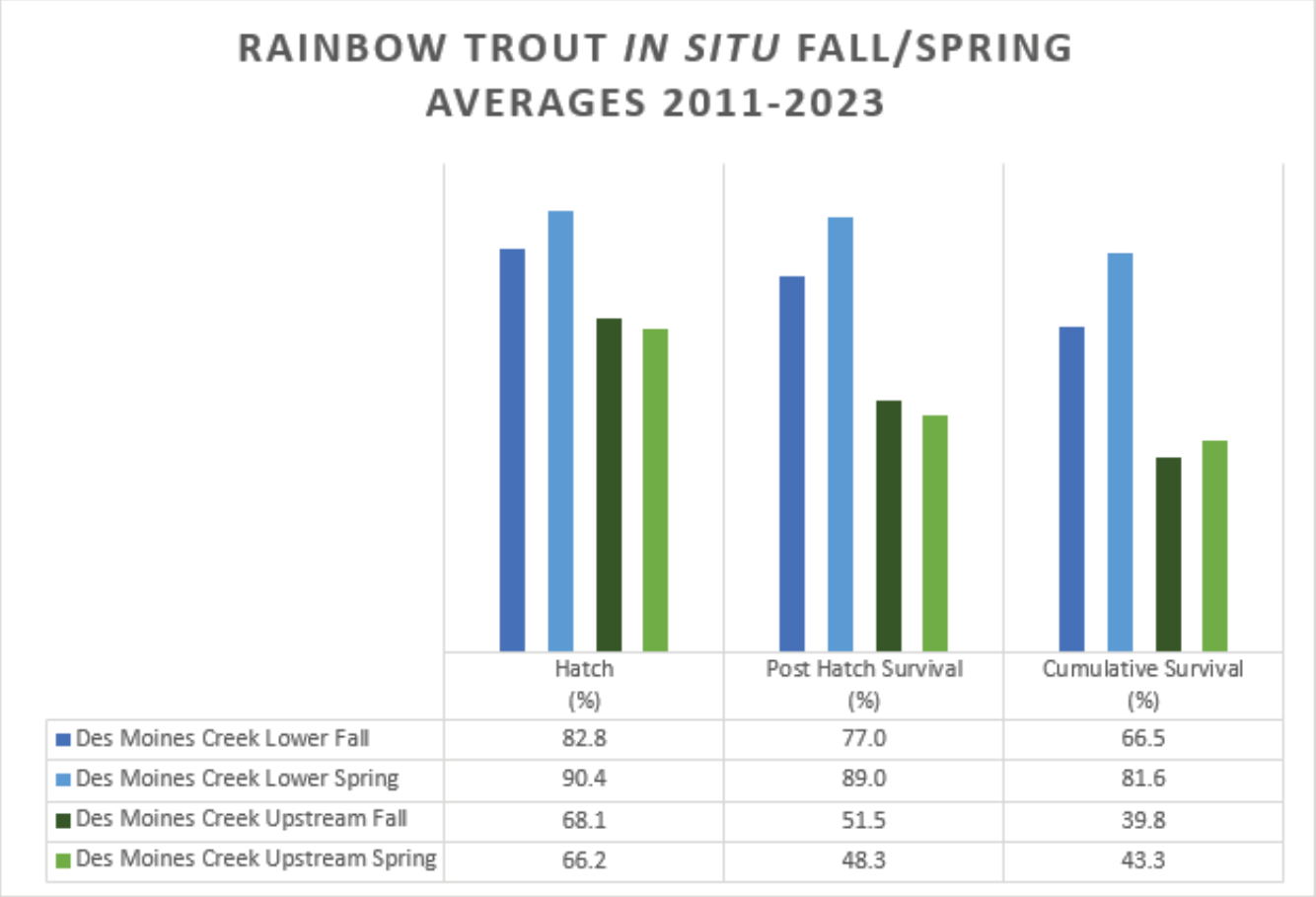
One interim and five terminal endpoints were evaluated:

1. Hatching success – an interim measure of the percentage of embryos hatched the day of the hatch inspection, or determined to have hatched based on the number of alevins present at the subsequent inspection, relative to the total number of embryos originally added.
2. Post-hatch survival - the percentage of organisms surviving at test termination relative to the number of embryos that hatched (these data help determine whether most mortalities occurred pre- or post-hatch or were distributed throughout the exposure period).
3. Cumulative survival - the percentage of surviving organisms at test termination relative to the number of embryos in each replicate at the beginning of the exposure.
4. Abnormality – the percentage of abnormal organisms at test termination relative to the number of surviving organisms.
5. Length – to the nearest 0.5 mm.
6. Weight – to the nearest 0.001 g.

The use of an upstream site demonstrates the quality of water prior to SEA discharge and the impact SEA discharge has on the water quality. Apart from Spring 2015, Spring 2018, and Spring 2020 testing events, Des Moines Creek Upstream has exhibited lower quality and reduced hatching/survival results since the testing program began in 2010. Typically, the Des Moines Creek Downstream location, which includes SEA discharges, shows better results than the upstream location. The addition of SEA's treated stormwater appears to dilute the contaminated water, thereby improving the water quality and improving hatching/survival rates (Chart 1).

Overall, the results of the acute, sublethal, and *in-situ* toxicity testing suggest that the Port has been largely successful in the design and implementation of their stormwater management program. There is no evidence of acute toxicity associated with the outfalls discharging stormwater runoffs and no toxicity in the sublethal tests performed on receiving water samples. In contrast, the result of the in-situ tests suggests the intermittent presence of impaired water quality, particularly in the Des Moines Creek basin upstream of SEA.

Chart 1. In-situ Toxicity Testing Results



	Hatch (%)	Post Hatch Survival (%)	Cumulative Survival (%)
Des Moines Creek Lower Fall	82.8	77.0	66.5
Des Moines Creek Lower Spring	90.4	89.0	81.6
Des Moines Creek Upstream Fall	68.1	51.5	39.8
Des Moines Creek Upstream Spring	66.2	48.3	43.3

5.1.3.2 *Effects of Stormwater on Listed Species*

Current treatment technologies can reliably reduce the concentration of known, commonly occurring stormwater contaminants like PAHs and metals. However, the regulated priority pollutants represent a fraction of the potentially thousands of chemical compounds found in stormwater and industrial wastewater. Some of these compounds are emerging contaminants of concern, for which the effectiveness of currently available treatment methods is not fully understood. It is unknown if treatment effectively removes non-regulated pollutants because neither testing methods nor thresholds have been established. In addition, there is insufficient information available to quantify potential biologically significant effects on listed species from exposure to chronic surface water pollutants generated by the Proposed Action. The *in-situ* toxicity testing is the only site-specific data available, and it supports the determination that the SDS and IWS are effective at treating stormwater and that any potential effects could not be meaningfully measured or evaluated.

The Proposed Action would result in construction of new, replaced, and retrofitted PGIS and associated stormwater and wastewater discharges (Table 3). All stormwater generated by the Proposed Action would meet current Ecology (2019, 2021) stormwater detention and water quality requirements before being released into area streams. As described in Section 2.4.2, existing SEA stormwater facilities collect and detain stormwater for treatment. Flow control would be provided for PGIS surfaces added by the Proposed Action. As such, project-related stormwater discharge would maintain the existing regulatory

requirement for receiving waters of pre-development forested baseline stream flows up to the 50-year storm event. During the infrequent storm events when flows exceed the 50-year storm event, FAA assumes there is likely to be elevated levels of pollutants associated with stormwater runoff, but it is unlikely that pollutant levels exceed water quality standards or reach levels that cause adverse effects based on results from monitoring.

In addition to flow control and water quality treatment, SEA implements a broad range of OSC BMPs to avoid and minimize the release of pollutants and intercept those pollutants before they enter the SDS and IWS (Section 2.7.2). SEA is also actively involved in ongoing research into the fate and transport of 6PPD-Q and the effectiveness of available treatment technologies (Section 2.8). Preliminary results from the Treatability Testing study are promising and demonstrate the effectiveness of commercially available filter media, indicating that there are options beyond 100% infiltration to treat 6PPD-Q (Table 16).

Table 16. Preliminary Treatability Testing Results

Media	Average 6PPD-Q Removal Efficiency (%)	Number of Sampling Events
Biochar	82	1
HS250	94	1
SCU	91.1	1
VCC	97.6	1
CESF + Biochar	96	4
CESF + HS250	97.9	5
CESF + SCU	96.9	4
CESF + VCC	98.8	5

*Sampled between February 28, 2024 – June 2, 2024

While the Port's existing and proposed structural and operational pollution controls are robust, SDS and IWS treated discharges unavoidably contain low levels of contaminants even after treatment. These residual contaminants could harm ESA-listed fish and their habitats through direct and indirect exposure through the food web. However, there is insufficient information available to meaningfully quantify potential biological effects on listed species and the effects are not reasonably certain to occur. The *in-situ* toxicity testing is the only site-specific data available, and it supports the determination that the SDS and IWS are effective at removing contaminants, even those that are not currently monitored. It is important to note that the difference between the Proposed Action and No Action is negligible.

Recent research has found 6PPD-Q, a contaminant found in rubber particles from automobile tire wear on roads, likely poses a significant risk to ESA-listed salmonids and potentially other aquatic life. However, it is unclear how or if aviation is a significant contributor of 6PPD-Q given the differences in the way aviation tires are produced and used. Lane et al. (2024) did not detect 6PPD-Q in Iowa surface water samples collected down-gradient of airports (N = 8).

Current studies indicate that fish sensitivity to 6PPD-Q varies among species.

- Coho salmon are acutely sensitive to 6PPD-Q in laboratory studies, suggesting this compound is a likely contributor to observed pre-spawn mortality in urban streams (Tian et al. 2021, 2022).
- Steelhead and Chinook salmon appear less sensitive. Brinkmann et al. (2022) and Lo et al. (2023) reported 24-hr LC50 of <2 and 67 ppb for steelhead and Chinook salmon, respectively.
- Sockeye salmon (*O. nerka*) and chum salmon (*O. keta*) were unaffected by exposure to stormwater contaminants, including 6PPD-Q, at concentrations sufficient to cause acute mortality in coho salmon (French et al. 2022; McIntyre et al. 2018, 2021).
- Bull trout and rockfish sensitivity are not currently known.
- It is difficult to make inferences from available research because the findings vary widely within and between species groups. For example, Ackerly et al. (2024) found no evidence of acute toxicity or sublethal physiological or morphological effects on early life stages of red drum (*Sciaenops ocellatus*) at exposure concentrations ranging from 10 to 500 ppb. In contrast, Varshney et al. (2021) observed a 24 h LC50 of 309 ppb and sublethal effects on swimming behavior in zebra fish larvae at exposure concentrations of 10 to 25 ppb.

The initial results of the 6PPD-Q treatment options have been largely successful with removal rates up to 99.9%. The results demonstrate that the Port would be able to meet proposed state limits.

5.1.3.3 *Effects of Stormwater on Critical Habitat*

The extent to which the Proposed Action would alter pollutant levels in habitats used by ESA-listed species cannot be meaningfully measured or evaluated and are not expected to reach the scale where take occurs. Broadly speaking, the Proposed Action would add new, replaced, and/or retrofitted PGIS to primarily developed areas within SEA property. These areas either currently have existing stormwater detention and treatment facilities that would be improved, or the Proposed Action includes construction of new facilities. The difference in stormwater runoff between the Proposed Action and No Action is negligible. While all existing and proposed new treatment facilities would meet current Ecology (2019, 2021) requirements, incorporate the relevant OSC BMPs described in Section 2.7.2, and treatment to remove 6PPD-Q, SDS and IWS discharges could include contaminants, the levels cannot be meaningfully measured or evaluated using best available scientific and commercial data. Because the fate and transport of many of these contaminants and their synergistic effects are not fully understood, the extent, duration, and severity of stormwater effects cannot currently be quantified with certainty. The contribution of the Proposed Action to pollutant concentrations and the distance from the outfalls required to dilute concentrations below levels likely to cause detectable effects is unknown and likely to vary. Results from the in-situ testing suggest that the treated stormwater discharge from SEA would have insignificant impacts and could help to improve water quality by diluting contaminant concentrations.

Discharge into the marine waters of Puget Sound further complicates the analysis, as salinity reduces the toxicity and bioavailability of contaminants such as metals. Runoff volumes vary and depend on the timing, intensity, and duration of individual storm events. Contaminant concentrations are likely to be greatest during first-flush events, after contaminants have accumulated on impervious surfaces during long periods of dry weather. Such events are most common in early and mid-autumn. However, the OSC BMPs implemented by the Port greatly reduce the impact of first-flush events.

Pollutant effects on water quality are determined by how contaminants are generated, how those pollutants are transported from source areas to aquatic environments, and the toxicity and biological availability of toxic compounds to receptors. This complex process is referred to as fate and transport (ATSDR 2022), the understanding of which varies by contaminant type. For example, the fate and transport of contaminants like PAHs and metals has received considerable study and is generally well understood. In contrast, while 6PPD-Q toxicity to certain salmonids has been clearly established in laboratory studies (Section 5.1.3.1), the fate and transport of this pollutant is not fully understood (Ecology 2022). Currently available information indicates that 6PPD-Q exposure risk is highest during first-flush events following extended dry periods (McKane et al. 2021; Ecology 2022). Accordingly, BMPs that intercept and remove weathered tire particles from impervious surfaces before first-flush events occur, such as existing SEA operations, management, and maintenance measures (Section 2.7.2), are likely to reduce exposure risks for ESA-listed fish and other aquatic species (Ecology 2022).

The freshwater aquatic habitats Miller Creek, Walker Creek, and Des Moines Creek are not mapped as designated critical habitat for ESA-listed species. The Proposed Action would discharge runoff from PGIS to SEA's IWTP Puget Sound outfall. Per direction from NMFS, the Port conservatively assumes the action area would include 6,560-foot effect radii around the outfall discharge points and from the seabed (MLLW 148 feet) to the water surface. This area lies within designated critical habitat for Chinook salmon, bull trout, bocaccio and yelloweye rockfish, and SRKW. The Proposed Action would constitute a small percentage of total pollutant loading discharged from this outfall. This minimal loading could constitute an incremental effect on ESA-listed species. However, there is insufficient information available to meaningfully measure or evaluate potential biologically significant effects on listed species and the effects cannot currently be quantified with certainty.

5.2 Indirect Effects/Delayed Consequences

Indirect effects, also known as delayed consequences, refer to consequences of the Proposed Action that may occur later in time or extend beyond the immediate footprint of the action, or to consequences of other activities that are caused by the project (WSDOT 2023b). A consequence is caused by the Proposed Action if it would not occur but for the project and it is reasonably certain to occur. The term "reasonably certain to occur" was defined as: A conclusion of reasonably certain to occur must be based on clear and substantial information, using the best scientific and commercial data available (WSDOT 2023b).

The Proposed Action would expand the amount of PGIS and could contribute to the ongoing delivery of treated stormwater pollutants to the aquatic component of the action area over the life of the project. As stated in the previous section, while SEA's combined SDS and IWS systems and OSCs represent the currently practicable state-of-the-art treatment options, treated discharges may result in a negligible contribution to chronic pollutant loading in the aquatic component of the action area that cannot be meaningfully measured or evaluated. While SEA represents a miniscule fraction of pollutant loading from regional sources, the Proposed Action could contribute incrementally to these effects. As such, the Proposed Action could incrementally

contribute to the indirect effects on ESA-listed species, but the extent and severity of those effects cannot currently be quantified and are not expected to reach the scale where take occurs.

The Proposed Action is being developed in response to strong current and projected growth in demand for air passenger and cargo services at SEA. Implementation of the NTPs would neither induce regional macro-economic growth nor demand for air services. However, the NTPs would increase SEA's ability to accommodate increased aircraft operations and passenger activity. As a result, it is assumed that after implementation, the number of aircraft operations and passengers will increase. However, the Port does not anticipate that the Proposed Action would fully accommodate the future needs for aircraft and passenger service projected in the unconstrained 2023 Updated Forecast (Leigh-Fisher 2023). Once the additional capacity provided by the NTPs is reached, the available airfield and airspace capacity at SEA will become the primary constraints on continued growth in air passenger services. The Proposed Action would have no measurable effect on regional development patterns and would not contribute to induced growth.

Therefore, the delayed consequences of the Proposed Action are limited to the incremental effects of the low concentrations of pollutants that would result from the related increase in PGIS and ongoing discharge of treated stormwater and wastewater from these new as well as existing impervious surfaces in the action area. However, it should be noted that the extent and severity of those effects cannot currently be meaningfully quantified or evaluated but are not expected to reach the scale where take occurs.

5.2.1 Indirect Effects on ESA-listed Salmonids

ESA-listed salmonids could be exposed to treated stormwater pollutants at low-levels in the water column and through consumption of contaminated prey organisms (Section 5.1.3.1). O'Neill and West (2009) and West et al. (2008, 2011) documented the bioaccumulation of persistent and toxic contaminants in stormwater runoff in zooplankton and forage fish species in Puget Sound, and in predator species including Chinook salmon. However, SEA is not a probable source of the studied contaminants. The extent and severity of the effects of the low levels of stormwater pollutants that could be discharged cannot currently be meaningfully quantified or evaluated but are not expected to reach the scale where take occurs.

Emerging research demonstrates that 6PPD-Q could contribute to chronic adverse effects on the salmonid food web. The broader implications for species at higher trophic levels, such as ESA-listed salmonids, are not currently quantifiable. Treatment for 6PPD-Q based on the results of the Treatability Testing study would be included, reducing any potential impact on ESA-listed salmonids.

Based on the findings presented here and in Section 5.1.3, there is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could result in delayed consequences for ESA-listed salmonids and their critical habitats. The effects cannot currently be quantified with certainty given insufficient information available. Therefore, the FAA has determined that the impact would be insignificant.

5.2.2 Indirect Effects on ESA-listed Rockfish

Eggs, larva, post-settlement juvenile, and adult bocaccio and yelloweye rockfish that occur in the aquatic component of the action area (Puget Sound) could be directly exposed to pollutants in treated operational stormwater discharge and indirectly exposed to pollutants through the consumption of contaminated prey organisms. It cannot currently be determined with certainty if this could result in adverse effects on survival and fitness of individuals over the life of the project (Section 5.1.3.1). Bocaccio and yelloweye rockfish are long-lived species, that take several years to reach reproductive age. Chronic exposure to and bioaccumulation of stormwater contaminants could lead to delayed consequences for individual survival or reproductive fitness. However, there is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated discharges produced by the Proposed Action could result in delayed consequences for ESA-listed bocaccio and yelloweye rockfish and their critical habitats.

5.2.3 Indirect Effects on Southern Resident Killer Whale

SRKW are likely to occur in the Puget Sound portion of the action area, but the likelihood of direct exposure to stormwater pollutants is discountable given the relatively limited area of effect and probable duration of occurrence. Indirect exposure to stormwater pollutants could occur over the life of the Proposed Action through consumption of bioaccumulated pollutants in salmon and other prey organisms. This long-lived species is exposed to a diverse array of known and potentially harmful chemical substances in the environment and through consumption of contaminated prey.

Mongillo et al. (2016) determined that chronic exposure to PAHs and certain persistent organic pollutants (POPs)[6] are a significant factor contributing to SRKW extinction risk. SRKW carry several of these contaminants at very high body burdens, the result of bioaccumulation through consumption of contaminated prey. Many of these contaminants are known or likely immune and endocrine system disruptors, so the bioaccumulation of these compounds is likely having a profound negative effect on both survival and reproductive fitness (Mongillo et al. 2016).

The final recovery plan for SRKW identifies quantity and quality of prey as a factor that may limit recovery of the species (NMFS 2008). As SRKWs in Puget Sound have a strong preference for Chinook salmon prey, stormwater impacts that affect Chinook abundance and indirect exposure to contaminants through consumption of contaminated prey have the potential to indirectly affect SRKW. NMFS (2023) produced a technical memorandum providing guidance on ESA consultation specific to SRKWs in the NMFS Northwest Region. The memorandum identifies two indirect effects pathways to consider when determining the likelihood of adverse effects: prey quantity and quality.

5.2.3.1 *Prey Quality*

Projects with potential contamination of waters used by Chinook salmon may represent a possible effect to SRKW through contamination of their prey. Proposed in-water work is limited to bridge construction

[6] Notably polychlorinated biphenyls, polybrominated diphenyl ethers, and dichlorodiphenyltrichloroethane (DDT) and its metabolites.

and culvert replacement in Miller Creek more than 4 miles upstream of Puget Sound. Construction BMPs would ensure that no delivery of suspended sediments and associated contaminants would occur. As such, no measurable effects on contaminant levels in Chinook salmon or other SRKW prey species are likely to occur because of project construction.

As discussed in Section 5.1.3, the Proposed Action would minimally increase the quantity of treated operational stormwater pollutants relative to existing conditions at points of discharge. However, the difference between the Proposed Action and No Action is negligible. The Proposed Action could contribute to ongoing exposure of Chinook salmon and other SRKW prey species to treated stormwater pollutants, and the ongoing bioaccumulation of certain contaminants through dietary exposure. There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could contribute to indirect effects to SRKW from impacts on prey quality.

5.2.3.2 *Prey Quantity*

Projects that result in impacts to Chinook salmon may also affect the quantity of prey available to SRKW. Impacts that result in a meaningful reduction in Chinook salmon abundance may reduce prey quantity sufficiently to constitute an adverse effect. This determination applies to construction impacts, which implies this threshold applies on a per-year basis. As described in Section 5.1.3, Proposed Action construction is unlikely to result in any measurable direct or indirect effects on the abundance or quantity of Chinook salmon and other prey organisms available to SRKW.

Proposed Action operations would generate treated stormwater discharges that could result in indirect adverse effects on Chinook salmon and therefore on SRKWs. These effects cannot be quantified with currently available information. There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could contribute to the reduction of the quantity and quality of prey resources available to SRKW.

5.3 Interrelated/Interdependent Actions

Interrelated actions are defined as actions that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02). The Proposed Action is part of the SAMP, a long-term master plan for improvements to SEA needed to support continuing operations and meet future needs for air travel and cargo transport. The Proposed Action is comprised of stand-alone projects (NTPs) that have independent utility, and no other projects depend upon the Proposed Action for their utility.

5.4 Cumulative Effects

Cumulative effects are those effects of future activities that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the Proposed Action are not considered in this section because they require separate consultation pursuant to Section 7. A cumulative effects analysis is required for projects undergoing formal consultation and to aid the Services in making jeopardy determinations, in preparing biological opinions, and in tracking the environmental conditions throughout the vicinity.

Future state, tribal, local, or private actions considered in this BE are unlikely to occur in the terrestrial component of the action area. The aquatic component of the action area is surrounded by and receives stormwater runoff from several local jurisdictions. Each jurisdiction has developed a comprehensive plan to guide future development, none of which includes elements that are contingent on the Proposed Action. However, each jurisdiction will continue to generate stormwater runoff and permitted wastewater discharges that will contribute to cumulative impacts in the action area. The Port anticipates that these jurisdictions will provide stormwater treatment and detention for retrofitted and new development consistent with the current or applicable future versions of the Ecology (2019) *Stormwater Management Manual for Western Washington* and/or the WSDOT (2019) *Highway Runoff Manual*. Similarly, existing and future wastewater discharges will comply with contemporary NPDES permit requirements. These design and compliance standards will minimize the delivery of pollutants to surface waters in the action area. The Proposed Action would contribute incrementally to these ongoing cumulative effects.

Taken as a whole, foreseeable future state, local, Tribal, and private actions will continue to result in cumulative effects to listed species habitat and conditions in the aquatic portion of the action area. Although some of these actions are likely to improve habitat conditions for listed aquatic species, over time, ongoing impacts from stormwater are likely to further degrade water quality in the action area. The Proposed Action would contribute minimally to these ongoing cumulative effects. There is not enough information available to meaningfully quantify or evaluate the cumulative impacts of the Proposed Action but they are not expected to reach the scale where take would occur.

6.0 CONCLUSIONS AND EFFECT DETERMINATIONS

The effects determination is the conclusion of the analysis of potential consequences of the Proposed Action on listed species and critical habitat. Regulatory guidance from the Final Section 7 Consultation Handbook (USFWS and NMFS 1998) was used to make the effects determination for the Proposed Action. The FAA relied on the best available scientific and commercial data available when making the determinations. A summary of the proposed effect determinations to species and critical habitat is presented in Table 17. The supporting rationale for each determination is provided in the following sections.

Table 17. Proposed action effects determinations for ESA-listed species and critical habitat

Species/Habitat	Effects Determination
Chinook salmon (Puget Sound ESU)	Not likely to adversely affect
Chinook salmon critical habitat	Not likely to adversely affect
Steelhead (Puget Sound ESU)	Not likely to adversely affect
Steelhead critical habitat	No effect
Bull trout (Coastal-Puget Sound DPS)	Not likely to adversely affect
Bull trout critical habitat	Not likely to adversely affect
Bocaccio rockfish (Puget Sound/Georgia Basin DPS)	Not likely to adversely affect
Bocaccio rockfish critical habitat	Not likely to adversely affect
Yelloweye rockfish (Puget Sound/Georgia Basin DPS)	Not likely to adversely affect
Yelloweye rockfish critical habitat	Not likely to adversely affect
Killer whale (Southern Resident DPS)	Not likely to adversely affect
Killer whale critical habitat	Not likely to adversely affect
DPS – Distinct population segment; ESU – Evolutionarily significant unit	

6.1 Puget Sound Chinook Salmon

The Proposed Action **may affect** Puget Sound Chinook salmon because of:

- Documented migration and foraging habitat (suboptimal) present in action area (Puget Sound).
- Gradient accessible but not documented in Miller Creek, Walker Creek, and Des Moines Creek in the action area.
- Construction of new, replaced, and retrofitted PGIS as part of the Proposed Action.

The Proposed Action is **not likely to adversely affect** Chinook salmon because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into the Proposed Action.
- Puget Sound in the action area is not suited for foraging due to extensive shoreline armoring, patchy beds of eelgrass, and other existing nearshore impacts (NMFS 2005a, 2005b, 2012c).
- Extent and severity of degraded water quality effects downstream cannot currently be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect Chinook salmon.

6.2 Chinook Salmon Critical Habitat

The Proposed Action **may affect** critical habitat for Chinook salmon because critical habitat is designated in Puget Sound within the action area, where PBFs 4, 5, and 6 occur.

The Proposed Action is **not likely to adversely affect** critical habitat for Chinook salmon because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into the Proposed Action.
- Though stormwater contaminants could remain in the treated discharge and degrade water quality within downstream designated critical habitat where rearing or migration could occur (PBFs 4, 5, and 6), the extent and severity of those effects cannot currently be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect Chinook salmon critical habitat.

6.3 Puget Sound Steelhead

The Proposed Action **may affect** Puget Sound steelhead because of:

- Documented migration and foraging habitat (suboptimal) present in the Puget Sound action area.
- Construction of new, replaced, and retrofitted PGIS as part of the Proposed Action.
- Proposed Action in-water work is located upstream of documented steelhead habitat/presence.

The Proposed Action is **not likely to adversely affect** steelhead because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into Proposed Action.
- Puget Sound in the action area is not suited for foraging due to extensive shoreline armoring, patchy beds of eelgrass, and other existing nearshore impacts (NMFS 2012, 2013).
- Though steelhead migrating adults could be directly exposed to degraded water quality and habitat quality could be degraded due to reduced water quality from Proposed Action stormwater pollutants, the extent and severity of those effects cannot be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect steelhead or its habitat.

6.4 Steelhead Critical Habitat

The Proposed Action would have **no effect** on critical habitat for steelhead because designated critical habitat is not located within the action area.

6.5 Coastal-Puget Sound Bull Trout

The Proposed Action **may affect** bull trout but is **not likely to adversely affect** bull trout because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into Proposed Action.

- Puget Sound in the action area is not suited for foraging, due to extensive shoreline armoring, patchy beds of eelgrass (*Zostera marina*), and other existing nearshore impacts (USFWS 2010b).
- Though bull trout could be directly exposed to degraded water quality and habitat quality could be degraded due to reduced water quality from Proposed Action treated stormwater pollutants, the extent and severity of those effects cannot be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect bull trout or its habitat.

6.6 Bull Trout Critical Habitat

The Proposed Action **may affect** critical habitat for bull trout because critical habitat for bull trout is designated in the Puget Sound portion of the action area, where PBFs 2, 3, 4, and 8 occur.

The Proposed Action are **not likely to adversely affect** critical habitat for bull trout because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into Proposed Action.
- Though stormwater contaminants could remain in the treated discharge and degrade water quality within downstream designated critical habitat where migration could occur (PBFs 2, 3, 4, and 8), the extent and severity of those effects cannot currently be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect bull trout critical habitat.

6.7 Puget Sound/Georgia Basin Bocaccio and Yelloweye Rockfish

The Proposed Action **may affect** bocaccio and yelloweye rockfish because planktonic eggs and larvae, post-settlement juvenile, and adult bocaccio and yelloweye rockfish could occur in the action area.

The Proposed Action is **not likely to adversely affect** bocaccio and yelloweye rockfish because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into Proposed Action.
- Though bocaccio and yelloweye rockfish could be directly exposed to degraded water quality and habitat quality could be degraded due to reduced water quality from Proposed Action stormwater pollutants, the extent and severity of those effects cannot be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect bocaccio and yelloweye rockfish or their habitat.

6.8 Bocaccio and Yelloweye Rockfish Critical Habitat

The Proposed Action **may affect** critical habitat for bocaccio and yelloweye rockfish because the following attributes are present in the offshore deepwater Puget Sound portion of the action area:

- Quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding.
- Water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding.

The Proposed Action is **not likely to adversely affect** critical habitat for bocaccio and yelloweye rockfish because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into Proposed Action.
- Though stormwater contaminants could remain in the treated discharge and result in an incremental degradation of water quality and potential indirect effects on prey resources from pollutant exposure, the extent and severity of those effects cannot currently be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect bocaccio and yelloweye rockfish critical habitat.

6.9 Southern Resident Killer Whale

The Proposed Action **may affect** SRKW because migration and foraging habitat are present in Puget Sound in the action area. The Proposed Action is **not likely to adversely affect** SRKW because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into Proposed Action.
- Though SRKW could be exposed to degraded water quality and habitat quality due to the Proposed Action, the extent and severity of those effects cannot be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect SRKW or its habitat.

6.10 Southern Resident Killer Whale Critical Habitat

The Proposed Action **may affect** critical habitat for SRKW because the Puget Sound portion of the action area overlaps designated critical habitat. The Proposed Action is **not likely to adversely affect** critical habitat for SRKW because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into Proposed Action.
- Though stormwater contaminants could remain in the treated discharge and result in an incremental degradation of water quality and potential indirect effects on prey resources from pollutant exposure, the extent and severity of those effects cannot currently be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect SRKW critical habitat.

7.0 EFFECTS TO ESSENTIAL FISH HABITAT

The MSA includes a mandate that NMFS must identify EFH for federally managed marine fishes, and federal agencies must consult with NMFS on all activities or proposed activities authorized, funded, or undertaken by the agency that may adversely affect EFH. The Pacific Fishery Management Council (PFMC) has designated EFH for the Pacific salmon fishery, federally managed groundfishes, and coastal pelagic fisheries (NMFS 1999; PFMC 1999).

7.1 Essential Fish Habitat Background

EFH is defined as, "Waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" in the MSA [16 United States Code 1802(10)]. Adverse effects on EFH include any direct or indirect impact that reduces the quality or quantity of EFH. The objective of this EFH evaluation is to determine whether the project "may adversely affect" designated EFH for relevant commercially, federally managed fisheries species within the action area. It also references conservation measures to avoid, minimize, or offset potential adverse effects to designated EFH resulting from the project.

7.2 Location and Description of Proposed Action

The FAA is consulting on the Port's Proposed Action, as described in Chapters 1.0 and 2.0 of this BE. The 29 NTPs have been designed to meet forecasted rising passenger and cargo demand at SEA by improving efficiency, safety, access to the airport, and support facilities for the airlines and the airport. In addition, the Port would construct and operate associated PSPs that are necessary for the implementation of the NTPs and provide mitigation for unavoidable impacts to wetlands, streams and wetland and stream buffers resulting from project construction.

The construction and operation of the Proposed Action would occur primarily on currently developed land at SEA, with some development requiring clearing of vegetated parcels adjacent to these currently developed areas. Stormwater and industrial wastewater discharges from the new NTP facilities would discharge to the following waterbodies: Miller Creek and Des Moines Creek, which flow directly into Puget Sound; Walker Creek, which drains into Miller Creek; and Puget Sound, which receives effluent from SEA's IWTP via an NPDES-permitted outfall that discharges approximately 1,600 feet waterward of the mouth of Des Moines Creek at a depth of -148 feet relative to MLLW. Changes in impervious surface area and PGIS resulting from the NTPs, and proposed SDS and IWS improvements are detailed in Section 2.4.2.

7.3 Conservation Measures and Best Management Practices

Conservation measures and BMPs are included for Proposed Action activities and are described in Chapter 2 of this BE. Conservation measures would avoid or minimize potential effects to existing habitat conditions, including EFH, in the action area. Mitigation would be provided to compensate for impacts to wetlands and to wetland and stream buffer.

7.4 Identification of Essential Fish Habitat

Under the MSA, the PFMC has designated EFH for federally managed fisheries within the waters of Washington, Oregon, and California. Detailed descriptions and identification of EFH are contained in the fishery management plans for groundfish (PFMC 2019a), coastal pelagic species (PFMC 2019b), and Pacific salmon (PFMC 2016).

Designated EFH for groundfish and coastal pelagic species encompasses all waters along the coasts of Washington, Oregon, and California that are seaward from the mean high-water line, including the upriver extent of saltwater intrusion in river mouths to the boundary of the U.S. economic zone, approximately 200 miles (321.9 km) offshore (PFMC 2019a, b).

Designated EFH for salmonid species within marine water extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (EEZ) offshore of Washington, Oregon, and California, north of Point Conception to the Canadian border (PFMC 2016).

Groundfish, coastal pelagic, and salmonid fish species and life-history stages that have designated EFH in the Puget Sound portions of the action area including project-related stormwater discharges are listed in Table 18. Salmonid fish species that have designated EFH in the Miller Creek, Walker Creek, and Des Moines Creek portion of the action area are listed in Table 19. Evaluation of the impacts on species that may occur in the action area is based on life-history stages described in PFMC (2016, 2019a, b).

Table 18. Species of fish with designated EFH that may be present in the Puget Sound action area.

EFH Species	Eggs	Larvae	Juvenile	Adult	Spawning
Groundfish					
Spiny dogfish, *Squalus acanthias*			x	x	
Spotted ratfish, *Hydrolagus colliei*			x	x	
Lingcod, *Ophiodon elongatus*			x		
Cabezon, *Scorpaenichthys marmoratus*			x		
Kelp greenling, *Hexagrammos decagrammus*			x		
Pacific cod, *Gadus macrocephalus*			x		
Pacific hake, *Merluccius productus*			x	x	
Sablefish, *Anoplopoma fimbria*		x	x	x	x
Brown rockfish, *S. auriculatus*		x		x	
China rockfish, *S. nebulosus*		x		x	
Copper rockfish, *S. caurinus*		x		x	
Quillback rockfish, *S. maliger*		x		x	
Thornyheads, *Sebastolobus* spp.		x		x	
Other rockfishes		x		x	
Pacific sanddab, *Citharichthys sordidus*		x	x	x	
Dover sole, *Microstomus pacificus*			x	x	
English sole, *Pleuronectes vetulus*		x	x	x	x
Flathead sole, *Hippoglossoides elassodon*		x	x	x	x
Petrale sole, *Eopsetta jordani*		x	x	x	
Rex sole, *Errex zachirus*		x	x	x	
Rock sole, *Pleuronectes bilineata*		x	x	x	x
Sand sole, *Psettichthys melanostictus*		x	x	x	
Starry flounder, *Platichthys stellatus*		x	x	x	x
Coastal Pelagic Species					
Northern anchovy, *Engrauilis mordax*		x	x	x	
Chub mackerel, *Scomber japonicus*				x	
Jack mackerel, *Trachurus symmetricus*				x	
Pacific sardine, *Sardinops sagax*				x	
Market squid, *Loligo opalescens*		x	x	x	x
Pacific Salmon Species					
Chinook salmon, *Oncorhynchus tshawytacha*			x	x	
Coho salmon, *O. kisutch*			x	x	
Puget Sound pink salmon, *O. gorbuscha*			x	x	
Sources: Pietsch and Orr 2015, Port 2016b, Windward 2010, NMFS 2024b.					

Table 19. Pacific salmon species with designated EFH that may be present in the freshwater aquatic component of the action area.

EFH Species	Eggs	Larvae	Juvenile	Adult	Spawning
Chinook salmon, *Oncorhynchus tshawytscha*[a]				x	
Coho salmon, *O. kisutch*				x	
Puget Sound pink salmon, *O. gorbuscha*[b]				x	

Sources: Pietsch and Orr 2015, Port 2016b, Windward 2010, NMFS 2024b.

[a] Chinook salmon presence in Miller Creek, Walker Creek, and Des Moines Creek is documented as gradient accessible with no documented spawning history (NWIFC 2024, WDFW 2024d, e).

[b] Miller Creek, Walker Creek, and Des Moines Creek are accessible to pink salmon, but the species is not known to use the creeks (NWIFC 2024, WDFW 2024d, e).

7.4.1 Groundfish

The west coast groundfish management unit includes 83 species that typically live on or near the bottom of the ocean. The EFH designation for groundfishes and coastal pelagics is defined as those waters and substrate necessary to ensure the production needed to support a long-term sustainable fishery. This includes, "All waters and substrate within the following areas: (1) depths less than or equal to 3,500 meters (1,914 fathoms) to MHHW or the upriver extent of saltwater intrusion, defined as upstream and landward to where ocean-derived salts measure less than 0.5 ppt [part per thousand] during the period of average annual low flow. (2) seamounts in depths greater than 3,500 meters as mapped in the EFH assessment geographic information system (GIS); and (3) areas designated as HAPCs [Habitats of Primary Concern] not already identified by the above criteria." (PFMC 2019a). Groundfish EFH occurs in the action area at Proposed Action-related stormwater discharges (NMFS 2024b):

- **Puget Sound**: Groundfish EFH is designated in the Puget Sound portion of the action area at the offshore NPDES stormwater outfall.
- **Miller Creek, Walker Creek, and Des Moines Creek:** Groundfish EFH is not present in these aquatic areas.

7.4.2 Coastal Pelagics

Coastal pelagics are schooling fishes, not associated with the ocean bottom, that migrate in coastal waters. West coast pelagics include finfish such as the Pacific sardine (*Sardinops sagax*), chub mackerel (*Scomber japonicus*), northern anchovy (*Engraulis mordax*), and jack mackerel (*Trachurus symmetricus*); market squid (*Loligo opalescens*); and krill. The EFH designation for coastal pelagics is defined as those waters and substrate necessary to ensure the production needed to support a long-term sustainable fishery. The EFH includes "*all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the EEZ and above the thermocline where sea surface temperatures range between 10°C and 26°C."* (PFMC 2019b). Coastal pelagic EFH occurs in the action area at stormwater discharges (NMFS 2024b):

- **Puget Sound**: Coastal pelagic EFH for finfish, market squid, and coastal pelagic krill is designated in the Puget Sound portion of the action area at the offshore NPDES stormwater outfall.
- **Miller Creek, Walker Creek, and Des Moines Creek:** Coastal pelagic EFH is not present in these aquatic areas.

7.4.3 Pacific Salmon

The Pacific salmon management unit includes Chinook salmon, coho salmon (*O. kisutch*), and pink salmon (*O. gorbuscha*). The EFH designation for the Pacific salmon fishery is divided into two groups:

- Freshwater group includes all those streams, lakes, ponds, wetlands, and other waterbodies currently or historically accessible to salmon in Washington, Oregon, Idaho, and California, except above the impassible barriers identified by PFMC (1999, 2016).
- Marine and estuarine group occurs "…from the extreme high tide line in nearshore and tidal submerged environments within state territorial waters out to the full extent of the EEZ (200 nautical miles or 370.4 km)" (PFMC 1999).

Pacific salmon EFH occurs in the action area at Proposed Action-related stormwater discharges:

- **Puget Sound:** Pacific salmon EFH is designated in the Puget Sound portion of the action area at the offshore NPDES stormwater outfall. Chinook salmon, coho salmon, and pink salmon all may use the nearshore habitat in Puget Sound near this outfall at some point in their life histories, particularly during juvenile outmigration and adult spawning migration.
- **Miller Creek, Walker Creek, and Des Moines Creek:** Pacific salmon EFH is present in all these aquatic areas. All three are considered gradient accessible to Chinook salmon. Coho salmon have been documented in each of these listed waterways. Miller Creek, Walker Creek, and Des Moines Creek are considered gradient accessible to pink salmon.

7.5 Potential Adverse Effects of Proposed Action

Chapter 6, Analysis of Effects, describes in detail the potential impacts to habitat constituents important to ESA-listed fish species, which are like those for EFH species. Analyses presented address potential elements specific to EFH, which for this Proposed Action is primarily stormwater. Those elements of the analysis are reiterated or cross referenced in the following sections. There are no potential construction impacts to EFH species in the action area. The specific stormwater drainages, as well as the associated changes in new NPGIS and PGIS, and changes in source control BMPs and treatment levels are summarized in Table 3.

7.5.1 Puget Sound

All new PGIS surfaces draining to Puget Sound, and freshwater habitats that drain to Puget Sound, would meet the airport flow and water quality requirements before being released. In addition, SEA implements a variety of operations and management BMPs that include pollutant prevention, interception, and maintenance measures to prevent and collect pollutants prior to entering the stormwater facilities (Sections 2.7 and 2.8). The Proposed Action would include expanded pond and bioretention swale capacity to treat new PGIS.

Recent research has found 6PPD-Q, a contaminant found in rubber particles from automobile tire wear on roads, to be a major contributor to pre-spawning mortality in coho salmon (Tian et al. 2021; 2022). These findings have spurred concerns that 6PPD-Q could pose a significant risk to other EFH salmonid species. Brinkmann et al. (2022) and Lo et al. (2023) reported 24-hr LC50 of 67 parts per billion (ppb) for Chinook salmon. While pink salmon sensitivity to 6PPD-Q has not yet been studied, the lethal concentrations observed in other salmonid species suggest that a presumption of potential for harm may be warranted but cannot be determined with certainty.

While the types of contaminants likely to be generated by the project are generally understood, the extent to which the project might affect ambient pollutant levels in stormwater is difficult to predict. The proposed action would increase the current amount of treated PGIS draining to Puget Sound and freshwater habitats that drain to Puget Sound. Runoff from these surfaces would flow through improved and expanded treatment and retention facilities that would drain to the same points of discharge currently permitted by Ecology (2021). As such, the contribution of the project to effluent pollutant concentrations and the distance from the outfall required to dilute concentrations below levels likely to cause detectable effects is unknown. Runoff volumes vary and depend on the timing, intensity, and duration of individual storm events. Contaminant concentrations are likely to be greatest during first-flush events, after contaminants have accumulated on roadways during long periods of dry weather. Such events are most common in early and mid-autumn. The project would constitute only a small proportion of the overall pollutant loading discharged into the Puget Sound. Discharge into the marine waters of Puget Sound is also a variable factor of pollutant concentrations, as salinity reduces the toxicity and bioavailability of contaminants such as metals.

7.5.2 Miller Creek, Walker Creek, and Des Moines Creek

Potential operational stormwater impacts to EFH species in Miller Creek, Walker Creek, and Des Moines Creek are like what is described above for Puget Sound. The Proposed Action would result in a net increase in PGIS of approximately 50 acres draining to Puget Sound comprising a combination of new, replaced, and retrofitted impervious surfaces (Table 3).

7.6 Conclusion and Effect Determinations

While the project would provide new, improved source control BMPs and treatment capacities (including methods to remove 6PPD-Q) that would minimize adverse impacts, the project would generate stormwater and wastewater discharge from new, replaced, and retrofitted PGIS. Stormwater and wastewater discharges would result in an incremental degradation of water quality from pollutant exposure, the extent and severity of those effects cannot currently be meaningfully quantified or evaluated.

7.6.1 Groundfish Essential Fish Habitat

Operational stormwater discharges would result in an incremental degradation of water quality and potential indirect effects on prey resources from pollutant exposure. However, these impacts cannot be quantified with certainty. Overall, based on the operational stormwater discharges of the project, the project is **not likely to adversely affect** groundfish EFH.

7.6.2 Coastal Pelagic Essential Fish Habitat

Operational stormwater discharges would result in an incremental degradation of water quality and potential indirect effects on prey resources from pollutant exposure. However, these impacts cannot be quantified with certainty. Overall, based on the operational stormwater discharges of the project, the project is **not likely to adversely affect** coastal pelagic EFH.

7.6.3 Pacific Salmon Essential Fish Habitat

Operational stormwater discharges would result in an incremental degradation of water quality and potential indirect effects on prey resources from pollutant exposure. However, these impacts cannot be quantified with certainty. Overall, based on the operational stormwater discharges of the project, the project **is not likely to adversely affect** Pacific salmon EFH.

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Appendix A
Species Lists

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Washington Fish And Wildlife Office
510 Desmond Drive Se, Suite 102
Lacey, WA 98503-1263
Phone: (360) 753-9440 Fax: (360) 753-9405

In Reply Refer To: 04/24/2024 21:21:40 UTC
Project Code: 2024-0081720
Project Name: Seattle-Tacoma International Airport: SAMP NTPs and PSPs

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological

evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

https://www.fws.gov/sites/default/files/documents/endangered-species-consultation-handbook.pdf

Migratory Birds: In addition to responsibilities to protect threatened and endangered species under the Endangered Species Act (ESA), there are additional responsibilities under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA) to protect native birds from project-related impacts. Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). For more information regarding these Acts, see https://www.fws.gov/program/migratory-bird-permit/what-we-do.

The MBTA has no provision for allowing take of migratory birds that may be unintentionally killed or injured by otherwise lawful activities. It is the responsibility of the project proponent to comply with these Acts by identifying potential impacts to migratory birds and eagles within applicable NEPA documents (when there is a federal nexus) or a Bird/Eagle Conservation Plan (when there is no federal nexus). Proponents should implement conservation measures to avoid or minimize the production of project-related stressors or minimize the exposure of birds and their resources to the project-related stressors. For more information on avian stressors and recommended conservation measures, see https://www.fws.gov/library/collections/threats-birds.

In addition to MBTA and BGEPA, Executive Order 13186: *Responsibilities of Federal Agencies to Protect Migratory Birds*, obligates all Federal agencies that engage in or authorize activities that might affect migratory birds, to minimize those effects and encourage conservation measures that will improve bird populations. Executive Order 13186 provides for the protection of both migratory birds and migratory bird habitat. For information regarding the implementation of Executive Order 13186, please visit https://www.fws.gov/partner/council-conservation-migratory-birds.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Code in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List

OFFICIAL SPECIES LIST

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

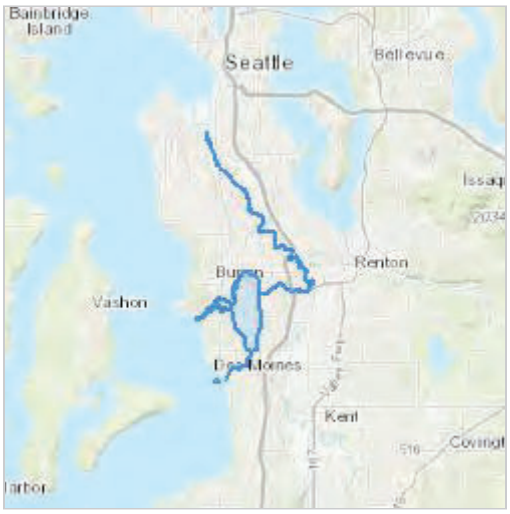
This species list is provided by:

Washington Fish And Wildlife Office
510 Desmond Drive Se, Suite 102
Lacey, WA 98503-1263
(360) 753-9440

PROJECT SUMMARY

Project Code: 2024-0081720
Project Name: Seattle-Tacoma International Airport: SAMP NTPs and PSPs
Project Type: Airport - Maintenance/Modification
Project Description: Species list request for updated 2024 SAMP NTP and PSP projects. Revised action area reflects expanded project list and potential for exposure to 6PPD-Q in stormwater and industrial wastewater discharge.
Project Location:

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@47.40305635,-122.33736132583623,14z



Counties: King County, Washington

ENDANGERED SPECIES ACT SPECIES

There is a total of 6 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

MAMMALS

NAME	STATUS
North American Wolverine *Gulo gulo luscus*	Threatened

No critical habitat has been designated for this species.
Species profile: https://ecos.fws.gov/ecp/species/5123

BIRDS

NAME	STATUS
Marbled Murrelet *Brachyramphus marmoratus*	Threatened

Population: U.S.A. (CA, OR, WA)
There is **final** critical habitat for this species. Your location does not overlap the critical habitat.
Species profile: https://ecos.fws.gov/ecp/species/4467

Yellow-billed Cuckoo *Coccyzus americanus*	Threatened

Population: Western U.S. DPS
There is **final** critical habitat for this species. Your location does not overlap the critical habitat.
Species profile: https://ecos.fws.gov/ecp/species/3911

REPTILES

NAME	STATUS
Northwestern Pond Turtle *Actinemys marmorata*	Proposed Threatened

No critical habitat has been designated for this species.
Species profile: https://ecos.fws.gov/ecp/species/1111

FISHES

NAME	STATUS
Bull Trout *Salvelinus confluentus*	Threatened

Population: U.S.A., coterminous, lower 48 states
There is **final** critical habitat for this species. Your location overlaps the critical habitat.
Species profile: https://ecos.fws.gov/ecp/species/8212

INSECTS

NAME	STATUS
Monarch Butterfly *Danaus plexippus*	Candidate

No critical habitat has been designated for this species.
Species profile: https://ecos.fws.gov/ecp/species/9743

CRITICAL HABITATS

There is 1 critical habitat wholly or partially within your project area under this office's jurisdiction.

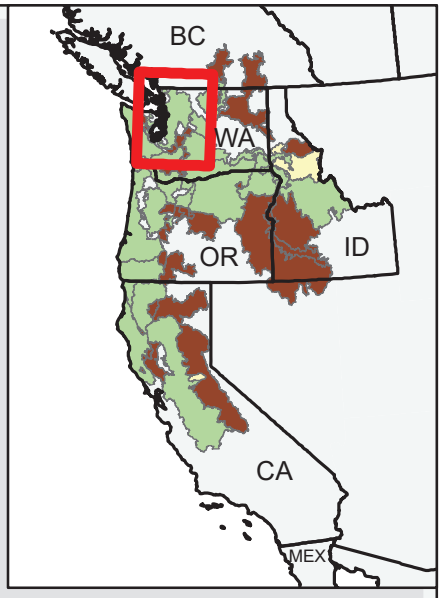
NAME	STATUS
Bull Trout *Salvelinus confluentus* https://ecos.fws.gov/ecp/species/8212#crithab	Final

IPAC USER CONTACT INFORMATION

Agency:	Federal Aviation Administration
Name:	Eric Doyle
Address:	146 N Canal St
Address Line 2:	Suite 111
City:	Seattle
State:	WA
Zip:	98103
Email	eric.doyle@confenv.com
Phone:	2063217314

Puget Sound Chinook Salmon Evolutionarily Significant Unit

Current as of January 2015



Nooksack River
North Fork Nooksack River
Bellingham
Skagit River
North Fork Stillaguamish River
South Fork Stillaguamish River
Port Angeles
Glines Canyon Dam
Dungeness River
Elwha River
Everett
Sultan River
Snohomish R.
North Fork Skykomish River
Skykomish River
Dosewallips River
Seattle
North Bend
Cushman Dam
SF Skokomish R.
Green River
Howard Hanson Dam
Tacoma
Puyallup River
Olympia
Nisqually River
La Grande Dam

County Boundary

Class

ESU Boundary

Historical Watershed: Anthropogenically Blocked

N

0 22.5

Kilometers

0 22.5

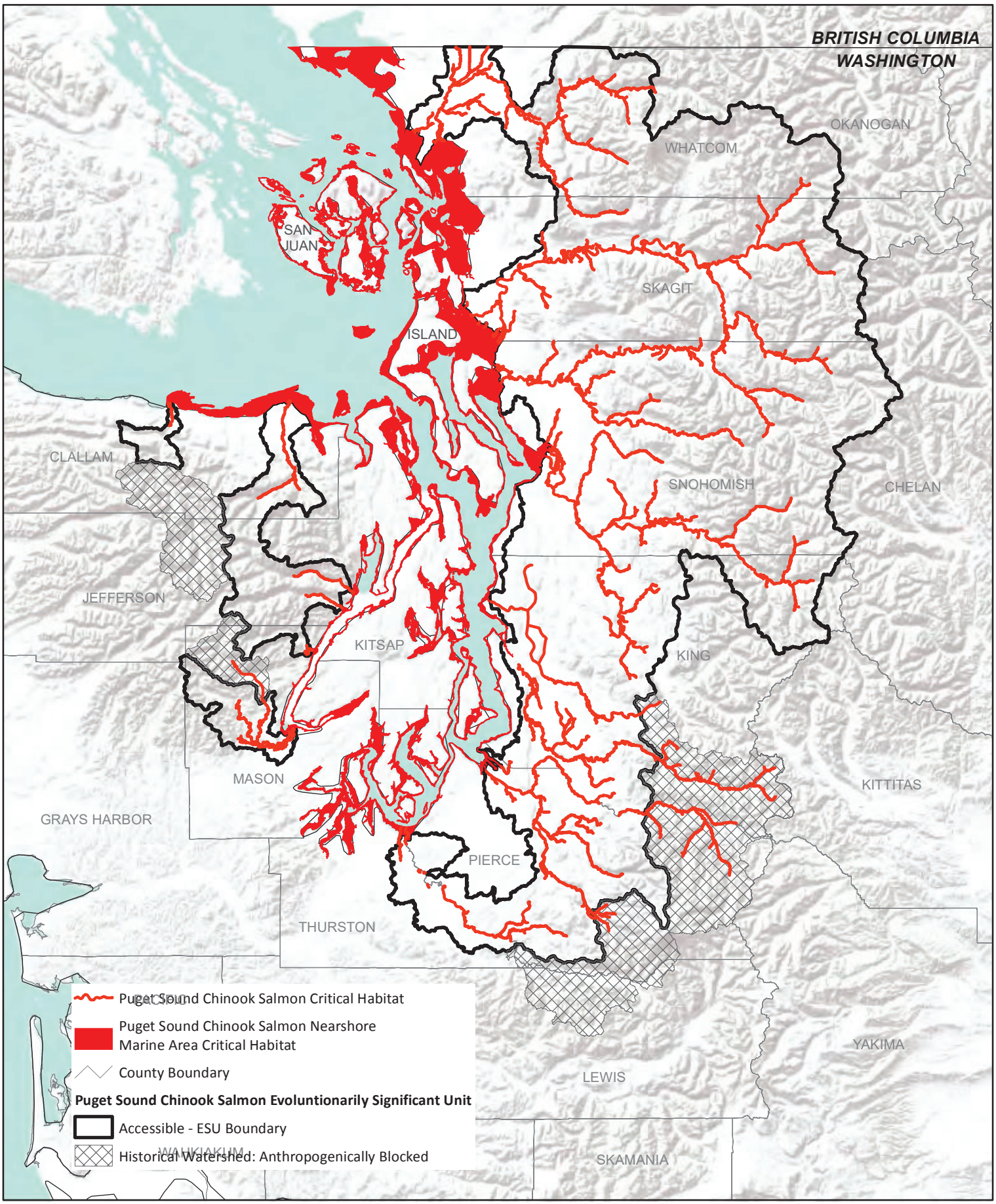
Miles

Map is for general reference only

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmosphperic Administration
NATIONAL MARINE FISHERIES SERVICE
PROTECTED RESOURCES DIVISION
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232

NOAA FISHERIES

Critical Habitat
Puget Sound Chinook Salmon



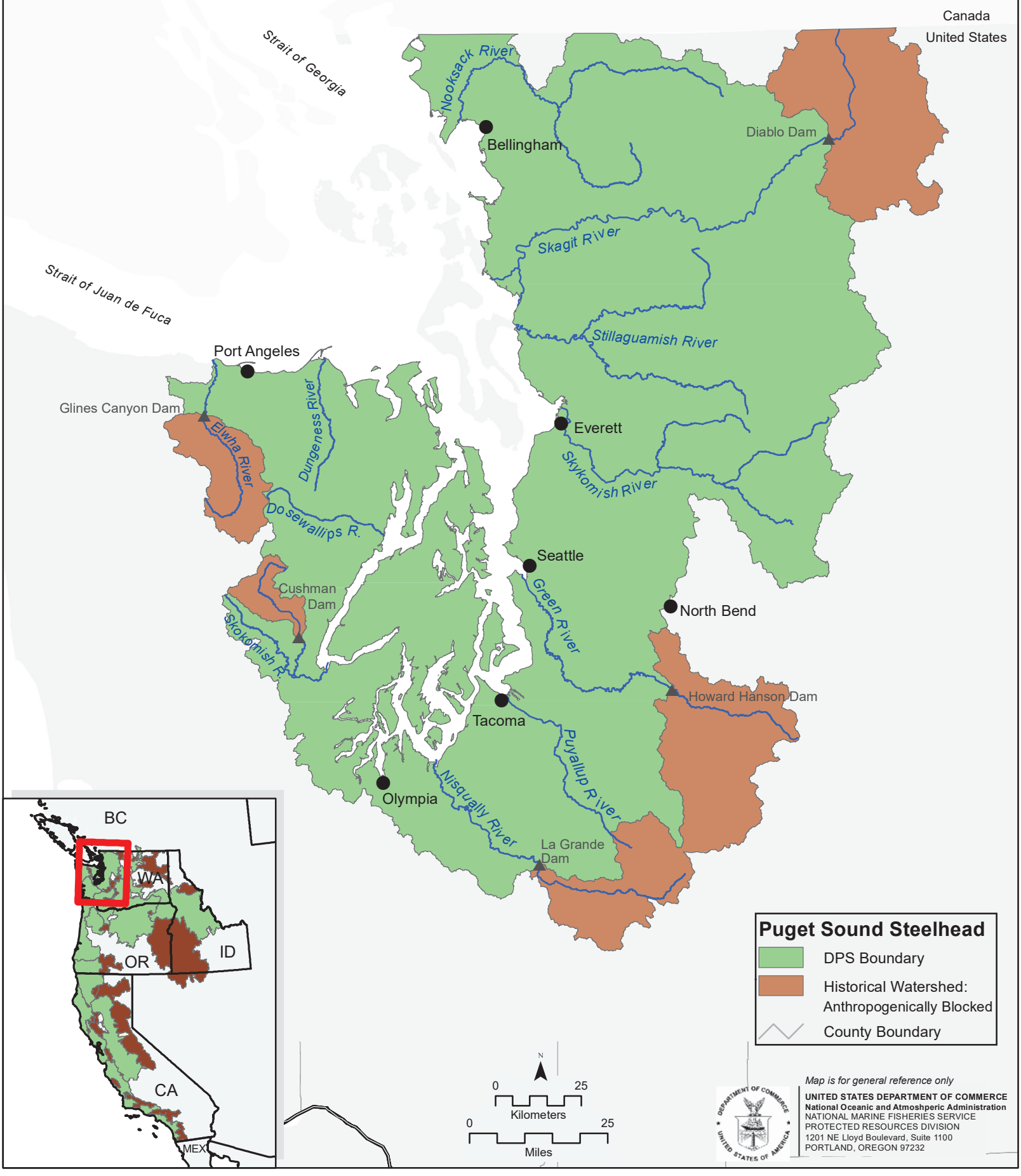
0 50 Miles

See Federal Register Notice for detailed description of critical habitat (70 FR 52630)

DOC-NOAA Fisheries-West Coast Region

Puget Sound Steelhead Distinct Population Segment

Current as of January 2013

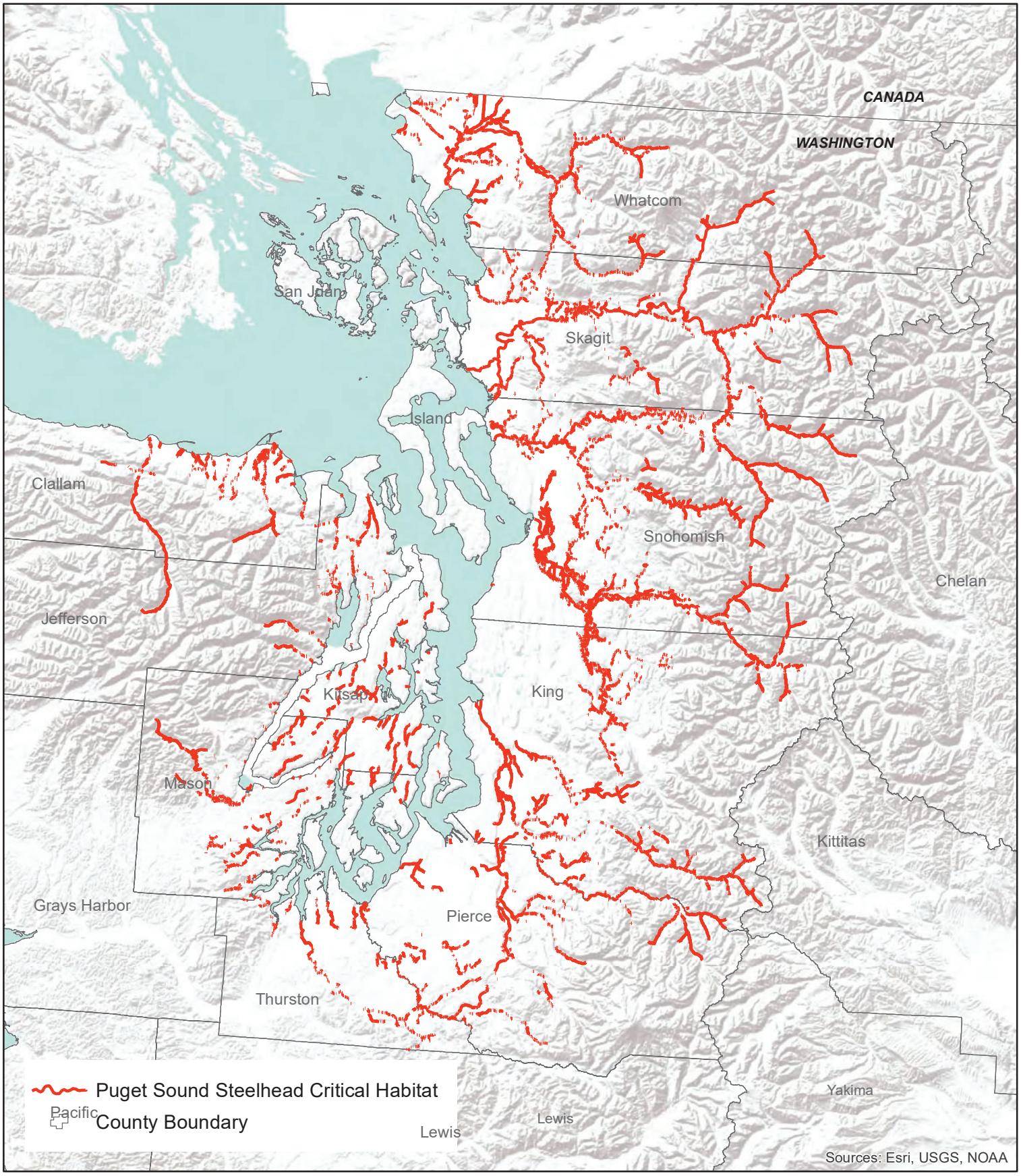


Map is for general reference only

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmoshperic Administration
NATIONAL MARINE FISHERIES SERVICE
PROTECTED RESOURCES DIVISION
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232

NOAA FISHERIES

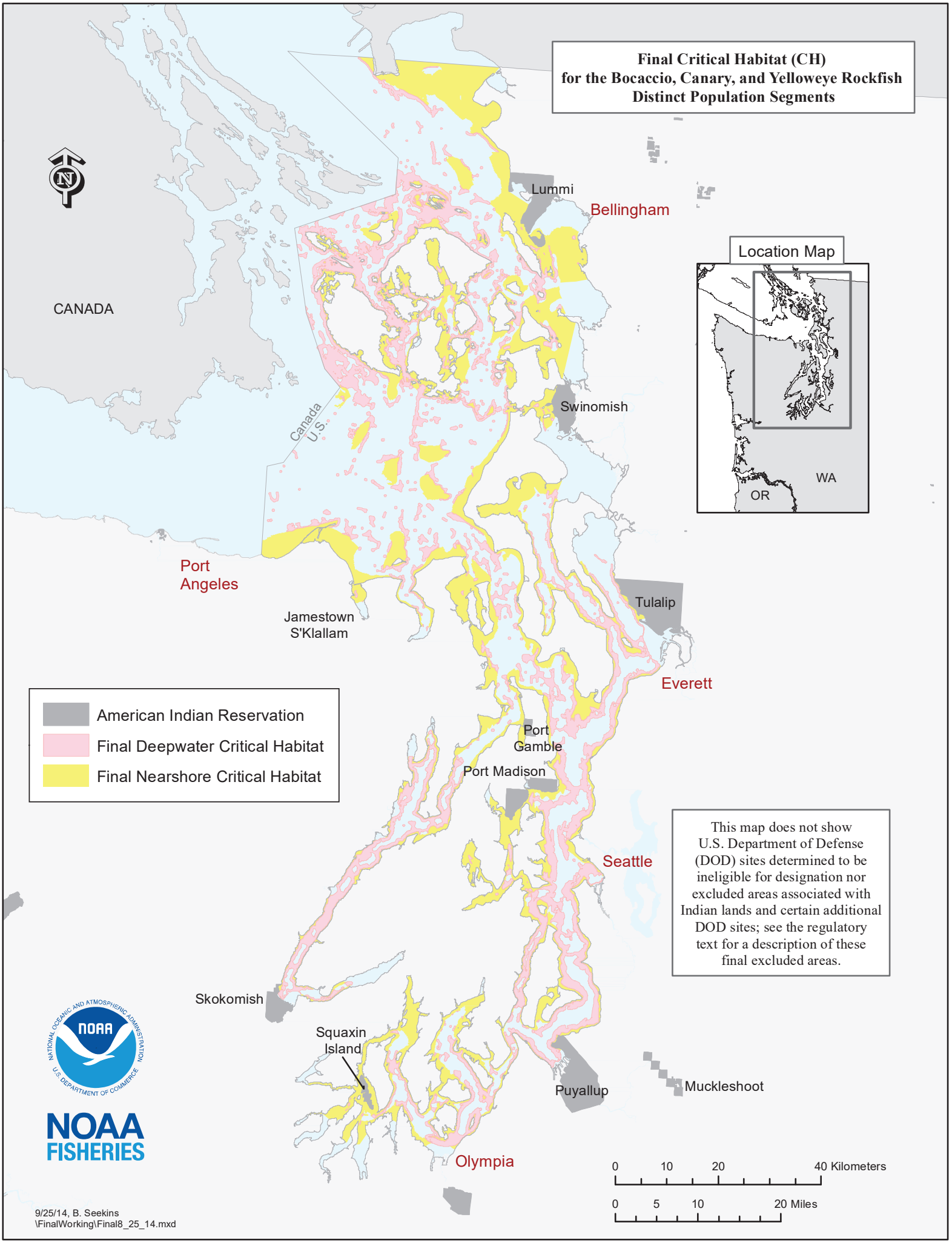
Final Critical Habitat
Puget Sound Steelhead



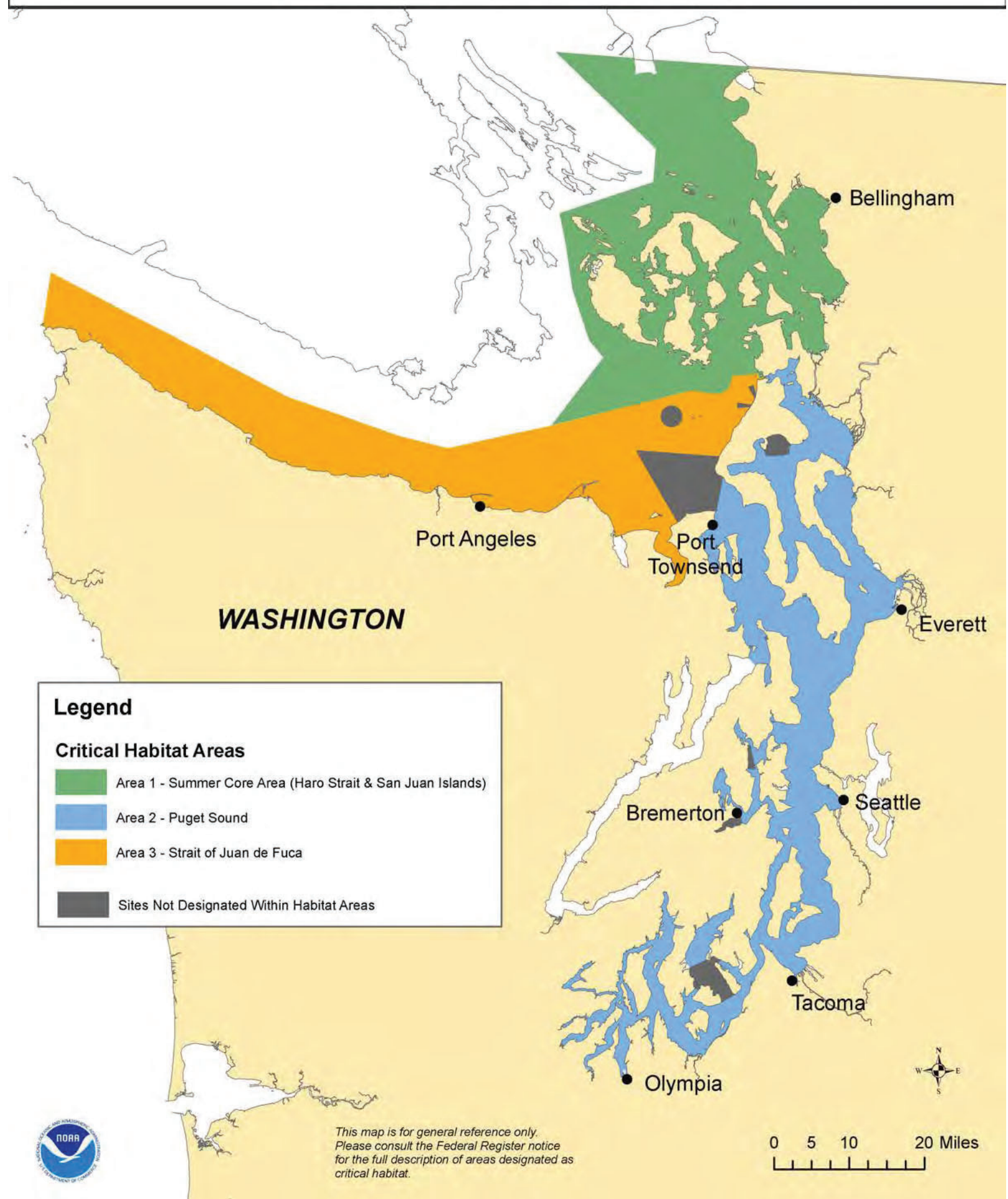
N

0 3.5 7 14 Miles

See Federal Register notice for detailed description of critical habitat (81 FR 9252, February 24, 2016)
DOC-NOAA Fisheries-West Coast Region


Final Critical Habitat (CH)
for the Bocaccio, Canary, and Yelloweye Rockfish
Distinct Population Segments
CANADA
Lummi
Bellingham
Location Map
WA
OR
Swinomish
Canada
U.S.
Port
Angeles
Jamestown
S'Klallam
Tulalip
Everett
American Indian Reservation
Final Deepwater Critical Habitat
Final Nearshore Critical Habitat
Port
Gamble
Port Madison
Seattle
This map does not show U.S. Department of Defense (DOD) sites determined to be ineligible for designation nor excluded areas associated with Indian lands and certain additional DOD sites; see the regulatory text for a description of these final excluded areas.
Skokomish
Squaxin
Island
Puyallup
Muckleshoot
Olympia
0 10 20 40 Kilometers
0 5 10 20 Miles
NOAA
FISHERIES
9/25/14, B. Seekins
\FinalWorking\Final8_25_14.mxd

Designated Critical Habitat for Southern Resident Killer Whales
November 2006
NOAA Fisheries, Northwest Region



This map is for general reference only. Please consult the Federal Register notice for the full description of areas designated as critical habitat.

Appendix B

SEA Water Quality Compliance Monitoring

IWS
PERMIT LIMITS

NPDES LIMITS

TABLE S1-1. IWS FLOW EFFLUENT LIMITS

OUTFALL 001 DISCHARGE TO PUGET SOUND		
Parameter	**Monthly Average**	**Maximum Daily**
Biochemical Oxygen Demand (BOD_5) November through March	45 mg/L	2665 lbs/day
Biochemical Oxygen Demand (BOD_5) April through October	25 mg/L	1480 lbs/day
Total Suspended Solids (TSS)	21 mg/L	33 mg/L
Oil and Grease as NWTPH-Dx	8 mg/L	15 mg/L
pH [b]	Daily minimum is equal to or greater than 6, and the daily maximum is less than 9.	

Footnotes:

[a] The monthly average effluent limits is based on the arithmetic mean of the samples taken during a calendar month.

[b] Indicates the range of permitted values. When pH is continuously monitored, excursions between 5.0 and 6.0, or 9.0 and 10.0 shall not be considered violations provided no single excursion exceeds 60 minutes in length and total excursions do not exceed 7 hours and 30 minutes per month. Any excursions below 5.0 and above 10.0 are violations. The instantaneous maximum and minimum pH must be reported monthly

S7. FACILITY LOADING

A. Design Criteria

Flows or waste loadings of the following design criteria for the permitted treatment facility must not be exceeded:

Daily Peak Flow @ Maximum Overflow Rate of 4.1 GPM/SF of Dissolved Air Flotation Surface Area	**7.1 MGD**

SANITARY SEWER
PERMIT LIMITS

Midway Sewer Discharge

TABLE S1-2: EFFLUENT LIMITS FOR MIDWAY SEWER DISCHARGE

Parameter	Average Monthly [a]	Maximum Daily [b]
Flow – GPD		
Boiler Blowdown - MBBD	1,000	15,000
Cooling Tower Blowdown - MTBD	18,000	250,000
Equipment Wash Rack Blowdown - EWBD	20,000	20,000
Bus Maintenance Facility Bus Wash & Chassis Blowdown - BWBD	4380	17,260
Oil and Grease – Equipment Wash Rack Blowdown, Bus Maintenance Facility Bus Wash & Chassis Blowdown	**N/A**	100 mg/L
pH – Equipment Wash Rack, Bus Maintenance Facility Bus Wash & Chassis Blowdown	Daily minimum is equal to or greater than 6, and the daily maximum is less than 9 standard units.	

[a] Daily flows averaged over a month.

[b] The maximum daily effluent limitation is defined as the highest allowable daily discharge. The daily discharge means the discharge of a pollutant measured during a calendar day. For pollutants with limits expressed in units of mass, the daily discharge is calculated as the total mass of the pollutant discharged over the day. For other units of measurement, the daily discharge is the average measurement of the pollutant over the day.

SDS
PERMIT LIMITS

TABLE 2S1-2: EFFLUENT LIMITS FOR INDUSTRIAL STORMWATER COMMON TO ALL OUTFALLS.

PARAMETER	DAILY MAXIMUM LIMITS - All Outfalls	SAMPLING FREQUENCY[1]		SAMPLING TYPE
		SDE4/S1, SDD05A, SDD05B	All Other Outfalls	
Turbidity[3]	25 NTU	2/Qtr	1/Qtr	Grab
pH	Between 6.5 - 8.5 S.U.	2/Qtr	1/Qtr	Grab
pH[4]	6.3 to 9.0 S.U. for outfalls SDN3A, SDW1A, SDW1B and SDW2	2/Qtr	1/Qtr	Grab
Oil and Grease (by NWTPH-Dx)	15 mg/L	2/Qtr	1/Qtr	Grab
Oil and Grease	No Visible Sheen	2/Qtr	1/Qtr	Visual
Ammonia[5]	14.7 mg/L	2/Qtr	1/Qtr	Comp[2]
Nitrate/Nitrite as N[5]	0.68 mg/L	2/Qtr	1/Qtr	Comp[2]
Priority Pollutants[6]	Report	2/year in year 3 of the permit		Comp[2]

TABLE 2S1-3: SITE SPECIFIC EFFLUENT LIMITS FOR INDUSTRIAL STORMWATER

PARAMETER	DAILY MAXIMUM LIMITS - Outfalls by Receiving Water						SAMPLING FREQUENCY[1]		SAMPLING TYPE
	Des Moines Creek - East Branch	Lake Reba	Northwest Ponds		Miller Creek	Walker Creek			
	SDE4/S1, SDD06A, SDD05A, SDD05B	SDN1, SDN2/3/4	SDS3/5, SDS6/7	SDS4	SDN3A, SDW1A, SDW1B	SDW2	SDE4/S1, SDD05A, SDD05B	All Other Outfalls	
Total Copper (µg/L)	25.6	28.5	32.2	32.2	59.2	47.9	2/Qtr	1/Qtr	Comp[2]
Total Zinc (µg/L)	117	117	117	71.4	117	117	2/Qtr	1/Qtr	Comp[2]

[1] Sampling frequency for new outfalls SDD05A and SDD05B (upon activation) is 2 storms/quarter, the second sample is required for a discharge at least 24 hours after the first. Sampling frequency for outfall SDE4/S1) is 2 storms/quarter for period (October – June) and 1 storm/quarter for period (July – September).

[2] Flow-weighted composite

[3] Turbidity effluent limits are at the end of the pipe. When this limit is exceeded, Permittee may conduct in-stream sampling (i.e., upstream and downstream) to assess turbidity and evaluate its compliance with water quality criteria.

[4] pH as low as 6.3 and as high as 9.0 shall not be considered a violation if results of concurrent sampling at the point of complete mix within the receiving water indicates pH range of 6.5 - 8.5 S.U.

[5] Required only if urea is applied. If urea is not applied, Permittee must certify it.

[6] See Appendix A to identify the specific pollutants in the priority pollutant groups listed. The Permittee must take samples twice per year, once during wet season and once during dry season in year 3 of the permit cycle, and submit the report to Ecology 180 days prior to permit expiration in conjunction with permit application.

CSW
PERMIT LIMITS

TABLE 2

EFFLUENT LIMITS	
Parameter	**Maximum Daily [a]**
Turbidity	**Turbidity in the** receiving water **must not exceed 5 nephelometric turbidity units (NTU) over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU.**[b]
Turbidity [c] (Batch or Continuous Treatment)	The maximum daily average must not exceed 5 NTU. [d]
Total Petroleum Hydrocarbons	5 mg/L - No visible sheen at any time [e]
pH (Batch or Continuous Treatment)	In the range of 6.5 to 8.5
pH [f]	In the range of 6.5 to 8.5 – With the human-caused variation within the above range of less than 0.2 units.

[a] The maximum daily effluent limitation is defined as the highest allowable daily discharge.

[b] In the **receiving water** here means at the point of complete mix to be determined by the Permittee.

[c] The treatment referred here is for batch or continuous treatment as specified by the DOE-SWMM, DOE Stormwater Treatment Technologies Approved through TAPE or CTAPE.

The average daily effluent limitation is based on the arithmetic mean of number of samples taken per day from the continuous discharge, or in case of batch treatment, based on the number of batch discharged per day.

[d] The maximum daily average is defined as maximum value of daily averages taken during a calendar month.

[e] TPH numerical limit must be applied and a sample must be taken only when visible sheen is observed. The numerical limit will not apply when there is no visible sheen observed.

[f] Indicates the range of permitted values. In the receiving water here means at the point of complete mix to be determined by the Permittee.

Footnotes:

(1) The method detection level (MDL) for turbidity is 1 NTU using a turbidimeter and Method Number 180.1 from 40 CFR Part 136 or *Standard Methods for the Examination of Water and Wastewater*, 18th Edition, 2130.

(2) The MDL for total petroleum hydrocarbons in 0.1 mg/L using Gas Chromatography and Flame Ionization Detector (FID) and method number Northwest Diesel (WTPH-D) from Washington State Department of Ecology Method WTPH-D. The quantitation level (QL) for TPH-D is 0.5 mg/L (5 x MDL).

Appendix C

Impacts Assessment for Aquatic Critical Areas

Parametrix
let's create tomorrow, together

Technical Memorandum

DATE:	May 22, 2024
TO:	Adele Pozzuto and Steve Rybolt, Port of Seattle
FROM:	Kaylee Moser, PWS and Josh Wozniak, PWS
SUBJECT:	Sustainable Airport Master Plan (SAMP) Impacts Assessment for Aquatic Critical Areas
CC:	Sarah Potter and Erik Schwenke, Landrum & Brown
PROJECT NUMBER:	553-2912-002
PROJECT NAME:	Sustainable Airport Master Plan (SAMP)

This memo describes estimated project impacts to aquatic critical areas based on the current designs for the Near-Term Projects (NTP). Impacts were calculated by overlaying the footprint of these NTPs and associated utility features provided by Landrum & Brown with mapped aquatic critical areas. Sources of mapped aquatic critical areas used in this analysis include:

- Wetland and streams delineated within the study areas (Parametrix 2024).
- Wetland and stream mapping provided by the Port for areas outside of the delineation study areas.
- Wetland and stream buffers created in compliance with SeaTac Municipal Code
- Wellhead protection areas and floodplains sourced from King County, City of SeaTac (SeaTac) and the Federal Emergency Management Agency (FEMA).

Impact assessments are based on the overlap between these GIS datasets and the NTP footprints. This memo provides only the spatial overlay of the projects with these features, pending further design refinement or technical studies. This memo and impact assessment provides information to the planning and design team, alerting them to potential aquatic critical area issues within certain portions of the NTP footprints.

Critical Areas Jurisdiction

The Port has its own jurisdiction over critical areas, and activities that affect critical areas at the Airport are not subject to municipal permit review. However, the Port substantially complies with local critical area codes to the extent practicable. The 2018 Port-SeaTac Interlocal Agreement (ILA) states that the City of SeaTac critical area regulations and standards shall apply to Port projects on Port property within the Airport Activity Area (AAA), with the exception of certain situations listed within the ILA (Port of Seattle 2018). The major exception is that if 401/404 or Hydraulic Project Act permitting is required for a project, the City's critical area regulations shall not apply. The Port administers permitting under these provisions for projects within the AAA as indicated by the 2018 Port-SeaTac ILA. The City implements critical area standards for Port projects on property outside the AAA. The Port will administer all of the critical areas permits except for projects in the North Study Area Zone, which is within City of SeaTac jurisdiction. This portion of the study area is directly north of State Route (SR) 518 (See Figure 1-1 Vicinity Map in Attachment A).

The City of SeaTac regulates the following aquatic critical areas under Chapter 15.700:

- Flood hazard areas
- Wetlands
- Stream
- Wellhead protection areas (WHPAs)
- Fish and wildlife habitat conservation areas

Overview of Project Impacts to Aquatic Critical Areas

The mapped aquatic critical areas within the study area include wetland, stream, floodways, WHPAs, and fish and wildlife habitat conservation areas. These layers were mapped by Parametrix or downloaded from the GIS data sites of government agencies, including the City of SeaTac, King County, and FEMA. The NTP footprints do not have any impacts on the mapped floodway or 100-year floodplain, nor are impacts to fish and wildlife habitat conservation areas anticipated to occur. The NTP footprints, utility lines, and stormwater ponds do have impacts to WHPAs, jurisdictional tributaries, wetlands, streams, and their associated buffers. Three WHPAs are mapped within the study area. The impacts to WHPAs were calculated based on a 10- year contaminant travel time. Wetlands and streams mapped within the study area were delineated between September and December 2019 and in March 2020, with a wetland and waters verification in January 2024. The mapped wetlands and streams within the study area drain into the Miller/Walker Creek, Gilliam Creek/Lower Green River, and Des Moines Creek drainage basins.

The NTPs are divided into five project groups: Airfield Operational Efficiency Projects, Airfield Safety/Standards Projects, Cargo Expansion Projects, North Terminal Projects, and Sustainable Aviation Fuel Projects. There is also associated utility infrastructure, including new stormwater ponds and 10 types of utility lines to be installed for the projects. Only the project elements that have impacts to aquatic critical areas are discussed in this memorandum. Permanent impacts to aquatic critical areas from utility line installation were calculated based on a 20- foot-wide buffer polygon applied to individual utility lines. Access roads are assumed to be 30 feet wide, with 5 feet of temporary disturbance on each side during construction, except in the vicinity of the Miller Creek crossing, where temporary disturbance extends to the limits of a covenant boundary that restricts impacts (20-50 feet). Temporary construction impact areas to critical areas were calculated based on a 50-foot buffer polygon applied to NTP footprints and stormwater ponds.

Impacts were specifically calculated so that there was no double counting for project elements that overlap spatially. In particular, for areas where permanent impacts from NTPs and utility lines overlapped, permanent “impact values” (acreages of impact) were assigned to the NTPs. As an example, consider a theoretical NTP served by an upgraded water line. The NTP would impact 0.5 acres of wetland. The new theoretical water line would impact 0.1 acre of the wetland inside the NTP footprint. Therefore, the water line impact would not be counted because it has already been included as an NTP impact. For areas where permanent impacts from new stormwater ponds and utility lines overlapped, permanent impact values were assigned to stormwater ponds. Where permanent and temporary buffer impacts overlapped, impact values were assigned to the project element that was permanent.

Table 1 summarizes the total permanent and temporary construction impacts for the NTP footprints, utility lines, and stormwater ponds within critical areas and associated buffers. Tables 2, 3, and 4 provide further details on permanent and temporary impacts for NTP footprints, utility lines, and stormwater ponds. In Tables 1 and 4 stream buffer impacts overlap wetland buffer impacts in some

areas but are accounted for separately. Also, all buffers have existing development such as buildings and impervious surfaces clipped out for the impact analysis.

See Attachment A for Figures 1-1 through 1-6d, displaying a vicinity map and the location of NTP footprints, utilities, stormwater ponds, and impacts to aquatic critical areas.

Table 1. Overview of Impacts to Aquatic Critical Areas and Buffers (acres)

Aquatic Critical Areas and Buffers	Permanent Impacts	Temporary Impacts
Stream/Jurisdictional Tributaries	0.02	0.08
Stream Buffer	0.12	0.20
Wetland	0.79	0.21
Wetland Buffer	2.66	3.43
Wetland, Stream and Buffer Total	**3.59**	**3.92**
Wellhead Protection Area	52.10	7.55

The current project design results in a total of 0.79 acres of permanent wetland impacts for all NTP footprints, utility lines, and stormwater ponds. Permanent stream/ jurisdictional tributary impacts—associated with the West Maintenance Campus access road—total 0.02 acre. Permanent wetland and stream buffer impacts total 2.66 acres and 0.12 acre, respectively. Temporary construction impacts, which would be restored after construction is complete, total 3.92 acres for wetland, stream, and buffer. Projects would protect WHPAs from groundwater contamination, as required by the State of Washington Department of Health. Based on the current spatial analysis, permanent WHPA impacts are estimated at 52.10 acres, with temporary construction impacts totaling 7.56 acres. Additional analysis of WHPA impacts will be conducted during design development for individual projects, and specific measures to protect WHPAs will be integrated into project designs as appropriate.

Permanent Impacts

Permanent project impacts are a result of excavation and fill to construct the NTPs, associated utility lines, and stormwater ponds. Permanent impacts for utility lines were calculated based on an assumption of a 20-foot-wide buffer polygon, as discussed with Landrum & Brown. Project impacts are a combination of impacts from the NTPs, as well as associated infrastructure. Impacts for NTP projects and associated infrastructure are broken down and described below.

The NTP footprints permanently impact a total of 0.23 acre of wetland and 2.31 acres of wetland buffer. Additionally, the NTP footprints permanently impact 0.01 acre of stream and impact 0.07 acre of stream buffer.

Associated infrastructure improvements (utility lines and stormwater ponds) permanently impact 0.56 acres of wetlands and 0.35 acres of wetland buffer. The infrastructure projects permanently impact 0.05 acre of stream buffer and 0.01 acre of streams/ jurisdictional tributaries. See Figure 1-4 for locations of permanent NTP impacts and Figure 1-5 for permanent utility/stormwater impacts.

Table 2 details the impacts to critical areas and buffers for individual project elements and sums up permanent impacts. Only the individual projects that have impacts to aquatic critical areas are listed.

Table 2. Permanent Impacts to Aquatic Critical Areas and Buffers (acres)

Project Element	Streams/ Jurisdictional Tributaries	Stream Buffer	Wetland	Wetland Buffer	WHPAs
Employee Parking Structure	--	--	0.02	0.60	--
Fuel Farm Expansion	--	--	0.21	0.01	--
North GT Holding Lot	--	--	--	--	5.02
Off-site Cargo PH 1 (L-Shape)	--	--	--	--	34.08
Off-site Cargo PH 2 (L-Shape)	--	--	--	--	3.17
Taxiway A/B Extension	--	--	--	--	6.12
Westside Maintenance Campus	0.01	0.07	<0.01	1.70	--
NTP Projects Subtotal	***0.01***	***0.07***	***0.23***	***2.31***	***48.39***
Stormwater Pond (Miller Creek detention pond)	--	--	0.55**	--	--
Stormwater Pond (Pond M)	--	--	--	0.11	--
Stormwater Pond (Pond F detention pond)	--	--	--	<0.01	--
Stormwater Pond (SDS4 pond)	--	--	--	<0.01	0.13
Sanitary Sewer Lines	--	--	--	0.01	2.24
Storm Lines	0.01	0.05	0.01	0.23	1.33
Water Lines	--	--	--	--	--
Infrastructure Improvements Subtotal	***0.01***	***0.05***	***0.56***	***0.35***	***3.71***
Grand Total*	***0.02***	***0.12***	***0.79***	***2.66***	***52.10***

Impacts values in the table are rounded from more detailed calculations. The grand total is rounded from the calculated grand total, not the sum of the individualrounded values presented in the table.
** Future design may include a vault, reducing or eliminating this impact.

Table 3 below summarizes all permanent wetland impacts by project element and Wetland ID (as identified in the Port wetland GIS layers and the 2024 Parametrix report).

Table 3. Permanently Impacted Wetlands

Project Element	Wetland Impact (acre)	Wetland ID	2014 Ecology Rating [a]
Employee Parking Structure	0.02	Wetland A	III
Westside Maintenance Campus	<0.01	Wetland 39	III
Stormwater Pond (Miller Creek detention pond)	0.55**	Wetland A20	III
Fuel Farm Expansion	0.21	Wetland E1	III
Storm (UMP Line)	<0.01	Wetland A14	III
	0.01	Wetland 44	II
	<0.01	Wetland A20	III
	<0.01	Wetland R13	II
	<0.01	Wetland R14a	II
Grand Total*	***0.79***		

[a] Hruby and Yahnke 2023
* Impacts values in the table are rounded from more detailed calculations. The grand total is rounded from the calculated grand total, not the sum of theindividual rounded values presented in the table.** Future design may include a vault, reducing or eliminating this impact.

Wetlands having the greatest permanent impact include Wetland E1, Wetland A20, and Wetland A. Wetland E1 is a Category III wetland permanently impacted by the Fuel Farm Expansion project within the Sustainable Aviation Fuel Project group (See Figure 1-6c in Attachment A). This wetland would be entirely impacted. Wetland A20 is a Category III wetland located near the WMC project and is fully permanently impacted by UMP projects including a stormwater pond (See Figure 1-6d in

Attachment A). Wetland A is a Category III wetland also located at the north end of the study area and is permanently impacted by the Employee Parking Structure (See Figure 1-6a in Attachment A).

More detailed information on these wetlands can be found within the Seattle-Tacoma International Airport Sustainable Airport Master Plan (SAMP) Near Term Projects Wetlands and Streams Report (Parametrix 2024).

Temporary Construction Impacts

Temporary construction impacts would occur where aquatic critical areas or buffers are affected by clearing and ground-disturbing work but are revegetated following construction. Temporary construction impacts were calculated based on the assumption of a 50-foot buffer polygon applied to NTP footprints and stormwater ponds, as discussed with Landrum & Brown. The temporary construction impacts for the WMC access road were calculated based on a 5- foot buffer from the edge of the road. At the Miller Creek stream crossing, the temporary construction impacts were extended to meet the boundaries of the restrictive covenant on either side of the road. The duration of temporary construction impacts is unknown at this time, and, therefore, temporary construction impacts are not further divided into short-term versus long-term.

The temporary construction impacts for wetlands are 0.21 acre for NTP footprints. The utility infrastructure projects would have 0.70 acre of temporary wetland buffer impacts. Additionally, 130 linear feet of jurisdictional tributaries would be permanently impacted for the WMC, Miller Creek detention pond, and some proposed utility lines.

Table 4 details the impacts to critical areas and buffers for individual project elements and sums up the temporary construction impacts. Only the individual projects that have temporary impacts to critical areas and/or associated buffers are listed in this table.

Table 4. Temporary NTP Construction Impacts to Aquatic Critical Areas and Buffers (acres)

Project Element	Stream	Stream Buffer	Wetland	Wetland Buffer	WHPAs
Employee Parking Structure	--	--	0.04	0.55	0.31
Fuel Farm Expansion	0.07	--	0.07	0.35	--
North GT Holding Lot	--	--	--	--	0.24
Off-site Cargo PH 1 (L-Shape)	--	--	--	--	1.79
Taxiway A/B Extension	--	--	--	0.42	4.58
Westside Maintenance Campus	0.01	0.20	0.10	1.41	--
NTP Projects Subtotal	*0.08*	*0.20*	*0.21*	*2.73*	*6.92*
Stormwater Pond (Miller Creek detention pond)	--	--		--	--
Stormwater Pond (Pond F detentionpond)	--	--	--	0.11	--
Stormwater Pond (SDS4 Pond)	--	--	--	0.06	0.63
Stormwater Pond buffer (Pond M)	--	--	--	0.53	--
Infrastructure Improvements Subtotal	*–*	*–*		*0.70*	*0.63*
Grand Total*	*0.08*	*0.20*	*0.21*	*3.43*	*7.55*

* Impact values in the table are rounded from more detailed calculations. The grand total is rounded from the calculated grand total, not the sum of the individual rounded values presented in the table.

Discussion of Impacts by Project Element

The following sections describe impacts for each NTP group and detail individual projects within each group that impact aquatic critical areas and/or buffers. Details on the use and purpose of these individual projects were extracted from the SAMP Facilities Implementation and Financial Feasibility

Technical Memorandum No. 7 and Environmental Overview Technical Memorandum No. 8 (Leigh-Fisher 2018a, 2018b). Utility line and stormwater pond project impacts are also discussed in this section.

Cargo Expansion Projects

The Cargo Expansion Projects group contains three individual projects with impacts to aquatic critical areas and/or associated buffers. Construction of these projects could permanently and temporarily impact WHPAs, wetlands, and wetland/stream buffers.

Land use conversion within a WHPA presents the potential for impact if construction or operation of new projects could result in a release of contaminants to groundwater. However, these impacts can be avoided by project design and operational measures that minimize the risk of contamination. During the project design and permitting phase, detailed geotechnical and hydrogeological assessments will be developed to characterize the potential for groundwater contamination from the proposed projects. The potential of the proposed uses to release contaminants will then be assessed, and appropriate measures applied to minimize any risk of contaminant release. The City of SeaTac requires non-residential developments within WHPAs to submit hazardous material inventory sheets to the respective water district at a minimum of once every two years. In addition, a critical area report may be required with details regarding geologic and hydrogeologic characteristics of the site, groundwater depth, and available historic water quality data. The Port will work with the relevant authorities to comply with all applicable requirements to avoid and/or minimize the potential for contamination.

- Off-site Cargo Phase 1 (L-Shape) – The building would provide warehouse and office space, truck terminals, and parking for visitors and employees. This NTP is located within the WHPA in the northern portion of the Port property. The project results in 34.08 acres of permanent land use conversion in the WHPA and 1.79 acres of temporary construction impacts to the WHPA.
- Off-site Cargo Phase 2 (L-Shape) – The building would provide warehouse and office space, truck terminals, and parking for visitors and employees. This NTP is located within the WHPA in the northern portion of the Airport. The project would result in 3.17 acres of permanent land use conversion in the WHPA.
- Westside Maintenance Campus – This project would relocate the Aviation Maintenance Facility from its current location in the North Cargo area to allow for construction of the Hardstand (north) project. This project would result in 0.01 acre of permanent wetland impact to Wetland 39 and 1.70 acre of permanent wetland buffer impact. The access road into the WMC crosses over Miller Creek and would result in 0.01 acre of permanent stream impact and 0.07 acre of permanent stream buffer impact. Temporary wetland impacts would be 0.1 acre, and temporary wetland buffer impacts would be 1.41 acre (See Figure 1-6d in Attachment A). Temporary stream impact would be 0.01 acre, and temporary stream buffer impact would be 0.20 acre.

North Terminal Projects

The North Terminal Projects group contains two individual projects with impacts to critical areas and/or associated buffers. Construction of these projects could permanently and temporarily impact WHPAs, wetland, and wetland/stream buffer.

- Employee Parking Structure – A large new parking structure would be constructed on Port property adjacent to and west of the North Employee Parking Lot, directly north of SR 518. Construction of this project would result in impacts to Wetland A. Permanent wetland

impacts are 0.02 acre and permanent wetland buffer impacts are 0.60 acre. Temporary construction impacts to the wetland are 0.04 acre and temporary wetland buffer impacts are 0.55 acre. This project is directly adjacent to the WHPA in the northern portion of the Port property and would result in 0.31 acre of temporary construction impacts to the WHPA.

- North Ground Holding (GT) Lot – A new GT lot is needed replace the current lot displaced by the Elevated Busway. This project is located within the WHPA in the northern portion of the Airport. The project results in 5.02 acres of permanent impacts and 0.24 acre of temporary construction impacts to the WHPA.

Fuel Farm Expansion Projects

The Fuel Farm Expansion Projects group includes the Fuel Farm Expansion project, which would have impacts to critical areas and/or associated buffers. Construction of this project would permanently and temporarily impact wetland, stream, and wetland/stream buffer.

Fuel Expansion of the fuel farm would include four new settling tanks, 10 million additional gallons of storage capacity, an approximately 500,000 gallon blending tank, an approximately 100,000-gallon Sustainable Aviation Fuel receipt tank, and infrastructure to support these improvements. The project is located in the southeast portion of the Airport, near the East Fork of Des Moines Creek. Construction would permanently impact the entirety of Wetland E1. Permanent impacts would include 0.21 acre of wetland and 0.01 acre of wetland buffer (See Figure 1-6c in Attachment A).

Taxiway A/B Projects

The Taxiway A/B Projects group contains the Taxiway A/B Extension project, which would have impacts to critical areas and/or associated buffers. Construction of this project would temporarily impact wetland buffers and would require protecting wellhead areas from impacts of contaminant discharge.

The extension of Taxiways A and B to provide access to the south end of Runway 16L/34R includes construction of parallel taxiway connectors from Taxiway B to Runway 16L/34R and the relocation of Taxiway S by 310 feet southward. The project would also include glideslope modifications the construction of a new vehicle service road bridge over S 188th St. Construction would result in 6.12 acres of permanent land use conversion within WHPAs. Temporary impacts would include 0.42 acre of wetland buffer associated with Wetland G12 and 4.58 acres of WHPA.

Utility Lines

As currently designed, the project would result in 0.01 acre of permanent wetland impacts and 0.01 acre of permanent stream impacts associated with stormwater utility lines. Wetlands impacted would include Wetland 44, Wetland A14a, and Wetland A20, all located on the west side of the airport. Additionally, utility lines would result in 0.24 acre of permanent wetland buffer impact for storm and water lines, and 3.57 acres of permanent land use conversion within WHPAs for sanitary sewer and storm lines (See Figure 1-6d in Attachment A).

Stormwater Ponds

The current design for stormwater ponds would result in 0.55 acre of permanent wetland impact. Wetland A20 near the WMC footprint would be entirely impacted by the Miller Creek detention pond (See Figure 1-6d in Attachment A). As the design evolves, it is possible that a vault rather than a stormwater pond will be proposed, reducing or eliminating this impact. New stormwater ponds would result in 0.70 acre of temporary wetland buffer impacts. Stormwater ponds would result in 0.13 acre of permanent land use conversion within WHPAs and would temporarily impact 0.63 acres.

Indirect Impacts

Indirect impacts from construction of the NTPs listed previously may result in long-term wetland degradation from stormwater discharges and alteration in wetland hydrology; however, stormwater detention and treatment activities would minimize long-term indirect water quality impacts on wetlands. Indirect impacts from stormwater ponds may also result in minimal wetland hydrology alteration. For aquatic habitat, indirect impacts would be minimal given the surrounding areas near project impacts are heavily developed.

Mitigation, Avoidance, And Minimization Measures

The avoidance and minimization of impacts to wetlands, streams and buffers was a guiding principle for the preliminary project design. Additional avoidance and minimization measures would be implemented, as practical, as the project design continues to develop. The Port is exploring options to reduce permanent wetland and stream impacts associated with utility lines and to minimize buffer impacts. Additional strategies include minimizing vegetation clearing and restoring temporarily affected areas as soon after the initial impact as possible.

The Port would comply with standard specifications, best management practices (BMPs),[1] and applicable federal and state mitigation requirements during design, construction, and post-construction activities. The Port would meet all regulatory requirements and continue to meet or exceed avoidance and minimization measures related to these BMPs in adherence with federal and state regulations.

[1] BMPs include various methods and devices to control, remove, or reduce pollution, and are listed in the Airport's Stormwater Pollution Prevention Plan (https://www.portseattle.org/file-documents/sea-tac-stormwater-pollution-prevention-plan). BMPs include operational practices (e.g. training and spill prevention), structural controls (e.g. stormwater ponds and oil/water separators), and erosion and sediment controls (e.g. silt fence and filter strips).

For unavoidable permanent impacts to wetlands, streams, temporary impacts to wetlands lasting more than one year, and permanent impacts to associated buffers, the Port would develop a compensatory mitigation plan during the permitting phase in accordance with applicable federal and state requirements and guidelines. These guidelines are listed in the U.S. Army Corps of Engineers and EPA's Compensatory Mitigation for Losses of Aquatic Resources[2], and Ecology's interagency guidance contained in Wetland Mitigation in Washington State: Parts 1 and 2[3]. The Port anticipates that it is has capacity on its current property to construct all or most of the mitigation, while acknowledging that other mechanisms, such as purchasing mitigation credits from banks or in-lieu fee programs, ensure capacity is available to provide the required quantity of mitigation.

The mitigation plan would be developed following a mitigation sequencing approach based on a hierarchy of avoiding and minimizing adverse impacts through careful design, rectifying temporary impacts, and compensating for unavoidable adverse impacts. The specific portfolio of mitigation, including location, design, and timing of permitting and construction, would be developed concurrent with the progression of NTP construction designs, which would be required to adhere to mitigation sequencing guidelines.

In cooperation with resource agencies and tribes, the Port would develop plans to mitigate unavoidable effects of the project on wetlands, streams, and regulatory buffers on a watershed basis. To the extent possible, compensatory mitigation sites would be identified and compensated for lost values in kind. It may be necessary to use several sites and mitigation approaches, given the project size, complexity of identifying mitigation opportunities, and mitigation requirements. The project would adhere to the mitigation requirements, including replacement ratios, specified by federal regulators, state resource agencies, and local critical area codes. Stream impacts are included in the wetland mitigation calculations below.

The Port has seven sites within its ownership identified as being suitable for compensatory mitigation. Proposed mitigation approaches have been evaluated and described based on each sites' opportunities and potential (Anchor 2019). Six sites are within the airport and one site is located along the Green River in Auburn. They encompass over 150 acres and include potential for greater than 40 acres of wetland re-establishment, 11 acres of wetland enhancement, almost 8 acres of preservation, and 80 acres of buffer enhancement (Anchor QEA 2019).

The area needed for compensatory mitigation is dictated by federal and state guidance, with a minimum 1:1 compensation ratio required by the Corps. Some agencies use the credit/debit system (Hruby 2012) to evaluate mitigation is some situations. Table 5 provides a summary of the compensatory mitigation ratios recommended by an interagency review committee composed of the Corps, EPA, and Ecology (Ecology, et al 2021).

Table 5. Interagency Recommended Compensatory Mitigation Ratios for Wetland Impacts

Category and Type of Wetland	Creation or Reestablishment	Rehabilitation	Enhancement
Category I: Mature Forested	6:1	12:1	24:1
Category I: Based on Functions	4:1	8:1	16:1
Category II	3:1	6:1	12:1
Category III	2:1	4:1	8:1
Category IV	1.5:1	3:1	6:1

[2] 33 CFR Parts 325 and 332/ 40 CFR Part 230

[3] *Wetland Mitigation in Washington State Part 1: Agency Policies and Guidance (2021),* and *Part 2: Developing Mitigation Plans* (2006)

Table 6 provides a summary of the compensatory wetland mitigation area calculation anticipated to be requiredby the current preliminary design, based on the unavoidable, permanent impacts to wetlands and the required mitigation ratios. Buffer impacts are mitigated at a 1:1 ratio and would require 2.66 acres.

Table 6. Compensatory Wetland Mitigation Area Calculations

Project Element	Wetland Impact (acre/Rating)	Re-establishment Area Needed (acres)	Rehabilitation Area Needed (acres)	Enhancement Area Needed (acres)
Facilities	0.23/III	0.46	0.92	1.84
UMP Line	0.01/III	0.02	0.04	0.08
Utility Lines	0.01/II	0.03	0.06	0.12
StormwaterPonds	0.55/III	1.10	2.75	4.40
	Total Areas	**1.61**	**3.77**	**6.44**

Based on these calculations, the mitigation areas identified by the Port have sufficient capacity to provide theneeded compensatory mitigation for the anticipated impacts of the proposed action.

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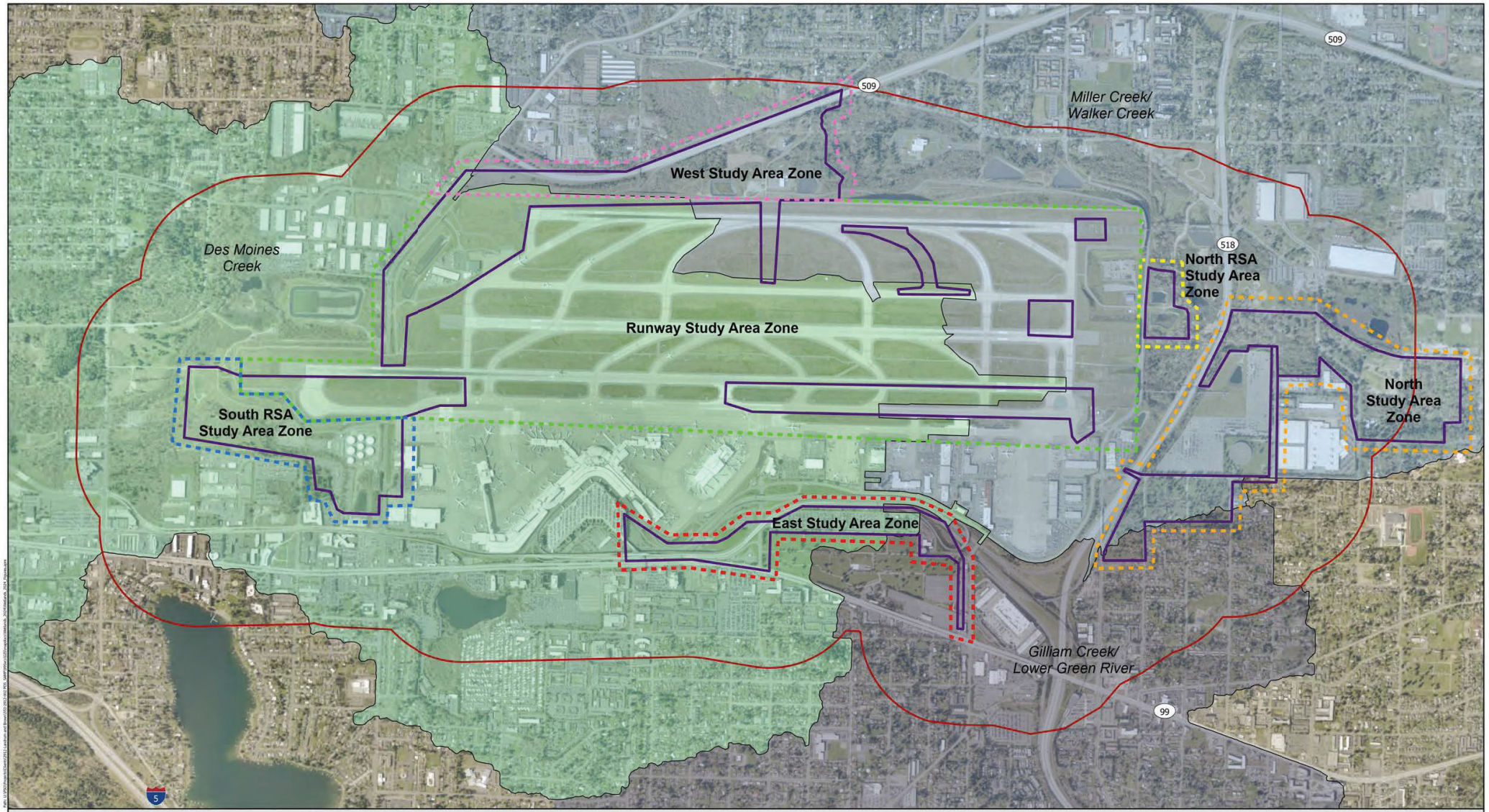
Attachment A

Figures



Parametrix

Date: 2/12/2024
Sources: King County, King County Aerial (2021)
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0 0.13 0.25 0.38 0.5 Miles



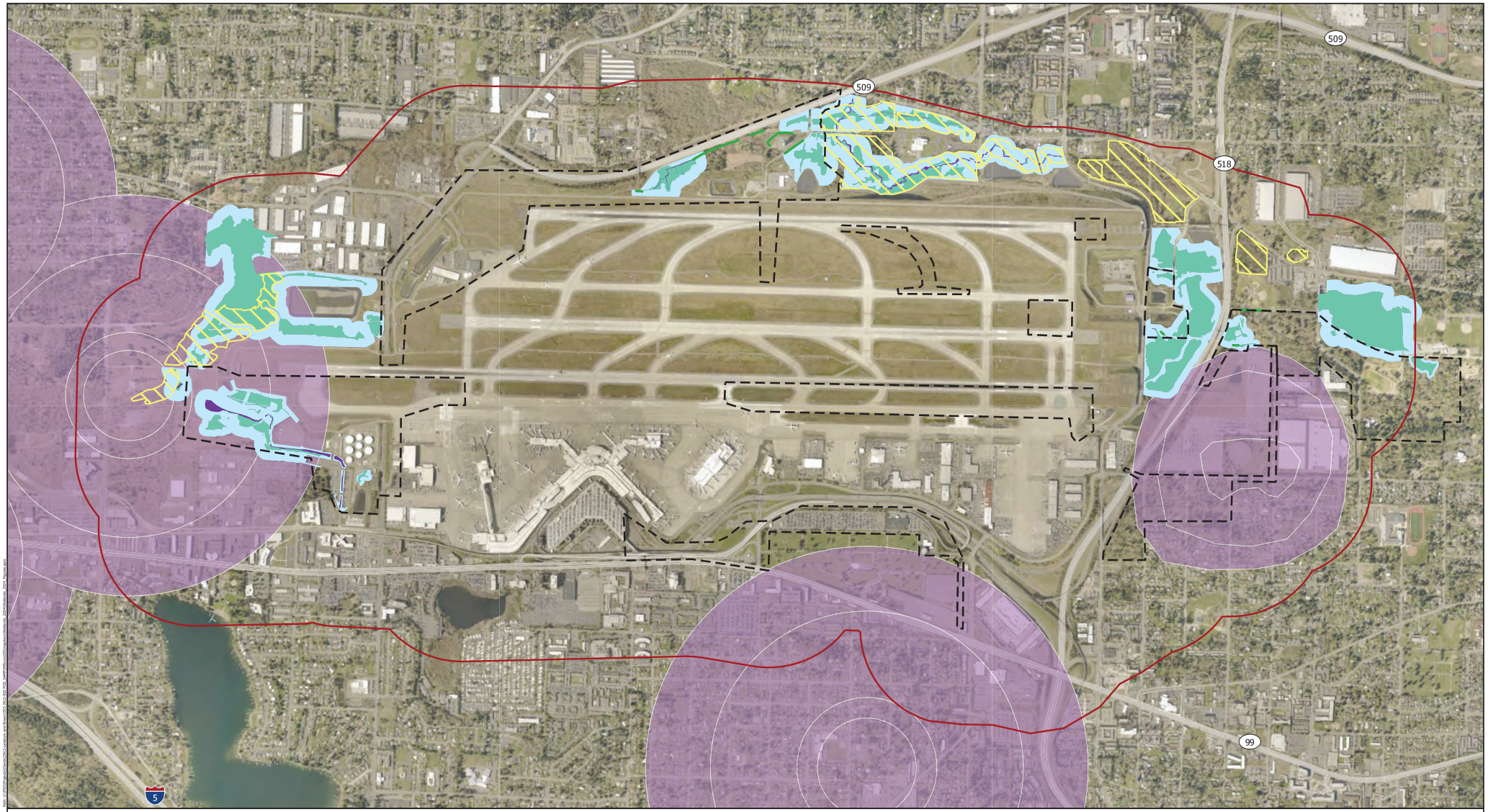
General Study Area
Field Survey Area

Drainage Basins
Des Moines Creek
Gilliam Creek/Lower Green River
Miller Creek/Walker Creek

Study Area Zones
East Zone
North RSA Zone
North Zone
Runway Zone
South RSA Zone
West Zone

Figure 1-1
Vicinity Map
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



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Sources: King County, King County Aerial (2021)
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0 0.13 0.25 0.38 0.5 Miles

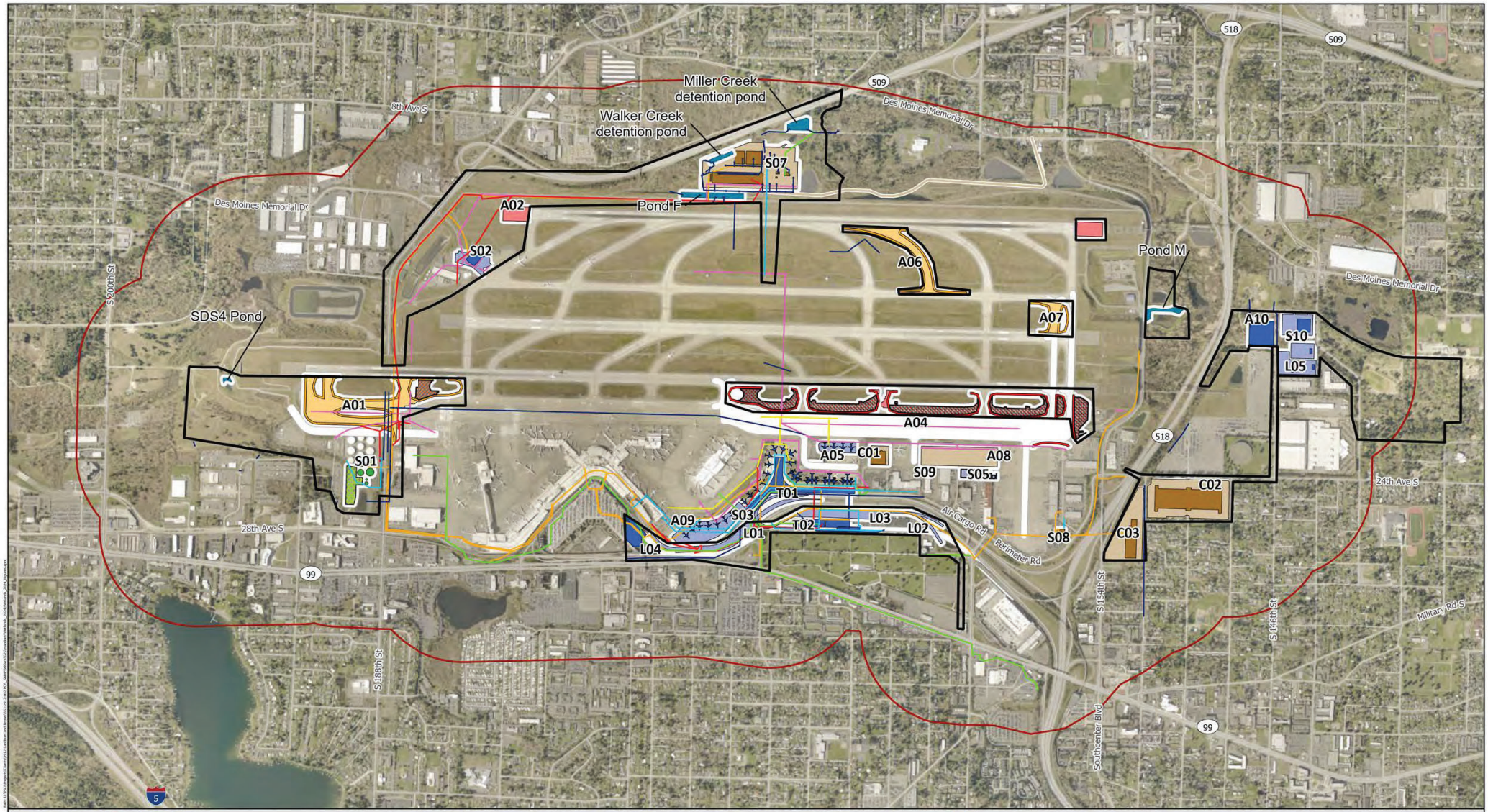
- Tributaries
- General Study Area
- Field Survey Area
- Restrictive Covenant

Critical Area Type

- Stream
- Wetland
- Stream/Wetland Buffer
- Wellhead Protection Area

Figure 1-2
Aquatic Critical Areas within the Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



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Date: 2/12/2024
Sources: King County, King County Aerial (2021)
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0 0.13 0.25 0.38 0.5 Miles

- Field Survey Area
- General Study Area
- Construction Area (50-ft buffer)
- Stormwater Pond (UMP Polygon)

Proposed Utilities (UMP Line)

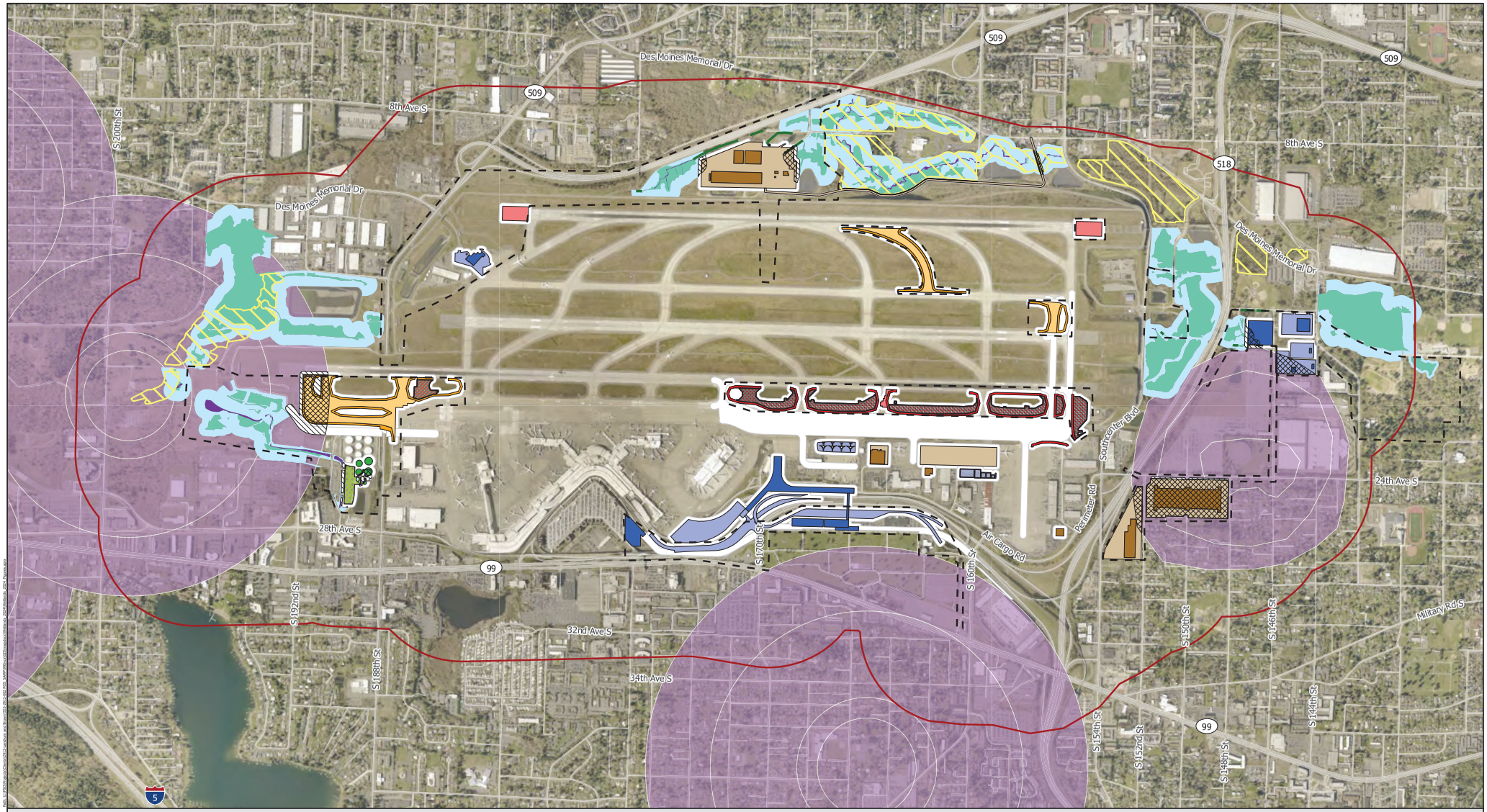
- ICT
- IWS
- Jet Fuel
- Power
- Sanitary Sewer
- Storm
- Water

Near Term Project (NTP) Type

- Airfield Operational Efficiency Projects
- Airfield Operational Efficiency Projects, Structure
- Airfield Operational Efficiency Projects, Surface
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects, Structure
- Airfield Safety/Standards Projects, Surface
- Cargo Expansion Projects, Structure
- Cargo Expansion Projects, Surface
- North Terminal Projects
- North Terminal Projects, Structure
- North Terminal Projects, Surface
- Sustainable Aviation Fuel Projects
- Sustainable Aviation Fuel Projects, Structure

Figure 1-3
Project Elements within the Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



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Date: 2/12/2024
Sources: King County, King County Aerial (2021)
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0 0.13 0.25 0.38 0.5 Miles

- Tributaries
- Tributaries Impact
- Permanent Impact Area
- Temporary Impact Area
- Construction Area (50-ft buffer)
- General Study Area
- Field Survey Area
- Restrictive Covenant

Critical Area Type

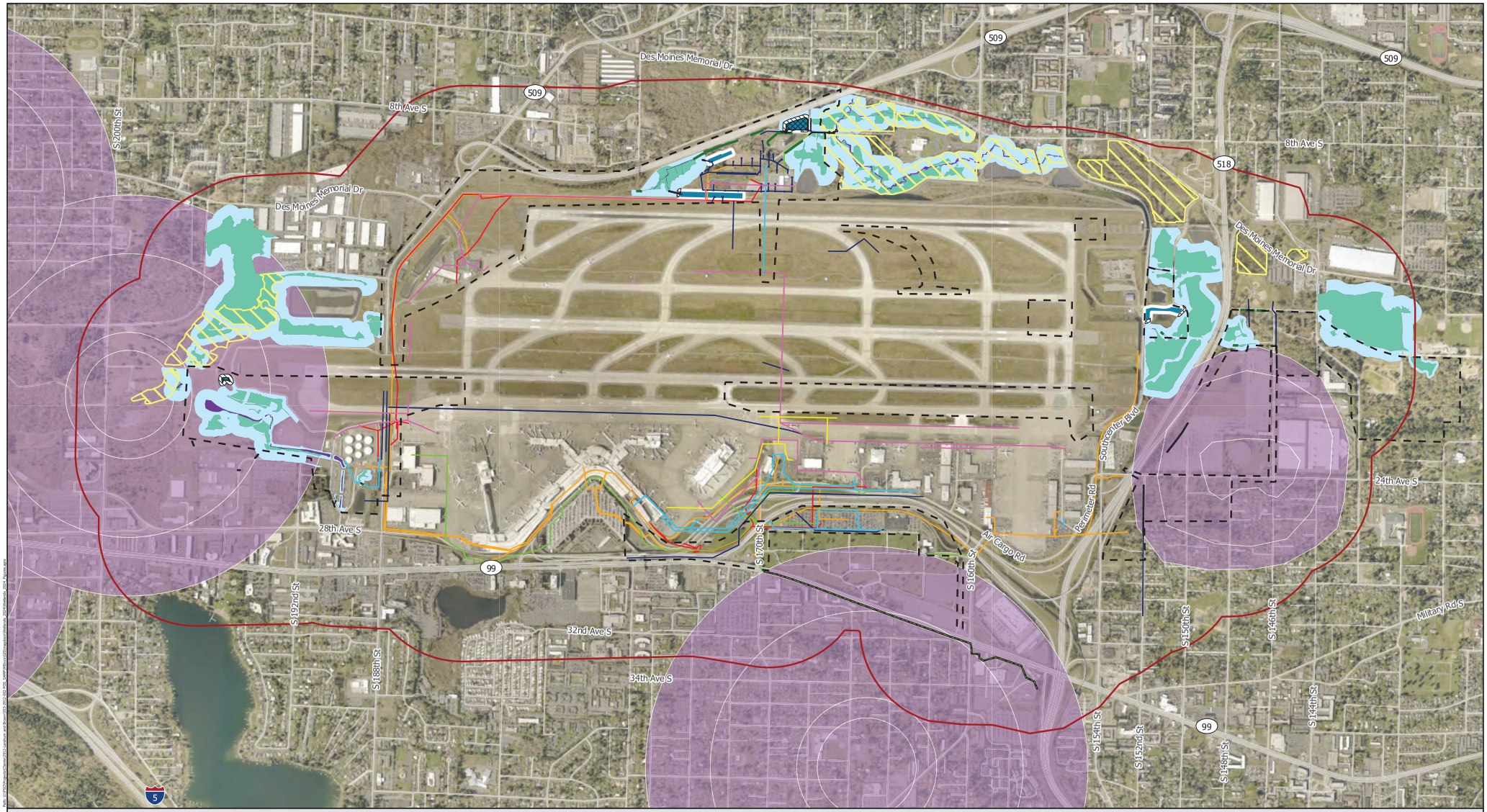
- Stream
- Wetland
- Stream/Wetland Buffer
- Wellhead Protection Area

Near Term Project (NTP) Type

- Airfield Operational Efficiency Projects
- Airfield Operational Efficiency Projects, Structure
- Airfield Operational Efficiency Projects, Surface
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects, Structure
- Airfield Safety/Standards Projects, Surface
- Cargo Expansion Projects, Structure
- Cargo Expansion Projects, Surface
- North Terminal Projects
- North Terminal Projects, Structure
- North Terminal Projects, Surface
- Sustainable Aviation Fuel Projects
- Sustainable Aviation Fuel Projects, Structure

Figure 1-4
NTP Impacts to Aquatic Critical Areas within the Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



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Date: 2/12/2024
Sources: King County, King County Aerial (2021)
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0 0.13 0.25 0.38 0.5 Miles

- Tributaries
- Tributaries Impact
- Permanent Impact Area
- Temporary Impact Area
- Construction Area (50-ft buffer)
- Field Survey Area
- General Study Area
- Restrictive Covenant

Critical Area Type

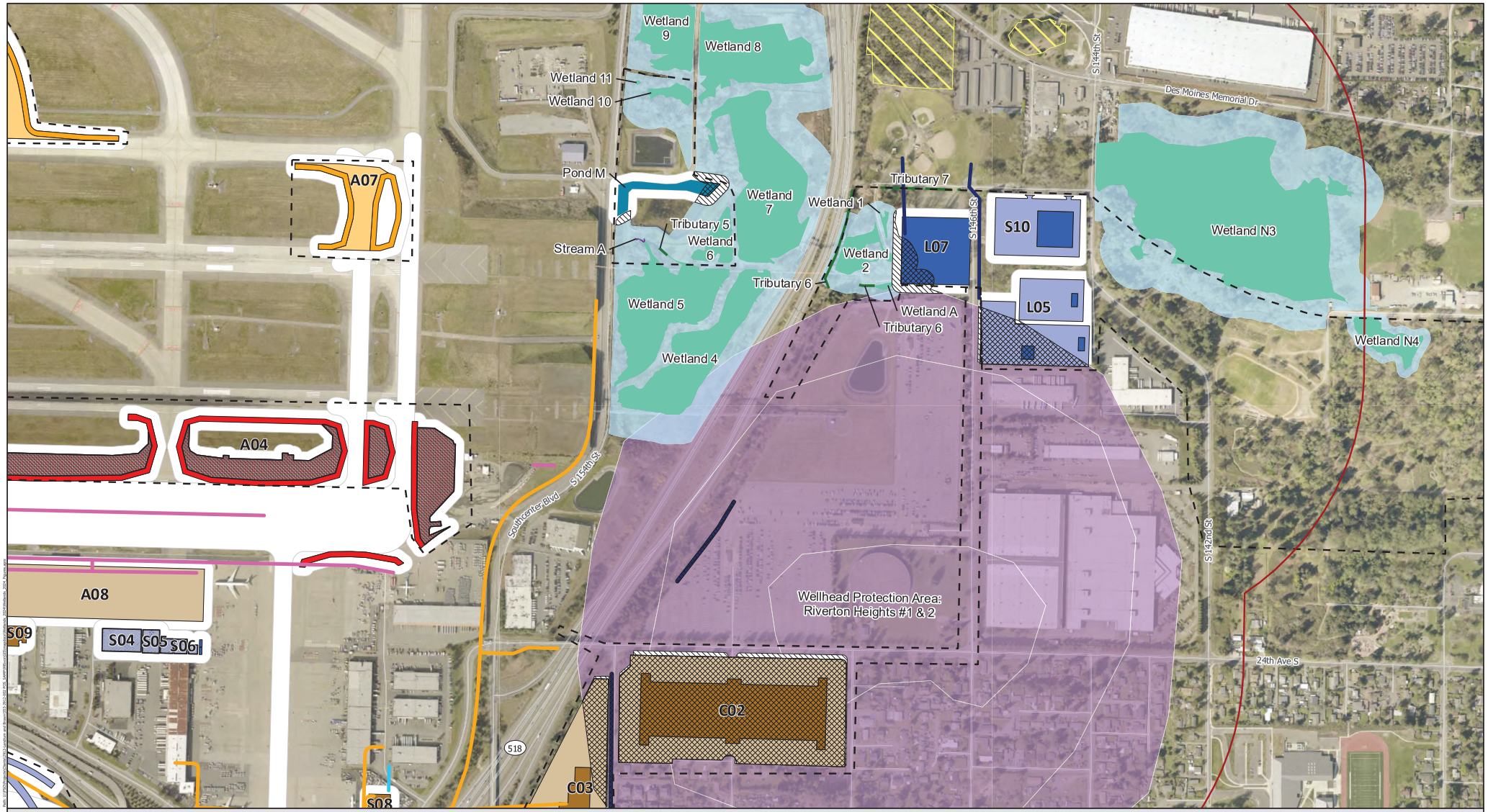
- Stream
- Wetland
- Stream/Wetland Buffer
- Wellhead Protection Area

Utility Master Plan (UMP) Type

- ICT
- IWS
- Jet Fuel
- Power
- Sanitary Sewer
- Storm
- Water

Figure 1-5
UMP Impacts to Aquatic Critical Areas within the Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



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Date: 2/12/2024
Sources: King County, King County Aerial (2021)
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0 250 500 1,000 Feet

- Tributaries
- Tributaries Impact
- General Study Area
- Field Survey Area
- Permanent Impact Area
- Temporary Impact Area
- Stormwater Pond
- Construction Area (50-ft buffer)
- Restrictive Covenant

Critical Area Type

- Stream
- Wetland
- Stream/Wetland Buffer
- Wellhead Protection Area

Utility Master Plan (UMP) Type

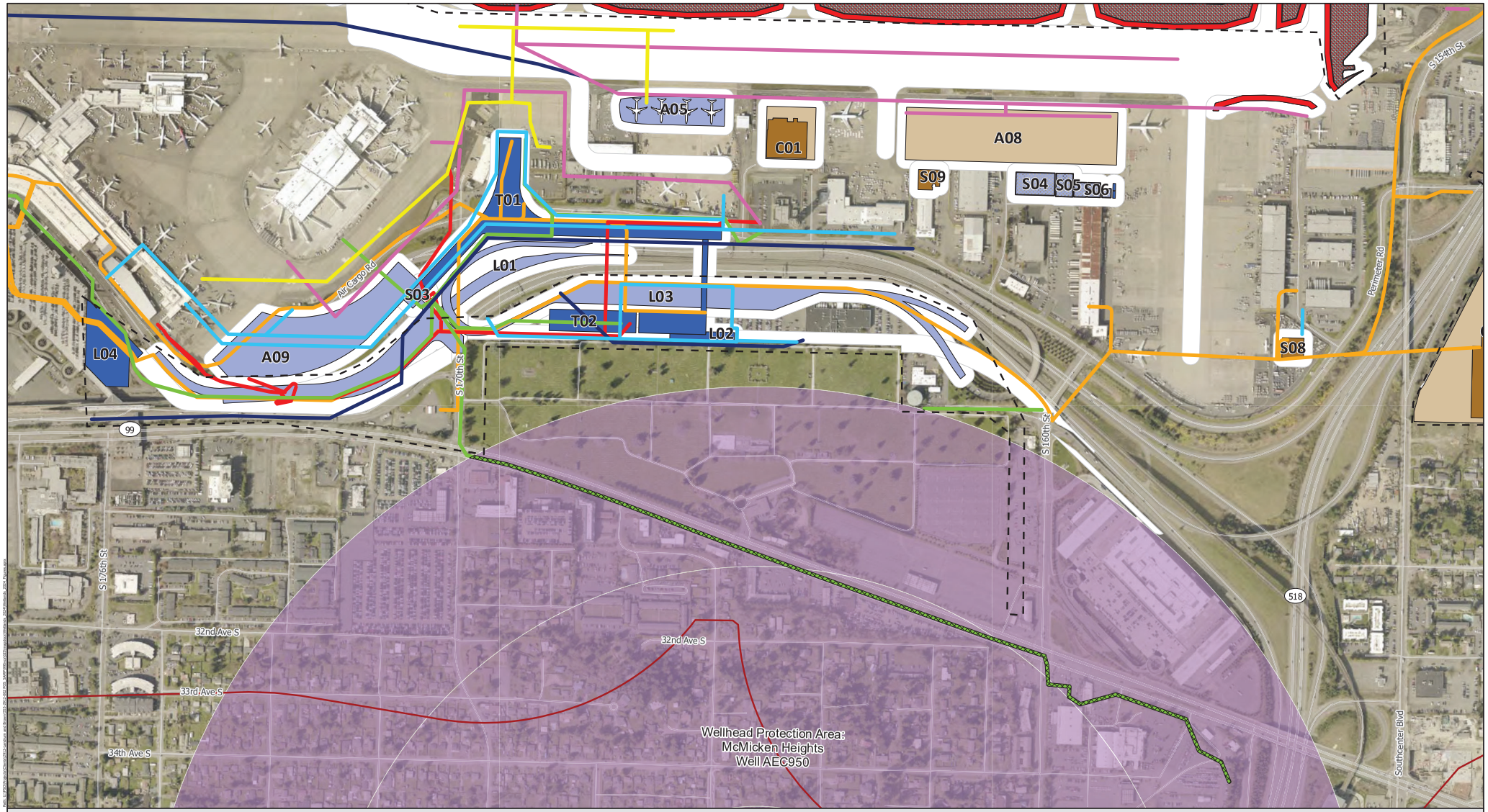
- ICT
- IWS
- Jet Fuel
- Power
- Sanitary Sewer
- Storm
- Water

Near Term Project (NTP) Type

- Airfield Operational Efficiency Projects
- Airfield Operational Efficiency Projects, Structure
- Airfield Operational Efficiency Projects, Surface
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects, Structure
- Airfield Safety/Standards Projects, Surface
- Cargo Expansion Projects, Structure
- Cargo Expansion Projects, Surface
- North Terminal Projects
- North Terminal Projects, Structure
- North Terminal Projects, Surface
- Sustainable Aviation Fuel Projects
- Sustainable Aviation Fuel Projects, Structure

Figure 1-6a
Project Impacts to Aquatic Critical Areas
in North Portion of Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



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Date: 2/12/2024
Sources: King County, King County Aerial (2021)
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0 250 500 1,000 Feet

- Tributaries
- Tributaries Impact
- General Study Area
- Field Survey Area
- Permanent Impact Area
- Temporary Impact Area
- Stormwater Pond
- Construction Area (50-ft buffer)
- Restrictive Covenant

Critical Area Type

- Stream
- Wetland
- Stream/Wetland Buffer
- Wellhead Protection Area

Utility Master Plan (UMP) Type

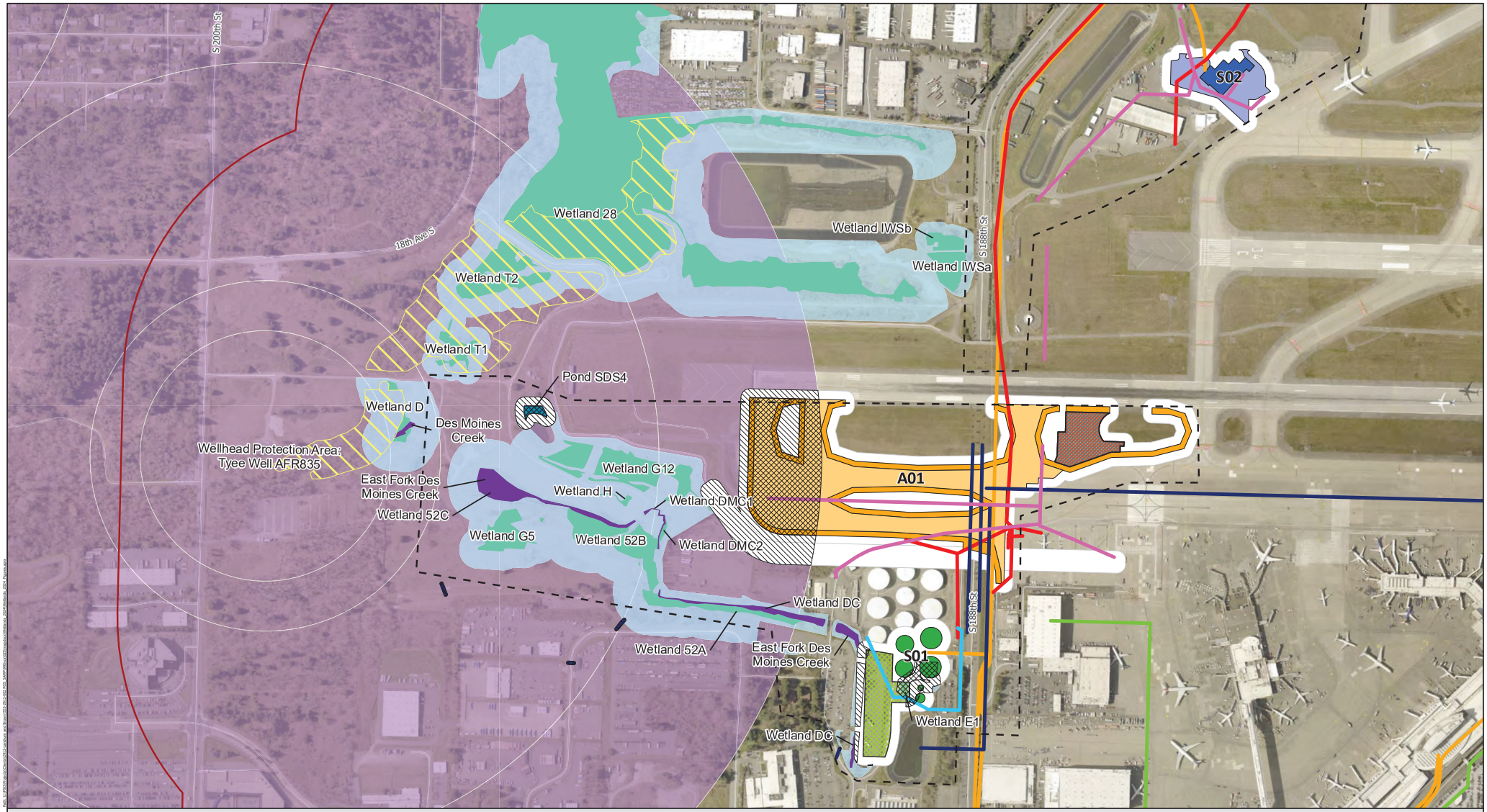
- ICT
- IWS
- Jet Fuel
- Power
- Sanitary Sewer
- Storm
- Water

Near Term Project (NTP) Type

- Airfield Operational Efficiency Projects
- Airfield Operational Efficiency Projects, Structure
- Airfield Operational Efficiency Projects, Surface
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects, Structure
- Airfield Safety/Standards Projects, Surface
- Cargo Expansion Projects, Structure
- Cargo Expansion Projects, Surface
- North Terminal Projects
- North Terminal Projects, Structure
- North Terminal Projects, Surface
- Sustainable Aviation Fuel Projects
- Sustainable Aviation Fuel Projects, Structure

Figure 1-6b
Project Impacts to Aquatic Critical Areas
in North Portion of Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



Parametrix

Date: 2/12/2024
Sources: King County, King County Aerial (2021)
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 250 500 1,000 Feet

- Tributaries
- Tributaries Impact
- General Study Area
- Field Survey Area
- Permanent Impact Area
- Temporary Impact Area
- Stormwater Pond
- Construction Area (50-ft buffer)
- Restrictive Covenant

Critical Area Type

- Stream
- Wetland
- Stream/Wetland Buffer
- Wellhead Protection Area

Utility Master Plan (UMP) Type

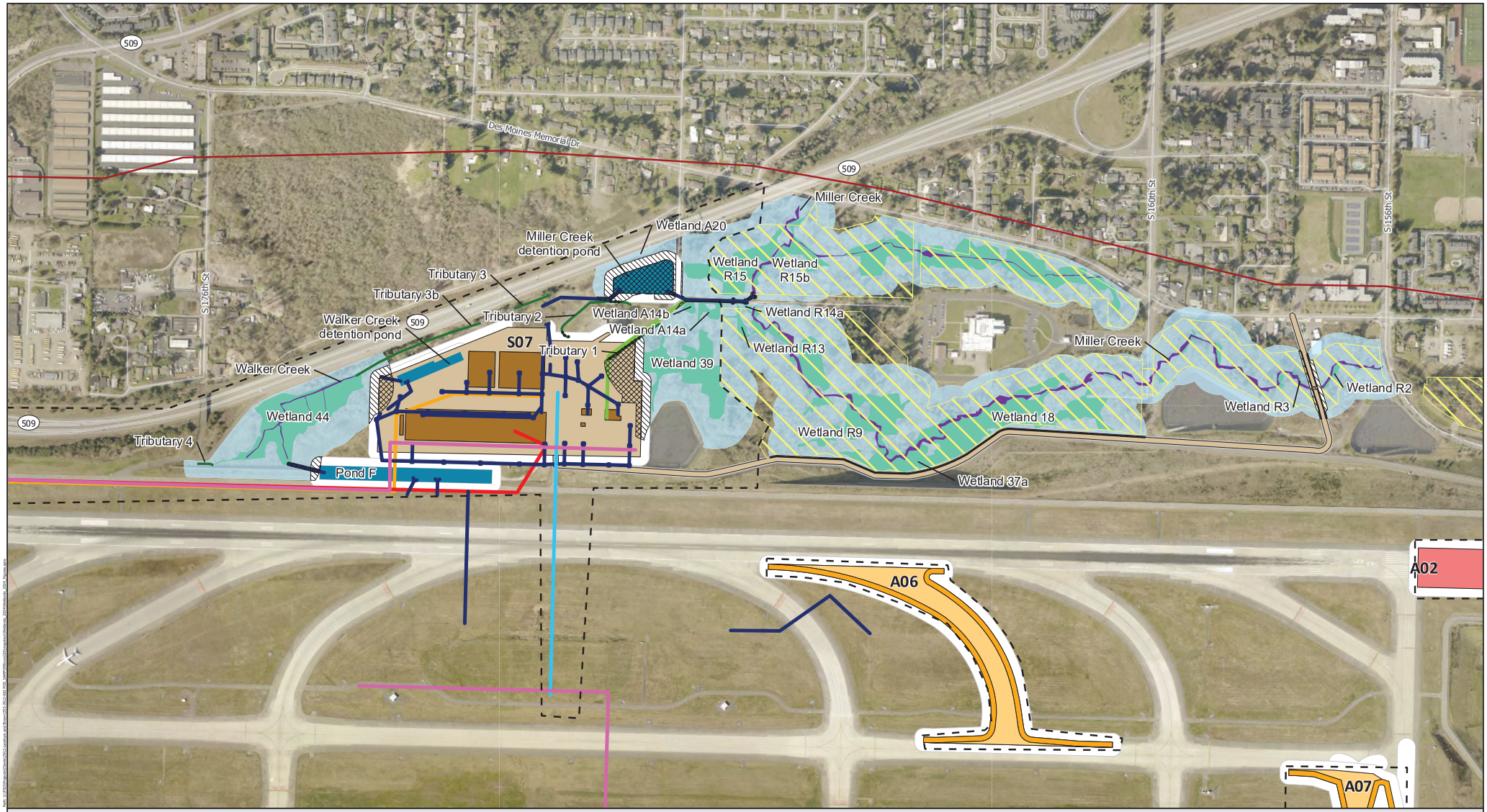
- ICT
- IWS
- Jet Fuel
- Power
- Sanitary Sewer
- Storm
- Water

Near Term Project (NTP) Type

- Airfield Operational Efficiency Projects
- Airfield Operational Efficiency Projects, Structure
- Airfield Operational Efficiency Projects, Surface
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects, Structure
- Airfield Safety/Standards Projects, Surface
- Cargo Expansion Projects, Structure
- Cargo Expansion Projects, Surface
- North Terminal Projects
- North Terminal Projects, Structure
- North Terminal Projects, Surface
- Sustainable Aviation Fuel Projects
- Sustainable Aviation Fuel Projects, Structure

Figure 1-6c
Project Impacts to Aquatic Critical Areas in North Portion of Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



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Date: 2/12/2024
Sources: King County, King County Aerial (2021)
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0 250 500 1,000 Feet

- Tributaries
- Tributaries Impact
- General Study Area
- Field Survey Area
- Permanent Impact Area
- Temporary Impact Area
- Stormwater Pond
- Construction Area (50-ft buffer)
- Restrictive Covenant

Critical Area Type
- Stream
- Wetland
- Stream/Wetland Buffer
- Wellhead Protection Area

Utility Master Plan (UMP) Type
- ICT
- IWS
- Jet Fuel
- Power
- Sanitary Sewer
- Storm
- Water

Near Term Project (NTP) Type
- Airfield Operational Efficiency Projects
- Airfield Operational Efficiency Projects, Structure
- Airfield Operational Efficiency Projects, Surface
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects, Structure
- Airfield Safety/Standards Projects, Surface
- Cargo Expansion Projects, Structure
- Cargo Expansion Projects, Surface
- North Terminal Projects
- North Terminal Projects, Structure
- North Terminal Projects, Surface
- Sustainable Aviation Fuel Projects
- Sustainable Aviation Fuel Projects, Structure

Figure 1-6d
Project Impacts to Aquatic Critical Areas in North Portion of Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA

Appendix D
Species Life Histories

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1.0 INTRODUCTION

The information in this appendix is meant to accompany and complement the more detailed environmental baseline and effect analysis information provided in the main body of the *Seattle-Tacoma International Airport Sustainable Airport Master Plan Near Term Projects Biological Assessment* (BA). The following sections discuss the Endangered Species Act (ESA) listing status, critical habitat status, and general life history information for each ESA-listed species addressed in the BA for the Proposed Action:

- Chinook salmon, Puget Sound Evolutionarily Significant Unit (ESU) (*Oncorhynchus tshawytscha)*
- Steelhead, Puget Sound Distinct Population Segment (DPS) (*O. mykiss)*
- Bull trout, Coastal-Puget Sound DPS (*Salvelinus confluentus)*
- Bocaccio rockfish, Puget Sound/Georgia Basin DPS (*Sebastes paucispinis*)
- Yelloweye rockfish, Puget Sound/Georgia Basin DPS (*S. ruberrimus*)
- Killer whale, Southern Resident DPS (SRKW) (*Orcinus orca*)
- Humpback whale, Central America and Western North Pacific DPS (*Megaptera novaeangliae*)
- Marbled murrelet (*Brachyramphus marmoratus*)

2.0 PUGET SOUND CHINOOK SALMON

The Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*) ESU was listed as threatened under the ESA on March 24, 1999 (64 FR 14308), and its threatened status was reaffirmed on June 28, 2005 (70 FR 37160). The 2016 5-year review of Puget Sound Chinook salmon concluded that this species should remain listed as threatened (80 FR 6695, NMFS 2017a).

Critical habitat for Puget Sound Chinook salmon was designated on September 2, 2005 (70 FR 52629). It includes 1,683 miles of stream/riverine habitat, 41 square miles of lake habitat, and 2,182 miles of nearshore habitat within Washington and Puget Sound.

2.1 Life History and Population Trajectory

Like most other salmonids, Chinook salmon exhibit an anadromous (meaning they migrate from saltwater to freshwater to spawn) and semelparous (meaning they die after their first reproductive event) life history, thereby occurring in both freshwater river systems as well as the brackish and saltwater waterways of the Puget Sound and Pacific Ocean (USEPA 2021). A Chinook salmon hatches in fresh water, rears in fresh and/or salt water, matures in the ocean,

and returns to its natal freshwater streams to breed. Chinook salmon can be separated into 2 distinct life history strategies: ocean-type and stream-type fish. Ocean-type Chinook salmon spend a limited amount of time (i.e., weeks or months) rearing in fresh water before migrating to the ocean, while stream-type fish spend approximately 1-year rearing in fresh water (COSEWIC 2019). Upon entering estuaries, stream-type Chinook salmon are much larger than ocean-type Chinook salmon (COSEWIC 2019). Adult Chinook salmon weigh 40 pounds on average, although as the largest of the west-coast salmon, they may grow up to 120 pounds (NOAA 2024a). Chinook salmon are a cold-water species that rely on clean waters no warmer than 25°C (COSEWIC 2019).

The Chinook salmon population in the Salish Sea (i.e., the larger Puget Sound region including the Strait of Georgia has declined "60% since the Pacific Salmon Commission began tracking salmon abundance in 1984" (EPA 2021). This drastic decline has been due to multiple anthropogenic factors, including reduced habitat quality and accessibility, over-harvesting, and reduced water quality. Recent stock assessments show that most Puget Sound Chinook salmon stocks remain well below population recovery thresholds (NMFS 2006; Pacific Salmon Commission 2022; Puget Sound Indian Tribes and WDFW 2022; Puget Sound Info 2023a). There is little indication that Puget Sound Chinook salmon will recover in the near future, although most populations have not significantly decreased over the last few years (Puget Sound Info 2023a).

2.2 Regional and Local Abundance

The Puget Sound ESU for Chinook salmon includes all naturally occurring Chinook salmon originating in rivers that flow into the Puget Sound. Currently 22 independent populations of naturally occurring Chinook salmon exist within the ESU (NMFS 2017a; Puget Sound Info 2023a). In addition to these 22 populations, 26 artificial propagation hatchery programs across the Puget Sound augment Chinook salmon escapement numbers by artificially increasing egg survivorship and the number of juveniles hatched (NMFS 2017a).

The population of Salish Sea Chinook salmon was estimated to be over 473,000 in 2018 (EPA 2021). Estimates of total Chinook salmon abundance across the Puget Sound are not conducted by the Pacific Salmon Commission due in part to the lack of long-term tag data for naturally occurring stocks (Pacific Salmon Commission 2018). However, escapement trends for various indicator stocks of Chinook salmon in the Puget Sound are available. Escapement indicator stocks for the Puget Sound include the Nooksack, Skagit, Stillaguamish, Snohomish, Lake Washington, and Green River stocks (Pacific Salmon Commission 2022). In the years from 1975 to 2021, the collective Puget Sound Chinook salmon indicator stock escapement for summer and fall stocks ranged from a low of approximately 10,300 individuals in 2011 to a high of 45,000 in 2004. The combined escapement was approximately 30,000 in 2021 (Pacific Salmon Commission

2022). Spawning abundance estimates for most populations have therefore not experienced significant change between 1999 and 2021 (Puget Sound Info 2023a).

2.3 Sensitivity to Environmental Stressors

Chinook salmon are sensitive to many environmental stressors and threats. These include exclusion from upstream habitat and spawning grounds by impassible barriers (i.e., culverts, dams, etc.), and habitat degradation due to human development, including increased sedimentation, water temperatures, and decreased water qualities (NOAA 2024a). The diverse environmental stressors that impact Chinook salmon can be summarized in 4 main factors (EPA 2021):

- Habitat loss and degradation: Chinook salmon require a vast area of diverse habitat over the span of their lives. Additionally, these habitats must meet specific requirements for Chinook salmon survival and reproduction, including high water quality, low water temperatures, overhanging vegetation and in-stream wood, appropriately sized and clean spawning gravels, etc. With these many requirements, Chinook is especially sensitive to upland development and other human activities that disturb the nearshore, estuarine, or riverine habitats, including agriculture, timber harvest, and coastal modification.
- Harvest Rates: Despite the protection under ESA for some ESU of Chinook salmon, almost 22 million Chinook have been harvested between 1975 and 2018. Harvest rates have decreased since the Puget Sound ESA-listing in 1999; however, harvest above sustainable limits outside of the Puget Sound may still occur.
- Hatchery Influence: Although hatcheries intend to bolster failing Chinook salmon stocks that are near extinction, they may also have negative impacts on the remaining wild stocks through increased competition, introduction of diseases, dilution of superior wild genetics, and impediment of wild stock migration.
- Water infrastructure that impedes migrations: Culverts, dams, and floodgates can all impact salmonid species by causing fish passage barriers, water quality impairments, loss of habitat, and hydrological changes.

Additionally, global climate change is impacting Chinook salmon stocks by further altering their habitat, increasing water temperatures, and decreasing water quality (EPA 2021).

Impacts or effect mechanisms that Puget Sound Chinook salmon would be especially sensitive to include the following:

- Turbidity/suspended sediment
- Water temperature
- Physical disturbance of organisms
- Shading
- Dissolved oxygen and pH
- Water quality/contaminants
- Change in habitat type

Direct effects to lower levels of the food web or other parts of the ecosystem are not expected to indirectly affect Puget Sound Chinook salmon.

3.0 PUGET SOUND STEELHEAD

The Puget Sound steelhead (*Oncorhynchus mykiss*) Distinct Population Segment (DPS) was listed as threatened under the ESA on May 11, 2007 (72 FR 26722). This listing was subsequently updated and reaffirmed on April 14, 2014 (79 FR 20802). The DPS includes naturally spawned steelhead within the Puget Sound, along with steelhead from 6 hatchery programs.

Critical habitat was designated for Puget Sound steelhead on February 24, 2016 (81 FR 9251). It includes approximately 2,031 miles of freshwater and estuarine habitat in Puget Sound.

3.1 Life History and Population Trajectory

The Puget Sound steelhead ESU is primarily composed of winter-run fish, with a few stocks of summer-run steelhead.

The population of Puget Sound steelhead has generally been in decline for more than a hundred years. Historical catch data suggests return sizes of 409,000 to 930,000 adult steelhead each year in the Puget Sound towards the end of the 19th century (NMFS 2019). The current run size is less than 5% to 10% of these historic numbers (Puget Sound Info 2023b).

3.2 Regional and Local Abundance

Puget Sound steelhead populations are found in all of the major river systems within the Puget Sound, including the Nooksack, Skagit, Stillaguamish, Skykomish, Green, Puyallup, and Nisqually Rivers (NMFS 2019). The Puget Sound DPS of steelhead also includes artificial propagation programs within Hood Canal. Thus, Puget Sound steelhead are well distributed throughout the Puget Sound. Due to the lack of regional abundance and distribution information, details are provided here at the scale of the entire Puget Sound.

Winter-run and ocean-maturing steelhead return as adults to Puget Sound tributaries from December to April (Hard et al. 2007). Spawning occurs from January to mid-June, with peak spawning occurring from mid-April through May. Most steelhead juveniles reside in fresh

water for 2 years prior to migrating to marine habitats, with limited numbers migrating as 1- or 3-year-old smolts. Smoltification and seaward migration occur principally from April to mid-May (Hard et al. 2007). The inshore migration pattern of steelhead in Puget Sound is not well understood; it is generally thought that steelhead smolts move quickly offshore (Hard et al. 2007).

3.3 Sensitivity to Environmental Stressors

Environmental stressors like those presented for Chinook salmon are also applicable to steelhead. However, since juvenile steelhead spend more time in freshwater than other species (2-5 years), steelhead are more affected by habitat conditions within a given stream. Puget Sound summer-run steelhead also spend more time in freshwater than other salmon (including winter-run steelhead), as they "return to freshwater during early summer in an immature condition and do not spawn until the following spring" (WDFW 2011). Thus, degraded watershed habitats and processes have a greater cumulative impact on steelhead. Steelhead can also survive to spawn in multiple years, meaning they require adequate downstream passage as well as upstream passage. (WDFW 2011)

Impacts or effect mechanisms that Puget Sound steelhead would be especially sensitive to include the following:

- Turbidity/suspended sediment
- Water temperature
- Physical disturbance of organisms
- Shading
- Dissolved oxygen and pH
- Water quality/contaminants
- Change in habitat type
- Downstream passage at dams or other obstructions

Direct effects to lower levels of the food web or other parts of the ecosystem are not expected to indirectly affect Puget Sound steelhead.

4.0 COASTAL-PUGET SOUND BULL TROUT

The Coastal-Puget Sound DPS of bull trout (*Salvelinus confluentus*) was listed as threatened under the ESA on June 10, 1998 (64 FR 58910). This DPS includes individuals in Idaho, Montana, Nevada, Oregon, and Washington. Critical habitat was subsequently designated in 2005 (70 FR 56212). The most recent version of critical habitat for bull trout was designated on September 30, 2010 (75 FR 63898). It includes approximately 18,795 miles of streams and 488,252 acres of lakes and reservoirs in Idaho, Oregon, Washington, Montana, and Nevada, along with 754 miles of marine shoreline in Washington. Bull trout are federally managed by the U.S. Fish and Wildlife Service (USFWS). Dolly Varden (*S. malma*) are listed as threatened under the ESA due to their similarity to bull trout.

4.1 Life History and Population Trajectory

Bull trout exhibit 2 main life history strategies: resident and migratory. Resident fish spend their entire life within the stream or tributary in which they were born. Migratory fish spawn in tributary streams but then migrate to either a lake (adfluvial form), river (fluvial form), or marine ecosystem (anadromous) (USFWS 2015). The form that occurs within the Puget Sound is the anadromous form. The different life history forms may be found together, and one can produce offspring of another type. Bull trout typically reach sexual maturity at ages of 4-7 years and usually live to be about 10 years old (USFWS 2015).

Bull trout have very specific habitat requirements, often referred to as "the four Cs": Cold, Clean, Complex, and Connected habitat (Rieman and McIntyre 1993). Water temperatures typically need to be less than 54°F and habitat should include complex elements like deep pools, overhanging banks, and large woody debris. Suitable habitat must also be connected to spawning and rearing areas.

Spawning typically occurs between August and November, when water temperatures are decreasing. Bull trout often build redds in stream reaches near springs or other sources of cold groundwater. Migratory bull trout can travel as far as 250 kilometers to reach spawning grounds (USFWS 2015).

Bull trout are opportunistic feeders, relying on a variety of terrestrial and aquatic insects, macro-zooplankton, and small fish. Their food habits primarily depend on their life stage and size. Within the Puget Sound, bull trout often feed on forage fish, like Pacific herring, Pacific sand lance, and surf smelt (USFWS 2015).

A status review of bull trout was completed in 2008, and it was determined that the listing of "threatened" was still warranted (USFWS 2008). Of the 121 core areas that were assessed, 75 had substantial threats to the success and survival of the population. Bull trout have been largely extirpated from about 60% of their historic range (USFWS 2015).

4.2 Regional and Local Abundance

The Chilliwack, Nooksack, lower and upper Skagit, Snohomish-Skykomish, Stillaguamish, upper Cedar, and Puyallup river basins all support populations of bull trout (USFWS 2020). Except for the Chilliwack and upper Cedar River basins, all these basins contain anadromous bull trout that also use the marine waters of the Puget Sound. Thus, bull trout are well distributed throughout the Puget Sound. Acoustic telemetry data on tagged bull trout between 2002 and 2008 showed significant migration distances within the Puget Sound (up to 95 km 1-way) and some use of non-spawning river systems (Goetz et al. 2012). During migrations, most fish stayed close to the shoreline, relying heavily on nearshore habitats.

Juvenile and sub-adult bull trout generally exit rivers and migrate downstream between mid-February to early September, with peak migration periods between April and July. When juvenile bull trout enter salt water, their time of residence is variable (1 day to more than 4 months). Upon entry into salt water, juveniles may rear in tidal delta marshes or tributary channels, or they may pass through into nearshore marine areas. Larger juveniles may migrate through the nearshore from the natal river to adjacent river basins (Goetz et al. 2012).

4.3 Sensitivity to Environmental Stressors

The recovery plan for bull trout published in 2015 laid out 5 main factors affecting the success and survival of the species (USFWS 2015):

- Present or threatened destruction, modification, or curtailment of its habitat or range
- Overutilization for commercial, scientific, or educational purposes
- Disease or predation
- Inadequacy of existing regulatory mechanisms
- Other natural or manmade factors affecting its continued existence

Habitat threats make up a large proportion of the overall factors threatening the population of bull trout within the Puget Sound. However, these threats primarily occur within the freshwater habitats used by bull trout for spawning and rearing. Overfishing and disease are generally minor threats to bull trout success, especially since the time of listing. Since listing, regulatory mechanisms to protect bull trout populations have improved and other factors are continuing to be assessed.

In the marine habitats of the Puget Sound, the main factors that could affect the success of bull trout populations include specific threats to nearshore resources. Nonetheless, major habitat concerns relate to fish barriers and changes to water quality in rivers and streams that preclude bull trout use (USFWS 2015).

Impacts or effect mechanisms that bull trout would be especially sensitive to include the following:

- Turbidity/suspended sediment
- Water temperature
- Physical disturbance of organisms
- Shading
- Dissolved oxygen and pH
- Water quality/contaminants
- Change in habitat type

Direct effects to lower levels of the food web or other parts of the ecosystem are not expected to indirectly affect bull trout.

5.0 ROCKFISH

Two species of rockfish are included here because of their listing under the ESA: bocaccio (*Sebastes paucispinis*) and yelloweye (*Sebastes ruberrimus*). Bocaccio were listed as endangered on April 28, 2010 and yelloweye were listed as threatened on the same date (75 FR 22276). This listing is specific to the Puget Sound/Georgia Basin DPS of each species. This includes all "yelloweye rockfish and bocaccio (listed rockfish) in the Puget Sound, the Strait of Georgia…and the Strait of Juan de Fuca east of Victoria Sill (approximately east of Port Angeles)" (NMFS 2017b).

Critical habitat was designated for these species in 2014 (79 FR 68041). It includes 590.4 square miles of nearshore habitat and 414.1 square miles of deepwater habitat within Puget Sound and the Salish Sea.

5.1 Life History and Population Trajectory

Rockfish are long-lived, iteroparous (have multiple reproductive cycles) species that bear live young, in contrast to most other bony fishes (Drake et al. 2010). Rockfish larvae typically spend several months in a pelagic state before settling to demersal habitat. The iteroparity of rockfish is believed to allow populations to persist through many years of poor production.

5.1.1 Puget Sound/Georgia Basin Bocaccio Rockfish

In northern and central Californian waters, bocaccio were found to mature typically around 3 years of age (Drake et al. 2010). Bocaccio females produce between 20,000 and 2,298,000 eggs annually (Love et al. 2002). Off the coasts of Washington and Oregon, larval release typically occurs between January and April (Drake et al. 2010). Most larvae remain in a pelagic state for about 3.5 months before settling into shallower habitats. Females typically grow more quickly than males and can reach larger sizes, which a maximum of 91 cm and 6.8 kg (Love et al. 2002; MacCall 2003). The maximum age has been estimated at 54 years.

Bocaccio rely on shallower habitats as juveniles but move out to deeper waters as they age. They typically remain within home ranges for most of their adult lives (Drake et al. 2010).

Bocaccio prey base changes as they grow. Bocaccio larvae feed on larval krill, diatoms, and dinoflagellates. Juveniles are opportunistic feeders, relying on fish larvae, copepods, and krill. As adults, their prey base shifts to primarily other fish, including hake, sablefish, anchovies, lanternfishes, squid, and other rockfish (Love et al. 2002). Predators of smaller bocaccio include Chinook salmon, terns, and harbor seals (Love et al. 2002).

The population of Puget Sound/Georgia Basin bocaccio has generally been in decline, warranting a listing under the ESA. Between 1975 and 1979, bocaccio were reported as 4.63% of rockfish catch on average, while no bocaccio were observed between 1996 and 2007 out of 2,238 rockfish identified from recreational catches (Drake et al. 2010).

5.1.2 Puget Sound/Georgia Basin Yelloweye Rockfish

Yelloweye rockfish are commonly found associated with rocky, high-relief zones, both as juveniles and adults (Drake et al. 2010). Juveniles are typically found in shallower habitats than adults. Adults have been found to have a high affiliation with caves and crevices in deepwater habitats (Drake et al. 2010). Yelloweye inhabit a wide depth range throughout their lives, with depths recorded between 15 and 549m (Drake et al. 2010). The lifespan of yelloweye can reach up to 150 years (NOAA 2023). As with other rockfish, yelloweye are internally fertilized and store sperm for several months prior to fertilization. In the Puget Sound, fertilization is believed to occur in the winter to summer months and birth in the early spring to late summer (Washington et al. 1978). Female yelloweye can produce 1.2 million to 2.7 million eggs in a given reproductive season.

Yelloweye larvae typically remain in a pelagic state for about 2 months prior to settlement. As they grow, they move towards deeper habitats, but generally associate with crevices and other rocky substrates. Throughout their lives, yelloweye are opportunistic feeders, with their prey resources depending on size and life stage. Adult yelloweye rockfish typically rely on sand lance, gadids, flatfishes, shrimp, crabs, and gastropods for prey (Love et al. 2002; Yamanaka et al. 2006).

The population of yelloweye rockfish in the Puget Sound/Georgia Basin has generally been in decline, warranting a listing under the ESA.

5.2 Regional and Local Abundance

The following sections describe specifics of the distribution and abundance of bocaccio and yelloweye rockfish throughout the Puget Sound and within the regions of interest identified in Section 1.

Bocaccio used to be relatively common along steep walls within the Puget Sound but have become more rare (Love et al. 2002). Yelloweye are also generally rare within the Puget Sound (Drake et al. 2010). Habitats within the Puget Sound (e.g., eelgrass, kelp, drift vegetation, and cobble fields) are more commonly used by juvenile rockfish following settlement (Puget Sound Institute 2011). As adults, when present in the Puget Sound, bocaccio and yelloweye rockfish are generally associated with deepwater habitats.

5.3 Sensitivity to Environmental Stressors

Rockfish are sensitive to a variety of environmental threats, including loss of habitat and overfishing. They are especially vulnerable to overfishing because most species do not start reproducing until 5-20 years of age, and very few young survive to adulthood (NOAA 2023). Habitat threats within the Puget Sound include loss of kelp forests and eelgrass beds. These habitats are especially important for juvenile rockfish.

Impacts or effect mechanisms that yelloweye rockfish and bocaccio would be especially sensitive to include:

- Turbidity/suspended sediment
- Water temperature
- Physical disturbance of organisms
- Shading
- Dissolved oxygen and pH
- Water Quality/contaminants
- Change in habitat type

Direct effects to lower levels of the food web or other parts of the ecosystem are not expected to indirectly affect yelloweye rockfish or bocaccio.

6.0 SOUTHERN RESIDENT KILLER WHALE

The Southern Resident Killer Whale (SRKW) (*Orcinus orca*) DPS was listed as endangered under the ESA on November 18, 2005 (70 FR 69903), and its endangered status was reaffirmed on April 4, 2007 (72 FR 16284). The final rule designating critical habitat for SRKW took effect in December of 2006 and includes the North Puget Sound (NPS), South Puget Sound, San Juan Islands, and Strait of Juan de Fuca (71 FR 69054).

6.1 Life History and Population Trajectory

While both resident and transient forms of killer whales occur in Puget Sound, resident whales of the SRKW DPS have historically been the most commonly observed in Puget Sound (Wiles 2004). The SRKW DPS is known to occupy the NPS at variable times of the year. This group consists of 3 pods (J, K, and L) and is considered a distinct stock under the Marine Mammal Protection Act. Whales of the J pod are seen year-round in the inland waterways of Puget Sound, the Strait of Juan de Fuca, and the Strait of Georgia (Wiles 2004; NMFS 2008). From late spring through midwinter, the K and L pods are also present in these waters. Individuals from all 3 pods have also been seen, albeit infrequently, at all times of the year in coastal waters from central California north to Vancouver Island (Ford et al. 1996; NMFS 2008). Whales of the SRKW DPS tend to remain outside of relatively confined bays or shallow water areas as they move through the central Puget Sound area.

Killer whales are social animals that live and hunt in pods of up to 20 individuals. Members of the pod rely on sound to communicate, navigate, and forage. Killer whales make a variety of noises, included clicks and pulsed calls. Male killer whales live for an average of 30 years, but may reach 60-years-old. Female killer whales live for an average of 50 years, but may reach 90 years of age. Females reach sexual maturity between 10 and 13 years old. Gestation occurs for 15 to 18 months, and once the calf is born, it nurses for a year or longer. The birthrate for killer whales is estimated at every 5 years, although birthrate is not well documented (NOAA 2024b).

The SRKW population is genetically isolated and rarely interbreeds with other killer whale populations (Hoelzel et al. 1998; Barrett-Lennard 2000; Barrett-Lennard and Ellis 2001). Whales of the SRKW DPS also differ behaviorally from transient killer whales in that they rely almost exclusively on fish as a food source. Observations in northern Puget Sound indicate that salmon are preferred prey for killer whales, representing over 96 percent of the prey during the summer and fall (Ford and Ellis 2005). This study also indicated that Chinook salmon constitutes over 70 percent of the identified salmonids taken in the summer and fall, although extensive feeding on chum salmon was also observed in the fall. While salmon appear to be a preferred prey item, 22 other species of fish and 1 species of squid (*Gonatopsis borealis*) are known to be eaten (Ford et al. 1996, 1998). Species such as rockfish (*Sebastes spp.*), Pacific halibut (*Hippoglossus stenolepis*), a number of flatfish, lingcod (*Ophiodon elongatus*), and greenling (*Hexagrammos* spp.) are likely consumed regularly by SRKWs (Ford et al. 1998).

The historical population size for SRKW in the Pacific Northwest has been estimated at no less than 140 individuals (NOAA 2024b). However, populations declined in the 1960s due to a live-capture SRKW fishery for use in marine mammal parks, and only 71 individuals of this DPS remained in the wild in 1974 (NOAA 2024b). While SRKW populations increased thereafter and peaked in 1995 with 98 individuals, recent whale census in 2023 has documented only 75 individuals (Center for Whale Research 2023).

6.2 Regional and Local Abundance

The following sections outline the regional SRKW abundance at the scale of the entire Puget Sound, including the San Juan Islands and the Strait of Juan de Fuca, when appropriate. The local abundance is also included for NPS.

From late spring to fall, most whales of the SRKW DPS can be found in the waters around the San Juan Islands, including Haro Strait, Boundary Passage, and the northeastern portion of the Strait of Juan de Fuca (Ford et al. 1996; Krahn et al. 2004). During this period, whales are also present in smaller numbers in Rosario Strait, the interior waters of the San Juan Islands, the southern portions of Georgia Strait and the Strait of Juan de Fuca, Admiralty Inlet, Puget Sound, and the outer coast. Individuals or groups from this population may also be seen at various locations in central Puget Sound each summer, typically for periods of a few days, but occasionally remaining in the area for more than a month. During early autumn, SRKW pods (especially the J pod) expand their movements into Puget Sound, likely to feed on returning adult chum and Chinook salmon (Osborne 1999). Considerably less is known about the wintertime movements of this stock. Whales from the J pod are commonly sighted in inshore waters in winter, while the K and L pods apparently spend more time offshore (Ford et al. 1996; Krahn et al. 2004).

As of July 1, 2023, the SRKW population totals 75 whales, including 25 in J Pod, 16 in K Pod, and 34 in L Pod (Center for Whale Research 2023).

Table 1. Summary of monthly killer whale sightings in North Puget Sound from 1990-2013

Month	Sightings
January	160
February	136
March	71
April	105
May	634
June	1,479
July	1,705
August	1,096
September	982
October	408
November	266
December	328
Source: (Olson 2014)	

Based on a review of Whale Museum data from 1948 through 2017, SRKWs are most likely to occur within the Puget Sound during the months of August through January. The months of February through July have relatively fewer sightings (Olson 2018). Guidance from the NMFS Northwest Region office defines SRKWs as extremely unlikely to occur in a particular area during a particular month if the Whale Museum data set includes a total of fewer than 6 sightings in that area during that month. However, given the highly mobile nature of this species, the current 75 members of the SRKW DPS could be present within the NPS at any time of the year.

6.3 Sensitivity to Environmental Stressors

The Federal Register (70 FR 69908) has put forth 5 reasons for SRKW decline as justification for the 2005 ESA listing, including present destruction of habitat or range, overuse for human gain, disease or predation, inadequacy of existing regulatory mechanisms, and other natural or human-caused factors affecting their continued existence. SRKW habitat modification and destruction has occurred with increases in pollution, vessel traffic, and decreases in prey availability (i.e., Chinook salmon). Commercial shipping, whale watching, ferry, and recreational boat traffic have all increased within the Puget Sound in recent years, all of which impact SRKW short-term behaviors and provide additional in-water sound that may reduce SRKW foraging efficiency and communication, thereby increasing energy expenditures. Increases in pollution, urbanization, and fisheries have also drastically reduced Chinook salmon stocks, the main prey for SRKW.

Although a reduction in prey and behavioral disturbance from underwater sound are major environmental stressors for SRKW, contaminants and oil spills are also factors in their recent declines. Contaminants in sea water can range from increased sediments from upland or intertidal disturbance, pathogens and bacteria from water treatment plants and sewer outfalls, and chemicals from agricultural practices or industrial uses. As top predators, SRKW take in bioaccumulated contaminants in their diet. These toxins may accumulate in the bodies of SRKW in blubber and cause harm to immune and reproductive systems, thereby reducing individuals' viability and reproductive success. Additionally, oil spills such as the 1989 Exxon Valdez oil spill in Prince William Sound caused the direct death of individual SRKW, and oil spills can also indirectly impact SRKW by decreasing prey populations (NOAA 2024b).

The impact or effect mechanism that SRKW would be especially sensitive to is sound/noise.

7.0 HUMPBACK WHALE

The Central America and Mexico DPS's of humpback whales (*Megaptera novaeangliae*) were listed as endangered under the Endangered Species Conservation Act, the precursor to the Endangered Species Act, on December 2, 1970 (NOAA 2024c). In September 2016, the Central America was reaffirmed as endangered, and the Mexico DPS was listed as threatened (81 FR 62259). Critical habitat for both was designated on April 21, 2021 (86 FR 21082). The current designation includes marine habitat in the North Pacific Ocean, with approximately 48,521 nmi^2 designated for the Central America DPS and approximately 116,098 nmi^2 designated for the Mexico DPS of humpback whales.

7.1 Life History and Population Trajectory

Humpback whales are found through all the world's major oceans. During the summer months, they feed on krill and small fish to build up stores of blubber for the winter. They can consume up to 3,000 pounds of food per day. Humpbacks can live about 80 to 90 years, reaching sexual maturity between ages 4 and 10. Females typically produce a single calf every 2 to 3 years.

The 2016 revision to the original listing of humpback whales determined that 9 of the 14 populations have recovered enough that they do not warrant listing (NOAA 2024c). Thus, the global population of humpbacks is largely recovering and expanding. However, the Central America DPS is still listed as endangered, and the Mexico DPS is still listed as threatened. Aerial surveys of marine mammals in Alaska in 2018 recorded 53 sightings of 79 humpback whales, including 2 calves (Clarke et al. 2019).

7.2 Regional and Local Abundance

Humpback whales have not been known to typically inhabit inland and coastal waters, but sightings have become more common within the Puget Sound.

The Puget Sound is now experiencing what has been termed a "humpback comeback", as humpbacks are being spotted more frequently in the inland and coastal waters (Banse 2019). This is largely believed to be related to the overall population expansion, as well as potential shifts in oceanographic conditions and prey availability (Puget Sound Express 2019). Cascadia Research Collective estimates that about 1,600 whales feed off the west coast of North America, and about 500 off Washington and British Columbia specifically (Puget Sound Express 2019).

7.3 Sensitivity to Environmental Stressors

Humpback whale populations were largely decimated by commercial whaling practices, prior to the moratorium in 1985 (NOAA 2024c). Primary threats continue to be from human and boat disturbance, including vessel strikes, entanglements, and harassment by vessels. These threats are of rising concern within the Puget Sound as numbers have increased in recent years (Boiko-Weyrauch 2019; Banse 2019).

The impact or effect mechanism that humpback whales would be especially sensitive to is sound/noise.

8.0 MARBLED MURRELET

Marbled murrelet (*Brachyramphus marmoratus*) are listed as threatened at the federal level, with defined critical habitat in nesting locations along the west coast of the United States (USFWS 2024a). Marbled murrelet were initially listed on October 1, 1992 (57 FR 45328). Critical habitat for the marbled murrelet was originally designated on May 24, 1996 (61 FR 26256) and further revised on October 5, 2011 (76 FR 61599). The current designation includes approximately 3,698,100 acres in Washington, Oregon, and California.

8.1 Life History and Population Trajectory

Marbled murrelets spend most of their lives in the marine environment, but nest in old-growth forests within range of the coast. Both males and females have a sooty-brown upperpart with dark bars and light, mottled brown underparts. Their breeding range extends from Bristol Bay, Alaska in the north to Monterey Bay, California in the south (USFWS 2024a). They breed in the early spring, laying one egg per nest and usually only nesting once per year (DNR 2014). Nesting birds typically forage more closely to the nesting habitats than do non-nesters, with a range size of 240 km^2 compared to 655 km^2, as measured on radio marked murrelets in northern California (Hébert and Golightly 2008). However, home range size was found to vary more greatly by year in Washington: 2,098 km^2 in 2005 compared to 469 km^2 in 2004 (Bloxton and Raphael 2008). In the marine environment, their preferred habitats include sheltered, nearshore waters within 3 miles of the shore (USFWS 2024b).

These seabirds are primarily opportunistic feeders, relying on small schooling fish (e.g. Pacific sand lance (*Ammodytes hexapterus*), northern anchovy (*Engraulis mordax*), and Pacific herring (*Clupea pallasii*), rockfish, and marine invertebrates like squid and shrimp (DNR 2014). Feeding primarily occurs in shallow, nearshore water that is less than 100 feet deep (USFWS 2024b). Foraging murrelets do not typically form groups but may collect around schools of fish or other food resources (Speich and Wahl 1989).

General population models and trends suggest that the marbled murrelet population is on a long-term downward trajectory (WDFW 2024). Past demographic models suggest losses of about 3 to 7 percent per year (McShane et al. 2004). However, a USFWS's 2019 5-year status review found that "while there continue to be significant declines in the murrelet population in Washington State, there does not appear to be a trend (negative or positive) at the listed-range scale" (USFWS 2019a), which is a change from their 2009 5-year status review.

8.2 Regional and Local Abundance

The following sections outline the regional abundance of marbled murrelets at the scale of the entire Puget Sound and North Puget Sound.

Puget Sound is encompassed by Conservation Zone 1, as defined in the original Marbled Murrelet Recovery Plan (USFWS 1997). According to at-sea population surveys conducted for annual monitoring, murrelets are estimated to have had an annual rate of change of -4.9% between the years of 2001-2016 within Conservation Zone 1 (USFWS 2019a). Nonetheless, marbled murrelets are considered to be fairly common within the Puget Sound throughout the year (Seattle Audubon Society 2019a).

8.3 Sensitivity to Environmental Stressors

Because marbled murrelets rely on both marine and terrestrial environments, they are sensitive to a variety of stressors. Threats discussed in this section will be divided into factors specific to terrestrial, nesting habitats and those affecting marbled murrelets in general.

The primary stressor within the marbled murrelet terrestrial range is loss of nesting habitat. Nesting habitat is threatened by commercial logging and other human disturbance, and climate change is likely to exacerbate habitat loss and fragmentation (USFWS 2019a). For this reason, much of the existing old-growth forest suitable for marbled murrelet nesting has been designated as critical habitat to limit the allowable actions within these areas (61 FR 26256).

Other threats impact marbled murrelets during the portion of their lives when they are in the marine environment. These factors include the following ((USFWS 2019b):

- Loss of habitat
- Predation

- Gill-net fishing operations
- Oil spills
- Marine pollution
- Disease

Impacts or effect mechanisms that marbled murrelets would be especially sensitive to include:

- Sound/noise
- Physical disturbance of organisms
- Stranding

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Appendix E

Rainbow Trout Early Life Stages in situ Monitoring

Nautilus Environmental

Port of Seattle- Seattle-Tacoma International Airport

Rainbow Trout Early Life Stages *In Situ* Monitoring Testing

Phase 1: Development and Demonstration - Fall 2011 and Spring 2012 Testing Events

Final Report

Report date: September 20, 2012

Submitted to:

Port of Seattle
Seattle-Tacoma International Airport
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1.0 INTRODUCTION

This report presents the results of the rainbow trout (RBT) early life stages (ELS) *in situ* monitoring tests conducted in the Fall 2011 and Spring 2012, as described in the Port of Seattle's Seattle-Tacoma International Airport *In situ* Monitoring Plan, Phase 1: Development and Demonstration (Nautilus 2010). Results for studies conducted in Fall 2010 and Spring 2011 were presented previously (Nautilus 2011). The objective of this program is to demonstrate the feasibility of using salmonid ELS as an *in situ* monitoring tool to assess the quality of receiving waters potentially affected by stormwater discharges from the Seattle-Tacoma International Airport (STIA), as well as a multitude of other discharges from the surrounding urban environment. The *in situ* bioassay and supporting analytical data are intended to serve as an indication of attainment of receiving water quality standards and associated beneficial uses related to salmonid spawning and rearing. Thus, the overall goal of Phase 1 is to validate the *in situ* approach, particularly with respect to determining if the selected sites and exposure methodologies are appropriate, or if they need to be modified to compensate for confounding variables (e.g., deposition of fine sediments, mobilization of anoxic sediments during storm events, etc.). Applied under the appropriate conditions, it is anticipated that the RBT *in situ* ELS bioassay will be an effective instream biological monitoring tool for assessing the potential effects of stormwater discharges on the receiving environment. In addition to continued evaluation of the *in situ* testing methodology, this report also compares the results of the current year's monitoring to results obtained the previous year to determine the extent to which they were consistent between years.

Phase I (i.e., Development and Demonstration) was originally intended to last for one year and include testing during the Spring and Fall seasons. However, this Phase is being extended to allow for additional comparison with the sublethal testing currently being conducted by the STIA at sites downstream of Port outfalls as identified in Part II, Special Condition S8 of their NPDES permit. The laboratory sublethal toxicity testing is used for permit compliance purposes, and has been conducted concurrently with *in situ* deployments when feasible to facilitate validation of the *in situ* methodology. Part II, Special Condition S9 of the permit allows for substitution of the laboratory sublethal test with *in situ* testing, but, because the *in situ* testing has been implemented on a watershed approach, direct substitution of the *in situ* test in place of the laboratory sublethal test is not appropriate at this time.

For the remainder of the permit cycle (through March 2014), *in situ* testing will continue to focus on the watershed-based sites identified in the monitoring plan, along with continued concurrent laboratory sublethal testing. Extended implementation of Phase I through the remainder of the current permit cycle will create a valuable dataset for use in comparing the *in situ* methodology with the laboratory sublethal test.

2.0 TEST METHODS

Guidance for conducting *in situ* ELS exposures with salmonids is available from a number of sources. For example, the British Columbia Ministry of Environment has a protocol for an *in situ* ELS salmonid test (BC MoE, 2003). In addition, Environment Canada has developed both laboratory and *in situ* test procedures for early lifestages of rainbow trout (Environment Canada, 1998). In the U.S., there are two general laboratory protocols for conducting fish early life stage toxicity tests (EPA, 1996; ASTM, 2005).

2.1 Design

The study design used for the Fall 2011 and Spring 2012 *in situ* testing involved exposure of eyed-embryos at three sampling sites, using four replicates per site. The locations of the sites are shown in Figure 1. The Study Design was consistent with the methodology used in the Spring 2011 monitoring event in which the two sites located downstream of all Airport discharges were augmented by an additional site on Des Moines Creek located upstream (Des Moines Creek Upstream) of any Airport discharges. The additional site was included to determine the extent to which sources upstream of any STIA inputs may contribute to adverse effects observed at the downstream site on Des Moines Creek. The study design for both events is summarized in Table 1.

The exposure period used in the *in situ* tests covers the major salmonid early life stage developmental milestones, beginning with the eyed egg stage, proceeding through hatching and alevin (yolk sac present and residing in gravel) stages, and ending with the early fry stage (also known as swim-up fry). At this point, the yolk sac is absorbed and, under natural conditions, the fish would leave the gravel to feed independently. The duration of the exposure period was expected to include multiple rain/runoff events, and corresponding fluctuations in flow, contaminant concentrations, temperature, water chemistry, etc. Collectively, these

attributes of the *in situ* approach provide highly relevant information regarding the suitability of the streams to support salmonids.

The eyed eggs for both *in situ* events were supplied locally by TroutLodge (Sumner, WA), which supplies these same organisms for the laboratory toxicity tests required in STIA's NPDES stormwater permit. The status of the *in situ* organisms was routinely monitored during the exposure, as well as at specific developmental stages and after significant storm events. Data were obtained on hatching, survival, development and growth. A subset of embryos was also reared in the laboratory to assess organism quality. Weekly temperature measurements from the field were used to adjust rearing temperatures for the laboratory controls so that development in the controls could be used to trigger field inspections at specific times (e.g., hatch, swim-up).

Table 1: Summary of the *in situ* ELS test study design.

Names of Sites	No. of Replicates	No. of Embryos per replicate
Miller Creek (MC8th)	4	30
Des Moines Creek at S 200th	4	30
Des Moines Creek Upstream	4	30
Laboratory Control	4	30

2.2 Monitoring Locations and Site Preparation

The exposures were conducted in two streams within STIA property boundaries, Miller Creek and Des Moines Creek, Figure 1. Two of the sites, Miller Creek and Des Moines Creek at S 200th, are located downstream of STIA inputs into their respective drainages. An additional site (Des Moines Creek Upstream) is located upstream of STIA stormwater outfalls into Des Moines Creek. This site is used to assess water quality in Des Moines Creek prior to receiving any STIA stormwater discharges; the Des Moines Creek basin upstream of STIA is heavily urbanized and potentially impacted by a variety of pollutant sources.

The chosen sampling sites generally do not have ideal substrate conditions, and are subjected to heavy sediment flow during storm events. Consequently, based on results obtained during the previous year, all four exposure replicates at each site were placed above the substrate in gravel contained within PVC crate frames (see Figure 2). The stakes and associated crates were placed so that replicate crates rested on the streambed in a row from upstream to downstream, at a sufficient distance apart such that flow patterns were reestablished between each crate. This

approach allowed for passage of water through the exposure chambers, but prevented smothering of embryos and fry by sediment.



Port of Seattle

Figure 1
Receiving Water Monitoring Locations

2.3 Field Exposure Apparatus

The trout embryos were contained in modified Whitlock-Vibert hatchboxes (Federation of Flyfishers, MO), which are comprised of two rectangular chambers located one above the other; the upper chamber is for embryo development and the lower chamber for rearing of hatched fish. The external sides of the hatchbox are plastic mesh that allows passage of water through the box, but prevents loss of embryos. The divider between the embryo chamber and the rearing chamber is comprised of slots that are narrow enough to prevent transfer of unhatched embryos, but wide enough to permit migration of hatched fish into the lower rearing chamber. Thus, upon hatch, alevins are able to migrate through the slots from the embryo chamber into the larger rearing chamber. To prevent escape of the hatched fry into the streams upon swim-up, plastic screening material (Darice® size 7 mesh) was attached to the external faces of the rearing chamber and held in place using small plastic zip ties.

The hatchboxes were contained within flexible plastic mesh bags surrounded by 1 – 2 inch diameter gravel, with the hatchbox placed centrally within the rocks in the bag. The gravel surrounding the hatchboxes acts to diffuse the current and prevent exposure of the embryos to sunlight. The bags were then placed within the PVC crates, which were held in place in the stream by stakes anchored in the substrate (Figure 2). Figure 3 shows the eyed eggs within the hatchbox, while Figure 4 is of fry within the hatchbox.

Figure 2: Photograph of the crate set up, Des Moines Creek at S 200th.



Figure 3: Photograph of eyed eggs in the upper chamber within the hatchbox.

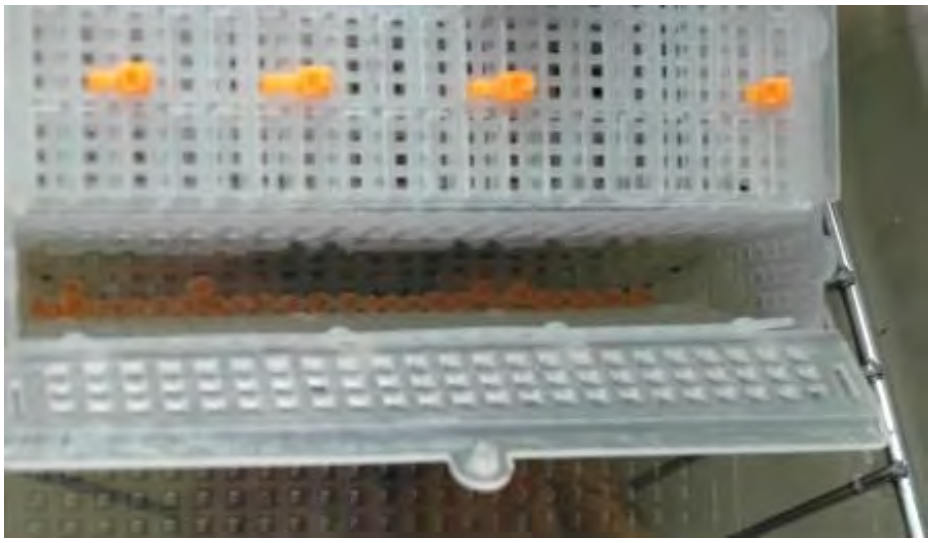


Figure 4: Photograph of fry within the hatchbox.



2.4 Test Organisms

Eyed-egg stage rainbow trout embryos were obtained from TroutLodge in Sumner, WA, on November 30, 2011 and March 27, 2012 for the Fall and Spring events, respectively. As supplied, the eyed embryos had developed for approximately 245 degree-days[1], as noted in communication with TroutLodge staff. The embryos were transported to the Airport Stormwater Laboratory or the Rainier Environmental Laboratory (Fife, WA), for the Fall and Spring monitoring events, respectively, where they were randomly counted into replicate units of 30 embryos apiece in individual opaque plastic food-storage containers (i.e., 450-mL opaque Ziploc plastic tubs). The containers were then placed in a cooler containing ice packs, and transported to the sites where the embryos were transferred into the hatchboxes in the creek on the same day. The embryos were transferred to the sites in laboratory control water, and all embryos were installed at the sites between 13:00 and 14:30 on November 30, 2011 for the Fall event, and between 14:45 and 15:45 on March 27, 2012 for the Spring event.

All personnel handling the embryos wore nitrile gloves. Containers were pre-cleaned with Liqui-nox soap (Alconox, Jersey City, NJ) and rinsed with deionized water.

2.5 Controls

Controls were used to assess the influence of the following factors on test results:

1. Quality (health and viability) of supplied organisms,
2. Transport and handling of organisms, and
3. Ambient stream temperatures, which affect the time to developmental milestones (e.g., hatch).

The controls consisted of a laboratory exposure (four replicates of 30 organisms each) conducted concurrently with each field exposure in clean laboratory water (moderately hard synthetic water [MHSW]) to monitor organism health and developmental milestones using a subset of the same batch of embryos used to begin the field exposures. These embryos were also counted out and placed in individual plastic containers filled with MHSW and transported to the sites with the other replicates; thus, they also served as transport controls. Upon returning to the

[1] Degree-days are used to standardize descriptions of fish development, regardless of rearing temperature. For example, it takes rainbow trout approximately 340 degree-days to reach hatch (Quinn, 2005). Thus, at 8°C, it takes approximately 42 days to reach hatch.

laboratory after deployment of all field organisms, the control replicates were transferred to 4-L plastic containers in the laboratory containing 2 liters of MHSW at the average site water temperature, ± 1°C. Gentle aeration was applied (100-200 bubbles per minute) to the control chambers. The controls were monitored daily for mortalities, and dead organisms removed. Temperature was adjusted on a weekly basis to correspond to temperatures measured in the field. Water renewals were conducted three times per week (Monday, Wednesday, Friday) using clean MHSW. Dissolved oxygen, pH, conductivity, and temperature were measured before and after water renewals. Developmental milestones (e.g., hatch and swim-up) were also recorded.

2.6 Monitoring of Field Exposures

The sites were visited approximately every week to assess the condition of the test organisms. During these checks, survival was recorded, as well as qualitative observations of organism health, site conditions, and sedimentation within the boxes. All dead organisms observed were removed on each visit. These observations were recorded on standard field data sheets included in Appendix A. In addition, temperature, pH, and dissolved oxygen (DO) and conductivity were measured during the site visits.

Monitoring of the installations required removal of the substrate overlying the hatchboxes from the mesh bag in the crate. The embryos or alevins in each hatchbox were then poured into a white plastic dishpan containing site water where they were enumerated. They were then returned to the hatchbox, which was placed back into the mesh-net bag of gravel, and the bag returned to its respective crate. Care was taken to minimize disturbance and damage to the test organisms.

2.7 Test Termination

The field exposures and laboratory controls were terminated when the field organisms reached the swim-up fry stage (i.e., yolk sac absorbed). This occurred on February 14th, 2012 for the Fall 2011 exposure, and on April 25th, 2012 for the Spring 2012 exposure. Surviving organisms were placed in their original plastic replicate containers, which were filled with site water, transported back to the laboratory and terminated. The fish were then wet-weighed (to the nearest 0.001 gram) on an analytical balance, and measured (total length, from tip of the snout to the end of the tail for the Fall exposure, and standard length, from tip of snout to caudal

peduncle for the Spring exposure) to the nearest 0.5 mm. Obvious external malformations were noted, including the affected body part (e.g., head, eye, spine) and type of abnormality (e.g., edema). Abnormality data were recorded on standard data sheets (Appendix A). The laboratory control fish were evaluated similarly on the same day.

2.8 Data Analysis

All test data were entered in CETIS (Comprehensive Environmental Toxicity Information System, Tidepool Scientific, McKinleyville, CA). Differences among the exposure sites and laboratory controls were evaluated using pair-wise multiple comparison tests according to the USEPA flow chart (USEPA 2002); significant differences were identified at p=0.05.

One interim and five terminal endpoints were evaluated; the endpoints are described below:

1. Hatching success – an interim measure of the percentage of embryos hatched the day of the hatch inspection, or determined to have hatched based on the number of alevins present at the subsequent inspection, relative to the total number of embryos originally added;
2. Post-hatch survival - the percentage of organisms surviving at test termination relative to the number of embryos that hatched (these data help determine whether the majority of mortalities occurred pre- or post-hatch, or were distributed throughout the exposure period);
3. Cumulative survival - the percentage of surviving organisms at test termination relative to the number of embryos in each replicate at the beginning of the exposure;
4. Abnormality – the percentage of abnormal organisms at test termination relative to the number of surviving organisms;
5. Length – to the nearest 0.5 mm;
6. Weight – to the nearest 0.001 g.

3.0 QA/QC

The QA/QC program for the field exposure involved the following:

- Consistent field staff leader throughout all visits;
- Field documentation of all primary data; i.e., the names of individuals collecting the samples, sampling location, time of sampling, site conditions (e.g., degree of

sedimentation), and other relevant observations, such as weather and any unusual conditions;

- Calibrated field meters;
- Use of pre-cleaned containers, with appropriate labels;
- Storing and transporting organisms in sealed containers in a cold, dark environment; cooling sample containers using ice or gel packs;
- Including transport controls to ascertain the extent of any transport-induced stress;
- Checking field organisms every week to monitor developmental progress, mortality and abnormality.

The QA/QC program for the laboratory portion of the study involved:

- Checks and maintenance of control organisms at regular intervals, including recording primary observations and water quality data on standardized data sheets;
- Review of datasheets by senior laboratory staff;
- Test termination activities (measurements, health assessment) conducted by qualified staff members using standardized datasheets to ensure consistent assessment of abnormalities and growth across all test sites and controls;
- Use of standard laboratory water and environmental chambers to maintain test organisms.

4.0 RESULTS

4.1 Water Quality Measurements

Water quality measurements are summarized in Tables 2 and 3 for the Fall 2011 and Spring 2012 monitoring events, respectively.

Table 2: Fall 2011 summary of water quality measurements collected during site visits and control renewals.

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	5.3 (1.2)	9.7 (0.6)	7.49 (0.19)	261.3 (19.4)
	[Min-Max]	[3.1 – 7.6]	[7.1 – 10.6]	[7.04 – 7.82]	[220 – 298]
Miller Creek		5.5 (1.2)	10.7 (2.2)	7.53 (0.17)	198.5 (51.5)
		[4.1 – 7.2]	[6.5 – 12.6]	[7.24 – 7.78]	[132 – 293]
Des Moines Creek		5.7 (1.3)	10.0 (1.3)	7.42 (0.26)	168.6 (69.1)
at S 200th		[3.4 – 7.3]	[7.1 – 11.5]	[7.12 – 7.81]	[93 – 327]
Des Moines Creek		5.5 (1.4)	10.9 (1.9)	7.40 (0.39)	114.6 (66.6)
Upstream		[3.0 – 7.9]	[6.9 – 13.1]	[6.48 – 7.9]	[27 – 214]

Data include average, (standard deviation) and [minimum - maximum]

Table 3: Spring 2012 summary of water quality measurements collected during site visits and control renewals.

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	10.6 (0.7)	10.9 (0.4)	7.87 (0.08)	353.1 (6.6)
	[Min-Max]	[9.5 – 12.0]	[10.2 – 11.6]	[7.70 – 8.00]	[341 – 365]
Miller Creek		10.5 (1.2)	10.1 (0.6)	7.60 (0.10)	211.4 (29.9)
		[9.3 – 12.3]	[9.4 – 10.7]	[7.47 – 7.74]	[170 – 247]
Des Moines Creek		11.1 (1.6)	9.5 (0.5)	7.45 (0.19)	178.6 (17.7)
at S 200th		[9.5 – 13.5]	[8.7 – 9.9]	[7.31 – 7.78]	[151 – 193]
Des Moines Creek		11.2 (1.6)	9.4 (0.3)	7.65 (0.31)	118.3 (6.7)
Upstream		[9.7 – 12.8]	[9.0 – 9.7]	[7.40 – 8.07]	[109 – 125]

Data include average, (standard deviation) and [minimum - maximum]

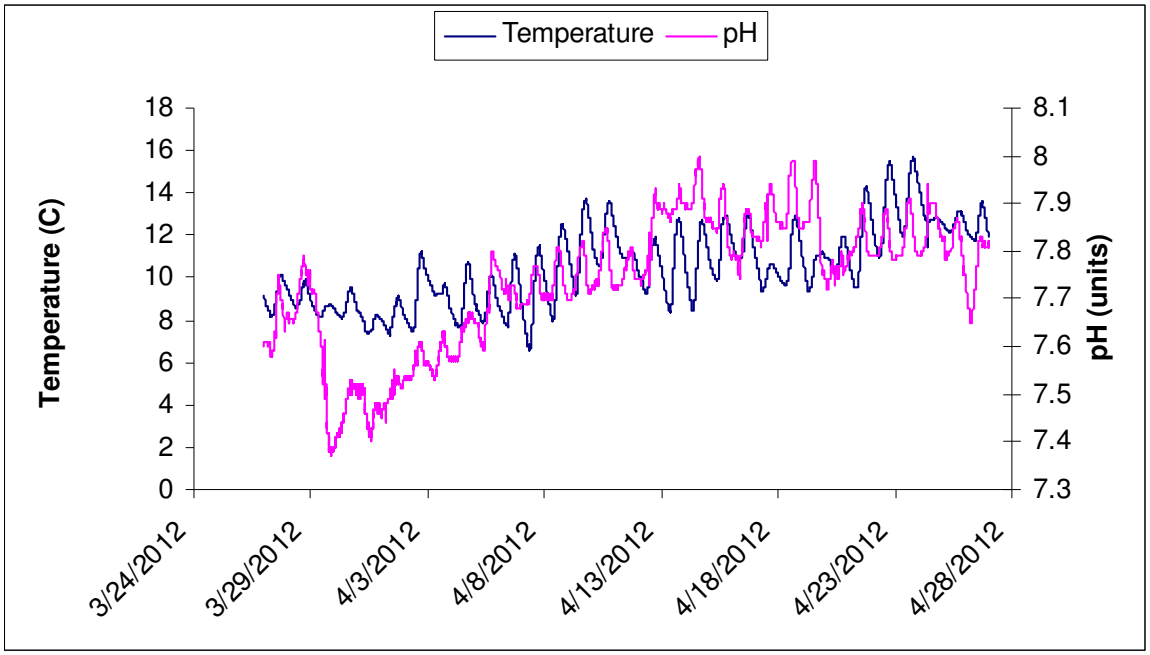
In the Fall 2011 *in situ* tests, temperatures for the three field sites and the control ranged from 3.0 to 7.9ºC. The field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays (60-100% saturation, and 6-9 pH units, respectively). The pH values were circumneutral, and DO ranged from 6.5 to 13.1 mg/L among all stream measurements. Although limited to weekly measurements, the field DO and pH data suggested generally good water quality conditions, with no indication of potential for adverse effects on organism survival and development. The conductivity measurements for all three sites exhibited some

variability throughout the exposure period, but the values remained well-within ranges tolerated by early life stages of salmonids.

In the Spring 2012 *in situ* tests, temperatures between the three field sites and the control ranged from 9.3 to 13.5ºC. These temperatures were about 5 degrees warmer than fall temperatures, which accounts for the difference in test durations between the two events (i.e., 77 days for the Fall event and 30 days for the Spring event). The field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays. The pH values were circumneutral, and DO ranged from 8.7 to 10.7 mg/L among all stream measurements. Consequently, the weekly field measurements of DO and pH suggested generally good water quality conditions, with no indication of potential for adverse effects on organism survival and development. As observed in the Fall event, the conductivity measurements for all three sites exhibited some variability throughout the exposure period, but the values remained well-within ranges tolerated by early life stages of salmonids.

Continuous measurements of pH and temperature were collected by CardnoTEC using data sondes at the Miller Creek site during the Spring 2012 monitoring event. These data are shown in Figure 5. The data generally agreed with the values collected during the weekly checks at the site, although temperature readings occasionally reached higher levels throughout the day than measured at a single weekly time point. Regardless, the average temperature over the exposure period was similar between methodologies (i.e., 10.5ºC with both continuous and weekly checks). pH readings obtained with continuous monitoring averaged 7.74 compared with an average of 7.60 calculated from the weekly checks. Data from both methodologies suggest that temperature and pH were well-within water quality ranges appropriate for survival and growth of local salmonids.

Figure 5: Continuous pH and temperature data from Miller Creek, Spring 2012



4.2 Precipitation During the Monitoring Events

Precipitation data were provided by STIA. Figure 6 shows the daily precipitation for the duration of the exposure for the Fall 2011 test. A number of storm events occurred during testing, with a total of 10.0 inches of rain/snow over 11 weeks, and the largest storm occurring on January 20th.

Figure 6: Daily precipitation for the duration of fall exposure

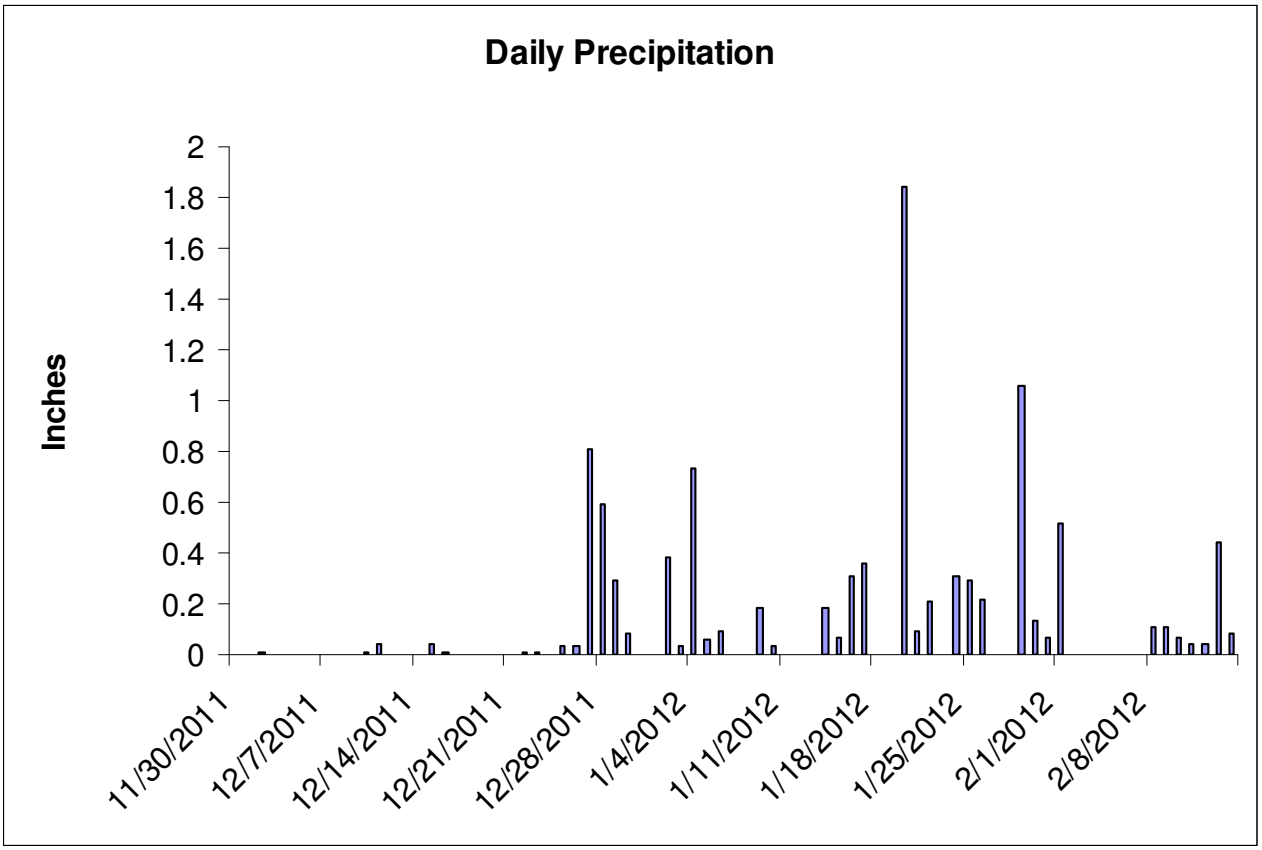
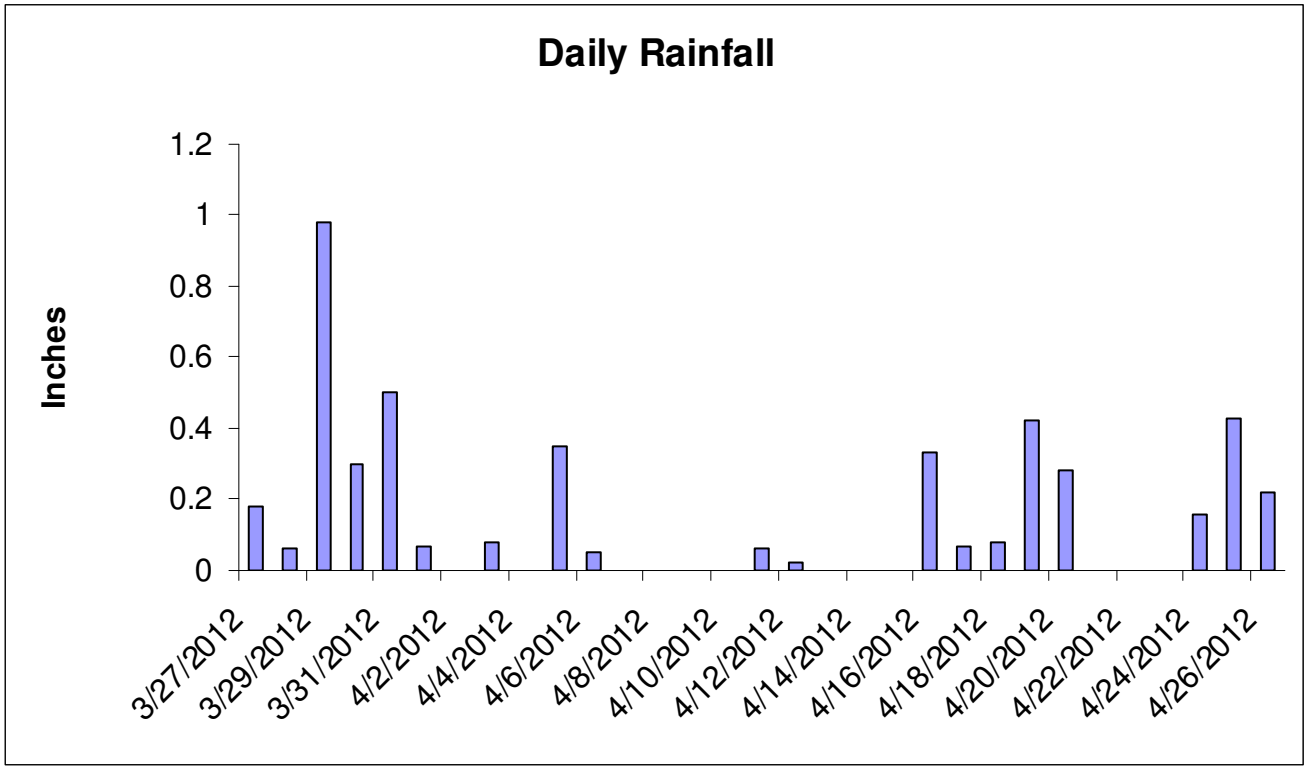


Figure 7 contains the daily rainfall for the duration of the exposure for the Spring 2012 test. Much less total precipitation (4.6 inches) and fewer storms occurred during this exposure period, compared with the fall. No snow occurred during the exposure period, and the largest storm was on March 29th.

Figure 7: Daily rainfall for the duration of the spring exposure



4.3 *In situ* Exposures

4.3.1 Fall 2011

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 4. Table 5 presents the growth endpoints. These same data are presented graphically in Figures 8 through 10 for ease of comparison.

At termination, fish in the controls had developed to 655 degree-days, while the site fish reached approximately 659 degree-days at Miller Creek, 676 degree-days at Des Moines Creek at S 200th, and 660 degree-days at the Des Moines Creek Upstream site.

Hatching success – Mean hatching success for the controls was 99.2%. The Miller Creek replicates exhibited 90.0% mean hatching success, the Des Moines Creek at S 200th replicates had 90.8% mean hatching success, while the Des Moines Creek Upstream replicates averaged 89.2% mean hatching success. Hatching success at Miller Creek, Des Moines Creek at S 200th and Des

Moines Creek Upstream were not statistically different from the controls, and there was no significant difference between the two Des Moines Creek sites.

Post-hatch survival – Control survival of alevins post-hatch was 93.3%. The Miller Creek replicates exhibited 68.0% post-hatch survival, and the Des Moines Creek at S 200th replicates exhibited 56.2% post-hatch survival, while the Des Moines Creek Upstream replicates averaged 50.3%. Post-hatch survival at Miller Creek was not significantly different from the controls. However, the two Des Moines Creek sites were significantly different from the controls, but not from each other.

Cumulative survival – Control survival from the initiation of the test to termination averaged 92.5%. The Miller Creek replicates exhibited an average survival of 63.3% through the duration of the exposure, whereas the Des Moines Creek at S 200th replicates exhibited an average survival of 50.0% compared with an average survival of 45.0% at the Des Moines Creek Upstream site. Statistically, these results were similar to post-hatch survival; thus, Miller Creek was not statistically different from the controls, and the two Des Moines Creek sites were significantly different from the controls, but not from each other.

Abnormalities – There were no abnormalities observed in any of the fish at termination. Some edema was noted during a field visit at both the Des Moines Creek Upstream site and Miller Creek, but these fish either died subsequent to that visit, or the edema had resolved itself by the end of the exposure.

Growth – Average weight in the controls was 119.7 mg, and length averaged 21.1 mm. Miller Creek fish averaged 111.7 mg and 21.7 mm, Des Moines Creek at S 200th fish averaged 104.1 mg and 21.8 mm, and Des Moines Creek Upstream fish averaged 107.4 mg and 21.7 mm. None of the differences in length or weight were significant among sites and controls.

Table 4: Fall 2011 results for hatching success, survival and abnormality in the control and field treatment groups[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	99.2 (1.6)	93.3 (5.4)	92.5 (4.2)	0
Miller Creek	90.0 (11.5)	68.0 (29.0)	63.3 (31.4)	0
Des Moines Creek at S 200th	90.8 (7.4)	56.2 (36.1)	50.0 (31.4)	0
Des Moines Creek Upstream	89.2 (11.0)			0

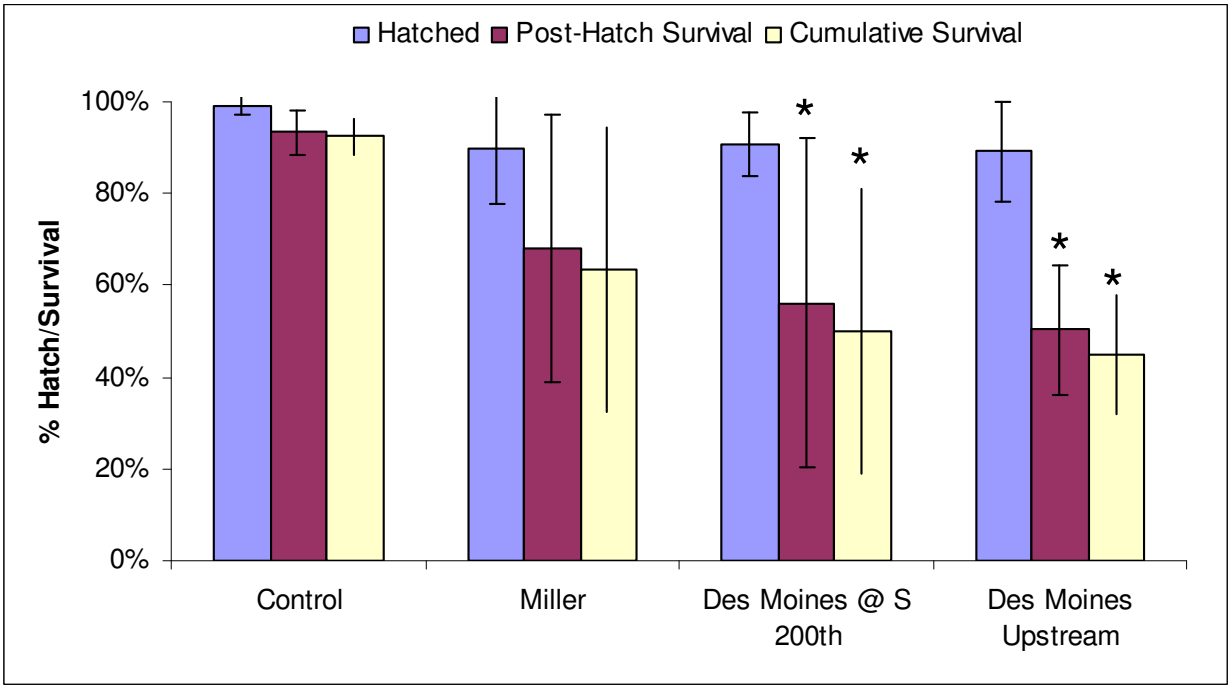
Notes:
1. Results are presented as mean and standard deviation
2. Gray shaded values are significantly different from the control

Table 5: Fall 2011 results for growth in the control and field treatment groups [1].

Site	Length (mm)	Weight (mg)
Control	21.1 (1.0)	119.7 (7.6)
Miller Creek	21.7 (0.49)	111.7 (8.3)
Des Moines Creek at South 200th	21.8 (0.55)	104.1 (17.0)
Des Moines Creek Upstream	21.7 (0.88)	107.4 (7.0)

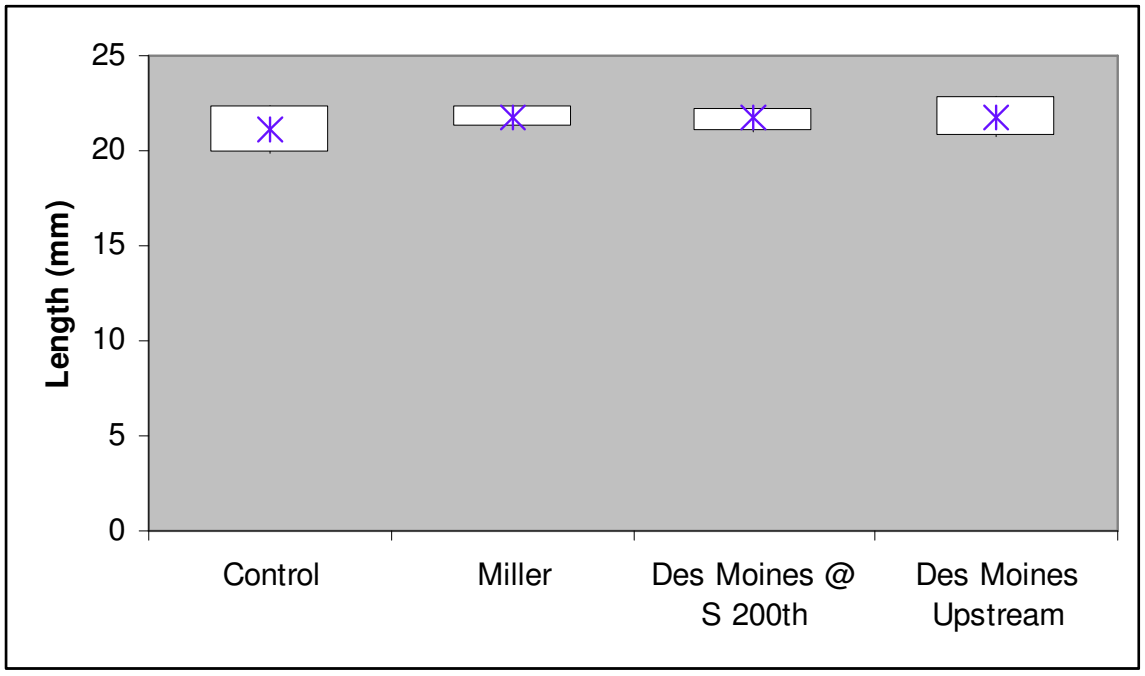
Notes:
1. Results are presented as mean and standard deviation
2. There were no statistical differences compared to the control

Figure 8: Fall 2011 hatching success, post-hatch survival and cumulative survival in the field and control treatment groups.



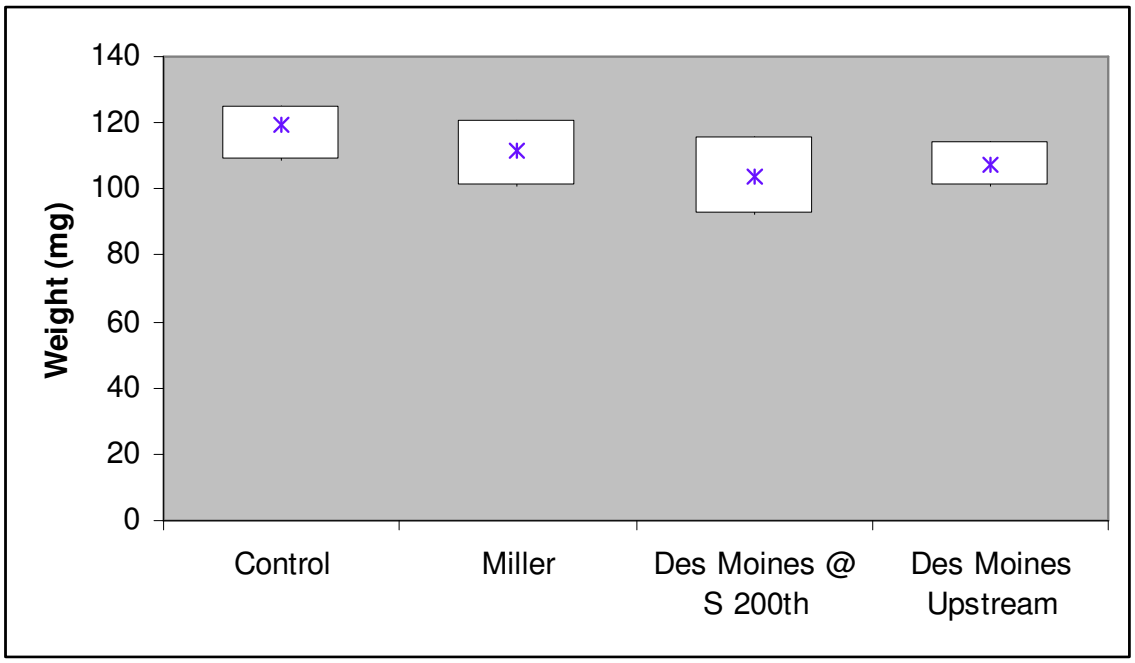
Error bars are standard deviations; asterisks denote significant difference from controls.

Figure 9: Fall 2011 average lengths for the laboratory control and exposure sites.



Data point is average, box is minimum to maximum values

Figure 10: Fall 2011 average weights for the laboratory control and exposure sites.



Data point is average, box is minimum to maximum values

4.3.2 Spring 2011

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 6. Table 7 presents the growth endpoints. These same data are presented graphically in Figures 11 through 13 for ease of comparison.

At termination, fish in the controls had developed for 552 degree-days, while the site fish developed to approximately 549 degree-days at Miller Creek, 564 degree-days at Des Moines Creek at S 200th, and 585 degree-days at the Des Moines Upstream site.

Hatching success – Mean hatching success for the controls was 100%. The Miller Creek replicates exhibited 95.0% mean hatching success, the Des Moines Creek at S 200th replicates had 100% hatching success, and the Des Moines Creek Upstream replicates averaged 94.2% hatching success. There were no significant differences in hatching success among the treatment and control groups.

Post-hatch survival – Control survival of alevins post-hatch was 100%. The Miller Creek replicates averaged 96.5% post-hatch survival, compared with 96.7% survival at Des Moines Creek at S 200th. Post-hatch survival at Miller Creek and Des Moines Creek at S 200th was not

significantly different from the controls. Conversely, fish in the Des Moines Creek Upstream replicates exhibited 0% post-hatch survival, which was significantly different from the controls and the other two exposure sites.

Cumulative survival – Control survival from the initiation of the test to termination averaged 100%. The Miller Creek replicates exhibited an average survival of 91.7% through the duration of the exposure, while Des Moines Creek at S 200th replicates averaged 96.7% survival; both of these values were not significantly different from the controls. The Des Moines Upstream replicates exhibited 0% survival at the end of the exposure, which was significantly different from the controls, as well as the other sites.

Abnormalities -- The incidence of abnormalities at termination was 0.83% in controls. The Miller Creek replicates averaged 1.1% abnormality, and there were no abnormalities at the Des Moines Creek at S 200th site, (complete mortality prevented determination of this endpoint for the Des Moines Creek Upstream site). The abnormal control fish exhibited a malformed head, while the abnormal Miller Creek fish was suffering from edema. There were no significant differences between the controls and the two sites.

Growth – Average weight in the controls was 127.4 mg, and length averaged 24.2 mm. Miller Creek fish averaged 137.3 mg and 24.5 mm for weight and length, respectively, and Des Moines Creek at S 200th fish averaged 134.2 mg and 24.3 mm. None of the differences in length or weight were significant between sites with surviving organisms and controls. Complete mortality prevented determination of these endpoints for the Des Moines Creek Upstream site.

Table 6: Spring 2012 results for hatching success, survival and abnormality in the control and field treatment groups[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	100 (0)	100 (0)	100 (0)	0.83 (1.7)
Miller Creek	95.0 (10)	96.5 (4.7)	91.7 (11.1)	1.1 (2.2)
Des Moines Creek at S 200th	100 (0)	96.7 (4.7)	96.7 (4.7)	0 (0)
Des Moines Upstream	94.2 (5.7)	0 (0)	0 (0)	NC

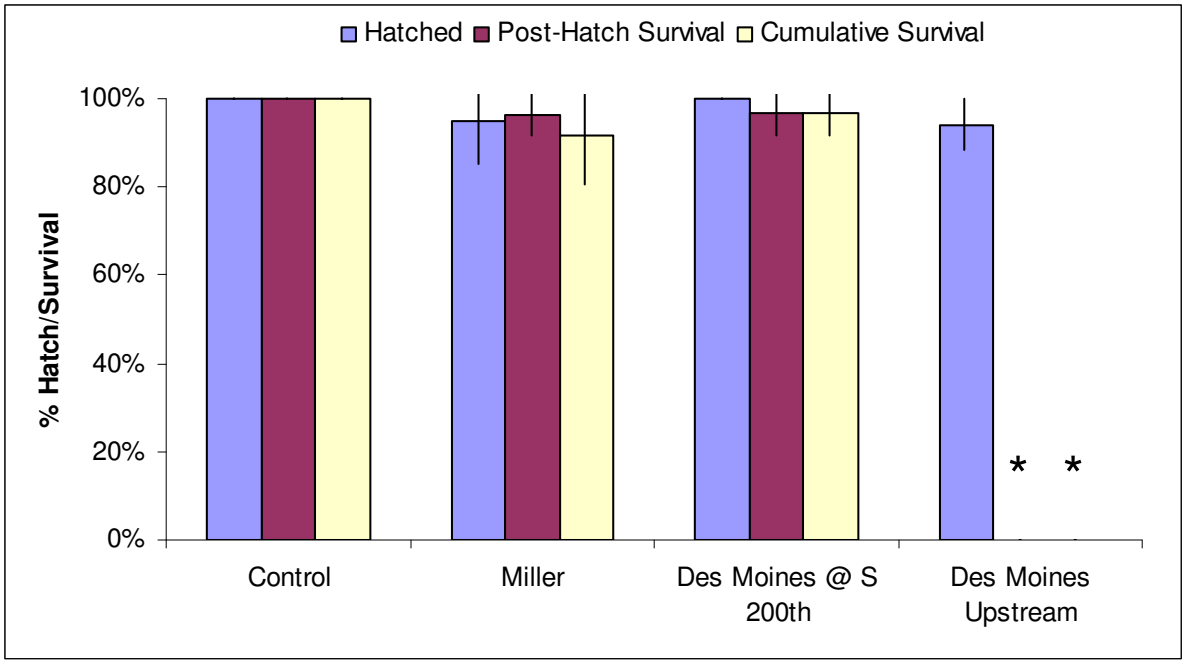
Notes:
1. Results are presented as mean and standard deviation
2. Gray shaded values are significantly different from control
3. NC- Not calculable

Table 7: Spring 2012 results for growth in the control and field treatment groups.

Site	Length (mm)	Weight (mg)
Control	24.2 (0.33)	127.4 (4.8)
Miller Creek	24.5 (0.51)	137.3 (4.9)
Des Moines Creek at S 200th	24.3 (0.13)	134.2 (6.8)
Des Moines Upstream	NC	NC

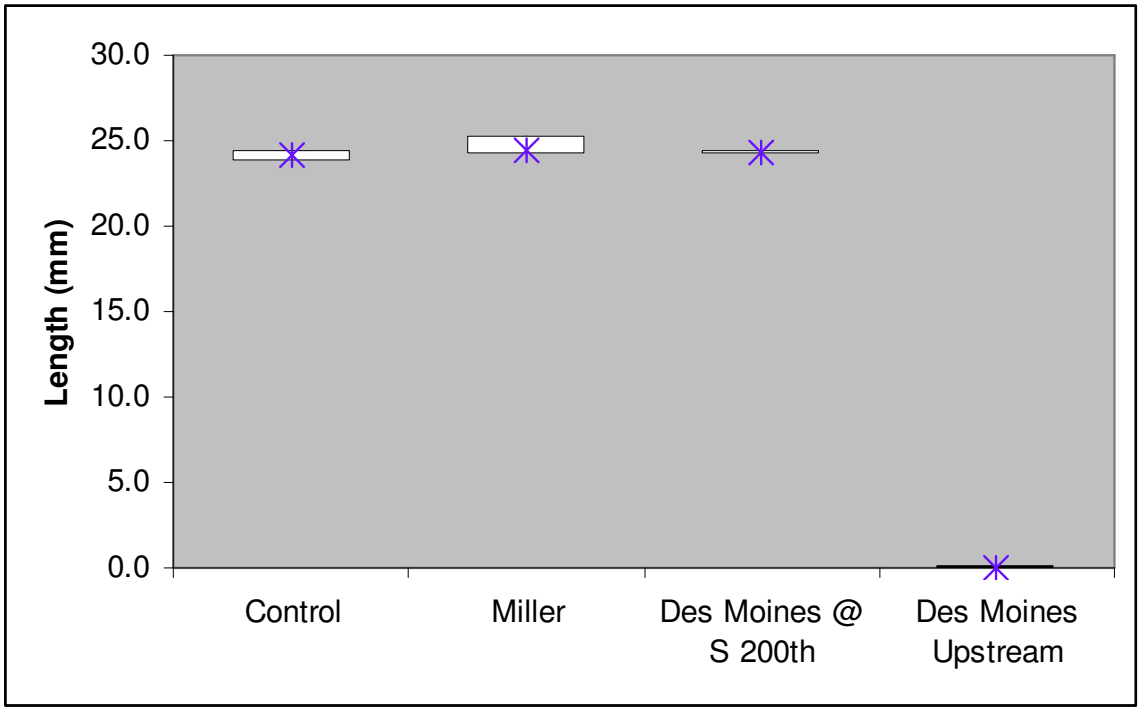
Notes:
1. Results are presented as mean and standard deviation
2. NC- Not calculable

Figure 11: Spring 2012 hatching success, post-hatch survival and cumulative survival in the field and control treatment groups.



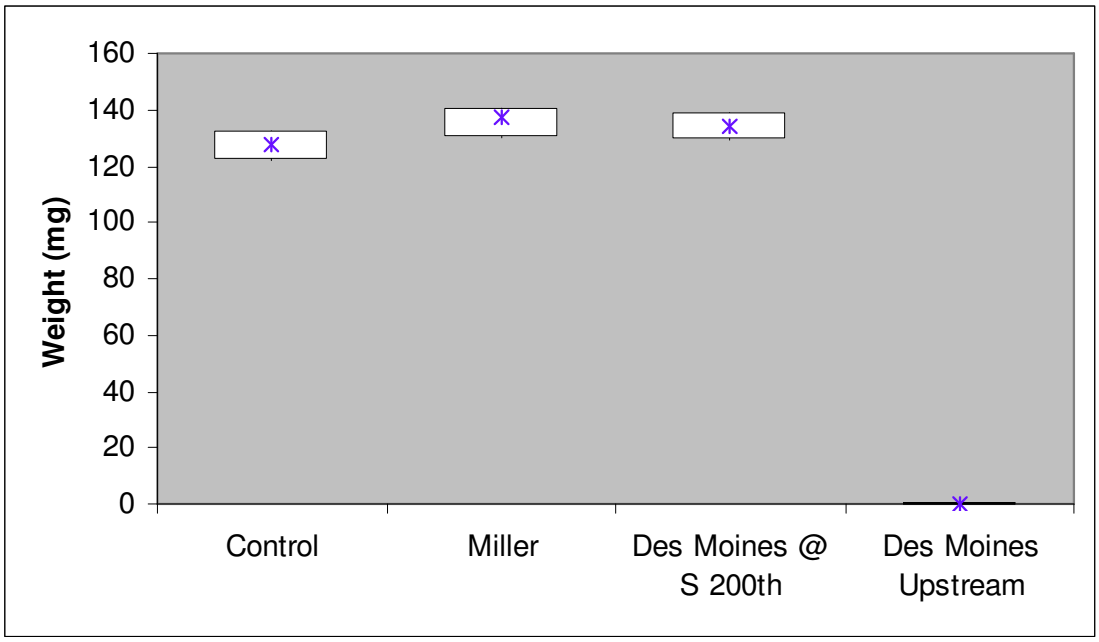
Error bars are standard deviations, asterisks denotes significant difference from controls.

Figure 12: Spring 2012 average lengths for the control and exposure groups.



Data point is average, box is minimum to maximum values. No data for Des Moines Upstream due to complete mortality.

Figure 13: Spring 2012 average weights for the control and exposure groups.

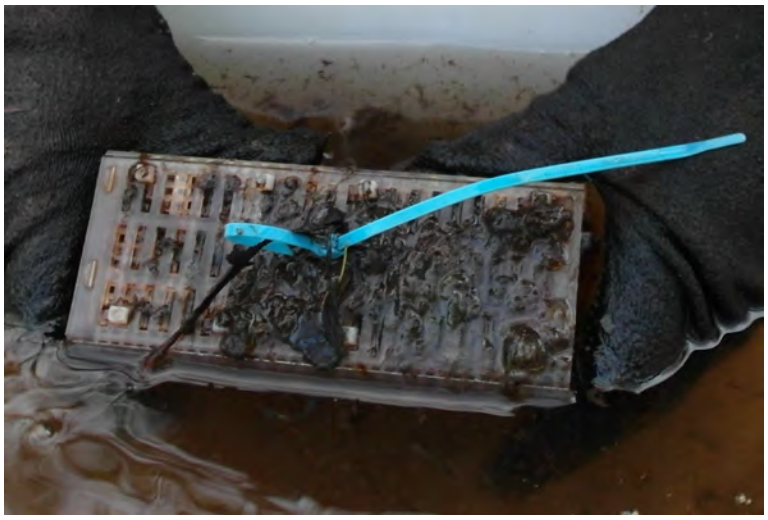


Data point is average, box is minimum to maximum values. No data for Des Moines Upstream due to complete mortality.

4.4 Field Observations

In the Fall 2011 event, all replicates at the Des Moines Creek at S 200th site were subject to biofouling, consisting of a brown filamentous substance (biofilm). This was also observed during the Fall 2010 monitoring event. The substance has not been identified, although it appeared to consist of a mixture of diatoms, bacteria, and possibly fungus. The biofilm was first noted 7 weeks (January 23, 2012) after test initiation, and the onset coincided with the first snow event of the year. In some cases, the growth was extensive (Figure 14). The biofilm did not appear to prevent flow of water into and through the crates. The biofilm was also found to a lesser degree at the Des Moines Upstream site. Miller Creek was also observed to have some biofilm on the hatchboxes, although the initial observation was made a week prior to when it was found in Des Moines Creek. The biofilm at Miller Creek was lighter in color and a different consistency, suggesting a different mixture of organisms. All hatchboxes were replaced the week the biofilm was found at all three sites. Des Moines Creek at S 200th was the only site to see new growth of the biofilm after the initial discovery; however, the texture of the film in the following weeks was different from the initial discovery, and the thickness of the coating was never as severe. Unlike the Fall 2010 event, the appearance of the biofilm did not coincide with mortality at Des Moines Creek at S 200th.

Figure 14: Photograph of hatchbox colonized by biofilm



As the biofilm was also found at the Des Moines Creek Upstream site the same week it appeared downstream, the source of the biofilm appears to be located outside of the area associated with Airport operations.

A biofilm was also observed during the Spring 2012 exposure, but was not present the previous spring. On the day of test termination, both Miller Creek and Des Moines Creek at S 200th replicates were found to be covered in brown algae. The appearance of the biofilm was different than the biofilm observed during the Fall event. Thus, these observations may reflect seasonal differences in composition of the biofilm. Unfortunately, the Des Moines Creek Upstream replicates had already been removed because of complete mortality, so it was not possible to establish the extent to which the biofilm originated upstream of STIA operations based on growth of biofilm on the hatchboxes.

5.0 DISCUSSION

The results of the Fall 2011 rainbow trout *in situ* early life stage exposure indicated that adverse effects on survival were found in Des Moines Creek at S 200th, compared with the laboratory controls. However, as similar effects were also seen at the Des Moines Creek Upstream location, these effects appear to be from an upstream source and not caused by Airport activities. While the Des Moines Creek Upstream location was not included in the Fall 2010 sampling event, results from Des Moines Creek at S 200th show improvement, although not statistically significant, when compared between the Fall 2010 and 2011 monitoring events (i.e., cumulative survival of 18.3% in Fall 2010 vs 50.0% in Fall 2011).

While average survival at Miller Creek was reduced during the Fall 2011 event, although not statistically different from controls, the distribution of the reduced survival is of potential interest. The two middle replicates at Miller Creek showed similar results to the controls with 90% and 86.6% survival in the second and third replicates, respectively. In comparison, the first replicate exhibited 53.3% survival and the fourth replicate only 23.3% survival. Water quality effects are unlikely to be observed in a pattern where only the furthest upstream and most downstream replicates are affected. Thus, the results instead suggest a potential replicate location issue. The downstream-most replicate is subjected to significant amounts of sediment being washed into the creek, especially during rain events. This may lead to smothering of the eggs or alevins between site visits. A similar explanation for why the first replicate had lower survival is unclear at this time and may simply reflect variability within the system or response. Survival in Miller Creek in Fall 2010 averaged 81.7%, compared with 63.3% in Fall 2011. However, there was no statistical difference between the two years, suggesting a relatively consistent pattern in water quality. Neither year exhibited significant differences from the control.

Sedimentation can be an issue at the Miller Creek site, especially after large storm events have washed fine particles into the creek. During one such storm in the Fall 2011, most of the boxes were almost completely full of sediment. While the alevins were able to stay on top of the sediment in the boxes, this might not have been the case if the check been delayed a day or two. This observation emphasizes the importance of checking the boxes soon after major storm events.

The results of the Spring 2012 *in situ* exposure indicated that adverse effects were associated only with the Des Moines Creek Upstream site, compared with the laboratory controls and Des

Moines Creek at S 200th. The large difference in survival between the two locations on Des Moines Creek suggests that the effects were relatively localized, and did not extend to lower reaches of the Creek. On two occasions, while at the Des Moines Creek Upstream site, the field crew observed that the water became extremely murky over the course of the visit, which coincided with a rising water level. It was actually raining on only one of these occasions, suggesting that a release of water was occurring further upstream.

The results for Spring monitoring events for both Miller and Des Moines Creeks at S 200th exhibited a statistical improvement from 2011 to 2012, as cumulative survival increased from 73.3% to 91.7% at Miller Creek, and from 76.7% to 96.7% at Des Moines Creek at S 200th. Conversely, survival at the Des Moines Creek Upstream site was lower in 2012 compared with 2011, with no survival occurring in 2012, compared with 42.5% survival in 2011.

Overall, cumulative survival was the primary endpoint affected, with reduced survival clearly associated with the post-hatch period. The fact that mortality was not observed until after hatching continues to suggest that the subsequent early juvenile development period is the most critical life stage for these exposures.

Seasonal differences in response are of interest, as preliminary data suggest that adverse effects are more consistently observed during the Fall exposure. Part of the difference could be the difference in duration of the exposure, which is dictated by the temperature in the creeks. The Fall event in 2011 required 11 weeks for eggs to develop from the eyed stage to swim up, compared with just 5 weeks in the Spring. Precipitation amounts also differed between seasons, with the Fall season receiving substantially more precipitation than the Spring. It should be noted, however, that the Fall events of the past two years have extended into the Winter months, and the effects may be more related to snow events and winter conditions than to Fall.

Regardless of seasonal differences, perhaps the most notable observation associated with these tests is the continued level of adverse effects found at the Des Moines Creek Upstream site. Adverse effects have been observed at this site during all monitoring events, and are present during both Spring and Fall. Since this site is located near the headwaters of Des Moines Creek, causes of impacts at this site arise outside of STIA property and have the potential to extend further downstream. The results of this study have been communicated to the City of Sea-Tac, who are working on determining the cause through the City's illicit discharge and elimination program.

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Nautilus Environmental

Port of Seattle- Seattle-Tacoma International Airport

Rainbow Trout Early Life Stages *In Situ* Monitoring Testing

Phase 1: Development and Demonstration - Fall 2012 and Spring 2013 Testing Events

Final Report

Report date: September 16, 2013

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1.0 INTRODUCTION

This report presents the results of the rainbow trout (RBT) early life stage (ELS) *in situ* monitoring tests conducted in the Fall 2012 and Spring 2013, as described in the Port of Seattle's Seattle-Tacoma International Airport *In situ* Monitoring Plan, Phase 1: Development and Demonstration (Nautilus 2010). Results for studies conducted in Fall 2010/Spring 2011 and Fall 2011/Spring 2012 have been presented previously (Nautilus 2011 and Nautilus 2012, respectively). The objective of this program is to demonstrate the feasibility of using salmonid ELS as an *in situ* monitoring tool to assess the quality of receiving waters potentially affected by stormwater discharges from the Seattle-Tacoma International Airport (STIA), as well as a multitude of other discharges from the surrounding urban environment. The *in situ* bioassay and supporting analytical data are intended to provide an indication of attainment of receiving water quality standards and associated beneficial uses related to salmonid spawning and rearing. Thus, the overall goal of Phase 1 is to validate the *in situ* approach, particularly with respect to determining if the selected sites and exposure methodologies are appropriate, or if they need to be modified to compensate for confounding variables (e.g., deposition of fine sediments, mobilization of anoxic sediments during storm events, etc.). Applied under the appropriate conditions, it is anticipated that the RBT *in situ* ELS bioassay will be an effective instream biological monitoring tool for assessing the potential effects of stormwater discharges on the receiving environment. In addition to continued evaluation of the *in situ* testing methodology, this report also compares the results of the current year's monitoring to results obtained the previous years to determine the extent to which they were consistent between years.

Phase I of the *In situ* Monitoring Plan (i.e., Development and Demonstration) was originally intended to last for one year and include testing during the Spring and Fall seasons. However, this Phase was extended to allow for additional comparison with the laboratory sublethal testing being conducted by the STIA at sites downstream of Port outfalls as identified in Part II, Special Condition S8 of their NPDES permit. The laboratory sublethal toxicity testing is used for permit compliance purposes, and has been conducted concurrently with *in situ* deployments (when feasible) to facilitate validation of the *in situ* methodology. Comparison of the two methods is conducted in the Combined Acute, Sublethal, In Situ Report (Nautilus 2013) as well as in Section 4.5 of this document. Notably, Part II, Special Condition S9, of the permit allows for substitution of the laboratory sublethal test with *in situ* testing but, because the *in situ* testing has been implemented at the watershed level, direct substitution of the *in situ* test in place of the

laboratory sublethal test was not considered appropriate until parallel testing could be performed.

For the remainder of the permit cycle (through March 2014), *in situ* testing will continue to focus on the watershed-based sites identified in the monitoring plan, along with continued concurrent laboratory sublethal testing. Extended implementation of Phase I through the remainder of the current permit cycle will create a valuable dataset for comparing the *in situ* methodology with the laboratory sublethal test.

2.0 TEST METHODS

Guidance for conducting *in situ* ELS exposures with salmonids is available from a number of sources. For example, the British Columbia Ministry of Environment has a protocol for an *in situ* ELS salmonid test (BCMOE, 2003). In addition, Environment Canada has developed both laboratory and *in situ* test procedures for early lifestages of rainbow trout (Environment Canada, 1998). In the U.S., there are two general laboratory protocols for conducting fish early life stage toxicity tests (EPA, 1996; ASTM, 2005). The procedures used in this study reflect refinements made to the general guidance provided in the documents above (Chalmers et al *in press*), and have been used successfully at a number of sites in both Canada and the United States. Additional refinements specific to applying the method to waterways present on Airport property are included in the descriptions below.

2.1 Design

The study design used for the Fall 2012 and Spring 2013 *in situ* testing involved exposure of eyed-embryos at three sampling sites, using four replicates per site with 30 embryos per replicate. The locations of the sites are shown in Figure 1. The Study Design was consistent with the methodology used in the three previous monitoring events in which the two sites located downstream of all Airport discharges were augmented by an additional site on Des Moines Creek located upstream (Des Moines Creek Upstream) of any Airport discharges. The additional site was included to determine the extent to which sources upstream of any STIA inputs may contribute to adverse effects observed at the downstream site on Des Moines Creek.

The exposure period used in the *in situ* tests covers the major salmonid early life stage developmental milestones, beginning with the eyed egg stage, proceeding through hatching and alevin (yolk sac present and residing in gravel) stages, and ending with the early fry stage (also known as swim-up fry). At this point, the yolk sac is absorbed and, under natural conditions, the fish would leave the gravel to feed independently. The duration of the exposure period is expected to include multiple rain/runoff events, and corresponding fluctuations in flow, contaminant concentrations, temperature, water chemistry, etc. Collectively, these attributes of the *in situ* approach provide highly relevant information regarding the suitability of waterbodies to support salmonids (Chalmers et al, *in press*).

The eyed eggs for both *in situ* events were supplied locally by TroutLodge (Sumner, WA), which supplies these same organisms for the laboratory toxicity tests required in STIA's NPDES

stormwater permit. The status of the *in situ* organisms was routinely monitored during the exposure, as well as at specific developmental stages and after significant storm events. Data were obtained on hatching, survival, development and growth. A subset of embryos was also reared in the laboratory to assess organism quality. Weekly temperature measurements from the field were used to adjust rearing temperatures for the laboratory controls so that development in the controls could be used to trigger field inspections at specific times (e.g., hatch, swim-up).

2.2 Monitoring Locations and Site Preparation

The exposures were conducted in two streams within the STIA property boundaries: Miller Creek and Des Moines Creek (Figure 1). Two of the sites, Miller Creek and Des Moines Creek at S 200th, are located downstream of STIA inputs into their respective drainages. An additional site (Des Moines Creek Upstream) is located upstream of STIA stormwater outfalls into Des Moines Creek. This site is used to assess water quality in Des Moines Creek prior to receiving any STIA stormwater discharges; the Des Moines Creek basin upstream of STIA is heavily urbanized and potentially impacted by a variety of pollutant sources.

Results from 2010 concluded that the chosen sampling sites generally do not have ideal substrate conditions and are subjected to heavy sediment flow during storm events. Consequently, all four exposure replicates at each site were placed above the substrate in gravel contained within PVC crate frames (see Figure 2) anchored to the substrate with steel stakes. The crates were placed so that replicate crates rested on the streambed in a row from upstream to downstream, at a sufficient distance apart such that flow patterns were re-established between each crate. This approach allowed for passage of water through the exposure chambers, but prevented smothering of embryos and fry by sediment.



Figure 1

Port of Seattle

2.3 Field Exposure Apparatus

The trout embryos were contained in modified Whitlock-Vibert hatchboxes (Federation of Flyfishers, MO), which are comprised of two rectangular chambers located one above the other; the upper chamber is for embryo development and the lower chamber for rearing of hatched fish. The external sides of the hatchbox are plastic mesh that allows passage of water through the box, but prevents loss of embryos. The divider between the embryo chamber and the rearing chamber is comprised of slots that are narrow enough to prevent transfer of unhatched embryos, but wide enough to permit migration of hatched fish into the lower rearing chamber. Thus, upon hatch, alevins are able to migrate through the slots from the embryo chamber into the larger rearing chamber. To prevent escape of the hatched fry into the streams upon swim-up, plastic screening material (Darice® size 7 mesh) was attached to the external faces of the rearing chamber and held in place using small plastic zip ties.

The hatchboxes were contained within flexible plastic mesh bags surrounded by 1 – 2 inch diameter gravel, with the hatchbox placed centrally within the rocks in the bag. The gravel surrounding the hatchboxes acts to diffuse the current and prevent exposure of the embryos to sunlight. The bags were then placed within the PVC crates, which were held in place in the stream by stakes anchored in the substrate (Figure 2). Figure 3 shows the eyed eggs within the hatchbox, while Figure 4 is of fry within the hatchbox.

Figure 2: Photograph of the crate set up, Des Moines Creek at S 200th.



2.4 Test Organisms

Eyed-egg stage rainbow trout embryos were obtained from TroutLodge in Sumner, WA, on October 17, 2012 for the Fall event. As supplied, the eyed embryos had developed for approximately 245 degree-days[1], as noted in communication with TroutLodge staff. For the Spring event, green eggs and sperm were collected from TroutLodge on March 27, 2013, brought to Rainier Environmental Laboratory (REL; Fife, WA) where the eggs were fertilized and raised to approximately 252 degree-days. On the day of test initiation for both events, eggs were brought to REL, or collected from there, and randomly counted into replicate units of 30 embryos apiece in individual opaque plastic food-storage containers (i.e., 450-mL Ziploc plastic tubs). These containers were then placed in a cooler containing ice packs, and transported to the sites where the embryos were transferred into the hatchboxes in the creek on the same day. The embryos were transferred to the sites in laboratory control water, and all embryos were installed at the sites between 14:00 and 15:30 on October 17th, 2012 for the Fall event, and between 12:00 and 13:30 on April 17th, 2013 for the Spring event.

All personnel handling the embryos wore nitrile gloves. Containers were pre-cleaned with Liqui-nox soap (Alconox, Jersey City, NJ) and rinsed with deionized water.

2.5 Controls

Controls were used to assess the influence of the following factors on test results:

1. Quality (health and viability) of supplied organisms,
2. Transport and handling of organisms, and
3. Ambient stream temperatures, which affect the time to developmental milestones (e.g., hatch).

The controls consisted of a laboratory exposure (four replicates of 30 organisms each) conducted concurrently with each field exposure in clean laboratory water (moderately hard synthetic water [MHSW]) using a subset of the same batch of embryos used to initiate the field exposures. These embryos were also counted out, placed into individual plastic containers filled with MHSW and transported to the sites with the other replicates; thus, they also served as transport

[1] Degree-days are used to standardize descriptions of fish development, regardless of rearing temperature. For example, it takes rainbow trout approximately 340 degree-days to reach hatch (Quinn, 2005). Thus, at 8°C, it takes approximately 42 days to reach hatch.

controls. Upon returning to the laboratory after deployment of all field organisms, the control replicates were transferred to 4-L plastic containers in the laboratory containing 2 liters of MHSW at the average site water temperature, ± 1°C. Gentle aeration was applied (100-200 bubbles per minute) to the control chambers. The controls were monitored daily for mortalities, and dead organisms removed. Temperature was adjusted on a weekly basis to correspond to temperatures measured in the field. Water renewals were conducted three times per week (Monday, Wednesday, Friday) using clean MHSW. Dissolved oxygen, pH, conductivity, and temperature were measured before and after water renewals. Developmental milestones (e.g., hatch and swim-up) were also recorded.

2.6 Monitoring of Field Exposures

The sites were visited approximately every week to assess the condition of the test organisms. During these checks, survival was recorded, as well as qualitative observations of organism health, site conditions, and sedimentation within the boxes. All dead organisms observed were removed on each visit. These observations were recorded on standard field data sheets included in Appendix A. In addition, temperature, pH, dissolved oxygen (DO) and conductivity were measured during the site visits.

Monitoring of the installations required removal of the substrate overlying the hatchboxes in the crate. The embryos or alevins in each hatchbox were then poured into a white plastic dishpan containing site water where they were enumerated. They were then returned to the hatchbox, which was placed back into the mesh-net bag of gravel, the overlying gravel replaced, and the bag returned to its respective crate. Care was taken to minimize disturbance and damage to the test organisms.

2.7 Test Termination

The field exposures and laboratory controls were terminated when the field organisms reached the swim-up fry stage (i.e., yolk sac absorbed). This occurred on November 14th, 2012 for the Fall 2012 exposure, and on May 9th, 2013 for the Spring 2013 exposure. Surviving organisms were placed in their original plastic replicate containers filled with site water, transported back to the laboratory, and terminated. The fish were then wet-weighed (to the nearest 0.001 gram) on an analytical balance, and measured (total length, from tip of the snout to the end of the tail) to the nearest 0.5 mm. Obvious external malformations were noted, including the affected body

part (e.g., head, eye, spine) and type of abnormality (e.g., edema). Abnormality data were recorded on standard data sheets (Appendix A). The laboratory control fish were evaluated similarly on the same day.

2.8 Data Analysis

All test data were entered in CETIS (Comprehensive Environmental Toxicity Information System, Tidepool Scientific, McKinleyville, CA). Differences among the exposure sites and laboratory controls were evaluated using pair-wise multiple comparison tests according to the USEPA flow chart (USEPA 2002); significant differences were identified at p=0.05.

One interim and five terminal endpoints were evaluated; the endpoints are described below:

1. Hatching success – an interim measure of the percentage of embryos hatched the day of the hatch inspection, or determined to have hatched based on the number of alevins present at the subsequent inspection, relative to the total number of embryos originally added;
2. Post-hatch survival - the percentage of organisms surviving at test termination relative to the number of embryos that hatched (these data help determine whether the majority of mortalities occurred pre- or post-hatch, or were distributed throughout the exposure period);
3. Cumulative survival - the percentage of surviving organisms at test termination relative to the number of embryos in each replicate at the beginning of the exposure;
4. Abnormality – the percentage of abnormal organisms at test termination relative to the number of surviving organisms;
5. Length – to the nearest 0.5 mm;
6. Weight – to the nearest 0.001 g.

3.0 QA/QC

The QA/QC program for the field exposure involved the following:

- Consistent field staff leader throughout all visits;
- Field documentation of all primary data; i.e., the names of individuals collecting the samples, sampling location, time of sampling, site conditions (e.g., degree of sedimentation), and other relevant observations, such as weather and any unusual conditions;
- Calibrated field meters;
- Use of pre-cleaned containers, with appropriate labels;
- Storing and transporting organisms in sealed containers in a cold, dark environment; cooling sample containers using ice or gel packs;
- Including transport controls to ascertain the extent of any transport-induced stress;
- Checking field organisms every week to monitor developmental progress, mortality and abnormality.

The QA/QC program for the laboratory portion of the study involved:

- Checks and maintenance of control organisms at regular intervals, including recording primary observations and water quality data on standardized data sheets;
- Review of datasheets by senior laboratory staff;
- Test termination activities (measurements, health assessment) conducted by qualified staff members using standardized datasheets to ensure consistent assessment of abnormalities and growth across all test sites and controls;
- Use of standard laboratory water and environmental chambers to maintain test organisms.

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4.0 RESULTS

4.1 Water Quality Measurements

Water quality measurements are summarized in Tables 1 and 2 for the Fall 2012 and Spring 2013 monitoring events, respectively.

Table 1: Summary of water quality measurements collected during site visits and control renewals (Fall 2012).

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	11.9 (1.1)	9.5 (0.6)	7.96 (0.10)	299.8 (5.0)
	[Min-Max]	[9.4 – 12.8]	[8.6 – 10.0]	[7.75 – 8.21]	[292 - 315]
Miller Creek		10.7 (1.2)	10.9 (1.1)	7.31 (0.19)	183.5 (35.8)
		[9.3 – 12.2]	[9.3-12.0]	[7.09 – 7.62]	[126 - 216]
Des Moines Creek		11.2 (1.2)	10.5 (1.2)	7.24 (0.12)	134.6 (27.3)
at S 200th		[9.7 - 12.5]	[9.0 – 11.4]	[7.12 – 7.42]	[93 - 160]
Des Moines Creek		12.0 (1.6)	10.2 (0.8)	7.34 (0.34)	105.2 (12.7)
Upstream		[9.7 – 14.2]	[9.1 – 11.2]	[6.87 – 7.68]	[85 - 117]

Table 2: Summary of water quality measurements collected during site visits and control renewals (Spring 2013).

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	12.0 (0.2)	9.7 (0.4)	7.38 (0.1)	263.1 (15.2)
	[Min-Max]	[11.6 – 12.3]	[8.8 – 10.5]	[7.15 – 7.55]	[237 - 282]
Miller Creek		11.7 (2.0)	10.2 (0.9)	7.58 (0.17)	250.6 (45.6)
		[10.0 – 14.0]	[8.9 – 11.0]	[7.40 – 7.77]	[183 - 294]
Des Moines Creek		12.4 (1.4)	9.9 (0.5)	7.43 (0.07)	187.8 (54.7)
at S 200th		[11.3 – 14.4]	[9.0 – 10.4]	[7.37 – 7.54]	[103 - 235]
Des Moines Creek		14.0 (1.9)	8.6 (1.2)	7.09 (0.24)	126.4 (30.2)
Upstream		[12.0 – 16.2]	[6.9 – 9.8]	[6.70 – 7.34]	[100 - 174]

In the Fall 2012 *in situ* tests, temperatures for the three field sites and the control ranged from 9.3 to 14.2°C. The field measurements of DO and pH were within acceptable ranges for rainbow

trout laboratory bioassays (60-100% saturation, and 6-9 pH units, respectively). The pH values were between 6.8 and 7.7, and DO ranged from 9.0 to 12.0 mg/L among all stream measurements. Although limited to weekly measurements, the field DO and pH data suggested good water quality conditions, with no indication of potential for adverse effects on organism survival and development. The conductivity measurements for all three sites exhibited some variability throughout the exposure period, but the values remained well-within ranges tolerated by early life stages of salmonids.

In the Spring 2013 *in situ* tests, temperatures among the three field sites and the control ranged from 10.0 to 16.2°C. These temperatures were similar, though slightly warmer than Fall temperatures. The field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays. The pH values were between 6.7 and 7.8, and DO ranged from 8.9 to 11.0 mg/L among all stream measurements. Consequently, the weekly field measurements of DO and pH suggested good water quality conditions, with no indication of potential for adverse effects on organism survival and development. As observed in the Fall event, the conductivity measurements for all three sites exhibited some variability throughout the exposure period, but the values remained well-within ranges tolerated by early life stages of salmonids.

During limited periods of both the fall and spring monitoring events, continuous measurements of pH and temperature were collected by CardnoTEC using data sondes at the Miller Creek site. This data was collected as part of another program and only covered limited portions of the exposure periods for the Fall and Spring. Nonetheless, the continuous monitoring data was in general agreement with the values collected during the weekly checks at the site, and are presented in Figures 5 and 6 for the Fall and Spring testing events, respectively.

Figure 5: Continuous pH and temperature data from Miller Creek, Fall 2012

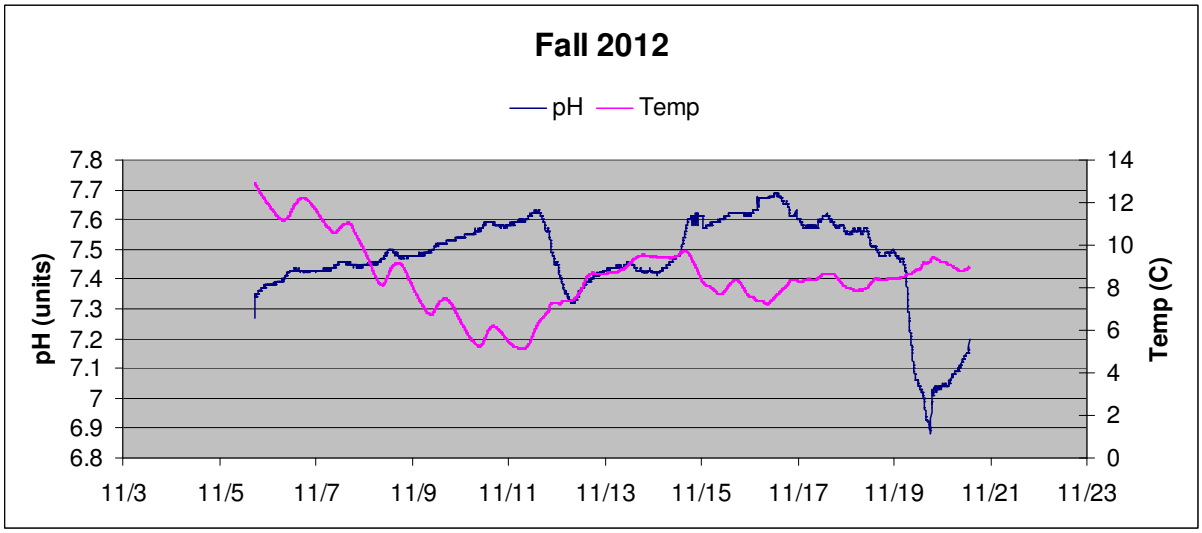
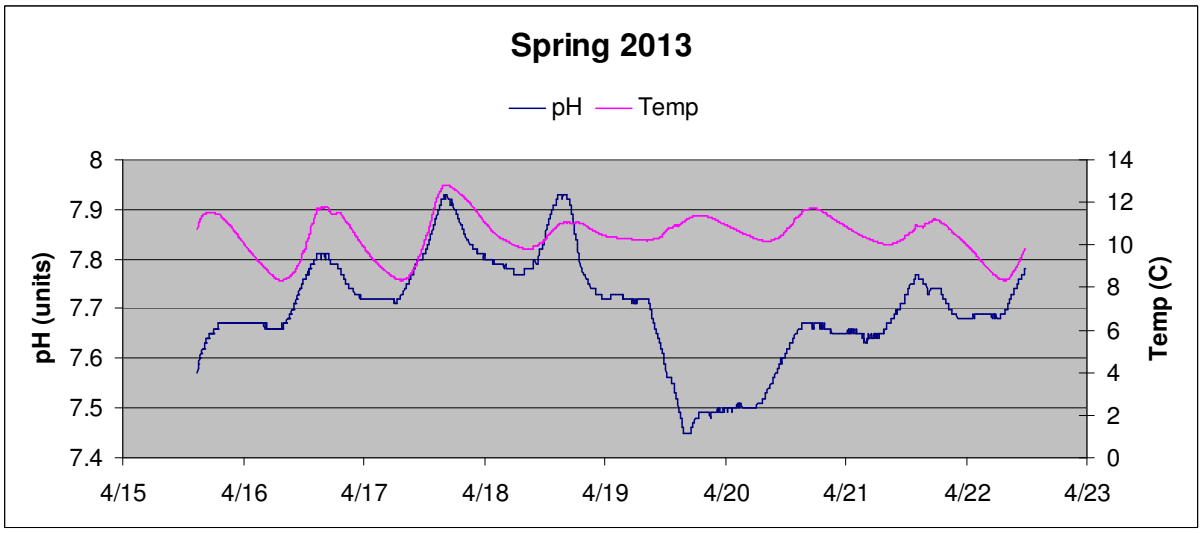


Figure 6: Continuous pH and temperature data from Miller Creek, Spring 2013



4.2 Precipitation During the Monitoring Events

Precipitation data were provided by STIA. Figure 7 shows the daily rainfall for the duration of the exposure for the Fall 2012 test. A number of storm events occurred during testing, with a total of 6.96 inches of rain over 4 weeks, and the largest storm occurring on October 30th. There was no snow during this testing event.

Figure 7: Daily rainfall for the duration of Fall exposure

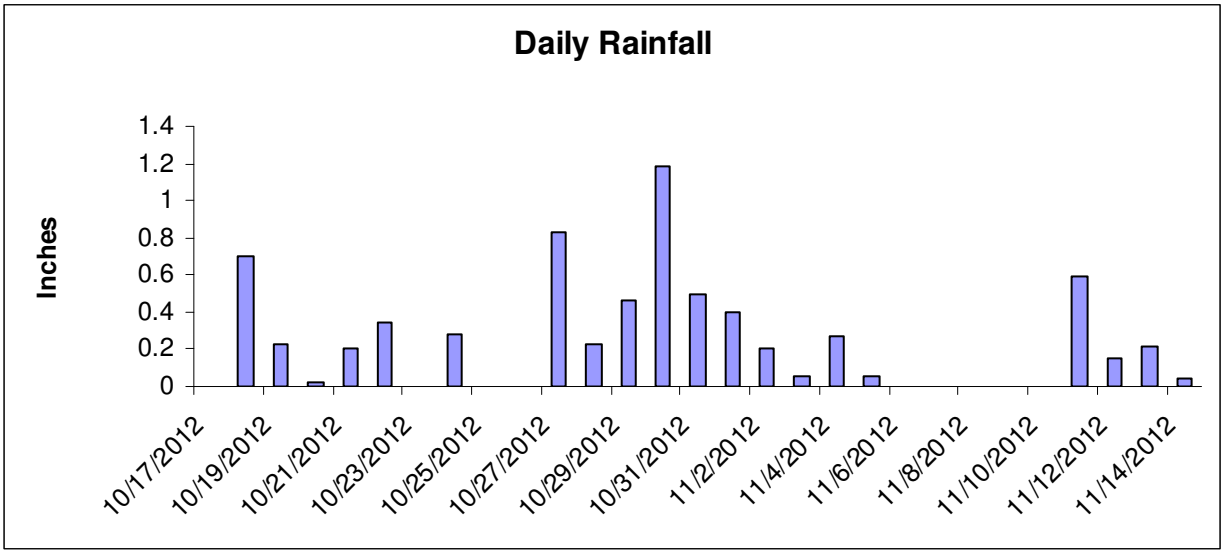
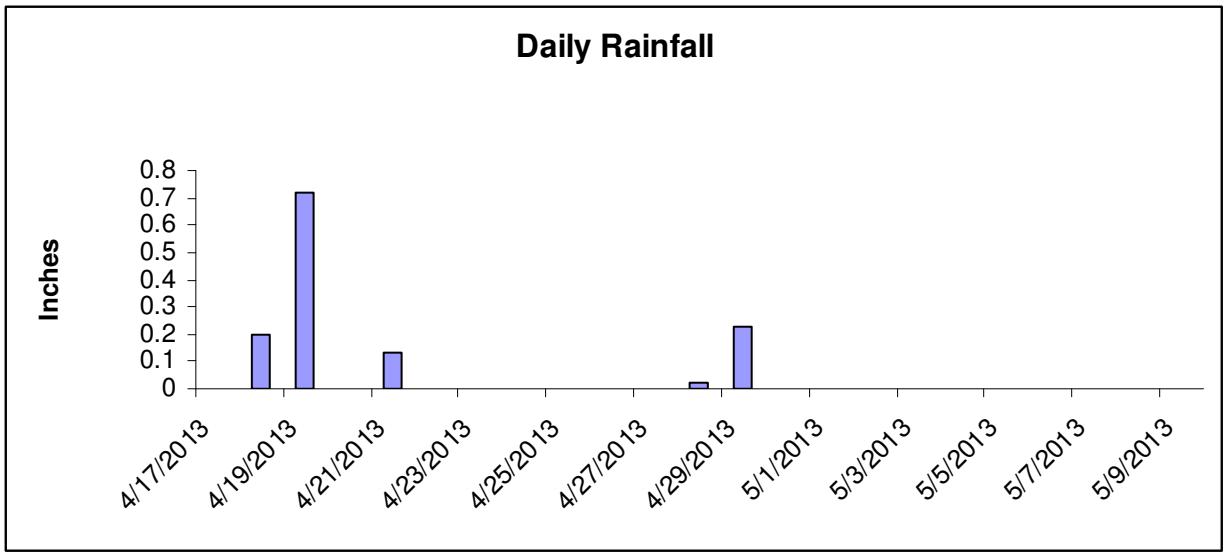


Figure 8 contains the daily rainfall for the duration of the exposure for the Spring 2013 test. Much less total precipitation (1.3 inches) and fewer storms occurred during this exposure period, compared with the Fall. No snow occurred during the exposure period, and the largest storm was on April 19th.

Figure 8: Daily rainfall for the duration of the spring exposure



4.3 *In situ* Exposures

4.3.1 Fall 2012

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 3. Table 4 presents the growth endpoints. These same data are presented graphically in Figures 9 through 11 for ease of comparison.

Hatching success – Mean hatching success for the controls was 99.2%. The Miller Creek replicates exhibited 71.7% mean hatching success, the Des Moines Creek at S 200th replicates had 85.8% mean hatching success, while the Des Moines Creek Upstream replicates averaged 60.0% mean hatching success. Hatching success at Des Moines Creek at S 200th was not statistically different from the controls; however, hatching success at Miller Creek and Des Moines Creek Upstream were significantly reduced relative to the control.

Post-hatch survival – Control survival of alevins post-hatch was 98.3%. The Miller Creek replicates exhibited 40.6% post-hatch survival, and the Des Moines Creek at S 200th replicates exhibited 90.1% post-hatch survival, while the Des Moines Creek Upstream replicates averaged 84.3%. Post-hatch survival at the two Des Moines Creek sites were not significantly different from the controls. However, the Miller Creek site was significantly different from the controls.

Cumulative survival – Control survival from the initiation of the test to termination averaged 97.5%. The Miller Creek replicates exhibited an average survival of 28.3% through the duration of the exposure, whereas the Des Moines Creek at S 200th replicates exhibited an average survival of 77.5% compared with an average survival of 55.0% at the Des Moines Creek Upstream site. Des Moines Creek at S 200th was not statistically different from the controls, whereas both Des Moines Upstream and Miller Creek were significantly reduced compared with the controls.

Abnormalities – There were few abnormalities over all, with just one in the controls, one at Miller Creek, and none at Des Moines Creek at S 200th; however, there were 4 total, (2 each in 2 replicates) at Des Moines Creek Upstream. The abnormalities at Des Moines Upstream were 2 spinal curvatures, one misshapen head, and one case of edema. These finding were not significantly different from the control. The abnormalities in both the control and Miller Creek fish were spinal curvatures.

Growth – Average weight in the controls was 84.6 mg, and length averaged 22.6 mm. Miller Creek fish averaged 80.4 mg and 22.0 mm, Des Moines Creek at S 200th fish averaged 81.0 mg and 21.9 mm, and Des Moines Creek Upstream fish averaged 78.4 mg and 22.1 mm. None of the differences in length were significant between sites and controls. Only Des Moines Upstream was significantly different from controls for weight.

Table 3: Results for hatching success, survival and abnormality in the control and field treatment groups (Fall 2012)[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	99.2 (1.7)	98.3 (1.9)	97.5 (1.7)	0.9 (1.7)
Miller Creek				8.3 (16.7)
Des Moines Creek at S 200th	85.8 (8.3)	90.1 (5.1)	77.5 (10.7)	0 (0)
Des Moines Creek Upstream		84.3 (23.8)		4.4 (5.1)

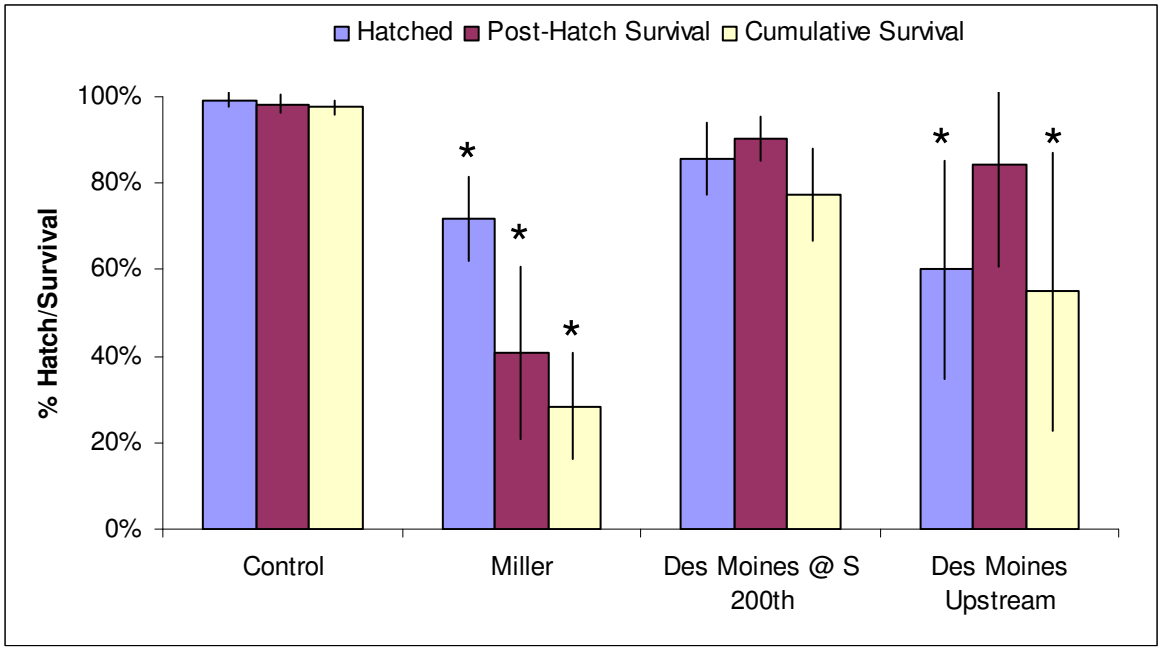
Notes:
1. Results are presented as mean and standard deviation
2. Gray shaded values are significantly different from the control

Table 4: Comparison of growth in the control and field treatment groups (Fall 2012)[1].

Site	Length (mm)	Weight (mg)
Control	22.6 (0.30)	84.6 (2.46)
Miller Creek	22.0 (0.71)	80.4 (5.42)
Des Moines Creek at South 200th	21.9 (0.26)	81.0 (1.22)
Des Moines Creek Upstream	22.1 (0.61)	

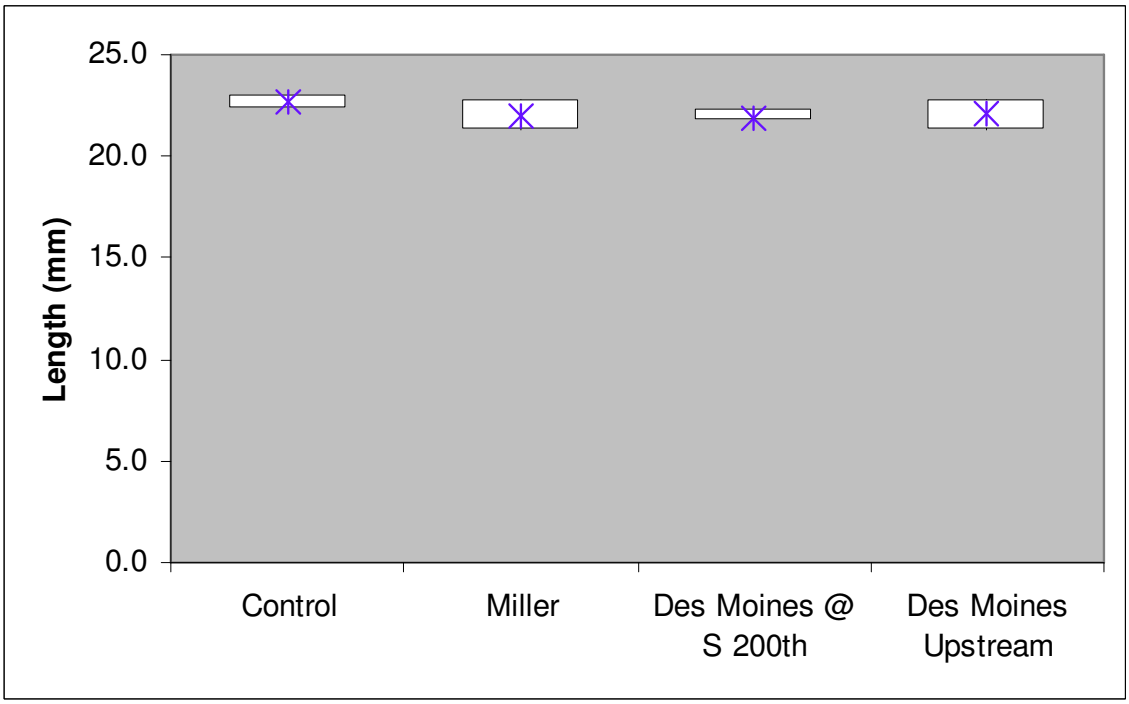
Notes:
1. Results are presented as mean and standard deviation
2. Gray shaded values are significantly different from the control

Figure 9: Hatching success, post-hatch survival and cumulative survival in the field and control treatment groups (Fall 2012).



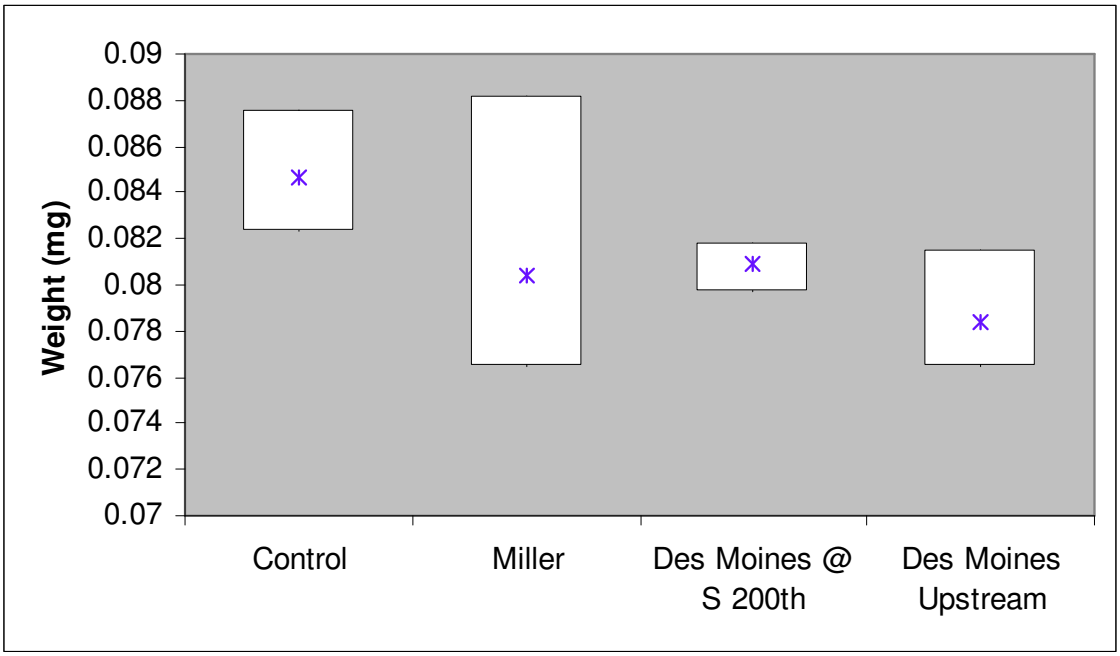
Error bars are standard deviations; asterisks denote significant difference from controls.

Figure 10: Average lengths for the laboratory control and exposure sites (Fall 2012).



Data point is the average; box represents range of minimum to maximum values

Figure 11: Average weights for the laboratory control and exposure sites (Fall 2012).



Data point is the average; box represents range of minimum to maximum values.

4.3.2 Spring 2013

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 5. Table 6 presents the growth endpoints. These same data are presented graphically in Figures 12 through 14 for ease of comparison.

Hatching success – Mean hatching success for the controls was 100%. The Miller Creek replicates exhibited 98.3% mean hatching success, the Des Moines Creek at S 200th replicates had 95.0% hatching success, and the Des Moines Creek Upstream replicates averaged 90.8% hatching success. There were no significant differences in hatching success among the treatment and control groups.

Post-hatch survival – Control survival of alevins post-hatch was 97.5%. The Miller Creek replicates averaged 90.8% post-hatch survival, compared with 90.7% survival at Des Moines Creek at S 200th, and 77.2% at Des Moines Upstream. Only Des Moines Upstream was significantly different from controls.

Cumulative survival – Control survival from the initiation of the test to termination averaged 97.5%. The Miller Creek replicates exhibited an average survival of 89.2% through the duration

of the exposure, while Des Moines Creek at S 200th replicates averaged 85.8% survival; both of these values were not significantly different from the controls. The Des Moines Upstream replicates exhibited 70.0% survival at the end of the exposure, which was significantly different from the controls.

Abnormalities -- There were few abnormalities over all, with just two in the controls, none at Miller Creek, and one at Des Moines Creek at S 200th, and one at Des Moines Creek Upstream. The abnormalities were one head shape, and three cases of edema. There were no significant differences from the controls.

Growth – Average weight in the controls was 156.2 mg, and length averaged 27.0 mm. Miller Creek fish averaged 153.4 mg and 26.6 mm, Des Moines Creek at S 200th fish averaged 152.8 mg and 26.5 mm, and Des Moines Creek Upstream fish averaged 152.0 mg and 26.6 mm. None of the differences in length were significant between sites and controls. Des Moines Upstream was significantly different from controls for weight.

Table 5: Hatching success, survival and abnormality in the control and field treatment groups (Spring 2013)[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	100 (0)	97.5 (3.2)	97.5 (3.2)	1.7 (3.5)
Miller Creek	98.3 (1.9)	90.7 (10.3)	89.2 (9.6)	0 (0)
Des Moines Creek at S 200th	95.0 (7.9)	90.7 (10.9)	85.8 (10.0)	1.0 (2.0)
Des Moines Upstream	90.8 (10.7)			1.3 (2.5)

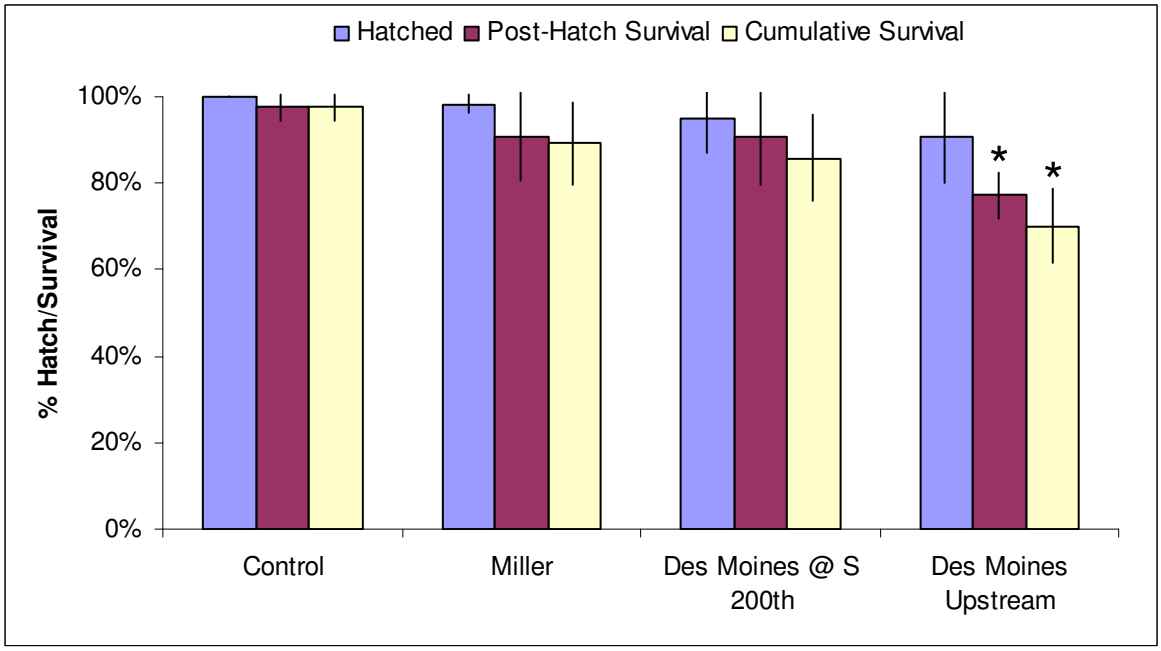
Notes:
1. Results are presented as mean and standard deviation
2. Gray shaded values are significantly different from the control

Table 6: Comparison of growth in the control and field treatment groups (Spring 2013).

Site	Length (mm)	Weight (mg)
Control	27.0 (0.31)	156.2 (1.7)
Miller Creek	26.6 (0.75)	153.4 (1.9)
Des Moines Creek at S 200th	26.5 (0.65)	152.8 (4.0)
Des Moines Upstream	26.6 (0.39)	

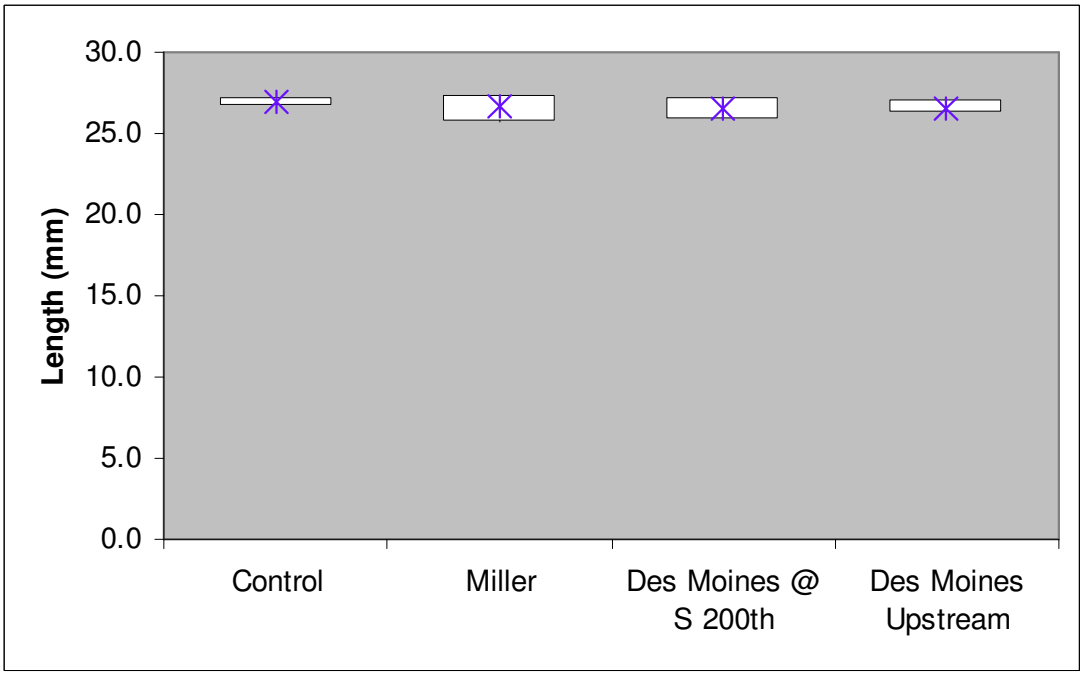
Notes:
1. Results are presented as mean and standard deviation
2. Gray shaded values are significantly different from the control

Figure 12: Hatching success, post-hatch survival and cumulative survival in the field and control treatment groups (Spring 2013).



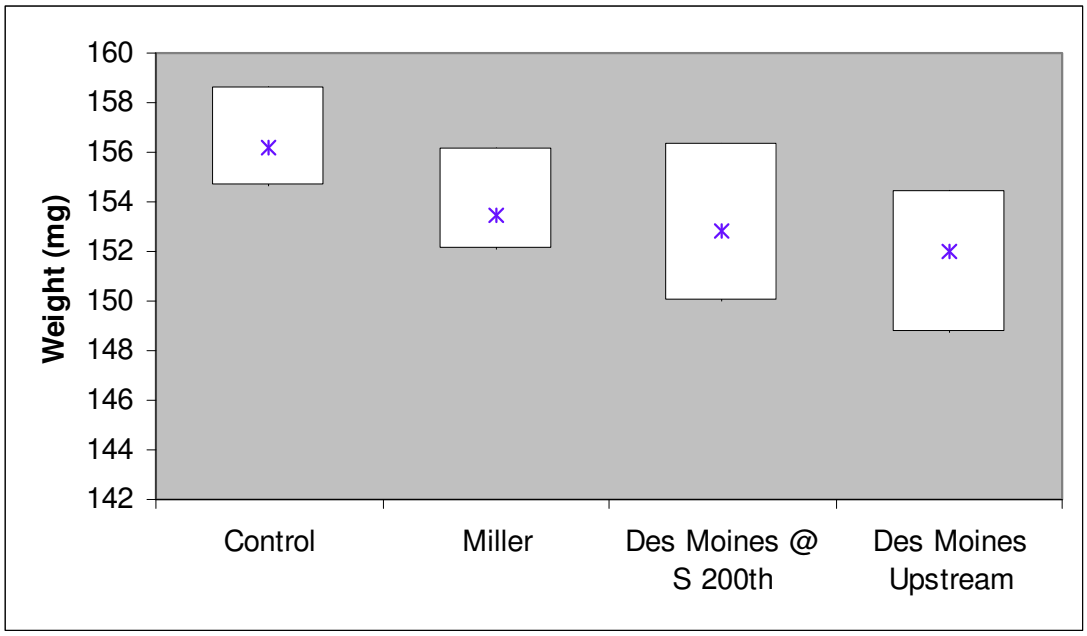
Error bars are standard deviations, asterisks denotes significant difference from controls.

Figure 13: Average lengths for the control and exposure groups (Spring 2013).



Data point is the average; box represents range of minimum to maximum values.

Figure 14: Average weights for the control and exposure groups (Spring 2013).



Data point is the average; box is minimum to maximum values.

4.4 Field Observations

During both testing events, hatch boxes were observed to be free of accumulating biofilm or other accumulation of organic material. During the Fall 2012 event, spawning salmon were observed in Miller Creek and in Des Moines Creek at S 200th. During both events, crayfish were often found within the crates at all sites, but not within the hatchboxes. Accumulation of sediments within the hatch boxes was observed during the Fall 2012 event at the Miller Creek site, with sediment volume reaching 80% and greater within the boxes.

4.5 Comparison of *in situ* and sublethal tests

In addition to the *in situ* testing, STIA also collects samples from the receiving water downstream of stormwater outfalls for sublethal toxicity testing with rainbow trout embryos during storm events: once in the fall, once in the spring, and once during deicing conditions each year. Including the initial first attempt in Fall 2010, there were 4 sampling periods for sublethal testing that overlapped with the *in situ* deployments (Table 7). As the upstream Des Moines Creek station is above any Airport outfalls, it is not included in the sublethal testing, so discussion here is limited to comparisons of Miller Creek (*in situ*) with MC8th (sublethal), and

Des Moines Creek at S 200th (*in situ*), with DME and EWCONF (sublethal). The Fall 2010 sublethal samples overlapped with the initial deployment of the *in situ* tests (i.e., the in-gravel portion of the exposures only). There was no toxicity in the laboratory tests, but the *in situ* replicates in both creeks were buried by a major precipitation event and needed to be restarted. The deicing sublethal samples in 2011 overlapped with the repeated Fall/Winter 2010 *in situ* testing; the DME and EWCONF sublethal samples exhibited toxicity in the laboratory, and toxicity was also observed in the *in situ* Des Moines Creek at S 200th site. There was no toxicity in Miller Creek or MC8th. There was no overlap in tests during either the Spring 2011 and Fall/Winter 2011 testing periods. The Spring 2012 sublethal tests coincided with the *in situ* exposures, and neither test type exhibited toxicity at the downstream locations. The two test types also overlapped during the Fall 2012 exposure period; adverse effects were observed in the Miller Creek *in situ* exposure, but not in any of the laboratory tests or at the downstream *in situ* exposure conducted on Des Moines Creek.

Table 7: Comparison of responses in sublethal and *in situ* tests.

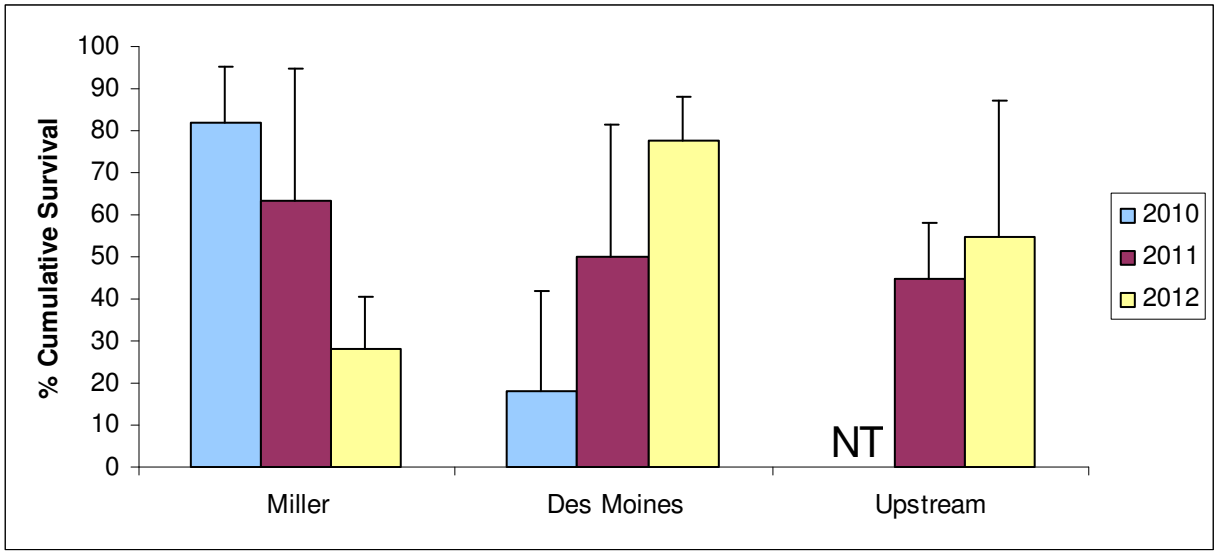
	***In situ* test results**	**Sublethal test results**
Fall 2010- 1st Attempt	Restart due to burial of replicates	Non-toxic
Fall/Winter 2010	Effects observed at Des Moines at S 200th	Toxicity in DME and EWCONF
Spring 2011	No overlap	
Fall/Winter 2011	No overlap	
Spring 2012	No effects observed	Non-toxic
Fall 2012	Effects observed at Miller Creek	Non-toxic
Spring 2013	No overlap	

5.0 DISCUSSION

The results of the Fall and Spring testing events that have been conducted to date are shown in Figures 15 and 16, respectively. Review of these data suggest that adverse effects are more consistently observed during the Fall exposure period, with the Fall season tending to receive substantially more precipitation than the Spring. It should also be noted, however, that the Fall events of the previous two years (2010 and 2011) extended into the Winter months and therefore, would have also reflected the effects of snow and winter conditions.

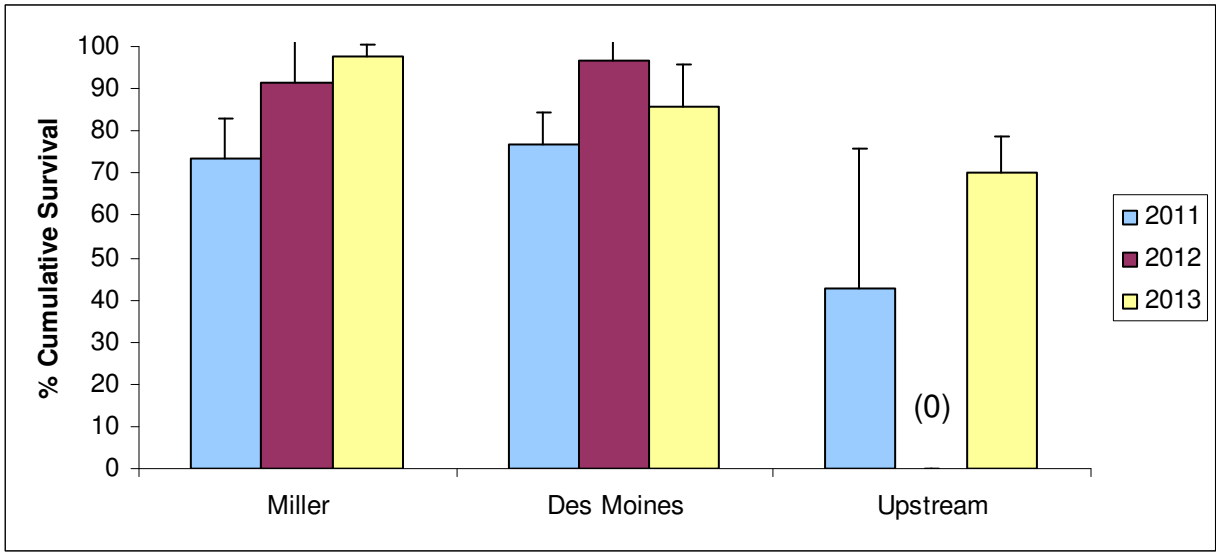
In Fall 2012, adverse effects on survival were observed in Miller Creek, with both hatching success and post-hatch survival significantly reduced compared to the controls. Sedimentation can be an issue at the Miller Creek site, particularly in the Fall after large storm events, and was again observed during the Fall 2012 event. The sedimentation is likely the result of comparatively large precipitation events and corresponding elevations in stream flow that lead to channel erosion and bedload movement, resulting in suspended sediments that tend to settle in the hatchboxes. Salmonid early life stages are known to be sensitive to suspended sediments, with concentrations as low as 7 mg/L resulting in reduced egg survival (BCMOE 1997). Notably, toxicity and chemistry data from STIA outfalls discharging upstream of the Miller Creek exposure location indicate no toxicity and low levels of turbidity and metals, suggesting that STIA inputs are not related to adverse effects observed in the *in situ* exposures.

Figure 15: Year to year comparisons of cumulative survival across sites during Fall events.



NT- Not tested

Figure 16: Year to year comparisons of cumulative survival across sites during Spring testing events.



Regardless of seasonal differences, perhaps the most notable observation associated with these tests is the continued level of adverse effects found at the Upstream Des Moines Creek site. Adverse effects have been observed at this site during all monitoring events, and are present during both Spring and Fall. Since this site is located near the headwaters of Des Moines Creek, causes of impacts at this site arise outside of STIA property and have the potential to extend further downstream. The results of this study have been previously communicated to the City of SeaTac, who are working to identify and remove illicit discharges and connections in the watershed through the City's illicit discharge detection and elimination program, which appears to be working, given the improvement in this site in Fall 2012 and Spring 2013 compared to previous years.

Overall, there has been general good agreement with results in the field and laboratory, with the laboratory tests helping to provide additional insight into the results of the field (i.e., *in situ*) tests. For example, lack of toxicity in the laboratory exposures may be helpful in terms of interpreting whether dissolved contaminants or suspended sediments are causing toxicity in the *in situ* exposures.

Finally, over the course of developing the *in situ* approach for use in the Airport's monitoring program, adjustments have been made in sampling location and methodology to address sedimentation impacts to the hatchboxes. However, sedimentation within the hatchboxes, even

with "above-gravel" installation, is still being observed at Miller Creek. Consequently, future testing will explore additional options for altering the exposure methodology and/or exposure sites in a manner that will more fully address this question.

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Nautilus Environmental

Port of Seattle- Seattle-Tacoma International Airport

Rainbow Trout Early Life Stages *In Situ* Monitoring Testing

Phase 1: Development and Demonstration - Fall 2013 and Spring 2014 Testing Events

Final Report

Report date: October 3, 2014

Submitted to:

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1.0 INFORMATION

This report presents the results of the rainbow trout (RBT) early life stage (ELS) *in situ* monitoring tests conducted in the Fall 2013 and Spring 2014, as described in the Port of Seattle's Seattle-Tacoma International Airport *In situ* Monitoring Plan, Phase 1: Development and Demonstration (Nautilus 2010). The objective of this program is to demonstrate the feasibility of using salmonid ELS as an *in situ* monitoring tool to assess the quality of receiving waters potentially affected by stormwater discharges from the Seattle-Tacoma International Airport (STIA), as well as a multitude of other discharges from the surrounding urban environment. Results for studies conducted in Fall 2010/Spring 2011, Fall 2011/Spring 2012, and Fall 2014/Spring 2013 have been presented previously (Nautilus 2011, Nautilus 2012, and Nautilus 2013, respectively).

Results from the *in situ* bioassays and supporting analytical data are intended to provide an indication of attainment of receiving water quality standards and associated beneficial uses related to salmonid spawning and rearing. Thus, the overall goal of Phase 1 is to validate the *in situ* approach, particularly with respect to determining if the selected sites and exposure methodologies are appropriate, or if they need to be modified to compensate for confounding variables (e.g., deposition of fine sediments, mobilization of anoxic sediments during storm events, etc.). Applied under the appropriate conditions, it is anticipated that the RBT *in situ* ELS bioassay will be an effective instream biological monitoring tool for assessing the potential effects of stormwater discharges on the receiving environment.

Phase I of the *In Situ* Monitoring Plan (i.e., Development and Demonstration) was originally intended to last for one year and include testing during the Spring and Fall seasons. However, this Phase was extended to allow for additional comparisons with the laboratory sublethal testing being conducted by the STIA at sites downstream of Port outfalls, as specified in Part II, Special Condition S8 of NPDES Permit No. WA-002465-1. The laboratory sublethal toxicity testing is used for permit compliance purposes, and has been conducted concurrently with *in situ* deployments (when feasible) to facilitate validation of the *in situ* methodology. A comparison of the two methods is presented in the Combined Acute, Sublethal, and *In Situ* Report (Nautilus 2013).

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2.0 TEST METHODS

Guidance for conducting *in situ* ELS exposures with salmonids is available from a number of sources. For example, the British Columbia Ministry of Environment has a protocol for an *in situ* ELS salmonid test (BCMOE, 2003). In addition, Environment Canada has developed both laboratory and *in situ* test procedures for early life stages of rainbow trout (Environment Canada, 1998). In the U.S., there are two general laboratory protocols for conducting fish early life stage toxicity tests (EPA, 1996; ASTM, 2005). The procedures used in this study reflect refinements made to the general guidance provided in the documents above (Chalmers *et al*, 2014), and have been used successfully at a number of sites in both Canada and the United States. Additional refinements specific to applying the method to waterways present on Airport property are included in the descriptions below.

2.1 Design

The study design used for the Fall 2013 and Spring 2014 *in situ* testing involved exposure of eyed-embryos at three sampling sites, using four replicates per site with 30 embryos per replicate. The locations of the sites are shown in Figure 1. The Study Design was consistent with the methodology used in the five previous monitoring events in which the sites located on Miller and Des Moines Creeks downstream of all Airport discharges were augmented by an additional site on Des Moines Creek located upstream of any Airport discharges. The additional site (i.e., Des Moines Creek Upstream) was included to determine the extent to which sources upstream of any STIA inputs may contribute to adverse effects observed at the downstream site on Des Moines Creek.

The exposure duration used in the *in situ* tests covers the major salmonid early life stage developmental milestones, beginning with the eyed egg stage, proceeding through hatching and alevin stages (yolk sac present and residing in the gravel), and ending with the early fry stage (also known as swim-up fry). At this point, the yolk sac is absorbed and, under natural conditions, the fish would leave the gravel to feed independently. The duration of the exposure period is expected to include multiple rain/runoff events, and corresponding fluctuations in flow, contaminant concentrations, temperature, water chemistry, etc. Collectively, these attributes of the *in situ* approach provide highly relevant information regarding the suitability of waterbodies to support salmonids (Chalmers *et al*, 2014).

The eyed eggs for both *in situ* events were supplied locally by TroutLodge (Sumner, WA), which supplies RBT eggs and sperm for the laboratory sublethal toxicity tests required in STIA's NPDES stormwater permit. The status of the *in situ* organisms was routinely monitored during the exposure, as well as at specific developmental stages and after significant storm events. Data were obtained on hatching, survival, development and growth. A subset of embryos was also reared in the laboratory to assess organism quality. Weekly temperature measurements from the field were used to adjust rearing temperatures for the laboratory controls so that development in the controls could be used to trigger field inspections at specific times (e.g., hatch, swim-up).

2.2 Monitoring Locations and Site Preparations

The exposures were conducted in two streams within the STIA property boundaries: Miller Creek and Des Moines Creek (Figure 1). Two of the sites, Miller Creek and Des Moines Creek at S 200th, are located downstream of STIA inputs into their respective drainages. An additional site (Des Moines Creek Upstream) is located upstream of STIA stormwater outfalls into Des Moines Creek. This site is used to assess water quality in Des Moines Creek prior to receiving any STIA stormwater discharges; the Des Moines Creek basin upstream of STIA is heavily urbanized and potentially impacted by a variety of pollutant sources.

Results from 2010 concluded that the chosen sampling sites generally do not have ideal substrate conditions and are subjected to heavy sediment flow during storm events. Consequently, all four exposure replicates at each site were placed above the substrate in gravel contained within PVC crate frames (see Figure 2) anchored to the substrate with steel stakes. The replicate crates at each site were placed in a row on the streambed, from upstream to downstream, at a sufficient distance apart so that flow patterns were re-established between each crate. This approach allowed for passage of water through the exposure chambers, but prevented smothering of embryos and fry by sediment.

2.3 Field Exposure Apparatus

The trout embryos were contained in modified Whitlock-Vibert hatchboxes (Federation of Flyfishers, MO), which are comprised of two rectangular chambers located one above the other; the upper chamber is for embryo development and the lower chamber for rearing of hatched fish. The external sides of the hatchbox are plastic mesh that allows passage of water through the box, but prevents loss of embryos. The divider between the embryo chamber and the rearing chamber is comprised of slots that are narrow enough to prevent transfer of unhatched embryos, but wide enough to permit migration of hatched fish into the lower rearing chamber. Thus, upon hatch, alevins are able to migrate through the slots from the embryo chamber into the larger rearing chamber. To prevent escape of the hatched fry into the streams upon swim-up, plastic screening material (Darice® size 7 mesh) was attached to the external faces of the rearing chamber and held in place using small plastic zip ties.

The hatchboxes were contained within flexible plastic mesh bags surrounded by 1 – 2 inch diameter gravel, with the hatchbox placed centrally within the rocks in the bag. The gravel surrounding the hatchboxes acts to diffuse the current and prevent exposure of the embryos to sunlight. The bags were then placed within the PVC crates, which were held in place in the stream by stakes anchored in the substrate (Figure 2). Figure 3 shows the eyed eggs within the hatchbox, while Figure 4 is of fry within the hatchbox.

Figure 2: Photograph of the crate set up, Des Moines Creek at S 200th.



2.4 Test Organisms

Eyed-egg stage rainbow trout embryos were obtained from TroutLodge on October 9, 2013 for the Fall event and April 9, 2014 for the Spring event. As supplied, the eyed embryos had developed for approximately 245 degree-days[1], as noted in communication with TroutLodge staff. On the day of test initiation for both events, eggs were brought to Rainier Environmental Laboratory (REL; Fife, WA), and randomly counted into replicate units of 30 embryos apiece in individual opaque plastic food-storage containers (i.e., 450-mL Ziploc plastic tubs). These containers were then placed in a cooler containing ice packs, and transported to the sites where the embryos were transferred into the hatchboxes in the creek on the same day. The embryos were transferred to the sites in laboratory control water, and all embryos were installed at the sites between 14:00 and 15:15 on October 9, 2013 for the Fall event, and between 13:45 and 15:45 on April 9, 2014 for the Spring event.

All personnel handling the embryos wore nitrile gloves. Containers were pre-cleaned with Liqui-nox soap (Alconox, Jersey City, NJ) and rinsed with deionized water.

2.5 Controls

Controls were used to assess the influence of the following factors on test results:

1. Quality (health and viability) of supplied organisms,
2. Transport and handling of organisms, and
3. Ambient stream temperatures, which affect the time to developmental milestones (e.g., hatch).

The controls consisted of a laboratory exposure (four replicates of 30 organisms each) conducted concurrently with each field exposure in clean laboratory water (moderately hard synthetic water [MHSW]) using a subset of the same batch of embryos used to initiate the field exposures. These embryos were also counted out, placed into individual plastic containers filled with MHSW and transported to the sites with the other replicates; thus, they also served as transport

[1] Degree-days are used to standardize descriptions of fish development, regardless of rearing temperature. For example, it takes rainbow trout approximately 340 degree-days to reach hatch (Quinn, 2005). Thus, at 8°C, it takes approximately 42 days to reach hatch.

controls. Upon returning to the laboratory after deployment of all field organisms, the control replicates were transferred to 4-L plastic containers in the laboratory containing 2 liters of MHSW at the average site water temperature, ±1°C. The control chambers are held in the dark, and gentle aeration was applied (100-200 bubbles per minute). The controls were monitored daily for mortalities, and dead organisms removed. Temperature was adjusted on a weekly basis to correspond to temperatures measured in the field. Water renewals were conducted three times per week (Monday, Wednesday, Friday) using clean MHSW. Dissolved oxygen, pH, conductivity, and temperature were measured before and after water renewals. Developmental milestones (e.g., hatch and swim-up) were also recorded.

2.6 Monitoring of Field Exposures

The sites were visited at approximately weekly intervals to assess the condition of the test organisms. During these checks, survival was recorded, as well as qualitative observations of organism health, site conditions, and sedimentation within the boxes. All dead organisms observed were removed on each visit. These observations were recorded on standard field data sheets included in Appendix A. In addition, temperature, pH, dissolved oxygen (DO) and conductivity were measured during the site visits.

Monitoring of the installations required removal of the substrate overlying the hatchboxes in the crate. The embryos or alevins in each hatchbox were then poured into a plastic dishpan containing site water where they were enumerated. They were then returned to the hatchbox, which was placed back into the mesh-net bag of gravel, the overlying gravel replaced, and the bag returned to its respective crate. Care was taken to minimize disturbance and damage to the test organisms.

2.7 Test Termination

The field exposures and laboratory controls were terminated when the field organisms reached the swim-up fry stage (i.e., yolk sac absorbed). This occurred on November 6, 2013 for the Fall exposure, and on May 6, 2014 for the Spring exposure. Surviving organisms were placed in their original plastic replicate containers filled with site water, transported back to the laboratory, and terminated. The fish were then wet-weighed (to the nearest 0.001 gram) on an analytical balance, and measured (total length, from tip of the snout to the end of the tail) to the nearest 0.5 mm. Obvious external malformations were noted, including the affected body part (e.g., head, eye, spine) and type of abnormality (e.g., edema). Abnormality data were recorded

on standard data sheets (Appendix A). The laboratory control fish were evaluated similarly on the same day.

2.8 Data Analysis

All test data were entered in CETIS (Comprehensive Environmental Toxicity Information System, Tidepool Scientific, McKinleyville, CA). Differences among the exposure sites and laboratory controls were evaluated using pair-wise multiple comparison tests according to the USEPA flow chart (USEPA 2002); significant differences were identified at $p \leq 0.05$.

One interim and five terminal endpoints were evaluated; the endpoints are described below:

1. Hatching success – an interim measure of the percentage of embryos hatched the day of the hatch inspection, or determined to have hatched based on the number of alevins present at the subsequent inspection, relative to the total number of embryos originally added;
2. Post-hatch survival - the percentage of organisms surviving at test termination relative to the number of embryos that hatched (these data help determine whether the majority of mortalities occurred pre- or post-hatch, or were distributed throughout the exposure period);
3. Cumulative survival - the percentage of surviving organisms at test termination relative to the number of embryos in each replicate at the beginning of the exposure;
4. Abnormality – the percentage of abnormal organisms at test termination relative to the number of surviving organisms;
5. Length – to the nearest 0.5 mm;
6. Weight – to the nearest 0.001 g.

3.0 QA/QC

The QA/QC program for the field exposure involved the following:

- Consistent field staff leader throughout all visits;
- Field documentation of all primary data; i.e., the names of individuals collecting the samples, sampling location, time of sampling, site conditions (e.g., degree of sedimentation), and other relevant observations, such as weather and any unusual conditions;
- Calibrated field meters;
- Use of pre-cleaned containers, with appropriate labels;
- Storing and transporting organisms in sealed containers in a cold, dark environment; cooling sample containers using ice or gel packs;
- Including transport controls to ascertain the extent of any transport-induced stress;
- Checking field organisms every week to monitor developmental progress, mortality and abnormality.

The QA/QC program for the laboratory portion of the study involved:

- Checks and maintenance of control organisms at regular intervals, including recording primary observations and water quality data on standardized data sheets;
- Review of datasheets by senior laboratory staff;
- Test termination activities (measurements, health assessment) conducted by qualified staff members using standardized datasheets to ensure consistent assessment of abnormalities and growth across all test sites and controls;
- Use of standard laboratory water and environmental chambers to maintain test organisms.

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4.0 RESULTS

4.1 Water Quality Measurements

Water quality measurements are summarized in Tables 1 and 2 for the Fall 2013 and Spring 2014 monitoring events, respectively.

Table 1: Summary of water quality measurements collected during site visits and control renewals (Fall 2013).

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	11.3 (1.2)	9.3 (0.2)	7.38 (0.14)	264.4 (3.5)
	[Min-Max]	[8.6 – 12.4]	[8.9– 9.7]	[7.19 – 7.67]	[257 - 271]
Miller Creek		9.8 (1.4)	10.4 (0.5)	7.31 (0.13)	271.8 (53.4)
		[8.0 – 11.7]	[9.8-10.9]	[7.14 – 7.50]	[182 - 307]
Des Moines		10.2 (1.2)	10.7 (1.4)	7.08 (0.36)	187.8 (32.8)
Creek at S 200th		[8.5 – 11.9]	[9.1 – 12.9]	[6.74 – 7.54]	[141 - 224]
Des Moines		12.3 (1.4)	9.9 (0.3)	6.87 (0.29)	107.2 (13.3)
Creek Upstream		[10.5– 14.1]	[9.4 – 10.2]	[6.50 – 7.19]	[94 - 126]

Table 2: Summary of water quality measurements collected during site visits and control renewals (Spring 2014).

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	12.0 (0.2)	9.1 (0.3)	7.45 (0.13)	284.9 (22.4)
	[Min-Max]	[11.5 – 12.4]	[8.3 – 9.4]	[7.17 – 7.67]	[244 - 312]
Miller Creek		11.9 (1.0)	11.3 (1.1)	6.96 (0.62)	201.2 (46.8)
		[10.7 – 13.3]	[10.5 – 13.1]	[6.05 – 7.78]	[148 - 270]
Des Moines		12.6 (1.0)	9.9 (0.6)	6.89 (0.39)	140.4 (30.8)
Creek at S 200th		[11.3 – 13.8]	[9.1 – 10.72]	[6.34 – 7.44]	[98 - 168]
Des Moines		12.8 (0.3)	10.2 (0.5)	6.77 (0.44)	92.0 (11.3)
Creek Upstream		[12.5 – 13.1]	[9.7 – 10.7]	[6.26 – 7.03]	[79 - 99]

In the Fall 2013 *in situ* tests, temperatures for the three field sites and the control ranged from 8.0 to 14.1^{0}C. The field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays (60-100% saturation, and 6-9 pH units, respectively). The pH values were between 6.5 and 7.7, and DO ranged from 9.1 to 12.9 mg/L among all stream measurements. Although limited to weekly measurements, the field DO and pH data suggested good water quality conditions, with no indication of potential for adverse effects on organism survival and development. The conductivity measurements for all three sites exhibited some variability throughout the exposure period, but the values remained well-within ranges tolerated by early life stages of salmonids.

In the Spring 2014 *in situ* tests, temperatures among the three field sites and the control ranged from 10.7 to 13.8^{0}C. These temperatures were similar to Fall temperatures. The field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays. The pH values were between 6.1 and 7.8, and DO ranged from 9.1 to 13.1 mg/L among all stream measurements. Consequently, the weekly field measurements of DO and pH suggested good water quality conditions, with no indication of potential for adverse effects on organism survival and development. As observed in the Fall event, the conductivity measurements for all three sites exhibited some variability throughout the exposure period, but the values remained well-within ranges tolerated by early life stages of salmonids.

Continuous measurements of pH were collected by CardnoTEC at the Miller Creek site using data sondes for limited periods primarily during the Fall 2013 monitoring event. These data were collected as part of another program, and show short-term variability in pH. The data are presented in Figure 5 for the Fall 2013 testing event.

Figure 5: Continuous pH data from Miller Creek, Fall 2013.



4.2 Precipitation During the Monitoring Events

Precipitation data were provided by STIA. Figure 6 shows the daily rainfall for the duration of the exposure for the Fall 2013 test. A limited number of storm events occurred during the *in situ* deployment, with a total of 1.53 inches of rain over 4 weeks. There was no snow during this testing event. Figure 7 shows the daily rainfall for the duration of the Spring 2014 exposure. Appreciably more rain (5.37 in) fell during the Spring event compared with the Fall. No snow occurred during the exposure period, and the largest storm was May 3rd.

Figure 6: Daily rainfall for the duration of Fall 2013 exposure.

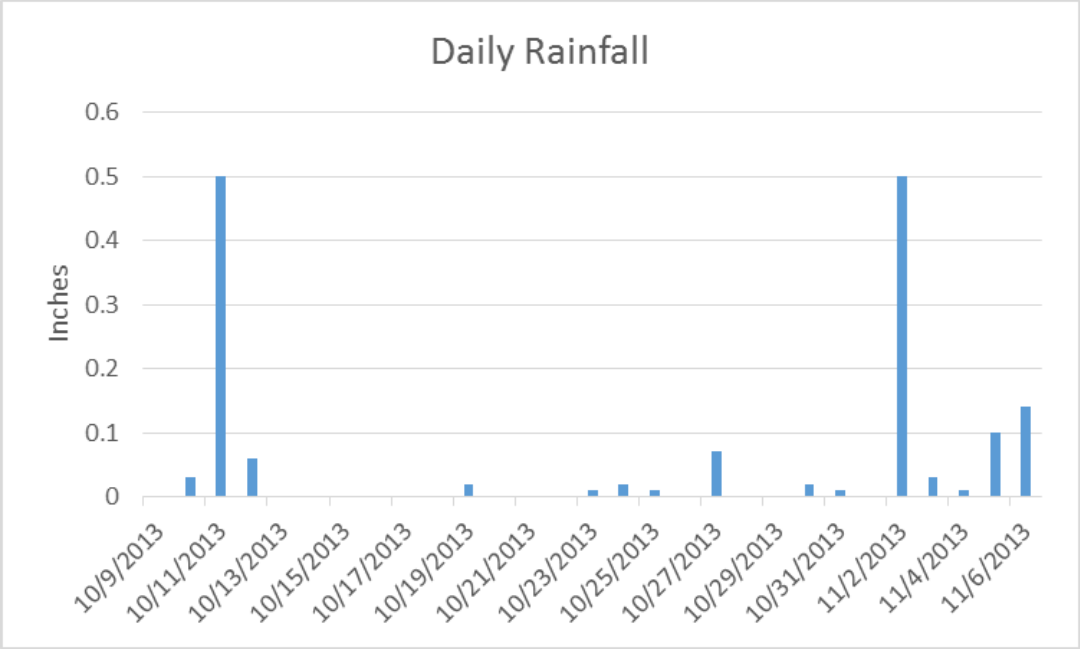
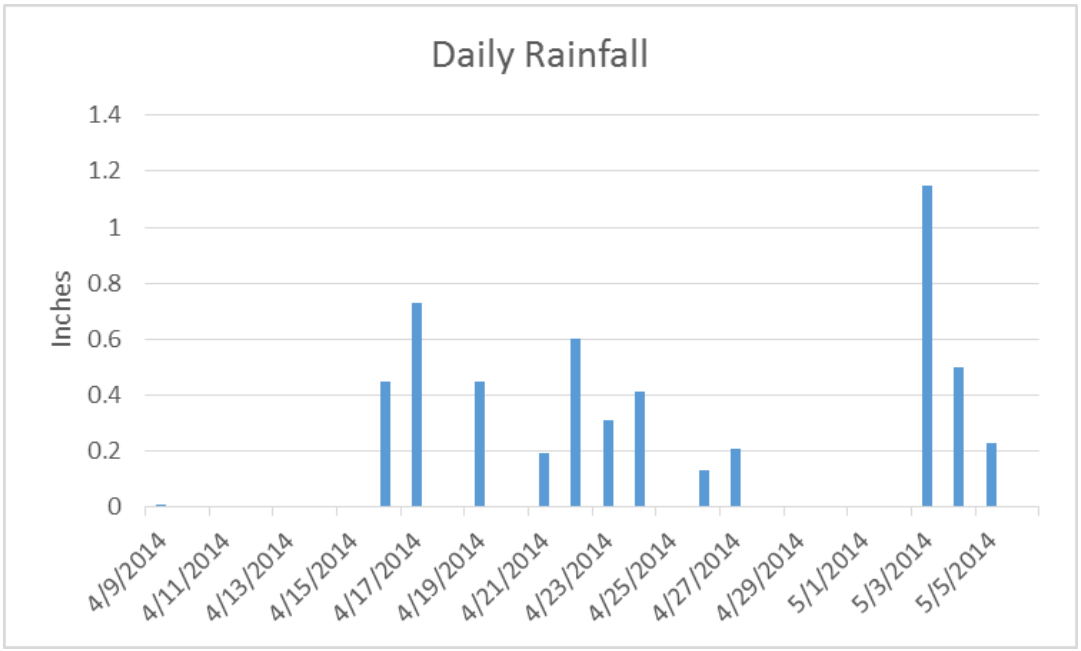


Figure 7: Daily rainfall for the duration of the Spring 2014 exposure.



4.3 *In situ* exposures

4.3.1 Fall 2013

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 3. Table 4 presents the growth endpoints. These same data are presented graphically in Figures 9 through 11 for ease of comparison.

During an interim check after the embryos had hatched, one of the replicates at Miller Creek was found without alive or dead alevins. As there is normally evidence of fish mortality in a replicate, the lack of any carcasses suggests escapement. Therefore, this replicate was removed from statistical analysis for all endpoints except hatching success.

Hatching success – Mean hatching success for the controls was 99.2%, compared with 58.3% at Miller Creek, 95.0% at Des Moines Creek at S 200th, and 44.2% at Des Moines Creek Upstream. Hatching success at Des Moines Creek at S 200th was not statistically different from the controls; however, hatching success at Miller Creek and Des Moines Creek Upstream were significantly reduced relative to the controls.

Post-hatch survival – Control survival of alevins post-hatch was 100%, compared with 61.6% at Miller Creek, 93.8% at Des Moines Creek at S 200th, and 11.2% Des Moines Creek Upstream. Post-hatch survival at Des Moines Creek Upstream and Miller Creek sites were significantly different from the controls. However, there was no difference in post-hatch survival between the controls and Des Moines Creek at S 200th.

Cumulative survival – Control survival from the initiation of the test to termination averaged 99.2%. For comparison, cumulative survival at the exposure sites averaged 45.6% at Miller Creek, 89.2% at Des Moines Creek at S 200th, and 5.8% at the Des Moines Creek Upstream site. Survival at Des Moines Creek at S 200th was not statistically different from the controls, whereas both Des Moines Upstream and Miller Creek were significantly reduced compared with the controls.

Abnormalities – There were few abnormalities observed across all treatments, with just one in the controls, one at Miller Creek, and one at Des Moines Creek at S 200th. The control fish exhibited edema, while the abnormal fish at Miller Creek was missing its tail, and the fish at Des Moines Creek at S 200th had small and misshapen eyes.

Growth – Average weight in the controls was 80.0 mg, and length averaged 22.4 mm. For comparison, Miller Creek fish averaged 64.2 mg and 20.8 mm, fish exposed at Des Moines Creek at S 200th averaged 76.7 mg and 21.9 mm, and Des Moines Creek Upstream fish averaged 76.0 mg and 21.7 mm, for weight and length, respectively. Growth of fish from Des Moines Creek Upstream (length only) and Miller Creek (length and weight) was significantly less than observed in the controls.

Table 3: Results for hatching success, survival and abnormality in the control and field treatment groups (Fall 2013)[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	99.2 (1.7)	100 (0.0)	99.2 (1.7)	0.9 (1.7)
Miller Creek	58.3 (22.9)	61.6 (36.4)	45.6 (31.5)	2.0 (3.4)
Des Moines Creek at S 200th	95.0 (7.9)	93.8 (2.0)	89.2 (8.8)	0.9 (1.7)
Des Moines Creek Upstream	44.2 (15.0)	11.2 (14.1)	5.8 (7.9)	0 (0)

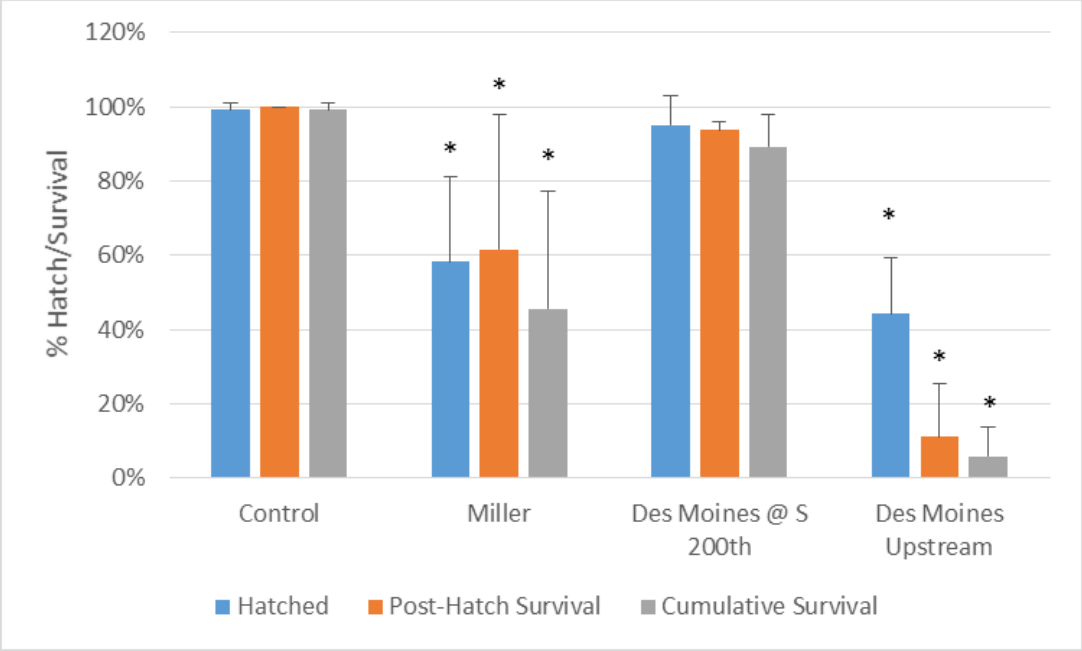
Notes:
1. Results are presented as mean and standard deviation.
2. Shaded values are significantly different from the control.

Table 4: Comparison of growth in the control and field treatment groups (Fall 2013)[1].

Site	Length (mm)	Weight (mg)
Control	22.4 (0.64)	80.0 (1.81)
Miller Creek	20.8 (0.47)	64.2 (4.55)
Des Moines Creek at South 200th	21.9 (0.39)	76.7 (0.93)
Des Moines Creek Upstream	21.7 (0.42)	76.0 (8.49)

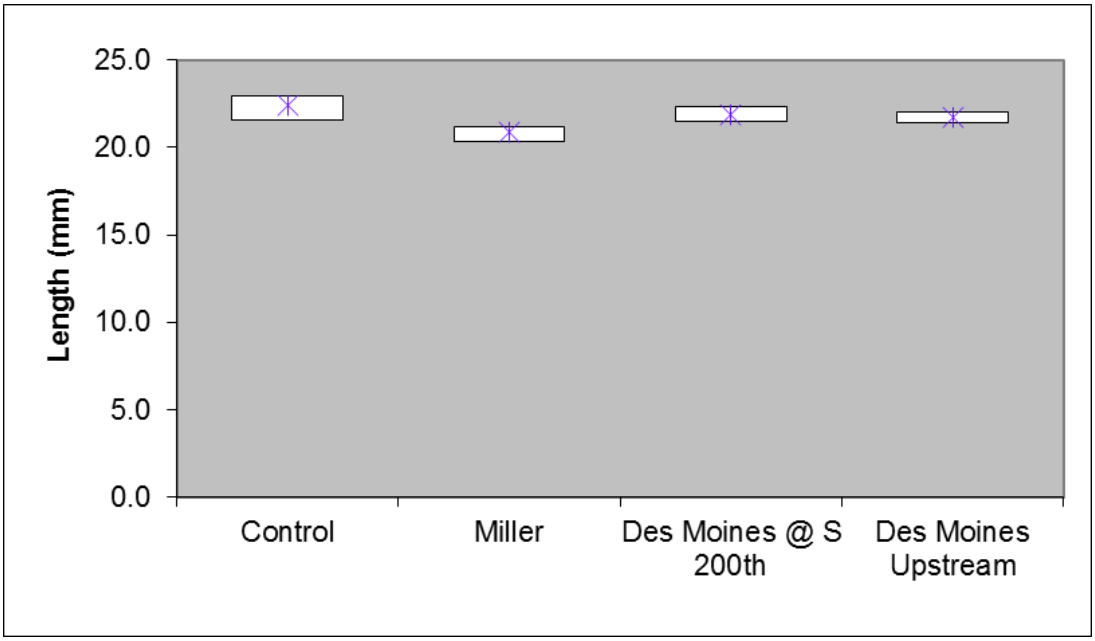
Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control

Figure 8: Hatching success, post-hatch survival and cumulative survival in the field and control treatment groups (Fall 2013).



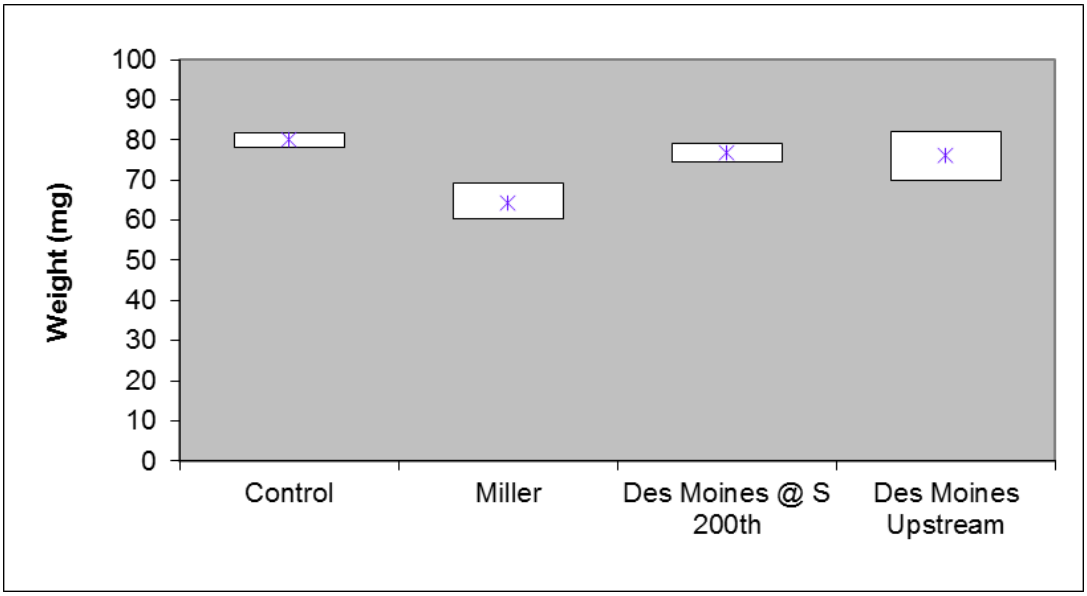
Error bars are standard deviations; asterisks denote significant difference from controls.

Figure 9: Average lengths for the laboratory control and exposure sites (Fall 2013).



Data point is the average; box represents range of minimum to maximum values.

Figure 10: Average weights for the laboratory control and exposure sites (Fall 2013).



Data point is the average; box represents range of minimum to maximum values.

4.3.2 Spring 2014

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 5. Table 6 presents the growth endpoints. These same data are presented graphically in Figures 12 through 14 for ease of comparison.

Hatching success – Mean hatching success for the controls was 100%, compared with 98.3% at Miller Creek, 92.5% at Des Moines Creek at S 200th, and 0.8% at Des Moines Creek Upstream. Hatching success at both Des Moines Creek sites was significantly less than the controls ($p \leq 0.05$); however, since the effect size at Des Moines Creek at S 200th was <10%, the p-value was changed to 0.01, per the WDOE guidance document (WDOE 2008), which removed the significance.

Post-hatch survival – Control survival of alevins post-hatch was 97.5%, compared with 96.6% at Miller Creek, 97.2% at Des Moines Creek at S 200th, and 0% at Des Moines Upstream. Only Des Moines Upstream was significantly different from controls.

Cumulative survival – Control survival from the initiation of the test to termination averaged 97.5%, compared with 94.4% at Miller Creek, and 90.0% at Des Moines Creek at S 200th. Neither of these sites differed significantly from the controls. No survival was observed at test

termination at the Des Moines Upstream site, which was significantly different from the controls.

Abnormalities -- There were few abnormalities observed in any of the treatments, with just one in the controls, and one at Miller Creek. Both abnormalities were misshapen jaws.

Growth – Average weight in the controls was 124.1 mg, compared with 129.2 mg at Miller Creek, and 127.1 mg at Des Moines Creek at S 200th. Surviving fish averaged 26.6 and 26.5 mm at Miller and Des Moines Creek at S 200th, respectively, compared with an average of 26.7 mm in the controls. There were no statistical differences in growth among sites.

Table 5: Hatching success, survival and abnormality in the control and field treatment groups (Spring 2014)[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	100 (0)	97.5 (3.2)	97.5 (3.2)	0.8 (1.7)
Miller Creek	98.3 (1.9)	96.6 (3.3)	94.4 (1.9)	1.2 (2.1)
Des Moines Creek at S 200th	92.5 (8.8)	97.2 (1.9)	90.0 (9.4)	0 (0.0)
Des Moines Upstream	0.8 (1.7)	0 (0.0)	0 (0.0)	NA

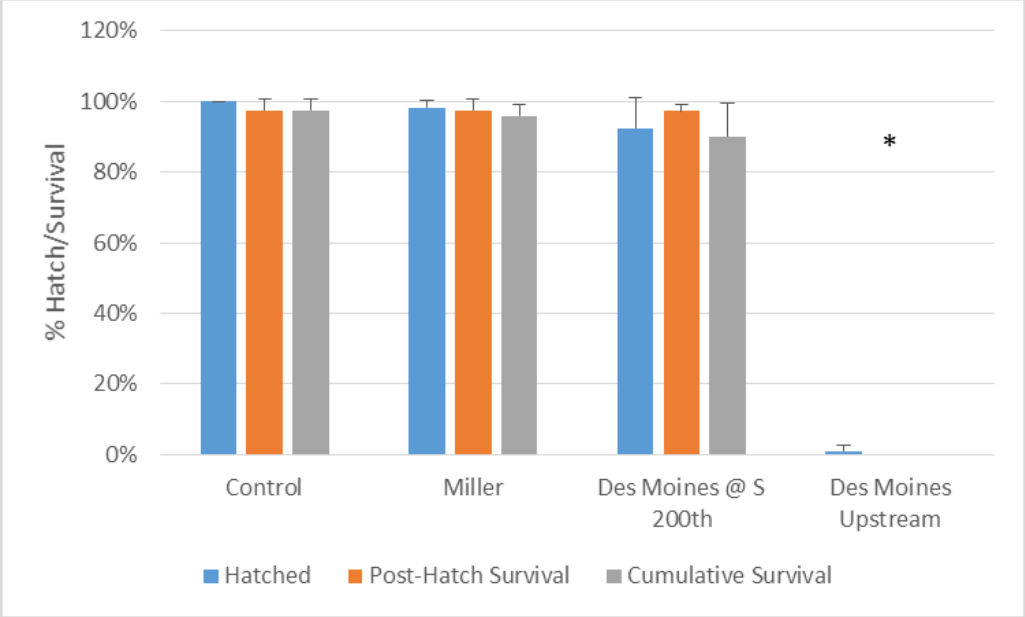
Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control
3. NA- Not applicable

Table 6: Comparison of growth in the control and field treatment groups (Spring 2014)[1].

Site	Length (mm)	Weight (mg)
Control	26.7 (0.14)	124.1 (2.5)
Miller Creek	26.6 (0.3)	129.2 (3.3)
Des Moines Creek at S 200th	26.5 (0.11)	127.1 (2.7)
Des Moines Upstream	NA	NA

Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control
3. NA- Not applicable

Figure 11: Hatching success, post-hatch survival and cumulative survival in the field and control treatment groups (Spring 2014).



Error bars are standard deviations; asterisks denote significant difference from controls.

Figure 12: Average length for the control and exposure group (Spring 2014).



Data point is the average; box represents range of minimum to maximum values.

Figure 13: Average weights for the control and exposure groups (Spring 2014).



Data point is the average; box represents range of minimum to maximum values.

4.4 Field Observations

During both testing events, hatch boxes were observed to be free of biofilm or other accumulation of organic material. During both events, crayfish were often found within the crates at all sites, but not within the hatchboxes. Tadpoles were observed in the Spring at the Miller Creek site. Accumulation of sediments within the hatch boxes was observed during the Spring 2014 event at the Miller Creek site, with sediment volume reaching 80% and greater within the boxes. Interestingly, no adverse effects were observed despite the relatively high level of sedimentation.

4.5 Relationships Between *In Situ* and Sublethal Tests

There were no overlaps between the Fall 2013 and Spring 2014 *in situ* deployments, and laboratory sublethal tests.

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5.0 DISCUSSION

In Fall 2013, adverse effects on survival were observed in Miller Creek, with hatching success, post-hatch survival and cumulative survival significantly reduced compared to the controls. The rainfall total for Fall 2013 was one of the smallest amounts recorded during an *in situ* exposure over the last 4 years, regardless of season. Therefore, the amount of discharge from STIA was limited; the stormwater outfall located immediately upstream of the site was only seen discharging on the day of termination. Thus, test conditions during the Fall may have been more representative of seasonal base flow conditions. No evidence of adverse effects were observed in the hatch boxes deployed at Miller Creek in Spring 2014, which experienced appreciably more discharge during the exposure period.

Adverse effects were not observed at Des Moines at S 200th during the Fall or Spring deployments. Conversely, significant effects were observed at the Upstream Des Moines Creek site in both events. This result is consistent with previous testing events, and continues to suggest that there are concerns with water quality at this site. Notably, this site is located near the headwaters of Des Moines Creek, upstream of inputs from STIA property. These findings have been communicated to the City of SeaTac, who are working to identify and remove illicit discharges and connections in the watershed through the City's illicit discharge detection and elimination program.

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Port of Seattle

September 2, 2014

Mr. Bobb Nolan
Washington Department of Ecology
Northwest Regional Office
3190 160th Ave SE
Bellevue, Washington 98008

Re: Storm Drainage System *In Situ* Monitoring– Fall 2014 and Spring 2015 Testing Events Final Report
Seattle-Tacoma International Airport
NPDES Permit WA-002465-1, Part II Special Condition S9

Dear Mr. Abbasi:

Please find attached the Nautilus Environmental *Phase 1: Development and Demonstration – Fall 2014 and Spring 2015 Testing Events Final Report* dated August 17, 2015. This report presents the results of the rainbow trout early life stages *in situ* bioassay, as described in the Port of Seattle's Seattle-Tacoma International Airport *In situ* Monitoring Plan, Phase 1: Development and Demonstration.

Deicing season sublethal laboratory testing was not able to be completed during the 2014/2015 season because trout embryos were not available for testing during the time when ground deicing occurred. The *in situ* bioassay was completed during both Fall and Spring seasons which continues to support the reliability of the *in situ* test in comparison to the laboratory sublethal test which is often encumbered by the timing of rainfall events and embryo availability.

If you have any questions regarding this letter, please contact me at 206/787-5528.

Sincerely,

Bob Duffner
Environmental Compliance Programs Manager, Aviation

Cc: Randy Marshall, Department of Ecology

Attachment: Nautilus Environmental, *Port of Seattle – Seattle Tacoma International Airport, Rainbow Trout Early Life Stages In Situ Monitoring Testing, Phase I: Development and Demonstration – Fall 2014 and Spring 2015 Testing Events, Final Report*, August 17, 2015.

Seattle-Tacoma
International Airport
P.O. Box 68727
Seattle, WA 98168-0727

Nautilus Environmental

Port of Seattle- Seattle-Tacoma International Airport

Rainbow Trout Early Life Stages *In Situ* Monitoring Testing

Phase 1: Development and Demonstration - Fall 2014 and Spring 2015 Testing Events

Final Report

Report date: August 17, 2015

Submitted to:

Port of Seattle
Seattle-Tacoma International Airport
PO Box 68727
Seattle, WA 98168

8663 Commerce Court
Burnaby, BC V5A 4N7

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1.0 INFORMATION

This report presents the results of the rainbow trout (RBT) early life stage (ELS) *in situ* monitoring tests conducted in the Fall 2014 and Spring 2015, as described in the Port of Seattle's Seattle-Tacoma International Airport *In situ* Monitoring Plan, Phase 1: Development and Demonstration (Nautilus 2010). The objective of this program is to demonstrate the feasibility of using salmonid ELS as an *in situ* monitoring tool to assess the quality of receiving waters potentially affected by stormwater discharges from the Seattle-Tacoma International Airport (STIA), as well as a multitude of other discharges from the surrounding urban environment. Results for studies conducted in Fall 2010/Spring 2011, Fall 2011/Spring 2012, Fall 2014/Spring 2013, and Fall 2013/Spring 2014 have been presented previously (Nautilus 2011, Nautilus 2012, Nautilus 2013, and Nautilus 2014, respectively).

Results from the *in situ* bioassays and supporting analytical data are intended to provide an indication of attainment of receiving water quality standards and associated beneficial uses related to salmonid spawning and rearing. Thus, the overall goal of Phase 1 is to validate the *in situ* approach, particularly with respect to determining if the selected sites and exposure methodologies are appropriate, or if they need to be modified to compensate for confounding variables (e.g., deposition of fine sediments, mobilization of anoxic sediments during storm events, etc.). Applied under the appropriate conditions, it is anticipated that the RBT *in situ* ELS bioassay will be an effective instream biological monitoring tool for assessing the potential effects of stormwater discharges on the receiving environment.

Phase I of the *In Situ* Monitoring Plan (i.e., Development and Demonstration) was originally intended to last for one year and include testing during the Spring and Fall seasons. However, this Phase was extended to allow for additional comparisons with the laboratory sublethal testing being conducted by the STIA at sites downstream of Port outfalls, as specified in Part II, Special Condition S8 of NPDES Permit No. WA-002465-1. The laboratory sublethal toxicity testing is used for permit compliance purposes, and has been conducted concurrently with *in situ* deployments (when feasible) to facilitate validation of the *in situ* methodology. A comparison of the two methods is presented in the Combined Acute, Sublethal, and *In Situ* Report (Nautilus 2013).

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2.0 TEST METHODS

Guidance for conducting *in situ* ELS exposures with salmonids is available from a number of sources. For example, the British Columbia Ministry of Environment has a protocol for an *in situ* ELS salmonid test (BCMOE, 2003). In addition, Environment Canada has developed both laboratory and *in situ* test procedures for early life stages of rainbow trout (Environment Canada, 1998). In the U.S., there are two general laboratory protocols for conducting fish early life stage toxicity tests (EPA, 1996; ASTM, 2005). The procedures used in this study reflect refinements made to the general guidance provided in the documents above (Chalmers *et al*, 2014), and have been used successfully at a number of sites in both Canada and the United States. Additional refinements specific to applying the method to waterways present on Airport property are included in the descriptions below.

2.1 Design

The study design used for the Fall 2014 and Spring 2015 *in situ* testing involved exposure of eyed-embryos at three sampling sites, using four replicates per site with 30 embryos per replicate. The locations of the sites are shown in Figure 1. The Study Design was consistent with the methodology used in the seven previous monitoring events in which the sites located on Miller and Des Moines Creeks downstream of all Airport discharges were augmented by an additional site on Des Moines Creek located upstream of any Airport discharges. The additional site (i.e., Des Moines Creek Upstream) was included to determine the extent to which sources upstream of any STIA inputs may contribute to adverse effects observed at the downstream site on Des Moines Creek.

The exposure duration used in the *in situ* tests covers the major salmonid early life stage developmental milestones, beginning with the eyed egg stage, proceeding through hatching and alevin stages (yolk sac present and residing in the gravel), and ending with the early fry stage (also known as swim-up fry). At this point, the yolk sac is absorbed and, under natural conditions, the fish would leave the gravel to feed independently. The duration of the exposure period is expected to include multiple rain/runoff events, and corresponding fluctuations in flow, contaminant concentrations, temperature, water chemistry, etc. Collectively, these attributes of the *in situ* approach provide highly relevant information regarding the suitability of waterbodies to support salmonids (Chalmers *et al*, 2014).

The eyed eggs for both *in situ* events were supplied locally by TroutLodge (Sumner, WA), which supplies RBT eggs and sperm for the laboratory sublethal toxicity tests required in STIA's NPDES stormwater permit. The status of the *in situ* organisms was routinely monitored during the exposure, as well as at specific developmental stages and after significant storm events. Data were obtained on hatching, survival, development and growth. A subset of embryos was also reared in the laboratory to assess organism quality. Weekly temperature measurements from the field were used to adjust rearing temperatures for the laboratory controls so that development in the controls could be used to trigger field inspections at specific times (e.g., hatch, swim-up).

2.2 Monitoring Locations and Site Preparations

The exposures were conducted in two streams within the STIA property boundaries: Miller Creek and Des Moines Creek (Figure 1). Two of the sites, Miller Creek and Des Moines Creek at S 200th, are located downstream of STIA inputs into their respective drainages. An additional site (Des Moines Creek Upstream) is located upstream of STIA stormwater outfalls into Des Moines Creek. This site is used to assess water quality in Des Moines Creek prior to receiving any STIA stormwater discharges; the Des Moines Creek basin upstream of STIA is heavily urbanized and potentially impacted by a variety of pollutant sources.

Results from 2010 concluded that the chosen sampling sites generally do not have ideal substrate conditions and are subjected to heavy sediment flow during storm events. Consequently, all four exposure replicates at each site were placed above the substrate in gravel contained within PVC crates anchored to the substrate with steel stakes. The replicate crates at each site were placed in a row on the streambed, from upstream to downstream, at a sufficient distance apart so that flow patterns were re-established between each crate. This approach allowed for passage of water through the exposure chambers, but prevented smothering of embryos and fry by sediment.

2.3 Field Exposure Apparatus

The trout embryos were contained in modified Whitlock-Vibert hatchboxes (Federation of Flyfishers, MO), which are comprised of two rectangular chambers located one above the other; the upper chamber is for embryo development and the lower chamber for rearing of hatched fish. The external sides of the hatchbox are plastic mesh that allows passage of water through the box, but prevents loss of embryos. The divider between the embryo chamber and the rearing chamber is comprised of slots that are narrow enough to prevent transfer of unhatched embryos, but wide enough to permit migration of hatched fish into the lower rearing chamber. Thus, upon hatch, alevins are able to migrate through the slots from the embryo chamber into the larger rearing chamber. To prevent escape of the hatched fry into the streams upon swim-up, plastic screening material (Darice® size 7 mesh) was attached to the external faces of each rearing chamber and held in place using small plastic zip ties.

The hatchboxes were contained within flexible plastic mesh bags surrounded by 1 – 2 inch diameter gravel, with the hatchbox placed centrally within the rocks in the bag. The gravel surrounding the hatchboxes acts to diffuse the current and prevent exposure of the embryos to sunlight. The bags were then placed within the PVC crates, which were held in place in the stream by stakes anchored in the substrate (Figure 2). Figure 3 shows the eyed eggs within the hatchbox, while Figure 4 is of fry within the hatchbox.

Figure 2: Photograph of the crate set up, Des Moines Creek at S 200th.



2.4 Test Organisms

Eyed-egg stage rainbow trout embryos were obtained from TroutLodge on October 9, 2014 for the Fall event and March 27, 2015 for the Spring event. According to TroutLodge staff, the eyed embryos had already developed for approximately 245 degree-days[1]. On the day of test initiation, eggs were brought to Rainier Environmental Laboratory (REL; Fife, WA), and randomly counted into replicate units of 30 embryos apiece in individual opaque plastic food-storage containers (i.e., 450-mL Ziploc plastic tubs). These containers were then placed in a cooler containing ice packs, and transported to the sites where the embryos were transferred into the hatchboxes in the creek on the same day. The embryos were transferred to the sites in laboratory control water, and all embryos were installed at the sites between 14:15 and 15:40 on October 9, 2014 for the Fall event, and between 13:45 and 15:00 on March 27, 2015 for the Spring event.

2.5 Controls

Controls were used to assess the influence of the following factors on test results:

1. Quality (health and viability) of supplied organisms,
2. Transport and handling of organisms, and
3. Ambient stream temperatures, which affect the time to developmental milestones (e.g., hatch).

The controls consisted of a laboratory exposure (four replicates of 30 organisms each) conducted concurrently with each field exposure in clean laboratory water (moderately hard synthetic water [MHSW]) using a subset of the same batch of embryos used to initiate the field exposures. These embryos were also counted out, placed into individual plastic containers filled with MHSW and transported to the sites with the other replicates; thus, they also served as transport controls. Upon returning to the laboratory after deployment of all field organisms, the control replicates were transferred to 4-L plastic containers in the laboratory containing 2 liters of MHSW at the average site water temperature, ±1°C. The control chambers are held in the dark, and gentle aeration was applied (100-200 bubbles per minute). The controls were monitored daily for

[1] Degree-days are used to standardize descriptions of fish development, regardless of rearing temperature. For example, it takes rainbow trout approximately 340 degree-days to reach hatch (Quinn, 2005). Thus, at 8°C, it takes approximately 42 days to reach hatch.

mortalities, and dead organisms removed. Temperature was adjusted on a weekly basis, as needed, to correspond to temperatures measured in the field. Water renewals were conducted three times per week (Monday, Wednesday, Friday) using clean MHSW. Dissolved oxygen (DO), pH, conductivity and temperature were measured before and after water renewals. Developmental milestones (e.g., hatch and swim-up) were also recorded.

2.6 Monitoring of Field Exposures

The sites were visited at approximately weekly intervals to assess the condition of the test organisms. During these checks, survival was recorded, as well as qualitative observations of organism health, site conditions and sedimentation within the boxes. All dead organisms observed were removed on each visit. These observations were recorded on standard field data sheets included in Appendix A. In addition, temperature, pH, DO and conductivity were measured during the site visits.

Monitoring of the installations required removal of the substrate overlying the hatchboxes in the crate. The embryos or alevins in each hatchbox were then poured into a plastic dishpan containing site water where they were enumerated. They were then returned to the hatchbox, which was placed back into the mesh-net bag of gravel, the overlying gravel replaced, and the bag returned to its respective crate. Care was taken to minimize disturbance and damage to the test organisms.

2.7 Test Termination

The field exposures and laboratory controls were terminated when the field organisms reached the swim-up fry stage (i.e., yolk sac absorbed). This occurred on November 5, 2014 for the Fall exposure, and on April 15, 2015 for the Spring exposure. Surviving organisms were placed in their original plastic replicate containers filled with site water, transported back to the laboratory, and terminated. The fish were then wet-weighed (to the nearest 0.001 gram) on an analytical balance, and measured (total length, from tip of the snout to the end of the tail) to the nearest 0.5 mm. Obvious external malformations were noted, including the affected body part (e.g., head, eye, spine) and type of abnormality (e.g., edema). Abnormality data were recorded on standard data sheets (Appendix A). The laboratory control fish were evaluated similarly on the same day.

2.8 Data Analysis

All test data were entered in CETIS (Comprehensive Environmental Toxicity Information System, Tidepool Scientific, McKinleyville, CA). Differences among the exposure sites and laboratory controls were evaluated using pair-wise multiple comparison tests according to the USEPA flow chart (USEPA 2002); significant differences were identified at $p \leq 0.05$.

One interim and five terminal endpoints were evaluated; the endpoints are described below:

1. Hatching success – an interim measure of the percentage of embryos hatched the day of the hatch inspection, or determined to have hatched based on the number of alevins present at the subsequent inspection, relative to the total number of embryos originally added;
2. Post-hatch survival - the percentage of organisms surviving at test termination relative to the number of embryos that hatched (these data help determine whether the majority of mortalities occurred pre- or post-hatch, or were distributed throughout the exposure period);
3. Cumulative survival - the percentage of surviving organisms at test termination relative to the number of embryos in each replicate at the beginning of the exposure;
4. Abnormality – the percentage of abnormal organisms at test termination relative to the number of surviving organisms;
5. Length – to the nearest 0.5 mm;
6. Weight – to the nearest 0.001 g.

3.0 QA/QC

The QA/QC program for the field exposure involved the following:

- Consistent field staff leader throughout all visits;
- Field documentation of all primary data; i.e., the names of individuals collecting the samples, sampling location, time of sampling, site conditions (e.g., degree of sedimentation), and other relevant observations, such as weather and any unusual conditions;
- Calibrated field meters;
- Use of pre-cleaned containers, with appropriate labels;
- Storing and transporting organisms in sealed containers in a cold, dark environment; cooling sample containers using ice or gel packs;
- Including transport controls to ascertain the extent of any transport-induced stress;
- Checking field organisms every week to monitor developmental progress, mortality and abnormality.

The QA/QC program for the laboratory portion of the study involved:

- Checks and maintenance of control organisms at regular intervals, including recording primary observations and water quality data on standardized data sheets;
- Review of datasheets by senior laboratory staff;
- Test termination activities (measurements, health assessment) conducted by qualified staff members using standardized datasheets to ensure consistent assessment of abnormalities and growth across all test sites and controls;
- Use of standard laboratory water and environmental chambers to maintain test organisms.

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4.0 RESULTS

4.1 Water Quality Measurements

Water quality measurements are summarized in Tables 1 and 2 for the Fall 2014 and Spring 2015 monitoring events, respectively.

Table 1: Summary of water quality measurements collected during site visits and control renewals (Fall 2014).

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	14.7 (1.0)	9.6 (0.4)	7.80 (0.25)	291.5 (18.1)
	[Min-Max]	[12.5 – 16.2]	[8.8 – 10.4]	[7.37 – 8.23]	[260 - 326]
Miller Creek		13.4 (1.0)	9.8 (0.4)	7.61 (0.17)	159.5 (61.7)
		[12.3 – 14.8]	[9.2-10.1]	[7.44 – 7.90]	[128 - 270]
Des Moines		16 (0.9)	9.8 (2.6)	7.18 (0.05)	101.0 (41.9)
Creek at S 200th		[12.4 – 14.4]	[8.2 – 14.3]	[7.13 – 7.24]	[58 - 171]
Des Moines		14.6 (2.1)	8.7 (0.9)	7.09 (0.20)	79.1 (30.4)
Creek Upstream		[12.6 – 17.7]	[7.4 – 9.8]	[7.24 – 7.36]	[44 - 127]

Table 2: Summary of water quality measurements collected during site visits and control renewals (Spring 2015).

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	12.2 (0.2)	9.2 (0.6)	7.41 (0.17)	283.5 (19.5)
	[Min-Max]	[11.6 – 12.5]	[8.2 – 10.1]	[7.15 – 7.85]	[246 - 311]
Miller Creek		10.6 (1.7)	11.1 (0.5)	7.29 (0.15)	212.8 (20.5)
		[8.9 – 13.3]	[10.3 – 11.5]	[7.10 – 7.45]	[187 - 236]
Des Moines		11.3 (1.3)	10.0 (0.5)	6.94 (0.11)	171.8 (21.7)
Creek at S 200th		[10.1 – 13.1]	[9.4 – 10.7]	[6.82 – 7.09]	[145 - 205]
Des Moines		12.9 (1.2)	10.0 (0.4)	6.81 (0.25)	107.0 (9.4)
Creek Upstream		[12.0 – 15.0]	[9.4 – 10.3]	[6.42 – 7.04]	[96 - 122]

In the Fall 2014, temperatures for the three field sites and the control ranged from 12.3 to 17.7^{0}C. The field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays (60-100% saturation, and 6-9 pH units, respectively). The pH values were between 7.1 and 7.9, and DO ranged from 7.4 to 14.3 mg/L. Although limited to weekly measurements, the field DO and pH data suggested good water quality conditions, with no indication of potential for adverse effects on organism survival and development. The conductivity measurements for all three sites exhibited some variability throughout the exposure period, but the values remained well-within ranges tolerated by early life stages of salmonids.

In the Spring 2015 *in situ* tests, temperatures among the three field sites and the control ranged from 8.9 to 15.0^{0}C. The field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays; specifically, the pH values were between 6.4 and 7.9, and DO ranged from 9.4 to 11.5 mg/L. These data suggested good water quality conditions, with no indication of potential for adverse effects on organism survival and development. As observed in the Fall event, the conductivity measurements remained well-within ranges tolerated by early life stages of salmonids.

4.2 Precipitation During the Monitoring Events

Precipitation data were provided by STIA. Figure 5 shows the daily rainfall for the duration of the exposure for the Fall 2014 test. Above average rainfall for October was recorded, with 7.66 inches of total rainfall. There was no snow during this testing event. Figure 6 shows the daily rainfall for the duration of the Spring 2015 exposure. Much less rain (total 1.5 in) fell during this event compared with the Fall, and no snow occurred during the exposure period. Approximately 35% of the total rainfall during this event was associated with a single day (13 April).

Figure 5: Daily rainfall for the duration of Fall 2014 exposure.

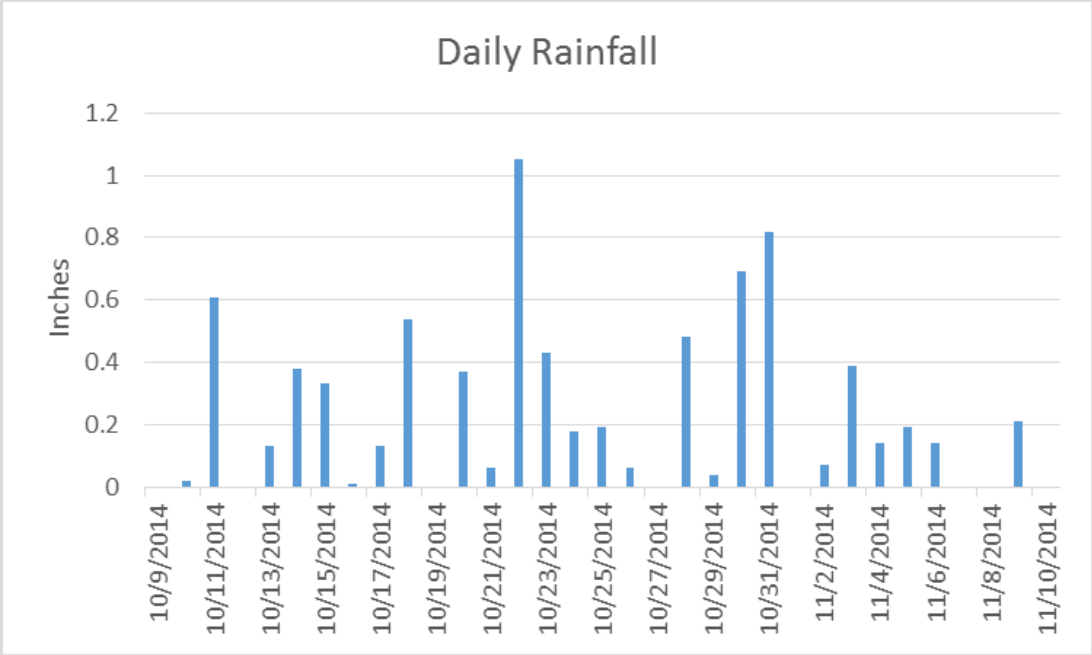
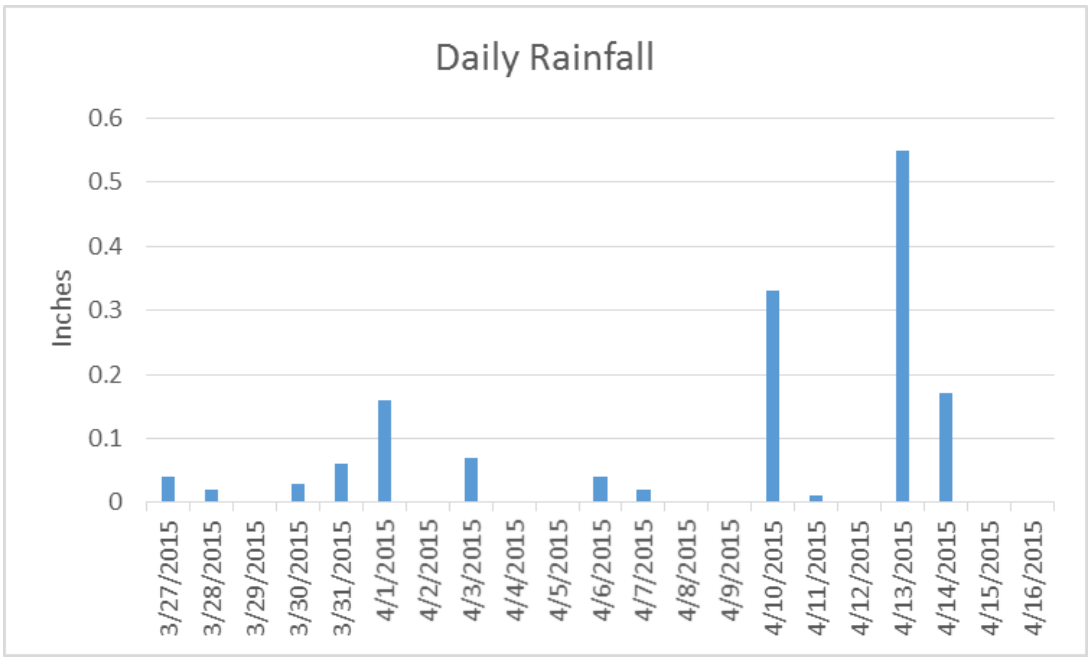


Figure 6: Daily rainfall for the duration of the Spring 2015 exposure.



4.3 *In situ* exposures

4.3.1 Fall 2014

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 3. Table 4 presents the growth endpoints. These same data are presented graphically in Figures 7 through 9 for ease of comparison.

Hatching success – Mean hatching success for the laboratory controls was 100%, compared with 60.8% at Miller Creek, 65.0% at Des Moines Creek at S 200th, and 53.3% at Des Moines Creek Upstream. Hatching success at all three sites was significantly reduced relative to the controls.

Post-hatch survival – Control survival of alevins post-hatch was 100%, compared with 77.3% at Miller Creek, 83.1% at Des Moines Creek at S 200th, and 2.4% Des Moines Creek Upstream. Post-hatch survival at Des Moines Creek Upstream was significantly different from the controls; however, there were no differences in post-hatch survival between the controls, Miller Creek and Des Moines Creek at S 200th.

Cumulative survival – Control survival from the initiation of the test to termination averaged 100%. For comparison, cumulative survival at the exposure sites averaged 38.9% at Miller Creek, 58.3% at Des Moines Creek at S 200th, and 1.7% at the Des Moines Creek Upstream site. Survival at all three sites was significantly reduced compared with the controls.

Abnormalities – There were few abnormalities observed across all treatments, with just one in the controls, and one at Des Moines Creek at S 200th. The control fish was missing its tail, while the abnormal fish at Des Moines Creek at S 200th exhibited edema.

Growth – Average weight in the controls was 89.7 mg, and length averaged 23.4 mm. For comparison, Miller Creek fish averaged 95.8 mg and 22.9 mm, fish exposed at Des Moines Creek at S 200th averaged 85.4 mg and 22.8 mm, and Des Moines Creek Upstream fish averaged 81.0 mg and 22.0 mm, for weight and length, respectively. Growth of fish from Des Moines Creek Upstream (length only) was significantly less than observed in the controls.

Table 3: Results for hatching success, survival and abnormality in the control and field treatment groups (Fall 2014)[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	100 (0)	100 (0.0)	100 (0)	0.8 (1.7)
Miller Creek	60.8 (12.9)	77.3 (45.5)	38.9 (30.2)	0 (0)
Des Moines Creek at S 200th	65.0 (25.9)	83.1 (23.6)	58.3 (33.8)	1.1 (2.2)
Des Moines Creek Upstream	53.3 (16.6)	2.4 (4.8)	1.7 (3.3)	0 (0)

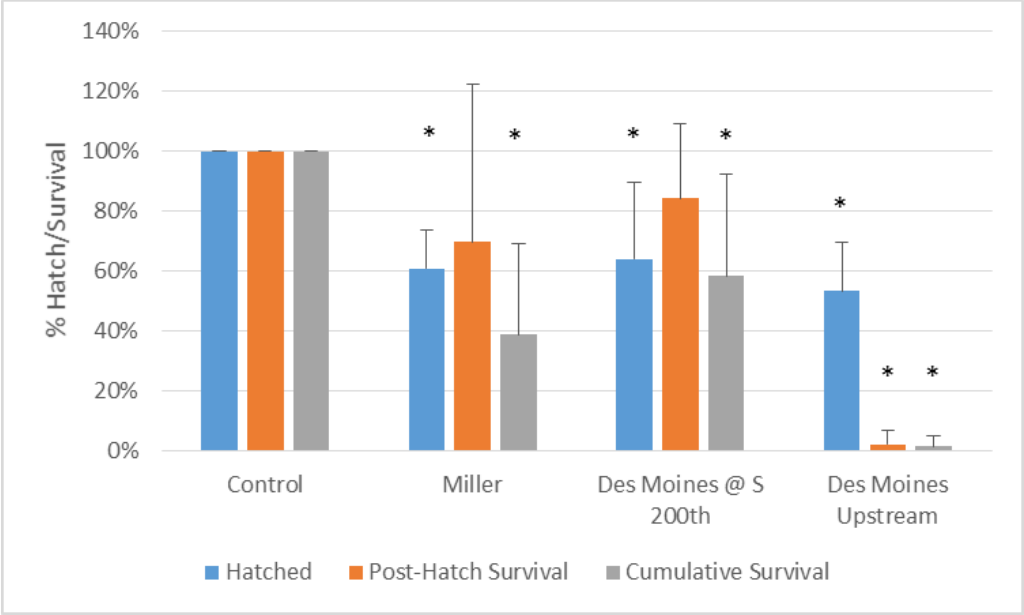
Notes:
1. Results are presented as mean and standard deviation.
2. Shaded values are significantly different from the control.

Table 4: Comparison of growth in the control and field treatment groups (Fall 2014)[1].

Site	Length (mm)	Weight (mg)
Control	23.4 (0.29)	89.7 (1.75)
Miller Creek	22.9 (0.61)	95.8 (2.94)
Des Moines Creek at South 200th	22.8 (0.26)	85.4 (5.42)
Des Moines Creek Upstream	22.0 (NC)	81.0 (NC)

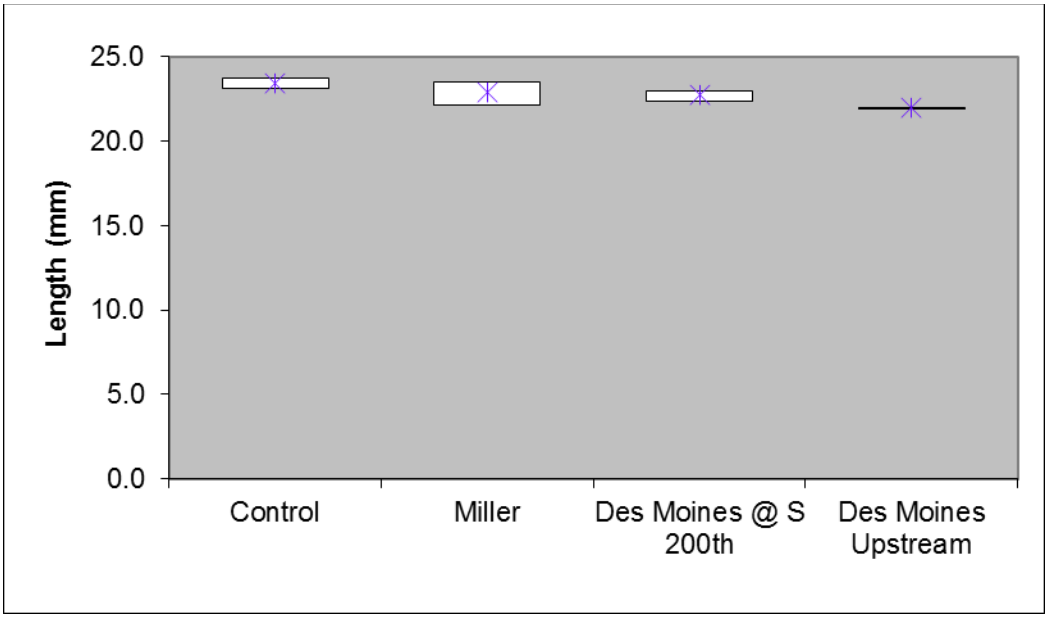
Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control
3. NC – Not calculable as only one replicate survived

Figure 7: Hatching success, post-hatch survival and cumulative survival in the field and control treatment groups (Fall 2014).



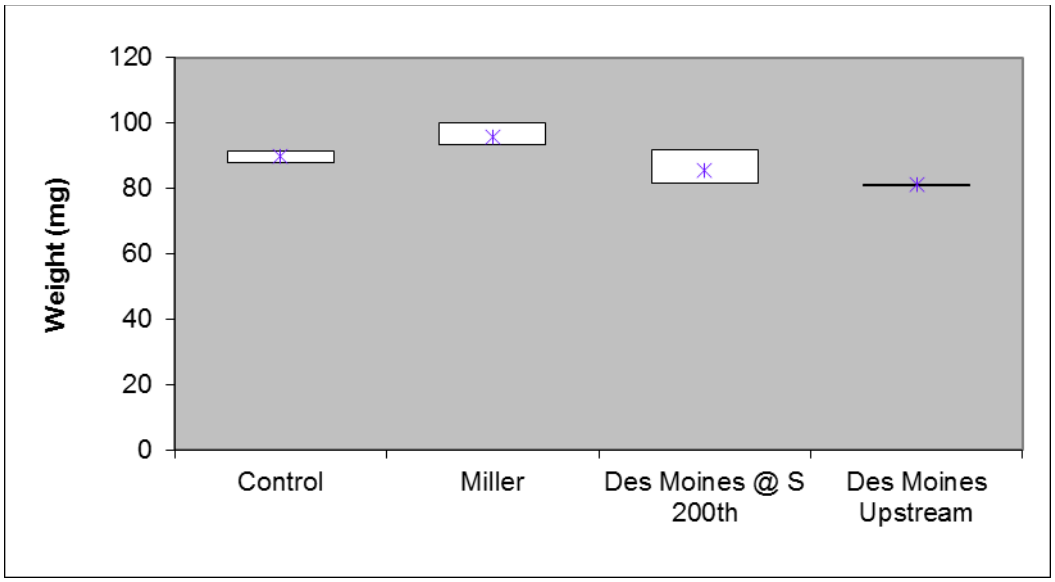
Error bars are standard deviations; asterisks denote significant difference from controls.

Figure 8: Average lengths for the laboratory control and exposure sites (Fall 2014).



Data point is the average; box represents range of minimum to maximum values.

Figure 9: Average weights for the laboratory control and exposure sites (Fall 2014).



Data point is the average; box represents range of minimum to maximum values.

4.3.2 Spring 2015

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 5. Table 6 presents the growth endpoints. These same data are presented graphically in Figures 10 through 12 for ease of comparison.

Hatching success – Mean hatching success for the controls was 98.3%, compared with 98.3% at Miller Creek, 95.0% at Des Moines Creek at S 200th, and 97.5% at Des Moines Creek Upstream. None of these differences were significantly different from the controls.

Post-hatch survival – Control survival of alevins post-hatch was 98.3%, compared with 99.2% at Miller Creek, 94.6% at Des Moines Creek at S 200th, and 94.9% at Des Moines Upstream. None of these differences were significantly different from the controls.

Cumulative survival – Control survival from the initiation of the test to termination averaged 96.6%, compared with 97.5% at Miller Creek, 90.0% at Des Moines Creek at S 200th, and 92.5% at Des Moines Creek Upstream. None of these differences were significantly different from the controls.

Abnormalities -- There were few abnormalities observed in any of the treatments, with just two abnormalities at Miller Creek. Both abnormalities were misshapen spines.

Growth – Average weight in the controls was 162.6 mg, and length averaged 26.6 mm. For comparison, Miller Creek fish averaged 154.1 mg and 26.2 mm, fish exposed at Des Moines Creek at S 200th averaged 153.3 mg and 26.2 mm, and Des Moines Creek Upstream fish averaged 157.2 mg and 26.9 mm, for weight and length, respectively. Weight for all field sites was significantly reduced compared to the controls ($p \leq 0.05$); however, since the effect size was <10%, the p-value was changed to 0.01, per the WDOE guidance document (WDOE 2008), which removed the significance for Des Moines Creek Upstream. Length was only significantly different from the controls at Miller Creek ($p \leq 0.05$); however, the effect size was <10% and changing the p-value removed the significance.

Table 5: Hatching success, survival and abnormality in the control and field treatment groups (Spring 2015)[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	98.3 (3.3)	98.3 (1.9)	96.7 (2.7)	0 (0.0)
Miller Creek	98.3 (1.9)	99.2 (1.7)	97.5 (1.7)	1.7 (3.4)
Des Moines Creek at S 200th	95.0 (5.8)	94.6 (7.0)	90.0 (9.8)	0 (0.0)
Des Moines Upstream	97.5 (1.7)	94.9 (4.4)	92.5 (4.2)	0 (0.0)

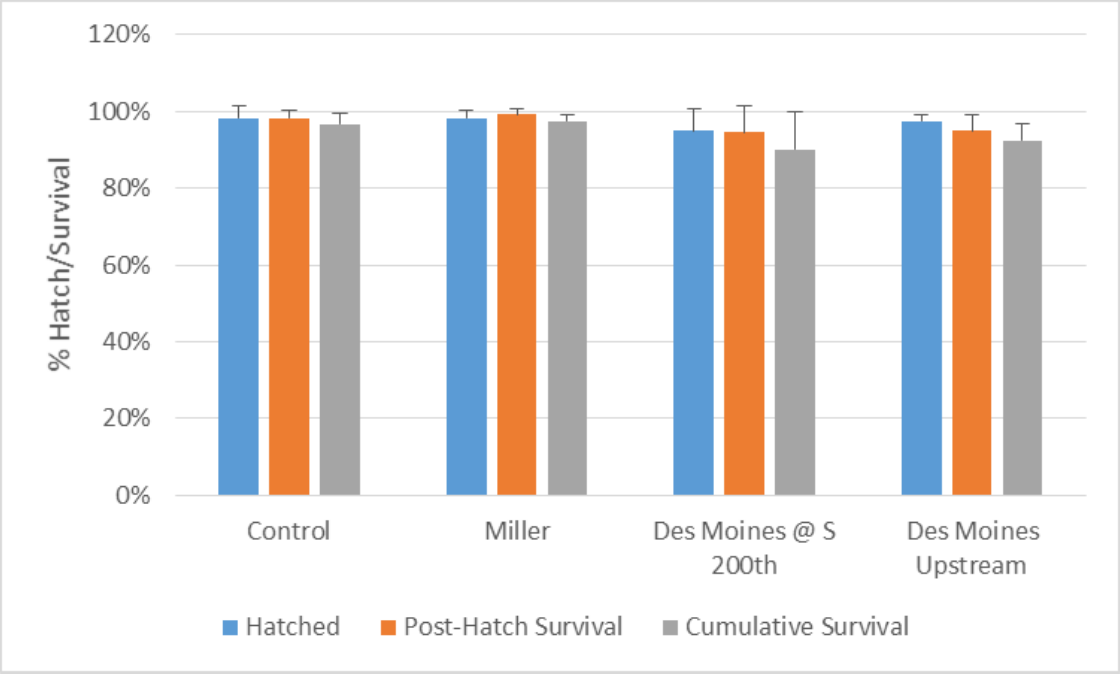
Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly lower than the control

Table 6: Comparison of growth in the control and field treatment groups (Spring 2015)[1].

Site	Length (mm)	Weight (mg)
Control	26.59 (0.26)	162.6 (2.7)
Miller Creek	26.16 (0.39)	154.1 (3.2)
Des Moines Creek at S 200th	26.24 (0.16)	153.3 (1.0)
Des Moines Upstream	26.90 (0.09)	157.2 (3.9)

Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly lower than the control
3. NA- Not applicable

Figure 10: Hatching success, post-hatch survival and cumulative survival in the field and control treatment groups (Spring 2015).



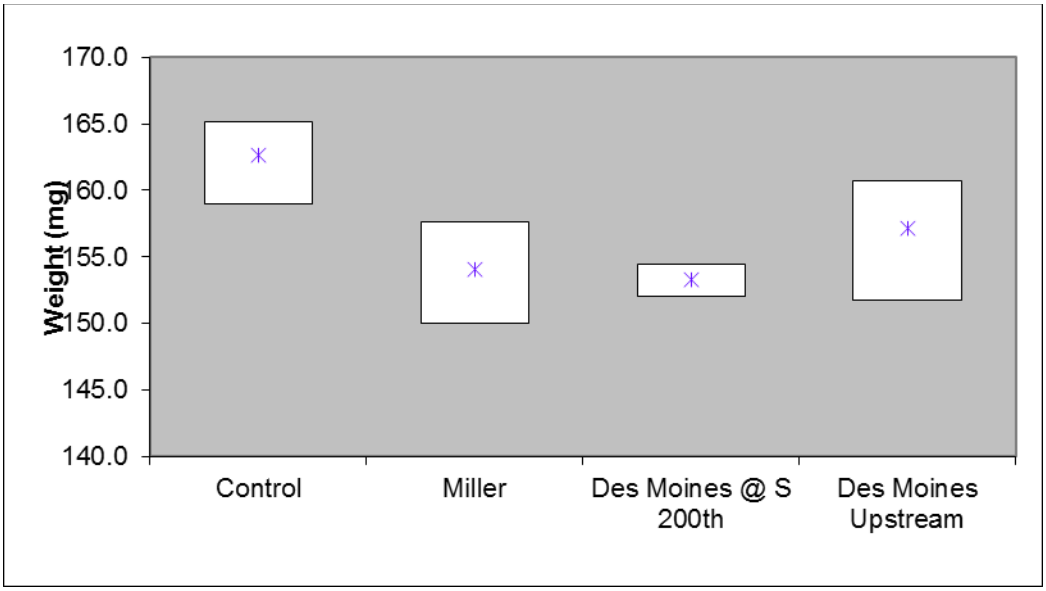
Error bars are standard deviations; asterisks denote significant difference from controls.

Figure 11: Average length for the control and exposure group (Spring 2015).



Data point is the average; box represents range of minimum to maximum values.

Figure 12: Average weights for the control and exposure groups (Spring 2015).



Data point is the average; box represents range of minimum to maximum values.

4.4 Field Observations

During both testing events, hatchboxes were observed to be free of biofilm or other accumulation of organic material. During both events, crayfish were often found within the crates at all sites, but not within the hatchboxes. A tadpole was observed in the Fall at the Miller Creek site. Accumulation of sediments within the hatchboxes was observed during the Fall 2014 event at the Miller Creek site, with sediment volume reaching 80% and greater within the boxes. Effects of sedimentation have shown variable results to date. While high sedimentation has been seen during testing events with significant mortality, other events have shown no effect despite high sedimentation rates. A number of factors likely play a role in the effects of sedimentation, including the size of the particles, the age of the fish, the duration between accumulation and our check, and amount of sediment.

4.5 Relationships Between *In Situ* and Sublethal Tests

Sublethal tests (i.e., 7-day trout embryo tests) overlapped with both the Fall and Spring testing events. There was no toxicity documented in any of the samples collected for the sublethal tests.

5.0 DISCUSSION

In Miller Creek, adverse effects on survival were observed in Fall 2014, with hatching success and cumulative survival significantly reduced compared to the controls. Limited evidence of adverse effects were observed in the hatchboxes deployed at Miller Creek in Spring 2014, with only weight differing from the control and an effect size of <10%.

Adverse effects were observed at Des Moines at S 200th during the Fall and Spring deployment. Hatching success and cumulative survival were significantly reduced compared to the controls in the Fall, compared with only small (<10%) effects on weight observed in the Spring.

Notably, significant adverse effects were observed at the Upstream Des Moines Creek site in Fall 2014, with reduced hatching success, increased mortality and reduced growth, suggesting that effects observed at the downstream site could be related to inputs originating upstream of STIA. Conversely, no adverse effects were observed at Upstream Des Moines Creek during the Spring 2015 event; this is the first time that Des Moines Creek Upstream has not exhibited significant adverse effects since testing at this site began in 2011.

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Rainbow Trout Early Life Stages *In Situ* Monitoring Testing

Fall 2015 and Spring 2016 Testing Events

Draft Report

September 16, 2016

Submitted to: **Port of Seattle**
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SIGNATURE PAGE

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This report has been prepared by Nautilus Environmental Company Inc. based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

1.0 INTRODUCTION

This report presents the results of the rainbow trout (RBT) early life stages (ELS) *in situ* monitoring tests conducted in the Fall 2015 and Spring 2016. The objective of this program is to use salmonid ELS as an *in situ* monitoring tool to assess the quality of receiving waters potentially affected by stormwater discharges from the Seattle-Tacoma International Airport (STIA), as well as a multitude of other discharges from the surrounding urban environment. Results for studies conducted in Fall 2010/Spring 2011, Fall 2011/Spring 2012, Fall 2014/Spring 2013, Fall 2013/Spring 2014, and Fall 2014/Spring 2015 have been presented previously (Nautilus 2011, Nautilus 2012, Nautilus 2013, Nautilus 2014, and Nautilus 2015 respectively).

Results from the *in situ* bioassays and supporting analytical data are intended to provide an indication of attainment of receiving water quality standards and associated beneficial uses related to salmonid spawning and rearing. Initial Phase 1 testing conducted previously demonstrated that the RBT *in situ* ELS bioassay is an effective instream biological monitoring tool for assessing the potential effects of stormwater discharges on the receiving environment.

The sampling events presented herein were conducted under NPDES Permit No. WA-002465-1, which was reissued in January 1, 2016. The Fall 2015 event was conducted under Phase I of the *In Situ* Monitoring Plan (i.e., Development and Demonstration), that was originally intended to last for one year (2010-2011) and include testing during the Spring and Fall seasons. However, this Phase was extended to allow for additional comparisons with the laboratory sublethal testing being conducted by the STIA at sites downstream of Port outfalls, as specified in Part II, Special Condition S8 of the NPDES permit. The laboratory sublethal toxicity testing is used for permit compliance purposes, and has been conducted concurrently with *in situ* deployments (when feasible) to facilitate validation of the in situ methodology. A comparison of the two methods was presented in the Combined Acute, Sublethal, and In Situ Report (Nautilus 2013).

The Spring 2016 event falls under the new Permit and is now required to be conducted biannually in the fall and spring, corresponding to the spawning regimes of local salmonid species. In addition to the locations used during Phase 1 testing, an additional site representing Walker Creek has been added to the sampling program. Details of the location are described in Section 2.2 below.

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2.0 METHODS

Guidance for conducting *in situ* ELS exposures with salmonids is available from a number of sources. For example, the British Columbia Ministry of Environment has a protocol for an *in situ* ELS salmonid test (BCMOE, 2003). In addition, Environment Canada has developed both laboratory and *in situ* test procedures for early life stages of rainbow trout (Environment Canada, 1998). In the U.S., there are two general laboratory protocols for conducting fish early life stage toxicity tests (EPA, 1996; ASTM, 2005). The procedures used in this study reflect refinements made to the general guidance provided in the documents above (Chalmers et al, 2014), and have been used successfully at a number of sites in both Canada and the United States. Additional refinements specific to applying the method to waterways present on Airport property are included in the descriptions below.

2.1 Design

The study design used for the Fall 2015 and Spring 2016 *in situ* testing involved exposure of eyed-embryos at four sampling sites, using four replicates per site with 30 embryos per replicate. The locations of the sites are shown in Figure 1. The Study Design was consistent with the methodology used in the nine previous monitoring events in which the sites located on Miller and Des Moines Creeks downstream of all Airport discharges were augmented by an additional site on Des Moines Creek located upstream of any Airport discharges. The additional site (i.e., Des Moines Creek Upstream) was included to determine the extent to which sources upstream of any STIA inputs may contribute to adverse effects observed at the downstream site on Des Moines Creek. New in 2016 is a site located in the headwaters of Walker Creek.

The exposure duration used in the *in situ* tests covers the major salmonid early life stage developmental milestones, beginning with the eyed egg stage, proceeding through hatching and alevin stages (yolk sac present and residing in the gravel), and ending with the early fry stage (also known as swim-up fry). At this point, the yolk sac is absorbed and, under natural conditions, the fish would leave the gravel to feed independently. The duration of the exposure period is expected to include multiple rain/runoff events, and corresponding fluctuations in flow, contaminant concentrations, temperature, water chemistry, etc. Collectively, these attributes of the in situ approach provide highly relevant information regarding the suitability of waterbodies to support salmonids (Chalmers et al, 2014).

The eyed eggs for both in situ events were supplied locally by TroutLodge (Sumner, WA), which also supplied RBT eggs and sperm for the laboratory sublethal toxicity tests required in STIA's expired NPDES stormwater permit. The status of the *in situ* organisms was routinely monitored

during the exposure, as well as at specific developmental stages and after significant storm events. Data were obtained on hatching, survival, development and growth. A subset of embryos was also reared in the laboratory to assess organism quality. Weekly temperature measurements from the field were used to adjust rearing temperatures for the laboratory controls so that development in the controls could be used to trigger field inspections at specific times (e.g., hatch, swim-up).

2.2 Monitoring Locations and Site Preparation

The Fall 2015 exposures were conducted in two streams within the STIA property boundaries: Miller Creek and Des Moines Creek (Figure 1). Two of the sites, Miller Creek and Des Moines Creek at S 200th, are located downstream of STIA inputs into their respective drainages. An additional site (Des Moines Creek Upstream) is located upstream of STIA stormwater outfalls into Des Moines Creek. This site is used to assess water quality in Des Moines Creek prior to receiving any STIA stormwater discharges; the Des Moines Creek basin upstream of STIA is heavily urbanized and potentially impacted by a variety of pollutant sources. For Spring 2016, a site in the headwaters of Walker Creek was added in addition to the three sites above. INSERT LOCATION info from Josh.

Results from 2010 concluded that the chosen sampling sites generally do not have ideal substrate conditions and are subjected to heavy sediment flow during storm events. Consequently, all four exposure replicates at each site were placed above the substrate in gravel contained within PVC crates anchored to the substrate with steel stakes. The replicate crates at each site were placed in a row on the streambed, from upstream to downstream, at a sufficient distance apart so that flow patterns were re-established between each crate. This approach allows passage of water through the exposure chambers, but prevents smothering of embryos and fry by sediment. This approach was also applied to the new Walker Creek site, as it also lacks appropriate substrate conditions.

Figure 1. Map of STIA with receiving monitoring stations.

2.3 Field Exposure Apparatus

The trout embryos were contained in modified Whitlock-Vibert hatchboxes (Federation of Flyfishers, MO), which are comprised of two rectangular chambers located one above the other; the upper chamber is for embryo development and the lower chamber for rearing of hatched fish. The external sides of the hatchbox are plastic mesh that allows passage of water through the box, but prevents loss of embryos. The divider between the embryo chamber and the rearing chamber is comprised of slots that are narrow enough to prevent transfer of unhatched embryos, but wide enough to permit migration of hatched fish into the lower rearing chamber. Thus, upon hatch, alevins are able to migrate through the slots from the embryo chamber into the larger rearing chamber. To prevent escape of the hatched fry into the streams upon swim-up, plastic screening material (Darice® size 7 mesh) was attached to the external faces of each rearing chamber and held in place using small plastic zip ties.

The hatchboxes were contained within flexible plastic mesh bags surrounded by 1 – 2 inch diameter gravel, with the hatchbox placed centrally within the rocks in the bag. The gravel surrounding the hatchboxes acts to diffuse the current and prevent exposure of the embryos to sunlight. The bags were then placed within the PVC crates, which were held in place in the stream by stakes anchored in the substrate (Figure 2). Figure 3 shows the eyed eggs within the hatchbox, while Figure 4 is of fry within the hatchbox.

Figure 2. Photograph of the crate set up, Des Moines Creek at S 200th.



2.4 Test Organisms

Eyed-egg stage rainbow trout embryos were obtained from TroutLodge on November 4, 2015 for the Fall event and March 23, 2016 for the Spring event. According to TroutLodge staff, the eyed embryos had already developed for approximately 245 degree-days[1]. On the day of test initiation, eggs were brought to Rainier Environmental Laboratory (REL; Fife, WA), and randomly counted into replicate units of 30 embryos apiece in individual opaque plastic food-storage containers (i.e., 450-mL Ziploc plastic tubs). These containers were then placed in a cooler containing ice packs, and transported to the sites where the embryos were transferred into the hatchboxes in the creek on the same day. The embryos were transferred to the sites in laboratory control water, and all embryos were installed at the sites between 13:30 and 14:30 on November 4, 2015 for the Fall event, and between 15:15 and 17:00 on March 23, 2016 for the Spring event.

2.5 Controls

Controls were used to assess the influence of the following factors on test results:

1. Quality (health and viability) of supplied organisms,
2. Transport and handling of organisms, and
3. Ambient stream temperatures, which affect the time to developmental milestones (e.g., hatch).

The controls consisted of a laboratory exposure (four replicates of 30 organisms each) conducted concurrently with each field exposure in clean laboratory water (moderately hard synthetic water [MHSW]) using a subset of the same batch of embryos used to initiate the field exposures. These embryos were also counted out, placed into individual plastic containers filled with MHSW and transported to the sites with the other replicates; thus, they also served as transport controls. Upon returning to the laboratory after deployment of all field organisms, the control replicates were transferred to 4-L plastic containers in the laboratory containing 2 liters of MHSW at the average site water temperature, ±1°C. The control chambers are held in the dark, and gentle aeration was applied (100-200 bubbles per minute). The controls were monitored daily for

[1] Degree-days are used to standardize descriptions of fish development, regardless of rearing temperature. For example, it takes rainbow trout approximately 340 degree-days to reach hatch (Quinn, 2005). Thus, at 8°C, it takes approximately 42 days to reach hatch.

mortalities, and dead organisms removed. Temperature was adjusted on a weekly basis, as needed, to correspond to temperatures measured in the field. Water renewals were conducted three times per week (Monday, Wednesday, Friday) using fresh MHSW. Dissolved oxygen (DO), pH, conductivity and temperature were measured before and after water renewals. Developmental milestones (e.g., hatch and swim-up) were also recorded.

2.6 Monitoring of Field Exposures

The sites were visited at approximately weekly intervals to assess the condition of the test organisms. During these checks, survival was recorded, as well as qualitative observations of organism health, site conditions and sedimentation within the boxes. All dead organisms observed were removed on each visit. These observations were recorded on standard field data sheets included in Appendix A. In addition, temperature, pH, DO and conductivity were measured during the site visits.

Monitoring of the installations required removal of the substrate overlying the hatchboxes in the crates. The embryos or alevins in each hatchbox were then poured into a plastic dishpan containing site water where they were enumerated. They were then returned to the hatchbox, which was placed back into the mesh-net bag of gravel, the overlying gravel replaced, and the bag returned to its respective crate. Care was taken to minimize disturbance and damage to the test organisms.

2.7 Test Termination

The field exposures and laboratory controls were terminated when the field organisms reached the swim-up fry stage (i.e., yolk sac absorbed). This occurred on December 16, 2015 for the Fall exposure, and on April 19, 2016 for the Spring exposure. Surviving organisms were placed in their original plastic replicate containers filled with site water, transported back to the laboratory, and terminated. The fish were then wet-weighed (to the nearest 0.001 gram) on an analytical balance, and measured (total length, from tip of the snout to the end of the tail) to the nearest 0.5 mm. Obvious external malformations were noted, including the affected body part (e.g., head, eye, spine) and type of abnormality (e.g., edema). Abnormality data were recorded on standard data sheets (Appendix A). The laboratory control fish were evaluated similarly on the same day.

2.8 Data Analysis

All test data were entered in CETIS (Comprehensive Environmental Toxicity Information System, Tidepool Scientific, McKinleyville, CA). Differences among the exposure sites and laboratory

controls were evaluated using pair-wise multiple comparison tests according to the USEPA flow chart (USEPA 2002); significant differences were identified at $p \leq 0.05$.

One interim and five terminal endpoints were evaluated; the endpoints are described below:

1. Hatching success – an interim measure of the percentage of embryos hatched the day of the hatch inspection, or determined to have hatched based on the number of alevins present at the subsequent inspection, relative to the total number of embryos originally added;
2. Post-hatch survival - the percentage of organisms surviving at test termination relative to the number of embryos that hatched (these data help determine whether the majority of mortalities occurred pre- or post-hatch, or were distributed throughout the exposure period);
3. Cumulative survival - the percentage of surviving organisms at test termination relative to the number of embryos in each replicate at the beginning of the exposure;
4. Abnormality – the percentage of abnormal organisms at test termination relative to the number of surviving organisms;
5. Length – to the nearest 0.5 mm;
6. Weight – to the nearest 0.001 g.

3.0 QA/QC

The QA/QC program for the field exposure involved the following:

- Consistent field staff leader throughout all visits;
- Field documentation of all primary data; i.e., the names of individuals collecting the samples, sampling location, time of sampling, site conditions (e.g., degree of sedimentation), and other relevant observations, such as weather and any unusual conditions;
- Calibrated field meters;
- Use of pre-cleaned containers, with appropriate labels;
- Storing and transporting organisms in sealed containers in a cold, dark environment; cooling sample containers using ice or gel packs;
- Including transport controls to ascertain the extent of any transport-induced stress;
- Checking field organisms every week to monitor developmental progress, mortality and abnormality.

The QA/QC program for the laboratory portion of the study involved:

- Checks and maintenance of control organisms at regular intervals, including recording primary observations and water quality data on standardized data sheets;
- Review of datasheets by senior laboratory staff;
- Test termination activities (measurements, health assessment) conducted by qualified staff members using standardized datasheets to ensure consistent assessment of abnormalities and growth across all test sites and controls;

Use of standard laboratory water and environmental chambers to maintain test organisms.

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4.0 RESULTS

4.1 Water Quality Measurements

Water quality measurements are summarized in Tables 1 and 2 for the Fall 2015 and Spring 2016 monitoring events, respectively.

Table 1. Summary of water quality measurements collected during site visits and control renewals (Fall 2015).

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	8.1 (2.4)	9.4 (0.5)	7.48 (0.22)	256.0(23.91)
	[Min-Max]	[4.8 – 11.5]	[8.4 – 10.1]	[7.12 – 8.03]	[212 - 322]
Miller Creek		7.5 (2.1)	11.4 (0.6)	7.18 (0.18)	160.5 (20.7)
		[4.7 – 9.8]	[10.5 -12.1]	[6.98 – 7.48]	[135 - 191]
Des Moines Creek at S 200th		7.8 (2.3)	9.3 (0.8)	6.82 (0.12)	148.5 (26.7)
		[5.4 – 10.5]	[7.7 – 9.8]	[6.68 – 7.04]	[106 - 174]
Des Moines Creek Upstream		7.5 (2.1)	10.2 (0.9)	6.43 (0.44)	96.7 (10.2)
		[5.0 – 11.8]	[8.8 – 11.2]	[5.81 – 6.96]	[80 - 111]

Table 2. Summary of water quality measurements collected during site visits and control renewals (Spring 2016).

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	11.1 (0.3)	9.3 (0.4)	7.53 (0.28)	269.0 (26.1)
	[Min-Max]	[10.7 – 11.8]	[8.7 – 10.2]	[7.05 – 8.01]	[211 – 299]
Miller Creek		11.3 (1.9)	10.9 (0.7)	7.58 (0.16)	225.4 (45.6)
		[8.7 – 13.7]	[9.9 – 11.6]	[7.44 – 7.85]	[178 – 271]
Walker Creek		11.8 (0.4)	10.7 (0.2)	6.93 (0.13)	268.8 (14.2)
		[11.4 – 12.3]	[10.5 – 10.9]	[6.75 – 7.06]	[248 – 280]
Des Moines Creek at S 200th		12.0 (1.7)	9.4 (0.4)	6.89 (0.15)	199.8 (33.8)
		[10.2 – 14.3]	[9.1 – 10.1]	[6.63 – 7.00]	[158 – 238]
Des Moines Creek Upstream		11.7 (1.8)	10.0 (0.6)	6.85 (0.17)	105.7 (11.5)
		[10.5 – 13.8]	[9.4 – 10.5]	[6.67 – 7.01)	[99 – 119]

In the Fall 2015, temperatures for the three field sites and the control ranged from 4.7 to 11.8^{0}C. Almost all field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays (60-100% saturation, and 6-9 pH units, respectively). One check at Des Moines Creek Upstream measured a pH of 5.81, which was confirmed by calibration recheck upon returning to the stormwater laboratory. All other pH values were between 6.68 and 8.03, and DO ranged from 7.7 to 12.1 mg/L. Although limited to weekly measurements, the field DO and pH data suggested overall good water quality conditions, with limited indication of potential for adverse effects on organism survival and development. The conductivity measurements for all three sites exhibited some variability throughout the exposure period, but the values remained well-within ranges tolerated by early life stages of salmonids.

In the Spring 2016 *in situ* tests, temperatures among the three field sites and the control ranged from 8.7 to 14.3^{0}C. The field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays; specifically, the pH values were between 6.63 and 8.01, and DO ranged from 8.7 to 11.6 mg/L. These data suggested good water quality conditions, with no indication of potential for adverse effects on organism survival and development. As observed in the Fall event, the conductivity measurements remained well-within ranges tolerated by early life stages of salmonids.

4.2 Precipitation during the Monitoring Events

Precipitation data were provided by STIA. Figure 5 shows the daily rainfall for the duration of the exposure for the Fall 2015 test. A total of 13.06 inches of total rainfall fell during the Fall event. There was no snow during this testing event. Figure 6 shows the daily rainfall for the duration of the Spring 2016 exposure. Much less rain (total 1.1 in) fell during this event compared with the Fall, and no snow occurred during the exposure period.

Figure 5. Daily rainfall for the duration of Fall 2015 exposure.

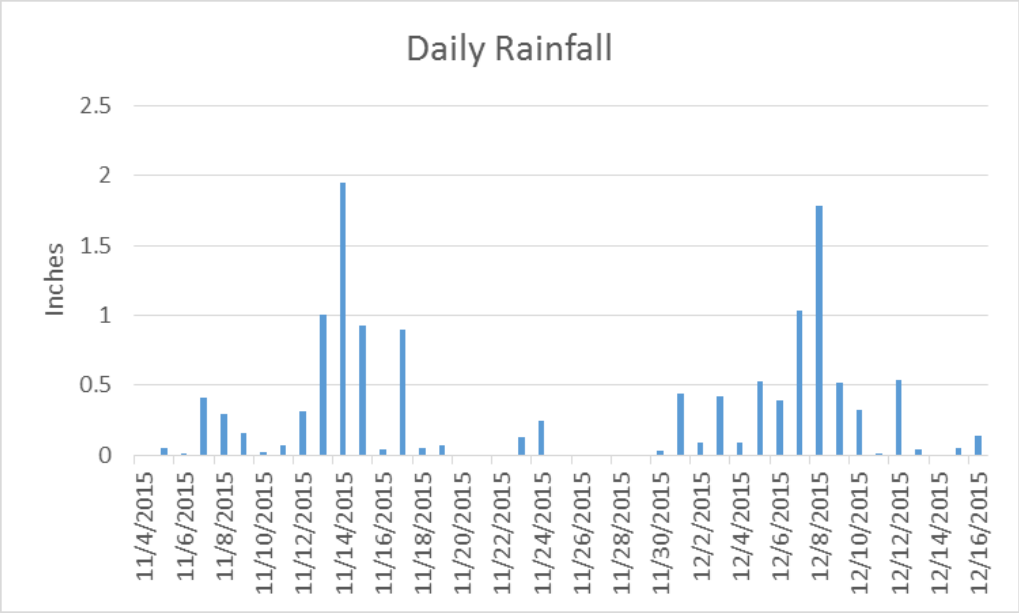
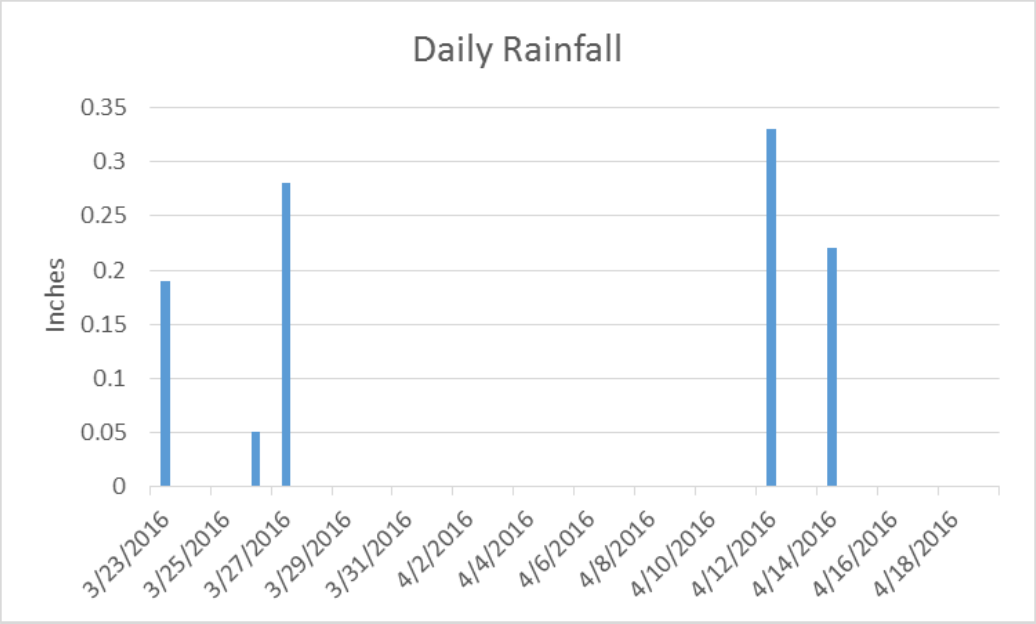


Figure 6. Daily rainfall for the duration of the Spring 2016 exposure.



4.3 *In situ* exposures

4.3.1 Fall 2015

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 3. Table 4 presents the growth endpoints. These same data are presented graphically in Figures 7 through 9 to facilitate comparisons.

Hatching success – Mean hatching success for the laboratory controls was 99.2%, compared with 100% at Miller Creek, 98.3% at Des Moines Creek at S 200th, and 72.5% at Des Moines Creek Upstream. Hatching success was significantly reduced (Steel Many-One Rank Sum Test) relative to the controls at the Des Moines Creek Upstream site, and there were no differences in hatching success between the controls and Miller Creek or Des Moines Creek at S 200th.

Post-hatch survival – Control survival of alevins post-hatch was 98.3%, compared with 96.7% at Miller Creek, 72.5% at Des Moines Creek at S 200th, and 33.1% Des Moines Creek Upstream. Post-hatch survival at Des Moines Creek Upstream was significantly different (Steel Many-One Rank Sum Test) from the controls; however, there were no differences in post-hatch survival between the controls, Miller Creek and Des Moines Creek at S 200th.

Cumulative survival – Control survival from the initiation of the test to termination averaged 97.5%. For comparison, cumulative survival at the exposure sites averaged 96.7% at Miller Creek, 71.7% at Des Moines Creek at S 200th, and 28.3% at the Des Moines Creek Upstream site. Survival was significantly reduced (Steel Many-One Rank Sum Test) relative to the controls at the Des Moines Creek Upstream site, and there were no differences in survival between the controls and Miller Creek or Des Moines Creek at S 200th.

Abnormalities – There were few abnormalities observed across all treatments, with just two in the controls. Both control fish had edema.

Growth – Average weight in the controls was 141.4 mg, and length averaged 26.4 mm. For comparison, Miller Creek fish averaged 140.0 mg and 25.6 mm, fish exposed at Des Moines Creek at S 200th averaged 138.7 mg and 25.7 mm, and Des Moines Creek Upstream fish averaged 127.0 mg and 25.0 mm, for weight and length, respectively. While length was significantly different (Bonferroni Adjusted T test) between the field sites and the controls for all locations, the largest difference was only 5%. The WDOE guidance document (WDOE 2016) allows alpha to be changed to 0.01 in cases of small differences, which removed the significance for Des Moines Creek at S 200th, but not for Miller Creek or Des Moines Creek Upstream. The Des Moines Creek Upstream site was the only site significantly different (Bonferroni Adjusted T test) from the control for weight, with a 10% effect.

Table 3. Results for hatching success, survival, and abnormality in the control and field treatment groups (Fall 2015)[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	99.2 (1.7)	98.3 (1.9)	97.5 (1.7)	1.7 (3.4)
Miller Creek	100 (0)	96.7 (4.7)	96.7 (4.7)	0 (0)
Des Moines Creek at S 200th	98.3 (1.9)	72.5 (37.5)	71.7 (37.6)	0 (0)
Des Moines Creek Upstream	72.5 (21.8)	33.1 (42.3)	28.3 (36.6)	0 (0)

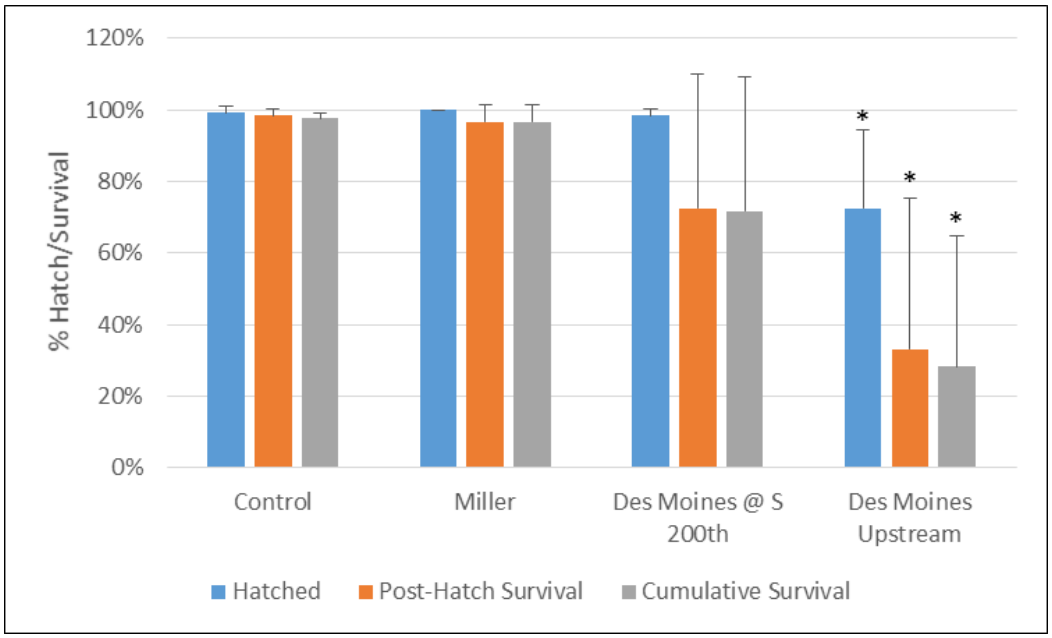
Notes:
1. Results are presented as mean and standard deviation.
2. Shaded values are significantly different from the control.

Table 4. Comparison of growth in the control and field treatment groups (Fall 2015)[1].

Site	Length (mm)	Weight (mg)
Control	26.4 (0.41)	141.4 (1.69)
Miller Creek	25.6 (0.28)	140.0 (1.86)
Des Moines Creek at South 200th	25.7 (0.26)	138.7 (8.27)
Des Moines Creek Upstream	25.0 (0.28)	127.0 (0.82)

Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control

Figure 7. Hatching success, post-hatch survival, and cumulative survival in the field and control treatment groups (Fall 2015).



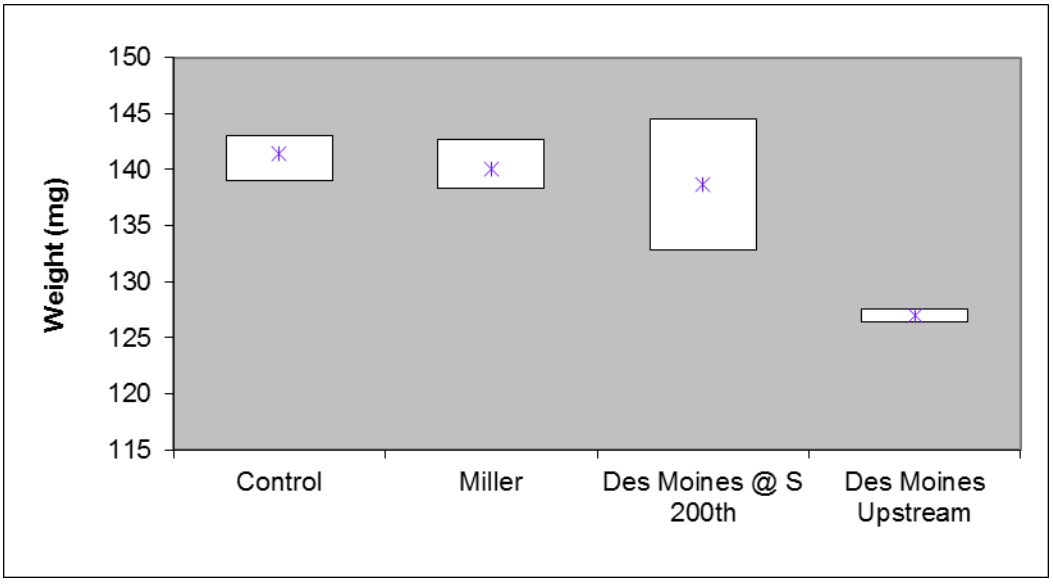
Error bars are standard deviations; asterisks denote significant difference from control.

Figure 8. Average lengths for the laboratory control and exposure sites (Fall 2015).



Data point is the average; box represents range of minimum to maximum values.

Figure 9. Average weights for the laboratory control and exposure site (Fall 2015).



Data point is the average; box represents range of minimum to maximum values.

4.3.2 Spring 2016

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 5. Table 6 presents the growth endpoints. These same data are also presented graphically in Figures 10 through 12.

Hatching success – Mean hatching success for the controls was 100%, compared with 96.7% at Miller Creek, 89.2% at Walker Creek, 96.7% at Des Moines Creek at S 200th, and 21.7% at Des Moines Creek Upstream. Both Walker Creek and Des Moines Creek Upstream were significantly different (Dunnett Multiple Comparison Test) from the controls, while Miller Creek and Des Moines at S 200th were not. Changing alpha for the small difference in effect does not remove the significance.

Post-hatch survival – Control survival of alevins post-hatch was 96.7%, compared with 98.2% at Miller Creek, 100% at Walker Creek, 98.2% at Des Moines Creek at S 200th, and 0% at Des Moines Upstream. Only Des Moines Creek Upstream was significantly different (Steel Many-One Rank Sum Test) from controls.

Cumulative survival – Control survival from the initiation of the test to termination averaged 96.7%, compared with 95.0% at Miller Creek, 89.2% at Walker Creek, 94.2% at Des Moines Creek at S 200th, and 0% at Des Moines Creek Upstream. Both Walker Creek and Des Moines Creek Upstream were significantly different (Dunnett Multiple Comparison Test) from controls. However, since the effect size was <10% at Walker Creek, and changing alpha removed the significance.

Abnormalities -- There were few abnormalities observed in any of the treatments, with one control abnormality, and two abnormalities at Miller Creek. Both abnormalities at Miller Creek were misshapen heads, while the control fish exhibited edema.

Growth – Average weight in the controls was 113.4 mg, and length averaged 25.2 mm. For comparison, Miller Creek fish averaged 115.0 mg and 25.1 mm, fish at Walker Creek averaged 115.9 mg and 25.6 mm, fish exposed at Des Moines Creek at S 200th averaged 115.5 mg and 25.3 mm. The lack of surviving fish at Des Moines Creek Upstream precluded growth assessments for this site. Neither weight nor length was significantly different (Dunnett Multiple Comparison Test) from controls in the sites with surviving fish.

Table 5. Hatching success, survival and abnormality in the control and field treatment groups (Spring 2016)[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	100 (0)	96.7 (2.7)	96.7 (2.7)	0.8 (1.7)
Miller Creek	96.7 (2.7)	98.2 (2.0)	95.0 (4.3)	1.8 (2.1)
Walker Creek	89.2 (4.2)	100 (0)	89.2 (4.2)	0 (0)
Des Moines Creek at S 200th	96.7 (4.7)	96.7 (4.7)	94.2 (5.7)	0 (0)
Des Moines Upstream	21.7 (11.4)	0 (0)	0 (0)	NC

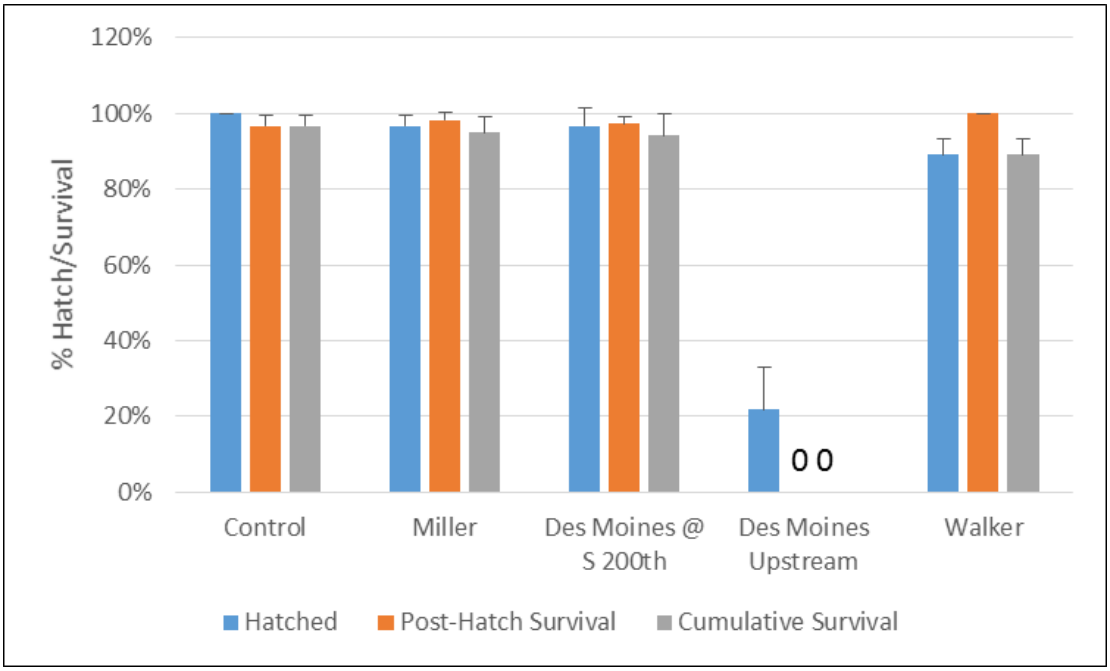
Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly lower than the control
3. NC – not calculable as there was no survival

Table 6. Comparison of growth in the control and field treatment groups (Spring 2016)[1].

Site	Length (mm)	Weight (mg)
Control	25.15 (0.26)	113.4 (3.1)
Miller Creek	25.11 (0.39)	115.0 (1.5)
Walker Creek	25.60 (0.14)	115.9 (2.5)
Des Moines Creek at S 200th	25.32 (0.46)	115.5 (4.8)
Des Moines Upstream	NC	NC

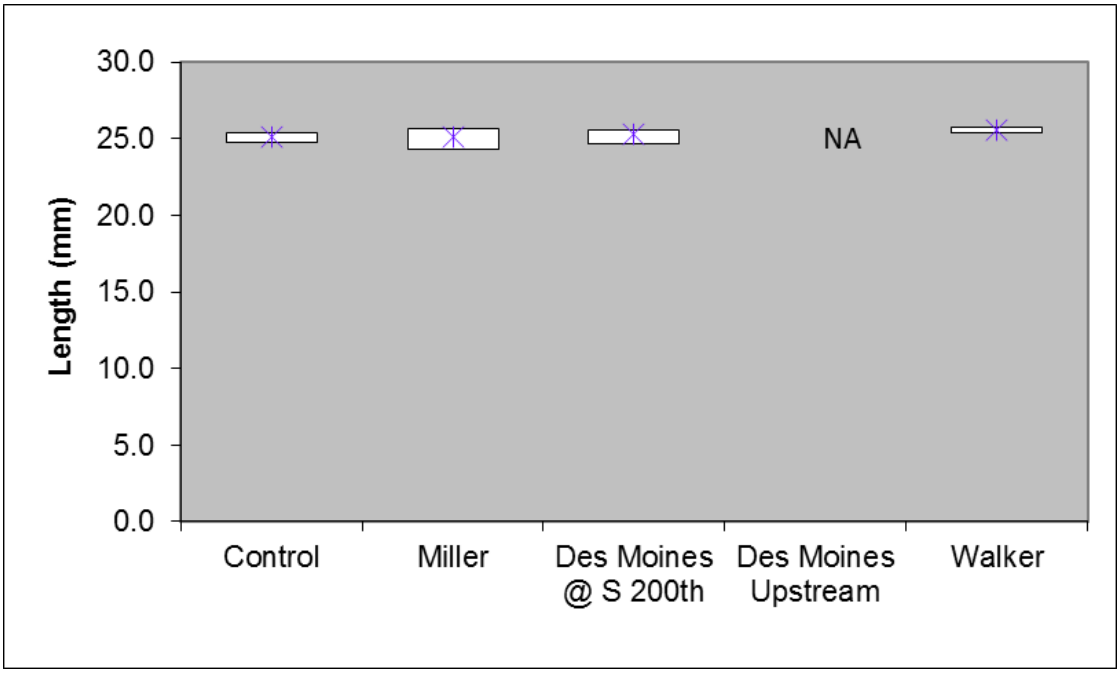
Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly lower than the control
3. NC – Not calculable, as there was no survival

Figure 10. Hatching success, post-hatch survival, and cumulative survival in the field and control treatment groups (Spring 2016).



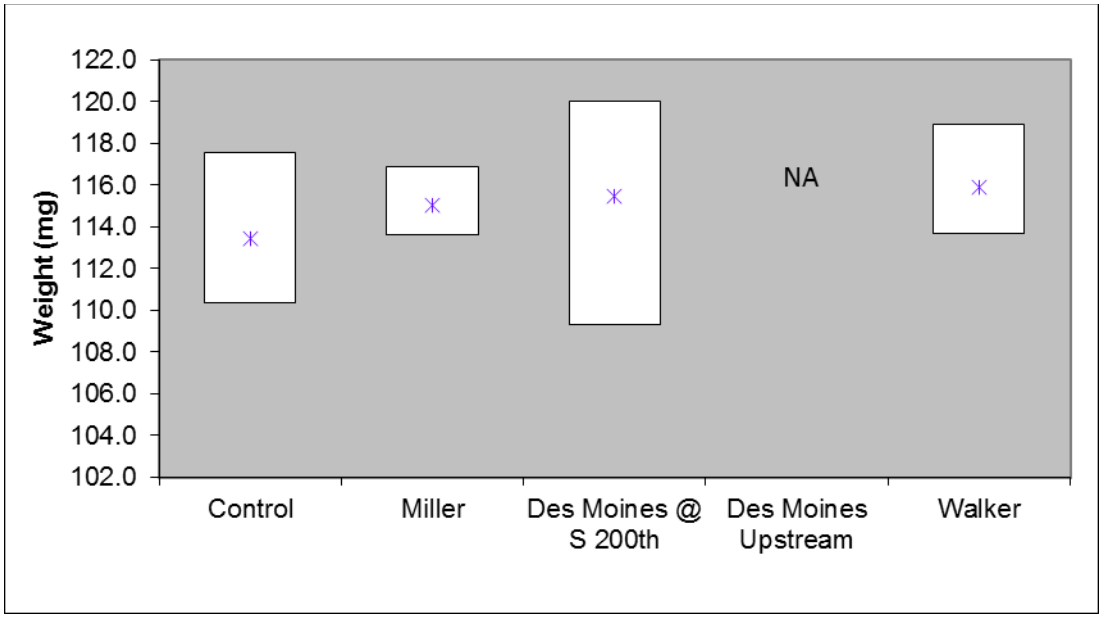
Error bars are standard deviations; asterisks denote significant differences from control.

Figure 11. Average length for the controls and exposure group (Spring 2016).



Data point is the average; box represents range of minimum to maximum values; NA – not applicable as there were not surviving fish.

Figure 12. Average weight for the control and exposure groups (Spring 2016).



Data point is the average; box represents range of minimum to maximum values; NA – not applicable as there were no surviving fish.

4.4 Field Observations

Towards the end of the Fall event, biofilm was observed on crates and hatchboxes at Des Moines at S 200th, and some at Des Moines Upstream. There did not appear to be a link between the occurrence of biofilm and the onset of mortality. During both events, crayfish were often found within the crates at all sites, but not within the hatchboxes. Accumulation of sediments within the hatchboxes was observed during the Fall 2015 event at all three sites, with sediment volume reaching 80% and greater within the boxes. Effects of sedimentation have shown variable results to date. While high sedimentation has been seen during testing events with significant mortality, other events have shown no effect despite high sedimentation rates. A number of factors likely play a role in the effects of sedimentation, including the size of the particles, the age of the fish, the duration between accumulation and our check, as well as the amount of sediment. There were no notable field observations for the Spring event.

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5.0 DISCUSSION

There were limited adverse effects observed at Miller Creek and Des Moines Creek at S 200th compared with controls in both testing events. Only length during the Fall 2015 event was significantly different ($p \leq 0.01$) with reductions in length of less than 5% relative to controls.

The addition of Walker Creek in the Spring 2016 event went smoothly. The only adverse effect observed was on hatching success, which was significantly different but only a 10% effect relative to controls.

Notably, significant adverse effects were observed at the Upstream Des Moines Creek site during both testing events, with reduced hatching success, increased mortality and reduced growth. With the exception of the Spring 2015 testing event (Nautilus Environmental 2015), this site has consistently exhibited evidence of adverse effects, suggesting an ongoing pattern of impaired water quality.

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Rainbow Trout Early Life Stages *In Situ* Monitoring Testing

Fall 2020 and Spring 2021

Final Report

September 23, 2021

Submitted to: **Port of Seattle**
Seattle-Tacoma International Airport

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SIGNATURE PAGE



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This report has been prepared by Nautilus Environmental Company Inc. based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

EXECUTIVE SUMMARY

The Port of Seattle monitors the potential effects of stormwater discharges from the Seattle-Tacoma International Airport (STIA) on the receiving environment as part of their National Pollutant Discharge Elimination System (NPDES) permit, which requires that *in situ* rainbow trout (RBT) early-life stage (ELS) tests be conducted biannually in the fall and spring. The testing program was initiated in Fall 2010; exposure sites include Miller Creek, Des Moines Creek Lower and Des Moines Creek Upstream, with Walker Creek being added to the study beginning Spring 2016. The creeks flow through STIA property boundaries, with monitoring points generally located downstream of STIA inputs; however, one site (Des Moines Creek Upstream) is located upstream of STIA stormwater outfalls to monitor for potential impacts originating upstream of Airport property. Results are compared to a laboratory control conducted concurrently with the *in-situ* tests.

During the Fall 2020 event, post-hatch and cumulative survival were both significantly reduced at all sites compared to the laboratory control, with the exception of Walker Creek. Des Moines Creek Upstream also had reduced hatching rates. During the Spring 2021 event, cumulative survival was significantly reduced at all sites except Walker Creek compared to the laboratory control; the hatching success was also significantly reduced at Miller Creek and Des Moines Creek Upstream; and the post-hatch success was significantly reduced at both Des Moines Creek Lower and Upstream. In terms of sublethal effects, adverse effects on length and weights were observed at Miller Creek and Des Moines Creek Lower during the Fall event; no adverse effects on growth were observed at any of the sites during the Spring event. Developmental abnormalities were minimal across all sites and controls during both events (i.e., ≤ 5%). Of note, with the exception of Spring 2015, Spring 2018 and Spring 2020 testing events, Des Moines Creek Upstream has historically exhibited adverse effects since the testing program began in 2010, which may be related to results observed further downstream at Des Moines Lower. Thus, inputs upstream of the STIA boundaries could be impairing water quality in the Des Moines Creek basin.

1.0 INTRODUCTION

This report presents the results of the rainbow trout (RBT) early life stages (ELS) *in situ* monitoring tests conducted in the Fall of 2020 and Spring of 2021. The objective of this program is to use salmonid ELS as an *in situ* monitoring tool to assess the quality of receiving waters potentially affected by stormwater discharges from the Seattle-Tacoma International Airport (STIA), as well as a multitude of other potential sources from the surrounding urban environment. Results for studies conducted in Fall 2010/Spring 2011, Fall 2011/Spring 2012, Fall 2012/Spring 2013, Fall 2013/Spring 2014, Fall 2014/Spring 2015, Fall 2015/Spring 2016, Fall 2016/Spring 2017, Fall 2017/Spring 2018, Fall 2018/Spring 2019, and Fall 2019/Spring 2020 have been presented previously (Nautilus Environmental 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019 and 2020, respectively), and have demonstrated that the RBT *in situ* ELS bioassay is an effective biological monitoring tool for assessing the potential effects of stormwater discharges on the receiving environment.

The sampling events presented herein were conducted under NPDES Permit No. WA-002465-1, which requires that *in situ* tests be conducted biannually in the fall and spring, corresponding to the spawning regimes of local salmonid species. Details of the locations tested are described in Section 2.2 below.

2.0 METHODS

Guidance for conducting *in situ* ELS exposures with salmonids is available from a number of sources. The British Columbia Ministry of Environment has a protocol for an *in situ* ELS salmonid test (BCMOE, 2003), and Environment Canada has developed laboratory test procedures for early life stages of rainbow trout (Environment Canada, 1998). In the USA, there are two general laboratory protocols for conducting fish early life stage toxicity tests (EPA, 1996; ASTM, 2005). The procedures used in this study reflect refinements made to the general guidance provided in the documents above (Chalmers et al., 2014), and have been used successfully at a number of sites in both Canada and the USA. Additional refinements specific to applying the method to waterways present on Airport property are included in the descriptions below.

2.1 Design

The study design used for the Fall 2020 and Spring 2021 *in situ* testing involved exposure of eyed-stage embryos at four sampling sites, using four replicates per site with 30 embryos per replicate. The locations of the sites are shown in Figure 1. The original sites were located on Miller and Des Moines Creeks downstream of all Airport discharges, and were subsequently augmented by an additional site on Des Moines Creek located upstream of any Airport discharges to determine the extent to which sources upstream of STIA inputs may contribute to adverse effects observed at the downstream site on Des Moines Creek. A site located in Walker Creek was also included in the study design beginning with the Spring 2016 testing event.

The exposure duration used in the *in situ* tests covers the major salmonid early life stage developmental milestones, beginning with the eyed egg stage, proceeding through hatching and alevin stages (yolk sac present, during which the fish reside in the gravel), and ending at the early fry stage (also known as swim-up fry). At this point, the yolk sac has been absorbed and, under natural conditions, the fish would leave the gravel to feed independently. The duration of the exposure period is expected to include multiple rain/runoff events, and corresponding fluctuations in flow, contaminant concentrations, temperature, water chemistry, etc. Collectively, these attributes of the *in situ* approach provide highly relevant information regarding the suitability of waterbodies to support salmonid development (Chalmers et al., 2014).

Eyed eggs for both *in situ* events were supplied by TroutLodge (Sumner, WA), which also supplies rainbow trout eggs and sperm for the laboratory sublethal toxicity tests required in the STIA NPDES stormwater permit. Following deployment, the status of the *in situ* organisms was routinely monitored during the exposure, as well as at specific developmental stages and after significant storm events. Data were obtained on hatching, survival, development and growth. A subset of embryos was also reared in the laboratory (Rainier Environmental, Fife, WA) to assess organism quality. Weekly temperature measurements from the field were used to adjust rearing temperatures for the laboratory controls so that development in the controls could be used to trigger field inspections at specific times (e.g., hatch, swim-up).

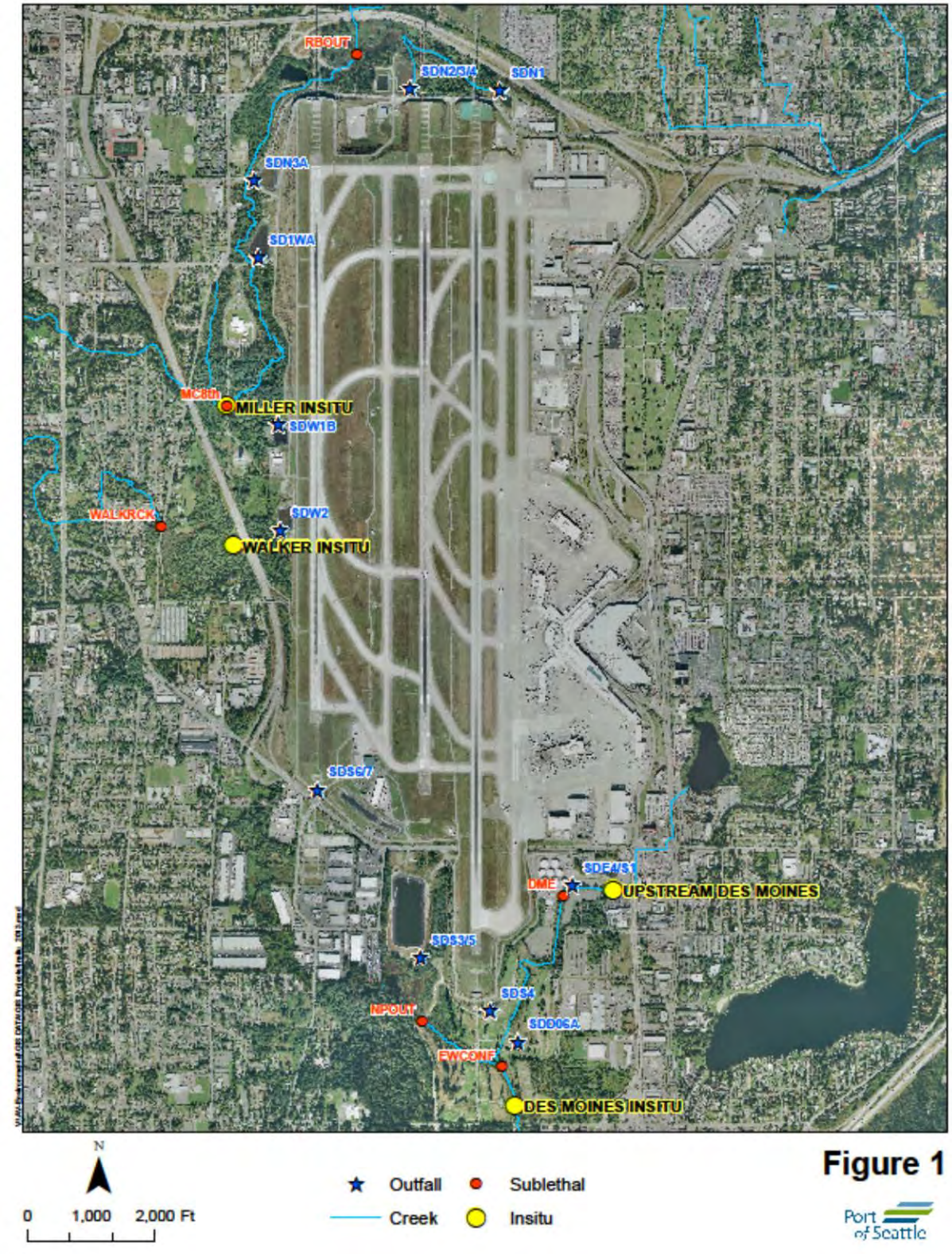
2.2 Monitoring Locations and Site Preparation

The exposures were conducted in three streams within the STIA property boundaries: Miller Creek, Walker Creek, and Des Moines Creek (Figure 1). Two sites are located on Des Moines Creek; Des Moines Creek Upstream is located on Airport property upstream of STIA stormwater outfalls into Des Moines Creek, and is used to assess water quality in Des Moines Creek prior to receiving any STIA stormwater discharges (the Des Moines Creek basin upstream of STIA is

heavily urbanized and potentially impacted by a variety of pollutant sources). The remaining sites, Miller Creek, Walker Creek and Des Moines Creek Lower, are located downstream of STIA inputs into their respective drainages (Figure 1).

Results from 2010 showed that the sampling sites generally do not have ideal substrate conditions for rearing salmonid ELS and are subjected to heavy sediment flow during storm events. Consequently, all four exposure replicates at each site were placed above the substrate in gravel contained within PVC crates which were anchored to the substrate with steel stakes. The replicate crates at each site were placed in a row on the streambed, from upstream to downstream, at a sufficient distance apart so that flow patterns were re-established between each crate. This approach allows passage of water through the exposure chambers, but prevents smothering of embryos and fry by sediment.

Figure 1. Map of STIA with receiving monitoring stations.



2.3 Exposure Apparatus

The RBT embryos were contained in modified Whitlock-Vibert hatchboxes (Federation of Flyfishers, MO), which are comprised of two rectangular chambers located one above the other; the upper chamber is for embryo development and the lower chamber for rearing of hatched fish. The external sides of the hatchbox are plastic mesh that allows passage of water through the box, but prevents loss of embryos. The divider between the embryo chamber and the rearing chamber is comprised of slots that are narrow enough to prevent transfer of unhatched embryos, but wide enough to permit migration of hatched fish into the lower rearing chamber. Thus, upon hatch, alevins are able to migrate through the slots from the embryo chamber into the larger rearing chamber. To prevent escape of the hatched fry into the streams upon swim-up, plastic screening material (Darice® size 7 mesh) was attached to the external faces of each rearing chamber and held in place using small plastic zip ties.

The hatchboxes were contained within flexible plastic mesh bags surrounded by 1 – 2 inch diameter gravel, with the hatchbox placed centrally within the rocks in the bag. The gravel surrounding the hatchboxes acts to diffuse the current and prevent exposure of the embryos to sunlight. The bags were then placed within the PVC crates, which were held in place in the stream by stakes anchored in the substrate (Figure 2). Figure 3 shows the eyed eggs within the hatchbox, and Figure 4 shows fry in the hatchbox.

Figure 2. Photograph of the crate set up, Des Moines Creek Lower.



2.4 Test Organisms

Eyed-egg stage rainbow trout embryos were obtained from TroutLodge on October 13, 2020 for the Fall event and March 23, 2021 for the Spring event. According to TroutLodge staff, the eyed embryos had developed to approximately 245 degree-days[1] for both testing events. On the day of test initiation, eggs were brought to Rainier Environmental Laboratory (REL; Fife, WA), and randomly counted into replicate units of 30 embryos each in individual opaque plastic food-storage containers (i.e., 450-mL Ziploc plastic tubs). These containers were then placed in a cooler containing ice packs, and transported to the sites where the embryos were transferred into the hatchboxes in the creek on the same day. The embryos were transferred to the sites in laboratory control water, and all embryos were installed at the sites between 15:00 and 18:00 on October 14, 2020 for the Fall event, and between 13:00 and 16:00 on March 24, 2021 for the Spring event.

2.5 Controls

Controls were used to assess the influence of the following factors on test results:

1. Quality (health and viability) of supplied organisms,
2. Transport and handling of organisms, and
3. Ambient stream temperatures, which affect the time to developmental milestones (e.g., hatch).

The controls consisted of a laboratory exposure (four replicates of 30 organisms each) conducted concurrently with each field exposure in clean laboratory water (moderately hard synthetic water [MHSW]) using a subset of the same batch of embryos used to initiate the field exposures. These embryos were distributed at the same time as the organisms used on site, placed into individual plastic containers filled with MHSW and transported to the sites with the other replicates; thus, they also served as transport controls. Upon returning to the laboratory after deployment of the field organisms, the control replicates were transferred to 4-L plastic

[1] Degree-days are used to standardize descriptions of fish development, regardless of rearing temperature, and reflects the sum of degrees during each day of development. For example, it takes rainbow trout approximately 340 degree-days to reach hatch (Quinn, 2005). Thus, at 8°C, it takes approximately 42 days to reach hatch.

containers in the laboratory containing 2 L of MHSW at ±1°C of the average site water temperature. The control chambers were held in the dark and gentle aeration was applied (100-200 bubbles per minute). The controls were monitored daily for mortalities, which were removed. Temperature was adjusted on a weekly basis, as needed, to correspond to temperatures measured in the field. Water renewals were conducted three times per week (Monday, Wednesday, Friday) using fresh MHSW. Dissolved oxygen (DO), pH, conductivity and temperature were measured before and after water renewals. Developmental milestones (e.g., hatch and swim-up) were also recorded.

2.6 Monitoring of Field Exposures

The sites were visited at approximately weekly intervals to assess the condition of the test organisms. During these checks, survival was recorded, as well as qualitative observations of organism health, site conditions and sedimentation within the boxes. Any dead organisms were removed during each visit. These observations were recorded on standard field data sheets, which are included in Appendix A. In addition, temperature, pH, DO and conductivity were measured during the site visits.

Monitoring of the installations required removal of the substrate overlying the hatchboxes in the crates. The embryos or alevins in each hatchbox were then poured into a plastic dishpan containing site water where they were enumerated. They were then returned to the hatchbox, which was placed back into the mesh-net bag of gravel, the overlying gravel replaced, and the bag returned to its respective crate. Care was taken to minimize disturbance and damage to the test organisms.

2.7 Test Termination

The field exposures and laboratory controls were terminated when the field organisms reached the swim-up fry stage (i.e., when the yolk sac was fully absorbed). This occurred on November 5, 2020, for the Fall exposure, and on April 20, 2021, for the Spring exposure. Surviving organisms were placed in their original plastic replicate containers filled with site water, transported back to the laboratory, and terminated. The fish were then weighed (to the nearest 0.001 gram) on an analytical balance, and measured (total length, from tip of the snout to the end of the tail) to the nearest 0.5 mm. Obvious external malformations were noted, including the affected body part (e.g., head, eye, spine) and type of abnormality (e.g., edema). Abnormality data were recorded on standard data sheets (Appendix A). The laboratory control fish were evaluated similarly on the same day.

2.8 Data Analysis

Test data were entered into CETIS (Comprehensive Environmental Toxicity Information System, Tidepool Scientific, McKinleyville, CA) for statistical analyses. Differences among the exposure sites and laboratory controls were evaluated using pair-wise multiple comparison tests according to the USEPA flow chart (USEPA 2002); significant differences were identified at $p \leq 0.05$.

One interim and five terminal endpoints were evaluated; the endpoints are described below:

1. Hatching success – an interim measure of the percentage of embryos hatched the day of the hatch inspection, or determined to have hatched based on the number of alevins present at the subsequent inspection, relative to the total number of embryos originally added;
2. Post-hatch survival - the percentage of organisms surviving at test termination relative to the number of embryos that hatched (these data help determine whether the majority of mortalities occurred pre- or post-hatch, or were distributed throughout the exposure period);
3. Cumulative survival - the percentage of surviving organisms at test termination relative to the number of embryos in each replicate at the beginning of the exposure;
4. Abnormality – the percentage of abnormal organisms at test termination relative to the number of surviving organisms;
5. Length – to the nearest 0.5 mm;
6. Weight – to the nearest 0.001 g.

3.0 QA/QC

The QA/QC program for the field exposure involved the following:

- Consistent field staff leader throughout all visits;
- Field documentation of all primary data; i.e., the names of individuals collecting the samples, sampling location, time of sampling, site conditions (e.g., degree of sedimentation), and other relevant observations, such as weather and any unusual conditions;
- Calibrated field meters;
- Use of pre-cleaned containers, with appropriate labels;
- Storing and transporting organisms in sealed containers in a cold, dark environment; cooling sample containers using ice or gel packs;
- Including transport controls to ascertain the extent of any transport-induced stress;
- Checking field organisms every week to monitor developmental progress, mortality and abnormality.

The QA/QC program for the laboratory portion of the study involved:

- Checks and maintenance of control organisms at regular intervals, including recording primary observations and water quality data on standardized data sheets;
- Review of datasheets by senior laboratory staff;
- Test termination activities (measurements, health assessment) conducted by qualified staff members using standardized datasheets to ensure consistent assessment of abnormalities and growth across all test sites and controls;
- Use of standard laboratory water and environmental chambers to maintain test organisms.

4.0 RESULTS

4.1 Fall 2020

4.1.1 Water Quality Measurements

Water quality measurements for the Fall 2020 monitoring event are summarized Table 1.

Table 1. Summary of mean, with (standard deviation) and [range], of water quality measurements collected during site visits and laboratory exposure (Fall 2020).

Creek	Temperature (°C)	Dissolved Oxygen (mg/L)	pH (units)	Specific Conductance (µS/cm)
Control	12.8 (0.9) [11.7 –14.0]	8.6 (0.4) [7.8 – 9.2]	7.78 (0.16) [7.52 – 8.01]	306.8 (9.9) [292 - 322]
Miller Creek	11.1 (1.9) [9.5 – 13.2]	10.4 (1.2) [9.2 – 12.0]	7.60 (0.14) [7.45 – 7.74]	226.8 (53.4) [173.8 – 290.0]
Walker Creek	12.4 (0.6) [11.9 – 13.2]	10.3 (1.1) [9.7 – 11.9]	7.20 (0.09) [7.09 – 7.30]	215.5 (19.2) [186.7 – 226.9]
Des Moines Creek Lower	11.4 (1.9) [9.6 – 13.8]	9.5 (1.2) [8.8 – 11.3]	6.81 (0.09) [6.72 – 6.93]	135.8 (36.3) [97 - 175]
Des Moines Creek Upstream	12.8 (1.6) [11.3 – 15.0]	9.0 (0.6) [8.4 – 9.5]	6.95 (0.04) [6.90 – 7.00]	100.8 (14.5) [79.8 – 112.4]

In the Fall 2020 *in situ* tests, temperatures for the four field sites and the control ranged from 9.5 to 15.0°C. Field measurements of pH were within acceptable ranges for rainbow trout laboratory bioassays (6-9 pH units); the pH values were between 6.72 and 8.01. Dissolved oxygen (DO) measurements were generally within acceptable ranges (60 – 100% saturation), although several readings during the test initiation and termination indicated super-saturation of between 102 and 110%; DO ranged from 7.8 to 12.0 mg/L.

Although limited to weekly measurements, the field temperature, DO and pH data suggested good water quality conditions overall, with limited indication of potential for adverse effects on organism survival and development. Supersaturation of dissolved oxygen recorded at Miller Creek on October 14 and 22 and at Walker Creek on October 22 are unusual but would not be expected to cause adverse effects unless total gas pressure was supersaturated.

The conductivity measurements for all four sites did not show much variability throughout the exposure period and remained within ranges tolerated by early life stages of salmonids; measurements ranged between 80 and 322 µS/cm.

4.1.2 Precipitation and Field Observations During the Fall 2020 Event

Field observations during each site visit are presented in Table 2. Precipitation data were provided by STIA. Figure 5 shows the daily precipitation over the duration of the exposure, in conjunction with monitoring milestones and associated observations. A total of 1.87 inches of rainfall fell during the Fall event, with no snow. Hatchboxes were installed on October 14 and the first site visit was on October 22, with weekly site visits thereafter. Conditions at all sites were good throughout the exposure.

At Miller Creek, alevins were observed to be escaping from gaps in hatchbox 4 during the October 22, 2020 site visit and the container was replaced with a new hatchbox. On October 28, the remains of a dead alevin was noted in hatchbox 1; shrimp were also present in the hatchbox. There was a gap in hatchbox 2 and was fixed. Leaf litter was observed on the bank during each site visit.

Algae was observed on all hatchboxes during each site visit at Walker Creek and leaf litter was on the bank. Amphipods were noted in hatchboxes 3 and 4 on October 28. All alevins appeared to have escaped hatchbox 2, despite the hatchbox being closed correctly. Consequently, this replicate was excluded from data analysis.

At the Des Moines Creek Lower site, there was consistent leaf litter covering the banks during each site visit. During the first site visit, algae was observed on hatchbox 2. On the following site visit on October 28, 2020, a flap on hatchbox 2 was exposed with fish trapped; a small gap was also noted on hatchbox 3. Both hatchboxes were repaired.

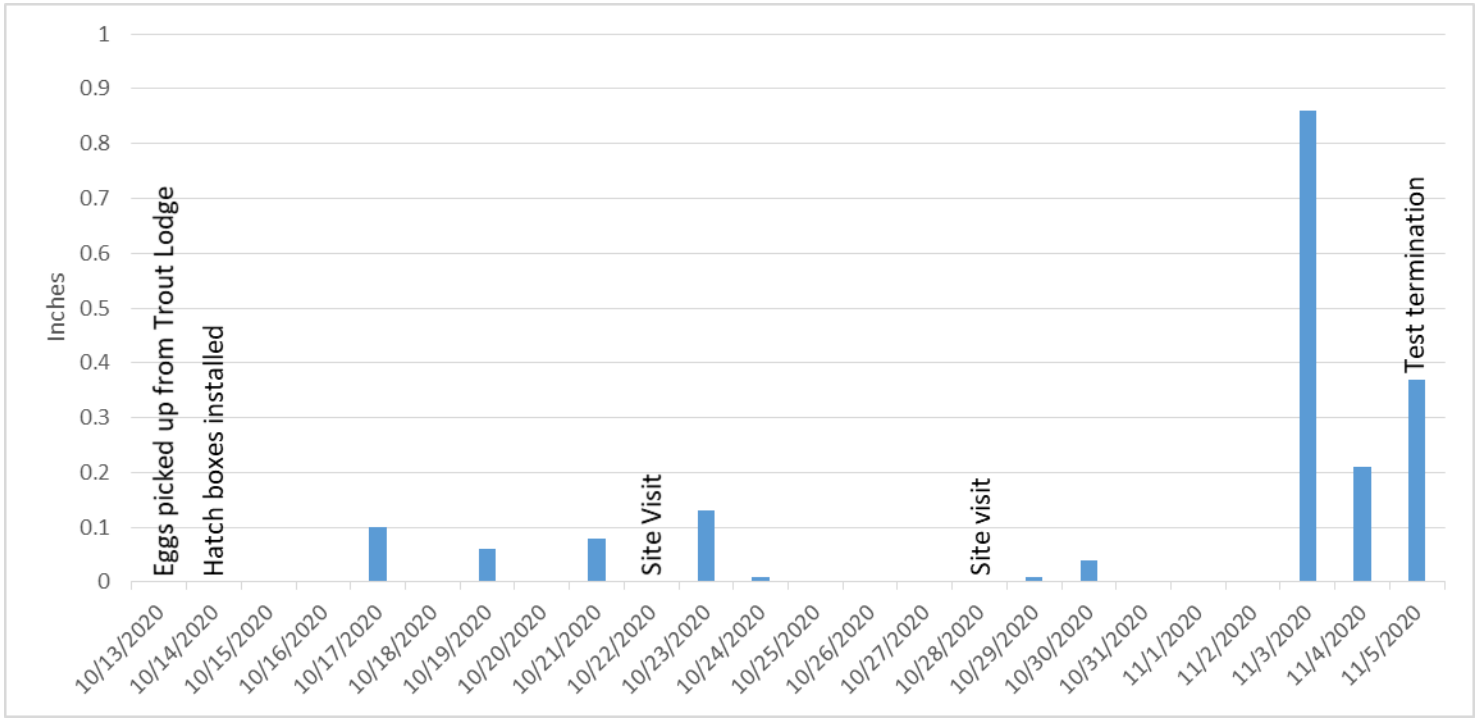
At the Des Moines Upstream site, snails, leeches or amphipods were observed in all hatchboxes on October 22 and 28, 2021. A small gap was noted in hatchbox 3 on October 28. Debris was caught around hatchbox 1 during the test termination. Leaf litter was observed on the bank during each site visit.

No sedimentation was observed in any of the hatchboxes for the duration of the exposure.

Table 2. Observations made during the Fall 2020 exposure.

Site	Observations			
	October 14, 2020	October 22, 2020	October 28, 2020	November 5, 2020
Des Moines Upstream	--	Leeches in hatchbox 1 and 3; snails in hatchbox 1; amphipods in hatchbox 4; leaf litter on bank	Amphipods in hatchbox 2, 3 and 4; leeches in hatchbox 3; leaf litter on bank	Debris around hatchbox; leaf litter on bank
Des Moines Lower	--	Algae on hatchbox 2; leaf litter on bank	Gaps in hatchbox 2 and 3 fixed; leaf litter on bank	Leaf litter on bank
Miller Creek	--	Leaf litter in crate 1; hatchbox 4 switched out due to alevins escaping through holes; leaf litter on bank	Gap in hatchbox 2 fixed; leaf litter on bank	Leaf litter on bank
Walker Creek	--	Algae on all hatchboxes; leaf litter on bank	Algae on all hatchboxes; amphipods in hatchbox 3 and 4; all alevins escaped hatchbox 2; Leaf litter on bank	Algae on all hatchboxes; leaf litter on bank

Figure 5. Daily rainfall during the Fall 2020 exposure.



4.1.3 Fall 2020 *In situ* exposure metrics

Data for the Fall sampling event are summarized in Tables 3 and 4, and are presented graphically in Figures 7 through 9.

Hatching success – Mean hatching success for the laboratory controls was 100%, compared with 90.8% at Miller Creek, 93.3% at Walker Creek, 95.8% at Des Moines Creek Lower, and 80.0% at Des Moines Creek Upstream. There was no significant differences in hatching success at any sites in comparison to the control except at Des Moines Creek Upstream (Bonferroni Adj t Test). There was no significant difference in hatching success between Des Moines Creek Lower compared to Des Moines Creek Upstream.

Post-hatch survival – Control survival of alevins post-hatch was 100%, compared with 82.3% at Miller Creek, 94.0% at Walker Creek, 87.8% at Des Moines Creek Lower, and 84.6% at Des Moines Creek Upstream. Post-hatch survival was significantly lower at Miller Creek, Des Moines Creek Lower and Des Moines Creek Upstream compared to the control (Bonferroni Adj t Test). There was no significant difference in post-hatch survival between Des Moines Creek Lower compared to Des Moines Creek Upstream.

Cumulative survival – Control survival from initiation to termination of the test averaged 100%. Cumulative survival at the exposure sites averaged 75.0% at Miller Creek, 87.8% at Walker Creek, 84.2% at Des Moines Creek Lower, and 68.3% at the Des Moines Creek Upstream site. Survival was significantly reduced relative to the controls at all sites (Bonferroni Adj t Test) except at Walker Creek. There was no significant difference in cumulative survival at Des Moines Creek Lower compared to Des Moines Creek Upstream.

Abnormalities – There were few abnormalities observed across treatments: two in Miller Creek; one at Walker Creek; and one at Des Moines Creek Lower. The fish in the Miller Creek and Des Moines Creek Lower were missing fins; in Walker Creek, the deformity was observed in the eyes.

Growth – Average weight and length in the controls was 103.5 mg and 23.2 mm, respectively. Miller Creek fish averaged 90.8 mg and 21.9 mm, fish exposed at Walker Creek averaged 107.9 mg and 23.9 mm, Des Moines Creek Lower averaged 93.0 mg and 22.2 mm, and Des Moines Creek Upstream fish averaged 111.0 mg and 23.9 mm, for weight and length, respectively. The length and weight of the fish in both Miller and Des Moines Creek Lower was significantly different compared to the control (Bonferroni Adj t Test). There was a significant difference in both growth endpoints at Des Moines Creek Lower compared to Des Moines Creek Upstream.

Table 3. Hatching success, survival and abnormality in the control and field treatment groups (Fall 2020).

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	100 (0.0)	100 (0.0)	100 (0.0)	0.0 (0.0)
Miller Creek	90.8 (8.3)	82.3 (10.9)	75.0 (14.0)	2.3 (2.8)
Walker Creek	93.3 (5.8)	94.0 (2.3)	87.8 (6.9)	1.2 (2.1)
Des Moines Creek Lower	95.8 (4.2)	87.8 (8.3)	84.2 (9.2)	1.1 (2.3)
Des Moines Creek Upstream	80.0 (13.6)	84.6 (11.5)	68.3 (18.2)	0.0 (0.0)

Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control

Table 4. Growth in the control and field treatment groups (Fall 2020).

Site	Length (mm)	Weight (mg)
Control	23.2 (0.2)	103.5 (2.7)
Miller Creek	21.9 (0.4)	90.8 (3.3)
Walker Creek	23.9 (0.6)	107.9 (9.3)
Des Moines Creek Lower	22.2 (0.4)	93.0 (2.9)
Des Moines Creek Upstream	23.9 (0.2)	111.0 (8.2)

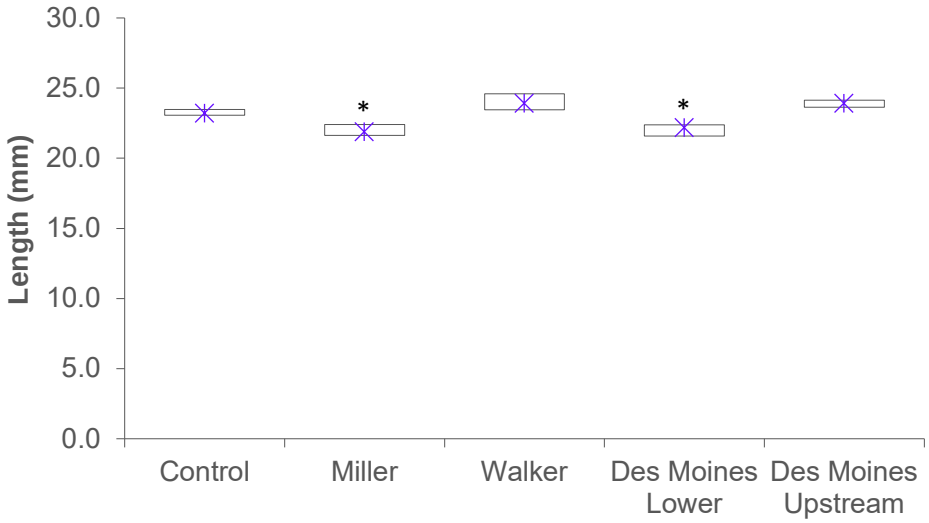
Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control

Figure 6. Hatching success, post-hatch survival, and cumulative survival in the field and control treatment groups (Fall 2020).



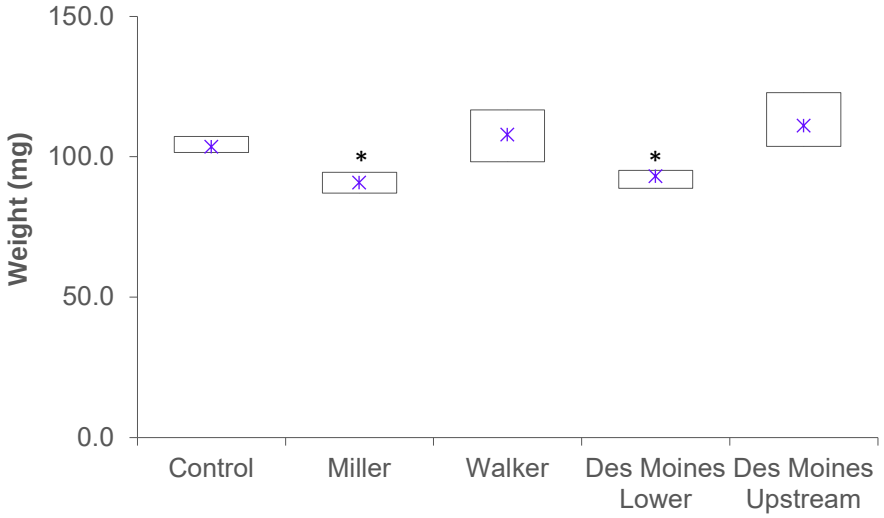
Error bars are standard deviations; asterisks denote significant difference from control.

Figure 7. Average lengths for the laboratory control and exposure sites (Fall 2020).



Data point is the average; box represents range of minimum to maximum values. Asterisks denote significant difference from control.

Figure 8. Average weights for the laboratory control and exposure sites (Fall 2020).



Data point is the average; box represents range of minimum to maximum values. Asterisks denote significant difference from control.

4.2 Spring 2021

4.2.1 Water Quality Measurements

Water quality measurements for the Spring 2021 monitoring event are summarized in Table 5.

Table 5. Summary of mean, with (standard deviation) and [range], of water quality measurements collected during site visits and laboratory exposure (Spring 2021).

Creek	Temperature (°C)	Dissolved Oxygen (mg/L)	pH (units)	Specific Conductance (µS/cm)
Control	10.2 (1.1) [8.4 – 11.7]	8.6 (0.4) [8.0 – 9.5]	7.64 (0.19) [7.3 – 8.0]	301.9 (8.9) [291 – 324]
Miller Creek	9.4 (1.2) [8.0 – 11.2]	11.1 (0.4) [10.4 – 11.4]	7.74 (0.09) [7.6 – 7.8]	261.6 (43.1) [202 – 316]
Walker Creek	11.4 (0.4) [10.7 – 11.7]	10.4 (0.2) [10.1 – 10.6]	7.12 (0.13) [7.0 – 7.3]	257.8 (21.2) [236 – 286]
Des Moines Creek Lower	10.1 (2.0) [7.4 – 11.9]	9.3 (0.8) [7.9 – 9.9]	7.06 (0.15) [6.9 – 7.2]	188.8 (23.6) [157 – 218]
Des Moines Creek Upstream	12.0 (2.1) [9.5 – 15.0]	9.0 (0.9) [7.9 – 10.2]	7.38 (0.11) [7.3 – 7.5]	171.4 (17.3) [148 – 195]

Temperatures among the four field sites and the control ranged from 7.4 to 15.0°C. The pH values were between 6.9 and 8.0, and DO ranged from 7.9 to 11.4 mg/L. All field measurements of pH and dissolved oxygen were within acceptable ranges for rainbow trout laboratory bioassays. Conductivity readings were similar at each site between each visit and ranged between 148 and 324 µS/cm.

4.2.2 Precipitation and Field Observations During the Spring 2021 Event

Field observations during each site visit are presented in Table 6. The daily rainfall for the duration of the Spring 2021 exposure is shown in Figure 9. The largest amount of rain (0.69 inches) was observed on March 25, 2021. A total of 1.63 in of rain fell and no snow occurred during the exposure period. Hatchboxes were installed on March 24, 2021, with weekly site visits thereafter.

At Miller Creek, woody debris was observed below crate 4 and recent plant trimmings were present nearby during the hatchbox installation; this debris was largely cleared prior to subsequent visits. Woody debris was observed on crates 2 and 3 on March 31, 2021; approximately 1 cm of sediment was also observed in hatchbox 3. Nymphs were observed in hatchboxes during the April 6 site visit and a brown biofilm was observed on hatchbox 1 on April 20, 2021.

At Walker Creek, organic debris was observed on crates 1 and 2 during the March 31, 2021 site visit. Two alevins were stuck in the corner of hatchbox 3 on April 6; the alevins were removed and the hatchbox replaced. Biofilm was observed on hatchbox 4 and there was an increase in algal growth noted on the stream substrate. Algae was growing on crate 4 the following week and nymphs were observed inside hatchbox 4 during termination on April 20, with the nymphs observed to be holding onto the live alevins.

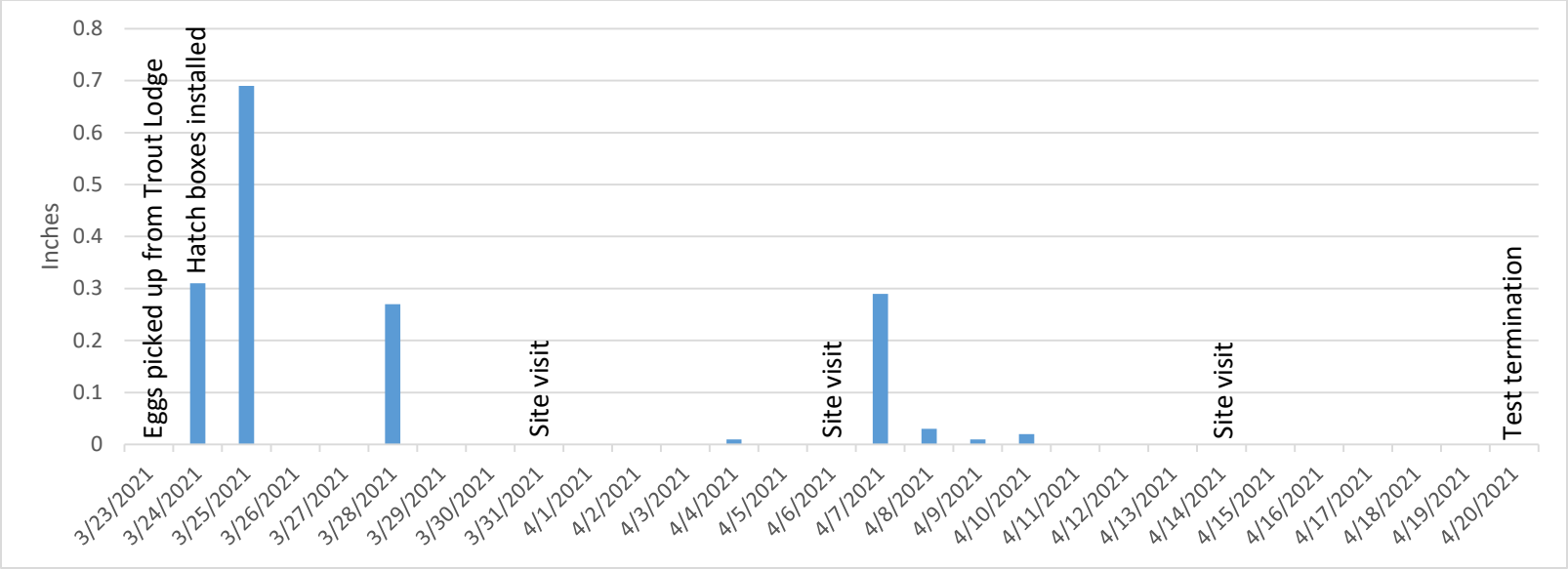
At Des Moines Lower, amphipods were observed in hatchboxes 3 and 4 during the site visit on April 6, 2021. Alevins were noted to have escaped hatchbox 1 on April 14 with only 4 remaining compared to 26 the week prior; consequently, this replicate was removed from analysis for all endpoints except hatching success. Two alevins were also noted to have lacerations in hatchbox 3. There was a brown tint observed in the water during the site visit on April 14 and during termination on April 20, 2021.

Brown biofilm was observed on all hatchboxes on April 6, 2021 at Des Moines Upstream. During the test termination, algal growth was noted in the stream. No sedimentation was observed in the hatchboxes at any of the sites at test termination.

Table 6. Observations made during the Spring 2021 exposure.

Site	Observations				
	March 24, 2021	March 31, 2021	April 6, 2021	April 14, 2021	April 20, 2021
Des Moines Upstream	--	Organic matter on rocks	Brown biofilm on all hatchboxes	--	Algae growth
Des Moines Lower	--	Small amount of biofilm on hatchbox 3	Amphipods in hatchboxes 3 and 4	Brownish tint to water; alevins escaped in hatchbox 1; 2 alevins with lacerations in hatchbox 2	Brownish tint to water
Miller Creek	Large woody debris below hatchbox 4; recent plant trimming nearby	Woody debris on crate 2; 1 cm sediment in hatchbox 3 and debris on crate	Nymphs in hatchboxes	Amphipods in hatchboxes	Brown biofilm on hatchbox 1
Walker Creek	--	Organic debris on crate 1 and 2	Biofilm on hatchbox 4; increased algae on substrate in stream	Algae on crate 4	Nymph holding onto live alevins in hatchbox 4; large amounts of green filamentous algae on stream substrate

Figure 9. Daily rainfall for the duration of the Spring 2021 exposure.



4.2.3 Spring 2021 *In situ* exposure metrics

Data for the spring sampling event are summarized in Tables 7 and 8, and presented graphically in Figures 10 through 12.

Hatching success – Mean hatching success for the controls was 99.2%, compared with 74.2% at Miller Creek, 94.2% at Walker Creek, 83.3% at Des Moines Creek Lower and 71.7% at Des Moines Creek Upstream. Hatching success at Miller and Des Moines Creek Upstream were significantly different from the control (Dunnett Multiple Comparison Test). There was no significant difference in hatching success at Des Moines Lower compared to Des Moines Creek Upstream.

Post-hatch survival – Control survival of alevins post-hatch was 99.1%, compared with 94.3% at Miller Creek, 93.0% at Walker Creek, 80.5% at Des Moines Creek Lower, and 85.0% at Des Moines Upstream. Des Moines Creek Lower and Des Moines Upstream were significantly different from the control (Dunnett Multiple Comparison Test), however, there was no significant difference observed between the two sites.

Cumulative survival – Control survival from initiation of the test to termination averaged 98.3%, compared with 70.0% at Miller Creek, 87.5% at Walker Creek, 67.8% at Des Moines Creek Lower, and 60.0% at Des Moines Creek Upstream. There was a significant difference at all of the sites compared to the control except at Walker Creek (Dunnett Multiple Comparison Test). There was no significant difference in cumulative survival between Des Moines Lower and Des Moines Creek Upstream.

Abnormalities – There were few abnormalities observed across treatments, with one each in the control, Walker Creek and Des Moines Creek Lower and two in Miller Creek. The abnormality of the fish in the control, Walker Creek and Des Moines Creek Lower were located in the spine and the abnormalities observed at Miller Creek were in the fins and spine.

Growth – Average weight in the controls was 104.5 mg, and length averaged 24.2 mm. In comparison, Miller Creek fish averaged 111.0 mg and 24.2 mm, fish from Walker Creek averaged 121.7 mg and 26.0 mm, fish exposed at Des Moines Creek Lower averaged 102.7 mg and 23.3 mm and fish from Des Moines Creek Upstream average 111.9 mg and 24.8 mm. Neither weight nor length were significantly different from the control at any sites (Dunnett Multiple Comparison Test). There was a significant difference in length between Des Moines Lower and Des Moines Creek Upstream.

Table 7. Hatching success, survival and abnormality in the control and field treatment groups (Spring 2021).

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	99.2 (1.7)	99.1 (1.7)	98.3 (3.3)	0.8 (1.7)
Miller Creek	74.2 (20.2)	94.3 (5.1)	70.0 (19.6)	1.7 (3.3)
Walker Creek	94.2 (4.2)	93.0 (4.9)	87.5 (3.2)	0.9 (1.8)
Des Moines Creek Lower	83.3 (20.7)	80.5 (10.6)	67.8 (26.9)	1.0 (2.0)
Des Moines Upstream	71.7 (17.7)	85.0 (9.3)	60.0 (11.9)	0.0 (0.0)

Notes:

1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control

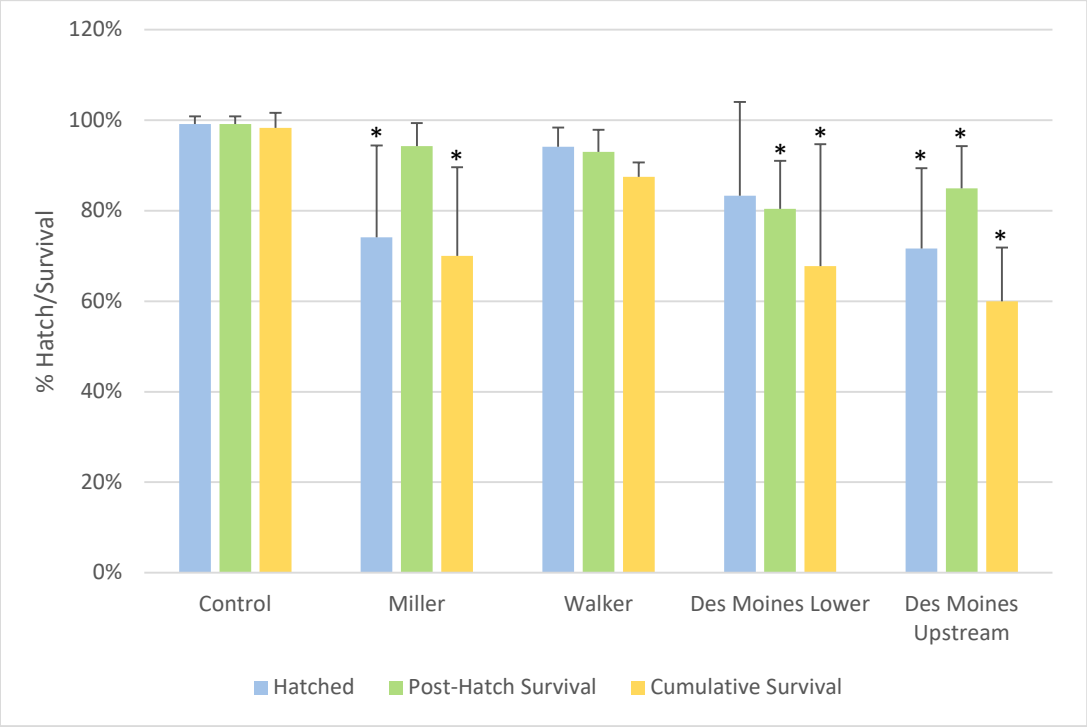
Table 8. Growth in the control and field treatment groups (Spring 2021).

Site	Length (mm)	Weight (mg)
Control	24.2 (0.5)	104.5 (2.6)
Miller Creek	24.2 (1.0)	111.0 (3.2)
Walker Creek	26.0 (0.0)	121.7 (8.4)
Des Moines Creek Lower	23.3 (0.6)	102.7 (9.5)
Des Moines Upstream	24.8 (0.5)	111.9 (2.6)

Notes:

1. Results are presented as mean and standard deviation

Figure 10. Hatching success, post-hatch survival, and cumulative survival in the field and control treatment groups (Spring 2021).



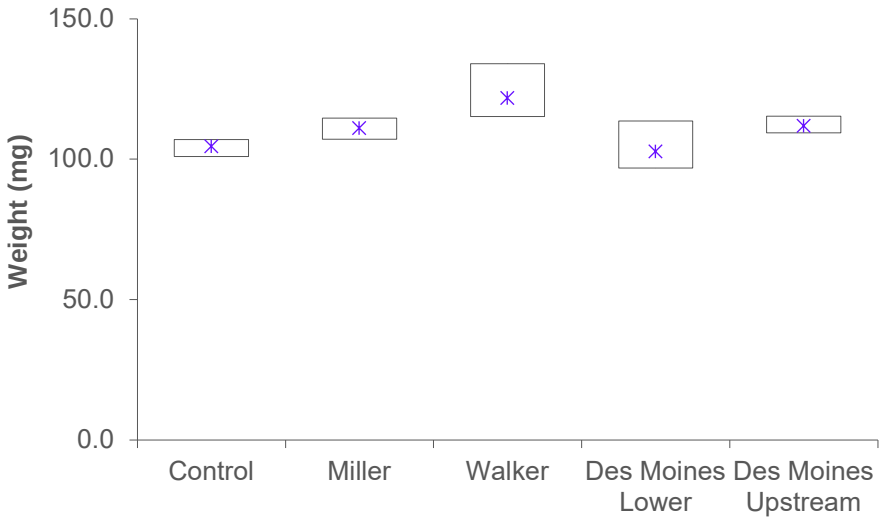
Error bars are standard deviations.

Figure 11. Average lengths for the laboratory control and exposure sites (Spring 2021).



Data point is the average; box represents range of minimum to maximum values.

Figure 12. Average weights for the laboratory control and exposure sites (Spring 2021).



Data point is the average; box represents range of minimum to maximum values.

5.0 DISCUSSION

There were only adverse effects associated with sublethal measurements, such as growth and incidence of deformities, for growth of alevins exposed in Miller Creek and Des Moines Creek Lower during the Fall event; there was a 5.6 and 4.4% reduction in length and 12.4 and 10.2 percent reduction in weight relative to the laboratory control at these two locations, respectively. In both cases, there was more residual yolk observed in these fish at test termination than at the other locations, indicating that the fish were developing more slowly at these sites. The temperature was lower at these locations by more than 1°C relative to the other locations and control exposure. Thus, the reduced growth at these locations may be reflective of the colder water temperatures causing slower growth, rather being indicative of a toxicological effect at these sites.

Survival of rainbow trout was relatively high in both test events at all locations, with the lowest cumulative survival occurring in Des Moines Upstream in both test periods (60.0 and 68.3% in the Fall and Spring events, respectively). A statistically significant reduction in survival was observed in Miller Creek and both Lower Des Moines Creek and Des Moines Upstream in both test events; however, the very high survival in the laboratory control (i.e., 100.0 and 98.3% respectively) resulted in a relatively high statistical sensitivity to detect adverse effects in these exposures.

Results for cumulative survival, incorporating both effects on hatch rate and survival post hatch, provided the best measure of adverse effects in the *in situ* exposures reported here. In the Fall 2020 event, cumulative survival in the exposure sites ranged from 68.3 to 87.8%, and was significantly decreased at all sites compared to the control (100% survival), with the exception of Walker Creek. In the Spring 2021 event, cumulative survival ranged from 60.0 to 87.5% across the sites, compared with 98.3% in the control, and similar to the Fall event, all sites were significantly lower than the control except at Walker Creek.

Of note, significant adverse effects were observed in both Fall 2020 and Spring 2021 events at the Des Moines Creek Lower and Des Moines Creek Upstream sites, with reduced post-hatch survival and cumulative survival at both locations; Des Moines Creek Upstream also had reduced hatching success during both events. During the Fall 2020 event, Des Moines Creek Lower had reduced growth, in both the length and weight endpoints. With the exception of the Spring 2015 (Nautilus Environmental 2015), Spring 2018 (Nautilus Environmental 2018) and the Spring 2020 (Nautilus Environmental 2020) testing events, Des Moines Upstream has generally exhibited evidence of adverse effects, suggesting an ongoing pattern of impaired water quality upstream of STIA inputs, which could also contribute to adverse effects observed further

downstream at Des Moines Creek Lower. In the present study, Des Moines Creek Lower produced results that were statistically significantly different from Des Moines Creek Upstream in length and weight of the exposed fish in Fall 2020 and in lengths in Spring 2021 suggesting the possibility of a localized impact at the downstream site, but there was no significant difference in cumulative survival between the upstream and downstream sites, and differences in growth may have resulted from different temperature profiles at these two locations.

In general, creek conditions and water quality parameters remained within suitable ranges for the duration of the both testing events and were unlikely to have contributed to any adverse effects observed. However, some exceedances were notable, including dissolved oxygen measurements that exceeded saturation during the Fall 2020 event. Elevated levels of total dissolved gas (TDG), which includes dissolved oxygen, can be harmful to salmonids (Carter 2008), and USEPA (1986) has set a criterion for TDG stating that levels should not exceed 110% of saturation. In all instances during the Fall event, dissolved oxygen was ≤110% saturation, and it is unknown if the supersaturated oxygen resulted in supersaturated TDG or not.

No sedimentation was observed in either event that may have affected embryo survival.

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Rainbow Trout Early Life Stages *In Situ* Monitoring Testing

Fall 2021 and Spring 2022

Final Report

June 30, 2022

Submitted to: **Port of Seattle**
Seattle-Tacoma International Airport

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SIGNATURE PAGE



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This report has been prepared by Nautilus Environmental Company Inc. based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

EXECUTIVE SUMMARY

The Port of Seattle monitors the potential effects of stormwater discharges from the Seattle-Tacoma International Airport (STIA) on the receiving environment as part of their National Pollutant Discharge Elimination System (NPDES) permit, which requires that *in situ* rainbow trout (RBT) early-life stage (ELS) tests be conducted biannually in the fall and spring. The testing program was initiated in Fall 2010; exposure sites include Miller Creek, Des Moines Creek Lower and Des Moines Creek Upstream, with Walker Creek being added to the study beginning Spring 2016. The creeks flow through STIA property boundaries, with monitoring points generally located downstream of STIA inputs; however, one site (Des Moines Creek Upstream) is located upstream of STIA stormwater outfalls to monitor for potential impacts originating upstream of Airport property. Results are compared to a laboratory control conducted concurrently with the *in situ* tests.

During the Fall 2021 event, hatching success, post-hatch survival and cumulative survival were all significantly reduced at Miller Creek and Des Moines Creek Upstream compared to the laboratory control. During the Spring 2022 event, post-hatch and cumulative survival was significantly reduced at Des Moines Creek Upstream compared to the laboratory control. In terms of sublethal effects, no effects were observed on length or weights at any site during either the Fall or Spring events. Developmental abnormalities were minimal across all sites and controls during both events (i.e., ≤ 5%). Of note, with the exception of Spring 2015, Spring 2018 and Spring 2020 testing events, Des Moines Creek Upstream has historically exhibited adverse effects since the testing program began in 2010.

1.0 INTRODUCTION

This report presents the results of the rainbow trout (RBT) early life stages (ELS) *in situ* monitoring tests conducted in the Fall of 2021 and Spring of 2022. The objective of this program is to use salmonid ELS as an *in situ* monitoring tool to assess the quality of receiving waters potentially affected by stormwater discharges from the Seattle-Tacoma International Airport (STIA), as well as a multitude of other potential sources from the surrounding urban environment. Results for studies conducted in Fall 2010/Spring 2011, Fall 2011/Spring 2012, Fall 2012/Spring 2013, Fall 2013/Spring 2014, Fall 2014/Spring 2015, Fall 2015/Spring 2016, Fall 2016/Spring 2017, Fall 2017/Spring 2018, Fall 2018/Spring 2019, Fall 2019/Spring 2020 and Fall 2020/2021 have been presented previously (Nautilus Environmental 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020 and 2021, respectively), and have demonstrated that the RBT *in situ* ELS bioassay is an effective biological monitoring tool for assessing the potential effects of stormwater discharges on the receiving environment.

The sampling events presented herein were conducted under NPDES Permit No. WA-002465-1, which requires that *in situ* tests be conducted biannually in the fall and spring, corresponding to the spawning regimes of local salmonid species.

2.0 METHODS

Guidance for conducting *in situ* ELS exposures with salmonids is available from a number of sources. The British Columbia Ministry of Environment has a protocol for an *in situ* ELS salmonid test (BCMOE, 2003), and Environment Canada has developed laboratory test procedures for early life stages of rainbow trout (Environment Canada, 1998). In the USA, there are two general laboratory protocols for conducting fish early life stage toxicity tests (EPA, 1996; ASTM, 2005). The procedures used in this study reflect refinements made to the general guidance provided in the documents above (Chalmers et al., 2014), and have been used successfully at a number of sites in both Canada and the USA. Additional refinements specific to applying the method to waterways present on Airport property are included in the descriptions below.

2.1 Design

The study design used for the Fall 2021 and Spring 2022 *in situ* testing involved exposure of eyed-stage embryos at four sampling sites, using four replicates per site with 30 embryos per replicate. The locations of the sites are shown in Figure 1. The original sites were located on Miller and Des Moines Creeks downstream of all Airport discharges, and were subsequently augmented by an additional site on Des Moines Creek located upstream of any Airport discharges to determine the extent to which sources upstream of STIA inputs may contribute to adverse effects observed at the downstream site on Des Moines Creek. A site located in Walker Creek was also included in the study design beginning with the Spring 2016 testing event.

The exposure duration used in the *in situ* tests covers the major salmonid early life stage developmental milestones, beginning with the eyed egg stage, proceeding through hatching and alevin stages (yolk sac present, during which the fish reside in the gravel), and ending at the early fry stage (also known as swim-up fry). At this point, the yolk sac has been absorbed and, under natural conditions, the fish would leave the gravel to feed independently. The duration of the exposure period is expected to include multiple rain/runoff events, and corresponding fluctuations in flow, contaminant concentrations, temperature, water chemistry, etc. Collectively, these attributes of the *in situ* approach provide highly relevant information regarding the suitability of waterbodies to support salmonid development (Chalmers et al., 2014).

Eyed eggs for both *in situ* events were supplied by TroutLodge (Sumner, WA), which also supplies rainbow trout eggs and sperm for the laboratory sublethal toxicity tests required in the STIA NPDES stormwater permit. Following deployment, the status of the *in situ* organisms was routinely monitored during the exposure, as well as at specific developmental stages and after significant storm events. Data were obtained on hatching, survival, development and growth. A subset of embryos was also reared in the laboratory (Rainier Environmental, Fife, WA) to assess organism quality. Weekly temperature measurements from the field were used to adjust rearing temperatures for the laboratory controls so that development in the controls could be used to trigger field inspections at specific times (e.g., hatch, swim-up).

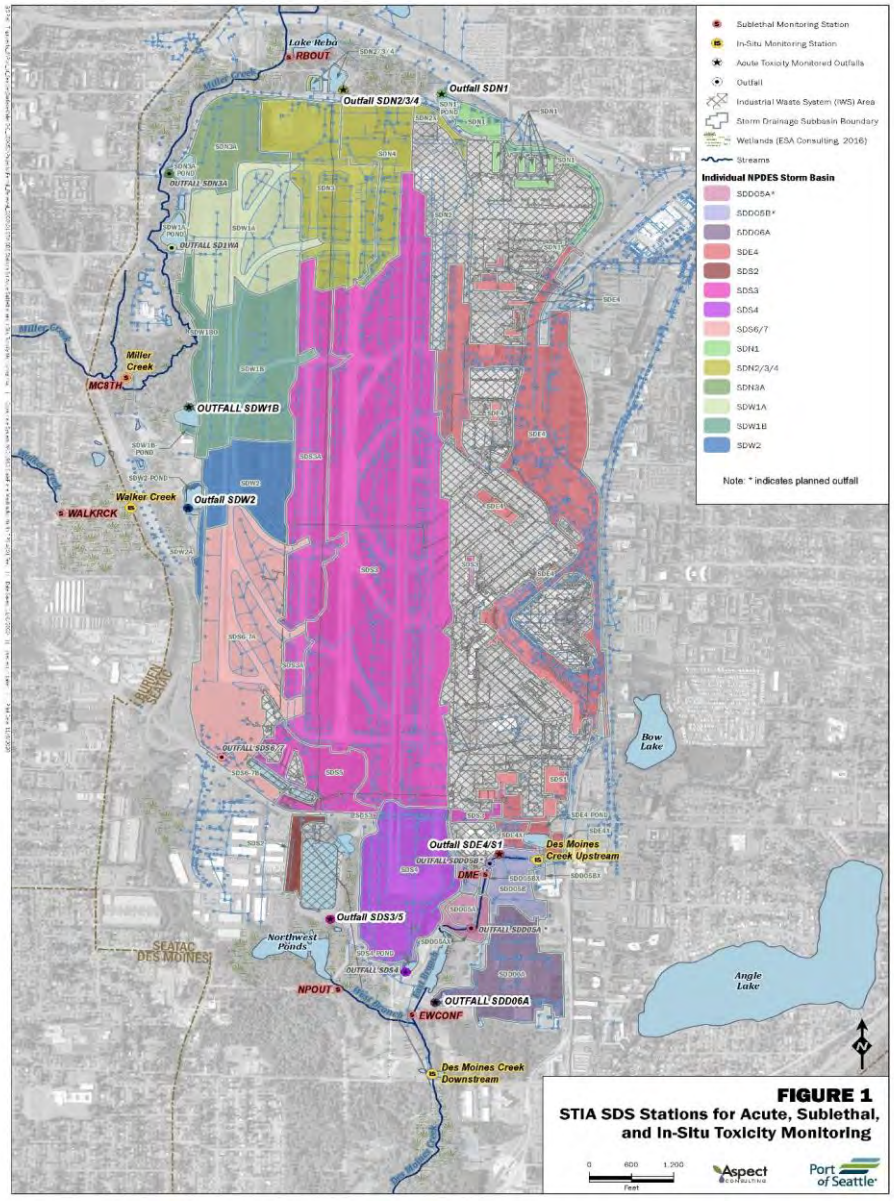
2.2 Monitoring Locations and Site Preparation

The exposures were conducted in three streams within the STIA property boundaries: Miller Creek, Walker Creek, and Des Moines Creek (Figure 1). Two sites are located on Des Moines Creek; Des Moines Creek Upstream is located on Airport property upstream of STIA stormwater outfalls into Des Moines Creek, and is used to assess water quality in Des Moines Creek prior to receiving any STIA stormwater discharges (the Des Moines Creek basin upstream of STIA is heavily urbanized

and potentially impacted by a variety of pollutant sources). The remaining sites, Miller Creek, Walker Creek and Des Moines Creek Lower, are located downstream of STIA inputs into their respective drainages (Figure 1).

Results from 2010 showed that the sampling sites generally do not have ideal substrate conditions for rearing salmonid ELS and are subjected to heavy sediment flow during storm events. Consequently, all four exposure replicates at each site were placed above the substrate in gravel contained within PVC crates which were anchored to the substrate with steel stakes. The replicate crates at each site were placed in a row on the streambed, from upstream to downstream, at a sufficient distance apart so that flow patterns were re-established between each crate. This approach allows passage of water through the exposure chambers, but prevents smothering of embryos and fry by sediment.

Figure 1. Map of STIA with receiving monitoring stations.



2.3 Exposure Apparatus

The RBT embryos were contained in hatchboxes comprised of 4 inch x 6 inch cylindrical stainless steel strainer. The external sides of the hatchbox are perforated to allow passage of water through the box, but prevents loss of embryos. These stainless streel hatchboxes replaced a former Whitlock-Vibert style box that at times allowed alevins to escape due to deformations in the plastic mesh chambers. With the new hatchboxes, embryos hatch and remain through alevin stage in a large (~100 square inch) rearing chamber.

The hatchboxes were contained within flexible plastic mesh bags surrounded by 1 – 2 inch diameter gravel, with the hatchbox placed centrally within the rocks in the bag. The gravel surrounding the hatchboxes acts to diffuse the current and prevent exposure of the embryos to sunlight. The bags were then placed within the PVC crates, which were held in place in the stream by stakes anchored in the substrate (Figure 2). Figure 3 and 4 shows top-down and side-view images of the stainless steel hatchboxes.

Figure 2. Photograph of the crate set up, Des Moines Creek Lower.



2.4 Test Organisms

Eyed-egg stage rainbow trout embryos were obtained from TroutLodge on October 18, 2021 for the Fall event and April 5, 2022 for the Spring event. According to TroutLodge staff, the eyed embryos had developed to approximately 245 degree-days[1] for both testing events. On the day of test initiation, eggs were brought to Rainier Environmental Laboratory (REL; Fife, WA), and randomly counted into replicate units of 30 embryos each in individual opaque plastic food-storage containers (i.e., 450-mL Ziploc plastic tubs). These containers were then placed in a cooler containing ice packs, and transported to the sites where the embryos were transferred into the hatchboxes in the creek on the same day. The embryos were transferred to the sites in laboratory control water, and all embryos were installed at the sites between 11:00 and 14:00 on October 19, 2021 for the Fall event, and between 8:00 and 13:00 on April 6, 2022 for the Spring event.

2.5 Controls

Controls were used to assess the influence of the following factors on test results:

1. Quality (health and viability) of supplied organisms,
2. Transport and handling of organisms, and
3. Ambient stream temperatures, which affect the time to developmental milestones (e.g., hatch).

The controls consisted of a laboratory exposure (four replicates of 30 organisms each) conducted concurrently with each field exposure in clean laboratory water (moderately hard synthetic water [MHSW]) using a subset of the same batch of embryos used to initiate the field exposures. These embryos were distributed at the same time as the organisms used on site, placed into individual plastic containers filled with MHSW and transported to the sites with the other replicates; thus, they also served as transport controls. Upon returning to the laboratory after deployment of the field organisms, the control replicates were transferred to 4-L plastic containers in the laboratory containing 2 L of MHSW at ±1°C of the average site water temperature. The control chambers

[1] Degree-days are used to standardize descriptions of fish development, regardless of rearing temperature, and reflects the sum of degrees during each day of development. For example, it takes rainbow trout approximately 340 degree-days to reach hatch (Quinn, 2005). Thus, at 8°C, it takes approximately 42 days to reach hatch.

were held in the dark and gentle aeration was applied (100-200 bubbles per minute). The controls were monitored daily for mortalities, which were removed. Temperature was adjusted on a weekly basis, as needed, to correspond to temperatures measured in the field. Water renewals were conducted three times per week (Monday, Wednesday, Friday) using fresh MHSW. Dissolved oxygen (DO), pH, conductivity and temperature were measured before and after water renewals. Developmental milestones (e.g., hatch and swim-up) were also recorded.

2.6 Monitoring of Field Exposures

The sites were visited at approximately weekly intervals to assess the condition of the test organisms. During these checks, survival was recorded, as well as qualitative observations of organism health, site conditions and sedimentation within the boxes. Any dead organisms were removed during each visit. These observations were recorded on standard field data sheets, which are included in Appendix A. In addition, temperature, pH, DO and conductivity were measured during the site visits.

Monitoring of the installations required removal of the substrate overlying the hatchboxes in the crates. The embryos or alevins in each hatchbox were then poured into a plastic dishpan containing site water where they were enumerated. They were then returned to the hatchbox, which was placed back into the mesh-net bag of gravel, the overlying gravel replaced, and the bag returned to its respective crate. Care was taken to minimize disturbance and damage to the test organisms.

2.7 Test Termination

The field exposures and laboratory controls were terminated when the field organisms reached the swim-up fry stage (i.e., when the yolk sac was fully absorbed). This occurred on November 19, 2021, for the Fall exposure, and on May 4, 2022, for the Spring exposure. Surviving organisms were placed in their original plastic replicate containers filled with site water, transported back to the laboratory, and terminated. The fish were then weighed (to the nearest 0.001 gram) on an analytical balance, and measured (total length, from tip of the snout to the end of the tail) to the nearest 0.5 mm. Obvious external malformations were noted, including the affected body part (e.g., head, eye, spine) and type of abnormality (e.g., edema). Abnormality data were recorded on standard data sheets (Appendix A). The laboratory control fish were evaluated similarly on the same day.

2.8 Data Analysis

Test data were entered into CETIS (Comprehensive Environmental Toxicity Information System, Tidepool Scientific, McKinleyville, CA) for statistical analyses. Differences among the exposure sites and laboratory controls were evaluated using pair-wise multiple comparison tests according to the USEPA flow chart (USEPA 2002); significant differences were identified at $p \leq 0.05$.

One interim and five terminal endpoints were evaluated; the endpoints are described below:

1. Hatching success – an interim measure of the percentage of embryos hatched the day of the hatch inspection, or determined to have hatched based on the number of alevins present at the subsequent inspection, relative to the total number of embryos originally added;
2. Post-hatch survival - the percentage of organisms surviving at test termination relative to the number of embryos that hatched (these data help determine whether the majority of mortalities occurred pre- or post-hatch, or were distributed throughout the exposure period);
3. Cumulative survival - the percentage of surviving organisms at test termination relative to the number of embryos in each replicate at the beginning of the exposure;
4. Abnormality – the percentage of abnormal organisms at test termination relative to the number of surviving organisms;
5. Length – to the nearest 0.5 mm;
6. Weight – to the nearest 0.001 g.

3.0 QA/QC

The QA/QC program for the field exposure involved the following:

- Consistent field staff leader throughout all visits;
- Field documentation of all primary data; i.e., the names of individuals collecting the samples, sampling location, time of sampling, site conditions (e.g., degree of sedimentation), and other relevant observations, such as weather and any unusual conditions;
- Calibrated field meters;
- Use of pre-cleaned containers, with appropriate labels;
- Storing and transporting organisms in sealed containers in a cold, dark environment; cooling sample containers using ice or gel packs;
- Including transport controls to ascertain the extent of any transport-induced stress;
- Checking field organisms every week to monitor developmental progress, mortality and abnormality.

The QA/QC program for the laboratory portion of the study involved:

- Checks and maintenance of control organisms at regular intervals, including recording primary observations and water quality data on standardized data sheets;
- Review of datasheets by senior laboratory staff;
- Test termination activities (measurements, health assessment) conducted by qualified staff members using standardized datasheets to ensure consistent assessment of abnormalities and growth across all test sites and controls;
- Use of standard laboratory water and environmental chambers to maintain test organisms.

4.0 RESULTS

4.1 Fall 2021

4.1.1 Water Quality Measurements

Water quality measurements for the Fall 2021 monitoring event are summarized Table 1.

Table 1. Summary of mean, with (standard deviation) and [range], of water quality measurements collected during site visits and laboratory exposure (Fall 2021).

Creek	Temperature (°C)	Dissolved Oxygen (mg/L)	pH (units)	Specific Conductance (µS/cm)
Control	11.0 (1.0) [9.5 – 12.1]	8.3 (0.4) [7.7 – 9.2]	7.88 (0.13) [7.62 – 8.1]	296.3 (13.3) [275 - 315]
Miller Creek	9.9 (1.2) [9.0 – 11.1]	10.5 (0.4) [9.9 – 10.8]	7.33 (0.23) [7.21 – 7.66]	202.1 (74.4) [167.2 – 317.7]
Walker Creek	11.0 (1.0) [10.9 – 11.9]	10.0 (1.2) [8.7 – 11.5]	7.22 (0.14) [7.06 – 7.45]	213.0 (26.8) [212.0 – 238.8]
Des Moines Creek Lower	10.5 (1.4) [9.4 – 12.2]	9.1 (0.8) [8.4 – 10.0]	6.86 (0.19) [6.61 – 7.02]	120.2 (23.9) [105.3 – 156.7]
Des Moines Creek Upstream	10.5 (1.8) [9.2 – 12.8]	9.6 (0.9) [8.5 – 10.8]	6.83 (0.28) [6.53 – 7.01]	115.0 (31.1) [97.6 – 154.1]

In the Fall 2021 *in situ* tests, temperatures for the four field sites and the control ranged from 9.0 to 12.8°C. Field measurements of pH were within acceptable ranges for rainbow trout laboratory bioassays (6-9 pH units); the pH values were between 6.53 and 8.10. Dissolved oxygen (DO) measurements were within acceptable ranges (60 – 100% saturation); DO ranged from 7.7 to 11.5 mg/L.

Although limited to weekly measurements, the field temperature, DO and pH data suggested good water quality conditions overall, with no indication of potential for adverse effects on organism survival and development.

The conductivity measurements for all four sites did not show much variability throughout the exposure period and remained within ranges tolerated by early life stages of salmonids; measurements ranged between 98 and 318 µS/cm.

4.1.2 Precipitation and Field Observations During the Fall 2021 Event

Field observations during each site visit are presented in Table 2. Precipitation data were provided by STIA. Figure 5 shows the daily precipitation over the duration of the exposure, in conjunction with monitoring milestones and associated observations. A total of 12.82 inches of rainfall fell during the Fall event, with no snow. Hatchboxes were installed on October 19 and the first site visit was on October 27, with weekly site visits thereafter. Standard water quality conditions (temp, pH, and DO) at all sites were generally acceptable throughout the exposure.

At Miller Creek, leaf litter was observed on the bank and in the stream. During the first site visit on October 27, all remaining unhatched eggs in hatchbox 1, 2 and 3 were dead, with no surviving alevins in hatchbox 1, seventeen in hatchbox 2 and one in hatchbox 3; algae was present in hatchbox 3. On November 3, sediment was observed in hatchbox 2, with alevins buried; a worm was also observed in hatchbox 3. The following site visit on November 10, leaf litter and sand were coving all hatchboxes. During termination, sand was also noted on all hatchboxes.

During the first site visit at Walker Creek, eight flatworms were observed in hatchbox 4 and algae in the water. In the following visit, a small red worm was observed in hatchbox 3. On November 10, increased leaf litter was observed in the area. During termination, leaves were observed on hatchboxes 1 and 2 and heavy leaf litter observed in the area.

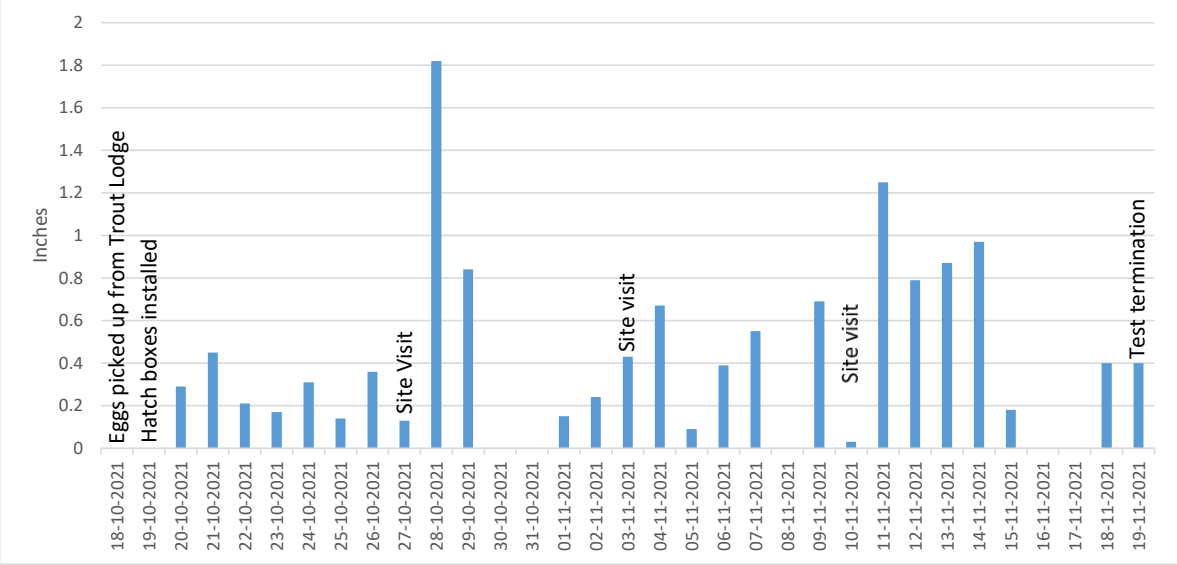
At the Des Moines Creek Lower site, a small amount of algae was observed on hatchbox 4 during the first site visit on October 27. Biofilm and iron associated bacterial growth coated hatchboxes 1 and 2 on November 3; sand was observed in hatchbox 3 and 4 and algae in hatchbox 3. On November 10, brown biofilm was observed on crate 1 and 2 and algae in hatchbox 4. Biological foam was observed in the stream. At termination, algae were present in all hatchboxes; leaf litter in hatchbox 2 and 4; and iron bacteria in hatchbox 2, 3 and 4. Foam was present in the stream.

At the Des Moines Upstream site, leaf litter was in the stream and anthropogenic waste was observed around the site on the initiation date of the test. Algae was present in the stream and on all hatch boxes during the following site visit on October 27, 2021; flatworms were also observed in hatchbox 1. On November 3, sand was observed in crates 1 and 4; leaf litter on crate 2 and some plastic insulation on crate 3. Algae was present on all crates. During the site visit on November 10, coarse sand was found in hatchbox 2 and 3 and algae in hatch box 1 and 4. Hatchbox 4 also had pine needles. During termination, hatchboxes 1, 2 and 4 had sand, leaves and/or branches covering the boxes.

Table 2. Observations made during the Fall 2021 exposure.

Site	Observations				
	October 19, 2021	October 27, 2021	November 3, 2021	November 10, 2021	November 19, 2021
Miller Creek	Leaf litter and branches on bank and stream	Algae present in water; all remaining eggs dead in hatchbox 1, 2 and 3	Sediment in crate and hatchbox 2; worm in hathbox 3; large amount of leaf litter on bank	Leaf litter and sand I hatchbox 2; leaf litter on bank and sand covering all hatchboxes	Sand on all crates and hatchboxes; stream is turbid, lots of down trees and branches
Walker Creek	Dense vegetation, leaf litter and plant debris on bank	Flatworms in hatchbox 4. Algae on alevins; algae in water	Red worm in hatchbox 2 and 3	Leaf litter on bank	Leaves on hatchbox 1 and 2; algae on hatchbox 2; heavy leaf litter on bank
Des Moines Lower	Lots of vegetation coverage on bank; minimal leaf litter	Algae on hatchbox 4	Biofilm and iron bacteria coating hatchbox; hatchbox 3; sand on/in hatchbox 3 and 4; leaf litter on bank	Brown biofilm on crate 1 and 2; algae in hatchbox 4; biological foam in stream	Algae on all hatchboxes; iron bacteria on hatchbox 2,3 and 4; leaves on hatchbox 2 and 4; lots of leaf litter and branches on bank; less foam in stream than previous week, near hatchbox 1
Des Moines Upstream	Leaf litter in stream; anthropogenic waste around site	Green algae present in water and on all hatchboxes; flatworm in hatchbox 1	Sand in crate 1 and 4; leaf litter on crate 2; plastic insulation on crate 3; green algae present on all crates	Algae coating hatchbox 3	Pine needles and sand in hatchbox 1; sand, leaf debris and branches covering hatchbox 2 and 4 and observed on bank

Figure 5. Daily rainfall during the Fall 2021 exposure.



4.1.3 Fall 2021 *In situ* exposure metrics

Data for the Fall sampling event are summarized in Tables 3 and 4, and are presented graphically in Figures 7 through 9.

Hatching success – Mean hatching success for the laboratory controls was 100%, compared with 39.2% at Miller Creek, 92.5% at Walker Creek, 87.5% at Des Moines Creek Lower, and 71.7% at Des Moines Creek Upstream. Significant differences in hatching success was observed at Miller Creek and Des Moines Creek Upstream in comparison to the control (Steel Many-One Rank Sum Test). There was no significant difference in hatching success between Des Moines Creek Lower compared to Des Moines Creek Upstream.

Post-hatch survival – Control survival of alevins post-hatch was 100%, compared with 57.0% at Miller Creek, 88.5% at Walker Creek, 91.9% at Des Moines Creek Lower, and 36.3% at Des Moines Creek Upstream. Post-hatch survival was significantly lower at Miller Creek and Des Moines Creek Upstream compared to the control (Bonferroni Adj t Test). There was a significant difference in post-hatch survival between Des Moines Creek Lower compared to Des Moines Creek Upstream, with the upstream site having lower survival.

Cumulative survival – Control survival from initiation to termination of the test averaged 100%. Cumulative survival at the exposure sites averaged 32.5% at Miller Creek, 82.5% at Walker Creek, 80.0% at Des Moines Creek Lower, and 26.7% at the Des Moines Creek Upstream site. Survival was significantly reduced relative to the controls at Miller Creek and Des Moines Creek Upstream (Dunnett Multiple Comparison Test). There was no significant difference in cumulative survival at Des Moines Creek Lower compared to Des Moines Creek Upstream.

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Abnormalities – There were few abnormalities observed across treatments: one occurred in Miller Creek and two at Des Moines Creek Lower. All the observed deformities were in the spine.

Growth – Average weight and length in the controls was 89.3 mg and 24.1 mm, respectively. Miller Creek fish averaged 110.2 mg and 24.6 mm, fish exposed at Walker Creek averaged 108.8 mg and 25.7 mm, Des Moines Creek Lower averaged 106.5 mg and 25.4 mm, and Des Moines Creek Upstream fish averaged 100.5 mg and 24.7 mm, for weight and length, respectively. No significance in either endpoint was observed when compared to the control (Bonferroni Adj t Test). There was no significant difference in either growth endpoints at Des Moines Creek Lower compared to Des Moines Creek Upstream.

Table 3. Hatching success, survival and abnormality in the control and field treatment groups (Fall 2021).

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	100 (0.0)	100 (0.0)	100 (0.0)	0.0 (0.0)
Miller Creek	39.2 (46.3)	57.0 (49.4)	32.5 (39.5)	2.2 (3.1)
Walker Creek	92.5 (8.8)	88.5 (10.4)	82.5 (16.6)	0.0 (0.0)
Des Moines Creek Lower	87.5 (14.5)	91.9 (7.6)	80.0 (12.5)	2.5 (2.8)
Des Moines Creek Upstream	71.7 (22.0)	36.3 (32.8)	26.7 (30.4)	0.0 (0.0)

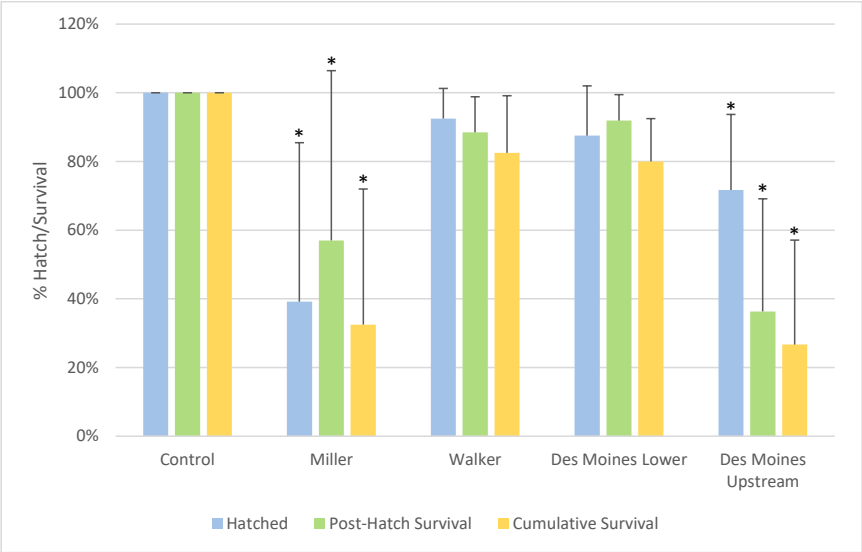
Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control

Table 4. Growth in the control and field treatment groups (Fall 2021).

Site	Length (mm)	Weight (mg)
Control	24.1 (0.9)	89.3 (2.7)
Miller Creek	24.6 (0.5)	110.2 (0.3)
Walker Creek	25.7 (0.3)	108.8 (2.9)
Des Moines Creek Lower	25.4 (0.4)	106.5 (2.6)
Des Moines Creek Upstream	24.7 (0.8)	100.5 (10.0)

Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control

Figure 6. Hatching success, post-hatch survival, and cumulative survival in the field and control treatment groups (Fall 2021).



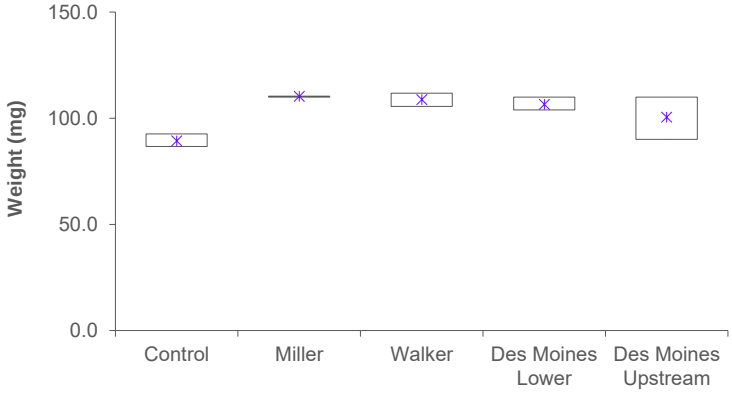
Error bars are standard deviations; asterisks denote significant difference from control.

Figure 7. Average lengths for the laboratory control and exposure sites (Fall 2021).



Data point is the average; box represents range of minimum to maximum values.

Figure 8. Average weights for the laboratory control and exposure sites (Fall 2021).



Data point is the average; box represents range of minimum to maximum values.

4.2 Spring 2022

4.2.1 Water Quality Measurements

Water quality measurements for the Spring 2022 monitoring event are summarized in Table 5.

Table 5. Summary of mean, with (standard deviation) and [range], of water quality measurements collected during site visits and laboratory exposure (Spring 2022).

Creek	Temperature (°C)	Dissolved Oxygen (mg/L)	pH (units)	Specific Conductance (µS/cm)
Control	9.7 (0.7) [8.9 – 11.9]	9.0 (0.3) [8.2 – 9.7]	7.86 (0.22) [7.1 – 8.2]	304.3 (23.7) [284 – 355]
Miller Creek	8.7 (1.1) [7.7 – 10.5]	11.4 (1.5) [9.7 – 13.5]	7.56 (0.35) [7.1 – 8.0]	257 (64.4) [154.8 – 327.9]
Walker Creek	10.3 (0.9) [9.3 – 11.6]	10.3 (1.2) [9.1 – 11.8]	7.41 (0.29) [7.0 – 7.7]	287.8 (21.7) [263.7 – 320.4]
Des Moines Creek Lower	10.2 (1.0) [9.4 – 11.9]	10.1 (0.7) [9.3 – 11.0]	7.04 (0.31) [6.6 – 7.4]	164.1 (20.5) [147.3 – 199.1]
Des Moines Creek Upstream	11.5 (1.6) [10.2 – 12.5]	10.4 (1.3) [9.7 – 12.1]	6.88 (0.41) [6.3 – 7.4]	152.3 (14.6) [147.6 – 175]

Temperatures among the four field sites and the control ranged from 7.7 to 12.5°C. Field measurements of pH were within acceptable ranges for rainbow trout laboratory bioassays (6-9 pH units); the pH values were between 6.3 and 8.2. Dissolved oxygen measurements were generally within acceptable ranges (80 – 100% saturation), although several readings during the test initiation and the third site visit indicated super-saturation of between 103 and 113%; dissolved oxygen ranged from 8.2 to 13.5 mg/L. Conductivity readings were similar at each site between each visit and ranged between 147 and 355 µS/cm.

The field temperature, dissolved oxygen and pH data suggested good water quality conditions overall, with limited indication of potential for adverse effects on organism survival and development. Supersaturation of dissolved oxygen recorded at Miller, Walker and Des Moines Creek Upstream on April 6 and Miller Creek on April 20 are unusual but would not be expected to cause adverse effects unless total gases were supersaturated.

4.2.2 Precipitation and Field Observations During the Spring 2022 Event

Field observations during each site visit are presented in Table 6. The daily rainfall for the duration of the Spring 2022 exposure is shown in Figure 9. The largest amount of rain (0.51 inches) was observed on April 30, 2022. A total of 2.58 of rain fell and no snow occurred during the exposure period. Hatchboxes were installed on April 6, 2022, with weekly site visits thereafter.

At Miller Creek, an earthworm was observed in the rocks in hatchbox 2 and mayflies in hatchbox 4 during the first site visit on April 12, 2022. A small amount of sedimentation was observed in hatchboxes at termination on May 4, 2022.

At Walker Creek, green algae was observed growing on the rocks and hatchboxes on April 12, 2022 and freshwater shrimp were found in hatchbox 2. The mesh screen on the bottom of hatchbox 3 was partially detached and the box was replaced to prevent loss of fish. During the following site visit on April 20, a small amount of algae was observed on hatchbox 2.

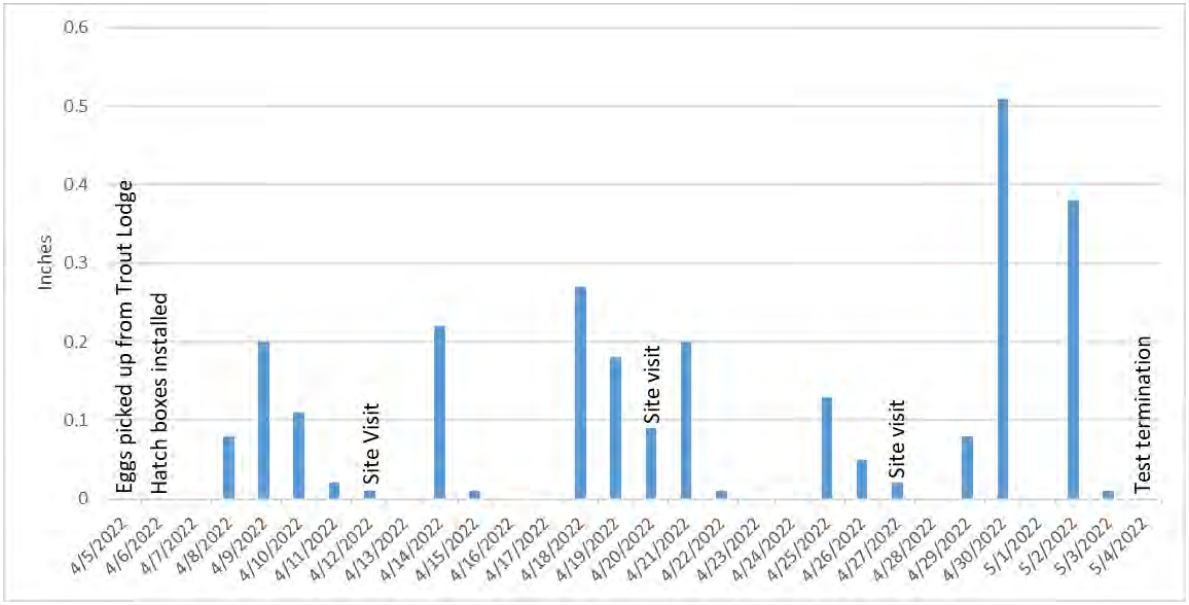
At Des Moines Lower, algal growth was observed in hatchboxes 1 and 2. A small amount of sediment was also observed in hatchbox 2. At termination, a foul odour was noted at the site for hatchboxes 1 and 2.

Brown algae was observed on the hatchboxes and in the water during the first site visit at Des Moines Upstream. During the following site visit on April 20, 2022, a plastic bag was removed from crate 1; a moderate amount of anthropogenic waste was also observed in the stream, including plastic bags and cigarette butts. On April 27 and May 4, algae was observed on all hatchboxes.

Table 6. Observations made during the Spring 2022 exposure.

Site	Observations				
	April 6, 2022	April 12, 2022	April 20, 2022	April 27, 2022	May 4, 2022
Miller Creek	Small amount of algal growth	Earthworm in rocks in hatchbox 2; mayflies in hatchbox 4	--	--	Some sedimentation in hatchboxes
Walker Creek	Small amount of algal growth	Green algae growing on rocks and hatchboxes; shrimp in hatchbox 2; hatchbox 3 not fully covered and replaced	Algae in hatchbox 2	--	Water clear
Des Moines Lower	No algal growth	Water very clear	Water very clear	Algae growth in hatchbox 1 and 2; a little sediment in hatchbox 2	Foul odour at site for hatchbox 1 and 2
Des Moines Upstream	Small amount of algal growth	Brown algae on hatchboxes and in water	Plastic bag on crate 1; moderate amount of anthropogenic waste in stream including plastic bags and cigarette butts	Algae in all hatchboxes	Algae in all hatchboxes

Figure 9. **Daily rainfall for the duration of the Spring 2022 exposure.**



4.2.3 Spring 2022 *In situ* exposure metrics

Data for the spring sampling event are summarized in Tables 7 and 8, and presented graphically in Figures 10 through 12.

Hatching success – Mean hatching success for the controls was 97.5%, compared with 95.0% at Miller Creek, 93.3% at Walker Creek, 99.2% at Des Moines Creek Lower and 90.8% at Des Moines Creek Upstream. There was no significant difference in hatching success at any site compared to the control (Dunnett Multiple Comparison Test). There was no significant difference in hatching success at Des Moines Lower compared to Des Moines Creek Upstream.

Post-hatch survival – Control survival of alevins post-hatch was 99.2%, compared with 96.5% at Miller Creek, 96.4% at Walker Creek, 95.8% at Des Moines Creek Lower, and 67.1% at Des Moines Upstream. A significant difference was observed at Des Moines Creek Upstream compared to the control (Dunnett Multiple Comparison Test); a significant difference was also observed between Des Moines Creek Lower and Upstream.

Cumulative survival – Control survival from initiation of the test to termination averaged 96.7%, compared with 91.7% at Miller Creek, 90.0% at Walker Creek, 95.0% at Des Moines Creek Lower, and 60.8% at Des Moines Creek Upstream. There was a significant difference at Des Moines Creek Upstream compared to the control (Dunnett Multiple Comparison Test) and a significant difference in cumulative survival between Des Moines Lower and Des Moines Creek Upstream.

Abnormalities – There were few abnormalities observed across treatments, with three in the control and one each in Miller Creek, Des Moines Creek Lower and Des Moines Creek Upstream. The abnormality of the fish in the control and Des Moines Creek Upstream were located in the spine, and the abnormality observed at Miller Creek was in the head.

Growth – Average weight in the controls was 101.9 mg, and length averaged 23.7 mm. In comparison, Miller Creek fish averaged 131.6 mg and 26.1 mm, fish from Walker Creek averaged 140.9 mg and 27.4 mm, fish exposed at Des Moines Creek Lower averaged 134.7 mg and 26.4 mm and fish from Des Moines Creek Upstream average 135.4 mg and 26.7 mm. Neither weight nor length were significantly lower than the control at any sites (Dunnett Multiple Comparison Test). There was also no significant difference in length or weight between Des Moines Lower and Des Moines Creek Upstream.

Table 7. Hatching success, survival and abnormality in the control and field treatment groups (Spring 2022).

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	97.5 (3.2)	99.2 (1.7)	96.7 (2.7)	2.6 (3.2)
Miller Creek	95.0 (1.9)	96.5 (2.9)	91.7 (4.3)	0.9 (1.8)
Walker Creek	93.3 (6.1)	96.4 (2.7)	90.0 (6.1)	0.0 (0.0)
Des Moines Creek Lower	99.2 (1.7)	95.8 (6.3)	95.0 (5.8)	0.9 (1.7)
Des Moines Upstream	90.8 (7.4)	67.1 (23.6)	60.8 (20.4)	2.3 (4.6)

Notes:

1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control

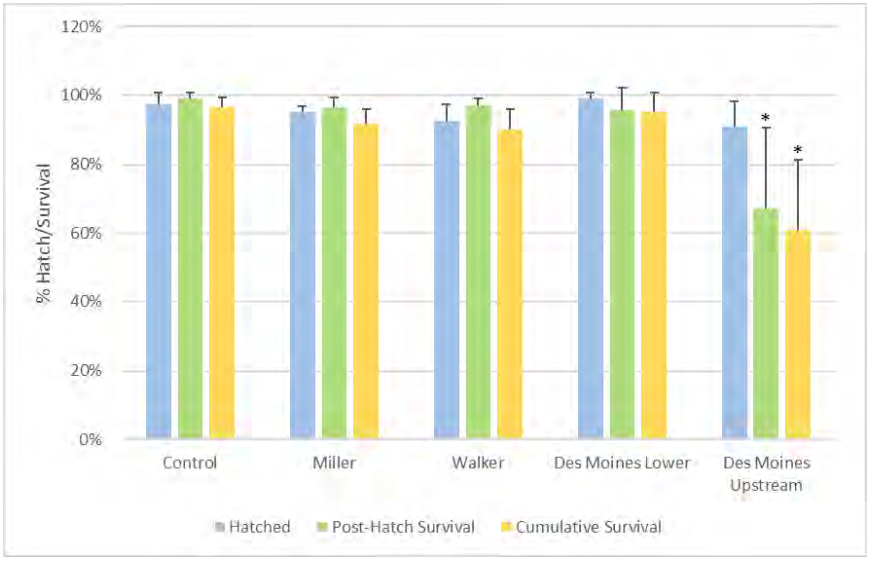
Table 8. Growth in the control and field treatment groups (Spring 2022).

Site	Length (mm)	Weight (mg)
Control	23.7 (0.7)	101.9 (6.6)
Miller Creek	26.1 (0.4)	131.6 (0.9)
Walker Creek	27.4 (0.4)	140.9 (7.6)
Des Moines Creek Lower	26.4 (0.5)	134.7 (6.2)
Des Moines Upstream	26.7 (0.4)	135.4 (5.1)

Notes:

1. Results are presented as mean and standard deviation

Figure 10. Hatching success, post-hatch survival, and cumulative survival in the field and control treatment groups (Spring 2022).



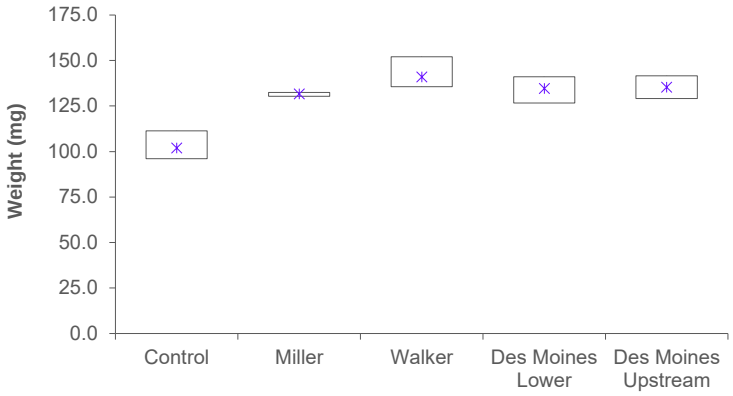
Error bars are standard deviations.

Figure 11. Average lengths for the laboratory control and exposure sites (Spring 2022).



Data point is the average; box represents range of minimum to maximum values.

Figure 12. Average weights for the laboratory control and exposure sites (Spring 2022).



Data point is the average; box represents range of minimum to maximum values.

5.0 DISCUSSION

There were only adverse effects associated with lethal measurements, such as hatching success and survival for alevins exposed in Miller Creek and Des Moines Creek Upstream during the Fall event and at Des Moines Creek Upstream during the Spring event. A statistically significant reduction in survival was observed in Miller Creek during the Fall event and in Des Moines Creek Upstream in both test events. Respectively, during the fall period there was a 60.8 and 28.3% reduction in hatching success and a 43 and 63.7% reduction in post-hatch survival relative to the laboratory control. At the remaining sites during the Fall event, survival was high (≥80%). With the exception of Des Moines Creek Upstream, post-hatch survival was high during the Spring event (≥90%); there was a 32.9% reduction in post-hatch survival at Des Moines Upstream relative to the laboratory control.

Results for cumulative survival, incorporating both effects on hatch rate and survival post hatch, provided the best measure of adverse effects in the *in situ* exposures reported here. In the Fall 2021 event, cumulative survival in the exposure sites ranged from 26.7 to 82.5%, and was significantly decreased at Miller (32.5%) and Des Moines Creek Upstream (26.7%) compared to the control (100% survival).

A high degree of egg and embryo mortality at Miller Creek and Des Moines was observed with the first site visit on October 27, 2021 during the Fall event, contributing to low cumulative survival numbers. Water quality measurements during the site visit were within acceptable ranges; therefore, the cause of mortality cannot be determined as water quality impairments, although observations are limited to the weekly site visits. No signs of predation or sedimentation were observed; however, a high degree of algae accumulation was observed within the hatchboxes at these locations during the initial visit and may have caused high mortality. Low overall cumulative survival through the remaining study period was likely impacted by a combination of high stream flows and sedimentation loads. Total rainfall through the 31 day fall study period was 12.82 inches, which is significantly higher than the Port's recorded long term monthly rainfall averages for October (4.24 inches) and November (6.36 inches). Both the overall volume and the moderate-high intensity of rainfall events throughout the study period lead to elevated streamflow conditions capable of carrying above average loads of late summer algae and sediment.

In the Spring 2021 event, cumulative survival ranged from 60.8 to 95.0% across the sites, compared with 96.7% in the control, with only Des Moines Creek Upstream being significantly lower than the control.

Of note, significant adverse effects were observed in both Fall 2021 and Spring 2022 events at the Des Moines Creek Upstream site, with reduced post-hatch survival and cumulative survival during both Fall and Spring events, and reduced hatching success in the Fall. With the exception of the Spring 2015 (Nautilus Environmental 2015), Spring 2018 (Nautilus Environmental 2018) and the Spring 2020 (Nautilus Environmental 2020) testing events, Des Moines Upstream has generally exhibited evidence of adverse effects, suggesting an ongoing pattern of impaired water quality upstream of STIA inputs, including anthropogenic waste often being observed at the site or in the creek.

In general, creek conditions and water quality parameters remained within suitable ranges for the duration of the both testing events and were unlikely to have contributed to any adverse effects observed. However, some exceedances were notable, including dissolved oxygen measurements that exceeded saturation during the Spring 2022 event. Elevated levels of total dissolved gas (TDG), which includes dissolved oxygen, can be harmful to salmonids (Carter 2008), and USEPA (1986) has set a criterion for TDG stating that levels should not exceed 110% of saturation. In most instances during the Spring event, dissolved oxygen was ≤110% saturation, and it is unknown if the supersaturated oxygen resulted in supersaturated TDG or not.

6.0 REFERENCES

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APPENDIX B
STATUS OF DESIGNATED CRITICAL HABITAT: BULL TROUT

Appendix B
Status of Designated Critical Habitat: Bull Trout

Past designations of critical habitat have used the terms "primary constituent elements" (PCEs), “physical and biological features” (PBFs) or "essential features" to characterize the key components of critical habitat that provide for the conservation of the listed species. The new critical habitat regulations (81 FR 7214) discontinue use of the terms “PCEs” or “essential features” and rely exclusively on use of the term PBFs for that purpose because that term is contained in the statute. To be consistent with that shift in terminology and in recognition that the terms PBFs, PCEs, and essential habit features are synonymous in meaning, we are only referring to PBFs herein. Therefore, if a past critical habitat designation defined essential habitat features or PCEs, they will be referred to as PBFs in this document. This does not change the approach outlined above for conducting the ‘‘destruction or adverse modification’’ analysis, which is the same regardless of whether the original designation identified PCEs, PBFs or essential features.

Current Legal Status of the Critical Habitat

Current Designation

The U.S. Fish and Wildlife Service (Service) published a final critical habitat designation for the coterminous United States population of the bull trout on October 18, 2010 (USFWS 2010, entire); the rule became effective on November 17, 2010. A justification document was also developed to support the rule and is available on the Service’s website: (http://www.fws.gov/pacific/bulltrout). The scope of the designation involved the species’ coterminous range, which includes the Coastal, Klamath, Mid-Columbia, Upper Snake, Columbia Headwaters and St. Mary’s Recovery Unit population segments. Rangewide, the Service designated reservoirs/lakes and stream/shoreline miles as bull trout critical habitat (Table 1). Designated bull trout critical habitat is of two primary use types: 1) spawning and rearing, and 2) foraging, migration, and overwintering (FMO).

Table 1. Stream/Shoreline Distance and Reservoir/Lake Area Designated as Bull Trout Critical Habitat.

State	Stream/Shoreline Miles	Stream/Shoreline Kilometers	Reservoir/ Lake Acres	Reservoir/ Lake Hectares
Idaho	8,771.6	14,116.5	170,217.5	68,884.9
Montana	3,056.5	4,918.9	221,470.7	89,626.4
Nevada	71.8	115.6	-	-
Oregon[1]	2,835.9	4,563.9	30,255.5	12,244.0
Oregon/Idaho[2]	107.7	173.3	-	-
Washington	3,793.3	6,104.8	66,308.1	26,834.0
Washington (marine)	753.8	1,213.2	-	-
Washington/Idaho	37.2	59.9	-	-
Washington/Oregon	301.3	484.8	-	-
Total[3]	19,729.0	31,750.8	488,251.7	197,589.2

[1] No shore line is included in Oregon
[2] Pine Creek Drainage which falls within Oregon
[3] Total of freshwater streams: 18,975

The 2010 revision increases the amount of designated bull trout critical habitat by approximately 76 percent for miles of stream/shoreline and by approximately 71 percent for acres of lakes and reservoirs compared to the 2005 designation.

The final rule also identifies and designates as critical habitat approximately 1,323.7 km (822.5 miles) of streams/shorelines and 6,758.8 ha (16,701.3 acres) of lakes/reservoirs of unoccupied habitat to address bull trout conservation needs in specific geographic areas in several areas not occupied at the time of listing. No unoccupied habitat was included in the 2005 designation. These unoccupied areas were determined by the Service to be essential for restoring functioning migratory bull trout populations based on currently available scientific information. These unoccupied areas often include lower main stem river environments that can provide seasonally important migration habitat for bull trout. This type of habitat is essential in areas where bull trout habitat and population loss over time necessitates reestablishing bull trout in currently unoccupied habitat areas to achieve recovery.

The final rule continues to exclude some critical habitat segments based on a careful balancing of the benefits of inclusion versus the benefits of exclusion. Critical habitat does not include: 1) waters adjacent to non-Federal lands covered by legally operative incidental take permits for habitat conservation plans (HCPs) issued under section 10(a)(1)(B) of the Endangered Species Act of 1973, as amended (Act), in which bull trout is a covered species on or before the publication of this final rule; 2) waters within or adjacent to Tribal lands subject to certain commitments to conserve bull trout or a conservation program that provides aquatic resource protection and restoration through collaborative efforts, and where the Tribes indicated that inclusion would impair their relationship with the Service; or 3) waters where impacts to national security have been identified (USFWS 2010, p. 63903). Excluded areas are approximately 10 percent of the stream/shoreline miles and 4 percent of the lakes and reservoir acreage of designated critical habitat. Each excluded area is identified in the relevant Critical Habitat Unit

(CHU) text, as identified in paragraphs (e)(8) through (e)(41) of the final rule. It is important to note that the exclusion of waterbodies from designated critical habitat does not negate or diminish their importance for bull trout conservation. Because exclusions reflect the often complex pattern of land ownership, designated critical habitat is often fragmented and interspersed with excluded stream segments.

The Physical and Biological Features

Conservation Role and Description of Critical Habitat

The conservation role of bull trout critical habitat is to support viable core area populations (USFWS 2010, p. 63898). The core areas reflect the metapopulation structure of bull trout and are the closest approximation of a biologically functioning unit for the purposes of recovery planning and risk analyses. CHUs generally encompass one or more core areas and may include FMO areas, outside of core areas, that are important to the survival and recovery of bull trout.

Thirty-two CHUs within the geographical area occupied by the species at the time of listing are designated under the revised rule. Twenty-nine of the CHUs contain all of the physical or biological features identified in this final rule and support multiple life-history requirements. Three of the mainstem river units in the Columbia and Snake River Basins contain most of the physical or biological features necessary to support the bull trout's particular use of that habitat, other than those physical biological features associated with physical and biological features (PBFs) 5 and 6, which relate to breeding habitat.

The primary function of individual CHUs is to maintain and support core areas, which 1) contain bull trout populations with the demographic characteristics needed to ensure their persistence and contain the habitat needed to sustain those characteristics (Rieman and McIntyre 1993, p. 19); 2) provide for persistence of strong local populations, in part, by providing habitat conditions that encourage movement of migratory fish (MBTSG 1998, pp. 48-49; Rieman and McIntyre 1993, pp. 22-23); 3) are large enough to incorporate genetic and phenotypic diversity, but small enough to ensure connectivity between populations (Hard 1995, pp. 314-315; Healey and Prince 1995, p. 182; MBTSG 1998, pp. 48-49; Rieman and McIntyre 1993, pp. 22-23); and 4) are distributed throughout the historic range of the species to preserve both genetic and phenotypic adaptations (Hard 1995, pp. 321-322; MBTSG 1998, pp. 13-16; Rieman and Allendorf 2001, p. 763; Rieman and McIntyre 1993, p. 23).

Physical and Biological Features for Bull Trout

Within the designated critical habitat areas, the PBFs for bull trout are those habitat components that are essential for the primary biological needs of foraging, reproducing, rearing of young, dispersal, genetic exchange, or sheltering. Based on our current knowledge of the life history, biology, and ecology of this species and the characteristics of the habitat necessary to sustain its essential life-history functions, we have determined that the PBFs, as described within USFWS 2010, are essential for the conservation of bull trout. A summary of those PBFs follows.

1. Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

2. Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.
3. An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.
4. Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.
5. Water temperatures ranging from 2 °C to 15 °C, with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.
6. In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount of fine sediment, generally ranging in size from silt to coarse sand, embedded in larger substrates, is characteristic of these conditions. The size and amounts of fine sediment suitable to bull trout will likely vary from system to system.
7. A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.
8. Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.
9. Sufficiently low levels of occurrence of non-native predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

The revised PBF's are similar to those previously in effect under the 2005 designation. The most significant modification is the addition of a ninth PBF to address the presence of nonnative predatory or competitive fish species. Although this PBF applies to both the freshwater and marine environments, currently no non-native fish species are of concern in the marine environment, though this could change in the future.

Note that only PBFs 2, 3, 4, 5, and 8 apply to marine nearshore waters identified as critical habitat. Also, lakes and reservoirs within the CHUs also contain most of the physical or biological features necessary to support bull trout, with the exception of those associated with PBFs 1 and 6. Additionally, all except PBF 6 apply to FMO habitat designated as critical habitat.

Critical habitat includes the stream channels within the designated stream reaches and has a lateral extent as defined by the bankfull elevation on one bank to the bankfull elevation on the opposite bank. Bankfull elevation is the level at which water begins to leave the channel and move into the floodplain and is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series. If bankfull elevation is not evident on either bank, the ordinary high-water line must be used to determine the lateral extent of critical habitat. The lateral extent of designated lakes is defined by the perimeter of the waterbody as mapped on standard 1:24,000 scale topographic maps. The Service assumes in many cases this is the full-pool level of the waterbody. In areas where only one side of the waterbody is designated (where only one side is excluded), the mid-line of the waterbody represents the lateral extent of critical habitat.

In marine nearshore areas, the inshore extent of critical habitat is the mean higher high-water (MHHW) line, including the uppermost reach of the saltwater wedge within tidally influenced freshwater heads of estuaries. The MHHW line refers to the average of all the higher high-water heights of the two daily tidal levels. Marine critical habitat extends offshore to the depth of 10 meters (m) (33 ft) relative to the mean low low-water (MLLW) line (zero tidal level or average of all the lower low-water heights of the two daily tidal levels). This area between the MHHW line and minus 10 m MLLW line (the average extent of the photic zone) is considered the habitat most consistently used by bull trout in marine waters based on known use, forage fish availability, and ongoing migration studies and captures geological and ecological processes important to maintaining these habitats. This area contains essential foraging habitat and migration corridors such as estuaries, bays, inlets, shallow subtidal areas, and intertidal flats.

Adjacent shoreline riparian areas, bluffs, and uplands are not designated as critical habitat. However, it should be recognized that the quality of marine and freshwater habitat along streams, lakes, and shorelines is intrinsically related to the character of these adjacent features, and that human activities that occur outside of the designated critical habitat can have major effects on physical and biological features of the aquatic environment.

Activities that cause adverse effects to critical habitat are evaluated to determine if they are likely to "destroy or adversely modify" critical habitat by no longer serving the intended conservation role for the species or retaining those PBFs that relate to the ability of the area to at least periodically support the species. Activities that may destroy or adversely modify critical habitat are those that alter the PBFs to such an extent that the conservation value of critical habitat is appreciably reduced (USFWS 2010, pp. 63898:63943; USFWS 2004a, pp. 140-193; USFWS 2004b, pp. 69-114). The Service's evaluation must be conducted at the scale of the entire critical habitat area designated, unless otherwise stated in the final critical habitat rule (USFWS and NMFS 1998, Ch. 4 p. 39). Thus, adverse modification of bull trout critical habitat is evaluated at the scale of the final designation, which includes the critical habitat designated for the Klamath River, Jarbidge River, Columbia River, Coastal-Puget Sound, and Saint Mary-Belly River population segments. However, we consider all 32 CHUs to contain features or areas essential to the conservation of the bull trout (USFWS 2010, pp. 63898:63901, 63944). Therefore, if a proposed action would alter the physical or biological features of critical habitat to an extent that appreciably reduces the conservation function of one or more critical habitat units for bull trout, a finding of adverse modification of the entire designated critical habitat area may be warranted (USFWS 2010, pp. 63898:63943).

Current Critical Habitat Condition Rangewide

The condition of bull trout critical habitat varies across its range from poor to good. Although still relatively widely distributed across its historic range, the bull trout occurs in low numbers in many areas, and populations are considered depressed or declining across much of its range (Ratliff and Howell 1992, entire; Schill 1992, p. 40; Thomas 1992, p. 28; Buchanan et al. 1997, p. vii; Rieman et al. 1997, pp. 15-16; Quigley and Arbelbide 1997, pp. 1176-1177). This condition reflects the condition of bull trout habitat. The decline of bull trout is primarily due to habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, past fisheries management practices, impoundments, dams, water diversions, and the introduction of nonnative species (USFWS 1998, pp. 31648-31649; USFWS 1999, p. 17111).

There is widespread agreement in the scientific literature that many factors related to human activities have impacted bull trout and their habitat, and continue to do so. Among the many factors that contribute to degraded PBFs, those which appear to be particularly significant and have resulted in a legacy of degraded habitat conditions are as follows: 1) fragmentation and isolation of local populations due to the proliferation of dams and water diversions that have eliminated habitat, altered water flow and temperature regimes, and impeded migratory movements (Dunham and Rieman 1999, p. 652; Rieman and McIntyre 1993, p. 7); 2) degradation of spawning and rearing habitat and upper watershed areas, particularly alterations in sedimentation rates and water temperature, resulting from forest and rangeland practices and intensive development of roads (Fraley and Shepard 1989, p. 141; MBTSG 1998, pp. ii - v, 20-45); 3) the introduction and spread of nonnative fish species, particularly brook trout and lake trout, as a result of fish stocking and degraded habitat conditions, which compete with bull trout for limited resources and, in the case of brook trout, hybridize with bull trout (Leary et al. 1993, p. 857; Rieman et al. 2006, pp. 73-76); 4) in the Coastal-Puget Sound region where amphidromous bull trout occur, degradation of mainstem river FMO habitat, and the degradation and loss of marine nearshore foraging and migration habitat due to urban and residential development; and 5) degradation of FMO habitat resulting from reduced prey base, roads, agriculture, development, and dams.

Effects of Climate Change on Bull Trout Critical Habitat

One objective of the final rule was to identify and protect those habitats that provide resiliency for bull trout use in the face of climate change. Over a period of decades, climate change may directly threaten the integrity of the essential physical or biological features described in PBFs 1, 2, 3, 5, 7, 8, and 9. Protecting bull trout strongholds and cold water refugia from disturbance and ensuring connectivity among populations were important considerations in addressing this potential impact. Additionally, climate change may exacerbate habitat degradation impacts both physically (e.g., decreased base flows, increased water temperatures) and biologically (e.g., increased competition with non-native fishes).

Many of the PBFs for bull trout may be affected by the presence of toxics and/or increased water temperatures within the environment. The effects will vary greatly depending on a number of factors which include which toxic substance is present, the amount of temperature increase, the likelihood that critical habitat would be affected (probability), and the severity and intensity of any effects that might occur (magnitude).

The ability to assign the effects of gradual global climate change bull trout critical habitat or to a specific location on the ground is beyond our technical capabilities at this time.

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Appendix C: Bull Trout Core Area Summaries

In 2015, the Puget Sound Geographic Region had three core areas that were considered Bull trout population strongholds, the Lower Skagit River, Upper Skagit River, and Chilliwack River Core Areas, and two core areas, the Puyallup River and Stillaguamish River Core Areas, that were identified as having small population sizes (USFWS 2015a, p. A-27). Some core areas have long-term data that can be used to provide information on the status of bull trout, with that information potentially extrapolated to other core areas when information is lacking. Bull trout within individual core areas within the CRU are monitored or surveyed at different levels and frequency. Based on bull trout monitoring surveys through 2019, the Puget Sound Geographic Region of the CRU is showing unstable and declining bull trout numbers in several core areas.

Table 1. Bull trout demographics for the Lower Skagit River, Stillaguamish River, Snohomish/Skykomish River, and the Puyallup River Core Areas (USFWS 2024b).

Core Area	Number of Local Populations	Core Area Trend (Declining/Stable)	Estimated Adult Breeding Population
Lower Skagit River	20	Declining	Greater Than 1000
Stillaguamish River	3	Declining	51-100
Snohomish/ Skykomish River	4	Declining	501-1000
Puyallup River	4	Stable	101-500

7.1.1 Snohomish/Skykomish River Core Area

The Snohomish/Skykomish River Core Area comprises the Snohomish, Skykomish, and Snoqualmie Rivers and their tributaries. Bull trout occur throughout the Snohomish River system downstream of barriers to anadromous fish. Bull trout are not known to occur upstream of Snoqualmie Falls, upstream of Spada Lake on the Sultan River, in the upper forks of the Tolt River, above Deer Falls on the North Fork Skykomish River, or above Alpine Falls on the Tye River. Fluvial, resident, and anadromous life history forms of bull trout occur in the Snohomish Skykomish River Core Area. A large portion of the migratory segment of this population is anadromous.

Four local populations are recognized within the Snohomish/Skykomish River Core Area (USFWS 2004, pp. 99-105; USFWS 2015b, p. A-14): (1) North Fork Skykomish River (including Goblin and West Cady Creeks); (2) Troublesome Creek (resident form only); (3) Salmon Creek; and (4) South Fork Skykomish River. Based on redd counts and number of adults passed over Sunset Falls (85 percent decline since 2006), trend information for bull trout in the Snohomish/Skykomish River Core Area also appears to be declining. The Snohomish/Skykomish River Core Area probably supports between 500 adults and 1,000 adults.

In 2008, it was believed that this core area supported just over 1,000 adults (USFWS 2008a, p. 2; USFWS 2008b, p. 35). However, abundance indices in the two primary local populations (North Fork Skykomish River and South Fork Skykomish River) have substantially declined since then (WDFW 2015c).

The Service (2015b, pp. A-14) identified four primary threats to bull trout in the Snohomish/ Skykomish River Core Area: Flood Control, Recreational Mining, Residential Development and Urbanization and Fish Passage Issues. As with other Puget Sound core areas, impacts to forage base and marine nearshore habitat likely significantly reduce fitness and resiliency of individual bull trout given the high frequency of anadromy in this core area. The Service expects a small percentage of the adult population in the Snohomish/Skykomish River Core Area may be distributed throughout the action area.

7.1.2 Puyallup River Core Area

The Puyallup River Core Area comprises the Puyallup, Mowich, and Carbon Rivers; the White River system, which includes the Clearwater, Greenwater, and the West Fork White Rivers; and Huckleberry Creek. Glacial sources in several watersheds drain the north and west sides of Mount Rainier and significantly influence water, substrate, and channel conditions in the mainstem reaches. The location of many of the basin's headwater reaches within Mount Rainier National Park and designated wilderness areas (Clearwater Wilderness, Norse Peak Wilderness) provides relatively pristine habitat conditions in these portions of the watershed. Anadromous, fluvial, and potentially resident bull trout occur within local populations in the Puyallup River system. Anadromous and fluvial bull trout use the mainstem reaches of the Puyallup, Carbon, and White Rivers to forage and overwinter, while the anadromous form also uses Commencement Bay and likely other nearshore areas within south Puget Sound.

Five local populations occur in the Puyallup River Core Area: (1) Upper Puyallup and Mowich Rivers; (2) Carbon River; (3) Upper White River; (4) West Fork White River; and (5) Greenwater River. The Puyallup River Core Area, considered to have small population numbers has had increased numbers of bull trout passed over Mud Mountain Dam since 2008 and an increase in bull trout redd numbers. In recent years, substantial efforts by the Puyallup Tribe and others have occurred to document abundance and movements of bull trout in the Puyallup River Core Area (Marks et al. 2019, 2020; Johnson 2021). Currently, fewer than 100 adults probably occur in each of the local populations in the White River system, based on adult counts at Mud Mountain Dam's Buckley Diversion fish trap and redd counts. Overall, the Service estimates that the total population of adult breeding bull trout in the Puyallup River Core Area is between 100-500 individuals.

Several primary threats were identified in the Puyallup River Core Area (USFWS 2015b, p. A-16) including:

- Extensive past and ongoing timber harvest and harvest-related activities;
- Agricultural practices, such as bank armoring, riparian clearing, and non-point discharges of chemical applications;
- Dams and diversions affecting migratory corridors;
- Nonnative species such as brook trout within spawning areas; and,
- Degraded water quality due to municipal and industrial effluent discharges in marine, estuarine, and river migratory and foraging habitat.

Water quality and impacts to nearshore foraging areas in South Puget Sound likely limit the resiliency of anadromous bull trout from the Puyallup River Core Area and bull trout from this core area are expected to be well distributed throughout the action area looking for quality foraging areas. The Service expects all anadromous adult and subadult bull trout from the Puyallup River Core Area will pass through the Port of Tacoma as the Puyallup River drains into that portion of the action area. We expect a large proportion to also use the Port of Seattle, though slightly less given the distance to the Puyallup River.

7.1.3 Lower Skagit River Core Area

The Lower Skagit River Core Area comprises the Skagit basin downstream of Seattle City Light's Gorge Dam, including the mainstem Skagit River and the Cascade, Sauk, Suiattle, White Chuck, and Baker Rivers, including the reservoirs (Baker Lake, Lake Shannon) upstream of upper and lower Baker Dams. Twenty local populations are recognized within the Lower Skagit River Core Area (USFWS 2015b, p. A-148). Bull trout occur throughout the Lower Skagit core and express fluvial, adfluvial, resident, and anadromous life history forms. Many subadult and adult bull trout use the lower river, estuary, and nearshore marine areas extensively for rearing and foraging. Key spawning and early rearing habitat, found in the upper portions of much of the basin, is generally on federally protected lands, including the North Cascades National Park, North Cascades National Recreation Area, Glacier Peak Wilderness, and Henry M. Jackson Wilderness Area.

The Lower Skagit River Core Area is believed to contain the largest spawning population of bull trout in Washington. Adult abundance is estimated to be between 5,000 individuals and 10,000 individuals based on partial spawner survey data from less than half of the core area (USFWS 2008a, p. 3). Bull trout redd counts have been conducted since 2002 in the Lower Skagit River Core Area. Peak number of redds occurred in 2006 (855 redds) and 2014 (1,010 redds). Between 2015 and 2019, the number of bull trout redds has decreased to the lowest number (175 redds observed in 2019) since 2002. Similarly, the 5-year mean shows a decline in bull trout redd numbers between 2014 and 2019. Redd numbers have decreased in most streams, with lowest numbers being found in Illabot Creek (7 redds), SF Sauk River (20 redds), and Downey Creek (21 redds). Based on these data sets, while habitat quality is relatively good across the core area, bull trout abundance appears to be declining (McKinney et al. 2022 p. 2). With the decrease in redd numbers in the Lower Skagit River Core Area, a similar decrease has been observed in captures of

juvenile bull trout in the lower Skagit River screw traps (WDFW 2011, 2012, 2013, 2014, 2015a, 2016, 2017, 2018, 2019a, 2020, and 2021).

The Baker River Hydroelectric Facility captures adult bull trout for transportation above the dams as well as juvenile bull trout for downstream passage. Upstream passage of adult bull trout has declined from 2015 to 2019, but the low number transported in 2019 (10 adults) is similar to those transported upstream in 2006 and 2007 (PSE 2019, 2020). Downstream captures of juveniles at Upper Baker Reservoir have also declined from 2015 (129 juveniles) to 2019 (32 juveniles), but juvenile numbers captured in Lower Baker Reservoir had the second highest captured in 2018 (28 juveniles) since 2003 (PSE 2019, 2020). In 2015, 81 juvenile bull trout were captured in Lower Baker Reservoir. The Lower Skagit River Core Area was considered a bull trout stronghold, but redd numbers, screw trap numbers, and observations of adult bull trout during spawning surveys, all indicated a downward trend in bull trout abundance.

There are five primary threats to bull trout in the Lower Skagit River Core Area (USFWS 2015b, pp. A- 11 to A-12): Legacy Forest Management; Flood Control; Agriculture Practices and Residential Development and Urbanization; Climate Change; and Fish Passage Issues. Similar to the Nooksack, impacts to estuarine nearshore foraging habitats and declines in forage fish species, particularly surf smelt and Pacific herring, in the marine nearshore areas of the Salish Sea (Therriault et al. 2009; Greene et al. 2015) likely limit the resiliency and fitness of the anadromous life history form. Declines in abundance of anadromous salmonids have reduced the bull trout forage base and may limit the abundance and productivity of the core area's bull trout populations (USFWS 2008a, p. 15).

Anadromous salmonids are vital to Lower Skagit River Core Area bull trout because they provide an abundant forage resource. However, the abundance of many species of anadromous salmonids in the Lower Skagit River Core Area has been in decline for a decade (chum salmon, O. keta) or more (Chinook salmon, *O. tshawytscha*, and steelhead trout, *O. mykiss*) (WDFW 2015c). Bull trout abundance and growth rates are positively correlated with abundance of spawning anadromous salmonids in the Lower Skagit River Core Area (Kraemer 2003, pp. 5, 9-10; Zimmerman and Kinsel 2010, pp. 26, 30) and elsewhere (Copeland and Meyer 2011, pp. 937-938).

Given the correlation of declining bull trout numbers and declining salmon numbers in the Lower Skagit River Core Area, there is strong evidence that a large portion of the population exhibits anadromy. Therefore, the Service expects up to 1,000 adult and subadult bull trout individuals may be in the Puget Sound during the year. We expect these individuals will be primarily distributed broadly throughout northern Puget Sound and in the Skagit River Estuary, with a very small percentage that will forage and migrate down into the action area.

7.1.4 Stillaguamish River Core Area

The Stillaguamish River Core Area is comprised of the Stillaguamish River basin, including the North Fork and South Fork Stillaguamish Rivers and their tributaries. Three local populations are recognized within the Stillaguamish River Core Area: (1) Upper Deer Creek; (2) South Fork Stillaguamish River; and (3) Canyon Creek. These local populations are relatively well-distributed throughout the core area. The Upper Deer Creek local population may be extirpated (USFWS 2015, p. A-13), based on the paucity of historical observations of bull trout and more recent failures to detect bull trout. Bull trout in the Stillaguamish River Core Area primarily consist of the anadromous and fluvial life-history forms (USFWS 2004, p. 96). Resident bull trout occur in the upper South Fork Stillaguamish River (USFWS 2004, p. 98; USFWS 2008a, p. 1) and possibly also upstream of the anadromous barrier on Higgins Creek (USFWS 2008a, p. 3).

The Stillaguamish River Core Area likely contains fewer than 1000 adults, however survey data is limited and origin of fish observed in the former North Fork Stillaguamish River local population is uncertain. Extremely low numbers of bull trout redds were observed between 2017 and 2019. The Stillaguamish River is identified as having low population abundance and has had only one bull trout redd identified between 2016 and 2019. In 2014 and 2015, ten bull trout redds were found in the Stillaguamish River. The highest number of bull trout redds were found in 2006 with 67 redds, and in 2008 with 64 redds. Bull trout redd numbers within the Stillaguamish River have always been low, with less than 30 redds occurring 12 times between 2002 and 2019. Bull trout abundance within the Stillaguamish River Core Area is inferred to be extremely low based on redd counts.

Six primary threats to bull trout in the Stillaguamish River Core Area were identified from forest management, recreational mining, residential development and urbanization, fish passage issues, and small population size (USFWS 2015a, p. A-13). Impacts to estuarine nearshore foraging habitats and declines in forage fish species, particularly surf smelt and Pacific herring, in the marine nearshore areas of the Salish Sea likely have a greater impact on the small declining populations in the Stillaguamish River Core Area.

Given the very small and declining population size of the Stillaguamish River Core Area and the distance between the core area and action area, the Service expects an extremely low number of adult and subadult individuals may be present in the action area.

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APPENDIX D: STORMWATER AND STORMWATER EFFECTS

Stormwater Pollutants / Contaminants of Concern

Untreated stormwater runoff contains a variety of pollutants that impair water quality and pose a risk to aquatic organisms (Herrera Environmental Consultants 2007). Table A identifies the variety of pollutants typically found in untreated stormwater runoff. Sources of pollutants found in untreated stormwater runoff include atmospheric deposition, direct and indirect deposition and application, and vehicles and vehicular traffic (Herrera Environmental Consultants 2007). Factors that influence the types and amounts of pollutants found in untreated stormwater runoff include average daily traffic and traffic conditions, weather and precipitation patterns, road conditions and maintenance, and surrounding land uses. One particularly important factor is the buildup of solids and other pollutants on pavement and in stormwater conveyances between storm events (Herrera Environmental Consultants 2007).

Data obtained from a variety of sources indicate that pollutant concentrations in untreated stormwater runoff are highly variable (Herrera Environmental Consultants 2007). Table B reports mean pollutant concentrations obtained from studies examining stormwater runoff in western Washington and nationwide.

Stormwater can be a significant contributor to overall pollutant loads in receiving waterbodies (Wheeler et al. 2005). Pollutants that are dissolved in, or mobilized by stormwater runoff, are easily transported to wetlands, streams, and rivers if the runoff is not intercepted and passively treated by vegetation, infiltrated, or conveyed to engineered treatment systems.

Some pollutants and contaminants of concern have a strong affinity for suspended solids and the particulate-phase or fraction of treated and untreated stormwater runoff (Grant et al. 2003; Wong et al. 2000). As a result, a large fraction of the toxic (inorganic and non-polar organic) contaminant load in treated and untreated stormwater is in particulate form, either sorbed onto, or complexed with solids (Fan et al. 2001; Grant et al. 2003, pp. viii, x; Marsalek et al. 1999, p. 34; Muthukrishnan and Selvakumar 2006, pp. 2, 5; Wong et al. 2000, p. 11). The heavy metals, especially copper (Cu), chromium (Cr), lead (Pb), and nickel (Ni) are closely associated with the particulate fraction (Grant et al. 2003, p. 5-7; Wong et al. 2000, p. 32); zinc (Zn) and cadmium (Cd) to a somewhat lesser extent. Polycyclic aromatic hydrocarbons (PAHs), oils and petroleum hydrocarbons generally, and other non-polar organic contaminants (such as pesticides and their decomposition products), are also closely associated with the particulate-phase or fraction. Most of the PAH load in treated and untreated stormwater is bound to solids.

PAHs are often ubiquitous in urban and developed environments, but the dissolved-phase or fraction sometimes represents as little as 10 percent of the whole-water concentration, total burden or load (Grant et al. 2003, p. 5-6; Marsalek et al. 1997; Wong et al. 2000, p. 11). For these and other reasons, some experts in the field have identified TSS as an appropriate indirect measure or indicator of toxic contaminant load (Grant et al. 2003, p. 1-4; Hallberg et al. 2007, p. ab). Where sampling and monitoring are concerned, TSS is a decidedly easier and cheaper parameter to sample and measure.

Table A. Typical pollutants in stormwater runoff (Herrera Environmental Consultants 2007).

Pollutant Parameter Category	Parameter
Suspended Solids	Total suspended solids
	Volatile suspended solids
Metals	Arsenic
	Cadmium
	Chromium
	Copper
	Iron
	Lead
	Mercury
	Nickel
	Zinc
Nutrients	Ammonia nitrogen
	Nitrate nitrogen
	Total Nitrogen
	Total Kjeldahl nitrogen
	Total Phosphorus
	Orthophosphate phosphorus
Organic Compounds	Polycyclic aromatic hydrocarbons
	Oil and grease
	Total petroleum hydrocarbons
	Pesticides
	Herbicides
Bacteria	Total coliform bacteria
	Fecal coliform bacteria
Oxygen Demand	Biological oxygen demand (5-day)
	Chemical oxygen demand
Conventional Parameters	Sodium (if deicing performed)
	Chloride (if deicing performed)
	pH
	Turbidity
	Conductivity Hardness

Table B. Constituents in untreated stormwater runoff (Herrera Environmental Consultants 2007): comparison of site mean concentrations.

Constituent	Western Washington Sites [a]	National Data [b]
Solids (mg/L)		
Total	No data	437 to 1,147
Dissolved	No data	356
Suspended	3 to 295 (27)	45 to 798
Volatile (dissolved)	No data	131
Volatile (suspended)	19 to 460 (5)	4.3 to 79
Volatile (total)	No data	57 to 242
Metals, total (µg/L)		
Antimony	1.2 to 8.7 (2)	Not reported
Arsenic	2.2 to 2.6 (2)	58
Barium	81 to 84 (2)	Not reported
Chromium	7.5 to 18 (2)	Not detected to 40
Cadmium	0.9 to 2.8 (2)	Not detected to 40
Cobalt	1.9 to 4.4 (2)	Not reported
Copper	4.6 to 72 (29)	22 to 7,033
Iron	No data	2,429 to 10,300
Lead	24 to 1,065 (10)	73 to 1,780
Lead[c]	24 to 61 (3)	73 to 1,780
Magnesium	No data	1,062
Mercury	0.02 (1)	3.22
Molybdenum	1.5 to 9.5 (2)	Not reported
Nickel	8.6 to 12.9 (2)	53
Vanadium	6.3 to 14.8 (2)	Not reported
Zinc	26 to 394 (29)	56 to 929
Metals, dissolved (µg/L)		
Copper	3.1 to 18.1 (21)	Not reported
Lead	1.0 to 3.2 (2)	Not reported
Lead[c]	3.2 (1)	Not reported
Zinc	13 to 134 (22)	Not reported
Nutrients (mg/L)		
Ammonia nitrogen	1.0 to 2.7 (2)	0.07 to 0.22
Nitrite nitrogen	No data	0.013 to 0.25
Nitrate nitrogen	No data	0.306 to 1.4
Nitrite+nitrate nitrogen	0.51 to 3.0 (6)	0.15 to 1.636
Organic nitrogen	No data	0.965 to 2.3
Total Kjeldahl nitrogen	0.38 to 3.4 (6)	0.335 to 55.0
Total nitrogen	0.78 to 21.7 (2)	4.1
Orthophosphate phosphorus	0.01 to 0.42 (9)	Not reported
Total phosphorus	0.03 to 0.57 (24)	0.113 to 0.998

Table B (continued). Constituents in untreated stormwater runoff.

Constituent	Western Washington Sites [a]	National Data [b]
Organic Compounds (mg/L)		
TPH-oil	0.42 to 7.9 (12)	Not reported
TPH-diesel	Not detected to 2.75 (8)	Not reported
Oil and grease	11.8 to 187 (4)	2.7 to 27
Bacteria		
Total coliform bacteria (CFU/100 mL)	9,350 (1)	570 to 6,200
Fecal coliform bacteria (CFU/100 mL)	35 to 11,775 (16)	50 to 590
E. coli bacteria (CFU/100 mL)	130 to 1,670 (3)	Not reported
Oxygen Demand (mg/L)		
Chemical oxygen demand	32 to 1377 (11)	14.7 to 272
Biological oxygen demand (5-day)	9.5 to 71 (2)	12.7 to 37
Conventionals		
pH	5.8 to 6.8 (5)	7.1 to 7.2
Specific conductivity (µS at 25 °C)	71.6 (1)	337 to 500
Total organic carbon (mg/L)	2.0 to 139.0 (8)	24 to 77
Turbidity (NTU)	16.3 to 86.7 (3)	19
Hardness (mg/L as $CaCO_3$)	11.1 to 86.1 (19)	Not reported
Alkalinity (mg/L as $CaCO_3$)	19.3 to 23.4 (2)	Not reported

Particle size distribution exerts a strong influence on contaminant-particulate dynamics and association. Heavy metals, PAHs, and other non-polar organic contaminants are generally bound in greatest concentration to the smallest of particles and colloids. For non-polar organic contaminants, particulate organic matter content also exerts a strong influence, but total particulate surface area is probably of greater significance. The smallest particles have the greatest "surface area to volume ratio", and therefore provide a comparatively larger total surface area to which contaminants may bind, sorb, and complex (Fan et al. 2001; Herngren et al. 2005, p. 150; John and Leventhal 1995, p. 13; Pettersson 2002, p. 1).

Ecology recently compiled and summarized stormwater and storm sediment discharge data collected by National Pollutant Discharge Elimination System (NPDES) Phase I municipal stormwater permittees in western Washington, including several counties (Clark, King, Pierce, and Snohomish Counties), cities (City of Seattle, City of Tacoma), and the Ports of Seattle and Tacoma (Hobbs et al. 2015). Ecology reports the following:

- "The Phase 1 permittees, all located in western Washington, collected highly representative storm-event data under a prescribed monitoring program that represented multiple land uses, storm characteristics, and seasons … Findings are based on the analysis of 44,800 data records representing 597 storm events … Up to 85 parameters were analyzed in stormwater samples, and 67 parameters were analyzed in stormwater sediments … Composite sample volumes … generally spanned 75 percent or more of the first 24 hours of each storm … Composite stormwater samples were found to be representative of storm length, storm volumes, and frequency of storm events in western

Washington … The data is suitable for characterizing stormwater quality in western Washington" (pp. 7, 11).

- "Stormwater pollutant concentrations were lower than those reported by the U.S. Environmental Protection Agency (EPA) in the mid-1980s, but higher than stream and river concentrations draining to Puget Sound during storms … The extensive multi-year effort to characterize sources and … inputs to Puget Sound (*Control of Toxic Chemicals in Puget Sound: Phase 3 Data and Load Estimates*; *PS Toxics Study*) took place concurrently … [and found] that concentrations and loadings of toxic pollutants in monitored rivers and streams were higher during storm events than during base flow, for all land uses" (pp. 7, 9).

- "Metals, hydrocarbons, phthalates, total nitrogen and phosphorus, pentachlorophenol, and [polychlorinated biphenyls (PCBs)] were detected more frequently and at higher concentrations from commercial and industrial areas than from residential areas … Residential areas exported stormwater with the highest dissolved nutrient concentrations" (p. 7).

- "Across all land uses, Cu, Zn, and Pb were found more often than not to exceed (not meet) water quality criteria. Mercury and total PCBs exceeded criteria in 17 percent and 41 percent of the samples, respectively. For most parameters measured in both stormwater and stormwater sediments, concentrations in stormwater sediments paralleled the trends found in water samples across all four land uses" (p. 7).

- "Metals except mercury were commonly detected; arsenic, Cu, Pb, magnesium, and Zn were found in 90 percent of the samples. Cd was detected in just over 60 percent of the samples" (p. 11).

- "PAHs were detected in 73 percent of the samples … total petroleum hydrocarbons (diesel range fractions) were detected in 73 percent of the samples … bis(2-ethylhexyl) phthalate was found in 62 percent of the samples … The detection rate of organic compounds (such as total petroleum hydrocarbons – diesel fractions, PAHs, and phthalates) and certain metals (Cu, Pb, and Zn) in stormwater sediments was more than 90 percent … Diesel, motor oil, Cu, and Zn were found in all stormwater sediment samples collected" (pp. 11, 12).

- "Across all four land uses, Cu, Zn, and Pb were−more often than not−found to exceed (not meet) water quality criteria … Dissolved Zn and Cu in stormwater samples exceeded acute aquatic life criteria in 36 percent and 50 percent of the samples, respectively, over the three years of data … Mercury and total PCBs exceeded chronic aquatic life criteria in 17 percent and 41 percent of the samples, respectively … Commercial and industrial lands contributed higher concentrations of these compounds … PAHs, a significant component … do not have promulgated numeric criteria in water for the protection of aquatic life" (pp. 12, 13).

- "When concentrations in stormwater sediments were compared to the Washington State Sediment Cleanup Objectives for freshwater sediments under the Sediment Management Standards, the number of samples exceeding the Sediment Cleanup Objectives was found highest for phthalates (82 percent and 29 percent of samples) and PAHs (34 percent of samples) … To a lesser extent, concentrations of phenolics (20 percent) and metals (1 to 18 percent) exceeded the Sediment Cleanup Objectives" (p. 13).

- "Higher contaminant concentrations and mass loads were measured for nutrients and metals during the dry season (May through September). This provides strong evidence for an influence of seasonality (or antecedent dry periods) on stormwater concentrations, particularly in late summer through early fall; it also supports the idea that there is a degree of 'buildup' in the dry periods between storms. Metals, diesel hydrocarbons, and total nutrient loads were higher in the dry season and highest from commercial and industrial areas" (p. 14).

- "PAHs, phthalates, and detected pesticides (dichlobenil and pentachlorophenol) did not exhibit this significant seasonal difference, suggesting a consistent source throughout the year and no 'buildup' in the dry months" (p. 13).

- "Hydrocarbon median concentrations (PAHs and total petroleum hydrocarbons) were measured at 5 to 26 times higher in this study than those in the *PS Toxics Study* … This compilation of stormwater discharge data corroborates the *PS Toxics Study* findings about the dominant source of PAHs … High concentrations of PAHs are observed during storm events, with the greatest contribution of PAHs from areas with commercial and industrial land uses … No seasonal differences in PAH concentrations were found in this study… Overall, the highest concentrations and the most frequent exceedances of water quality criteria for toxic compounds were found in stormwater and stormwater sediments discharged from basins with a higher percentage of commercial and industrial land uses" (p. 16).

- Recommendations include, "Stormwater management programs can sweep and conduct other housekeeping BMPs in industrial and commercial areas during the dry season to reduce high stormwater loads of metals, diesel hydrocarbons, and total nutrients during the first-season storms," and future studies should "…explicitly test the influence of antecedent dry periods and seasonal first-flush events in stormwater discharges … and analyze the relationship between the timing of the highest metals concentrations from commercial and industrial areas and whether BMPs can reduce the discharge of Cu, Zn, and Pb" (pp. 16, 17).

Stormwater Runoff Treatment Systems

There are a variety of engineered stormwater treatment systems and technologies. These systems and technologies vary with regard to which pollutants or pollutant categories they are best capable of treating, and the effectiveness with which they treat specific pollutants. Treatment efficiency and effectiveness depend both on the specific treatment systems and technologies employed, and on how well these systems are designed, operated, and maintained. Studies

indicate significant variation among different treatment technologies and facilities (Schueler 1987; WSDOT 2006; Young et al. 1996).

The WSDOT designs and constructs stormwater runoff treatment facilities and structural best management practices (BMPs) according to guidelines and criteria set forth in the Highway Runoff Manual (HRM) (WSDOT 2019). These guidelines are approved by Ecology and meet State requirements for stormwater management. Facilities and BMPs designed, constructed, and managed according to the HRM represent the controls deemed necessary to reduce discharge of pollutants to the "maximum extent practicable" (Ecology 2010a). [Note: The FHWA and Service expect that minimum stormwater management requirements may and likely will be further revised; if/when this occurs, the FHWA and Service expect, and will require, that all projects fully comply with the most current and applicable manual and management requirements.]

Stormwater conveyance, treatment, and flow control facilities require routine maintenance to ensure proper function (Ecology 2010a; Ecology 2010b; WSDOT 2008). Failure to adequately maintain facilities and structural BMPs almost inevitably leads to reduced performance and efficiency. Anderson et al. (2002, p. 280) have pointed to excessive sediment accumulation, and (related) shortened hydraulic residence time, as factors that reduce settling pond performance. In addition, long-neglected facilities and structural BMPs can become a source, rather than a sink, of some pollutants found in stormwater runoff. Re-suspension and hydraulic flushing of accumulated sediments from facilities and BMPs have been implicated as a cause of failure and a significant maintenance concern (Anderson et al. 2002, p. 281; Fan et al. 2001; Starzec et al. 2005, p. ab); this concern is heightened where accumulated sediments contain levels of metal or organic contamination sufficient to exert toxicological effects (Marsalek et al. 2002, pp. ab, 9).

Acute Physiological and Behavioral Effects (Lethal and Sub-Lethal)

Stormwater pollutants can affect the physiology and/or behavior of exposed salmonids in ways that disrupt normal behaviors (i.e., free movement, feeding, and sheltering), reduce growth, migratory success, and reproduction. In sufficient concentrations, stormwater pollutants can also result in acute toxicity and death. Acute effects to aquatic life are influenced by the size and dilution capacity of the receiving waterbody, background water quality conditions, concurrent discharges and/or background levels of other contaminants, frequency and duration of exposure, concentration and relative toxicity of the pollutant(s), biological uptake and availability, and life stage of the organism.

Potential acute effects from exposures that may occur in and around points of stormwater discharge, such as outfalls, are of primary concern. On an event basis, pollutant concentrations contained in stormwater discharges may exceed the State's criteria for the protection of freshwater aquatic life and/or other criteria associated with adverse sub-lethal effects. Upon entering the receiving waterbody, stormwater discharges will typically mix with and be diluted by flow and the ambient water quality conditions. In order to assess the potential for adverse effects stemming from acute exposures, it is necessary to know something of the physical and temporal extents of the pollutant mixing zone(s).

Stormwater runoff is a complex chemical mixture. Even during the course of a single discharge event, physical and chemical properties (including pollutant concentrations) can vary by orders of magnitude (Glenn et al. 2002, p. 3). Conditions in the receiving waterbody are also dynamic, and therefore estimates of the probable extent or duration of resulting mixing zones are imprecise and subject to uncertainty. Additional sources of uncertainty include the effect of intermittent, episodic, or transient exposures (Burton et al. 2000, p. ab; Marsalek et al. 1999, p. 34); variations in tolerance among exposed individuals and/or populations (Ellis 2000, p. 89; Hodson 1988, p. ab; Lloyd 1987, p. 502); and the potential for synergistic or additive effects among pollutants with similar or the same modes of toxic action (Burton et al. 2000, p. ab; Ellis 2000, p. 88; Lloyd 1987, p. 494). Burton et al. (2000, p. ab) warn that traditional toxicity tests may not lead to reliable predictions or conclusions if not tailored to reflect real-world patterns of exposure. Lloyd (1987, pp. 492, 501) has expressed concern that pollutants may have increased toxicity to salmonids under conditions of reduced dissolved oxygen, and has advised that aquatic life criteria (i.e. water quality standards) should apply to whole groups of contaminants with common modes of action, rather than individual contaminants.

The Service relies on toxicity data for other salmonids when specific information on toxicity to bull trout is not available. Due to taxonomic similarity, species in the Salmonidae family are better surrogates for bull trout than non-salmonids. However, Hansen et al. (2002) demonstrate that even among the members of Salmonidae specific sensitivities to chemical contaminants and mixtures of contaminants may differ. The Service has relied on toxicity data for species in the following preferential order: species (bull trout) > genus (Salvelinus) > family (Salmonidae). Rainbow trout (*Oncorhynchus mykiss*) are the primary freshwater fish species used by the EPA when developing toxicity data for regulatory purposes; therefore, the majority of data available in the literature have been generated from studies using rainbow trout as test subjects (family Salmonidae).

The most commonly reported end points in the toxicity literature are concentrations at which 50 percent of the test subjects died (LC50). Concentrations that result in the death of a smaller percentage of the test population (e.g., LC10) are likely to be somewhat lower. Bull trout and other salmonids would be adversely affected if exposed to lethal concentrations with the potential to result in acute toxicity and death, or if exposed to contaminant concentrations known to result in sub-lethal effects with consequences for normal behavior (i.e., effects that significantly disrupt the ability to successfully feed, move, and/or shelter).

A variety of stormwater pollutants exhibit toxic mechanisms of action, including volatile organic compounds, organic herbicides and pesticides, and metals. Volatile organics and organic herbicides and pesticides may be present in untreated stormwater runoff at concentrations sufficient to cause adverse effects (Kayhanian et al. 2003; Van Metre et al. 2000). However, for the purpose of this consultation, it is assumed that metals originating from vehicular sources pose the greatest risk of acute lethal and sub-lethal effects to bull trout. Traffic residues contain several metals, including Zn, Pb, Cd, Ni, Cu, and Cr, with toxic mechanisms of action (Wheeler et al. 2005). These metals originate from disintegrating tires, brake pads, and other vehicle parts and frequently accumulate in roadside dust and soil (Wheeler et al. 2005).

Acute (Lethal and Sub-Lethal) Effects – Dissolved Metals

There are three known physiological pathways by which salmonids may be directly exposed to and/or may uptake metals: 1) uptake of ionic metals at the gill surfaces (Niyogi et al. 2004), 2) dietary uptake, and 3) olfaction (sense of smell) involving receptor neurons (Baldwin et al. 2003). Of these three pathways, the mechanism of dietary uptake is least understood. For dissolved metals, the most direct pathway is through the gill surfaces.

Measurements of total recoverable metal concentration include a fraction that is bound to suspended solids and/or complexed with organic matter or other ligands; this fraction is not available to bind to gill receptor sites. As such, most metal toxicity studies have examined the dissolved metal fraction which is more bioavailable and therefore of greater significance for acute exposure and toxicity.

The relative toxicity of a metal or metal species can be altered by hardness, water temperature, pH, organic content, phosphate concentration, suspended solid concentration, the presence of other metals or contaminants (i.e., synergistic effects), and other factors. Eisler (1998) and Playle (2004) found that dissolved metal mixtures exhibit greater than additive toxicity. Water hardness affects the bio-available fraction of metals; as hardness increases, metals become less bio-available for uptake at the gill surfaces and therefore less toxic (Hansen et al. 2002; Niyogi et al. 2004). However, Baldwin et al. (2003) found water hardness did not influence the inhibiting effects of Cu on salmon olfactory functions.

Copper (Cu)

Even at low concentrations, Cu is acutely toxic to fish. Effects of Cu exposure include 1) weakened immune function and impaired disease resistance, 2) impaired respiration, 3) disruptions to osmoregulation, 4) impaired function of olfactory organs and brain, 5) altered blood chemistry, 6) altered enzyme activity and function, and 7) pathology of the kidneys, liver, and gills (Eisler 1998).

Sprague (1964) and Sprague and Ramsay (1965) reported Incipient Lethal Levels for dissolved Cu of 48 µg/L and 32 µg/L at water hardnesses of 20 and 14 mg/L, respectively. The Incipient Lethal Level is that concentration which is required to kill half of the fish tested within 1 week of exposure. Sprague and Ramsay (1965) found that higher concentrations of Cu killed juvenile salmon much more rapidly than did lower concentrations at 14 mg/L hardness.

Baldwin et al. (2003) found that short pulses of dissolved Cu, at concentrations as low as 2 µg/L, reduced olfactory sensory responsiveness by approximately 10 percent within 10 minutes, and by 25 percent within 30 minutes. At 10 µg/L responsiveness was reduced by 67 percent within 30 minutes. Baldwin et al. (2003) identified a Cu concentration neurotoxic threshold of an increase of 2.3 to 3.0 µg/L, when background levels are 3.0 µg/L or less. When exceeded, this threshold is associated with olfactory inhibition. The authors also reference three other studies examining long-duration Cu exposures (i.e., exceeding 4 hours); these studies found that long-duration exposures resulted in cell (olfactory receptor neuron) death in rainbow trout and Atlantic and Chinook salmon (*Salmo salar*, and *O. tshawytscha*, respectively). Baldwin et al. (2003) found

that water hardness did not influence the toxicity of Cu to coho salmon (*O. kisutch*) sensory neurons.

More recently, Sandahl et al. (2007) documented sensory physiological impairment, and related disruption to predator avoidance behaviors, in juvenile coho at concentrations as low as 2 µg/L dissolved Cu.

The effects of short term Cu exposure may persist for hours and possibly longer. Although salmonids may actively avoid surface waters containing an excess of dissolved Cu, those individuals that are exposed may experience olfactory function inhibition within minutes of exposure. Furthermore, avoidance of a chemical plume may cause fish to leave refugia or preferred habitats in favor of less suitable or less productive habitats. This, in turn, can make fish more vulnerable to predation and can impair foraging success, feeding efficiency, and thereby growth.

Folmar (1976) observed avoidance responses in rainbow trout fry when exposed to a Lowest Observed Effect Concentration of 0.1 µg/L dissolved Cu (hardness of 90 mg/L). The EPA (1980a) also documented avoidance by rainbow trout fry of dissolved Cu concentrations as low as 0.1 µg/L during a 1 hour exposure, as well as a LC10 for smolts exposed to 7.0 µg/L for 200 hours, and a LC10 for juveniles exposed to 9.0 µg/L for 200 hours.

Zinc (Zn)

Zn occurs naturally in the environment and is an essential trace element for most organisms. However, in sufficient concentrations and when bioavailable for uptake by aquatic organisms, excess Zn is toxic. Toxicity in the aquatic environment and for exposed aquatic organisms is influenced by water hardness, pH, organic matter content, levels of dissolved oxygen, phosphate, and suspended solids, the presence of mixtures (i.e., synergistic effects), trophic level, and exposure frequency and duration (Eisler 1993). Bioavailability of Zn increases under conditions of high dissolved oxygen, low salinity, low pH, and/or high levels of inorganic oxides and humic substances. Most of the Zn introduced into aquatic environments is eventually partitioned into sediments (Eisler 1993).

Effects of Zn exposure include 1) weakened immune function and impaired disease resistance (Ghanmi et al. 1989), 2) impaired respiration, including potentially lethal destruction of gill epithelium (Eisler 1993), 3) altered blood and serum chemistry, and enzyme activity and function (Hilmy et al. 1987a; Hilmy et al. 1987b), 4) interference with gall bladder and gill metabolism (Eisler 1993), 5) hyperglycemia, and 6) jaw and branchial abnormalities (Eisler 1993).

Hansen et al. (2002) determined 120-day lethal concentrations of Zn for test subjects that included bull trout and rainbow trout fry. Multiple pairs of tests were performed with a nominal pH of 7.5, hardness of 30 mg/L, and at a temperature of 8 °C. Bull trout LC50 values measured under these conditions ranged from 35.6 to 80.0 µg/L, with an average of 56.1 µg/L. Hansen et al. (2002) found that rainbow trout fry are more sensitive to Zn (i.e., exhibit a lower LC50) than are bull trout fry. The authors also report that older, more active juvenile bull trout are more

sensitive than younger, more docile juvenile bull trout based on observed changes in behavior at the juvenile life stage. The authors argue that the timing of Zn and Cd exposure and the activity level of the exposed fish are germane to predicting toxicity in the field.

The mode of action for Zn toxicity relates to net loss of calcium. Studies suggest that Zn exposure inhibits calcium uptake, although it appears this effect is reversible once fish return to clean water. The apparent difference in sensitivity between rainbow trout and bull trout may be due to the lesser susceptibility of bull trout to calcium loss. Hansen et al. (2002) state that differences in sensitivity between these two salmonids may reflect different physiological strategies for regulating calcium uptake. These strategies may include gills that differ structurally, differences in the mechanisms for calcium uptake, and/or variation in resistance to or tolerance for calcium loss.

There are no known studies or data describing adult bull trout response to lethal or near-lethal concentrations of Zn. Active feeding and increased metabolic activity are apparently related to sensitivity. It is unknown whether sensitivity to Zn varies between adult, subadult, and juvenile bull trout. Activity level may be a better predictor of sensitivity than age.

In addition to the physiological effects of Zn exposure, studies have also documented a variety of behavioral responses. Among these, Eisler (1993) includes altered avoidance behavior, decreased swimming ability, and hyperactivity. The author also suggests Zn exposure has implications for growth, reproduction, and survival.

Sub-lethal endpoints have been evaluated with test subjects that include both juvenile and adult rainbow trout (Eisler 1993; USEPA 1980b; USEPA 1987). Some of these test results clearly indicate that juvenile rainbow trout are more sensitive than adult rainbow trout. Using juvenile rainbow trout as test subjects, studies have found that sub-lethal effects occur at concentrations approximately 75 percent lower (5.6 µg/L) than the concentrations that result in lethal effects (24 µg/L) (Eisler 1993; Hansen et al. 2002). Sprague (1968) found that at concentrations as low as 5.6 µg/L juvenile rainbow trout exhibit avoidance behavior.

Although salmonids may actively avoid surface waters containing an excess of dissolved Zn, it can generally be assumed that stormwater runoff contains a mixture of pollutants, including some known to affect the olfactory system, such as dissolved Cu. Bull trout exposed to these mixtures may not always be capable of detecting and avoiding elevated levels of dissolved Zn. Furthermore, avoidance of a chemical plume may cause fish to leave refugia or preferred habitats in favor of less suitable or less productive habitats. This can make fish more vulnerable to predation and can impair foraging success, feeding efficiency, and thereby growth.

Pollutant Loadings and Chronic Effects

Pollutant loads bound or complexed with the particulate-phase or fraction of stormwater runoff represent a persistent, long term source of potential chronic exposures and effects (Chen et al. 1996, p. ab; Fan et al. 2001; Glenn et al. 2002, p. 2; Grant et al. 2003, p. 4-3; Pettersson 2002, p. 1). Heavy metals do not degrade in the environment (Glenn et al. 2002, p. 2; Muthukrishnan and Selvakumar 2006, p. 2), and organic contaminants easily persist for durations that exceed the life

spans of individual fish or multiple generations of fish (Heintz et al. 2000, p. 214). Chronic effects to individuals stem from repeated exposures over time, through multiple exposure pathways, and from multiple stressors and combinations of stressors (Burton et al. 2000, p. ab; Ellis 2000, p. 86; Heintz et al. 2000, p. 214). Ellis (2000, p. 89) has argued that sediment-mediated exposures and effects have not yet been given adequate attention, and furthermore that "…procedures for the identification of chronic, sub-lethal no effects limits are still to be achieved." Emphasizing the tendency for accumulation in sediments, both Hodson (1988, p. ab) and Pettersson (2002, p. 1) have argued that loads and not simply water concentrations should be a focus for management where discharges of metals and persistent organic pollutants are concerned.

Fate and Transport of Contaminants Present in Stormwater Runoff

As stormwater runoff moves from the edge-of-pavement, through drainage/conveyance structures, and treatment and flow control facilities and BMPs, it passes through a succession of varying physical and chemical environments. Treatment facilities and BMPs use controlled conditions to remove pollutants through adsorption, complexation, settling, and filtration. However, upon release to the receiving waterbody, stormwater discharges enter a more complex and dynamic environment. Contaminant fate and transport in the aquatic environment is influenced by a host of factors, including the unique chemical and physical properties of the contaminant of concern, the chemical and physical properties of particulates/solids present in both runoff and the receiving waterbody, and changing ambient chemical, physical, and biological conditions in the receiving waterbody.

The factors influencing metal and non-polar organic contaminant fate and transport in the aquatic environment, including the important role of solids and the particulate fraction of stormwater runoff, are described thoroughly elsewhere (Glenn et al. 2002; Grant et al. 2003; John and Leventhal 1995; Lloyd 1987). However, to more fully appreciate the significance of pollutant loadings, and the nature of sediment-mediated exposures and effects, it is essential to understand a few fundamental premises: 1) partitioning of metals between the solid and aqueous phases has a strong influence on mobility, storage, export, and ultimate fate, 2) solids, whether particulates in discharge or sediments in the natural environment, can act as both sinks and sources for metals and non-polar organic contaminants, and 3) the ambient conditions which govern whether solids will act as sources or sinks are dynamic and can change over time.

Solid/liquid-phase dynamics and partitioning have a strong influence on the fate and transport of metal contaminants present in stormwater runoff. These processes begin when road solids are first brought into contact with precipitation. They continue as runoff passes through treatment and flow control facilities, and once stormwater runoff is released to the environment (Grant et al. 2003). Within stormwater conveyance and treatment systems, partitioning coefficients, residence time (i.e., how long road solids and runoff remain in contact), and the degree of mixing exert a strong influence on equilibrium concentrations in the particulate (solid) and dissolved (liquid) phases (Glenn et al. 2002, p. 3). Upon release to the environment, metal speciation, pH, redox potential, temperature, organic matter content, and other factors influence partitioning amongst six fractions present in suspended solids, soils, and sediment (John and Leventhal 1995, pp. 10, 11). These metal fractions exhibit widely-varying mobilities in the environment;

exchangeable (dissolved) cations exhibit high mobility, while iron-manganese and organically-bound fractions exhibit medium mobilities; crystalline fractions are relatively immobile (John and Leventhal 1995, p. 10).

Solids can act as both sinks and sources for metals and non-polar organic contaminants. Contaminants are "…reversibly bound to suspended particles….", and these particles can act as a "…source of water column toxicity or interstitial (pore) water toxicity." (Grant et al. 2003, p. 4-3) Adsorption and complexation are physiochemical processes that would tend to remove contaminants from the liquid-phase and sequester them in the solid-phase (Lloyd 1987, p. 491, 499). Redox potential (i.e., oxidizing or reducing conditions) and pH influence how contaminants are bound and, under varying conditions, can act to either keep contaminants bound in the solid-phase, or conversely, to release or desorb contaminants to the dissolved (liquid) phase (Bostick et al. 1998, p. 1; John and Leventhal 1995, p. 13). Some contaminated sediments constitute a persistent, continuing source of toxic contamination (Fan et al. 2001).

There is considerable evidence to illustrate how stormwater runoff can create accumulations of metals and non-polar organic contaminants in receiving waters. Carr et al. (2000, p. ab) and Rhoads and Cahill (1999, p. ab) both found that quality was degraded, and conditions potentially toxic where sediments were located close to stormwater outfalls. Similarly, Maltby et al. (1995, p. ab) observed toxicity in sediments, attributable to metals and PAHs, downstream of stormwater discharges. Chalmers et al. (2007, p. ab) found that urban lakes exhibited metal and PAH contaminant accumulation rates that were orders of magnitude greater than reference lakes, and concluded that sediment concentrations were attributable to local sources. Lester and Wilson (2002, p. ab) and Moshenberg (2004, p. 27), investigating sediment quality and toxic potential in urban lakes of the Seattle metropolitan area, found that samples exceeded sediment quality guidelines (SQGs) for metals and PAHs at some locations, including the vicinity of stormwater discharges to Lake Sammamish. Because contaminated sediments are recognized as potential sources of toxic exposure and effects, the development of reliably predictive SQGs is an area of continuing interest for researches and resource managers alike.

Ambient conditions determine whether contaminated sediments will act as continuing sources or sinks for toxic metals and non-polar organic contaminants. Because ambient conditions are dynamic and can change over time and space, equilibrium levels of metals and organic contaminants in sediments, in interstitial/pore water, and the water column, are also variable. "Bioavailability is a complex function of many factors ... Many of these factors vary seasonally and temporally, and most factors are interrelated." (John and Leventhal 1995, p. 10) Changes in ambient water and sediment chemistry, including redox state, dissolved oxygen concentration, pH, temperature, and buffering capacity/carbonate concentration/hardness, can release sequestered contamination to interstitial pore water or the water column (Chen et al. 1996, p. ab; Marsalek et al. 2002, p. 7; Muthukrishnan and Selvakumar 2006, p. 10; Wong et al. 2000, p. 10). Bostick et al. (1998, pp. 2, 4), Chen et al. (1996, p. ab), and John and Leventhal (1995, pp. 14, 17) each describe changes in Zn partitioning and bioavailability in response to altered chemical environments. Bostick et al. (1998, pp. 2, 4) found that changes in redox state within a contaminated wetland influenced the size of fractions complexed to sorbents with varying properties. Chen et al. (1996, p. ab) found that 74 percent of Zn from bottom sediments of urban reservoirs was in easily remobilized fractions. John and Leventhal (1995, p. 14, 17) found that

contaminated sediments can release significant amounts of Zn to the dissolved phase when oxidized or exposed to acidic conditions.

In fluvial environments, hydrology and fine and coarse sediment dynamics also exert a strong influence on patterns of sediment contamination. Rhoads and Cahill (1999, p. ab) describe variation in levels of sediment metal contamination reflecting distance from the source (outfalls), reach-scale variation in geomorphic conditions, and the degree of bed material sorting. Foster and Charlesworth (1996, p. ab) and Marsalek et al. (2002, pp. ab, 9) also emphasize the role of sediment deposition, accumulation, and remobilization. Baun et al. (2003, p. 4-4) and Chen et al. (1996, p. ab) suggest that hydraulic resuspension of contaminated sediments, and sporadic disturbance and release of contaminated interstitial pore water, influences bioavailability. Ellis (2000, p. 86) has argued that understanding the "…probability of biotic uptake and ecosystem response … requires incorporation of water quality effects with impacts on sediment and pore waters as well as habitat impairments resulting from flow hydraulics".

Bioavailability and Toxicity of Contaminated Sediments

Contaminated sediments are widely recognized as potential sources of toxic exposure and effects. This concern has created interest in the development of predictive (non-regulatory) SQGs and of analytical tools for the assessment of bioavailability and toxicity (e.g., bioassays, AVS/SEM ratios, etc.). Grant et al. (2003, p. 4-12) have provided a concise summary and review of current methods for the measurement of sediment toxicity.

SQGs are "…numerical limits recommended to support and maintain aquatic life", and generally reflect the sensitivities of sediment-dwelling organisms (MacDonald et al. 2000, p. 20; Marsalek et al. 2002, p. 6). The EPA has published guidance for the derivation of sediment benchmarks, and Ecology implements several programs (e.g., Aquatic Lands Clean-Up, Water Quality, Environmental Assessment, etc.) engaged in the development and refinement of SQGs. MacDonald et al. (2000) provide a good summary of published freshwater SQGs; SQGs derived using an effects level approach are in fairly wide use.

Marsalek et al. (1997; 2002; 2006) have evaluated the toxic potential of accumulated bottom sediments and suspended particulates found in urban stormwater ponds through comparisons of measured sample concentrations with Canadian SQGs. Marsalek et al. (1997, p. ab) report "marginal-to-significant" pollution for six heavy metals. More recent work has documented widespread "marginal-to-intermediate" pollution of heavy metals (80 to 100 percent of samples), and several instances of "severe" Zn pollution, including in sediments from oil and grit separators (Marsalek et al. 2006, p. ab). Marsalek et al. (2002) found that sample concentrations for five metals, including Cu and Zn, frequently exceeded Threshold Effect Levels (TELs), and occasionally exceeded Probable Effect Levels (PELs). Applying the same TELs and PELs that are in use in the State of Washington (i.e., as interim SQGs), the authors found that the highest incidence of biological effects would result from concentrations of Cu and Zn. The incidence of adverse biological effects associated with Cu concentrations present in accumulated bottom sediments and suspended particulates may be as high as 38 percent, and does not account for potential additive or synergistic effects (Marsalek et al. 2002, p. 7). Marsalek et al. (2002, p. ab) have concluded that "…suspended solids passing through stormwater ponds (are) polluted and

could cause toxic effects in downstream waters." These findings suggest that the suspended solid fractions not settled and retained in stormwater treatment facilities, or the fractions discharged to the receiving waterbody, sometimes contain metal concentrations sufficient to cause toxicological effects in exposed biota.

Lester and Wilson (2002, p. ab) report findings from an evaluation of sediment quality in Lake Sammamish, Washington. Using comparisons of measured sample concentrations with the State of Washington's interim SQGs, the authors report the following: both heavy metal and organic contaminant concentrations exceed guidelines; some observed concentrations indicate severe pollution and a high probability of adverse effects to biota; and, "…the highest levels of sediment associated contaminants were found in the vicinity of stormwater discharges." However, Lester and Wilson (2002, p. ab) also note that benthic community structure in the study area reflects the influence of nutrient enrichment, and it is difficult to separate effects associated with enrichment and sediment associated contaminants.

Baun et al. (2003) report findings from a study evaluating toxicity of interstitial pore water and sediment suspensions collected from an urban stream receiving large inputs of untreated runoff. Undiluted pore water samples were toxic to an algal test subject, but no statistically significant correlations were found between individual metal or organic parameters and observed pore water toxicity. Prepared sediment suspensions exhibited toxicities approximately 50 times greater than pore waters from the same sediment samples. The authors conclude that contaminated "…sediments may contribute significantly to toxic effects in receiving waters" as a result of "…release of pore water and/or suspension of particles." (Baun et al. 2003, p. 4-5)

Maltby et al. (1995, p. ab) report findings from a study evaluating toxicity of ambient water and sediments collected from locations downstream of stormwater discharges. Ambient water did not exhibit toxicity in the test subject, a benthic amphipod, but a reduction in survival was found to result from exposure to the same water spiked with sediment. Hydrocarbons, Cu, and Zn were identified as potential toxicants, with most of the observed toxicity attributable to PAHs.

Chronic Effects to Aquatic Community Composition, Function, and Productivity

Sediments are an essential component of healthy, properly functioning aquatic ecosystems. Sediments function as both the physical growth medium and source of energy for benthic communities. Most of the organisms responsible for primary production in fluvial ecosystems, whether autotrophic (i.e., the green plants and algae) or heterotrophic (i.e., bacteria), rely crucially on sediments; in turn these organisms "…represent the foundation of food webs upon which all other aquatic organisms depend." (MacDonald and Ingersoll 2002, p. 74)

Numerous studies have investigated aquatic community composition and structure in disturbed systems. These communities frequently exhibit a decline in species diversity and changes to the relative representation of various taxa; species that are tolerant of varying environmental conditions usually dominate communities subject to frequent disturbance. In urban settings conditions favor species tolerant of stormwater pollutants (Wong et al. 2000, p. 17), low-quality food sources and/or reduced organic matter inputs, and hydrological extremes of erosion and deposition (Ellis 2000, p. 86).

Maltby et al. (1995, p. ab) found that abundance of *Gammarus pulex*, a benthic amphipod, was greatly reduced downstream of stormwater discharges. Carr et al. (2000, p. ab) conducted a triad study where chemical analyses, controlled toxicity tests, and field benthic indicators were used to assess impairment of sediment quality, and found that "…four of the five most degraded (locations) were stormwater outfall sites." Scoggins et al. (2007, p. ab) characterized biological communities above and below stormwater discharges and found reduced invertebrate diversity and density, and a relative increase in tolerant taxa at downstream sites. Scoggins et al. also found that "…increases in PAH sediment-toxicity units between upstream and downstream sites explained decreases in taxon richness and density".

Moshenberg (2004, p. 27) reports the findings of a triad study investigating sediment and benthic community impairment in Lake Union, Lake Washington, and Lake Sammamish. The study found widespread impairment of sediment quality. The State of Washington's SQGs (King County 2019a,b; Smith et al. 1996) were frequently exceeded for PCBs (70 percent of stations), metals (50 percent), phthalates (46 percent), and PAHs (23 percent). Zn and Cu were found to exceed their respective SQGs more frequently than any pollutant except Aroclor 1254 (Moshenberg 2004, p. 54). The study found that observed toxicity more closely correlated with organic contaminant concentrations than metal concentrations (Moshenberg 2004, p. 58), and there were only weak to moderate correlations between contaminant concentrations and most indicators of benthic community alteration. However, metal and PAH pollutant concentrations were a significant predictor of the Shannon-Weaver invertebrate diversity index (Moshenberg 2004, p. 56). In discussing potential sources of impairment, the author suggests that stormwater and transportation-related land uses are potential sources of Zn, Cu, and PAH contamination (Moshenberg 2004, pp. 58, 59).

Heintz et al. (2000) have reported findings that suggest a link between PAH exposure during egg incubation and subsequent rates of marine survival and growth for salmonids. The study found that statistically significant reductions in marine survival, or increases in delayed rates of mortality, resulted from exposure to concentrations as low as 5.4 ppb total PAH. The study also found that juvenile salmon surviving embryonic exposure exhibited reduced growth in response to doses as low as 18 ppb total PAH. The authors suggest that reductions in marine survival and growth are most likely attributable to biochemical impairment of gene and/or enzyme function, and that fish populations whose natal habitats are contaminated with PAHs "…can be expected to experience the compound effects of mortality during exposure, reduced survivorship afterwards, and reduced reproductive output at maturity." (Heintz et al. 2000, pp. 213, 214)

McCarthy et al. (2008) have examined three case studies which provide an excellent summary of current research and our evolving understanding of potential stormwater effects on fish and fisheries of the Pacific Northwest. One of these case studies summarizes current investigations of coho salmon pre-spawn mortality in urban streams of the Seattle metropolitan area. The authors argue that high temperature, low dissolved oxygen, overcrowding, disease, and accidental spills have all been ruled out as causal mechanisms, and "…the weight of evidence suggests that adult coho are acutely sensitive to … stormwater runoff from urban landscapes." (McCarthy et al. 2008, p. 6) The authors acknowledge uncertainty as to whether the observed pre-spawn mortalities result from exposure to a single contaminant, to a mixture of

contaminants, and/or the additive effect of toxicological and other environmental stressors. The authors observe that while "…pollution occasionally causes fish kills, most contaminant exposures are sublethal", a fact that heightens our need to understand how toxic exposures influence reproductive success (McCarthy et al. 2008, p. 2).

Another of the case studies described by McCarthy et al. (2008) examines PAH developmental toxicity, modes of action, and consequences for exposed embryonic fish. The authors summarize work identifying effects to cardiac development, form, and function (McCarthy et al. 2008, p. 13). These effects to the embryonic heart may explain the common malformation syndrome and reduced growth and survival frequently documented where embryonic exposures to PAH contamination have been investigated. The authors observe that while we know the "…developing fish heart is vulnerable … to multiple members of the PAH family", "…there are still a large number of PAH compounds whose individual toxicity is unknown, and PAH mixtures in stormwater are more complicated." (McCarthy et al. 2008, p. 13)

These findings, and others reported in the literature, demonstrate that where stormwater discharges cause or contribute to sediment metal and PAH contamination, they may exert an influence on aquatic community composition and structure. These findings do not address whether observed shifts in aquatic community composition and structure have significance for primary production, or nutrient and organic cycling and dynamics. In this sense, it is difficult to know how completely or fundamentally aquatic food webs may be affected. However, these findings and others reported in the scientific literature do indicate that toxic constituents found in stormwater runoff can exert a direct adverse effect on exposed fish with implications for growth, development, long term survival, and reproductive fitness.

Chronic effects stem from repeated exposures over time, through multiple exposure pathways, and from multiple stressors and combinations of stressors. The assessment of chronic effects, including cumulative toxicity, requires consideration of exposure sequences, post-exposure stress, and their accumulative effects and significance for growth, reproductive fitness, and rates of mortality (Ellis 2000, pp. 86, 87; Grant et al. 2003, p. 4-2; McCarthy et al. 2008, p. 2).

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APPENDIX E
WASTEWATER POLLUTANTS AS ENVIRONMENTAL STRESSORS

Wastewater Pollutants as Environmental Stressors

This Appendix provides background information regarding wastewater pollutants of concern, including information to describe how pollutants act as stressors when released to the aquatic environment.

Conventional Pollutants and Parameters

Temperature

Temperature is the most important abiotic factor influencing metabolic rate in fish and other ectotherms (Barnes et al. 2011, p. 397). As temperature increases towards the thermal tolerance limit, metabolic rate increases exponentially, sometimes with consequences for growth. With increasing water temperatures, oxygen solubility is lowered and fish must also contend with reduced dissolved oxygen levels (Barnes et al. 2011, p. 397).

Bull trout require cold water and temperature has been identified as an important limiting factor for the species (Howell et al. 2010, p. 96). Investigating the influence of temperature and other environmental variables on the distribution of small, resident and/or juvenile bull trout at the southern margin of their range, Dunham et al. (2003, pp. 894, 900, 901) found that maximum daily temperature was a statistically significant and strong predictor of the probability of occurrence. At maximum daily temperatures above 16 °C, predicted probabilities of occurrence become increasingly low.

Selong et al. (2001, p. 1026) have investigated the effect of temperature on growth and survival of young bull trout, and their results demonstrate that young bull trout exhibit a lower upper thermal limit and growth optima compared to most other North American salmonids. After 60-day chronic exposures, survival of age-0 bull trout was at least 98 percent at 8, 10, 12, 14, 16, and 18 °C, but was 0 percent at 22, 24, 26, and 28 °C. Selong et al. (2001, pp. 1026, 1027) report upper incipient lethal temperatures, the temperatures at which mortalities are approximately 50 percent, of 20.9 °C and 23.5 °C for 60-day and 7-day chronic exposures, respectively. Peak growth occurred at 13.2 °C, feed consumption declined significantly at temperatures greater than 16 °C, and fish held at temperatures of 22 °C and higher did not feed. Metabolic efficiencies (i.e., feed, lipid, and protein conversion efficiencies) were similar across the range of 8 to18 °C, but declined significantly at 20 °C. Reduced growth and feed consumption, both of which are considered sub-lethal responses indicative of thermal stress, were first detected at 15.9 °C and 16.3 °C, respectively (Selong et al. 2001, p. 1033). The authors state that "…metabolic costs rise exponentially with temperature"; at temperatures greater than 18 °C young bull trout exhibited significantly reduced food consumption, growth, and feed conversion efficiency, and "…exhibited outward signs of stress suggesting that extended exposure to elevated temperatures would rapidly deplete their energy reserves." (Selong et al. 2001, p. 1033).

These and other field and laboratory studies document bull trout sensitivity to temperature. However, there is also a growing body of literature which demonstrates variation in thermal tolerance among salmonid populations adapted to differing temperature regimes (Barnes et al.

2011; Cooke et al. 2012; Eliason et al. 2011). And it has long been recognized, both that thermal tolerances appear to differ among bull trout at different life stages, and that migratory bull trout frequently experience and tolerate temperature maximums that substantially exceed their optima (Baxter 2002; Buchanan and Gregory 1997; Fraley and Shepard 1989; Homel and Budy 2008; Rieman and McIntyre 1993; Rieman and McIntyre 1995; Rieman et al. 1997; Swanberg 1997).

Salmonids are considered "metabolic conformers", they exhibit a metabolic rate that is dependent upon environmental conditions, and therefore they are commonly understood to be less tolerant of high temperatures and/or hypoxia (i.e., a condition of reduced dissolved oxygen availability) (Barnes et al. 2011, p. 397). Barnes et al. (2011), Cooke et al. (2012), and Eliason et al. (2011) have investigated environmental tolerances in sockeye (*Oncorhynchus nerka*) and Atlantic (*Salmo salar*) salmon. Their research documents physiological adaptation to high temperatures and/or hypoxia at the level of the population or stock. Individuals from populations that have experienced more variable and/or physiologically challenging environments appear to exhibit a greater capacity for metabolic regulation. This research suggests that salmonids are not strict "metabolic conformers", and would indicate that thermal tolerance is a complex adaptive response that varies between populations.

Cooke et al. (2012) and Eliason et al. (2011) examined variation in aerobic scope among sockeye salmon populations from the Fraser River (British Columbia, Canada) and its significance for migration through a complex and challenging set of riverine environments. Aerobic scope, the difference between resting and maximum oxygen consumption rates, varies among individuals and would appear to explain a corresponding variation in the tolerance for a thermally and hydraulically challenging environment. Eliason et al. (2011, p. 111) state that "…upstream migration is clearly impossible at T_{crit} [(i.e., when aerobic scope is zero), but] exactly how much scope is required for successful river migration is unknown." Cooke et al. (2012, p. 1763) state that "even though the exact cause of temperature-induced mortality is unknown, the aerobic challenge of up-river migration … appears to be a significant bottleneck when river temperatures are warmer than normal." Each individual's aerobic scope places an upward limit on the delivery of oxygen for locomotion and other basic functions.

Cook et al. (2012, pp. 1758, 1764) have emphasized that environmental stressors rarely act alone and the authors provide a useful graphic illustrating aerobic scope, both as a function of temperature under ideal conditions and under the influence of secondary stressors (Figure 1):

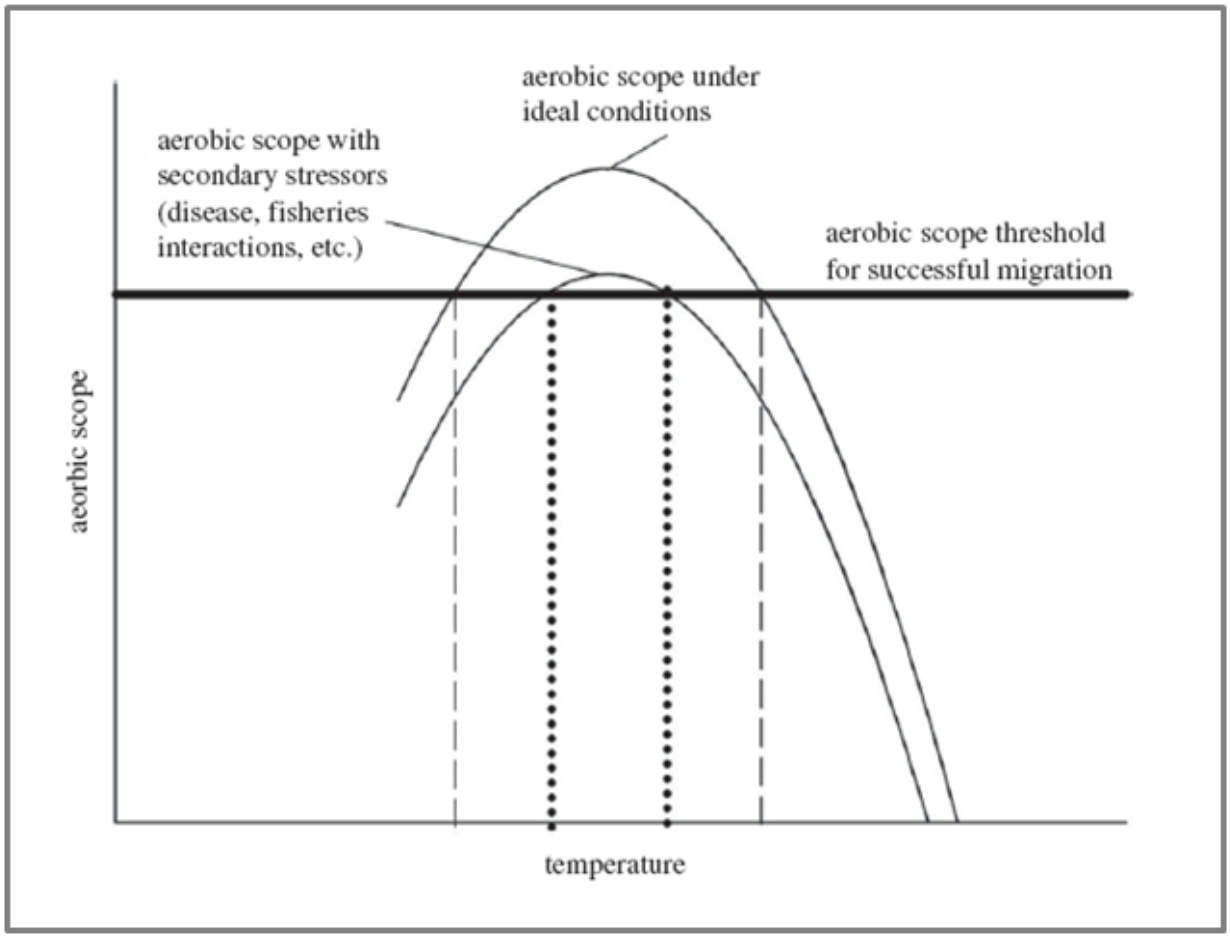

Figure 1. Aerobic scope under the influence of temperature and other stressors (Cooke et al. 2012, p. 1764).

"For a given salmon population, there is a minimum aerobic scope threshold for successful migration to reach the spawning ground. This threshold will vary yearly depending on environmental conditions (e.g. may increase or decrease due to varying river flow, etc.). The optimal range of temperatures is restricted when fish are physiologically compromised due to secondary stressors (dotted lines)."

Howell et al. (2010) studied spatial and temporal patterns of thermal habitat use by migratory adult bull trout. Tagged fish routinely experienced 7-day average daily maximums within the range of 18 to 25 °C and there was no apparent use of cold water thermal refuges. The authors state, "in spite of potential physiological consequences, bull trout … sometimes used relatively warm waters even when cooler water was available upstream." (Howell et al. 2010, p. 103)

Biochemical Oxygen Demand

BOD_5, or 5-day biochemical oxygen demand, is a standardized methodology for assessing oxygen consumption resulting from bacterial decomposition of organic material. The measure is of limited value in and of itself, but can be used in conjunction with other parameters (e.g.,

temperature, nutrient levels) to evaluate what effect effluent discharges may have on dissolved oxygen concentrations in the receiving waterbody. Dissolved oxygen, or oxygen saturation, is a relative measure of the amount of available oxygen. Both BOD_5 and dissolved oxygen are generally measured and reported in mg/L, or parts per million.

Dissolved oxygen is essential to the health and function of aquatic ecosystems. Under Washington State law, freshwater dissolved oxygen criteria are specified for several aquatic life categories (W.A.C. 173-201A-200): char spawning and rearing (9.5 mg/L), core summer salmonid habitat (9.5 mg/L), salmonid spawning, rearing, and migration (8.0 mg/L), etc.

In freshwater systems, oxygen concentrations and availability are primarily influenced by temperature and rates of consumption and replenishment. Rates of consumption and replenishment are dependent upon or influenced by the community of respiring (i.e., oxygen-consuming) organisms, the community of photosynthesizing (i.e., oxygen-producing) organisms, benthic and bacterial processes (including decomposition of dissolved and particulate organic material), and other atmospheric, climatological, and physical processes (e.g., mixing and stratification). At 8 °C and 95 percent saturation, dissolved oxygen concentrations are approximately 12 mg/L. At water temperatures in excess of 20 °C, dissolved oxygen concentrations may drop to 6 mg/L or lower.

It is widely known that low or extremely low dissolved oxygen concentrations are a common cause for fish kills. However, there is less appreciation for the significant sub-lethal effects that can result from exposure to hypoxic conditions. Kramer (1987) has provided a useful summary review of fish behavioral responses to dissolved oxygen availability. As with exposure to high temperatures, exposure to hypoxic conditions frequently imposes a metabolic cost that results in less energy being available for locomotion and other basic functions which are important to growth and survival. Oxygen concentration indicates the "… amount of medium which must be ventilated in order to obtain a given amount of oxygen", and the increased ventilation rates that are required under hypoxic conditions place a burden on metabolic and energetic reserves (Kramer 1987, pp. 83, 85). Both sustained swimming and effective escape movements also place demands on energy, and therefore predator avoidance and locomotion may be compromised under conditions of low dissolved oxygen availability (Kramer 1987, p. 85).

The Canadian Ministry of Natural Resources considered the implications of aerobic scope (or "scope-for-activity") when evaluating dissolved oxygen criteria for the protection of lake trout (*Salvelinus namaycush*) habitat (Evans 2006). The metabolic energy available to support daily movements, prey capture, predator avoidance, and migration is unconstrained by dissolved oxygen concentrations that exceed the "threshold for respiratory dependence" (Evans 2006, pp. 3-6). Evans (2006, pp. 5-8) reports that lake trout scope-for-activity is 100 percent at 8.1 mg/L dissolved oxygen and 14 °C, and at 7.7 mg/L dissolved oxygen and 18 °C. Growth studies conducted with six different salmonid species suggest that significant impacts to bioenergetics would begin to occur at dissolved oxygen concentrations below 7.0 mg/L (Evans 2006, p. 11).

Ammonia

Ammonia occurs naturally in surface waters, it is highly soluble in water, and its speciation is influenced by a wide variety of environmental parameters, including pH, temperature, and ionic strength (EPA 2012a, p. 57). In aqueous solutions, an equilibrium exists between un-ionized (NH3) and ionized (NH4 +) ammonia species. Un-ionized ammonia refers to all forms of ammonia in water with the exception of the ammonium ion (NH4 +). Un-ionized ammonia is toxic to fish and other aquatic life. Un-ionized ammonia may be toxic because it passes through biological membranes more readily (EPA 2012a, p. 57). Based on ambient pH conditions, toxic un-ionized ammonia (NH3) should be present at concentrations that approximate 1 to 1.5 percent of the total ammonia (Ammonia-N) concentration.

When reporting their decision regarding adoption of new chronic ammonia criteria, the WDOE expressed uncertainty regarding the protectiveness of criteria recommended by the U.S. Environmental Protection Agency (EPA) (WDOE 2002, p. 2). WDOE cited the work of Arillo et al. (1981), which found that "…concentrations of un-ionized ammonia less than 20 µg/L … cause changes in biochemical parameters related to brain, kidney, and liver metabolism." The WDOE stated, "… although rarely used in criteria development … [these] subtle effects … may be of significance to salmonids in the Pacific Northwest." (WDOE 2002, p. 10)

The Service has previously identified low concentrations of un-ionized ammonia as a source of measurable adverse effects (*Biological Opinion – City of Puyallup Wastewater Treatment Plant NPDES Permit Reissuance, Permit No. WA-003716-8, Ref. No. 13410-2011-F-0148*; *Biological Opinion – City of Arlington WWTP*, *Ref. No. 13410-2009-F-0175*). Here the Service relied on the work of Wicks et al. (2002), in finding that un-ionized ammonia concentrations over 40 µg/L may cause adverse exposures and effects to individuals.

The work of Wicks et al. (2002), Shingles et al. (2001), and others, presents evidence of measurable, sub-lethal effects resulting from un-ionized ammonia exposure with potential consequences for growth, survival, and reproduction. McKenzie et al. (2007) have provided a useful review and synthesis of these findings. While some findings suggest the link between ammonia exposure and reduced critical swimming speed reflects competing whole-body metabolic needs, McKenzie et al. (2007, p. 59) claim "…there is [also] now good evidence to indicate that exposure to sub-lethal concentrations of ammonia impairs the function of white muscle." McKenzie et al. have offered a useful explanation for the biological relevance of these exposures. If ammonia exposures result in depolarisation of white muscle, fish may be incapable of achieving the swimming speeds necessary to "negotiate velocity barriers" or find refuge from "seasonal storms and floods." (McKenzie et al. 2007, p. 59)

Fecal Coliform Bacteria

Fecal coliform bacteria is an indirect measure or indicator parameter for possible sewage contamination (EPA 2012b). Since it is difficult, time-consuming, and expensive to test directly for the presence of a large variety of pathogens, surface waters and effluent discharges are usually tested for coliforms instead. Although generally not harmful themselves, these coliforms

indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans (EPA 2012b).

Copper

Even at low concentrations, copper is acutely toxic to fish. Effects of exposure to copper include 1) weakened immune function and impaired disease resistance, 2) impaired respiration, 3) disruptions to osmoregulation, 4) impaired function of olfactory organs and brain, 5) altered blood chemistry, 6) altered enzyme activity and function, and 7) pathology of the kidneys, liver, and gills (Eisler 1998).

The acute lethality of copper has been evaluated for bull trout. Hansen et al. (2002) examined acute toxicity and determined that rainbow trout fry and bull trout fry have similar sensitivities. The authors describe a 96-hour and 120-hour LC50 for bull trout under test conditions (100 mg/L hardness and 8 ºC), approximately 66.6 and 50.0 µg/L, respectively.

Baldwin et al. (2003) found that short pulses of dissolved copper, at concentrations as low as 2 µg/L, reduced olfactory sensory responsiveness by approximately 10 percent within 10 minutes, and by 25 percent within 30 minutes. At 10 µg/L responsiveness was reduced by 67 percent within 30 minutes. Baldwin et al. (2003) identified a copper concentration neurotoxic threshold of an increase of 2.3 to 3.0 µg/L, when background levels are 3.0 µg/L or less. When exceeded, this threshold is associated with olfactory inhibition. The authors also reference three other studies examining long-duration copper exposures (i.e., exceeding 4 hours); these studies found that long-duration exposures resulted in cell (olfactory receptor neuron) death in rainbow trout and Atlantic and Chinook salmon. Baldwin et al. (2003) found that water hardness did not influence the toxicity of copper to coho salmon sensory neurons.

More recently, Sandahl et al. (2007) documented sensory physiological impairment, and related disruption to predator avoidance behaviors, in juvenile coho at concentrations as low as 2 µg/L dissolved copper.

The effects of short-term copper exposure may persist for hours and possibly longer. Although salmonids may actively avoid surface waters containing an excess of dissolved copper, exposed individuals may experience olfactory function inhibition. Avoidance of a chemical plume may cause fish to leave refugia or preferred habitats in favor of less suitable or less productive habitats. This, in turn, can make fish more vulnerable to predation and can impair foraging success, feeding efficiency, and thereby growth.

Folmar (1976) observed avoidance responses in rainbow trout fry when exposed to a Lowest Observed Effect Concentration of 0.1 µg/L dissolved copper (hardness of 90 mg/L). The EPA (1980a) also documented fry avoidance of dissolved copper concentrations as low as 0.1 µg/L during a 1 hour exposure, as well as a LC10 for smolts exposed to 7.0 µg/L for 200 hours, and a LC10 for juveniles exposed to 9.0 µg/L for 200 hours.

Zinc

Zinc occurs naturally in the environment and is an essential trace element for most organisms. However, in sufficient concentrations and when bioavailable for uptake by aquatic organisms, excess zinc is toxic. Toxicity in the aquatic environment and for exposed aquatic organisms is influenced by water hardness, pH, organic matter content, levels of dissolved oxygen, phosphate, and suspended solids, the presence of mixtures (i.e., synergistic effects), trophic level, and exposure frequency and duration (Eisler 1993). Bioavailability of zinc increases under conditions of high dissolved oxygen, low salinity, low pH, and/or high levels of inorganic oxides and humic substances. Most of the zinc introduced into aquatic environments is eventually partitioned into sediments (Eisler 1993).

Effects of zinc exposure include 1) weakened immune function and impaired disease resistance (Ghanmi et al. 1989), 2) impaired respiration, including potentially lethal destruction of gill epithelium (Eisler 1993), 3) altered blood and serum chemistry, and enzyme activity and function (Hilmy et al. 1987a; Hilmy et al. 1987b), 4) interference with gall bladder and gill metabolism (Eisler 1993), 5) hyperglycemia, and 6) jaw and branchial abnormalities (Eisler 1993).

Hansen et al. (2002) determined 120-day lethal concentrations of zinc for test subjects that included bull trout and rainbow trout fry. Multiple pairs of tests were performed with a nominal pH of 7.5, hardness of 30 mg/L, and at a temperature of 8 °C. Bull trout LC50 values measured under these conditions ranged from 35.6 to 80.0 µg/L, with an average of 56.1 µg/L. Hansen et al. (2002) found that rainbow trout fry are more sensitive to zinc (i.e., exhibit a lower LC50) than are bull trout fry. The authors also report that older, more active juvenile bull trout are more sensitive than younger, more docile juvenile bull trout based on observed changes in behavior at the juvenile life stage. The authors argue that the timing of zinc and cadmium exposure and the activity level of the exposed fish are germane to predicting toxicity in the field.
The mode of action for zinc toxicity relates to net loss of calcium. Studies suggest that zinc exposure inhibits calcium uptake, although it appears this effect is reversible once fish return to clean water. The apparent difference in sensitivity between rainbow trout and bull trout may be due to the lesser susceptibility of bull trout to calcium loss. Hansen et al. (2002) state that differences in sensitivity between these two salmonids may reflect different physiological strategies for regulating calcium uptake. These strategies may include gills that differ structurally, differences in the mechanisms for calcium uptake, and/or variation in resistance to or tolerance for calcium loss.

There are no known studies or data describing adult bull trout response to lethal or near-lethal concentrations of zinc. Active feeding and increased metabolic activity are apparently related to sensitivity. It is unknown whether sensitivity to zinc varies between adult, subadult, and juvenile bull trout. Activity level may be a better predictor of sensitivity than age.

In addition to the physiological effects of zinc exposure, studies have also documented a variety of behavioral responses. Among these, Eisler (1993) includes altered avoidance behavior, decreased swimming ability, and hyperactivity. The author also suggests zinc exposure has implications for growth, reproduction, and survival.

Sub-lethal endpoints have been evaluated with test subjects that include both juvenile and adult rainbow trout (Eisler 1993; EPA 1980b; EPA 1987). Some of these test results clearly indicate that juvenile rainbow trout are more sensitive than adult rainbow trout. Using juvenile rainbow trout as test subjects, studies have found that sub-lethal effects occur at concentrations approximately 75 percent lower (5.6 µg/L) than the concentrations that result in lethal effects (24 µg/L) (Eisler 1993; Hansen et al. 2002). Sprague (1968) found that at concentrations as low as 5.6 µg/L juvenile rainbow trout exhibit avoidance behavior. Avoidance of a chemical plume may cause fish to leave refugia or preferred habitats in favor of less suitable or less productive habitats. This can make fish more vulnerable to predation and can impair foraging success, feeding efficiency, and thereby growth.

pH

Hydrogen ion (H +) concentration, or pH, is a measure of acid-base equilibrium. In unimpaired surface waters pH typically ranges between 6.5 and 8.5.

Changes in pH affect the disassociation of weak acids and bases, and thereby influence the bioavailability and toxicity of many compounds (EPA 2012a, p. 60). For freshwater ecosystems, the primary concern is that changes in pH can substantially affect the chemical forms and toxicity of other substances. For example, the acute toxicity of ammonia has been found to increase as pH decreases. Hydrogen ion concentration affects the solubility of metal compounds, and pH thereby influences the bioavailability and toxicity of dissolved metals (EPA 2012a, p. 60).

Total Suspended Solids

Some pollutants and contaminants of concern have a strong affinity for suspended solids and the particulate-phase or fraction of discharged effluent (Grant et al. 2003; Wong et al. 2000). As a result, a portion of the toxic, inorganic and non-polar organic contaminant load is in particulate form, either sorbed onto, or complexed with solids (Fan et al. 2001; Grant et al. 2003, pp. viii, x; Marsalek et al. 1999, p. 34; Muthukrishnan and Selvakumar 2006, pp. 2, 5; Wong et al. 2000, p. 11). Pollutant loads bound or complexed with the particulate-phase or fraction represent a persistent, long-term source of potential chronic exposures.

The heavy metals, especially copper, chromium, lead, and nickel are closely associated with the particulate fraction (Grant et al. 2003, p. 5-7; Wong et al. 2000, p. 32); zinc and cadmium to a somewhat lesser extent. Polybrominated diphenyl ethers (PBDEs), polycyclic aromatic hydrocarbons (PAHs), oils and petroleum hydrocarbons generally, and other non-polar organic contaminants, such as pesticides and their decomposition products, are also closely associated with the particulate-phase or fraction. For these and other reasons, some experts in the field have identified TSS as an appropriate indirect measure or indicator of toxic contaminant load (Grant et al. 2003, p. 1-4; Hallberg et al. 2007, p. ab). Where sampling and monitoring are concerned, TSS is a decidedly easier and cheaper parameter to sample and measure.

Particle size distribution exerts a strong influence on contaminant-particulate dynamics and association. Heavy metals, PAHs, and other non-polar organic contaminants are generally bound in greatest concentration to the smallest of particles and colloids. For non-polar organic contaminants, particulate organic matter content also exerts a strong influence, but total particulate surface area is probably of greater significance. The smallest particles have the greatest "surface area to volume ratio", and therefore provide a comparatively larger total surface area to which contaminants may bind, sorb, and complex (Fan et al. 2001; Herngren et al. 2005, p. 150; John and Leventhal 1995, p. 13; Pettersson 2002, p. 1).

Pollutant loads bound or complexed with the particulate-phase or fraction represent a persistent, long-term source of potential chronic exposures and effects (Chen et al. 1996, p. ab; Fan et al. 2001; Glenn et al. 2002, p. 2; Grant et al. 2003, p. 4-3; Pettersson 2002, p. 1). Heavy metals do not degrade in the environment (Glenn et al. 2002, p. 2; Muthukrishnan and Selvakumar 2006, p. 2), and organic contaminants easily persist for durations that exceed the life spans of individual fish or multiple generations of fish (Heintz et al. 2000, p. 214). Chronic effects to individuals stem from repeated exposures over time, through multiple exposure pathways, and from multiple stressors and combinations of stressors (Burton et al. 2000, p. ab; Ellis 2000, p. 86; Heintz et al. 2000, p. 214). Ellis (2000, p. 89) has argued that sediment-mediated exposures and effects have not yet been given adequate attention, and furthermore that "…procedures for the identification of chronic, sub-lethal no effects limits are still to be achieved." Emphasizing the tendency for accumulation in sediments, both Hodson (1988, p. ab) and Pettersson (2002, p. 1) have argued that loads and not simply water concentrations should be a focus for management where discharges of metals and persistent organic pollutants are concerned.

Solids can act as both sinks and sources for metals and non-polar organic contaminants. Contaminants are "…reversibly bound to suspended particles….", and these particles can act as a "…source of water column toxicity or interstitial (pore) water toxicity." (Grant et al. 2003, p. 4-3) Adsorption and complexation are physiochemical processes that would tend to remove contaminants from the liquid-phase and sequester them in the solid-phase (Lloyd 1987, p. 491, 499). Redox potential (i.e., oxidizing or reducing conditions) and pH influence how contaminants are bound and, under varying conditions, can act to either keep contaminants bound in the solid-phase, or conversely, to release or desorb contaminants to the dissolved (liquid) phase (Bostick et al. 1998, p. 1; John and Leventhal 1995, p. 13). Some contaminated sediments constitute a persistent, continuing source of toxic contamination (Fan et al. 2001).

Ambient conditions determine whether contaminated sediments will act as continuing sources or sinks for toxic metals and non-polar organic contaminants. Because ambient conditions are dynamic and can change over time and space, equilibrium levels of metals and organic contaminants in sediments, in interstitial/pore water, and the water column, are also variable. "Bioavailability is a complex function of many factors ... Many of these factors vary seasonally and temporally, and most factors are interrelated." (John and Leventhal 1995, p. 10) Changes in ambient water and sediment chemistry, including redox state, dissolved oxygen concentration, pH, temperature, and buffering capacity/carbonate concentration/hardness, can release sequestered contamination to interstitial pore water or the water column (Chen et al. 1996, p. ab; Marsalek et al. 2002, p. 7; Muthukrishnan and Selvakumar 2006, p. 10; Wong et al. 2000, p. 10).

In fluvial environments, hydrology and fine and coarse sediment dynamics also exert a strong influence on patterns of sediment contamination. Rhoads and Cahill (1999, p. ab) describe variation in levels of sediment metal contamination reflecting distance from the source (outfalls), reach-scale variation in geomorphic conditions, and the degree of bed material sorting. Foster and Charlesworth (1996, p. ab) and Marsalek et al. (2002, pp. ab, 9) also emphasize the role of sediment deposition, accumulation, and remobilization. Baun et al. (2003, p. 4-4) and Chen et al. (1996, p. ab) suggest that hydraulic resuspension of contaminated sediments, and sporadic disturbance and release of contaminated interstitial pore water, influences bioavailability. Ellis (2000, p. 86) has argued that understanding the "…probability of biotic uptake and ecosystem response … requires incorporation of water quality effects with impacts on sediment and pore waters as well as habitat impairments resulting from flow hydraulics."

Unconventional Pollutants and Emerging Contaminants

Unconventional wastewater contaminants have been a focus of intense study over the past decade. Pollutants associated with wastewater are ubiquitous in U.S. waters, including natural and synthetic steroids and hormones, pharmaceuticals, detergent metabolites, plasticizers, and fire retardants (Figure 2) (Kolpin et al. 2002). Many of these are biologically active and relevant at exceedingly low concentrations, and some share a common mode of action or affect related biochemical pathways.

In support of a previous consultation(s), the EPA provided a useful summary of available literature to describe the presence of unconventional contaminants in wastewater, and current information regarding their potential for toxicological, neural, endocrine, reproductive, developmental, and behavioral effects in exposed aquatic life (EPA 2012a, pp. 97-113). However, while current research continues to provide better information with which to understand the presence and potential effects of these contaminants, there are still a great many unanswered questions. As an indication of the scope of this problem, consider that that the U.S. public uses more than 200 varieties of prescribed medication (PEIAR in EPA 2012a, p. 97), and that many of these compounds and/or their metabolites are likely present at some concentration in both treated and untreated wastewaters.

Emerging contaminants, wastewater contaminants for which there is only incomplete information, include pharmaceuticals and personal care products (e.g., antibiotics, painkillers and anti-inflammatories, anti-depressants, fragrances, and compounds found in cosmetics), natural and synthetic steroids and hormones (e.g., cholesterol, estradiol, ethynyl estradiol, and 17a-estradiol), disinfectants and detergent metabolites (e.g., triclosan, phenol, nonylphenols, and octylphenols), plasticizers (e.g., bis-2-ethylhexyl phthalate-DEHP, diethyl phthalate-DEP), fire retardants (e.g., PBDEs, chlorinated phosphates), herbicides and pesticides (e.g., carbaryl, carbazole, diazinon, pentachlorophenol, and permethrin), and even common and seemingly innocuous compounds such as caffeine.

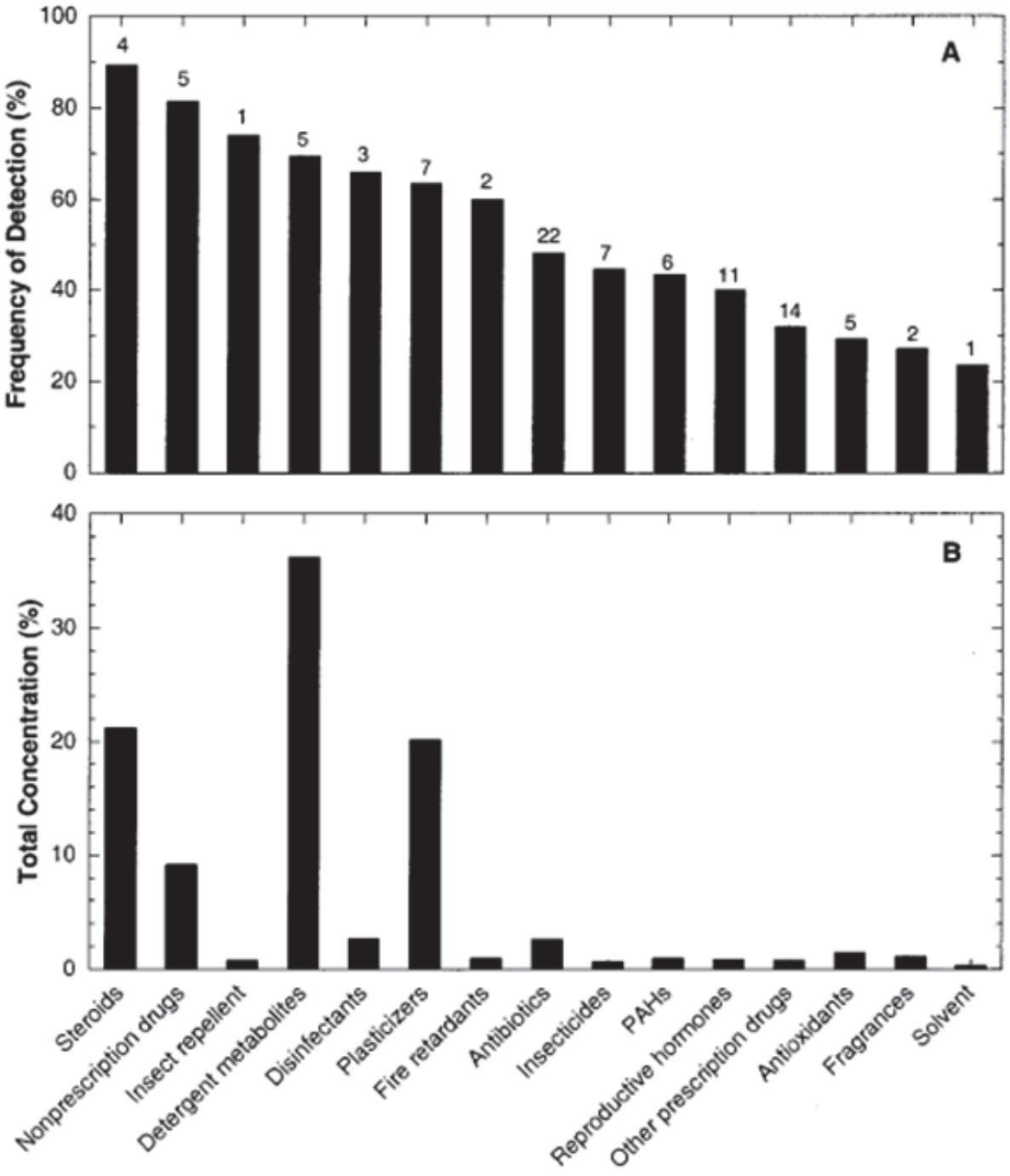

Figure 2. Wastewater contamination in U.S. streams; frequency of detection and percent of total measured concentration for organic contaminants, by general use category (Kolpin et al. 2002).

For nearly all of these chemical compounds there is only incomplete information to describe their presence in treated and untreated wastewaters, the efficiency with which treatment processes accomplish removal from the waste stream, their fate and transport in the environment

(including biotransformation and bioavailability), and their potential for independent, additive, antagonistic, and/or synergistic effects in exposed aquatic life.

The WDOE has investigated and reported on the removal of conventional pollutants, pharmaceuticals and personal care products (PPCPs), hormones, natural and synthetic endocrine disruptors, and other organic compounds at municipal WWTPs; this work evaluated wastewater influent, secondary effluent, tertiary effluent, and biosolids produced at two secondary treatment and three advanced/tertiary treatment facilities (Lubliner et al. 2010, abstract):

- "PPCPs were found in all samples at concentrations comparable to those found in the literature. Secondary treatment alone achieved high removals of hormones and steroids. Approximately 21 percent of the 172 analytes were reduced to below reporting limits by conventional secondary treatment, whereas 53 percent were reduced to below reporting limits by … advanced nutrient-removal technology."

- "Roughly 20 percent of the 172 analytes (mainly PAHs) were found only in the biosolids and not the wastewater samples. Some analytes were clearly concentrating in the biosolids."

- "Three PPCPs … were relatively untreated by the surveyed WWTP technologies. These three PPCPs may serve well as human-influence tracer compounds in the environment."

- "Overall, this screening study indicates that (1) there are differences in PPCP removal between the WWTP processes, and (2) advanced nutrient reduction and tertiary filtration may provide additional PPCP removal."

There are at least three issues for the science of contaminant behavior in the environment that currently confound and will continue to confound our efforts to understand the potential effects of wastewater exposures (EPA 2012a, pp. 97, 98, 105): 1) wastewater discharges are an exceedingly complex and variable mixture of hundreds of chemical compounds; 2) ecologically relevant surface water concentrations are poorly understood and not always a focus for study or consideration; and, 3) there are a huge variety of potentially relevant acute and chronic "endpoints" (or biological responses). Mesocosm and caged fish studies have been employed to address some of these inherent challenges, but examining the full spectrum of relevant exposure scenarios will take many years of future research. Furthermore, to the extent that much toxicological research still focuses on lethal effects and/or developmental effects, and the variety of potentially relevant chronic and sub-lethal endpoints remains poorly defined, it will remain difficult to interpret the significance of exposures to unconventional wastewater pollutants.

Endocrine disruption, and the potential for resulting reproductive and developmental effects in aquatic life, is of particular concern. Some of the known or suspected endocrine disrupting compounds (EDCs) present in wastewater include natural and synthetic steroids and hormones, phenols found in detergents, phthalates found in plasticizers, bisphenol A (BPA) found in plastics, and a number of anti-fungals and/or pesticides. EDCs interfere with or mimic the natural hormones responsible for maintenance, reproduction, development, and/or behavior in organisms (USGS 1998, p. 2). EDCs can act independently or as a complex mixture to reduce or

suppress the production of natural hormones, affect the release of hormones from glands, simulate or counteract the action of hormones at target tissues, and/or speed-up the metabolism and thereby reduce the action of natural hormones. Wastewater discharges have been investigated as a common cause or partial cause for the occurrence of EDCs in surface waters, and have been implicated for observed endocrine disruption in some fish populations (Barber et al. 2012, pp. 1, 2).

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APPENDIX D

Biological Resources

Biological Evaluation

From: Krull, Kandice (FAA) <Kandice.Krull@faa.gov>
Sent: Monday, June 30, 2025 12:47 PM
To: 'WashingtonFWO@fws.gov' <WashingtonFWO@fws.gov>
Cc: 'owco.wa.consultationrequest@noaa.gov' <owco.wa.consultationrequest@noaa.gov>; Jennifer Quan - NOAA Federal <jennifer.quan@noaa.gov>; Kathleen Wells - NOAA Federal <kathleen.wells@noaa.gov>; dayv.lowry@noaa.gov; jeff.vanderpham@noaa.gov; Rybolt, Steve <rybolt.s@portseattle.org>; Sarah Potter <Sarah.Potter@landrumbrown.com>; Garrison, William (FAA) <william.garrison@faa.gov>; Zulauf, Ryan C (FAA) <ryan.c.zulauf@faa.gov>
Subject: RE: SEA SAMP NTPs Biological Evaluation and Section 7 Consultation Request

Good morning,

As requested, I am resubmitting the final Biological Evaluation (BE) and request for informal consultation for the Seattle-Tacoma International Airport Near Term Projects to the consultation request inbox.

The FAA would like to request informal consultation under the Endangered Species Act for the Near-Term Projects (Proposed Project) at the Seattle-Tacoma International Airport (Airport). The purpose of the Proposed Action is to accommodate projected passenger demand and cargo levels; provide airfield infrastructure that meets current FAA airport design standards; enhance the efficiency of the taxiway layout; and to meet projected fuel storage demand including sustainable aviation fuel initiatives. All NTPs are anticipated to be complete or in final construction by 2032.

A Biological Evaluation (BE), prepared by the FAA, is enclosed. The BE evaluated the potential project effects on twelve listed species, one proposed for listing species, and one candidate species. The FAA made the following effect determinations:

•

Chinook salmon (Oncorhynchus tshawytscha, Puget Sound ESU) - **May affect, not likely to adversely affect.**

- Chinook salmon critical habitat- **May affect, not likely to adversely affect.**
- Steelhead (O. mykiss, Puget Sound ESU) - **May affect, not likely to adversely affect.**
- Steelhead critical habitat No effect
- Bull trout (Salvelinus confluentus, Coastal-Puget Sound DPS) - **May affect, not likely to adversely affect.**
- Bull trout critical habitat- **May affect, not likely to adversely affect.**
- Bocaccio rockfish (Sebastes paucispinus, Puget Sound/Georgia Basin DPS) - **May affect, not likely to adversely affect.**
- Bocaccio rockfish critical habitat- **May affect, not likely to adversely affect.**
- Yelloweye rockfish (S. ruberrimus, Puget Sound/Georgia Basin DPS) - **May affect, not likely to adversely affect.**
- Yelloweye rockfish critical habitat- **May affect, not likely to adversely affect.**
- Killer whale (Orcinus orca, Southern Resident DPS) - **May affect, not likely to adversely affect.**
- Killer whale critical habitat- **May affect, not likely to adversely affect.**
- North American wolverine (Gulo gulo luscus) – **No effect**
- Yellow-billed cuckoo (Coccyzus americanus) – **No effect**
- Marbled murrelet (Brachyramphus mamoratus) – **No effect**
- Northwestern pond turtle (Actinemys marmorata) – **No effect**
- Monarch butterfly (Danaus Plexippus) - **No effect**
- Suckley's Cuckoo Bumble Bee (*Bombus suckleyi)* – **No effect**
- Southern Pacific eulachon (Thaleichthys pacificus) – **No effect**
- Central America/Western North Pacific Humpback Whale (Megaptera novaeangliae) – **No effect**
- Southern green sturgeon (Acipenser medirostris) – **No effect**

DPS – Distinct population segment; ESU – Evolutionarily significant unit

The FAA determined these effect determinations using the best available scientific and commercial data, including 14 years of *in-situ* toxicity testing, acute toxicity testing, and sublethal testing conducted on treated stormwater discharges as well as recent 6PPD-Q treatment testing results. The FAA also considered the Port's robust stormwater and industrial wastewater treatment systems and Operational Source Control Best Management Practices. Any potential effects of the Proposed Action cannot be meaningfully measured or evaluated but are not expected to reach the scale where take occurs.

The fate and transport of many of the stormwater contaminants and their synergistic effects are not fully understood, therefore, the extent, duration, and severity of stormwater effects cannot currently be meaningfully quantified or evaluated with certainty.

The BE is attached to this email.

The FAA respectfully requests an expedited review of the consultation request, as agreed to during our call on June 17, 2025. If you have any comments, questions, or concerns regarding the analyses and conclusions used to determine the potential effects of the proposed project on ESA resources, or have any questions regarding the project, please do not hesitate to contact me.

Thanks so much,
Kandice

Kandice Krull
Environmental Protection Specialist
FAA - Denver Airports District Office
303-342-1261

From: Krull, Kandice (FAA)
Sent: Wednesday, October 2, 2024 8:10 AM
To: WashingtonFWO@fws.gov
Cc: owco.wa.consultationrequest@noaa.gov; bonnie.shorin@noaa.gov; joshua_emery@fws.gov; Sara.potter@noaa.gov; Potter, Sara L <sara_potter@fws.gov>; Rybolt, Steve (Rybolt.S@portseattle.org) <Rybolt.S@portseattle.org>; Sarah Potter <sarah.potter@landrumbrown.com>
Subject: SEA SAMP NTPs Biological Evaluation and Section 7 Consultation Request EMAIL 1 of 3

Good morning Sara,

As requested, I am submitting the final Biological Evaluation (BE) and request for informal consultation to the consultation request inbox. Four of the reports that are supposed to be included in Appendix E are protected and cannot be added to the BE. I have attached one of the four to this email and I will need to send additional emails to include the other three. The 2023 report may be too large to email. I am working with the Port to see if we can get the file size reduced. Is there another option for submittal if I am unable to get it to a size that can be emailed?

The FAA would like to request informal consultation under the Endangered Species Act for the Near-Term Projects (Proposed Project) at the Seattle-Tacoma International Airport (Airport). The purpose of the Proposed Action is to accommodate projected passenger demand and cargo levels; provide airfield infrastructure that meets current FAA airport design standards; enhance the efficiency of the taxiway layout; and to meet projected fuel storage demand including sustainable aviation fuel initiatives. All NTPs are anticipated to be complete or in final construction by 2032.

A Biological Evaluation (BE), prepared by the FAA, is enclosed. The BE evaluated the potential project effects on twelve listed species, one proposed for listing species, and one candidate species. The FAA made the following effect determinations:

Chinook salmon (Oncorhynchus tshawytscha, Puget Sound ESU) - **May affect, not likely to adversely affect.**

- Chinook salmon critical habitat- **May affect, not likely to adversely affect.**
- Steelhead (O. mykiss, Puget Sound ESU) - **May affect, not likely to adversely affect.**
- Steelhead critical habitat No effect
- Bull trout (Salvelinus confluentus, Coastal-Puget Sound DPS) - **May affect, not likely to adversely affect.**
- Bull trout critical habitat- **May affect, not likely to adversely affect.**
- Bocaccio rockfish (Sebastes paucispinus, Puget Sound/Georgia Basin DPS) - **May affect, not likely to adversely affect.**
- Bocaccio rockfish critical habitat- **May affect, not likely to adversely affect.**
- Yelloweye rockfish (S. ruberrimus, Puget Sound/Georgia Basin DPS) - **May affect, not likely to adversely affect.**
- Yelloweye rockfish critical habitat- **May affect, not likely to adversely affect.**
- Killer whale (Orcinus orca, Southern Resident DPS) - **May affect, not likely to adversely affect.**
- Killer whale critical habitat- **May affect, not likely to adversely affect.**
- North American wolverine (Gulo gulo luscus) – **No effect**
- Yellow-billed cuckoo (Coccyzus americanus) – **No effect**
- Marbled murrelet (Brachyramphus mamoratus) – **No effect**
- Northwestern pond turtle (Actinemys marmorata) – **No effect**
- Monarch butterfly (Danaus Plexippus) - **Not likely to jeopardize continued existence**
- Southern Pacific eulachon (Thaleichthys pacificus) – **No effect**
- Central America/Western North Pacific Humpback Whale (Megaptera novaeangliae) – **No effect**
- Southern green sturgeon (Acipenser medirostris) – **No effect**

DPS – Distinct population segment; ESU – Evolutionarily significant unit

The basis for the effect determinations is provided in the BE. The FAA considered the following in reaching the effect determinations:

- The Port's existing and proposed structural and operational pollution controls are robust and state of the art. All stormwater generated at SEA meets Ecology's requirements before being released into area streams.
- Rainbow trout (RBT) early life stages (ELS) *in situ* monitoring tests completed twice a year in accordance with the NPDES permit includes testing sites upstream of SEA and downstream of treated stormwater discharges into Des Moines Creek. The downstream location consistently has better results than the upstream location, demonstrating how the release of treated stormwater is actually helping to improve the water quality of Des Moines Creek.
- The Port has been testing four commercially available filter media individually and in combination with Chitosan Enhanced Sand Filtration to identify an alternative BMP to 100% infiltration to treat 6PPD-Q in stormwater for the past eight months and has identified methods that show promising results (up to 98.8% removal efficiency). The NTPs will include the effective BMPs as part of the proposed project.

- There is insufficient information available to quantify potential biologically significant effects on listed species from exposure to chronic surface water pollutants generated by the Proposed Action.
- The fate and transport of many of the stormwater contaminants and their synergistic effects are not fully understood, therefore, the extent, duration, and severity of stormwater effects cannot currently be quantified with certainty.

The BE is attached to this email.

The FAA respectfully requests written concurrence with our effect determinations. If you have any comments, questions, or concerns regarding the analyses and conclusions used to determine the potential effects of the proposed project on ESA resources, or have any questions regarding the project, please do not hesitate to contact me.

Thanks so much,
Kandice

Kandice Krull
Environmental Protection Specialist
FAA - Denver Airports District Office
303-342-1261

US Department of Transportation
Federal Aviation Administration
Northwest Mountain Region – Seattle Airports District Office

Seattle-Tacoma International Airport
Sustainable Airport Master Plan Near Term Projects

FINAL BIOLOGICAL EVALUATION

Prepared by:

Kandice Krull
Environmental Protection Specialist
FAA Denver Airports District Office

June 2025

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ACRONYMS AND ABBREVIATIONS

6PPD	N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine
6PPD-Q	6PPD-quinone
ARFF	Aircraft Rescue and Firefighting
BE	Biological evaluation
Biochar	Biochar-Black Owl Stormwater Mix
BMPs	Best management practices
BOD	Biological oxygen demand
CESF	Chitosan enhanced sand filtration
CFR	Code of Federal Regulations
Construction SWPPP	Site-specific construction stormwater pollution prevention plan
CRDC	Centralized receiving and distribution center
dBA	A-weighted decibel
DPS	Distinct population segment
Ecology	Washington State Department of Ecology
EEZ	Exclusive economic zone
EFH	Essential fish habitat
ESA	Endangered Species Act
ESU	Evolutionarily significant unit
FAA	Federal Aviation Administration
FMO	Foraging, migration, and overwintering
FR	Federal Register
GSA	General study area
GSE	Ground service equipment
HS250	Hydrosil HS-250
IWS	Industrial wastewater system
IWTP	Industrial Wastewater Treatment Plant IWTP
km	Kilometer
mg/L	Milligrams per liter
MLLW	Mean lower low water
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NAE	North Airport Expressway
NGT	North Ground Transportation
NMFS	National Marine Fisheries Service
NOS	Natural-origin spawners
NPDES	National Pollutant Discharge Elimination System
NPGIS	Non-pollution-generating impervious surface
NTPs	Near-term project
NWSA	Northwest Seaport Alliance’s
OSC	Operational source control
PAHs	Polyaromatic hydrocarbons
PBF	Physical and biological feature

PCE	Primary constituent element
PFMC	Pacific Fishery Management Council
PGIS	Pollution-generating impervious surface
Port	Port of Seattle
ppb	Parts per billion
PPP	Pollution Prevention Plan
PSP	Program support project
RIM	Runway incursion mitigation
RM	River mile
SAMP	Sustainable Airport Master Plan
SCU	SCU-Evoqua
SDS	Stormwater drainage system
SEA	Seattle-Tacoma International Airport
SEA SWPPP	Seattle-Tacoma International Airport Stormwater Pollution Prevention Plan
Section 404	Section 404 of the Clean Water Act
Services	National Marine Fisheries Service, and U.S. Fish and Wildlife Service
SRKW	Killer whale, Southern Resident Distinct Population Segment
UMP	Utilities Master Plan
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VCC	Virgin coconut carbon
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resources Inventory Area
WSDOT	Washington State Department of Transportation

EXECUTIVE SUMMARY

The Port of Seattle (Port) completed a Sustainable Airport Master Plan for the Seattle-Tacoma International Airport (SEA) that identified a Long-Term Vision to accommodate future needs over the 20-year planning horizon. From this, the Port developed 31 Near-Term Projects (NTPs) to improve safety and meet forecasted passenger and cargo demand. While the NTPs are the Port's intended development at SEA, only some of these development components are subject to federal approval and/or funding. The Federal Aviation Administration (FAA) determined it does not have approval authority for L04 – Northeast Ground Transportation Center and S01 – Fuel Farm Expansion in accordance with of Section 163 of HR 302, the "FAA Reauthorization Act of 2018" (P.L. 115-254) and Section 743 of HR 3935, the "FAA Reauthorization Act of 2024" (P.L. 118-63).

The Proposed Action addressed in this Biological Evaluation (BE) comprises the construction and operation of 29 NTPs funded and/or authorized by FAA, the construction and operation of associated program support projects necessary for implementation of these NTPs, habitat mitigation for unavoidable impacts to wetlands and wetland buffers resulting from project construction, and best management practices used by the Port to avoid and minimize environmental impacts from the construction and operation of the Proposed Action.

The federal actions associated with the Proposed Action constitute a federal nexus necessitating consultation under Section 7 of the Endangered Species Act (ESA). This BE evaluates the Proposed Action's potential effects on ESA-listed species and critical habitats that occur in the action area. The action area includes terrestrial and aquatic habitats in Water Resources Inventory Area 9 (Green/Duwamish and Central Puget Sound Watershed). The aquatic component of the action area is limited to hydrologic unit code 17110019 (Central Puget Sound) while the terrestrial component overlaps the boundary between hydrologic unit codes 17110019 and 17110013 (Duwamish).

Summary of Anticipated Effects to Listed Species

Table ES-1 summarizes the species evaluated in the BE and effects determinations for each species and critical habitat. The Proposed Action would not result in direct construction effects on ESA-listed species or critical habitat. Anticipated effects would result from delayed consequences associated with operational treated stormwater runoff and treated industrial wastewater discharges that would be generated by the Proposed Action. It is important to note that the difference between the Proposed Action and No Action is negligible. The FAA determined these effect determinations using the best available scientific and commercial data, including 14 years of *in-situ* toxicity testing, acute toxicity testing, and sublethal testing conducted on treated stormwater discharges as well as recent 6PPD-Q treatment testing results. The FAA also considered the Port's robust stormwater and industrial wastewater treatment systems and Operational Source Control Best Management Practices.

Table ES-1. Effects determinations for ESA-listed species and designated critical habitat

Species/Habitat	Effects Determination
Chinook salmon (*Oncorhynchus tshawytscha,* Puget Sound ESU)	Not likely to adversely affect
Chinook salmon critical habitat	Not likely to adversely affect
Steelhead (*O. mykiss*, Puget Sound ESU)	Not likely to adversely affect
Steelhead critical habitat	No effect
Bull trout (*Salvelinus confluentus*, Coastal-Puget Sound DPS)	Not likely to adversely affect
Bull trout critical habitat	Not likely to adversely affect
Bocaccio rockfish (*Sebastes paucispinus*, Puget Sound/Georgia Basin DPS)	Not likely to adversely affect
Bocaccio rockfish critical habitat	Not likely to adversely affect
Yelloweye rockfish (*S. ruberrimus,* Puget Sound/Georgia Basin DPS)	Not likely to adversely affect
Yelloweye rockfish critical habitat	Not likely to adversely affect
Killer whale (*Orcinus orca*, Southern Resident DPS)	Not likely to adversely affect
Killer whale critical habitat	Not likely to adversely affect
North American wolverine (Gulo gulo luscus)	No effect
Yellow-billed cuckoo (Coccyzus americanus)	No effect
Marbled murrelet (Brachyramphus mamoratus)	No effect
Northwestern pond turtle (*Actinemys marmorata)*	No effect
Monarch butterfly (Danaus Plexippus)	No effect
Suckley's Cuckoo Bumble Bee (Bombus suckleyi)	No effect
Southern Pacific eulachon (Thaleichthys pacificus)	No effect
Central America/Western North Pacific Humpback Whale (*Megaptera novaeangliae)*	No effect
Southern green sturgeon (*Acipenser medirostris)*	No effect
DPS – Distinct population segment; ESU – Evolutionarily significant unit	

Summary of Anticipated Effects to Essential Fish Habitat

The Proposed Action was also evaluated for its potential effects on essential fish habitat (EFH). It was determined that the Proposed Action is not likely to adversely affect EFH for groundfish, coastal pelagic, and Pacific salmon species in Puget Sound and EFH for Pacific salmon species in tributaries that drain to Puget Sound from SEA. All effects to EFH would result from delayed consequences associated with operational treated stormwater runoff and treated industrial wastewater discharges that are generated by the Proposed Action.

1.0 INTRODUCTION

The Port of Seattle (Port) completed a Sustainable Airport Master Plan (SAMP) for the Seattle-Tacoma International Airport (SEA) that identified a Long-Term Vision to accommodate future needs over the 20-year planning horizon. From this, the Port developed 31 Near-Term Projects (NTPs) to improve safety and meet forecasted passenger and cargo demand. The NTPs include airfield projects, terminal projects, cargo projects, landside projects, and airline/airport support projects.

This biological evaluation (BE) has been developed to initiate consultation between the Federal Aviation Administration (FAA), the lead federal action agency, and the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS), collectively "the Services," under Section 7 of the Endangered Species Act (ESA) of 1973 (16 United States Code 1531-1544). Section 7 requires federal agencies to ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of listed species or species proposed for listing under the ESA or result in the destruction or adverse modification of critical habitat for those species.

Section 163 of H.R. 302, the "FAA Reauthorization Act of 2018" (Public Law 115-254) and Section 743 of H.R. 3935, the "FAA Reauthorization Act of 2024" (Public Law 118-63) limited FAA's authority in certain circumstances. While the Port intends to develop all 31 NTPs, only some of the NTPs are subject to federal approval or funding. The FAA determined it does not have approval authority for L04 – Main Terminal North GT Lot and S01 – Fuel Farm Expansion; therefore, these projects are not considered in this consultation. These projects are considered as part of the future environmental baseline.

The Proposed Action addressed in this BE comprises the construction and operation of 29 NTPs and associated program support projects (PSPs), habitat mitigation for unavoidable impacts to wetlands, and best management practices (BMPs) to avoid and minimize environmental impacts from the construction and operation of the 29 NTPs. The provision of federal funding and/or authorization for these projects constitutes a federal nexus necessitating consultation under Section 7 of the ESA.

The action area comprises terrestrial and aquatic habitats in Water Resources Inventory Area 9 (Green/Duwamish and Central Puget Sound Watershed). The aquatic component of the action area is in hydrologic unit code 17110019 (Central Puget Sound). The terrestrial component of the action area overlaps the boundary between hydrologic unit codes 17110019 and 17110013 (Duwamish).

This BE evaluates the potential direct effects and delayed consequences of the Proposed Action on species that are listed, or proposed to be listed, as endangered or threatened under the ESA. Wherever possible, NMFS utilizes existing interagency coordination processes to fulfill consultation requirements for the Magnuson-Stevens Fishery Conservation and Management Act (MSA) consultations with federal agencies. For this Proposed Action, this goal is being met by incorporating MSA consultation into this ESA Section 7 consultation.

1.1 Biological Evaluation Contents

- Chapter 1.0, Introduction, provides an overview of the project, explains the federal nexus, and introduces the species covered in the BE.
- Chapter 2.0, Project Description, describes the Proposed Action, including specific details of each of the NTPs, PSPs, plans for mitigation, and BMPs to minimize environmental impacts.
- Chapter 3.0, Action Area, defines the project's action area.
- Chapter 4.0, Environmental Setting/Baseline, describes the baseline conditions within the terrestrial and aquatic portions of the action area, and the federal status, occurrence, and critical habitat of listed species that may be affected by the Proposed Action.
- Chapter 5.0, Analysis of Effects, analyzes direct effects and delayed consequences of the Proposed Action, identifies interrelated and interdependent actions, and cumulative effects of the Proposed Action, organizing the discussion by potential mechanism of effect to listed species.
- Chapter 6.0, Conclusions and Effects Determinations, summarizes the conclusions of the effects analysis for each listed species and designated critical habitat.
- Chapter 7.0, Effects to Essential Fish Habitat (EFH), assesses impacts to EFH resulting from the Proposed Action.

1.2 Key Issue and Species Addressed

While all potential direct and indirect effects of the Proposed Action were analyzed (Chapter 5.0), the key issue addressed in this BE is the potential effects that could result from permitted treated stormwater and industrial wastewater discharges. Stormwater is the surface runoff that results from rain and snowmelt. Urban development alters the land's natural infiltration, and human activity generates a host of pollutants that can accumulate on paved surfaces. Current treatment technologies can reliably reduce the concentrations of known, commonly occurring stormwater contaminants like polyaromatic hydrocarbons (PAHs) and metals.

While the list of contaminants prioritized for regulation under the National Pollutant Discharge Elimination System (NPDES) is broad (USEPA 2010), it represents a fraction of the thousands of chemicals that routinely occur in stormwater runoff and wastewater discharges. It is unknown if treatment effectively removes contaminants not included under NPDES because neither testing methods nor thresholds have been established.

There is uncertainty about the effectiveness of current stormwater treatment technology for emerging contaminants of concern. For example, the chemical 6PPD-quinone (6PPD-Q) has been identified as a causal agent of pre-spawn mortality of salmonids (Ecology 2022). Vehicle tires contain the chemical 6PPD (N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine) to prevent tires from degrading. Tires wear down through contact with roads, releasing particles into the environment. When 6PPD in these particles reacts with ozone in the air, it forms 6PPD-Q. When it rains, stormwater from hard surfaces, like parking lots and streets, washes these particles into streams and other water bodies.

The extent of potential downstream transport of treated stormwater and industrial wastewater discharges defines the action area for this BE (Chapter 3.0) and therefore the species addressed. Species lists from USFWS (2024a) and NMFS (2024a) were obtained from the agencies' websites in April

2024 and June 2025 (Appendix A). The following species occur in, have potential to occur in, and/or have designated critical habitat present in the action area (Section 4.4):

- Chinook salmon, Puget Sound Evolutionarily Significant Unit (ESU) (*Oncorhynchus tshawytscha)*
- Steelhead, Puget Sound Distinct Population Segment (DPS) (*O. mykiss)*
- Bull trout, Coastal-Puget Sound DPS (*Salvelinus confluentus)*
- Bocaccio rockfish, Puget Sound/Georgia Basin DPS (*Sebastes paucispinis*)
- Yelloweye rockfish, Puget Sound/Georgia Basin DPS (*S. ruberrimus*)
- Killer whale, Southern Resident DPS (SRKW) (*Orcinus orca*)

1.3 Species Not Addressed

Table 1 shows NMFS and USFWS-listed species that may occur in King County but that are not found in the action area for the reasons described below and the Proposed Action will have no effect on.

Table 1. ESA-listed species and critical habitat with No Effects

Species	Scientific Name	Lead Agency	Federal Status	Critical Habitat in Action Area
North American wolverine	*Gulo gulo luscus*	USFWS	Threatened	No
Yellow-billed cuckoo	*Coccyzus americanus*	USFWS	Threatened	No
Marbled murrelet	*Brachyramphus marmoratus*	USFWS	Threatened	No
Northwestern pond turtle	*Actinemys marmorata*	USFWS	Proposed Threatened	No
Monarch butterfly	*Danaus plexippus*	USFWS	Proposed Threatened	No
Suckley's Cuckoo Bumble Bee	*Bombus suckleyi*	USFWS	Proposed Endangered	No
Southern Pacific eulachon	*Thaleichthys pacificus*	NMFS	Threatened	No
Central America/Western North Pacific Humpback Whale	*Megaptera novaeangliae*	NMFS	Endangered	No
Southern green sturgeon	*Acipenser medirostris*	NMFS	Threatened	No

1.3.1 North American Wolverine

1.3.1.1 *Federal Status*

The North American wolverine is listed as a threatened species (88 Federal Register [FR] 83726). Critical habitat has not been proposed in Washington.

1.3.1.2 *Occurrence*

The North American wolverine is found in the western and northwestern United States, Canada, and Alaska. Wolverines are rare in Washington State and generally occur in alpine and sub-alpine habitats of the Cascades and eastern Washington. The Washington Department of Fish and Wildlife (WDFW) estimates the population within the Cascades to be less than 25 individuals (2024a). Wolverines are very solitary and tend to avoid interactions with humans and areas of human activity.

1.3.1.3 *Rationale for Exclusion*

The Proposed Action would have no effect on the North American wolverine or its habitat because the urbanized environment of the action area does not provide suitable habitat for the species.

1.3.2 Yellow-Billed Cuckoo

1.3.2.1 *Federal Status*

The yellow-billed cuckoo is listed as a threatened species (79 FR 59991). Critical habitat has not been proposed in Washington.

1.3.2.2 *Occurrence*

Yellow-billed cuckoos are migratory birds that arrive in western North America in May, nest from June through August, and leave in September. They have a strong preference for large, continuous riparian zones composed of willows and cottonwoods (at least 50 acres). They were once considered abundant along the Columbia River and occasionally observed in western Washington, but they no longer breed in Washington (Wiles and Kalasz 2017). Recent reports of individual cuckoos in Washington are rare and occur east of the Cascade Mountains (Wiles and Kalasz 2017).

1.3.2.3 *Rationale for Exclusion*

The Proposed Action would have no effect on the yellow-billed cuckoo or its critical habitat because the cuckoo has been functionally extirpated from Washington State and the action area does not provide suitable habitat for this species.

1.3.3 Marbled Murrelet

1.3.3.1 *Federal Status*

The USFWS listed the marbled murrelet as threatened in 1992 (57 FR 45328). Critical habitat was designated in 1996 (61 FR 26256) and revised in 2011 (76 FR 61599), covering 3,698,100 acres in Washington, Oregon, and California.

1.3.3.2 *Occurrence*

Marbled murrelets spend most of their life foraging in shallow, nearshore marine waters across the west coast but migrate inland for nesting in old-growth forests with large trees and multiple canopies (USFWS 2024c). Murrelets live and forage in Puget Sound, and adults and subadults are routinely observed at a long-term monitoring location approximately 2 km west of the IWTP outfall (Falxa et al. 2013; McIver et al. 2021). Designated critical habitat is limited to remaining tracts of old growth and mature late-successional forest that provide suitable habitat conditions for nesting.

1.3.3.3 *Rationale for Exclusion*

Though the marbled murrelet may occur in the action area, the likelihood of effects is insignificant and discountable for this wide-ranging species. Critical habitat does not occur in the action area.

1.3.4 Northwestern Pond Turtle

1.3.4.1 *Federal Status*

The USFWS proposed to list the northwestern pond turtle as threatened in 2023 (88 FR 68370). Critical habitat has not been proposed in Washington.

1.3.4.2 *Occurrence*

The northwestern pond turtle is native to the northwest United States, occurring in Washington, Oregon, Nevada, and California. The northwestern pond turtle is primarily aquatic, leaving the water only to lay eggs, overwinter, or disperse to new water bodies. The species was extirpated from Washington State in 1990. Because of recovery efforts, there are now 6 populations in the state, none of them occurring in King County.

1.3.4.3 *Rationale for Exclusion*

The Proposed Action would have no effect on the northwestern pond turtle or its habitat because this species does not occur in the action area.

1.3.5 Monarch Butterfly

1.3.5.1 *Federal Status*

The USFWS proposed to list the monarch butterfly as threatened in 2024 (89 FR 100662). Critical habitat has not been proposed.

1.3.5.2 *Occurrence*

Monarch butterflies in Washington occur primarily east of the Cascades in weedy fields, sparsely vegetated habitats along large river courses, and in wetland areas where their obligate milkweed host plant (primarily Asclepias spp.) grows. The number of monarchs in Washington is relatively low. Milkweeds are patchily distributed within the Columbia Basin. Migrating monarchs often concentrate along the large river courses of the Columbia and Snake Rivers (WDFW 2024c).

1.3.5.3 *Rationale for Exclusion*

The Proposed Action would have no effect on the monarch butterfly or its habitat because this species does not occur in the action area.

1.3.6 Suckley's Cuckoo Bumble Bee

1.3.6.1 *Federal Status*

The USFWS proposed to list the Suckley's Cuckoo Bumble Bee as endangered in 2024 (89 FR 102074). Critical habitat has not been proposed in Washington.

1.3.6.2 *Occurrence*

Suckley's cuckoo bumble bee species historically occurred throughout the State of Washington. Recent range-wide surveys in Washington detected the species in only six localities, primarily in remote subalpine and montane areas.

1.3.6.3 *Rationale for Exclusion*

The Proposed Action would have no effect on the monarch butterfly or its habitat because this species does not occur in the action area.

1.3.7 Southern Pacific Eulachon

1.3.7.1 *Federal Status*

The Southern DPS of eulachon is listed as threatened (75 FR 13012). Critical habitat for the Southern DPS of eulachon was finalized in 2011 (76 FR 65323). Critical habitat in Washington is limited and has not been designated in any documented spawning tributaries in Puget Sound.

1.3.7.2 *Occurrence*

Eulachon are anadromous; they spawn in fresh water and spend their juvenile and adult lives in marine waters. Although eulachon range from northern California to western Alaska, the Southern DPS consists of populations spawning in rivers south of the Nass River in British Columbia, Canada, to and including the Mad River in California. The major production areas include the Columbia and Fraser rivers (WDFW and ODFW 2023). The species is not known to spawn in Puget Sound streams and has been found infrequently in Puget Sound (Pietsch and Orr 2015).

1.3.7.3 *Rationale for Exclusion*

The Proposed Action would have no effect on the Southern Pacific eulachon or its critical habitat because the eulachon are unlikely to occur in the action area.

1.3.8 Central America and Western North Pacific Humpback Whale

1.3.8.1 *Federal Status*

The Central America DPS and Western North Pacific DPS of humpback whale was listed as endangered in 1970 (35 FR 18319) and revised in 2016 (81 FR 62259)). The NMFS designated critical habitat for the Western North Pacific DPS and Central America DPS on April 21, 2021 (86 FR 21082). Critical habitat for humpback whales is not present in the action area.

1.3.8.2 **Occurrence**

Humpback whales are found throughout the world, including along Washington's coastline. Puget Sound is not considered a part of their natural habitat, and they are unlikely or infrequent in Puget Sound (City of Seattle 2015). Prior to 1990, humpback whale sightings in Puget Sound were extremely rare (Calambokidis and Steiger 1990). In recent years, incidental sightings have occurred within Puget Sound, including humpbacks visiting Puget Sound during migration and some documented staying through the winter months (Calambokidis et al. 2018; Whale Museum 2023). Humpback whales are unlikely to occur in shallow nearshore habitats in Puget Sound.

1.3.8.3 *Rationale for Exclusion*

The Proposed Action would have no effect on the humpback whale or its critical habitat because critical habitat does not occur in Puget Sound and the humpback whale is unlikely to occur in the action area.

1.3.9 Southern Green Sturgeon

1.3.9.1 *Federal Status*

The Southern DPS of green sturgeon is listed as threatened (50 CFR 223.102). In Washington, critical habitat for this DPS is established in the lower Columbia River, Willapa Bay, and Grays Harbor (50 CFR 226.219). No critical habitat is present in the action area.

1.3.9.2 *Occurrence*

In Washington, green sturgeons are found primarily in the Columbia River basin and coastal waters including Willapa Bay and Grays Harbor. The current spawning range is limited to the Sacramento and Klamath river basins in California and the Rogue River in Oregon. Green sturgeon is migratory and anadromous, spending most of their lifecycle in coastal marine waters and large coastal estuaries of Washington, Oregon, and California. Occurrence in the Puget Sound is rare at best (Moser et al. 2020).

1.3.9.3 *Rationale for Exclusion*

The Proposed Action would have no effect on the Southern DPS of green sturgeon or its critical habitat because critical habitat does not occur in Puget Sound and green sturgeon are unlikely to occur within the action area.

2.0 PROJECT DESCRIPTION

The Proposed Action comprises the following elements:

- NTPs (Section 2.4): Airfield, terminal, cargo, landside, and airport/airline support projects designed to increase airport capacity and operational efficiency to meet projected future needs.
- PSPs (Section 2.5): Infrastructure improvements needed to support NTP development, as identified in the Port of Seattle Utilities Master Plan (UMP; Port 2022a):
  - Operational infrastructure improvements (electrical, fuel, gas, water, sewer, and information and telecommunications technology).
  - Stormwater drainage system (SDS) and industrial wastewater system (IWS) improvements.
- Mitigation (Section 2.7): Planned mitigation for anticipated wetland and buffer impacts.
- BMPs (Section 2.8): BMPs used by the Port to avoid and minimize environmental impacts from the construction and operation of the NTPs and UMP PSPs.

All components of the Proposed Action are currently at planning or conceptual levels of development. NTP and PSP dimensions and construction footprints may change during project design. The Port and FAA anticipate such changes would be small and would not measurably alter the effects to ESA-listed species and critical habitat or effects determinations presented herein.

2.1 Project Location

SEA is located primarily within the City of SeaTac in southern King County, Washington, 12 miles south of downtown Seattle, and 20 miles north of the City of Tacoma. SEA owns approximately 2,800 acres of land generally bound by SR 99 to the east, SR 509 to the west, S. 142nd Place to the north, and S. 200th Street to the south. Additional land owned by the Port and used for runway protection and noise compatibility extends northward to S. 136th Street and southward to S. 216th Street. Land uses adjacent to SEA include industrial, commercial, residential, and park land.

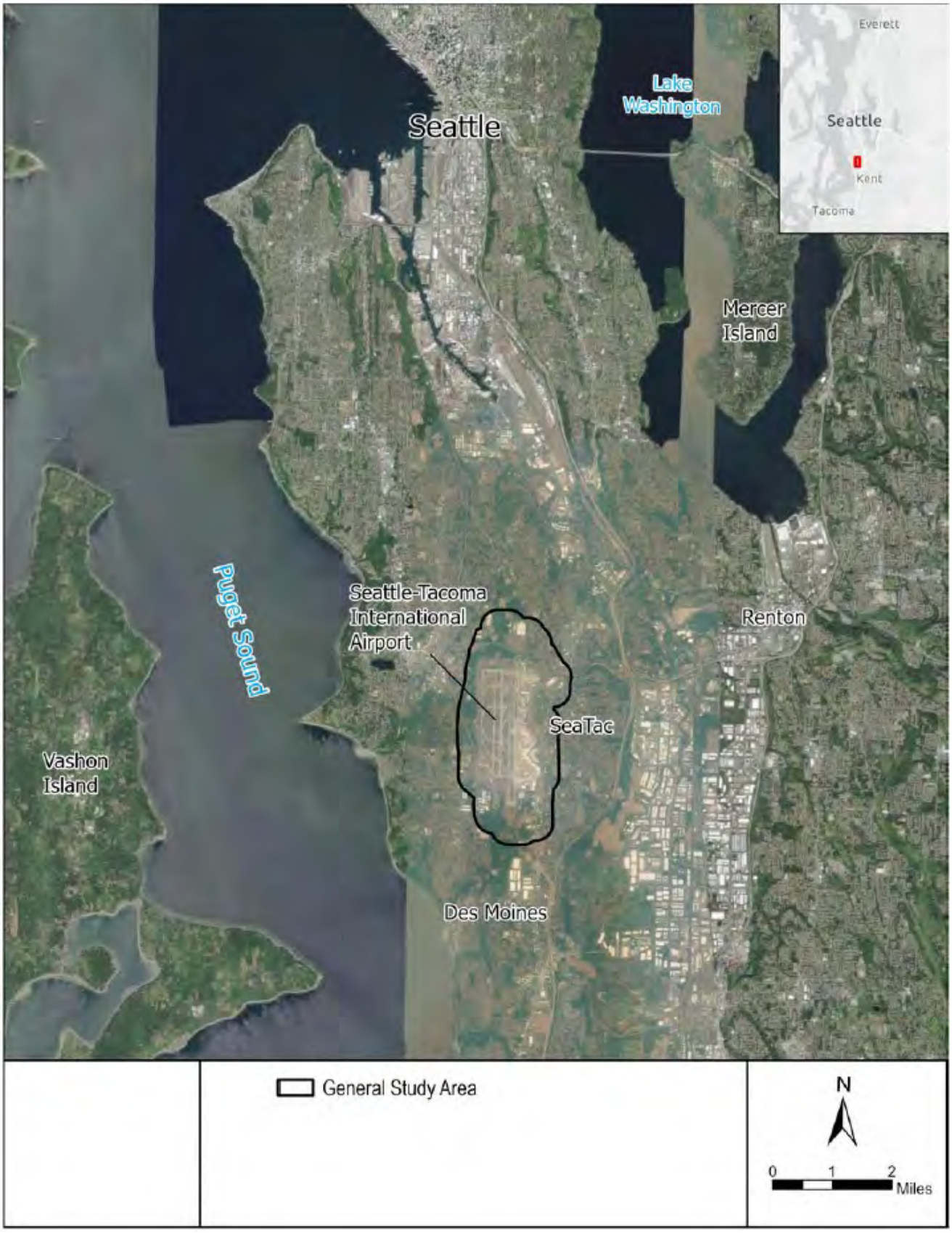
The Proposed Action would be implemented entirely on Port property within and adjacent to SEA in the general study area (GSA) considered in the National Environmental Policy Act analysis for the project. The GSA is shown in Figure 1.

2.2 Consultation History

The FAA submitted an initial BE for the Proposed Action to the Northwest Seaport Alliance's (NWSA's) ESA consultation liaison on March 19, 2024. The ESA liaison conducts ESA Section 7 consultations for NWSA member projects on behalf of the Services, with the intent of streamlining and expediting the consultation process. The liaison provided initial comments and recommendations to the Port and FAA, identifying additional information and analyses needed to initiate consultation. The Port and FAA subsequently met with NMFS staff on April 26, 2024, to discuss BE requirements and obtain guidance on consultation requirements.

The FAA submitted a request for informal consultation on September 26, 2024. NMFS provided a letter of non-concurrence on November 12, 2024. The FAA and NMFS held meetings on January 15, 2025, March 13, 2025, May 14, 2025, and June 17, 2025, to discuss the consultation request.

Figure 1. Project vicinity and GSA



2.3 Purpose for the Project

The Proposed Action addresses five independent needs that affect the future ability of SEA to maintain its essential function as the primary commercial airport in the Pacific Northwest.

- Insufficient passenger processing facilities and gates to accommodate 56 million annual passengers at an optimal level of service.
- Insufficient facilities to accommodate projected cargo demand.
- Airfield infrastructure that does not meet current FAA airport design standards.
- Insufficient/inadequate taxiway layout.
- Lack of fuel storage to meet projected demand and the Port's Sustainable Aviation Fuel initiative.

The purpose of the Proposed Action is to accommodate project passenger and cargo demand; provide airfield infrastructure that meets current FAA airport design standards; enhance the efficiency of the taxiway layout; and to meet projected fuel storage demand including sustainable aviation fuel initiatives. All NTPs are anticipated to be complete or in final construction by 2032.

2.4 Proposed NTPs

The NTPs are grouped into five categories (Figure 2):

- Airfield projects (A): Modification and improvement of runways, taxiways, aircraft holding areas, and related facilities to improve operational efficiency and meet FAA airport design standards.
- Terminal projects (T): Development of new terminal concourses, aircraft loading/unloading aprons, and associated parking facilities to provide increased passenger handling capacity.
- Cargo projects (C): Development of new cargo warehouses and appurtenant loading/unloading, parking, and administrative facilities to meet projected needs for increased cargo capacity.
- Landside projects (L): Improvements to existing and construction of new airport access roads, mass transit infrastructure, holding lots, and parking facilities needed to meet projected future passenger and employee transportation requirements.
- Airport/airline support projects (S): Improvements to airport infrastructure needed to support routine operations and maintenance activities, including aircraft fueling, aircraft maintenance, firefighting and emergency response, and de-icing and snow removal.

The NTPs are identified by their category prefix and project number (e.g., airfield project A01). Recognizing that treated stormwater and wastewater discharges are the primary source of potential impact to ESA-listed species from the Proposed Action, the estimated total and net acres of pollution-generating and non-pollution-generating impervious surface (PGIS and NPGIS, respectively) are included and summarized in Table 2. The Proposed Action would add approximately 72 acres of impervious surface (increase of 7.6% overall), which includes 50.03 acres of PGIS (increase of 5.4% overall) and 21.42 acres of NPGIS.

Certain NTPs require the demolition of existing buildings and infrastructure to make room for construction. Demolished buildings and structures would either be relocated elsewhere on Port property, replaced by new facilities, or incorporated into existing facilities with improvements.

Figure 2. Locations of proposed SAMP NTPs

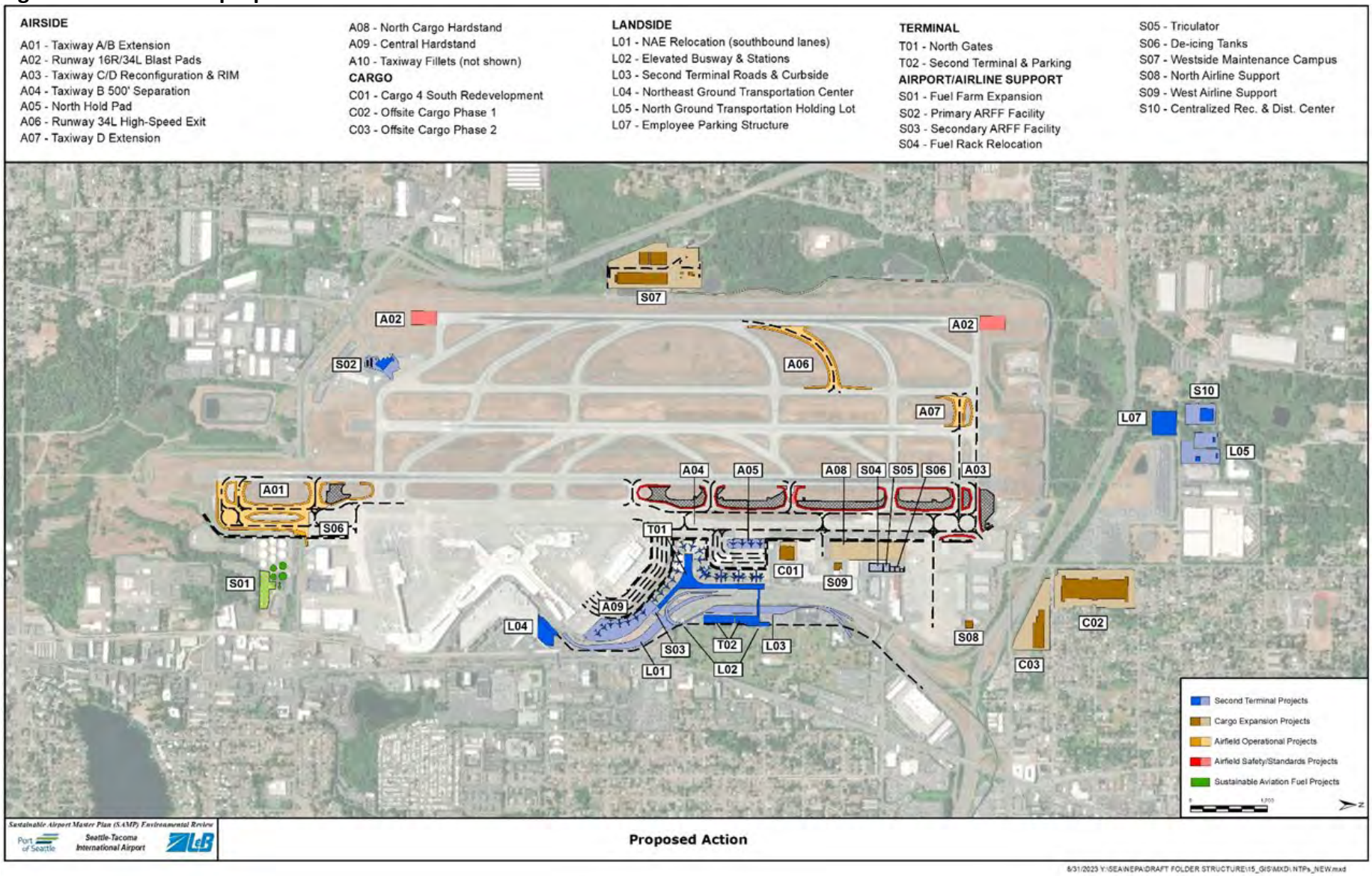


Table 2. Estimated NTP and PSP construction footprints, net change in impervious surface area, and permanent habitat impacts.

Project	Construction Footprint (acres)	Existing Impervious (acres)	Total Impervious Added (acres)	Net Change NPGIS (acres)	Net Change PGIS (acres)	Drainage Basin	Wetland	Wetland Buffer	Stream	Stream Buffer
A01 – Taxiway A/B Extension	33.2	17.83	1.84	0.00	1.84	SDS4; SDS3	--	--	--	--
A02 – Runway 16R/34L Blast Pads	7.2	2.17	1.87	1.87	0.00	SDS6-7 SDN3A	--	--	--	--
A03 – Taxiway C/D Reconfiguration & RIM	17.1	10.52	-0.41	0.00	-0.41	IWS	--	--	--	--
A04 - Taxiway B 500-foot Separation	46.8	51.17	-6.36	0.00	-6.36	SDN2; SDS3; SDE4; IWS	--	--	--	--
A05 – North Hold Pad	3.9	2.06	0.00	0.00	0.00	IWS	--	--	--	--
A06 – Runway 34L High-Speed Exit	13.6	1.53	5.17	0.00	5.17	SDW1B; SDS3A	--	--	--	--
A07 – Taxiway D Extension	6.3	1.38	1.47	0.00	1.47	SDN3	--	--	--	--
A08 – North Cargo Hardstand	11.5	7.87	0.09	-2.40	2.49	IWS	--	--	--	--
A09 – Central Hardstand	10.1	4.13	2.58	0.00	2.58	IWS	--	--	--	--
A10 – Taxiway Fillets	<1	--	<1	--	--	--	--	--	--	--
T01 – North Gates	11.5	11.77	7.31	3.35	3.96	SDE4; IWS	--	--	--	--
T02 – Second Terminal & Parking Garage	4.9	2.37	0.00	2.37	-2.37	SDE4; IWS	--	--	--	--
C01 – Cargo 4 South Redevelopment	3.3	1.84	0.00	0.00	0.00	SDE4	--	--	--	--
C02 – Offsite Cargo Phase 1	21.5	0.64	16.41	7.57	8.84	N of SR 518	--	--	--	--
C03 – Offsite Cargo Phase 2	12.7	0.23	8.85	2.04	6.81	N of SR 518	--	--	--	--
L01 – NAE Relocation	13.0	2.85	2.60	0.00	2.60	SDE4	--	--	--	--
L02 – Elevated Busway and Stations	1.7	0.36	0.15	0.51	-0.36	SDE4	--	--	--	--
L03 – Second Terminal Roads/Curbside	16.7	5.03	1.08	0.00	1.08	SDE4	--	--	--	--
L05 – NGT Holding Lot	8.5	0.00	5.63	0.24	5.39	N of SR 518	--	--	--	--
L07 – Employee Parking Structure	5.2	0.09	3.19	0.00	3.19	N or SR 518	0.02	0.60	--	--
S02 – Primary ARFF Facility	4.9	2.26	0.40	0.00	0.40	IWS	--	--	--	--
S03 – Secondary ARFF Facility	0.9	0.12	0.09	0.21	-0.12	IWS	--	--	--	--
S04 – Fuel Rack Relocation	1.6	0.61	0.02	0.63	-0.61	IWS	--	--	--	--
S05 – Triculator	1.3	0.37	0.04	0.41	-0.37	IWS	--	--	--	--
S06 – De-icing Tanks	1.0	0.21	0.01	0.22	-0.21	IWS	--	--	--	--
S07 – Westside Maintenance Campus	25.5	4.56	15.91	2.88	13.03	SDW2; SDW2A; IWS	<0.01	1.70	0.01	0.07
S08 – North Airline Support	1.0	0.31	0.00	0.31	-0.31	IWS	--	--	--	--
S09 – West Airline Support	1.0	0.29	0.00	0.29	-0.29	SDE3	--	--	--	--
S10-Centralized Receiving and Distribution	5.6	0.00	3.51	0.92	2.59	N of SR 518	--	--	--	--

Project	Construction Footprint (acres)	Existing Impervious (acres)	Total Impervious Added (acres)	Net Change NPGIS (acres)	Net Change PGIS (acres)	Drainage Basin	Wetland	Wetland Buffer	Stream	Stream Buffer
Information/Communications Technology	19.6	12.90	0.00	0.00	0.00	--	--	--	--	--
Power	8.4	4.50	0.00	0.00	0.00	--	--	--	--	--
Water	6.6	5.80	0.00	0.00	0.00	--	--	--	--	--
Sanitary Sewer	9.3	5.80	0.00	0.00	0.00	--	--	0.01	--	--
Aviation Fuel	2.2	2.10	0.00	0.00	0.00	--	--	--	--	--
SDS4 Pond Expansion	0.63	0.10	0.00	0.00	0.00	--	--	<0.01	--	--
Pond M Expansion	1.87	0.80	0.00	0.00	0.00	--	--	0.11	--	--
Miller Creek Detention Pond Construction	1.27	0.30	0.00	0.00	0.00	--	0.55	--	--	--
Pond F Relocation/Replacement	2.56	0.90	0.00	0.00	0.00	--	--	<0.01		
Walker Creek Detention Pond Construction	1.18	1.40	0.00	0.00	0.00	--	--	--	--	--
Stormwater Lines	14.4	9.70	0.00	0.00	0.00	--	0.01	0.23	0.01	0.05
Industrial Wastewater Lines	13.7	8.80	0.00	0.00	0.00	--	--	--	--	--
Grand Total	373.21	185.67	71.45	21.42	50.03	--	0.58	2.65	0.02	0.12

2.4.1 Airside Projects

2.4.1.1 *A01 – Taxiway A/B Extension*

Extension of parallel Taxiway A/B by approximately 1,800 feet to provide access to the south end of Runway 16L/34R. This NTP includes:

- Shifting Taxiway A east by approximately 100 feet and Taxiway B west by approximately 100 feet to create two separate taxiways. Existing pavement will be reconfigured, including relocation of Taxiway S 310 feet to the south.
- Relocation of Runway 34R glideslope antenna and associated equipment shed approximately 100 feet east. These features are in the mowed field between Taxiway A/B and Runway 16L/34R.
- Relocation of a service vehicle bridge over S 188th Street approximately 60 feet east of the existing road. This bridge would be approximately 100 feet long by 25 feet wide (0.06 acre).

NTP A01 relocates or retrofits approximately 17.83 acres of PGIS and creates 1.84 acres of new PGIS.

2.4.1.2 *A02 – Runway 16R/34L Blast Pads*

Expansion of Runway 16R/34L blast pads from the existing 200 by 200 feet (0.9 acre) to 220 by 400 feet (2.0 acres) to meet FAA design standards. Blast pads would be poured concrete construction on cleared and compacted ground. Includes relocation of navigational aids to enable construction. Blast pad expansion would retrofit 2.17 acres of existing NPGIS and create 1.87 acres of new NPGIS.

2.4.1.3 *A03 – Taxiway C/D Reconfiguration and Runway Incursion Mitigation*

Modification of existing taxiway geometry of Taxiways C and D to correct non-standard intersection angles and reconfigure non-standard intersections. Includes the extension of Taxiways C and D by approximately 500 feet to intersect with Taxilane A and the removal of 2,670 square feet (0.06 acre) of existing impervious surfaces for runway incursion mitigation. Approximately 100,000 square feet (2.3 acres) of pavement north of Taxiway C would be removed to offset the increase in impervious surfaces. In total, this NTP would result in a net reduction in PGIS of 0.41 acres.

2.4.1.4 *A04 - Taxiway B 500-foot Separation*

Relocation of Taxiways A and B 100 feet east between Taxiways C and L to provide the required 500 ft runway/taxiway separation. This would require extending Taxiways C, D, E, H, and K 100 feet to connect with the relocated Taxiway B. Existing paved surfaces would be removed to offset the increase in impervious area, resulting in a net reduction in PGIS of 6.36 acres.

2.4.1.5 *A05 – North Hold Pad*

Construction of an approximately 90,000-square-foot (2.1-acre) hold pad for up to four aircraft to reduce congestion on the taxiways and at the terminal. This new surface would be constructed entirely on existing PGIS, resulting in no net change in PGIS.

2.4.1.6 *A06 – Runway 34L High-Speed Exit*

Construction of a new high-speed exit for Runway 34L arrivals between Taxiways J and E to allow for more efficient use of the runway by arriving aircraft. Construction would require clearing and grading of the field and relocation of the multilateration remote unit. This NTP would add a total of approximately 5.2 acres of mostly new PGIS. A small percentage (less than 5%) of NTP acreage would be constructed on existing impervious surfaces on the runway and taxiway shoulders.

2.4.1.7 *A07 – Taxiway D Extension*

Extension of Taxiway D by approximately 500 feet from Runway 16C/34C west to Taxiway T. This NTP would add approximately 1.47 acres of new PGIS. Construction would require clearing and grading of approximately 1.6 acres of maintained field between the runway and taxiway. A small percentage (less than 5%) would be constructed on the existing taxiway shoulders.

2.4.1.8 *A08 – North Cargo Hardstand*

Construction of an approximately 360,000-square-foot (8.3-acre) cargo aircraft hardstand in the North Cargo area east of Taxiway A. The hardstand would accommodate five aircraft for loading and unloading cargo freight and parking of cargo aircraft. Construction would require the relocation of the United maintenance hangar and Swissport cargo facility (S08), the Port's aviation maintenance facility (S07), and ground service equipment (GSE) maintenance facility (S09). All construction would occur on existing impervious surfaces. This NTP would increase PGIS by 2.49 acres.

2.4.1.9 *A09 – Central Hardstand*

Construction of an approximately 292,000-square-foot (6.7-acre) hardstand for seven aircraft north of Concourse D and east of the North Satellite to accommodate increased demand for passenger hardstand operations and overnight parking of passenger aircraft. Requires relocating portions of the North Airport Expressway (NAE) (L01). This NTP would add approximately 2.58 acres of PGIS.

2.4.1.10 *A10 – Taxiway Fillets*

Construction of new full strength pavement panels and shoulders to meet FAA standards. This NTP would be constructed entirely on existing impervious surfaces and would result in no net change in impervious area or PGIS. The anticipated project footprint is small (less than 1 acre) and too broadly distributed to be displayed on Figure 2 but would be associated with all taxiways.

2.4.2 Terminal Projects

2.4.2.1 *T01 – North Gates*

Construction of a new multi-level concourse and aircraft apron to accommodate up to 19 gates. The new concourse would have a footprint of approximately 203,000 square feet (4.7 acres), all of which would be NPGIS. The associated aircraft apron would have a footprint of approximately 500,000 square feet (11.5 acres) of existing and new impervious surfaces. The new facility would displace the Aircraft Rescue and Firefighting (ARFF) station (S02), Cargo 6 warehouse (C01), deicing tanks (S06), NAE (L01) and fuel rack (S04). This NTP would increase PGIS by 3.96 acres.

2.4.2.2 *T02 – Second Terminal and Parking Garage*

Construction of a new multi-level passenger terminal on the east side of the NAE from proposed T01, connected via an elevated pedestrian walkway. Includes the construction of a new multi-level parking garage with approximately 1,350 parking spaces. The new terminal and garage would have a combined footprint of approximately 286,000 square feet (6.6 acres). The new facilities would displace the Doug Fox Parking Lot and would reduce existing PGIS by approximately 2.37 acres.

2.4.3 Cargo Projects

2.4.3.1 *C01 – Cargo 4 South Redevelopment*

Construction of an approximately 80,000-square-foot cargo facility (warehouse, office space, truck terminals, and parking) at the Cargo 4 South site in the central cargo area to replace the Cargo 6 warehouse, which will be demolished for T01. The new facility would have a footprint of approximately 1.8 acres. This NTP would result in no net change in NPGIS or PGIS.

2.4.3.2 *C02 – Offsite Cargo Phase 1*

Construction of a new 330,000-square-foot (7.6-acre) cargo warehouse on the Port's L-shaped parcel located north of SR 518. The facility footprint (warehouse, office space, truck terminals, parking, and access roads) would cover approximately 16.0 acres. Approximately 98% of the project footprint is vegetated pervious surface that would be cleared for construction. This NTP would create approximately 7.6 and 8.8 acres of new NPGIS and PGIS, respectively.

2.4.3.3 *C03 – Offsite Cargo Phase 2*

Construction a new 90,000-square-foot (2.1-acre) cargo warehouse on the triangular portion of the Port's L-shaped parcel located north of SR 518. The entire facility footprint (warehouse, office space, truck terminals, parking, and access roads) would cover approximately 8.1 acres. Approximately 98% of the project footprint is vegetated pervious surface that would be cleared for construction. This NTP would create approximately 2.1 and 6.8 acres of new NPGIS and PGIS, respectively.

2.4.4 Landside Projects

2.4.4.1 *L01 – North Airport Expressway Relocation (Southbound Lanes)*

Construction of approximately 7,300-linear-feet of NAE to replace the section displaced by construction of A09 and T01. The relocated portion would be widened from 3 to 4 lanes, provide access to T02, and alleviate congestion. This NTP would create about 2.60 acres of new PGIS.

2.4.4.2 *L02 – Elevated Busway and Stations*

Construction of approximately 6,000-linear-feet of elevated busway and three stations to connect the main terminal, new second terminal, and rental car facility. The busway and stations would be located along the eastern edge of SEA property and would tie into existing bus routes. L02 would displace the existing ground transportation holding lot by cutting off access to SEA, which would be replaced with L05. In total, this NTP would reduce existing PGIS by approximately 0.36 acre.

2.4.4.3 *L03 – Second Terminal Roads and Curbside*

Construction of a new loop ramp connecting the NAE to T02 from the existing S 160th Street Loop, westbound SR 518 on-ramp at S. 160th Street, and northbound lanes of the NAE. Split-level curbsides would be constructed for arriving vehicles, departing vehicles, and commercial vehicles (shuttles, taxis, and ride-share companies). This NTP would increase existing PGIS by 1.08 acres.

2.4.4.4 *L05 – North Ground Transportation (GT) Holding Lot*

Relocation of GT Holding Lot to Port property north of SR 518 and south of S 144th Street to replace the parking lot displaced by L02. Construction would require clearing and grading of existing vegetated upland habitat and would create approximately 0.24 and 5.39 acres of new NPGIS and PGIS, respectively.

2.4.4.5 *L07 – Employee Parking Structure*

Construction of a new 8-story (1 below grade and 7 above grade), 3,500-stall employee parking structure on Port property north of SR 518 and south of S 144th Street. The structure would have a footprint of approximately 3.3 acres. This NTP would create approximately 3.19 acres of new PGIS.

2.4.5 Airport/Airline Support Projects

2.4.5.1 *S02 – Primary Aircraft Rescue and Firefighting Facility*

Relocation of the Primary ARFF station to accommodate construction of T01. The new 50,000-square-foot (1.1-acre) ARFF would be located on the south airfield between Runway 16R/34L and Runway 16C/34C. The ARFF building and associated vehicle pads, access roads, and parking areas would have a combined footprint of approximately 2.7 acres. This NTP would displace an existing building and parking lot. The new facility would increase PGIS by 0.40 acres.

2.4.5.2 *S03 – Secondary Aircraft Rescue and Firefighting Facility*

Construction of an approximately 10,000-square-foot (0.2-acre) secondary ARFF to provide ambulatory and fire response to the terminals and concourses and back-up emergency response to the airfield. The Secondary ARFF facility would be integrated within T01 at the southeast end of the concourse, decreasing existing PGIS by 0.12 acre.

2.4.5.3 *S04 – Fuel Rack Relocation*

Relocation of the fuel rack from its existing location in the Cargo 6 area to the Cargo 3 area to accommodate T01. The fuel rack is part of the airport fuel distribution system where aircraft fuel trucks refill. The replaced facility would have a construction footprint of approximately 1.6 acres and would be constructed entirely on existing impervious surfaces, reducing existing PGIS by 0.61 acre.

2.4.5.4 *S05 – Triculator*

Relocation of the airport triculator building from east of the ARFF to the north cargo area for construction of A09. The triculator transfers aircraft waste to the sewer system. The relocated facility would have a footprint of approximately 12,200 square feet (0.4 acre) of NPGIS and would be constructed entirely on existing impervious surfaces, resulting in a net reduction in PGIS of 0.37 acre.

2.4.5.5 *S06 – De-icing Tanks*

Relocation of the de-icing fluid tanks from Cargo 6 and Cargo 7 to the east of A08 and near A01 service vehicle bridge to accommodate T01. Each site would have a containment system, blending station, and two tanks (Type I de-icing fluid and Type IV de-icing fluid). The two sites would have a combined footprint of approximately 14,000 square feet (0.3 acre) of NPGIS and would be constructed entirely on existing impervious surfaces, reducing existing PGIS by 0.21 acre.

2.4.5.6 *S07 – Westside Maintenance Campus*

Relocation of the Port's Aviation Maintenance Facility to the west side of the airfield for construction of A08. The facility includes a vehicle fuel rack, airfield deicer storage, snow equipment storage, multi-bay buildings, and associated maintenance facilities. The Westside Maintenance Campus would have a combined total footprint of approximately 29.1 acres, comprising approximately 6.0 acres of new buildings/structures and 15.3 acres of access roads, parking areas, hardstands, and retaining walls. In total, this NTP would add approximately 13.03 acres of PGIS.

NTP S07 would be developed on an existing slope on an 11-acre upper and 6-acre lower platform constructed on the hillside, bounded by retaining walls with a footprint. Retaining walls would reach a maximum height of up to 65 feet at the southern end of the site and would most likely be mechanically stabilized earth construction. Facility construction could require up to 1,550,000 cubic yards of combined cut and fill. Construction would permanently displace a fraction (<0.01) of an acre of wetland and 1.7 acres of wetland buffer habitat. Includes the reconstruction of S. 168th St. access and construction of a new access road from S. 157th Place to the new facility. The S 157th Place access road would require improvements to an existing culvert crossing over Miller Creek to support long-term operations. Roadway surfacing and stormwater improvements at this crossing would result in approximately 0.01 and 0.07 acre of permanent impacts to stream and stream buffer, respectively.

2.4.5.7 *S08 – North Airline Support*

Construction of an approximately 15,000-square-foot (0.3-acre) airline support building in the northeast corner of the North Cargo area on existing impervious surface. This enabling project would accommodate aircraft maintenance functions displaced by construction of A08. The new building would replace existing PGIS with NPGIS, resulting in a net reduction in PGIS of 0.31 acre.

2.4.5.8 *S09 – West Airline Support*

Expansion of the existing AMB/AFCO III building by approximately 12,500 square feet (0.3 acre) to replace GSE maintenance functions displaced by construction of A08. The new building would replace existing PGIS with NPGIS, resulting in a net reduction in PGIS of 0.29 acre.

2.4.5.9 *S10 – Centralized Receiving and Distribution Center (CRDC)*

Construction of an approximately 55,000-square-foot (1.3-acre) CRDC on Port property north of SR 518 and south of S. 144th Street. This facility would service the dining and retail concessionaires in passenger terminals and is needed to improve the security and efficiency of food, beverage, and inventory distribution. The new CRDC building would be constructed on vacant ground, requiring clearing and grading of the entire project footprint. This NTP would create 2.59 acres of new PGIS.

2.5 Proposed Program Support Projects

2.5.1 Utilities Projects

The UMP (Port 2022a) identified several water, sewer, electrical, heating and cooling, and information and communications technology projects necessary to support NTP development. In addition, T01 would require the installation of new jet fuel distribution lines. The Proposed Action includes the construction of new underground lines, ducts, and utility tunnels. Table 3 summarizes the planned length and construction footprint acreages for utilities projects by category. Utility line corridors would be installed under existing pervious and impervious surfaces. Corridor segments outside of NTP footprints would be restored to pre-construction conditions and would result in no net change in impervious surface area. Planned utility locations are shown in Figures 3 to 5.

The Proposed Action also includes planned upgrades to the SEA mechanical plant. These upgrades comprise replacement of and improvements to internal equipment and systems within existing infrastructure footprints. No measurable effects on the outside environment are anticipated.

Table 3. UMP projects needed to support NTP development.

Utility Type	Construction Type	Length (miles)	Temporary Construction Footprint (acres)	Impervious Surfaces Construction Footprint (acres)
Water	Buried mainlines	2.74	6.6	5.8
Sanitary sewer	Buried trunk lines	3.82	9.3	5.8
Power	Underground lines/duct banks	3.39	8.4	4.5
Information/Communication Technology	Underground duct banks	7.70	19.6	12.9
Aviation fuel	Buried lines	0.89	2.2	2.1

Figure 3. Proposed UMP projects, northeast section of project area.

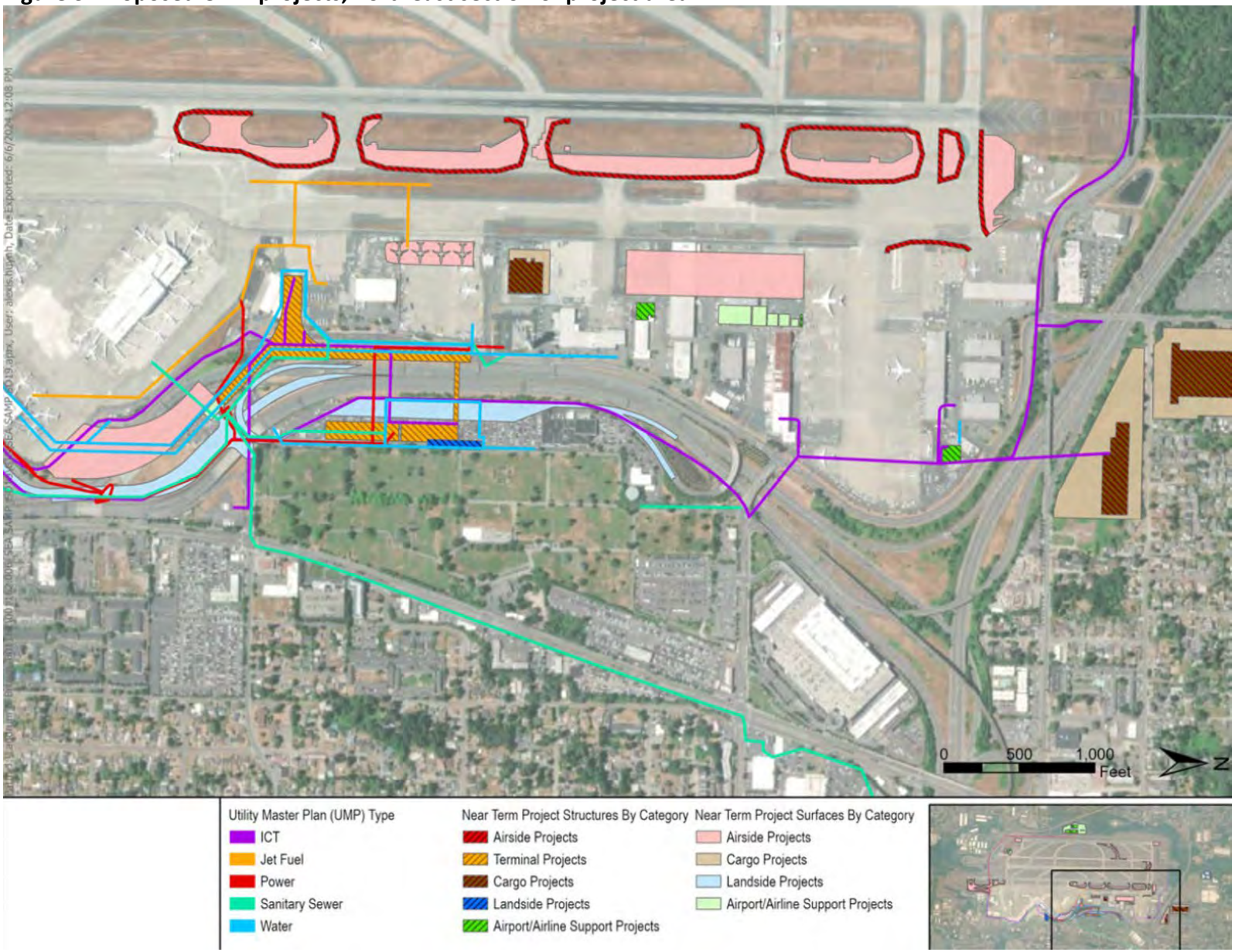


Figure 4. Proposed UMP projects, southeast section of project area.

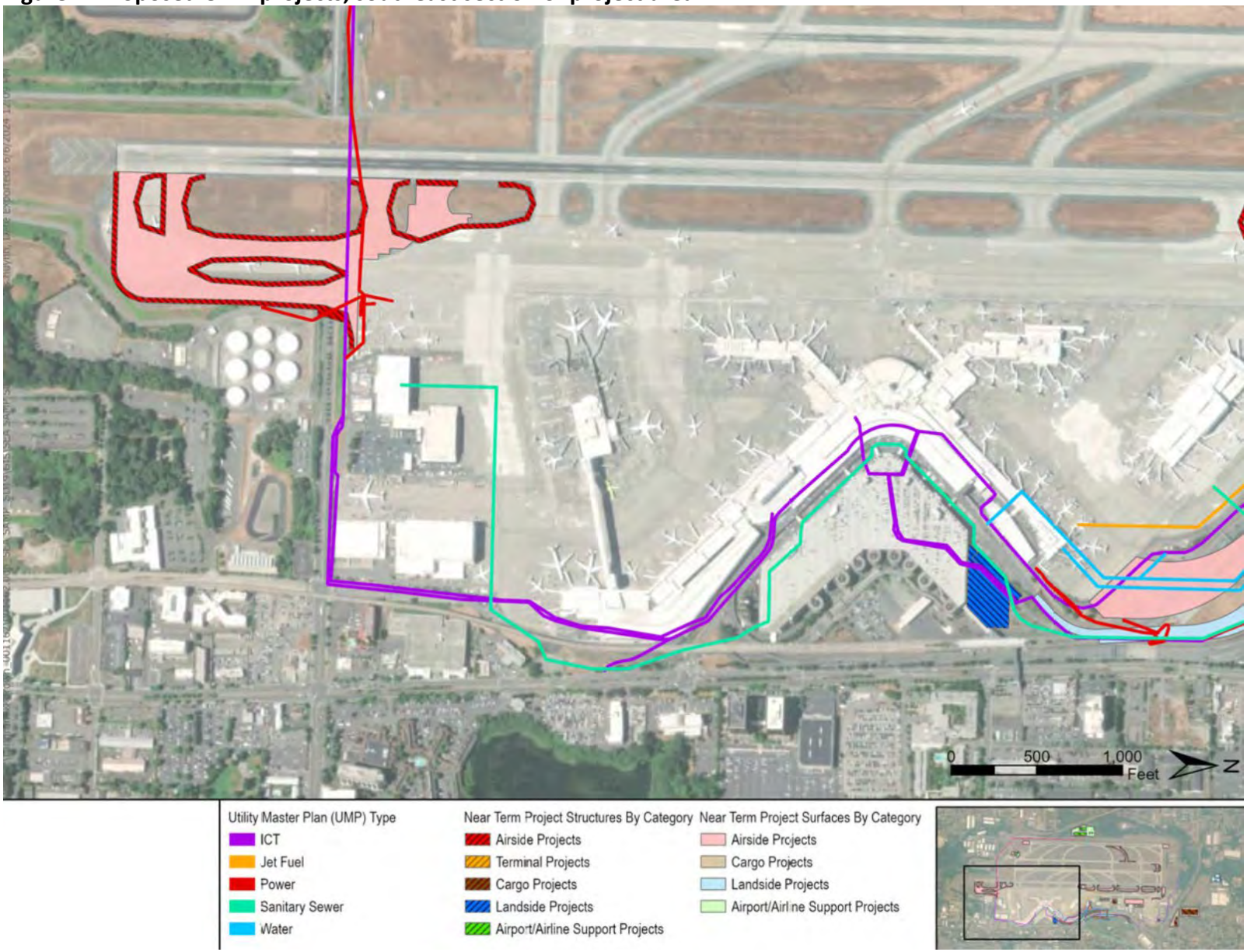
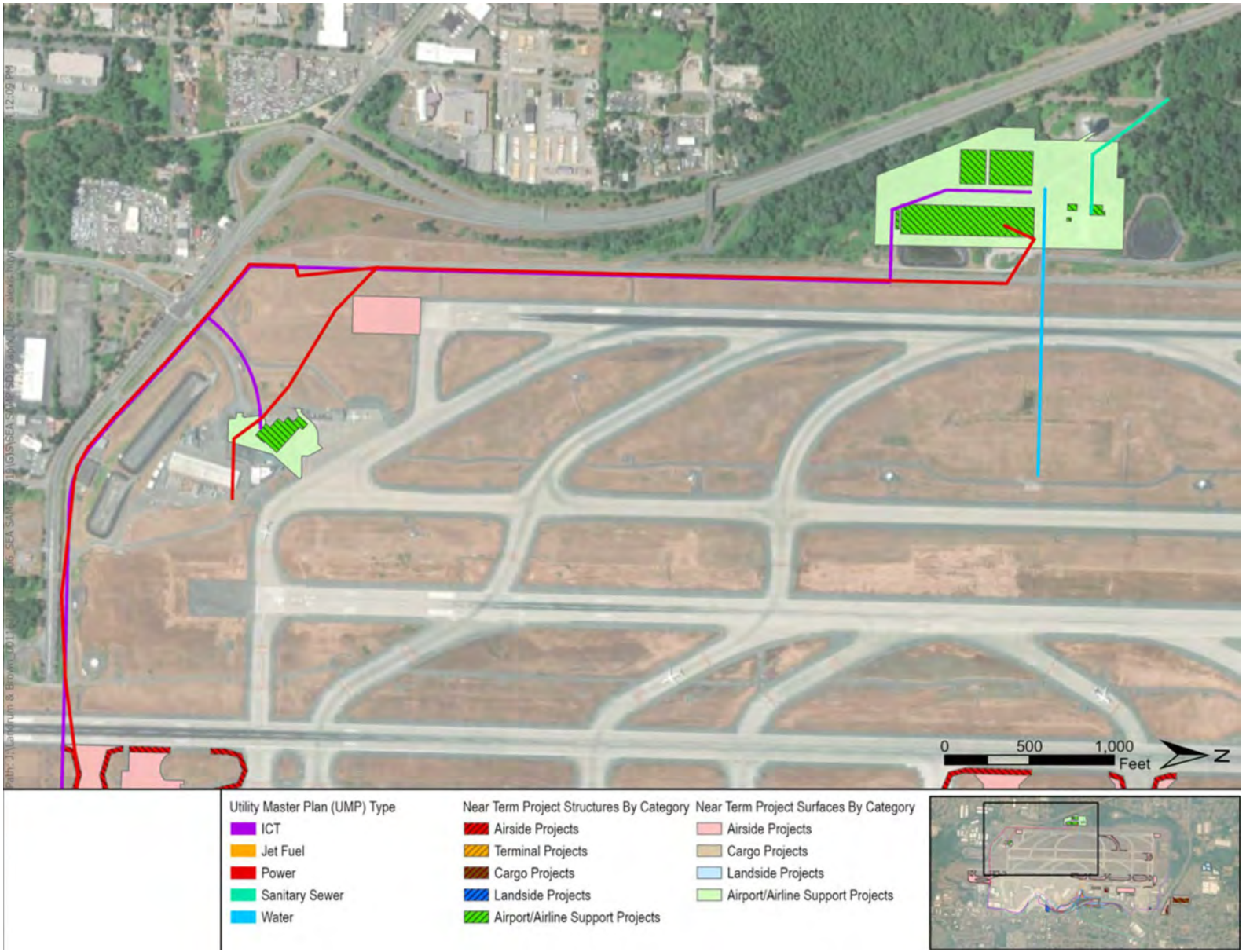


Figure 5. Proposed UMP projects, southwest section of project area.



2.5.2 Stormwater and Wastewater Projects

The Proposed Action includes improvements to and expansion of the SDS and IWS to provide the additional detention and treatment capacity needed to support NTP development. This program, described in detail in the *Seattle-Tacoma International Airport Stormwater Pollution Prevention Plan* (SEA SWPPP) (Port 2022b), comprises 4 primary components:

- The SDS: Structural stormwater detention and treatment infrastructure.
- The IWS: The Port's permitted Industrial Wastewater Treatment Plant (IWTP) system, wastewater drainage basins, and associated detention and conveyance infrastructure.
- Operational source controls (OSCs): BMPs used to avoid and minimize pollutant releases from SEA operations, reducing the quantity of pollutants discharging to the SDS.
- Water quality monitoring: The Port's NPDES permit is broken down into three parts: Part 1: Industrial Wastewater, Part 2: Industrial Stormwater, and Part 3: Construction Stormwater. The NPDES permit establishes conditions, prohibitions, and management practices designed to reduce the discharge of pollutants from the SDS and IWS, to protect water quality, and to comply with appropriate CWA requirements. One of the conditions is compliance monitoring at all points of discharge for the SDS and IWS systems. A summary of the Port's water quality monitoring activities, including priority constituents and monitoring frequency, is provided in Appendix B. The Port has established pollutant monitoring protocols for the sanitary sewer system (Port 2021a), the IWS (Port 2020, 2021b), and the SDS (Port 2021c, 2021d).

Existing SDS and IWS drainage basins and detention infrastructure are shown in Figure 6. The SDS comprises 12 stormwater drainage basins and a network of conveyance pipes, detention vaults, and ponds used to capture and treat stormwater runoff from approximately 1,284 acres of SEA property. Over half of this area is impervious and primarily associated with airport runways, taxiways, parking lots, roads, and roof tops. The remainder is pervious which consists of landscaped or fallow open spaces and areas associated with stormwater treatment BMPs such as runway filter strips. About 25 percent of the area drained by the SDS flows to Miller Creek. This drainage area represents about 7 percent of Miller Creek's watershed. Approximately 71 percent of the total SDS area drains to the Northwest Ponds and Des Moines Creek, which represents about 21 percent of Des Moines Creek's watershed.

The Airport's SDS is segregated into separate stormwater subbasins that each drain to individual outfall locations. The NPDES permit lists a total of thirteen (13) outfalls in two categories: Existing & New Outfalls and Subbasins, and Future Outfalls to be activated during future development. As of June 30, 2023, eleven (11) of the thirteen (13) outfalls are active.

The IWS comprises 2 drainage basins covering a combined 325.1 acres that service the aircraft operations area and a 26.5-acre drainage basin servicing the airport parking garage. The IWS services portions of the Port where aircraft de-icing and handling fuel, paint, lubricants, degreasers, and other hazardous materials routinely occur. The IWS conveyance system includes approximately 35 miles of piping, 1,200 manholes and catch basins, two below-grade vaults in the parking garage, and 11 pump stations. The IWS collects stormwater from flush gutters and catch basins and conveys the stormwater to the IWS storage lagoons. Prior to entering the storage lagoons, the wastewater is automatically analyzed, and flow is directed to specific lagoons based upon biological oxygen demand (BOD)

concentration. The primary purpose of Lagoons #1 and #2 is for collection of the "first flush" of high BOD influent from the South Aviation and North Aviation areas, respectively. Although the primary purpose of Lagoon #3 is for collection of low BOD runoff, high BOD runoff during de-icing periods may also be stored in Lagoon #3 when Lagoons #1 and #2 reach full capacity. Prior to treatment, the wastewater flows from Lagoons #1 and #2 through mechanical screening devices, which are sized to remove large objects. Water stored in Lagoons #1 and #2 drain by gravity to the IWTP. Water is pumped from Lagoon #3 to the IWTP. Some settling of solids occurs in the lagoons. The lagoons are typically cleaned every other year pending summer weather conditions. The IWTP discharges treated effluent to either the Puget Sound or to the sanitary sewer system.[1]

Quantification of existing impervious surface acreage in SDS and IWS drainage basins affected by the Proposed Action are provided in Table 4. Table 4 also summarizes the existing structural source controls and level of treatment provided in each drainage basin, proposed SDS and IWS improvements, and relevant OSC BMPs. Treatment levels are defined in Table 5, which apply Washington State Department of Ecology (Ecology) terminology (Ecology 2019).

As detailed in Table 2, the Proposed Action would increase the total amount of impervious surface by approximately 71 acres and increase PGIS by approximately 50 acres. None of the vegetation that will be removed is located directly adjacent to or near water sources or habitat for aquatic species. All new PGIS would be treated prior to draining to the Puget Sound via Miller, Walker, or Des Moines creeks or the IWTP discharge. The Proposed Action includes construction of new and improvements to existing SDS and IWS infrastructure. The stormwater and wastewater projects included in the Proposed Action are shown in Figures 7 to 10 and are summarized in Table 6.

OSCs comprise an array of operational BMPs designed to prevent avoidable releases of pollutants, minimize unavoidable releases, and reduce the quantity of pollutants discharged to the SDS and IWS. All NTPs would be subject to the OSC BMPs applicable to the functions they provide. OSC BMPs are described in Section 2.7.2. Table 4 identifies 3 specific BMP actions—runway rubber removal, dry sweeping of impervious surfaces, and sediment management—that are relevant for avoiding and minimizing impacts to ESA-listed species from stormwater contaminants. Additional information about the frequency and extent of these activities is provided in Section 2.7.2.

Construction of proposed SDS and IWS improvements would result in permanent impacts to approximately 0.01 acre of streams and 0.05 acre of stream buffer and up to 0.56 acre of wetland and 0.35 acre of wetland buffer habitats. These impacts are described in Section 5.1.2. Anticipated mitigation requirements are summarized in Section 2.6.

[1] The receiving body for IWTP discharge is determined by effluent BOD. Per Individual NPDES Permit WA-0024651 effluents with BOD concentrations below the BOD threshold are permitted for direct discharge to Puget Sound. Effluents exceeding this threshold are diverted to the sanitary sewer per King County Industrial Waste Discharge Permit 7810-05.

Figure 6. Existing SDS and IWS drainage basins and stormwater infrastructure

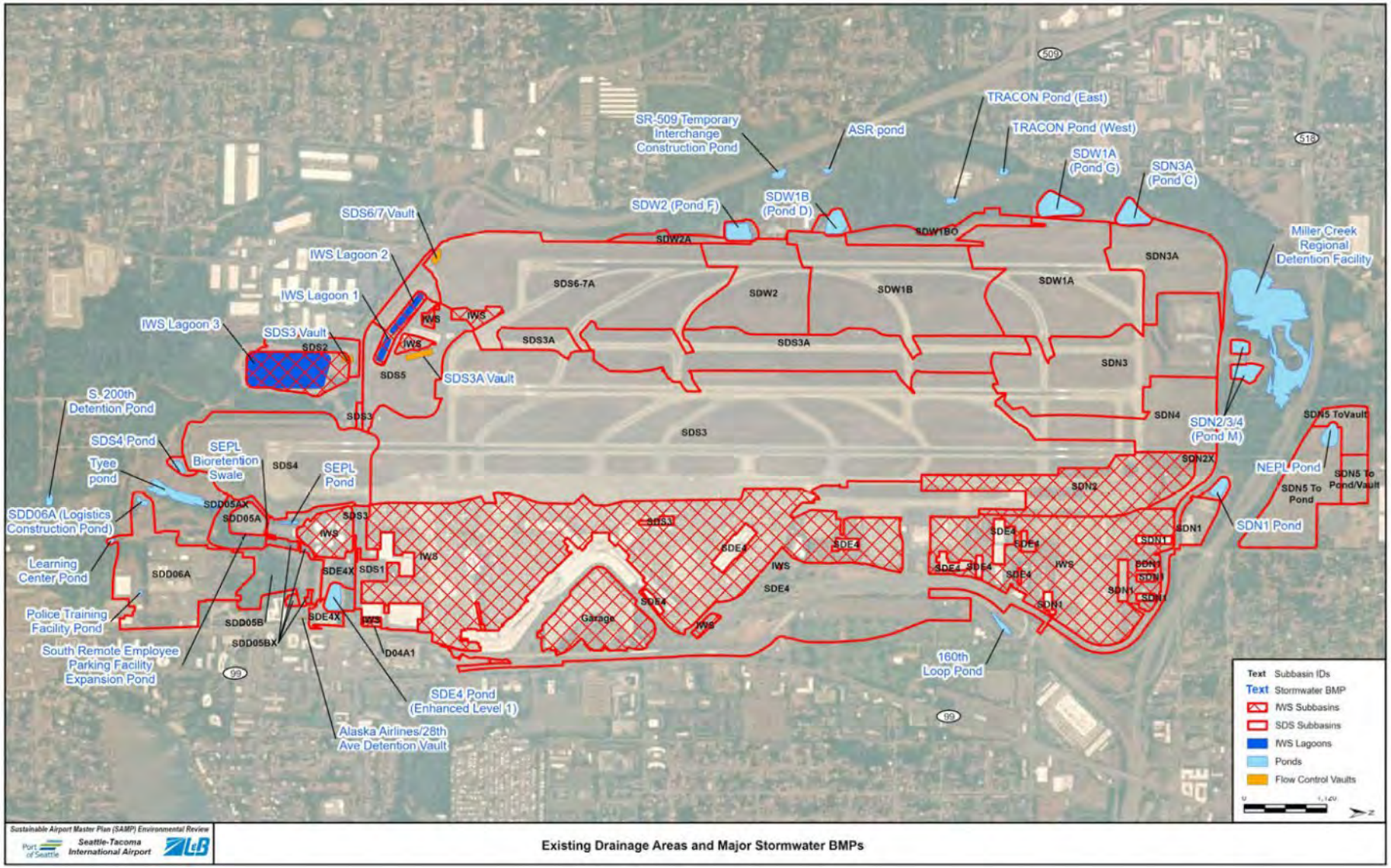


Figure 7. Proposed SDS and IWS projects, northeast section of project area

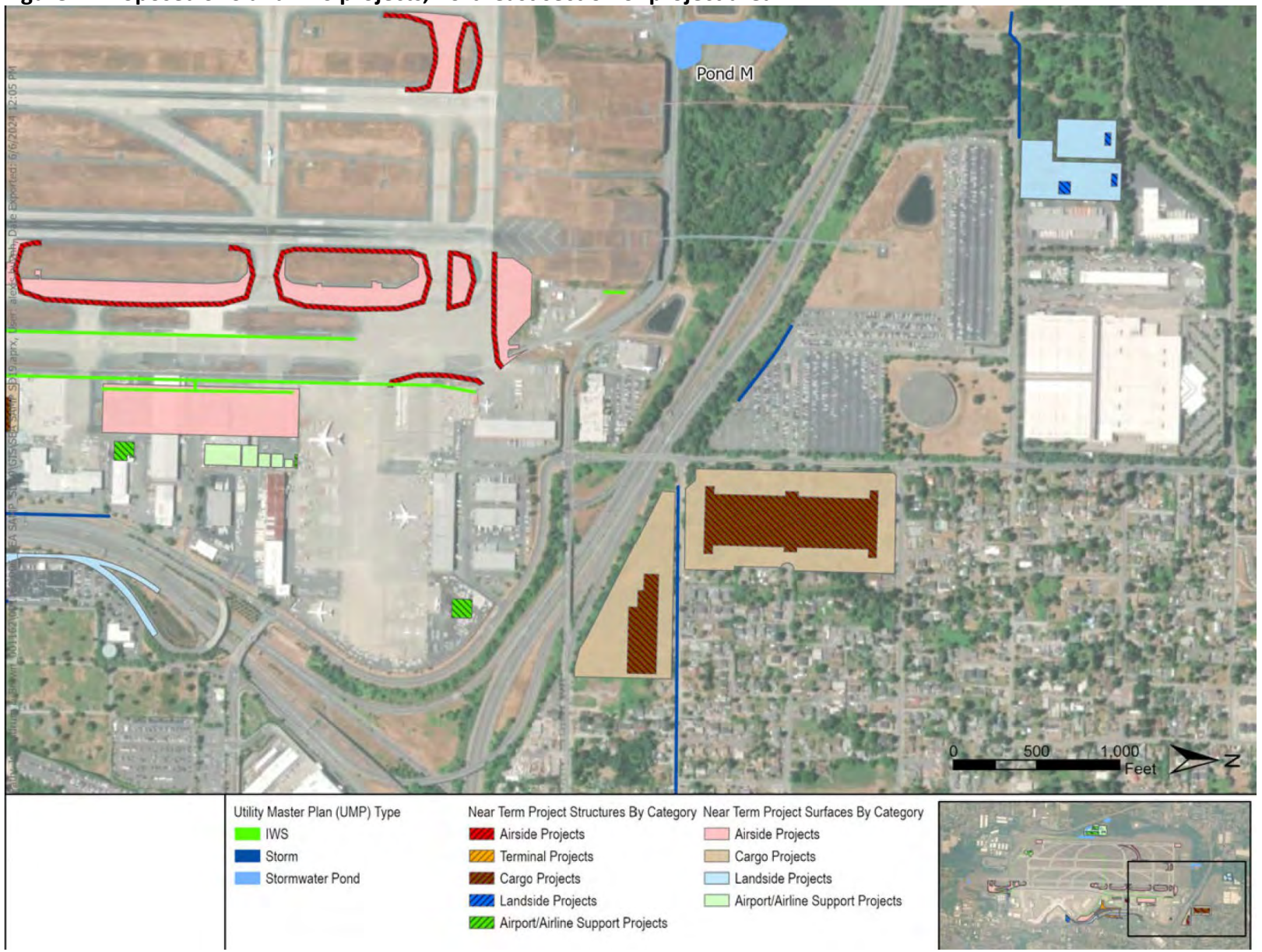


Figure 8. Proposed SDS and IWS projects, east section of project area

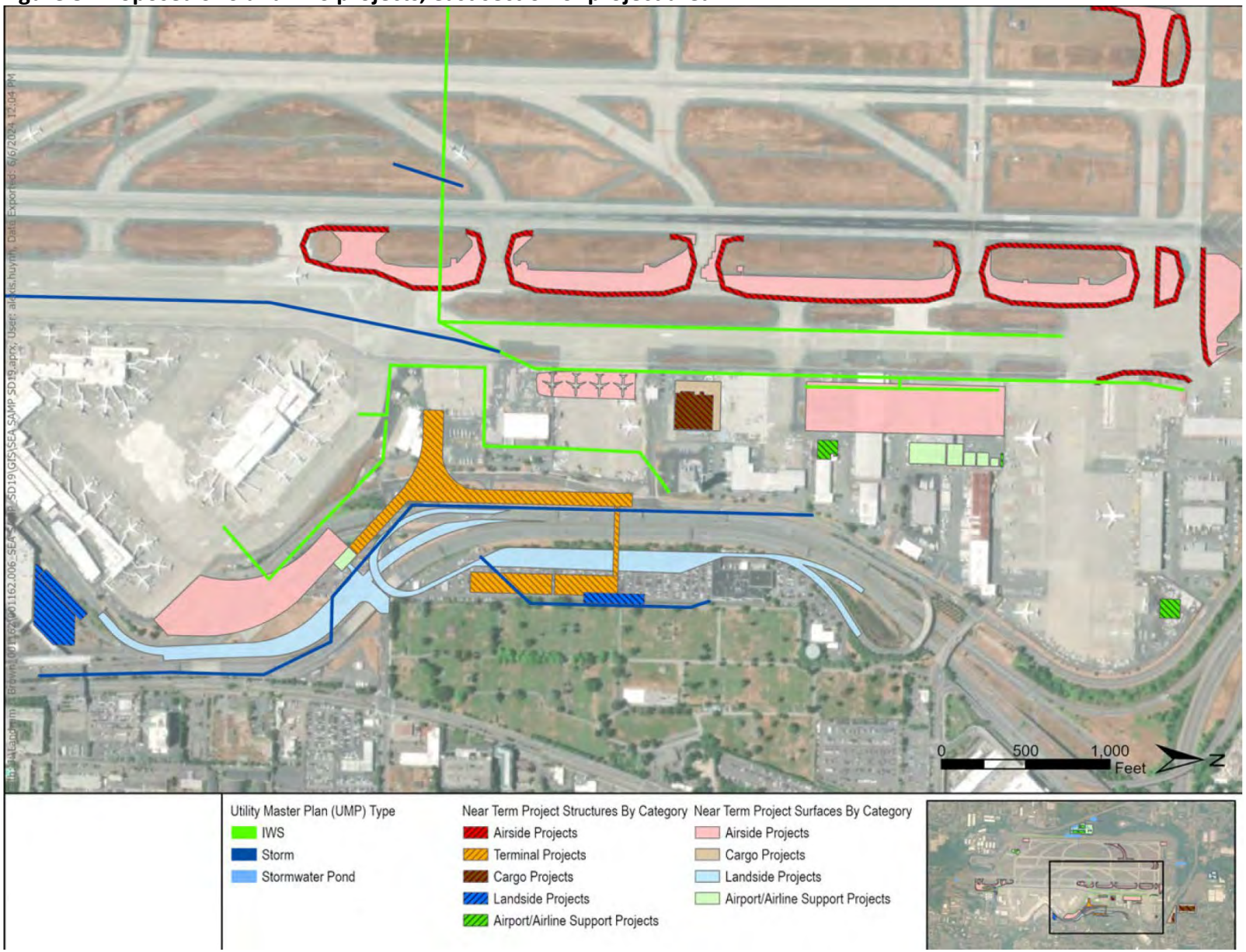


Figure 9. Proposed SDS and IWS projects, southeast section of project area

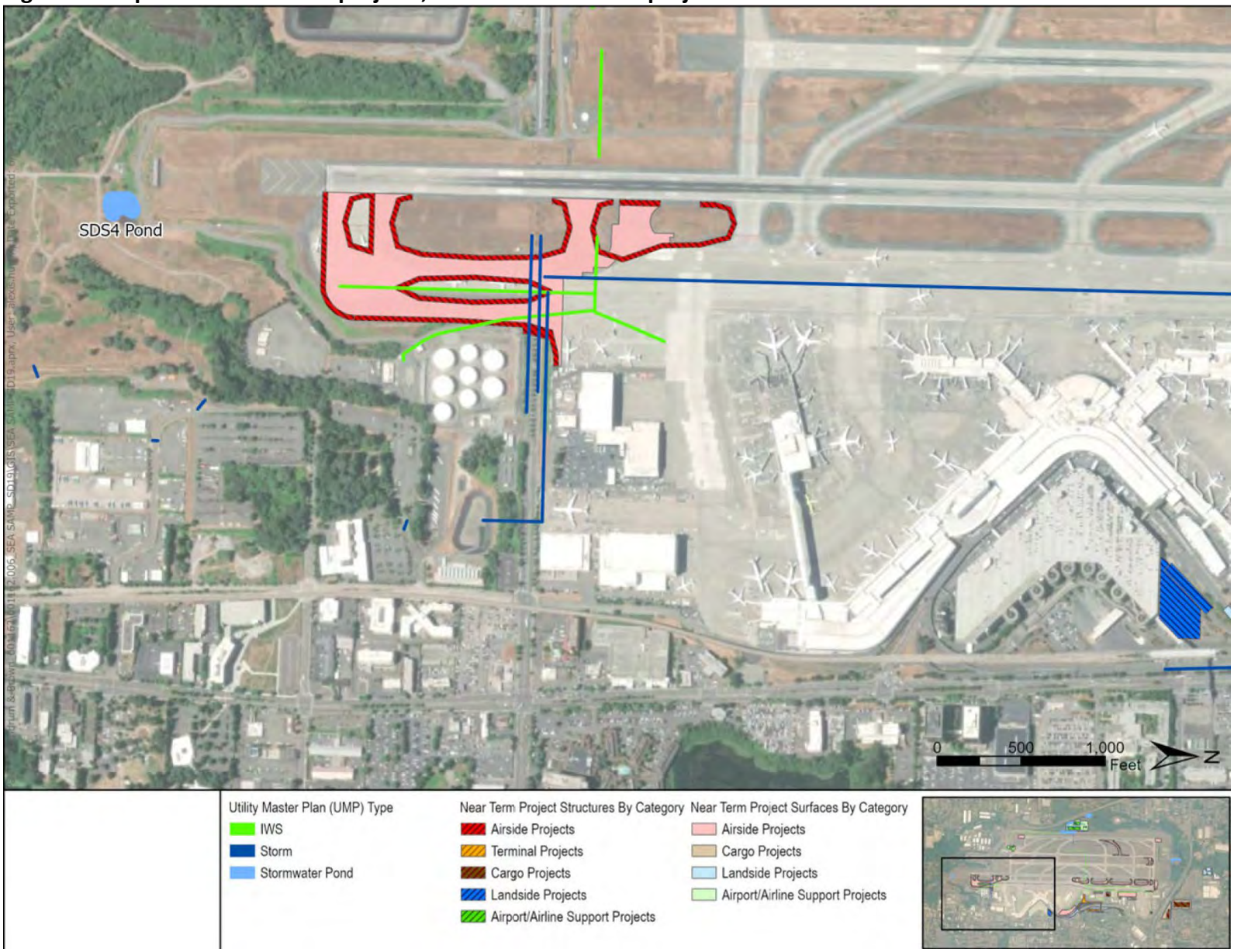


Figure 10. Proposed SDS and IWS projects, southwest section of project area

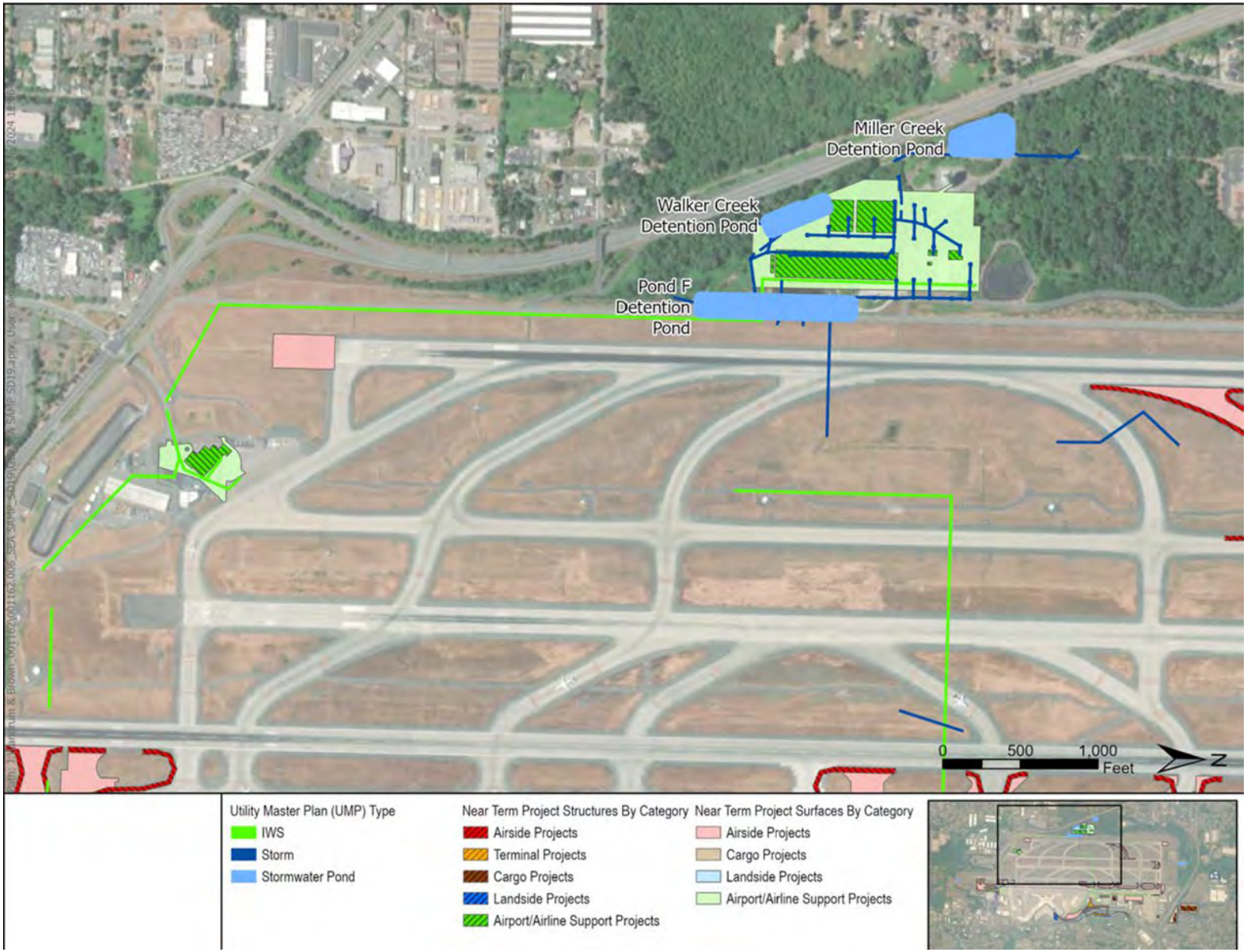


Table 4. Existing and proposed structural and OSC BMPs and net change in impervious areas and PGIS resulting from the Proposed Action by drainage basin and receiving body.

Receiving Water	SDS/IWS Drainage Basin	Existing Drainage Total Area (acres)	Existing Drainage Basin Total Impervious (acres)	Existing Drainage Basin NPGIS (acres)	Existing Drainage Basin PGIS (acres)	Existing Structural Source Control BMPs and Treatment Level[2]	Proposed Structural Source Control BMPs and Treatment Level[2]	OSC BMPs[3]
Des Moines Creek East	SDD05B	22.8	9.6	0.2	9.5	Oil/Enhanced ▪ Vegetated filter strips. ▪ SEPL Bioretention Swale. ▪ SDD05B Pond, enhanced level 1 flow control.	Increase Enhanced treatment capacity: ▪ Expand SDD05B Pond volume by 2.3 acre-feet. ▪ Pursue opportunities for infiltration if practicable. ▪ Integrate on-site LID techniques where practicable.	SM
	SDD06A	45.3	27.2	3.0	24.1	Oil/Enhanced ▪ 4 Biofiltration swales followed by oyster shell media bed. ▪ Oil/water separators. ▪ SDD06A Pond – Level 1 flow control detention pond.	Increase Enhanced treatment capacity: ▪ Expand existing detention pond volume by 6.4 acre-feet. ▪ Pursue opportunities for infiltration if practicable. ▪ Integrate on-site LID techniques where practicable.	SM
	SDE4/SDS1	190.2	141.9	40.4	101.5	Oil/Enhanced ▪ SDS1: Bioswales (SDS1). ▪ SDE4: SE Pond detention and treatment – Enhanced Level 1. ▪ 600-cartridge media filter vault with enhanced treatment. ▪ Media-augmented biotreatment swale. ▪ Oil/water separators.	Increase Oil/Enhanced treatment capacity: ▪ Install two oil/water separators and canister filters. ▪ Additional water quality treatment for runoff from garage and toll booth plaza.	SS, SM
	Receiving water totals	*258.3*	*178.7*	*43.6*	*135.1*			
NW Ponds and Des Moines Creek West	SDS4	67.6	25.9	0.1	25.9	Oil/Enhanced: ▪ Compost amended vegetated filter strips. ▪ SDS4 Pond. ▪ Biotreatment swale with design media. ▪ Oil/water separators.	Add additional Basic treatment capacity: ▪ Expand SDS4 Pond detention volume and bioretention swale footprint at outfall. ▪ Expand detention volume by 0.1 acre-feet to address development within basin only (assuming no diversion from SDS3/5). ▪ Expand bioretention swale footprint by 90 square feet or provide equivalent detention and treatment alternative. ▪ Integrate on-site low-impact development techniques as feasible. ▪ Pursue opportunities for shallow / deep infiltration to offset storage requirements.	R3, SM
	SDS3/5	456.8	250.6	3.2	247.3	Oil/Enhanced: ▪ Compost amended vegetated filter strips. ▪ Two bioswales. ▪ Two enhanced Level 1 flow control detention facilities.	Expand Basic treatment capacity: ▪ Divert runoff to SDS4 outfall to avoid need for additional storage. ▪ Increase detention pond volume.	R3, SM
	SDS6/7	117.1	48.2	0.1	48.1	Enhanced: ▪ 3.5-acre-foot vault for enhanced level 1 flow control. ▪ Compost-amended vegetated filter strips. ▪ Bioswales adjacent to runways and taxiways.	Maintain existing Enhanced treatment capacity	R3, SM
	Receiving water totals	*641.5*	*324.7*	*3.4*	*321.3*			
Miller Creek	SDW1b	87.5	25.3	0.0	25.3	Enhanced: ▪ Compost amended vegetated filter strips. ▪ SDW1B Pond (Pond D) for flow control. ▪ Sedimentation management for water quality.	Increase Enhanced treatment capacity: ▪ Expand SDW1b Pond detention volume by 4.4 acre-feet. ▪ Provide additional source controls, including oil/water separator. ▪ Pursue opportunities for infiltration. ▪ Integrate LID techniques where practicable.	R3, SM
	SDN3A	33.9	8.1	0.1	8.0	Enhanced: ▪ Compost amended vegetated filter strips. ▪ SDN3A Pond (Pond C) -- Level 2 flow control. ▪ Sedimentation management for water quality.	Maintain existing Enhanced treatment capacity	R3, SM
	New Development North of SR 518	42.7	0.9	0.0	0.9	N/A	Develop new Enhanced treatment capacity: ▪ Install new on-site detention and water quality treatment.	SM
	Receiving water totals	*164.1*	*34.3*	*0.1*	*34.2*			

2 Oil, Basic, and Enhanced structural treatment levels as defined by Ecology (2019), see Table 5.
3 OSC BMPs applicable to 6PPD-Q and other stormwater contaminants: R3 (runway rubber removal); SS (dry sweeping of PGIS); SM (sedimentation management). See Section 2.7.2 for details.

Receiving Water	SDS/IWS Drainage Basin	Existing Drainage Total Area (acres)	Existing Drainage Basin Total Impervious (acres)	Existing Drainage Basin NPGIS (acres)	Existing Drainage Basin PGIS (acres)	Existing Structural Source Control BMPs and Treatment Level[2]	Proposed Structural Source Control BMPs and Treatment Level[2]	OSC BMPs[3]
Miller Creek via Lake Reba	SDN2/3/4	115.9	44.6	0.4	44.2	Enhanced: ▪ Compost amended vegetated filter strips in airfield. ▪ SDN2/3/4-POND (Pond M) for flow control. ▪ Sedimentation management for water quality.	Increase Enhanced treatment capacity: ▪ Expand SDN2/3/4 Pond detention volume by up to 4.7 acre-feet. ▪ Pursue opportunities for infiltration at SR518 Pond. ▪ Integrate on-site LID techniques where practicable.	R3, SM
	Receiving water total	*115.9*	*44.6*	*0.4*	*44.2*			
Walker Creek	SDW2/SDW2A	44.4	10.8	0.0	10.8	Basic/Enhanced: ▪ Compost amended vegetated filter strips. ▪ SDW2-POND (Pond F) for flow control. Sedimentation management for water quality.	Increase Enhanced treatment capacity, add Oil treatment: ▪ Detention Pond F displaced by NTP S07. Relocate or convert to an underground vault with total storage capacity of 14.3 acre-feet (existing plus 2.4 acre-feet of additional storage). ▪ Expand SDW2 Pond detention volume and relocate basin to accommodate development. ▪ Integrate on-site LID techniques where practicable. ▪ Pursue opportunities for shallow / deep infiltration to offset storage requirements if practicable. ▪ Provide additional treatment including oil/water separator. ▪ Pursue opportunities for infiltration.	R3, SM
	Receiving water totals	44.4	10.8	0.0	10.8			
Puget Sound and/or Sanitary Sewer	IWS Combined	372.4	339.1	16.1	323.0	IWTP treatment (oil/basic): ▪ Oil/water separators. ▪ 6 dissolved air flotation units (DAFs) ▪ Settling Lagoons 1, 2, and 3	Increase on-site IWTP treatment and storage capacity: ▪ Convert SDS vaults SDS3 and SDS3A to IWS vaults. ▪ Construct 5.68 miles of new IWS pipe for vault discharge to IWS.	SS, SM
	Receiving water totals	*372.4*	*339.1*	*16.1*	*323.0*			

Table 5. Structural treatment level definitions

Structural Treatment Level	Treatment Objectives
Oil	▪ No ongoing or recurring visible sheen. ▪ Daily average total petroleum hydrocarbon concentration no greater than 10 milligrams per liter (mg/L) with a maximum of 15 mg/L for discrete (grab) samples.
Basic	▪ 80 percent removal of total suspended solids for an influent concentration range of 100 mg/L to 200 mg/L.[1] ▪ For influent concentration less than 100 mg/L the effluent goal is 20 mg/L total suspended solids.[1]
Enhanced	Meet Basic Treatment objectives, and provide: ▪ 30 percent removal of dissolved copper for influent concentration range of 0.005 mg/L to 0.02 mg/L[1] ▪ 60 percent removal of dissolved zinc for influent concentration range of 0.02 mg/L to 0.30 mg/L[1]
Phosphorous	▪ Meet Basic Treatment objectives and provide 50 percent total phosphorus removal for an influent concentration range of 0.1 to 0.5 mg/L. [1]

[1] Samples with influent concentrations that are greater than the range may be included by artificially setting the value at the upper end of the concentration range prior to completing the pollutant removal efficiency calculations. If the applicant opts to include samples with concentrations that are greater than the influent concentration range, they must include all valid samples that are greater than the range.

Table 6. Proposed stormwater and wastewater PSPs

Project Type	PSP	Permanent Footprint (acres)	Temporary Construction Footprint (acres)	Impervious Surface in Construction Footprint (acres)[1, 2]
SDS lines	Construct 5.93 miles of new SDS lines	n/a (buried)	14.4	9.7
IWS lines	Construct 5.68 miles of new IWS lines	n/a (buried)	13.7	8.8
Expand existing detention ponds	Expand SDS4 Pond by 0.1 acre	0.13	0.63	0.1
	Expand Pond M by 0.7 acre	0.76	1.87	0.8
Construct new detention ponds	Miller Creek pond	1.13	1.27	0.3
	Pond F relocation	1.69	2.56	0.9
	Walker Creek pond	0.49	1.18	1.4

[1] SDS and IWS lines are buried construction. A portion of line length routed under existing impervious surfaces (e.g., access roads). All affected surfaces are PGIS as detailed in Table 2. Remaining length would require clearing and excavation of managed fields and existing vegetation. All excavated surfaces would be restored to prior condition on completion of construction and would result in no net change in impervious and PGIS acreage.

[2] Detention pond construction activities would impact impervious surfaces around pond perimeters. The affected acreage is all NPGIS.

2.6 Project Construction

The Proposed Action would be constructed in stages beginning in 2025 and continuing through 2032[4]. The project designs for each NTP and associated PSPs are still in development and project-specific details are not yet available. Each project would be constructed using typical methods and equipment employed in large facility and infrastructure development. The specific types of construction equipment, number of equipment units, and construction scheduling would be determined during the project design process and may be modified to comply with relevant permit requirements.

2.6.1 Construction Equipment

Anticipated equipment types are shown in Table 7. Not all the equipment types shown would be used on every NTP project. For example, the hardstand and blast pad projects would not require cranes or power tools but would likely require excavators, graders, ground compactors, concrete mixers, and haul trucks. In contrast, new terminal development would require a broad range of construction equipment at various stages of construction.

Table 7. Anticipated construction equipment types

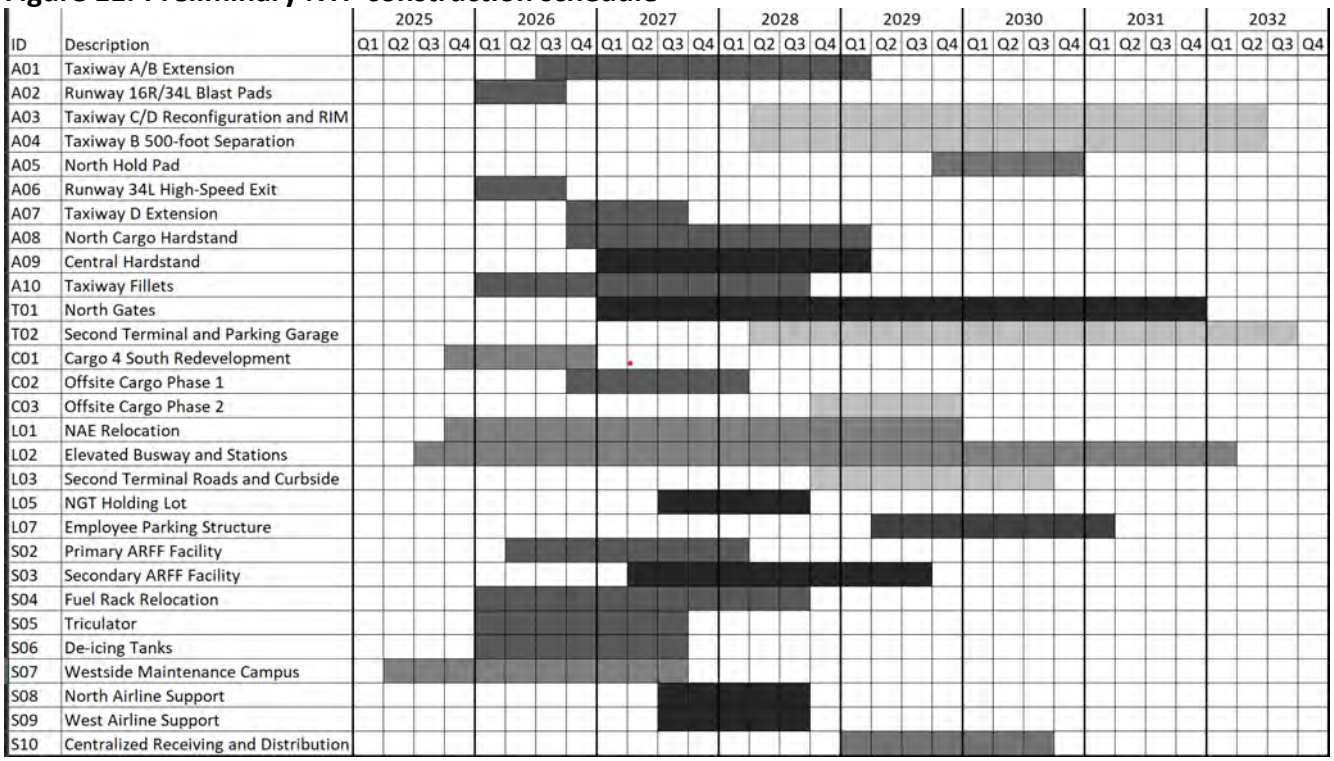
Equipment Category	Equipment Type		
General	Asphalt Truck	Flat Bed Truck	Street Sweeper
	Water Tanker Truck		
Heavy	Auger Drill Rig	Drill Rig Truck	Mounted Impact Hammer (hoe ram)
	Backhoe	Drum Mixer	Rock Drill
	Clam Shovel (dropping)	Dump Truck	Roller
	Compactor (ground)	Excavator	Slurry Plant
	Compressor (air)	Forklift	Slurry Trenching Machine
	Concrete Mixer Truck	Front End Loader	Vacuum Excavator (Vac-Truck)
	Concrete Pump Truck	Grader	Vibrating Hopper
	Crane	Horizontal Boring Hydraulic Jack	Vibratory Pile Driver
	Dozer	Impact Pile Driver	Woodchipper
Light	Boring Jack Power Unit	Jackhammer	Vacuum Street Sweeper
	Generator	Man Lift	Vibratory Concrete Mixer
	Grapple (on backhoe)	Sand Blasting	
Paving	Concrete Saw	Paver	Pavement Scarifier
Misc.	Hot Tar Kettle Trailer	Refrigerator Unit	Ventilation Fan
	Pumps	Scraper	Warning Horn
Power/Hand Tools	Chain Saw	Hammer Drill	Rivet Buster/Chipping Gun
	Grinder	Pneumatic Tools	Welder/Torch

4 Construction will begin once all environmental processes have been completed, all permits are acquired, and the project is ready to move forward.

2.6.2 Preliminary Project Schedule

The preliminary construction schedule for the NTPs and associated PSPs is provided in Figure 11. As shown, NTP construction would commence in 2025[5] and would continue through 2032. The 29 planned NTP projects would be staggered, with four projects commencing construction in 2025, 11 in 2026, six in 2027, five in 2028, and three in 2029. The anticipated duration of construction varies depending on the complexity of the project, ranging from less than one year to over 6 years.

Figure 11. Preliminary NTP construction schedule



2.7 Wetland Mitigation

The Port selected the proposed sites for project development to avoid and minimize impacts to wetlands, streams, and buffers to the extent practicable. The Port will continue to explore opportunities to further reduce impacts during design; however, based on the proposed NTP footprints, some impacts to wetlands, streams, and associated buffers are likely to occur. The anticipated permanent impacts, which are described in Section 5.1.2, are used to estimate mitigation requirements. These impact estimates represent a worst-case scenario based on currently available information. The Port would fully restore all sites temporarily impacted by project construction.

5 Construction will begin once all environmental processes have been completed, all permits are acquired, and the project is ready to move forward.

2.7.1 Anticipated Wetland Mitigation Requirements

The Port anticipates that the Proposed Action could result in up to 0.58 acre of permanent impacts to delineated Category II and III wetlands. Up to 0.55 acre of this total may be avoided if a stormwater vault is constructed in lieu of the proposed Miller Creek detention pond.

Compensatory mitigation requirements are dictated by federal, state, and local guidance. Table 8 identifies the compensatory mitigation ratios for Category II and III wetlands recommended by an interagency review committee representing the U.S. Army Corps of Engineers (USACE) Seattle District, U.S. Environmental Protection Agency (USEPA) Region 10, and Ecology (Ecology et al. 2021).

Table 8. Recommended compensatory wetland impact mitigation ratios by mitigation type.

Wetland Category[1]	Buffer Mitigation	Wetland Mitigation Ratio[2]		
		Creation or Reestablishment	Rehabilitation	Enhancement
Category II	1:1	3:1	6:1	12:1
Category III	1:1	2:1	4:1	8:1

[1] Hruby and Yahnke (2023).

[2] Ecology, USACE Seattle District, and USEPA Region 10 (2021).

Parametrix (2024a) characterized projected impacts to wetlands and wetland buffers resulting from the NTPs and associated PSPs (Appendix C). Projected mitigation requirements for the anticipated acres of impacts from the Proposed Action on Category II and III wetlands are provided in Table 9.

The Proposed Action would include 2.65 acres of mitigation for wetland buffer impacts and at least 1.17 acres and potentially up to 4.68 acres of compensatory mitigation for wetland impacts, depending on the type of mitigation provided. In addition, improvements to an existing culvert crossing on Miller Creek as part of S07 would result in impacts to streams (0.02 acre) and stream buffers (0.13 acre).

Table 9. Anticipated compensatory wetland mitigation acreage requirements.

Project Element	Wetland Category	Impacts Resulting from Proposed Action (acres)		Compensatory Wetland Mitigation Requirement by Type (acres)			
		Wetland	Buffer	Re-establishment	Rehabilitation	Enhancement	Buffer
NTPs	III	0.02	2.30	0.04	0.08	0.16	2.30
PSP – UMP sanitary sewer line	III	0.00	0.01	0.00	0.00	0.00	0.01
PSP – Stormwater conveyance	II	0.01	0.23	0.03	0.06	0.12	0.23
PSP – Stormwater ponds	III	0.55	0.11	1.10	2.75	4.40	0.11
Total Areas		0.58	2.65	1.17	2.89	4.68	2.65

Source: Parametrix (2024a).

2.7.2 Mitigation Plan and Sequencing

The Port would develop a compensatory mitigation plan for unavoidable permanent impacts to wetlands, streams and associated buffers, and temporary impacts to wetlands lasting more than one year during the permitting phase for each project in accordance with applicable state and federal guidance (Ecology et al. 2006, 2021). The mitigation plan would be developed following a mitigation sequencing approach based on a hierarchy of avoiding and minimizing impacts during design, rectifying temporary impacts, and compensating for unavoidable impacts.

The Port has seven sites within its ownership identified as being suitable for compensatory wetland mitigation (Anchor QEA 2019). Six sites are on SEA property and one site is located along the Green River in Auburn. They encompass over 150 acres and include potential for greater than 40 acres of wetland re-establishment, 11 acres of wetland enhancement, almost eight acres of preservation, and 80 acres of buffer enhancement (Anchor QEA 2019). The Port anticipates that these sites have sufficient capacity to accommodate the mitigation requirements for the Proposed Action. However, other mechanisms, such as purchasing mitigation credits from banks or in-lieu fee programs, or a combination of these mechanisms may be used to meet mitigation requirements.

If practicable, all permanent stream and stream buffer impacts would be mitigated by fully restoring the affected habitat functions on site or in proximity to the impacts. Should this approach prove infeasible, SEA is within the service area of several existing mitigation banks and in-lieu fee programs with available mitigation credits sufficient to offset the projected impacts.

To the extent possible, the Port would emphasize in-kind mitigation within the same watershed where the impacts occurred. However, out of watershed mitigation (e.g., at the Green River site) may be considered should state and federal resource agencies determine this would produce the most desirable ecological outcomes. Regardless of mechanism, the Port will commit to providing sufficient mitigation to comply with local, state, and federal requirements at the highest replacement ratios.

2.8 Best Management Practices

The Port would comply with standard specifications, BMPs, and applicable federal and state regulatory requirements during design, construction, and operation of the Proposed Action. BMPs that are designed to protect water and sediment quality with vegetation are expected to be most effective at reducing adverse effects from stormwater discharges over short and long terms.

2.8.1 Construction Best Management Practices

The SEA SWPPP (Port 2021e, or current version) defines compliance requirements and expectations for all construction activities that occur on Port property. This plan is periodically updated to reflect current state and federal guidance and regulatory requirements for avoiding and minimizing impacts to the environment. It comprises the following 13 programmatic elements:

1. Preserving Vegetation and Marking Clearing Limits: Maintain natural vegetation to the extent practicable and clearly mark construction limits to minimize land-disturbing impacts.
2. Establishing Construction Access: Minimize construction activity in unpaved areas, establish stabilize access points, and use vacuum sweeping and wheel washing to limit sediment track out.

3. Control Flow Rates: Stormwater management measures to minimize discharge and runoff from construction sites.
4. Sediment Controls: Filter all stormwater runoff through appropriate sediment removal BMPs and test to verify compliance with turbidity and pH limits before discharge from the site.
5. Soil Stabilization: Stabilize exposed and unworked soil with application of effective BMPs to prevent erosion throughout the life of the project.
6. Slope Protection: Design, construction, and protection of cut and fill slopes to minimize erosion.
7. Drain Inlet Protection: Protect storm drain inlets/culverts using temporary plugs, phasing, and/or inlet protection to prevent untreated water from entering drainage conveyance system.
8. Channel and Outlet Stabilization: Design, construction, and protection of temporary onsite conveyance channels to prevent erosion from the expected peak 10-minute velocity of flow from a 10-year, 24-hour recurrence-interval storm.
9. Pollutant Control: All pollutants, including waste and demolition debris, generated onsite will be handled and disposed of in a manner that does not cause contamination of stormwater.
10. Dewatering Control: Discharge dewatering water from open-cut excavation, tunneling, foundation work, trenches, or underground vaults into a controlled conveyance system prior to discharge to a sediment trap or sediment pond.
11. Construction BMP Maintenance: Inspection, maintenance, and repair of temporary and permanent erosion and sediment control BMPs as needed to ensure continued performance in accordance with intended functions. Visual monitoring of the BMPs should be conducted daily and within 24 hours of any stormwater or non-stormwater discharge from the site.
12. Project Management: Scheduling, phasing, inspecting, maintaining, and managing construction projects to avoid/minimize stormwater impacts. Includes seasonal phasing of ground-disturbance.
13. Protect Low-Impact Development (LID) BMPs: All LID BMPs on and downstream of Port property will be protected by appropriate erosion and sediment control BMPs.

The Port requires every construction project on SEA property to develop a site-specific construction SWPPP that details the methods and procedures used to comply with the programmatic elements listed above, and the Port's standard operating procedures for construction water quality monitoring (Port 2016a). The Port would require each contractor to develop Construction SWPPPs for their respective projects. The typical Construction SWPPP comprises:

- Stormwater BMP implementation and site-specific performance monitoring plan, (required for all sites larger than 1 acre)
- Pollution Prevention Plan (PPP): site-specific hazardous materials management plan
  - Site specific description and drawings
  - Contractor pollution prevention contact personnel
  - Known or potential hazardous materials inventory list
  - Safety data sheets all inventoried hazardous materials
  - Container labeling system
  - Container storage and handling procedures
  - Spill prevention, control, and response procedures

  - Hazardous material cleanup and disposal procedures
  - Reporting procedures
  - Signed acknowledgement of PPP requirements by all subcontractors
- Contractor Erosion and Sediment Control Plan (site-specific)
  - Site description and drawings
  - Contractor-designated erosion and sediment control personnel
  - Construction schedule and sequencing
  - BMP installation, maintenance, and inspection procedures
  - Record keeping requirements
  - BMP removal procedures
  - Emergency response plan
  - Construction dewatering plan
  - Fugitive dust management plan
  - Utility plan
  - Contractor education procedures
- Contract plans and specifications

2.8.2 Operational Source Control Best Management Practices

The Port would continue to implement the 16 OSC BMPs detailed in the SEA SWPPP (Port 2022b) to avoid and minimize adverse impacts to ESA-listed species. These BMPs, outlined in Table 10, would be adapted as needed to address ongoing and new operational activities resulting from the Proposed Action. OSC BMP 1.0 defines a set of 39 management measures grouped into 8 categories. These categorical measures apply to all potential pollutant generating operations that occur on Port property. The remaining 15 OSC BMPs specify the additional categorical measures used to avoid and minimize stormwater impacts from specific operations and maintenance activities.

Table 10. OSC BMP summary

OSC BMP	Purpose	Targeted Pollutant(s)	Measures
1.0 – General Industrial Activities	Established general compliance measures for preventing and reducing discharge of pollutants to the SDS and IWS. This BMP comprises 39 compliance measures that are applicable to all Port and tenant operations with potential to impact stormwater.	All potential pollutants used or generated on Port property.	39 general measures in 8 categories: ▪ *Pollution prevention team:* Establishes responsibilities, points of contact, and communication protocols. ▪ *Good housekeeping practices*: Establish standard practices for pollutant prevention, interception, and IWS and SDS maintenance of treatment systems to limit pollutant releases. ▪ *Minimizing exposure of pollutants to stormwater*: Limits industrial activities and hazardous materials handling to IWS drainage basins. ▪ *Preventative maintenance*: Routine maintenance of SDS and IWS to ensure that system is functioning at maximum pollutant control capacity and efficacy. ▪ *Spill prevention and response planning*: Spill prevention and response planning and compliance procedures. ▪ *Facility inspections*: Routine inspection of Port facilities and Port and tenant activities to ensure proper function and compliance with BMPs. ▪ *Employee/tenant/contractor training*: Training to ensure familiarity and compliance with Port environmental policies and procedures, including BMP implementation. ▪ *Recordkeeping and reporting*: Establishes procedures for compliance with NPDES Permit reporting requirements.
2.0 – Aircraft, Vehicle, and Equipment Maintenance	Preventing and reducing releases of pollutants associated with aircraft, vehicle, and equipment maintenance activities.	▪ Fuel, oil, grease ▪ Solvents/ cleaning solutions ▪ Battery acid ▪ Paint ▪ Anti-freeze ▪ Other vehicle fluids	13 activity-specific pollution control measures in the *good housekeeping practices, minimize exposure of pollutants to stormwater, preventative maintenance, spill prevention and response,* and *routine facility inspections* categories.
3.0 – Aircraft, Vehicle, and Equipment Cleaning	Prevent and reduce releases of pollutants associated with aircraft, vehicle, and equipment washing, and cleaning and degreasing actions.	▪ Oil and grease ▪ Solvents ▪ Vehicle fluids ▪ Cleaning solutions	Nine activity-specific pollution control measures in the *good housekeeping practices, minimize exposure of pollutants to stormwater, preventative maintenance, routine facility inspections,* and *recordkeeping and reporting* categories.
4.0 – Aircraft, Vehicle, and Equipment Storage	Prevent fuel spills/leaks, prevent contact with petroleum products and metals, and reduce their impacts to stormwater.	▪ Oil and grease ▪ Fuel ▪ Vehicle fluids ▪ Metals	Five activity-specific pollution control measures in the g*ood housekeeping practices* and *minimize exposure of pollutants to stormwater* categories.
5.0 – Outdoor Handling, Storage, and Disposal of Wastes and Materials	Prevent or reduce the discharge of pollutants to stormwater from outdoor handling, storage, and disposal of materials and waste.	All potential pollutants used or generated on Port property	24 activity-specific pollution control measures in *good housekeeping, minimize exposure of pollutants to stormwater, preventative maintenance, spill prevention and response, routine facility inspections, employee/contractor training,* and *recordkeeping and reporting* categories. Management of stormwater runoff measures to protect waste material storage areas from stormwater accumulation and runoff (e.g., prioritizing indoor storage, coverage for outdoor storage areas, secondary containment, etc.).

OSC BMP	Purpose	Targeted Pollutant(s)	Measures
6.0 – Fuel Storage and Delivery	Prevent fuel spills and leaks and reduce their impacts to stormwater.	Fuel and petroleum products	21 activity-specific pollution control measures in the *good housekeeping, minimize exposure of pollutants to stormwater, preventative maintenance, spill prevention and response, routine facility inspections, employee/contractor training, and recordkeeping* and *reporting* categories.
7.0 – Building and Grounds Maintenance	Prevent or reduce discharge of pollutants through best practices for building/grounds maintenance, keeping debris from entering storm drains, and routine maintenance of stormwater system.	▪ Pesticides/herbicides /fertilizers ▪ Oil and grease ▪ Zinc ▪ Landscape waste ▪ Washdown waste ▪ Sediment ▪ Particulate matter (paint chips, roofing aggregate, tire dust)	24 activity-specific pollution control measures in the *good housekeeping, minimize exposure of pollutants to stormwater, preventative maintenance, spill prevention and response, routine facility inspections,* and *employee/contractor training* categories. These measures include: ▪ Dry sweeping of aircraft and vehicle operations surfaces. ▪ Runway rubber removal. ▪ Routine maintenance and cleaning of catch basins, vaults, and separators to remove accumulated particulates, including rubber particles.
8.0 – Vehicle and Equipment Painting	Prevent the discharge of pollutants to stormwater from vehicle and equipment painting.	▪ Paint ▪ Metals ▪ Solvents	14 activity-specific pollution control measures in *good housekeeping, minimize exposure of pollutants to stormwater, preventative maintenance, spill prevention and response, management of stormwater runoff,* and *employee/contractor training* categories.
9.0 – Garbage Handling and Disposal	Prevent or reduce discharge of pollutants to stormwater from garbage/municipal solid waste handling/disposal by preventing runoff from trash compactors and dumpsters.	▪ Dumpster waste ▪ Compactor fluids ▪ Trash ▪ Nutrient pollution contributing to biological oxygen demand (BOD)	Nine activity-specific pollution control measures in the *good housekeeping, minimize exposure of pollutants to stormwater, preventative maintenance, routine facility inspections, management of stormwater runoff,* and *employee/contractor training* categories.
10.0 – Aircraft De-icing and Anti-icing	Prevent discharge of pollutants to stormwater from aircraft de-icing and anti-icing procedures.	▪ Ethylene glycol ▪ Propylene glycol ▪ BOD	10 activity-specific pollution control measures in *good housekeeping, minimize exposure of pollutants to stormwater, preventative maintenance, spill prevention and response,* and *routine facility inspections* categories.
11.0 – Aircraft Lavatory Waste Servicing	Prevent the discharge of pollutants to stormwater from aircraft de-icing and anti-icing procedures.	▪ Lavatory chemicals ▪ Lavatory waste ▪ Lavatory truck wash water	10 activity-specific pollution control measures in *good housekeeping, minimize exposure of pollutants to stormwater, preventative maintenance, spill prevention and response, routine facility inspections,* and *management of stormwater runoff* categories.
12.0 – Potable Water System Flushing	Prevent discharges to the storm drain system associated with flushing of aircraft and vehicle potable water systems.	▪ Purine ▪ Chlorine bleach	Two activity-specific pollution control measures in the minimize exposure of pollutants to stormwater category.
13.0 – Roadway, Ramp, and Runway Maintenance and Cleaning	Prevent or reduce the discharge of pollutants to stormwater from maintenance activities, and through routine cleaning of roads, ramps, and runways.	▪ Oil and grease ▪ Fuel ▪ De-icing/anti-icing ▪ Chemicals ▪ Sediments ▪ Foreign object debris ▪ Tire particles ▪ Solvents/cleaning solutions	10 activity-specific pollution control measures in *good housekeeping, minimize exposure of pollutants to stormwater, preventative maintenance, routine facility inspections,* and *management of stormwater runoff* categories.

OSC BMP	Purpose	Targeted Pollutant(s)	Measures
14.0 – Fire Suppression and Aqueous Film Forming Foam Discharge	Prevent discharges to the storm drain system associated with flushing or testing of firefighting foam systems.	Aqueous film-forming foam	Five activity-specific pollution control measures in *good housekeeping*, *minimize exposure of pollutants to stormwater*, *preventative maintenance*, and *routine facility inspections* categories.
15.0 – Animal Handling	Prevent discharges to the storm drain system associated with animal handling and cargo.	Fecal coliform	Five activity-specific pollution control measures in *good housekeeping* and *minimize exposure of pollutants to stormwater* categories.
16.0 – Spill Response and Clean-Up	Identify and establish roles and responsibilities for all spills at SEA.	▪ Fuels ▪ Biffy spills ▪ Hydraulic fluids ▪ Oil and grease ▪ Glycols ▪ De-icing/anti-icing chemicals	Establishes standard spill response practices and notification procedures for spills by pollutant category.

Table 4 (Section 2.4.2) identifies 3 OSC activities that are relevant for avoiding and minimizing impacts to ESA-listed species from stormwater contaminants: runway rubber removal, impervious surface sweeping, and detention basin, vault, and separator maintenance. These specific activities, associated OSC BMPs, and typical frequency are described in Table 11.

Table 11. OSC BMP activities to avoid/minimize risks to aquatic habitat from 6PPD-Q and metals.

OSC Activity (code)	Associated OSC BMPs	BMP Activities and Frequency
Runway rubber removal (R3)	1.0, 13.0	▪ Regular testing of runways for rubber accumulation. ▪ Rubber removals are scheduled based on observed accumulation levels. ▪ Typical removal frequencies are every 6 weeks for runway 16R/34L, twice a year on 16C/34C, and four times/year for 16L/34R.
Surface sweeping (SS)	1.0, 7.0, 13.0	▪ Dry sweeping of roads, ramps, and runways to prevent or reduce the discharge of pollutants to stormwater from maintenance and cleaning of PGIS. ▪ Sweeping occurs daily on both landside and airside pavements.
Detention basin, vault, and separator maintenance (SM)	1.0, 7.0	▪ Regular cleaning and maintenance of manhole sumps and oil/water separators. ▪ Regularly clean any catch basins which receive runoff from a maintenance area. Install and maintain catch basin filter inserts in areas prone to high volumes of debris. ▪ Regularly inspect and maintain stormwater control devices. ▪ Remove accumulated sediment from targeted ponds and vaults annually in the summer, prior to fall rains (i.e., first flush).

2.9 Additional Conservation Measures

The Port's Aviation Environmental staff have been proactively reviewing available research and guidance on stormwater management of 6PPD-Q since the University of Washington published their findings on this emerging contaminant in late 2020. The Port is voluntarily conducting research on the fate and transport of 6PPD-Q at SEA, and the effectiveness of available treatment methods.

- Ongoing participation in Ecology's Stormwater Working Group and 6PPD-Q subgroup.
- Funding an independent stormwater media treatment study (Treatability Testing) to determine if available technologies can effectively remove 6PPD-Q from SEA stormwater discharge. Four commercially available filter media are being evaluated individually and in combination with Chitosan Enhanced Sand Filtration (CESF):
  - Chitosan Enhanced Sand Filtration (CESF) - Combines chitosan (shells from crustaceans) with sand filtration to remove pollutants from water.
  - Virgin Coconut Carbon (VCC) - Adsorption media effective at removing most compounds found in both stormwater and process water.
  - Hydrosil HS-250 (HS250) - A 50/50 mix of a pure zeolite based organoclay and 6 x 30 tyler mesh anthracite coal that is effective at removing oil, heavy metals, and organics from water.
  - SCU-Evoqua (SCU) - An Ion exchange media effective at removing trace metals from water.
  - Biochar-Black Owl Stormwater Mix (Biochar) - A biochar-based media effective at removing COD, TSS, metals, and Mercury from stormwater.

The Treatability Testing study is an incredibly proactive approach. The Port is searching for solutions years before regulations are in place. The results of this study will be useful in finding BMPs other than 100% infiltration that are effective at removing 6PPD-Q from stormwater given the limited availability of 100% infiltration. The first year of testing was largely successful with removal rates up to 99.9%. The results demonstrate that the Port would be able to meet proposed state limits. The Port is prepared to share the findings of this study with NMFS and Ecology's Stormwater Working Group when the results are available. The Port is hopeful that this effort will contribute to regional efforts to reduce the adverse effects of 6PPD-Q on the aquatic environment.

3.0 ACTION AREA

The action area for this ESA analysis is defined as "all areas to be affected directly or indirectly by the Proposed Action and not merely the immediate area directly adjacent to the action" (50 CFR 402.02). The action area includes all surrounding areas where project activities could potentially affect the environment. The action area encompasses all areas exposed to direct and indirect effects, as well as any effects of interrelated or interdependent actions.

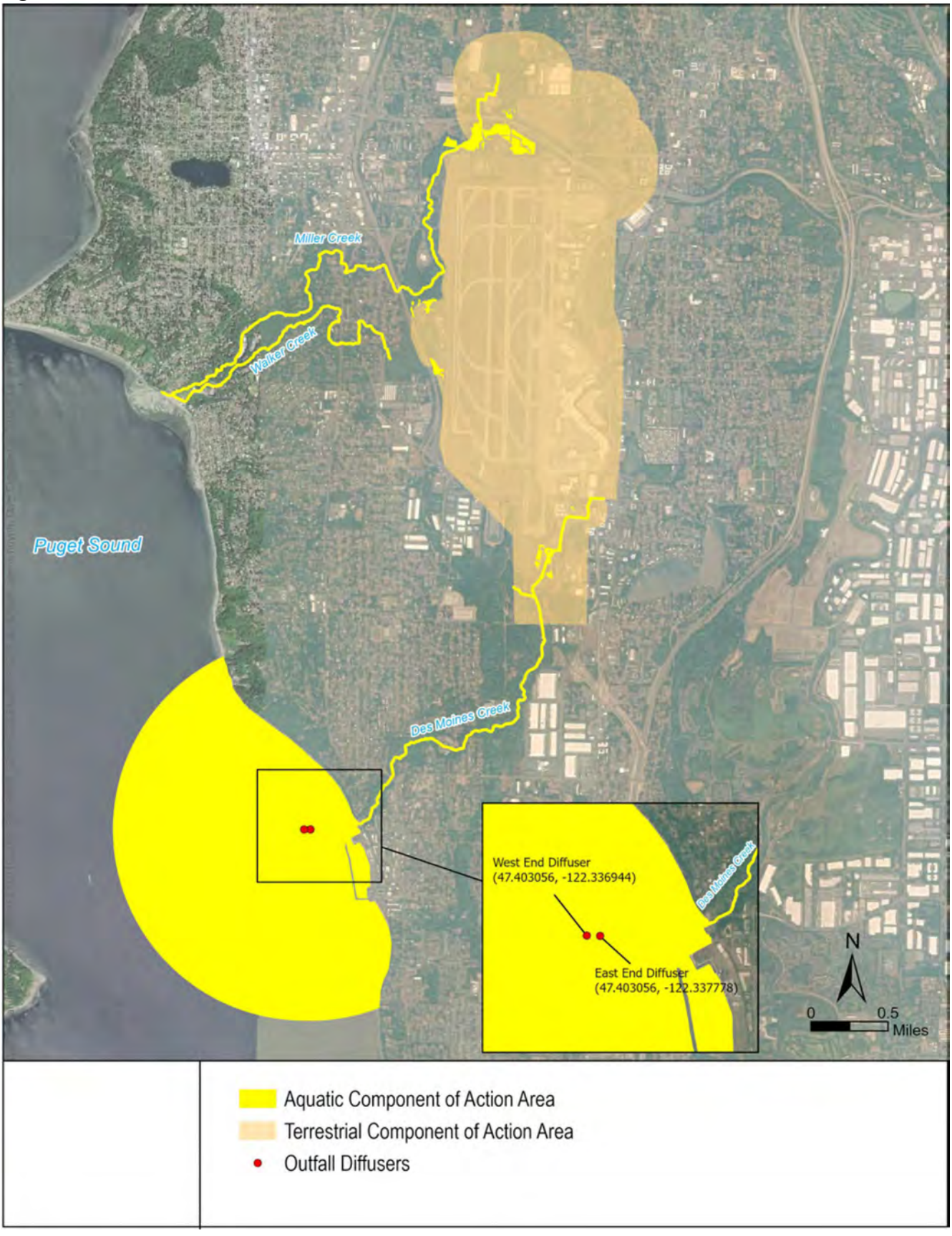
The Proposed Action would result in temporary and permanent modification to existing developed and undeveloped surfaces on Port property. The Proposed Action would retrofit existing and create new impervious surfaces. In addition, project construction would result in temporary and permanent impacts to wetlands, streams, and buffer habitats.

The action area comprises discrete terrestrial and aquatic components, which are summarized in Table 12 and displayed in Figure 12. As described in Section 3.1, the terrestrial component of the action area comprises all habitats directly within the construction footprint of the NTPs, PSPs, and mitigation, areas exposed to construction noise and activity levels that exceed baseline conditions, and project operations. The aquatic component of the action area is described in Section 3.2 and comprises all aquatic habitats exposed to temporary and permanent construction impacts and anticipated operational stormwater and industrial treated wastewater discharges from the NTPs.

Table 12. Action area dimensions

Action Area Component	Location(s)	Impact Producing Activity	Dimensions
Terrestrial	Locations where construction or operations would occur, including wetland buffers and areas exposed to construction noise above ambient levels.	▪ NTP and PSP construction ▪ NTP operations ▪ Wetland mitigation	2,554 acres
Aquatic	Wetlands on SEA property	▪ NTP and PSP construction ▪ Operational stormwater	43.9 acres
	Miller Creek	NTP construction	0.02 acre (stream) 0.12 acre (stream buffer)
		Operational stormwater	4.76 miles
	Walker Creek	Operational stormwater	2.42 miles
	Des Moines Creek	Operational stormwater	3.66 miles
	Puget Sound	Industrial wastewater	1,833 acres
		Operational stormwater	~2 acres

Figure 12. Action area



3.1 Terrestrial Component

The terrestrial component of the action area is defined by the physical extent of measurable effects (both temporary and permanent) resulting from the construction and operation of the Proposed Action. The Proposed Action comprises a range of activities, including the construction and operation of the NTPs and PSPs, habitat mitigation, and the ongoing implementation of operational BMPs. These activities will occur at multiple locations throughout SEA. Therefore, the terrestrial component of the action area is defined by the SEA property boundary.

3.2 Aquatic Component

The aquatic component of the action area includes construction activities proposed within wetland and stream aquatic habitats, areas potentially exposed to treated stormwater pollutants, and the dilution zones around treated stormwater outfalls that serve the Proposed Action. Construction activities would not cause elevated underwater noise levels outside of the temporary impact from project construction anticipated for aquatic habitats.

The Proposed Action would generate stormwater and industrial wastewater that would discharge through new and existing infrastructure after treatment to Miller Creek, Walker Creek, Des Moines Creek, and the Puget Sound. The Proposed Action includes structural SDS and IWS improvements and OSC BMPs to service the new, replaced, and retrofitted PGIS.

Miller Creek and Des Moines Creek flow into Puget Sound, and Walker Creek flows into Miller Creek near its confluence with Puget Sound. As detailed in Section 4.2, the action area includes several wetlands in the headwaters of these tributaries that would receive treated stormwater discharge. SEA's IWTP discharges treated industrial wastewater to Puget Sound from an NPDES-permitted offshore outfall with 2 diffusers located at a mean lower low water (MLLW) depth of 148 feet.

The action area also includes theoretical contaminant exposure zones around the NPDES-permitted outfall for the SEA IWTP, located approximately 1,600 feet offshore of the mouth of Des Moines Creek. Per direction from NMFS, this exposure zone extends up to 6,560 feet (2 kilometers [km]) from each diffuser and extends from the seabed to the top of the water surface. The combined extent of these mixing zones is approximately 1,833 acres, providing a conservative surrogate for potential operational stormwater-related effects in the absence of stormwater pollutant data and a quantitative method to determine the spatial extent of effects.

4.0 ENVIRONMENTAL SETTING/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.

4.1 Terrestrial Habitat

SEA property is a fully developed international airport facility where terrestrial habitats have been substantially altered from historical conditions. Land cover primarily comprises developed airport facilities, fragmented open space including managed fields adjacent to runways and taxiways, open fields and shrublands, forested areas, stormwater ponds, wetlands, and wetland and riparian buffers. These habitats are managed for tree height and wildlife control to maintain aircraft safety. Many vegetated habitats around the outer edge of SEA were previously developed for residential uses. These properties were subsequently purchased, cleared for airport noise mitigation, and have revegetated over time. None of these open spaces provide suitable habitat for ESA-listed species.

4.2 Aquatic Habitat

The aquatic component of the action area comprises a 4.76-mile segment of Miller Creek extending from the upstream limit of measurable construction effects and stormwater discharge to the confluence with Puget Sound; 2.42 miles of Walker Creek from headwaters to the confluence with Puget Sound; 3.66 miles of Des Moines Creek and tributaries from the upstream limit of measurable construction and stormwater effects to the confluence with Puget Sound; nearshore and marine areas of Puget Sound in proximity to action area tributary confluences and within a 1.2-mile (2-km) radius of the IWTP outfall; and all wetlands impacted by construction and receiving stormwater runoff from the Proposed Action. All marine, estuarine, and freshwater aquatic habitats within the action area are listed as 303(d) impaired waters due to exceedances of a variety of parameters (Table 14).

Parametrix (2024b) prepared an aquatic critical areas impact assessment memorandum for the Proposed Action based on wetland, pond, and stream delineations completed in 2019 and 2020 and field verified in 2024. The report identified 31 wetlands covering approximately 74.5 acres (Table 13).

Table 13. Wetlands in action area

Wetland	Area (acres)	USFWS Classification	Hydrogeomorphic Classification	Ecology Rating	Habitat Rating	Buffer Width (feet)
N3	18.97	PFO/PSS/PEM	Depressional	I	7	165
N4	1.22	PFO/PSS	Slope	IV	4	40
1	0.11	PSS	Slope	IV	3	40
2	0.84	PFO/PSS/PEM	Slope	III	5	105
A	0.11	PSS/PEM	Slope	III	4	60
4	4.71	PFO	Depressional	II	6	165
5	5.27	PFO	Depressional	II	6	165
6	0.91	PFO	Depressional	II	6	165
7	6.75	PFO	Depressional	II	6	165
8	4.57	PFO/PSS/PEM	Depressional	I	7	165
9	3.10	PFO/PSS/PEM	Depressional	II	6	165
10	0.41	PFO/PSS/PEM	Depressional	III	6	165
11	0.01	PFO	Depressional	III	4	60
39	2.60	PFO/PSS	Slope	III	6	165
R15	2.21	PFO	Depressional	II	6	165
A20	0.55	PFO/PSS/PEM	Depressional	III	5	105
A14a	0.21	PFO/PSS/PEM	Slope	III	6	165
A14b	0.12	PFO/PEM	Slope	III	6	165
44	3.12	PFO	Depressional	II	6	165
E1	0.21	PFO	Slope	III	4	60
52A	1.72	PFO	Slope	II	6	165
DMC1	<0.01	PSS/PEM	Slope	III	5	105
DMC2	0.05	PSS/PEM	Slope	III	5	105
52B	1.01	PFO/PSS	Slope	III	6	165
52C	0.82	PFO/PEM	Riverine	II	6	165
G12	2.41	PFO/PSS/PEM	Depressional/Slope	II	6	165
G1	<0.01	PFO/PSS	Slope	III	5	105
G4	0.01	PSS	Slope	III	5	105
G5	0.93	PSS/PEM	Slope	III	5	105
H	0.07	PSS/PEM	Slope	III	5	105
D	3.81	PFO/PSS	Riverine	II	6	165
PFO – Palustrine forested; PSS – Palustrine scrub-shrub; PEM – Palustrine emergent						

4.2.2 Des Moines Creek

The southern portion of SEA drains into the Des Moines Creek Drainage Basin. The headwaters of Des Moines Creek are located on the south side of SEA. There is an East Branch to the creek near the headwater. Des Moines Creek and the East Branch of the creek are associated with ponds and wetland systems. SEA outfalls drain into Des Moines Creek, the East Branch, and wetland/pond systems. The creek flows south and southwest for about 3.6 miles through wetlands, forested parks, and various developments beneath roads with culverts before flowing into Puget Sound.

WDFW identifies Des Moines Creek as gradient-accessible to fall Chinook salmon and winter steelhead 0.9 miles downstream of SEA property, however, neither species has been documented in the system (WDFW 2024d). Chum salmon (*O. keta*) are documented in the lower 0.2 miles of the creek, and coho salmon (*O. kisutch*) presence is documented from the mouth to 0.2 miles downstream of SEA property (WDFW 2024d). Resident cutthroat trout (*O. clarkii*) presence is documented in the upstream reach of the creek and the East Branch (NWIFC 2024, WDFW 2024d, e).

4.2.3 Miller Creek

The north and western portions of SEA drain into the Miller Creek/Walker Creek Drainage Basin. The headwaters of Miller Creek are located on the north side of SEA and an East Branch to the creek is near the headwater. The Miller Creek main channel originates north of SEA, north of SR 518, and the East Branch flows through wetlands, ponds, and Lake Reba on the north side of SEA. SEA outfalls drain into Miller Creek and Lake Reba. The creek flows for about 4.7 miles through wetlands, forested parks, and various developments beneath roads with culverts before flowing into Puget Sound. Walker Creek flows into Miller Creek a short distance from the creek outlet to Puget Sound.

WDFW (2024d) identifies Miller Creek as potentially accessible to fall Chinook salmon and winter steelhead based on modeled suitable habitat up to an existing barrier culvert at 1st Avenue S, approximately 0.65 mile downstream of SEA property. However, neither species is currently documented (WDFW 2024d). Chum salmon, coho salmon, and resident cutthroat trout are documented as known or potentially occurring in Miller Creek. Documented coho salmon potential presence and resident cutthroat trout presence in the upper reach (NWIFC 2024, WDFW 2024d, e).

The Miller and Walker Creek Executive Committee (2006) state that Chinook salmon did not occur naturally in Miller Creek and are not currently present, but the species has been occasionally observed in the system as recently as 2000 due to a failed attempt to introduce Chinook salmon to the Miller Creek system in the 1980s and 1990s. Chinook salmon do not occur in any independent tributaries adjacent to or in proximity to Miller Creek, despite being equally accessible and providing similar habitat (WDFW 2024d. There are no recent records of Chinook salmon occurrence in Miller Creek and none of the documented observations are less than 20 years old. Therefore, it is reasonable to conclude that the Miller Creek system does not currently support Chinook and is unlikely to do so in the future.

4.2.4 Walker Creek

Walker Creek is within the Miller Creek/Walker Creek Drainage Basin on the north and western portions of SEA. SEA outfalls drain into Walker Creek and associated tributaries and ponds. The approximately 2.4-mile creek flows beneath SR 509 before flowing through wetlands, forested parks, residential areas, and

beneath roads with culverts before flowing into Miller Creek a short distance from the Miller Creek outlet to Puget Sound.

WDFW identifies Walker Creek as gradient-accessible to fall Chinook salmon and winter steelhead up to the South Normandy Road crossing at Airport Park, approximately 0.2 mile downstream of SEA property. However, neither species has been documented in this system. Chum salmon, coho salmon, and resident cutthroat trout are documented in the system (NWIFC 2024, WDFW 2024d, e). As described above for Miller Creek, it is reasonable to conclude that the Walker Creek system does not currently support ESA-listed Chinook and is unlikely to do so in the future.

4.2.5 Puget Sound

The aquatic component of the action area includes nearshore areas of Puget Sound at the mouths of Miller, Walter, and Des Moines creeks, and an offshore area within approximately 6,560 feet (2 km) of paired diffusers at the existing stormwater outfall for the IWS, located approximately 1,600 feet waterward of the mouth of Des Moines Creek at a depth of -148 feet relative to MLLW. The nearshore portions of the action area are located on broad subtidal flats composed of predominantly sand and gravel substrate. Patchy beds of eelgrass (*Zostera marina*) and various species of marine algae are present (Ecology 2023). Kelp beds are absent, likely due to a lack of large-grained substrate material suitable for holdfast anchoring. Virtually the entire shoreline adjacent to the action area has been armored to protect development (Ecology 2023). Sparse clam populations and a sparce array of polychaete species are present. Geoduck clams (*Panopea generosa*) may be present in deeper waters (Dethier 2010). Upper shore areas, as in mixed-fine habitats, tend to be composed of depauperate steep gravel-sand sediments. All ESA-listed species covered in this evaluation may be present within the Puget Sound portion of the action area periodically throughout the year.

4.3 Water Quality

Ecology is responsible for monitoring water quality standards throughout the state of Washington. Ecology's Water Quality Atlas identifies 303(d) listed waterbodies, which are those with impaired water or sediment quality. Marine, estuarine, and freshwater aquatic habitats within the action area are listed as 303(d) impaired waters due to exceedances of a variety of parameters under Categories 1, 2, 4a, and 5 waters (Ecology 2024). Table 14 summarizes the water quality parameters with identified exceedances within the action area per aquatic habitat, as reported by Ecology.

Table 14. Water quality parameters in the action area

Water Quality Parameter	Category	Puget Sound	Des Moines Creek	Miller Creek	Walker Creek
4, 4'-DDD/DDE/DDT	5	No	No	No	No
Alpha-BHC	5	No	No	No	No
Arsenic, Inorganic	5	No	No	No	No
Bacteria – Enterococci	5	Yes	No	No	No
Bacteria – Fecal coliform	5	Yes	Yes	Yes	Yes
Benzo(a)anthracene	5	No	No	No	No
Benzo(a)pyrene	5	No	No	No	No
Benzo(b)flouranthene	5	No	No	No	No
Benzo(k)flouranthene	5	No	No	No	No
Bis(2-ethylhexyl)phthalate	5	No	No	No	No
Chrysene	5	No	No	No	No
Copper	5	No	Yes	No	No
Dibenzo(a,h)anthracene	5	No	No	No	No
Indeno(1,2,3-c,d)pyrene	5	No	No	No	No
Dissolved oxygen	5	No	Yes	Yes	Yes
Mercury	5	No	No	No	No
PCBs*	5	No	No	No	No
pH	5	No	No	No	No
Temperature	5	No	Yes	Yes	Yes
Temperature	4A	No	No	No	No
Bacteria – Escherichia coli	2	No	No	No	No
Bacteria – Fecal coliform	2	Yes	No	No	No
Benzo(a)anthracene	2	Yes	No	No	No
Benzo(a)pyrene	2	Yes	No	No	No
Benzo(b)flouranthene	2	Yes	No	No	No
Bis(2-ethylhexyl)phthalate	2	No	No	No	No
Copper	2	No	No	Yes	No
Dissolved oxygen	2	No	No	No	No
Mercury	2	No	No	No	No
Polychlorinated biphenyls	2	Yes	No	No	No
pH	2	No	No	Yes	Yes
Phosphorus	2	No	Yes	No	No
1,2-Dichlorobenzene	1	No	No	No	No
1,3-Dichlorobenzene	1	No	No	No	No
1,4-Dichlorobenzene	1	No	No	No	No
3,3-Dichlorobenzidine	1	No	No	No	No
2,4-Dichlorophenol	1	No	No	No	No

Water Quality Parameter	Category	Puget Sound	Des Moines Creek	Miller Creek	Walker Creek
2,4-Dinitrophenol	1	No	No	No	No
2,4-Dinitrotoluene	1	No	No	No	No
1,2-Diphenylhydrazine	1	No	No	No	No
2,4,6-Trichlorophenol	1	No	No	No	No
Anthracene	1	No	No	No	No
Antimony	1	No	No	No	No
Arsenic	1	No	No	No	No
Ammonia-N	1	No	Yes	Yes	Yes
Bis(2-chloroethyl) ether	1	No	No	No	No
Bis(2-chloroisopropyl) ether	1	No	No	No	No
Chlordane	1	No	No	No	No
Chloride	1	No	No	No	No
Di-n-butyl phthalate	1	No	No	No	No
Diethyl phthalate	1	No	No	No	No
Dimethyl phthalate	1	No	No	No	No
Fluoranthene	1	No	No	No	No
Fluorene	1	No	No	No	No
Hexachlororobutadiene	1	No	No	No	No
Hexachlororobenzene	1	No	No	No	No
Hexachlororocyclopentadiene	1	No	No	No	No
Hexachlororocyclohexane (Lindane)	1	No	No	No	No
Isophorone	1	No	No	No	No
Hexachloroethane	1	No	No	No	No
Mercury	1	No	No	No	No
N-Nitrosodiphenylamine	1	No	No	No	No
Nickel	1	No	No	No	No
Nitrobenzene	1	No	No	No	No
Pentachlorophenol	1	No	No	No	No
Phenol	1	No	No	No	No
PCBs*	1	No	No	No	No
pH	1	No	No	No	No
Pyrene	1	No	No	No	No
Selenium	1	No	No	No	No
Thalium	1	No	No	No	No
Zinc	1	No	Yes	Yes	No

Category 5 = polluted waters that require a water improvement project
Category 4 = Impaired waters with a USEPA-approved total Maximum Daily Load attainment plan in place
Category 2 = waters of concern
Category 1 = waters that meet tested water quality standards

4.4 ESA-listed Species and Critical Habitat Occurrence in Action Area

The ESA-listed species covered in this BE that could occur within the action area are Chinook salmon, steelhead, bull trout, yelloweye rockfish, bocaccio rockfish, and SRKW. Species status and presence of designated critical habitat in the action area are identified in Table 15. Effects to designated critical habitat physical and biological features (PBFs) are also analyzed in this BE. This BE uses the preferred term PBFs, per 81 FR 7414, which replaces the older term, Primary Constituent Elements (PCEs). The older Federal Register documents identifying critical habitat use the term PCEs. See Appendix D for additional information about species' life histories.

Table 15. ESA-listed species and critical habitat in the action area

Species	Lead Agency	Federal Status	Critical Habitat in Action Area
Chinook salmon (Puget Sound ESU)	NMFS	Threatened	Yes
Steelhead (Puget Sound DPS)	NMFS	Threatened	No
Bull trout (Coastal-Puget Sound DPS)	USFWS	Threatened	Yes
Bocaccio rockfish (Puget Sound/Georgia Basin DPS)	NMFS	Endangered	Yes
Yelloweye rockfish (Puget Sound/Georgia Basin DPS)	NMFS	Threatened	Yes
Killer whale (Southern Resident DPS)	NMFS	Endangered	Yes

4.4.1 Puget Sound Chinook Salmon

4.4.1.1 Federal Status

Puget Sound Chinook salmon were listed as a threatened species on June 28, 2005, and updated on April 14, 2014 (70 FR 37160). A recovery plan is in place for Puget Sound Chinook (SSPS 2007; NMFS 2007). The recovery plan adopts ESU and population-level viability criteria recommended by the Puget Sound Technical Recovery Team (Ruckelshaus et al. 2002).

4.4.1.2 Occurrence

The Puget Sound ESU consists of 22 extant populations. Several Chinook salmon populations could occur in the aquatic component of the action area, specifically the mixing zones for stormwater and industrial wastewater discharge to Puget Sound. WDFW (2024d) identifies Miller Creek, Walker Creek, and Des Moines Creek as potentially suitable habitat based on gradient, but the species is not currently documented in these systems. Chinook salmon are most likely to occur in the marine portion of the action area, specifically in offshore waters of Puget Sound around the IWTP outfall as pre-spawn migratory adults and in offshore and nearshore habitats as outmigrant juveniles. Adults are most likely to be returning migrants from the Puyallup River, White River, Nisqually River, and Green River populations (NMFS 2007; 2017a). Juveniles are also most likely to be members of these populations. However, juvenile Chinook range widely throughout Puget Sound and individuals occurring in the action area could come from any population in the ESU (Hayes et al. 2019).

Juvenile Chinook salmon rely on estuarine and nearshore habitats of Puget Sound for rearing and to make their transition from fresh to saltwater conditions (smoltification) before migrating out to the open ocean. They use these habitats for migration, foraging, refuge, and the osmoregulatory transition to salt water (City of Seattle 2015). Juveniles rely on shallow nearshore habitats such as eelgrass beds, intertidal flats

or marshes, and subtidal channels. The Puget Sound portion of the action area comprises intertidal and subtidal flats with some patchy eelgrass, indicating that the area has limited suitable habitat for and may be used by juvenile Chinook salmon on occasion. The frequency and time in this area is limited by the patchy beds of eelgrass (*Zostera marina*) and armoring of virtually the entire shoreline adjacent to the action area (Ecology 2023).

The Chinook populations likely to occur in the action area are at abundance levels well below recovery objectives (GSRO 2022). According to the 2016 5-year review of the status of the Puget Sound Chinook salmon ESU, the most recent available, all Puget Sound Chinook populations are below the planning ranges identified for recovery. There is concern that recovery to a naturally sustaining harvestable population is hindered by habitat factors as well as competition for habitat and food sources between naturally spawning fish and hatchery fish. Population trends vary depending on whether hatchery fish are combined or analyzed separately from natural-origin fish on the river system. NMFS has identified the effect of hatchery strays on wild Chinook salmon production in river systems such as the Green/Duwamish as a key concern leading to the listing of Chinook salmon (West Coast Salmon Biological Review 2003).

4.4.1.3 *Critical Habitat*

Critical habitat for Puget Sound Chinook salmon was designated on September 2, 2005 (70 FR 52630). The freshwater habitats in Miller Creek, Walker Creek and Des Moines Creek are not mapped as designated critical habitat (NOAA 2024). The mouths of these systems into Puget Sound contain estuarine and nearshore marine areas designated as critical habitat. Puget Sound contains both nearshore and offshore marine areas designated as critical habitat.

The PBFs relevant to the action area are as follows:

(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, and side channels; and

iii. Juvenile and adult forages support 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.

(6) Offshore marine areas with water quality conditions and forage supporting growth and maturation.

4.4.2 Puget Sound Steelhead

4.4.2.1 *Federal Status*

Puget Sound steelhead trout were listed as a threatened species in 2007, and the listing was updated on April 14, 2014 (72 FR 26722). A recovery plan is in place for Puget Sound steelhead, produced through a wide collaboration by the Puget Sound Steelhead Recovery Team (NMFS 2019).

4.4.2.2 *Occurrence*

In Washington, steelhead are present in most coastal streams, the lower Columbia River, and in all the larger drainages of the Salish Sea (Pietsch and Orr 2015). Steelhead spend the first 1 to 2 years of life rearing in freshwater rivers before out-migrating to the ocean. Steelhead then spend about 1 to 2 years at sea before returning to their freshwater streams of origin to spawn. A small percentage of adults, predominantly females, are repeat spawners. These individuals, referred to as kelts, migrate to the ocean to feed and recover and return to freshwater to spawn again the following year.

Steelhead are most likely to occur in the marine portion of the action area, specifically the offshore waters of Puget Sound around the IWTP outfall, as pre-spawn migratory adults and outmigrant juveniles. There are currently 10 extant stocks of ESA-listed winter run steelhead that are likely to occur within this marine migratory corridor, three originating from the Puyallup/ White River system, one from the Nisqually, and five from independent tributaries to the South Puget Sound Basin (Scott and Gill 2008), all of which are part of the Puget Sound DPS (NMFS 2019). Outmigrant juveniles typically migrate rapidly through the offshore waters of Puget Sound, moving from natal rivers to the open ocean within days to weeks (Berejikian 2016; Moore et al. 2015; Moore and Berejikian 2017) and do not make extensive use of the nearshore habitat (Puget Sound Partnership and WDFW 2011).

According to NMFS 5-year review of the Puget Sound steelhead DPS, risks have not changed since the species' listing in 2007 and the DPS is at very low viability. Scott and Gill (2008) considered Puyallup/White and Nisqually winter-run steelhead populations to be at moderate/high risk of extinction by 2100 based on abundance trends through 2005, but abundance of each component stock has increased since 2005. The current abundance of all stocks potentially occurring in the action area remain well below recovery goals (NWFSC 2015; NMFS 2017a, 2019). Insufficient information is available to evaluate the status of south Puget Sound and east Kitsap stocks.

4.4.2.3 *Critical Habitat*

Critical habitat for 12 ESUs of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho was designated on September 2, 2005 (70 FR 52630). The freshwater habitats in Miller Creek, Walker Creek and Des Moines Creek are not included in Puget Sound steelhead critical habitat (NOAA 2024). Critical habitat for Puget Sound steelhead does not include marine habitats. Therefore, no designated critical habitat for Puget Sound steelhead is present in the action area.

4.4.3 Coastal-Puget Sound Bull Trout

4.4.3.1 *Federal Status*

Bull trout were listed as threatened species on November 1, 1999 (64 FR 58910). The listing applies to all bull trout in the coterminous United States, including the Coastal-Puget Sound DPS. A recovery plan is in place (USFWS 2015).

4.4.3.2 *Occurrence*

Most bull trout reside their entire lives in streams, large rivers, and lakes, but the Coastal-Puget Sound DPS is amphidromous, meaning that the species flexibly uses freshwater, estuarine, and nearshore marine waters at various points during its life cycle. Bull trout from Puget Sound rivers are known to migrate and forage in nearshore waters, using the nearshore zone as a migratory corridor between seasonal habitats in natal and non-natal watersheds (Goetz et al. 2004, 2021). These foraging, migrating, and overwintering

(FMO) habitats are crucial to the conservation of the species. Bull trout have more specific habitat requirements than other salmonids. Specifically, they require a narrower range of colder water temperatures for spawning and rearing, and they are more sensitive to passage barriers and fine sediment in spawning substrates.

Puget Sound bull trout populations spend a significant portion of their lifecycle in salt water, moving back and forth between mouths of rivers and streams (Pietsch and Orr 2015). Marine FMO habitat includes portions of Puget Sound, particularly the highly productive nearshore and estuarine areas that provide complex habitat structure and abundant prey, which is not present in the action area. Important prey species include juvenile salmonids, sandlances (*Ammodytes hexapterus*), surf smelts (*Hypomesus pretiosus*), Pacific herring (*Clupea pallasi*), and shiner perch (*Cymatogaster aggregata*).

The final bull trout recovery plan identifies the Puget Sound nearshore zone as FMO habitat (USFWS 2015) for the Skagit, Stillaguamish, Snohomish-Skykomish, and Puyallup River core areas. The action area lies between the Stillaguamish and Snohomish-Skykomish core areas to the north and the Puyallup River core area to the south, the latter being closest based on marine migration distance. Based on observed amphidromous behavior (Goetz et al. 2004, 2021), the nearshore zone of Puget Sound within the action area is well within the maximum migratory range of bull trout from each of these core areas. However, based on observed mean migration ranges reported by Goetz et al. (2021), most bull trout that occur in the action area are likely to originate from the Puyallup River.

Current Coastal-Puget Sound bull trout distribution is like probable historical distribution, but the abundance of contributing subpopulations has decreased over approximately 50 percent of their range (USFWS 2004). Bull trout in the Puget Sound region are stable overall, with the population neither increasing nor decreasing (USFWS 2015). Bull trout may occur in action area as adults or subadults foraging in or migrating through nearshore habitats, though the presence is likely limited by the limited habitat structure and armoring of virtually the entire shoreline adjacent to the action area (Ecology 2023). As stated, bull trout could occur in the action area at any time but are most likely to be present from March through July (Goetz et al. 2021). Bull trout is least likely to occur in the action area from October through February.

4.4.3.3 ***Critical Habitat***

Critical habitat for bull trout was designated on October 26, 2005, and then revised on October 18, 2010 (75 FR 63898). Critical habitat comprises the following primary habitat types:

- Spawning and rearing
- FMO (marine nearshore areas used by bull trout for foraging and migration)

The revised critical habitat designation comprises 32 critical habitat units and support PBFs required for spawning, rearing, and FMO between suitable habitats. The Puget Sound critical habitat unit contains 1,144 miles of streams and 443 miles of marine shoreline, as well as lake areas.

The aquatic component of the action area overlaps the Marine Critical Habitat Subunit of Critical Habitat Unit 2: Puget Sound. Unit 2 includes the marine and tidally influenced estuarine shorelines of Puget Sound and contributing river systems from the mean higher high water (MHHW) line to the depth of 10 meters (33 feet) relative to the MLLW line.

The PBFs relevant to the action area (Puget Sound) are as follows (75 FR 63898):

(2) Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

(3) An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

(4) Complex river, stream, lake, reservoir, and marine shoreline aquatic environments and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.

(5) Water temperatures ranging from 2 to 15 °C (36 to 59 °F), with adequate refugia available for temperatures at the upper end of the range.

(8) Sufficient water quality and quantity to support normal reproduction, growth, and survival.

4.4.4 Puget Sound/Georgia Basin Boccacio Rockfish

4.4.4.1 *Federal Status*

Puget Sound/Georgia Basin bocaccio rockfish (bocaccio) were listed as an endangered species in 2010 (75 FR 22276). A recovery plan is in place for Puget Sound/Georgia Basin bocaccio and yelloweye rockfish (NMFS 2017b).

4.4.4.2 *Occurrence*

Bocaccio is a deep-water species of rockfish typically found along steep slopes of sand or rock substrates. They prefer high relief boulder fields and rocks and may school with other rockfish species. They may occasionally wander onto mudflats or be found well off the bottom substrate (Love et al. 2002). Adults are found in waters ranging from 12 to 478 meters (39 to 1,568 feet) deep but are most frequently found at depths ranging from 50 to 250 meters (164 to 820 feet).

Larvae and pelagic juveniles are found near the surface; juveniles prefer shallow, algae-covered rocks or eelgrass, or may shelter under kelp mats (Love et al. 2002; USACE 2012). The juveniles move to deeper waters within 3 to 3.5 months (Love et al. 2002). Larvae of bocaccio can be widely dispersed by surface currents. Offshore of Washington and Oregon, larval release begins in January and may run through April (Drake et al. 2010); little is known of the timing of breeding within Puget Sound.

The bocaccio was once common on steep walls throughout Puget Sound, but this species is now much rarer (Love et al. 2002). Drake et al. (2010) report that in the Puget Sound most bocaccio occur in the southern sound and are rare north of Tacoma. Adult and juvenile bocaccio could potentially occur in the Puget Sound portion of the action area, particularly in the mixing zone of the industrial wastewater outfall in Puget Sound but may be limited due to by the patchy beds of eelgrass (*Zostera marina*) and armoring of virtually the entire shoreline adjacent to the action area (Ecology 2023). Bocaccio eggs and larvae are likely to occur in nearshore marine habitats as well as this mixing zone.

Bocaccio populations have declined severely throughout their range. In Puget Sound, stocks appear to have declined based on the frequency of recreational catches between the 1970s and 1990s and were not identified in dockside surveys of several thousand rockfish caught between 1996 and 2007. This suggests a strong decline in bocaccio in these inland waters (Drake et al. 2010, NMFS 2017b).

4.4.4.3 *Critical Habitat*

The NMFS designated critical habitat for bocaccio and yelloweye rockfish within Puget Sound/Georgia Basin in 2014 (79 FR 68041). This habitat is segmented into nearshore and deepwater rockfish critical habitat (79 FR 68041). Essential habitat features associated with rockfish are separated by life stage (NMFS 2013). The aquatic component of the action area overlaps bocaccio nearshore critical habitat for larval and juvenile bocaccio at the mouths of the Miller, Walker, and Des Moines Creeks, and deepwater critical habitat at the mixing zone of the industrial wastewater outfall.

Critical habitat attributes useful for analyzing project impacts in Section 7 consultations comprise the following (79 FR 68041):

1) Quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities; and
2) Water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities.

4.4.5 Puget Sound/Georgia Basin Yelloweye Rockfish

4.4.5.1 *Federal Status*

Yelloweye rockfish were listed as a threatened species in 2010 (75 FR 22276). A recovery plan is in place for Puget Sound/Georgia Basin bocaccio and yelloweye rockfish (NMFS 2017b).

4.4.5.2 *Occurrence*

Yelloweye rockfish is a deep-water species associated with rocky reefs, kelp canopies, artificial structures, and rocky bottoms, often near steep slopes (Palsson et al. 2009). This species occurs in deeper waters ranging from 80 to 1,560 feet but is most common between 300 and 590 feet. Juveniles and subadults prefer shallower waters, while the adults tend to use deeper waters. Subadults and adults tend to be solitary and prefer staying close to the substrate in rocky areas with high relief and shelter such as overhangs, caves, or boulder piles (Love et al. 2002). Yelloweye rockfish eat a variety of prey, including smaller fish, shrimps, and crabs. Larval release occurs primarily in March to July off British Columbia (Love et al. 2002). Little is known about this species' breeding timing within Puget Sound but may occur in early spring to late summer in the Sound.

Of the two listed species, yelloweye rockfish appear to be more abundant with the widest distribution. Pietsch and Orr (2015) records indicate a range from the south end of Saratoga Passage to Golden Gardens and Elliott Bay, with additional isolated records elsewhere in Puget Sound. Juvenile yelloweye rockfish are not typically found in intertidal waters (Love et al. 1991; Studebaker et al. 2009, NMFS 2017b). Juvenile and larval yelloweye could potentially occur in the Puget Sound portion of the action area, particularly in the mixing zone of the industrial wastewater outfall.

The yelloweye rockfish is slowly recovering from a significant decrease in abundance across its range. This species is rare to uncommon in Puget Sound, and harvested numbers have historically been too small to discern population status and trends (Drake et al. 2010; NMFS 2016).

4.4.5.3 *Critical Habitat*

The NMFS designated critical habitat for yelloweye rockfish within Puget Sound/Georgia Basin in 2014 (79 FR 68041). There is no nearshore critical habitat for yelloweye rockfish (79 FR 68041). Essential habitat

features associated with rockfish are separated by life stage (NMFS 2013). The aquatic component of the action area overlaps yelloweye rockfish deepwater critical habitat at the mixing zone of the industrial wastewater outfall in Puget Sound.

Critical habitat attributes useful for analyzing project impacts in Section 7 consultations comprise the following (79 FR 68041):

1) Quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities; and

2) Water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities.

4.4.6 Southern Resident Killer Whale

4.4.6.1 *Federal Status*

SRKW was listed as endangered on November 18, 2005 (70 FR 57565) and updated on April 14, 2014.

4.4.6.2 *Occurrence*

The SRKW comprises three distinct pods (J, K, and L), totaling 74 individuals (MMC 2024). The three pods are regularly present in the inland waters of Puget Sound, inland waters of southern British Columbia, and the Strait of Juan de Fuca from April through September. During much of this time, they tend to be concentrated around the San Juan Islands. SRKW pods tend to move farther south within Puget Sound in the fall, likely following runs of Chinook and chum salmon. May and June are the months with the fewest sightings in the central Puget Sound region.

These family groups are highly mobile and can travel over 80 miles (160 km) in a single day. From 2020 to 2022, there were 277 SRKW observations submitted to the whale museum in the east passage of Puget Sound from Elliot Bay south the Des Moines, Washington (Whale Museum 2023). Of these, the 43 records identified as SRKW occurred on 28 unique days in the months of July, September, October, November, December, and January.

SRKW have not been recorded within the freshwater portion of the action area and are not expected to enter freshwater. SRKW would likely pass through in the mixing zone of the industrial wastewater outfall discharging into Puget Sound. In addition, SRKWs may be affected via trophic link, as any impacts to Chinook salmon would affect prey availability for SRKWs.

The SRKW population is relatively stagnant at just 0.1 percent rate of increase in size per year, well below the target 2.3 percent increase needed for the species to be delisted (Wiles 2016). From 1995 to 2005, J pod grew, K pod stayed largely the same, and L pod decreased. Reproduction can be heavily affected by prey availability. Wasser et al. (2017) observed that low availability of Chinook salmon was a substantial cause of late pregnancy failure. If Chinook salmon abundance remains constant or increases, J pod has the potential to double in size in the next 25 years (Wiles 2016).

A final recovery plan (NMFS 2008) stated that reduced prey availability and quality, high levels of contaminants, and disturbance from both vessels and sound were among the factors limiting the recovery of the species. NMFS (2011) has informed affected constituents about the importance of Chinook salmon to the diet of SRKWs and the potentially serious implications of the salmon fisheries and other activities affecting Chinook salmon on the survival and recovery of these whales. Mongillo et al. (2016) determined

that the bioaccumulation of toxic and physiologically damaging chemicals through consumption of contaminated prey poses a significant ongoing risk to species recovery.

4.4.6.3 *Critical Habitat*

Critical habitat was originally designated on November 29, 2006 (71 FR 69054) and revised on August 29, 2021, to include coastal marine waters of Washington, Oregon, and California (86 FR 41668). The revised designation includes the following three specific areas in the inland marine waters of Washington State:

- The Summer Core Area in Haro Strait and waters around the San Juan Islands
- The Puget Sound Area
- The Strait of Juan de Fuca Area

Critical habitat for the SRKW includes all marine waters in the Puget Sound area waterward of 20 feet (6.1 meters) below extreme high water (86 FR 41668). The action area overlaps this critical habitat at one location: in the mixing zone of the industrial wastewater outfall discharge in Puget Sound.

PBFs associated with the SRKW are as follows:

- Water quality to support growth and development.
- Prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth.
- Passage conditions to allow for migration, resting, and foraging.

5.0 ANALYSIS OF EFFECTS

Effects of the action are 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 (i.e., interrelated, and interdependent activities). 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 based on clear and substantial information, using the best scientific and commercial data available. In other words, potential or speculative consequences or worst-case scenarios or pessimistic assumptions are not considered a consequence of the action. As noted in the Maine Lobsterman's Association v. National Marine Fisheries Service decision (No. 22-5238 D.C. Cir. 2023), "nothing in Section 7 requires distorting the decision-making process by overemphasizing highly speculative harms whenever data is wanting."

Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (i.e., indirect effects, also referred to as delayed consequences). Examples of delayed consequences are as follows:

- Changes to ecological systems resulting in altered predator/prey relationships.
- Changes to ecological systems resulting in long-term habitat alteration.
- Anticipated changes in human activities, including changes in land use.

Effects are generally categorized as being insignificant, discountable, beneficial, or adverse. Insignificant effects relate to the size of the impact (and should never reach the scale where take occurs), while discountable effects are those that are extremely unlikely to occur. Based on best judgment, one would not be able to meaningfully measure, detect, or evaluate insignificant effects or expect discountable effects to occur. Beneficial effects are those effects of an action that are wholly positive, without any adverse effects, on a listed species or designated critical habitat.

Adverse effects are those that are not discountable or insignificant and are expected to result in take of species or designated critical habitat. "Take," as defined by the ESA, includes such activities that harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct (ESA Section 3[19]). "Harm" is defined to include substantial habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering. "Harass" is further defined as actions that create the likelihood of injury to listed species to such an extent as to substantially disrupt normal behavior patterns that include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3). Adverse effects to designated critical habitat may include significant habitat modification or degradation where it kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. In general, take is assumed when harm or harassment to a species or designated critical habitat is demonstrated. The effects of exposure range in severity from chronic sub-lethal effects to immediate lethality, depending on the type of pollutant or pollutants, exposure mechanisms (i.e., direct or dietary), and concentration, duration, and frequency of exposure (Brette et al. 2014; Feist et al. 2011; Gobel et al. 2007; Incardona et al. 2004, 2005; McIntyre et al. 2012; Meador et al. 2006; Sandahl et al. 2007; Spromberg et al. 2016). Repeated exposure to certain pollutants, even at sublethal concentrations, can lead to prolonged adverse effects on survival and fitness (Feist et al. 2011; Spromberg and Meador 2006; Spromberg and Scholz 2011).

5.1 Direct Effects

Direct effects are defined as direct or immediate effects of the Proposed Action on the species or its habitat. Potential direct effects of the Proposed Action include short-term construction impacts and long-term permanent effects from operation of the Proposed Action.

5.1.1 Noise

Construction-related noise is a function of the types of equipment being used, distance to receptors, and duration of construction activities. Background or ambient sound levels can vary greatly depending on site-specific factors. Ambient sound levels can effectively mask construction noise. While most of the NTPs are located near SEA operation areas with high ambient noise levels, a few of the NTPs are located on the perimeter, such as at the north end of SEA, where background sound levels are more consistent with populated urban areas. The construction noise analysis concluded that most NTPs are in areas with an ambient sound level of 76.5 dBA, while the five NTPs located north of SR 518 (C02, C03, L05, L07, and S10) are in areas with ambient sound levels of 66 dBA (Landrum & Brown 2024). Noise from construction equipment may at times exceed ambient noise levels and be noticeable to nearby receivers for the five NTPs located north of SR 518. These increases in noise would be short-term, temporary increases only occurring during active construction. As described in Section 1.4, no potential suitable habitat for ESA-listed terrestrial species is located within miles of the action area. The Proposed Action does not include any activities that are likely to result in elevated in-air noise levels in potential terrestrial habitat for ESA-listed species during construction or long-term operations. Therefore, in-air noise effects are not considered further in this BE.

The Proposed Action does not include any activities that are likely to result in elevated in-water noise levels during construction or long-term operations. In addition, all in-water construction activities would take place at locations that are not accessible to ESA-listed species. Therefore, underwater noise effects are not considered further in this BE.

5.1.2 Habitat Modification

Construction would occur primarily in paved and developed areas of SEA property where no or limited landscape vegetation exists. Vegetation and tree removal would occur for five projects north of SR 518, in areas that were previously cleared and are currently comprised of trees, low shrubs, maintained and unmaintained fields, and paved residential roads. Construction of S07 would require clearing and regrading of approximately 18.6 acres of maintained grass, shrubs, and deciduous and coniferous trees typical of unmanaged urban green spaces. S07 also includes improvements to an existing culvert crossing that would impact streams (0.01 acre) and stream buffers (0.05 acre).

Construction activities within wetland and wetland buffers include a total of approximately 0.58 acre of wetland impacts and 2.65 acres of wetland buffer impacts. Compensatory mitigation is proposed for all wetland and wetland buffer impacts. As shown on Table 9, the Proposed Action would include 2.65 acres of mitigation for wetland buffer impacts and at least 1.17 acres and potentially up to 4.68 acres of compensatory mitigation for wetland impacts, depending on the type of mitigation provided.

5.1.2.1 *Effects of Habitat Modification on Listed Species*

Proposed wetland impacts would occur in habitats upstream of Miller Creek and Des Moines Creek, where no ESA-listed species occur and more than 2 miles upstream of where the potential presence of ESA-listed species is documented. There are no measurable potential impacts to ESA-listed species associated with wetland and wetland buffer impacts under the Proposed Action.

5.1.2.2 *Effects of Habitat Modification Critical Habitat*

Designated critical habitat is not present in the portion of the action area where impacts to wetlands and stream habitats would occur, nor in downstream habitats in Des Moines Creek, Walker Creek, and Miller Creek where temporary construction-related effects on water quality could occur. Proposed in-water work is limited to wetland fill, buffer impacts, stormwater pond development, and culvert improvements in headwater areas at least 2 miles upstream of Puget Sound. Construction BMPs would ensure that no delivery of suspended sediments and associated contaminants to designated critical habitat in nearshore areas of Puget Sound would occur. Therefore, habitat modifications resulting from the Proposed Action would have no measurable effects on designated critical habitat.

5.1.3 Stormwater

The Proposed Action includes construction of new, replaced, and retrofitted PGIS. As noted in Section 2.4.2, stormwater runoff on SEA property is collected in existing stormwater treatment systems. All stormwater and wastewater from new, replaced, and retrofitted PGIS that drains to the SDS would discharge through existing and proposed SEA stormwater outfalls to Miller Creek, Walker Creek, and Des Moines Creek. This drainage area represents about 7 percent of Miller Creek's and about 21 percent of Des Moines Creek's watersheds. The IWS discharges via the IWTP outfall to Puget Sound. Miller Creek and Des Moines Creek flow directly into Puget Sound, while Walker Creek flows into Miller Creek immediately upstream of its confluence with Puget Sound.

The Port's SDS and IWS comprise a combination of robust structural controls and OSC BMPs designed to intercept pollutants before they enter stormwater runoff and provide treatment to reduce contaminant concentrations to the greatest extent practicable. For example, current OSCs include dry sweeping of PGIS, runway rubber removal, and regular maintenance of vaults, detention basins, and filtration systems. These operational BMPs are consistent with Ecology (2022) recommendations for limiting contamination of surface waters by 6PPD-Q and other emerging contaminants of concern.

The Proposed Action includes improvements to existing and construction of new structural source controls and expansion of OSCs to all new impervious surfaces and PGIS. In combination, these measures are likely to be highly effective at minimizing adverse effects to listed species from stormwater and wastewater pollutants. SEA's SDS and IWS systems represent the currently practicable state-of-the-art treatment options that are fully compliant with state and federal regulations. These regulations protect beneficial uses, including for aquatic life. In addition, SEA implements numerous initiatives, such as low impact development techniques to avoid/reduce stormwater runoff, conservation of potable water through rainwater capture and reuse, ongoing habitat protection and restoration programs, and invasive weed and debris removal. It is important to note that the difference between the Proposed Action and No Action is negligible. Therefore, the Proposed Action is expected to result in insignificant effects to threatened and endangered species in the action area.

5.1.3.1 ***NPDES Related Testing***

Under the NPDES permit, SEA is required to conduct *in-situ* toxicity testing biannually and acute and sublethal testing the year prior to permit renewal. Acute toxicity tests are performed on stormwater samples collected from stormwater outfalls. Sublethal toxicity tests are performed on ambient receiving water samples collected downstream of stormwater outfalls. Finally, *in-situ* testing is conducted using a watershed approach.

Acute toxicity tests measure mortality as the significant response to the toxicity of the effluent from seven representative outfalls discharging stormwater from SEA (SDS3/5, SDD06A, SDE4/S1, SDN1, SDN2/3/4, SDW1B, and SDW2). Acute testing is required once during the last winter and last summer prior to the submittal of the NPDES permit renewal application. Acute toxicity testing procedures follow guidelines provided by the USEPA (2002). The last acute toxicity test was completed in 2020. Survival in the 100 percent undiluted samples, and in both the unadjusted and hardness-adjusted samples, was equal to or greater than 90 percent for both species (Daphnia pulex and fathead minnows), indicating that no acute toxicity was demonstrated by any of the samples (Nautilus 2020).

Sublethal testing under the NPDES is part of the Whole Effluent Toxicity (WET) testing. WET tests measure the aggregate toxic effect of an effluent (wastewater discharge) on aquatic organisms and are crucial for ensuring that water quality standards are met, and aquatic life is protected. Sublethal toxicity testing is required once during the last winter and last summer prior to the submittal of the NPDES permit renewal application. Stormwater outfalls at SEA discharge into five local receiving waters identified in the NPDES permit (Miller Creek, Des Moines Creek, Walker Creek, Northwest Ponds, and Lake Reba). Samples from six representative sites were tested for sublethal toxicity using the 7-day rainbow trout embryo test (Environment Canada 1998; modifications from Canaria et al 1999). Receiving water samples consistently showed no evidence of sublethal toxicity in the tests conducted from 2019 to 2020 (Nautilus 2020).

In addition, the NPDES permit requires rainbow trout (RBT) early life stages (ELS) *in situ* monitoring tests be conducted biannually in the fall and spring (Appendix E). The objective of the testing is to use salmonid ELS as an *in-situ* monitoring tool to assess the quality of receiving waters potentially affected by stormwater discharges from SEA, as well as a multitude of the other discharges from the surrounding urban environment. Results from the *in-situ* bioassays and supporting analytical data are intended to provide an indication of attainment of receiving water quality standards and associated beneficial uses related to salmonid spawning and rearing. The program was initiated in Fall 2010.

The exposure sites include Miller Creek, Des Moines Creek Downstream, and Des Moines Creek Upstream, with Walker Creek being added to the study beginning in Spring 2016. Monitoring points are generally located downstream of SEA inputs. However, one site is located upstream of SEA stormwater outfalls to monitor potential impacts originating upstream of SEA (Des Moines Creek basin upstream of SEA is heavily urbanized). Results are compared to a laboratory control conducted concurrently with the *in-situ* tests.

All test data were entered in CETIS (Comprehensive Environmental Toxicity Information System, Tidepool Scientific, McKinleyville, CA). Differences among the exposure sites and laboratory controls were evaluated using pair-wise multiple comparison tests according to the USEPA flow chart (USEPA 2002); significant differences were identified at $p \leq 0.05$.

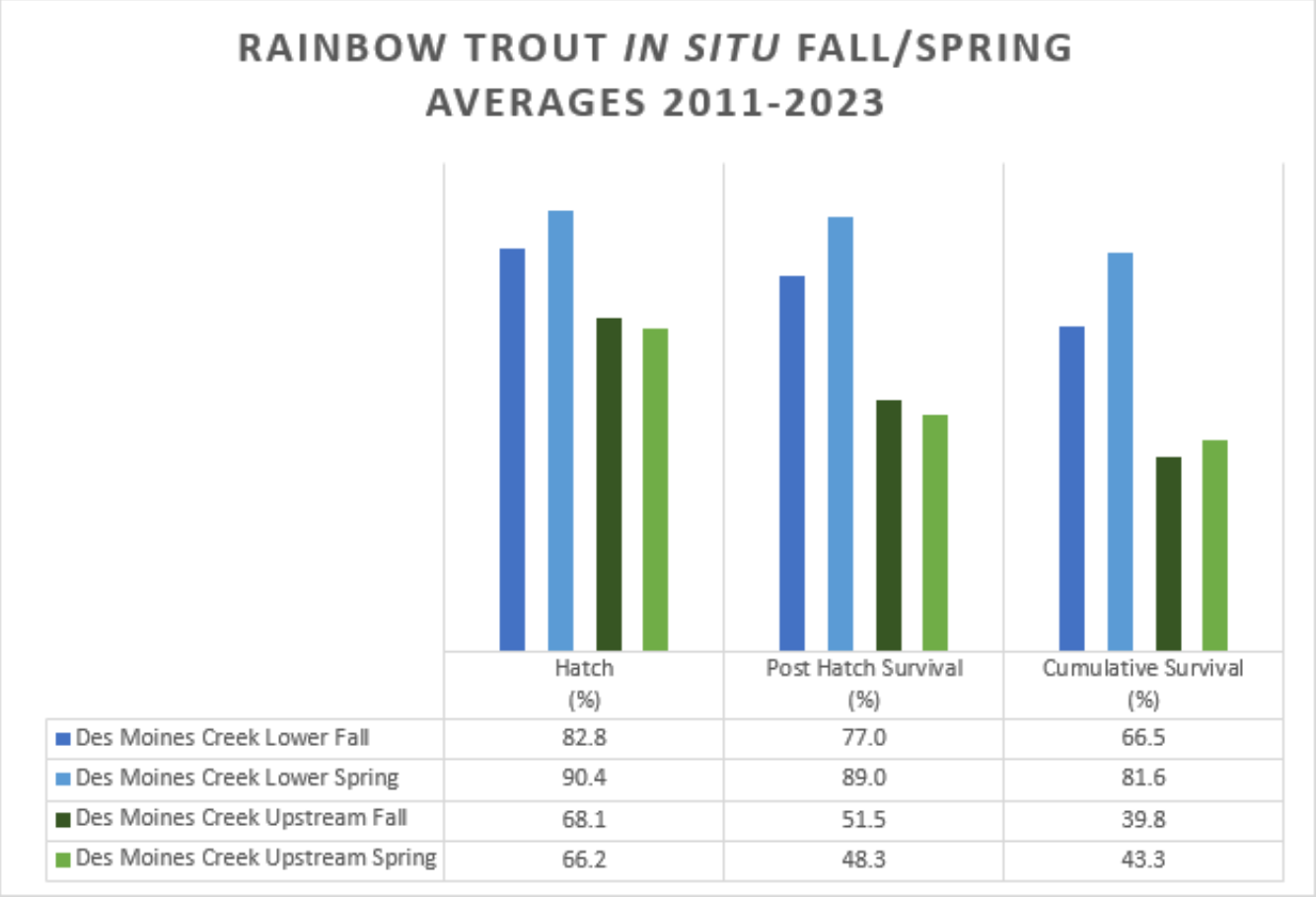
One interim and five terminal endpoints were evaluated:

1. Hatching success – an interim measure of the percentage of embryos hatched the day of the hatch inspection, or determined to have hatched based on the number of alevins present at the subsequent inspection, relative to the total number of embryos originally added.
2. Post-hatch survival - the percentage of organisms surviving at test termination relative to the number of embryos that hatched (these data help determine whether most mortalities occurred pre- or post-hatch or were distributed throughout the exposure period).
3. Cumulative survival - the percentage of surviving organisms at test termination relative to the number of embryos in each replicate at the beginning of the exposure.
4. Abnormality – the percentage of abnormal organisms at test termination relative to the number of surviving organisms.
5. Length – to the nearest 0.5 mm.
6. Weight – to the nearest 0.001 g.

The use of an upstream site demonstrates the quality of water prior to SEA discharge and the impact SEA discharge has on the water quality. Apart from Spring 2015, Spring 2018, and Spring 2020 testing events, Des Moines Creek Upstream has exhibited lower quality and reduced hatching/survival results since the testing program began in 2010. Typically, the Des Moines Creek Downstream location, which includes SEA discharges, shows better results than the upstream location. The addition of SEA's treated stormwater appears to dilute the contaminated water, thereby improving the water quality and improving hatching/survival rates (Chart 1).

Overall, the results of the acute, sublethal, and *in-situ* toxicity testing suggest that the Port has been largely successful in the design and implementation of their stormwater management program. There is no evidence of acute toxicity associated with the outfalls discharging stormwater runoffs and no toxicity in the sublethal tests performed on receiving water samples. In contrast, the result of the in-situ tests suggests the intermittent presence of impaired water quality, particularly in the Des Moines Creek basin upstream of SEA.

Chart 1. In-situ Toxicity Testing Results



	Hatch (%)	Post Hatch Survival (%)	Cumulative Survival (%)
Des Moines Creek Lower Fall	82.8	77.0	66.5
Des Moines Creek Lower Spring	90.4	89.0	81.6
Des Moines Creek Upstream Fall	68.1	51.5	39.8
Des Moines Creek Upstream Spring	66.2	48.3	43.3

5.1.3.2 *Effects of Stormwater on Listed Species*

Current treatment technologies can reliably reduce the concentration of known, commonly occurring stormwater contaminants like PAHs and metals. However, the regulated priority pollutants represent a fraction of the potentially thousands of chemical compounds found in stormwater and industrial wastewater. Some of these compounds are emerging contaminants of concern, for which the effectiveness of currently available treatment methods is not fully understood. It is unknown if treatment effectively removes non-regulated pollutants because neither testing methods nor thresholds have been established. In addition, there is insufficient information available to quantify potential biologically significant effects on listed species from exposure to chronic surface water pollutants generated by the Proposed Action. The *in-situ* toxicity testing is the only site-specific data available, and it supports the determination that the SDS and IWS are effective at treating stormwater and that any potential effects could not be meaningfully measured or evaluated.

The Proposed Action would result in construction of new, replaced, and retrofitted PGIS and associated stormwater and wastewater discharges (Table 3). All stormwater generated by the Proposed Action would meet current Ecology (2019, 2021) stormwater detention and water quality requirements before being released into area streams. As described in Section 2.4.2, existing SEA stormwater facilities collect and detain stormwater for treatment. Flow control would be provided for PGIS surfaces added by the Proposed Action. As such, project-related stormwater discharge would maintain the existing regulatory

requirement for receiving waters of pre-development forested baseline stream flows up to the 50-year storm event. During the infrequent storm events when flows exceed the 50-year storm event, FAA assumes there is likely to be elevated levels of pollutants associated with stormwater runoff, but it is unlikely that pollutant levels exceed water quality standards or reach levels that cause adverse effects based on results from monitoring.

In addition to flow control and water quality treatment, SEA implements a broad range of OSC BMPs to avoid and minimize the release of pollutants and intercept those pollutants before they enter the SDS and IWS (Section 2.7.2). SEA is also actively involved in ongoing research into the fate and transport of 6PPD-Q and the effectiveness of available treatment technologies (Section 2.8). Preliminary results from the Treatability Testing study are promising and demonstrate the effectiveness of commercially available filter media, indicating that there are options beyond 100% infiltration to treat 6PPD-Q (Table 16).

Table 16. Preliminary Treatability Testing Results

Media	Average 6PPD-Q Removal Efficiency (%)	Number of Sampling Events
Biochar	82	1
HS250	94	1
SCU	91.1	1
VCC	97.6	1
CESF + Biochar	96	4
CESF + HS250	97.9	5
CESF + SCU	96.9	4
CESF + VCC	98.8	5

*Sampled between February 28, 2024 – June 2, 2024

While the Port's existing and proposed structural and operational pollution controls are robust, SDS and IWS treated discharges unavoidably contain low levels of contaminants even after treatment. These residual contaminants could harm ESA-listed fish and their habitats through direct and indirect exposure through the food web. However, there is insufficient information available to meaningfully quantify potential biological effects on listed species and the effects are not reasonably certain to occur. The *in-situ* toxicity testing is the only site-specific data available, and it supports the determination that the SDS and IWS are effective at removing contaminants, even those that are not currently monitored. It is important to note that the difference between the Proposed Action and No Action is negligible.

Recent research has found 6PPD-Q, a contaminant found in rubber particles from automobile tire wear on roads, likely poses a significant risk to ESA-listed salmonids and potentially other aquatic life. However, it is unclear how or if aviation is a significant contributor of 6PPD-Q given the differences in the way aviation tires are produced and used. Lane et al. (2024) did not detect 6PPD-Q in Iowa surface water samples collected down-gradient of airports (N = 8).

Current studies indicate that fish sensitivity to 6PPD-Q varies among species.

- Coho salmon are acutely sensitive to 6PPD-Q in laboratory studies, suggesting this compound is a likely contributor to observed pre-spawn mortality in urban streams (Tian et al. 2021, 2022).
- Steelhead and Chinook salmon appear less sensitive. Brinkmann et al. (2022) and Lo et al. (2023) reported 24-hr LC50 of <2 and 67 ppb for steelhead and Chinook salmon, respectively.
- Sockeye salmon (*O. nerka*) and chum salmon (*O. keta*) were unaffected by exposure to stormwater contaminants, including 6PPD-Q, at concentrations sufficient to cause acute mortality in coho salmon (French et al. 2022; McIntyre et al. 2018, 2021).
- Bull trout and rockfish sensitivity are not currently known.
- It is difficult to make inferences from available research because the findings vary widely within and between species groups. For example, Ackerly et al. (2024) found no evidence of acute toxicity or sublethal physiological or morphological effects on early life stages of red drum (*Sciaenops ocellatus*) at exposure concentrations ranging from 10 to 500 ppb. In contrast, Varshney et al. (2021) observed a 24 h LC50 of 309 ppb and sublethal effects on swimming behavior in zebra fish larvae at exposure concentrations of 10 to 25 ppb.

The initial results of the 6PPD-Q treatment options have been largely successful with removal rates up to 99.9%. The results demonstrate that the Port would be able to meet proposed state limits.

5.1.3.3 *Effects of Stormwater on Critical Habitat*

The extent to which the Proposed Action would alter pollutant levels in habitats used by ESA-listed species cannot be meaningfully measured or evaluated and are not expected to reach the scale where take occurs. Broadly speaking, the Proposed Action would add new, replaced, and/or retrofitted PGIS to primarily developed areas within SEA property. These areas either currently have existing stormwater detention and treatment facilities that would be improved, or the Proposed Action includes construction of new facilities. The difference in stormwater runoff between the Proposed Action and No Action is negligible. While all existing and proposed new treatment facilities would meet current Ecology (2019, 2021) requirements, incorporate the relevant OSC BMPs described in Section 2.7.2, and treatment to remove 6PPD-Q, SDS and IWS discharges could include contaminants, the levels cannot be meaningfully measured or evaluated using best available scientific and commercial data. Because the fate and transport of many of these contaminants and their synergistic effects are not fully understood, the extent, duration, and severity of stormwater effects cannot currently be quantified with certainty. The contribution of the Proposed Action to pollutant concentrations and the distance from the outfalls required to dilute concentrations below levels likely to cause detectable effects is unknown and likely to vary. Results from the in-situ testing suggest that the treated stormwater discharge from SEA would have insignificant impacts and could help to improve water quality by diluting contaminant concentrations.

Discharge into the marine waters of Puget Sound further complicates the analysis, as salinity reduces the toxicity and bioavailability of contaminants such as metals. Runoff volumes vary and depend on the timing, intensity, and duration of individual storm events. Contaminant concentrations are likely to be greatest during first-flush events, after contaminants have accumulated on impervious surfaces during long periods of dry weather. Such events are most common in early and mid-autumn. However, the OSC BMPs implemented by the Port greatly reduce the impact of first-flush events.

Pollutant effects on water quality are determined by how contaminants are generated, how those pollutants are transported from source areas to aquatic environments, and the toxicity and biological availability of toxic compounds to receptors. This complex process is referred to as fate and transport (ATSDR 2022), the understanding of which varies by contaminant type. For example, the fate and transport of contaminants like PAHs and metals has received considerable study and is generally well understood. In contrast, while 6PPD-Q toxicity to certain salmonids has been clearly established in laboratory studies (Section 5.1.3.1), the fate and transport of this pollutant is not fully understood (Ecology 2022). Currently available information indicates that 6PPD-Q exposure risk is highest during first-flush events following extended dry periods (McKane et al. 2021; Ecology 2022). Accordingly, BMPs that intercept and remove weathered tire particles from impervious surfaces before first-flush events occur, such as existing SEA operations, management, and maintenance measures (Section 2.7.2), are likely to reduce exposure risks for ESA-listed fish and other aquatic species (Ecology 2022).

The freshwater aquatic habitats Miller Creek, Walker Creek, and Des Moines Creek are not mapped as designated critical habitat for ESA-listed species. The Proposed Action would discharge runoff from PGIS to SEA's IWTP Puget Sound outfall. Per direction from NMFS, the Port conservatively assumes the action area would include 6,560-foot effect radii around the outfall discharge points and from the seabed (MLLW 148 feet) to the water surface. This area lies within designated critical habitat for Chinook salmon, bull trout, bocaccio and yelloweye rockfish, and SRKW. The Proposed Action would constitute a small percentage of total pollutant loading discharged from this outfall. This minimal loading could constitute an incremental effect on ESA-listed species. However, there is insufficient information available to meaningfully measure or evaluate potential biologically significant effects on listed species and the effects cannot currently be quantified with certainty.

5.2 Indirect Effects/Delayed Consequences

Indirect effects, also known as delayed consequences, refer to consequences of the Proposed Action that may occur later in time or extend beyond the immediate footprint of the action, or to consequences of other activities that are caused by the project (WSDOT 2023b). A consequence is caused by the Proposed Action if it would not occur but for the project and it is reasonably certain to occur. The term "reasonably certain to occur" was defined as: A conclusion of reasonably certain to occur must be based on clear and substantial information, using the best scientific and commercial data available (WSDOT 2023b).

The Proposed Action would expand the amount of PGIS and could contribute to the ongoing delivery of treated stormwater pollutants to the aquatic component of the action area over the life of the project. As stated in the previous section, while SEA's combined SDS and IWS systems and OSCs represent the currently practicable state-of-the-art treatment options, treated discharges may result in a negligible contribution to chronic pollutant loading in the aquatic component of the action area that cannot be meaningfully measured or evaluated. While SEA represents a miniscule fraction of pollutant loading from regional sources, the Proposed Action could contribute incrementally to these effects. As such, the Proposed Action could incrementally

contribute to the indirect effects on ESA-listed species, but the extent and severity of those effects cannot currently be quantified and are not expected to reach the scale where take occurs.

The Proposed Action is being developed in response to strong current and projected growth in demand for air passenger and cargo services at SEA. Implementation of the NTPs would neither induce regional macro-economic growth nor demand for air services. However, the NTPs would increase SEA's ability to accommodate increased aircraft operations and passenger activity. As a result, it is assumed that after implementation, the number of aircraft operations and passengers will increase. However, the Port does not anticipate that the Proposed Action would fully accommodate the future needs for aircraft and passenger service projected in the unconstrained 2023 Updated Forecast (Leigh-Fisher 2023). Once the additional capacity provided by the NTPs is reached, the available airfield and airspace capacity at SEA will become the primary constraints on continued growth in air passenger services. The Proposed Action would have no measurable effect on regional development patterns and would not contribute to induced growth.

Therefore, the delayed consequences of the Proposed Action are limited to the incremental effects of the low concentrations of pollutants that would result from the related increase in PGIS and ongoing discharge of treated stormwater and wastewater from these new as well as existing impervious surfaces in the action area. However, it should be noted that the extent and severity of those effects cannot currently be meaningfully quantified or evaluated but are not expected to reach the scale where take occurs.

5.2.1 Indirect Effects on ESA-listed Salmonids

ESA-listed salmonids could be exposed to treated stormwater pollutants at low-levels in the water column and through consumption of contaminated prey organisms (Section 5.1.3.1). O'Neill and West (2009) and West et al. (2008, 2011) documented the bioaccumulation of persistent and toxic contaminants in stormwater runoff in zooplankton and forage fish species in Puget Sound, and in predator species including Chinook salmon. However, SEA is not a probable source of the studied contaminants. The extent and severity of the effects of the low levels of stormwater pollutants that could be discharged cannot currently be meaningfully quantified or evaluated but are not expected to reach the scale where take occurs.

Emerging research demonstrates that 6PPD-Q could contribute to chronic adverse effects on the salmonid food web. The broader implications for species at higher trophic levels, such as ESA-listed salmonids, are not currently quantifiable. Treatment for 6PPD-Q based on the results of the Treatability Testing study would be included, reducing any potential impact on ESA-listed salmonids.

Based on the findings presented here and in Section 5.1.3, there is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could result in delayed consequences for ESA-listed salmonids and their critical habitats. The effects cannot currently be quantified with certainty given insufficient information available. Therefore, the FAA has determined that the impact would be insignificant.

5.2.2 Indirect Effects on ESA-listed Rockfish

Eggs, larva, post-settlement juvenile, and adult bocaccio and yelloweye rockfish that occur in the aquatic component of the action area (Puget Sound) could be directly exposed to pollutants in treated operational stormwater discharge and indirectly exposed to pollutants through the consumption of contaminated prey organisms. It cannot currently be determined with certainty if this could result in adverse effects on survival and fitness of individuals over the life of the project (Section 5.1.3.1). Bocaccio and yelloweye rockfish are long-lived species, that take several years to reach reproductive age. Chronic exposure to and bioaccumulation of stormwater contaminants could lead to delayed consequences for individual survival or reproductive fitness. However, there is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated discharges produced by the Proposed Action could result in delayed consequences for ESA-listed bocaccio and yelloweye rockfish and their critical habitats.

5.2.3 Indirect Effects on Southern Resident Killer Whale

SRKW are likely to occur in the Puget Sound portion of the action area, but the likelihood of direct exposure to stormwater pollutants is discountable given the relatively limited area of effect and probable duration of occurrence. Indirect exposure to stormwater pollutants could occur over the life of the Proposed Action through consumption of bioaccumulated pollutants in salmon and other prey organisms. This long-lived species is exposed to a diverse array of known and potentially harmful chemical substances in the environment and through consumption of contaminated prey.

Mongillo et al. (2016) determined that chronic exposure to PAHs and certain persistent organic pollutants (POPs)[6] are a significant factor contributing to SRKW extinction risk. SRKW carry several of these contaminants at very high body burdens, the result of bioaccumulation through consumption of contaminated prey. Many of these contaminants are known or likely immune and endocrine system disruptors, so the bioaccumulation of these compounds is likely having a profound negative effect on both survival and reproductive fitness (Mongillo et al. 2016).

The final recovery plan for SRKW identifies quantity and quality of prey as a factor that may limit recovery of the species (NMFS 2008). As SRKWs in Puget Sound have a strong preference for Chinook salmon prey, stormwater impacts that affect Chinook abundance and indirect exposure to contaminants through consumption of contaminated prey have the potential to indirectly affect SRKW. NMFS (2023) produced a technical memorandum providing guidance on ESA consultation specific to SRKWs in the NMFS Northwest Region. The memorandum identifies two indirect effects pathways to consider when determining the likelihood of adverse effects: prey quantity and quality.

5.2.3.1 *Prey Quality*

Projects with potential contamination of waters used by Chinook salmon may represent a possible effect to SRKW through contamination of their prey. Proposed in-water work is limited to bridge construction

[6] Notably polychlorinated biphenyls, polybrominated diphenyl ethers, and dichlorodiphenyltrichloroethane (DDT) and its metabolites.

and culvert replacement in Miller Creek more than 4 miles upstream of Puget Sound. Construction BMPs would ensure that no delivery of suspended sediments and associated contaminants would occur. As such, no measurable effects on contaminant levels in Chinook salmon or other SRKW prey species are likely to occur because of project construction.

As discussed in Section 5.1.3, the Proposed Action would minimally increase the quantity of treated operational stormwater pollutants relative to existing conditions at points of discharge. However, the difference between the Proposed Action and No Action is negligible. The Proposed Action could contribute to ongoing exposure of Chinook salmon and other SRKW prey species to treated stormwater pollutants, and the ongoing bioaccumulation of certain contaminants through dietary exposure. There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could contribute to indirect effects to SRKW from impacts on prey quality.

5.2.3.2 *Prey Quantity*

Projects that result in impacts to Chinook salmon may also affect the quantity of prey available to SRKW. Impacts that result in a meaningful reduction in Chinook salmon abundance may reduce prey quantity sufficiently to constitute an adverse effect. This determination applies to construction impacts, which implies this threshold applies on a per-year basis. As described in Section 5.1.3, Proposed Action construction is unlikely to result in any measurable direct or indirect effects on the abundance or quantity of Chinook salmon and other prey organisms available to SRKW.

Proposed Action operations would generate treated stormwater discharges that could result in indirect adverse effects on Chinook salmon and therefore on SRKWs. These effects cannot be quantified with currently available information. There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could contribute to the reduction of the quantity and quality of prey resources available to SRKW.

5.3 Interrelated/Interdependent Actions

Interrelated actions are defined as actions that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02). The Proposed Action is part of the SAMP, a long-term master plan for improvements to SEA needed to support continuing operations and meet future needs for air travel and cargo transport. The Proposed Action is comprised of stand-alone projects (NTPs) that have independent utility, and no other projects depend upon the Proposed Action for their utility.

5.4 Cumulative Effects

Cumulative effects are those effects of future activities that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the Proposed Action are not considered in this section because they require separate consultation pursuant to Section 7. A cumulative effects analysis is required for projects undergoing formal consultation and to aid the Services in making jeopardy determinations, in preparing biological opinions, and in tracking the environmental conditions throughout the vicinity.

Future state, tribal, local, or private actions considered in this BE are unlikely to occur in the terrestrial component of the action area. The aquatic component of the action area is surrounded by and receives stormwater runoff from several local jurisdictions. Each jurisdiction has developed a comprehensive plan to guide future development, none of which includes elements that are contingent on the Proposed Action. However, each jurisdiction will continue to generate stormwater runoff and permitted wastewater discharges that will contribute to cumulative impacts in the action area. The Port anticipates that these jurisdictions will provide stormwater treatment and detention for retrofitted and new development consistent with the current or applicable future versions of the Ecology (2019) *Stormwater Management Manual for Western Washington* and/or the WSDOT (2019) *Highway Runoff Manual*. Similarly, existing and future wastewater discharges will comply with contemporary NPDES permit requirements. These design and compliance standards will minimize the delivery of pollutants to surface waters in the action area. The Proposed Action would contribute incrementally to these ongoing cumulative effects.

Taken as a whole, foreseeable future state, local, Tribal, and private actions will continue to result in cumulative effects to listed species habitat and conditions in the aquatic portion of the action area. Although some of these actions are likely to improve habitat conditions for listed aquatic species, over time, ongoing impacts from stormwater are likely to further degrade water quality in the action area. The Proposed Action would contribute minimally to these ongoing cumulative effects. There is not enough information available to meaningfully quantify or evaluate the cumulative impacts of the Proposed Action but they are not expected to reach the scale where take would occur.

6.0 CONCLUSIONS AND EFFECT DETERMINATIONS

The effects determination is the conclusion of the analysis of potential consequences of the Proposed Action on listed species and critical habitat. Regulatory guidance from the Final Section 7 Consultation Handbook (USFWS and NMFS 1998) was used to make the effects determination for the Proposed Action. The FAA relied on the best available scientific and commercial data available when making the determinations. A summary of the proposed effect determinations to species and critical habitat is presented in Table 17. The supporting rationale for each determination is provided in the following sections.

Table 17. Proposed action effects determinations for ESA-listed species and critical habitat

Species/Habitat	Effects Determination
Chinook salmon (Puget Sound ESU)	Not likely to adversely affect
Chinook salmon critical habitat	Not likely to adversely affect
Steelhead (Puget Sound ESU)	Not likely to adversely affect
Steelhead critical habitat	No effect
Bull trout (Coastal-Puget Sound DPS)	Not likely to adversely affect
Bull trout critical habitat	Not likely to adversely affect
Bocaccio rockfish (Puget Sound/Georgia Basin DPS)	Not likely to adversely affect
Bocaccio rockfish critical habitat	Not likely to adversely affect
Yelloweye rockfish (Puget Sound/Georgia Basin DPS)	Not likely to adversely affect
Yelloweye rockfish critical habitat	Not likely to adversely affect
Killer whale (Southern Resident DPS)	Not likely to adversely affect
Killer whale critical habitat	Not likely to adversely affect
DPS – Distinct population segment; ESU – Evolutionarily significant unit	

6.1 Puget Sound Chinook Salmon

The Proposed Action **may affect** Puget Sound Chinook salmon because of:

- Documented migration and foraging habitat (suboptimal) present in action area (Puget Sound).
- Gradient accessible but not documented in Miller Creek, Walker Creek, and Des Moines Creek in the action area.
- Construction of new, replaced, and retrofitted PGIS as part of the Proposed Action.

The Proposed Action is **not likely to adversely affect** Chinook salmon because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into the Proposed Action.
- Puget Sound in the action area is not suited for foraging due to extensive shoreline armoring, patchy beds of eelgrass, and other existing nearshore impacts (NMFS 2005a, 2005b, 2012c).
- Extent and severity of degraded water quality effects downstream cannot currently be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect Chinook salmon.

6.2 Chinook Salmon Critical Habitat

The Proposed Action **may affect** critical habitat for Chinook salmon because critical habitat is designated in Puget Sound within the action area, where PBFs 4, 5, and 6 occur.

The Proposed Action is **not likely to adversely affect** critical habitat for Chinook salmon because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into the Proposed Action.
- Though stormwater contaminants could remain in the treated discharge and degrade water quality within downstream designated critical habitat where rearing or migration could occur (PBFs 4, 5, and 6), the extent and severity of those effects cannot currently be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect Chinook salmon critical habitat.

6.3 Puget Sound Steelhead

The Proposed Action **may affect** Puget Sound steelhead because of:

- Documented migration and foraging habitat (suboptimal) present in the Puget Sound action area.
- Construction of new, replaced, and retrofitted PGIS as part of the Proposed Action.
- Proposed Action in-water work is located upstream of documented steelhead habitat/presence.

The Proposed Action is **not likely to adversely affect** steelhead because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into Proposed Action.
- Puget Sound in the action area is not suited for foraging due to extensive shoreline armoring, patchy beds of eelgrass, and other existing nearshore impacts (NMFS 2012, 2013).
- Though steelhead migrating adults could be directly exposed to degraded water quality and habitat quality could be degraded due to reduced water quality from Proposed Action stormwater pollutants, the extent and severity of those effects cannot be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect steelhead or its habitat.

6.4 Steelhead Critical Habitat

The Proposed Action would have **no effect** on critical habitat for steelhead because designated critical habitat is not located within the action area.

6.5 Coastal-Puget Sound Bull Trout

The Proposed Action **may affect** bull trout but is **not likely to adversely affect** bull trout because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into Proposed Action.

- Puget Sound in the action area is not suited for foraging, due to extensive shoreline armoring, patchy beds of eelgrass (*Zostera marina*), and other existing nearshore impacts (USFWS 2010b).
- Though bull trout could be directly exposed to degraded water quality and habitat quality could be degraded due to reduced water quality from Proposed Action treated stormwater pollutants, the extent and severity of those effects cannot be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect bull trout or its habitat.

6.6 Bull Trout Critical Habitat

The Proposed Action **may affect** critical habitat for bull trout because critical habitat for bull trout is designated in the Puget Sound portion of the action area, where PBFs 2, 3, 4, and 8 occur.

The Proposed Action are **not likely to adversely affect** critical habitat for bull trout because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into Proposed Action.
- Though stormwater contaminants could remain in the treated discharge and degrade water quality within downstream designated critical habitat where migration could occur (PBFs 2, 3, 4, and 8), the extent and severity of those effects cannot currently be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect bull trout critical habitat.

6.7 Puget Sound/Georgia Basin Bocaccio and Yelloweye Rockfish

The Proposed Action **may affect** bocaccio and yelloweye rockfish because planktonic eggs and larvae, post-settlement juvenile, and adult bocaccio and yelloweye rockfish could occur in the action area.

The Proposed Action is **not likely to adversely affect** bocaccio and yelloweye rockfish because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into Proposed Action.
- Though bocaccio and yelloweye rockfish could be directly exposed to degraded water quality and habitat quality could be degraded due to reduced water quality from Proposed Action stormwater pollutants, the extent and severity of those effects cannot be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect bocaccio and yelloweye rockfish or their habitat.

6.8 Bocaccio and Yelloweye Rockfish Critical Habitat

The Proposed Action **may affect** critical habitat for bocaccio and yelloweye rockfish because the following attributes are present in the offshore deepwater Puget Sound portion of the action area:

- Quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding.
- Water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding.

The Proposed Action is **not likely to adversely affect** critical habitat for bocaccio and yelloweye rockfish because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into Proposed Action.
- Though stormwater contaminants could remain in the treated discharge and result in an incremental degradation of water quality and potential indirect effects on prey resources from pollutant exposure, the extent and severity of those effects cannot currently be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect bocaccio and yelloweye rockfish critical habitat.

6.9 Southern Resident Killer Whale

The Proposed Action **may affect** SRKW because migration and foraging habitat are present in Puget Sound in the action area. The Proposed Action is **not likely to adversely affect** SRKW because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into Proposed Action.
- Though SRKW could be exposed to degraded water quality and habitat quality due to the Proposed Action, the extent and severity of those effects cannot be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect SRKW or its habitat.

6.10 Southern Resident Killer Whale Critical Habitat

The Proposed Action **may affect** critical habitat for SRKW because the Puget Sound portion of the action area overlaps designated critical habitat. The Proposed Action is **not likely to adversely affect** critical habitat for SRKW because:

- Proposed structural and operational pollution controls, including 6PPD-Q treatment, are incorporated into Proposed Action.
- Though stormwater contaminants could remain in the treated discharge and result in an incremental degradation of water quality and potential indirect effects on prey resources from pollutant exposure, the extent and severity of those effects cannot currently be meaningfully quantified or evaluated but are not expected to reach the scale where take would occur.
- There is not enough information available to reasonably conclude that the ongoing discharge of low levels of contaminants in treated stormwater and wastewater discharges produced by the Proposed Action could adversely affect SRKW critical habitat.

7.0 EFFECTS TO ESSENTIAL FISH HABITAT

The MSA includes a mandate that NMFS must identify EFH for federally managed marine fishes, and federal agencies must consult with NMFS on all activities or proposed activities authorized, funded, or undertaken by the agency that may adversely affect EFH. The Pacific Fishery Management Council (PFMC) has designated EFH for the Pacific salmon fishery, federally managed groundfishes, and coastal pelagic fisheries (NMFS 1999; PFMC 1999).

7.1 Essential Fish Habitat Background

EFH is defined as, "Waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" in the MSA [16 United States Code 1802(10)]. Adverse effects on EFH include any direct or indirect impact that reduces the quality or quantity of EFH. The objective of this EFH evaluation is to determine whether the project "may adversely affect" designated EFH for relevant commercially, federally managed fisheries species within the action area. It also references conservation measures to avoid, minimize, or offset potential adverse effects to designated EFH resulting from the project.

7.2 Location and Description of Proposed Action

The FAA is consulting on the Port's Proposed Action, as described in Chapters 1.0 and 2.0 of this BE. The 29 NTPs have been designed to meet forecasted rising passenger and cargo demand at SEA by improving efficiency, safety, access to the airport, and support facilities for the airlines and the airport. In addition, the Port would construct and operate associated PSPs that are necessary for the implementation of the NTPs and provide mitigation for unavoidable impacts to wetlands, streams and wetland and stream buffers resulting from project construction.

The construction and operation of the Proposed Action would occur primarily on currently developed land at SEA, with some development requiring clearing of vegetated parcels adjacent to these currently developed areas. Stormwater and industrial wastewater discharges from the new NTP facilities would discharge to the following waterbodies: Miller Creek and Des Moines Creek, which flow directly into Puget Sound; Walker Creek, which drains into Miller Creek; and Puget Sound, which receives effluent from SEA's IWTP via an NPDES-permitted outfall that discharges approximately 1,600 feet waterward of the mouth of Des Moines Creek at a depth of -148 feet relative to MLLW. Changes in impervious surface area and PGIS resulting from the NTPs, and proposed SDS and IWS improvements are detailed in Section 2.4.2.

7.3 Conservation Measures and Best Management Practices

Conservation measures and BMPs are included for Proposed Action activities and are described in Chapter 2 of this BE. Conservation measures would avoid or minimize potential effects to existing habitat conditions, including EFH, in the action area. Mitigation would be provided to compensate for impacts to wetlands and to wetland and stream buffer.

7.4 Identification of Essential Fish Habitat

Under the MSA, the PFMC has designated EFH for federally managed fisheries within the waters of Washington, Oregon, and California. Detailed descriptions and identification of EFH are contained in the fishery management plans for groundfish (PFMC 2019a), coastal pelagic species (PFMC 2019b), and Pacific salmon (PFMC 2016).

Designated EFH for groundfish and coastal pelagic species encompasses all waters along the coasts of Washington, Oregon, and California that are seaward from the mean high-water line, including the upriver extent of saltwater intrusion in river mouths to the boundary of the U.S. economic zone, approximately 200 miles (321.9 km) offshore (PFMC 2019a, b).

Designated EFH for salmonid species within marine water extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (EEZ) offshore of Washington, Oregon, and California, north of Point Conception to the Canadian border (PFMC 2016).

Groundfish, coastal pelagic, and salmonid fish species and life-history stages that have designated EFH in the Puget Sound portions of the action area including project-related stormwater discharges are listed in Table 18. Salmonid fish species that have designated EFH in the Miller Creek, Walker Creek, and Des Moines Creek portion of the action area are listed in Table 19. Evaluation of the impacts on species that may occur in the action area is based on life-history stages described in PFMC (2016, 2019a, b).

Table 18. Species of fish with designated EFH that may be present in the Puget Sound action area.

EFH Species	Eggs	Larvae	Juvenile	Adult	Spawning
Groundfish					
Spiny dogfish, *Squalus acanthias*			x	x	
Spotted ratfish, *Hydrolagus colliei*			x	x	
Lingcod, *Ophiodon elongatus*			x		
Cabezon, *Scorpaenichthys marmoratus*			x		
Kelp greenling, *Hexagrammos decagrammus*			x		
Pacific cod, *Gadus macrocephalus*			x		
Pacific hake, *Merluccius productus*			x	x	
Sablefish, *Anoplopoma fimbria*		x	x	x	x
Brown rockfish, *S. auriculatus*		x		x	
China rockfish, *S. nebulosus*		x		x	
Copper rockfish, *S. caurinus*		x		x	
Quillback rockfish, *S. maliger*		x		x	
Thornyheads, *Sebastolobus* spp.		x		x	
Other rockfishes		x		x	
Pacific sanddab, *Citharichthys sordidus*		x	x	x	
Dover sole, *Microstomus pacificus*			x	x	
English sole, *Pleuronectes vetulus*		x	x	x	x
Flathead sole, *Hippoglossoides elassodon*		x	x	x	x
Petrale sole, *Eopsetta jordani*		x	x	x	
Rex sole, *Errex zachirus*		x	x	x	
Rock sole, *Pleuronectes bilineata*		x	x	x	x
Sand sole, *Psettichthys melanostictus*		x	x	x	
Starry flounder, *Platichthys stellatus*		x	x	x	x
Coastal Pelagic Species					
Northern anchovy, *Engrauilis mordax*		x	x	x	
Chub mackerel, *Scomber japonicus*				x	
Jack mackerel, *Trachurus symmetricus*				x	
Pacific sardine, *Sardinops sagax*				x	
Market squid, *Loligo opalescens*		x	x	x	x
Pacific Salmon Species					
Chinook salmon, *Oncorhynchus tshawytacha*			x	x	
Coho salmon, *O. kisutch*			x	x	
Puget Sound pink salmon, *O. gorbuscha*			x	x	
Sources: Pietsch and Orr 2015, Port 2016b, Windward 2010, NMFS 2024b.					

Table 19. Pacific salmon species with designated EFH that may be present in the freshwater aquatic component of the action area.

EFH Species	Eggs	Larvae	Juvenile	Adult	Spawning
Chinook salmon, *Oncorhynchus tshawytscha*[a]				x	
Coho salmon, *O. kisutch*				x	
Puget Sound pink salmon, *O. gorbuscha*[b]				x	

Sources: Pietsch and Orr 2015, Port 2016b, Windward 2010, NMFS 2024b.

[a] Chinook salmon presence in Miller Creek, Walker Creek, and Des Moines Creek is documented as gradient accessible with no documented spawning history (NWIFC 2024, WDFW 2024d, e).

[b] Miller Creek, Walker Creek, and Des Moines Creek are accessible to pink salmon, but the species is not known to use the creeks (NWIFC 2024, WDFW 2024d, e).

7.4.1 Groundfish

The west coast groundfish management unit includes 83 species that typically live on or near the bottom of the ocean. The EFH designation for groundfishes and coastal pelagics is defined as those waters and substrate necessary to ensure the production needed to support a long-term sustainable fishery. This includes, "All waters and substrate within the following areas: (1) depths less than or equal to 3,500 meters (1,914 fathoms) to MHHW or the upriver extent of saltwater intrusion, defined as upstream and landward to where ocean-derived salts measure less than 0.5 ppt [part per thousand] during the period of average annual low flow. (2) seamounts in depths greater than 3,500 meters as mapped in the EFH assessment geographic information system (GIS); and (3) areas designated as HAPCs [Habitats of Primary Concern] not already identified by the above criteria." (PFMC 2019a). Groundfish EFH occurs in the action area at Proposed Action-related stormwater discharges (NMFS 2024b):

- **Puget Sound**: Groundfish EFH is designated in the Puget Sound portion of the action area at the offshore NPDES stormwater outfall.
- **Miller Creek, Walker Creek, and Des Moines Creek:** Groundfish EFH is not present in these aquatic areas.

7.4.2 Coastal Pelagics

Coastal pelagics are schooling fishes, not associated with the ocean bottom, that migrate in coastal waters. West coast pelagics include finfish such as the Pacific sardine (*Sardinops sagax*), chub mackerel (*Scomber japonicus*), northern anchovy (*Engraulis mordax*), and jack mackerel (*Trachurus symmetricus*); market squid (*Loligo opalescens*); and krill. The EFH designation for coastal pelagics is defined as those waters and substrate necessary to ensure the production needed to support a long-term sustainable fishery. The EFH includes "*all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the EEZ and above the thermocline where sea surface temperatures range between 10°C and 26°C."* (PFMC 2019b). Coastal pelagic EFH occurs in the action area at stormwater discharges (NMFS 2024b):

- **Puget Sound**: Coastal pelagic EFH for finfish, market squid, and coastal pelagic krill is designated in the Puget Sound portion of the action area at the offshore NPDES stormwater outfall.
- **Miller Creek, Walker Creek, and Des Moines Creek:** Coastal pelagic EFH is not present in these aquatic areas.

7.4.3 Pacific Salmon

The Pacific salmon management unit includes Chinook salmon, coho salmon (*O. kisutch*), and pink salmon (*O. gorbuscha*). The EFH designation for the Pacific salmon fishery is divided into two groups:

- Freshwater group includes all those streams, lakes, ponds, wetlands, and other waterbodies currently or historically accessible to salmon in Washington, Oregon, Idaho, and California, except above the impassible barriers identified by PFMC (1999, 2016).
- Marine and estuarine group occurs "…from the extreme high tide line in nearshore and tidal submerged environments within state territorial waters out to the full extent of the EEZ (200 nautical miles or 370.4 km)" (PFMC 1999).

Pacific salmon EFH occurs in the action area at Proposed Action-related stormwater discharges:

- **Puget Sound:** Pacific salmon EFH is designated in the Puget Sound portion of the action area at the offshore NPDES stormwater outfall. Chinook salmon, coho salmon, and pink salmon all may use the nearshore habitat in Puget Sound near this outfall at some point in their life histories, particularly during juvenile outmigration and adult spawning migration.
- **Miller Creek, Walker Creek, and Des Moines Creek:** Pacific salmon EFH is present in all these aquatic areas. All three are considered gradient accessible to Chinook salmon. Coho salmon have been documented in each of these listed waterways. Miller Creek, Walker Creek, and Des Moines Creek are considered gradient accessible to pink salmon.

7.5 Potential Adverse Effects of Proposed Action

Chapter 6, Analysis of Effects, describes in detail the potential impacts to habitat constituents important to ESA-listed fish species, which are like those for EFH species. Analyses presented address potential elements specific to EFH, which for this Proposed Action is primarily stormwater. Those elements of the analysis are reiterated or cross referenced in the following sections. There are no potential construction impacts to EFH species in the action area. The specific stormwater drainages, as well as the associated changes in new NPGIS and PGIS, and changes in source control BMPs and treatment levels are summarized in Table 3.

7.5.1 Puget Sound

All new PGIS surfaces draining to Puget Sound, and freshwater habitats that drain to Puget Sound, would meet the airport flow and water quality requirements before being released. In addition, SEA implements a variety of operations and management BMPs that include pollutant prevention, interception, and maintenance measures to prevent and collect pollutants prior to entering the stormwater facilities (Sections 2.7 and 2.8). The Proposed Action would include expanded pond and bioretention swale capacity to treat new PGIS.

Recent research has found 6PPD-Q, a contaminant found in rubber particles from automobile tire wear on roads, to be a major contributor to pre-spawning mortality in coho salmon (Tian et al. 2021; 2022). These findings have spurred concerns that 6PPD-Q could pose a significant risk to other EFH salmonid species. Brinkmann et al. (2022) and Lo et al. (2023) reported 24-hr LC50 of 67 parts per billion (ppb) for Chinook salmon. While pink salmon sensitivity to 6PPD-Q has not yet been studied, the lethal concentrations observed in other salmonid species suggest that a presumption of potential for harm may be warranted but cannot be determined with certainty.

While the types of contaminants likely to be generated by the project are generally understood, the extent to which the project might affect ambient pollutant levels in stormwater is difficult to predict. The proposed action would increase the current amount of treated PGIS draining to Puget Sound and freshwater habitats that drain to Puget Sound. Runoff from these surfaces would flow through improved and expanded treatment and retention facilities that would drain to the same points of discharge currently permitted by Ecology (2021). As such, the contribution of the project to effluent pollutant concentrations and the distance from the outfall required to dilute concentrations below levels likely to cause detectable effects is unknown. Runoff volumes vary and depend on the timing, intensity, and duration of individual storm events. Contaminant concentrations are likely to be greatest during first-flush events, after contaminants have accumulated on roadways during long periods of dry weather. Such events are most common in early and mid-autumn. The project would constitute only a small proportion of the overall pollutant loading discharged into the Puget Sound. Discharge into the marine waters of Puget Sound is also a variable factor of pollutant concentrations, as salinity reduces the toxicity and bioavailability of contaminants such as metals.

7.5.2 Miller Creek, Walker Creek, and Des Moines Creek

Potential operational stormwater impacts to EFH species in Miller Creek, Walker Creek, and Des Moines Creek are like what is described above for Puget Sound. The Proposed Action would result in a net increase in PGIS of approximately 50 acres draining to Puget Sound comprising a combination of new, replaced, and retrofitted impervious surfaces (Table 3).

7.6 Conclusion and Effect Determinations

While the project would provide new, improved source control BMPs and treatment capacities (including methods to remove 6PPD-Q) that would minimize adverse impacts, the project would generate stormwater and wastewater discharge from new, replaced, and retrofitted PGIS. Stormwater and wastewater discharges would result in an incremental degradation of water quality from pollutant exposure, the extent and severity of those effects cannot currently be meaningfully quantified or evaluated.

7.6.1 Groundfish Essential Fish Habitat

Operational stormwater discharges would result in an incremental degradation of water quality and potential indirect effects on prey resources from pollutant exposure. However, these impacts cannot be quantified with certainty. Overall, based on the operational stormwater discharges of the project, the project is **not likely to adversely affect** groundfish EFH.

7.6.2 Coastal Pelagic Essential Fish Habitat

Operational stormwater discharges would result in an incremental degradation of water quality and potential indirect effects on prey resources from pollutant exposure. However, these impacts cannot be quantified with certainty. Overall, based on the operational stormwater discharges of the project, the project is **not likely to adversely affect** coastal pelagic EFH.

7.6.3 Pacific Salmon Essential Fish Habitat

Operational stormwater discharges would result in an incremental degradation of water quality and potential indirect effects on prey resources from pollutant exposure. However, these impacts cannot be quantified with certainty. Overall, based on the operational stormwater discharges of the project, the project **is not likely to adversely affect** Pacific salmon EFH.

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Appendix A
Species Lists

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Washington Fish And Wildlife Office
510 Desmond Drive Se, Suite 102
Lacey, WA 98503-1263
Phone: (360) 753-9440 Fax: (360) 753-9405

In Reply Refer To: 04/24/2024 21:21:40 UTC
Project Code: 2024-0081720
Project Name: Seattle-Tacoma International Airport: SAMP NTPs and PSPs

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological

evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

https://www.fws.gov/sites/default/files/documents/endangered-species-consultation-handbook.pdf

Migratory Birds: In addition to responsibilities to protect threatened and endangered species under the Endangered Species Act (ESA), there are additional responsibilities under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA) to protect native birds from project-related impacts. Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). For more information regarding these Acts, see https://www.fws.gov/program/migratory-bird-permit/what-we-do.

The MBTA has no provision for allowing take of migratory birds that may be unintentionally killed or injured by otherwise lawful activities. It is the responsibility of the project proponent to comply with these Acts by identifying potential impacts to migratory birds and eagles within applicable NEPA documents (when there is a federal nexus) or a Bird/Eagle Conservation Plan (when there is no federal nexus). Proponents should implement conservation measures to avoid or minimize the production of project-related stressors or minimize the exposure of birds and their resources to the project-related stressors. For more information on avian stressors and recommended conservation measures, see https://www.fws.gov/library/collections/threats-birds.

In addition to MBTA and BGEPA, Executive Order 13186: *Responsibilities of Federal Agencies to Protect Migratory Birds*, obligates all Federal agencies that engage in or authorize activities that might affect migratory birds, to minimize those effects and encourage conservation measures that will improve bird populations. Executive Order 13186 provides for the protection of both migratory birds and migratory bird habitat. For information regarding the implementation of Executive Order 13186, please visit https://www.fws.gov/partner/council-conservation-migratory-birds.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Code in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List

OFFICIAL SPECIES LIST

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

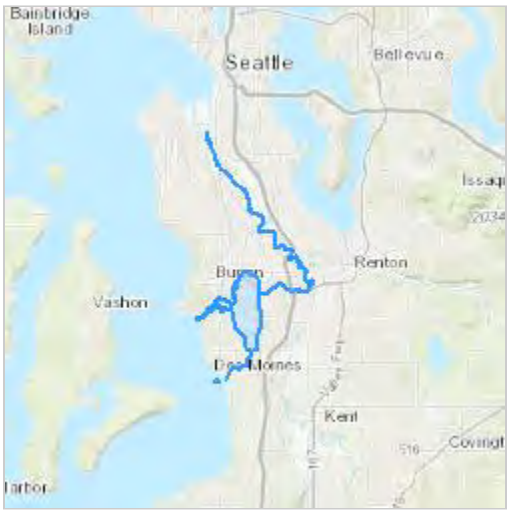
This species list is provided by:

Washington Fish And Wildlife Office
510 Desmond Drive Se, Suite 102
Lacey, WA 98503-1263
(360) 753-9440

PROJECT SUMMARY

Project Code: 2024-0081720
Project Name: Seattle-Tacoma International Airport: SAMP NTPs and PSPs
Project Type: Airport - Maintenance/Modification
Project Description: Species list request for updated 2024 SAMP NTP and PSP projects. Revised action area reflects expanded project list and potential for exposure to 6PPD-Q in stormwater and industrial wastewater discharge.
Project Location:

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@47.40305635,-122.33736132583623,14z



Counties: King County, Washington

ENDANGERED SPECIES ACT SPECIES

There is a total of 6 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

---

1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

MAMMALS

NAME	STATUS
North American Wolverine *Gulo gulo luscus*	Threatened

No critical habitat has been designated for this species.
Species profile: https://ecos.fws.gov/ecp/species/5123

BIRDS

NAME	STATUS
Marbled Murrelet *Brachyramphus marmoratus*	Threatened

Population: U.S.A. (CA, OR, WA)
There is **final** critical habitat for this species. Your location does not overlap the critical habitat.
Species profile: https://ecos.fws.gov/ecp/species/4467

Yellow-billed Cuckoo *Coccyzus americanus*	Threatened

Population: Western U.S. DPS
There is **final** critical habitat for this species. Your location does not overlap the critical habitat.
Species profile: https://ecos.fws.gov/ecp/species/3911

REPTILES

NAME	STATUS
Northwestern Pond Turtle *Actinemys marmorata*	Proposed Threatened

No critical habitat has been designated for this species.
Species profile: https://ecos.fws.gov/ecp/species/1111

FISHES

NAME	STATUS
Bull Trout *Salvelinus confluentus*	Threatened

Population: U.S.A., coterminous, lower 48 states
There is **final** critical habitat for this species. Your location overlaps the critical habitat.
Species profile: https://ecos.fws.gov/ecp/species/8212

INSECTS

NAME	STATUS
Monarch Butterfly *Danaus plexippus*	Candidate

No critical habitat has been designated for this species.
Species profile: https://ecos.fws.gov/ecp/species/9743

CRITICAL HABITATS

There is 1 critical habitat wholly or partially within your project area under this office's jurisdiction.

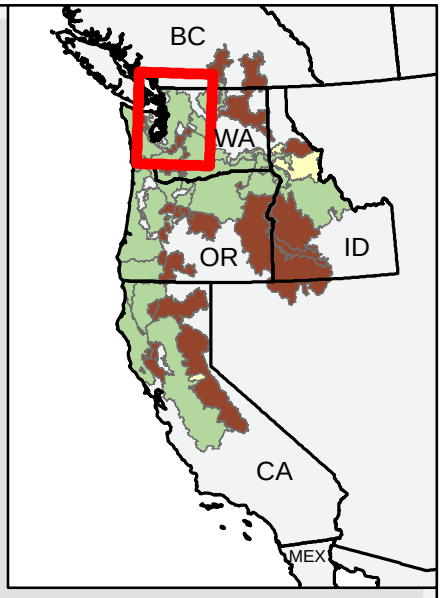
NAME	STATUS
Bull Trout *Salvelinus confluentus* https://ecos.fws.gov/ecp/species/8212#crithab	Final

IPAC USER CONTACT INFORMATION

Agency:	Federal Aviation Administration
Name:	Eric Doyle
Address:	146 N Canal St
Address Line 2:	Suite 111
City:	Seattle
State:	WA
Zip:	98103
Email	eric.doyle@confenv.com
Phone:	2063217314

Puget Sound Chinook Salmon Evolutionarily Significant Unit

Current as of January 2015



Nooksack River
North Fork Nooksack River
Bellingham
Skagit River
North Fork Stillaguamish River
South Fork Stillaguamish River
Port Angeles
Glines Canyon Dam
Dungeness River
Elwha River
Everett
Sultan River
Snohomish R.
North Fork Skykomish River
Skykomish River
Dosewallips River
Seattle
Cushman Dam
SF Skokomish R.
North Bend
Green River
Howard Hanson Dam
Tacoma
Puyallup River
Olympia
Nisqually River
La Grande Dam

County Boundary

Class

ESU Boundary

Historical Watershed: Anthropogenically Blocked

N

0 22.5 Kilometers

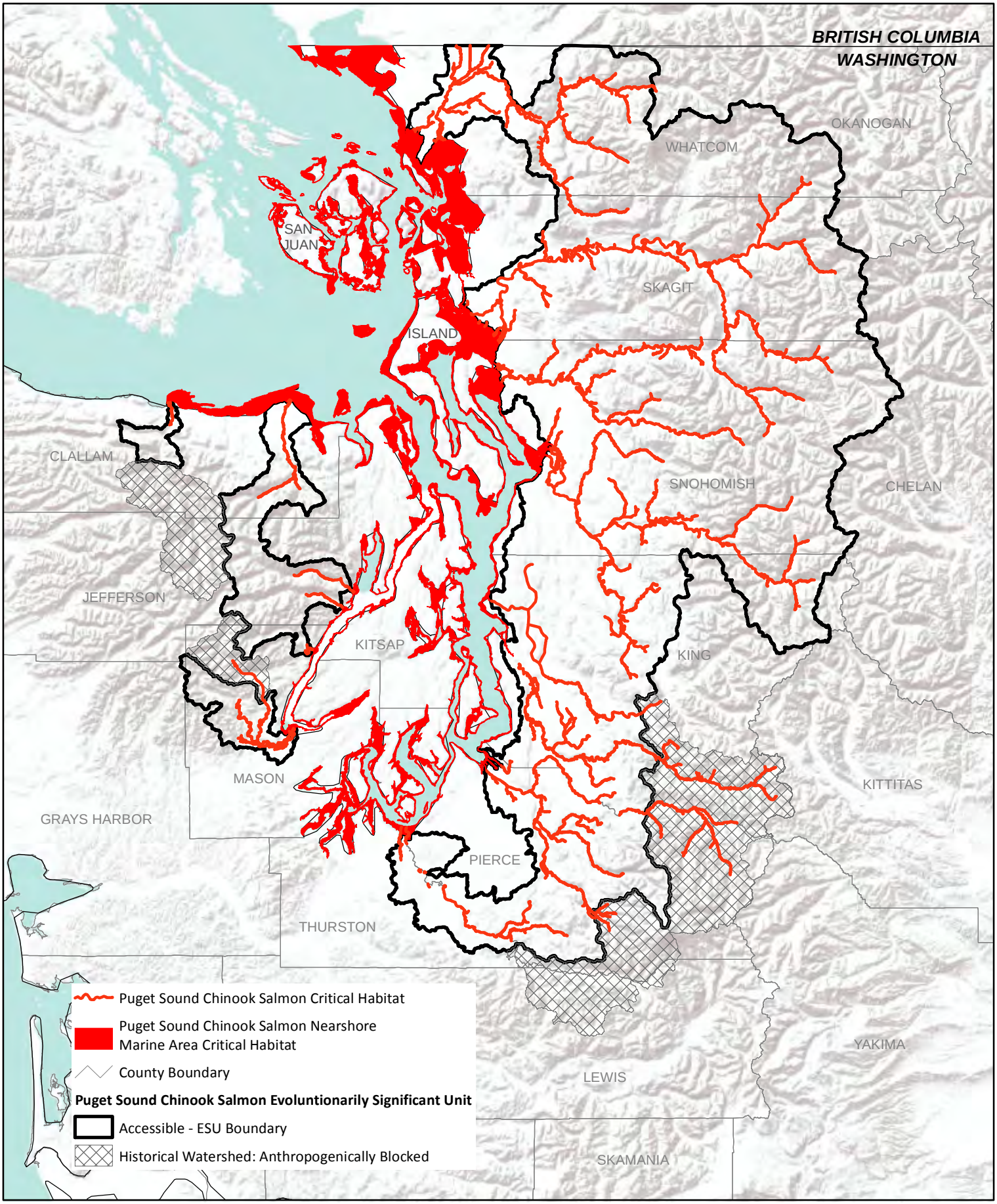
0 22.5 Miles

Map is for general reference only

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmoshperic Administration
NATIONAL MARINE FISHERIES SERVICE
PROTECTED RESOURCES DIVISION
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232

NOAA FISHERIES

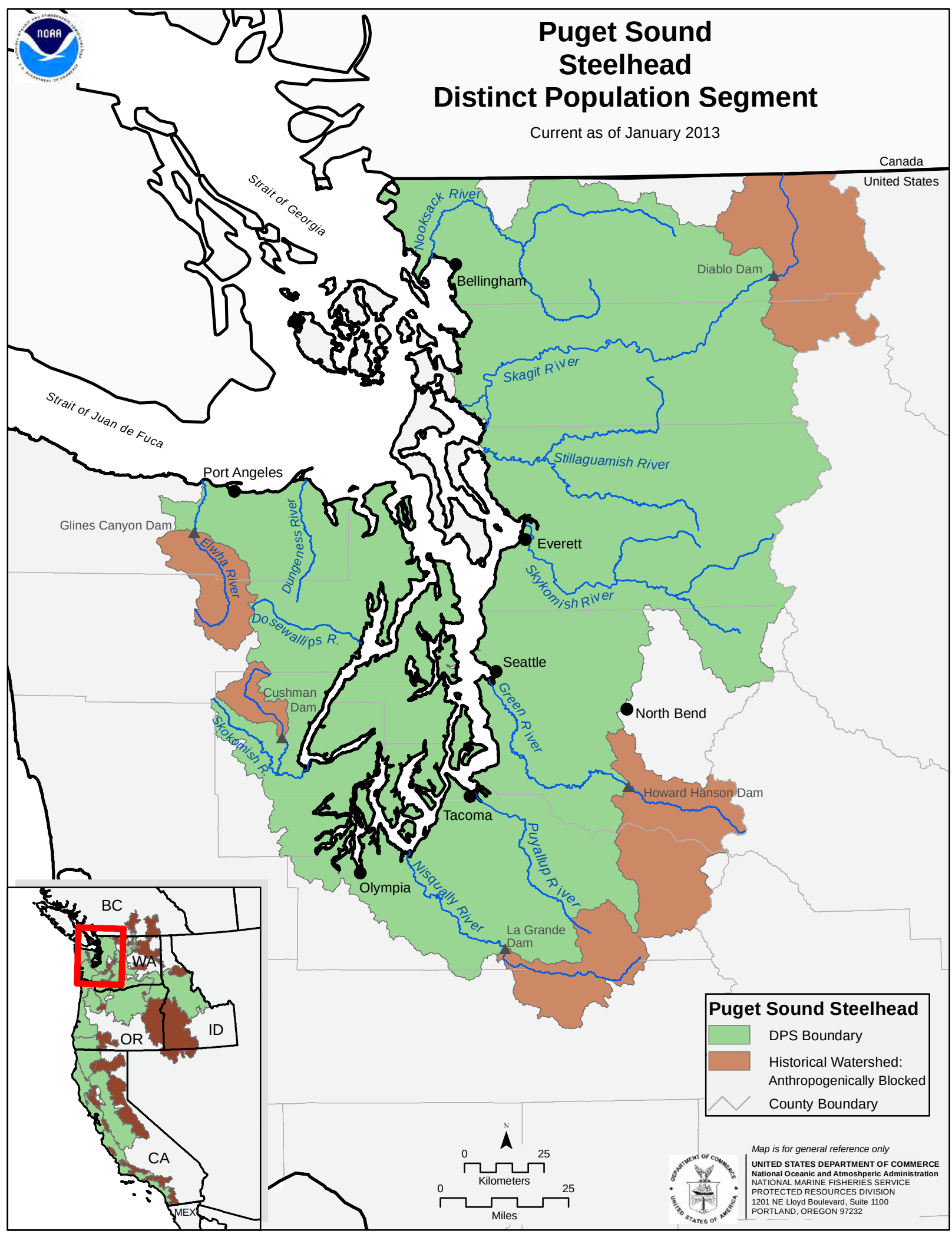
Critical Habitat
Puget Sound Chinook Salmon



0 50 Miles

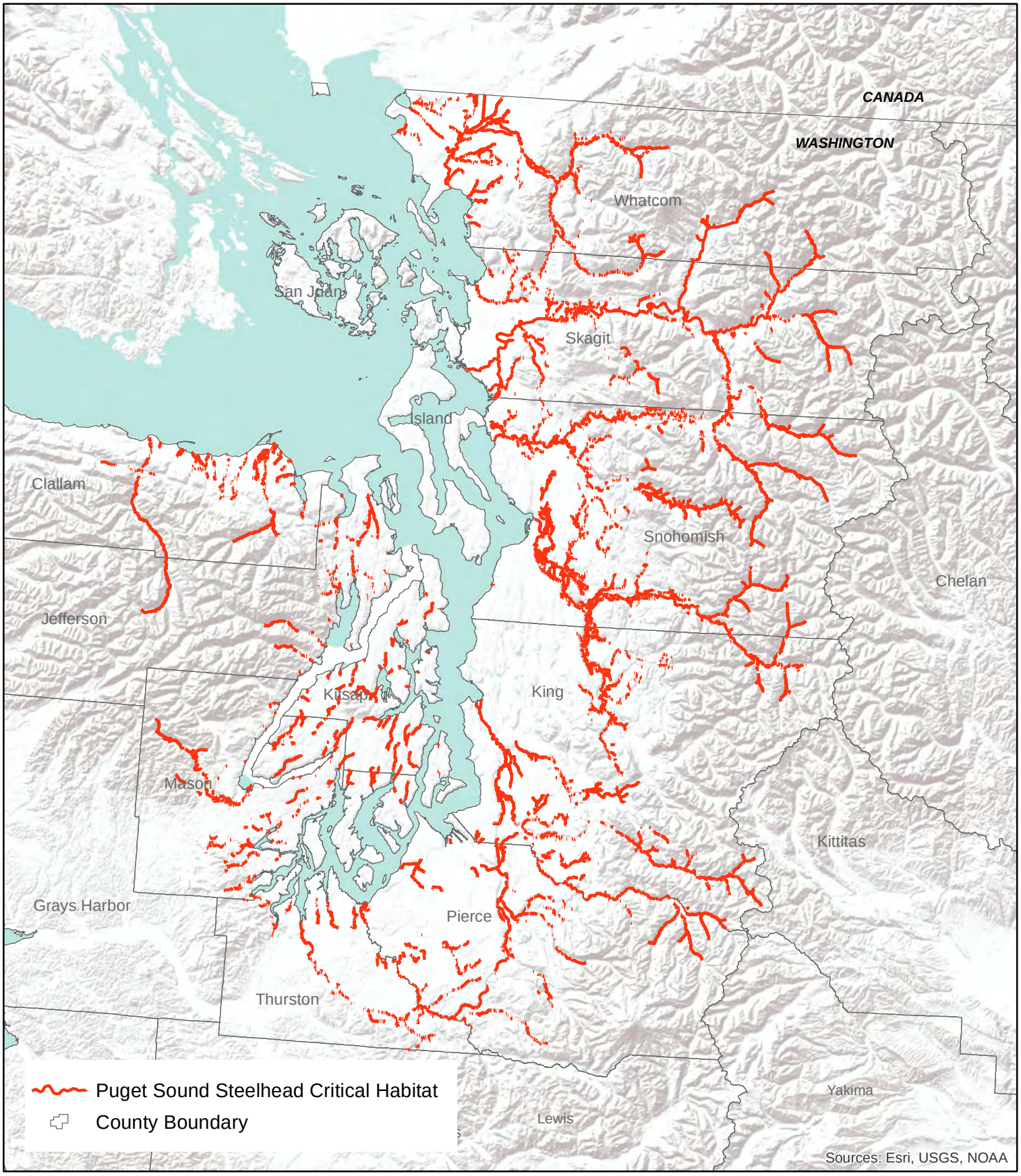
See Federal Register Notice for detailed description of critical habitat (70 FR 52630)

DOC-NOAA Fisheries-West Coast Region


Puget Sound
Steelhead
Distinct Population Segment
Current as of January 2013
Canada
United States
Strait of Georgia
Strait of Juan de Fuca
Nooksack River
Bellingham
Diablo Dam
Skagit River
Stillaguamish River
Port Angeles
Glines Canyon Dam
Elwha River
Dungeness River
Everett
Skykomish River
Dosewallips R.
Seattle
Cushman Dam
Skokomish R.
Green River
North Bend
Howard Hanson Dam
Tacoma
Puyallup River
Olympia
Nisqually River
La Grande Dam
BC
WA
OR
ID
CA
MEX
Puget Sound Steelhead
DPS Boundary
Historical Watershed: Anthropogenically Blocked
County Boundary
N
0
25
Kilometers
0
25
Miles
Map is for general reference only
UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmoshperic Administration
NATIONAL MARINE FISHERIES SERVICE
PROTECTED RESOURCES DIVISION
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232

NOAA FISHERIES

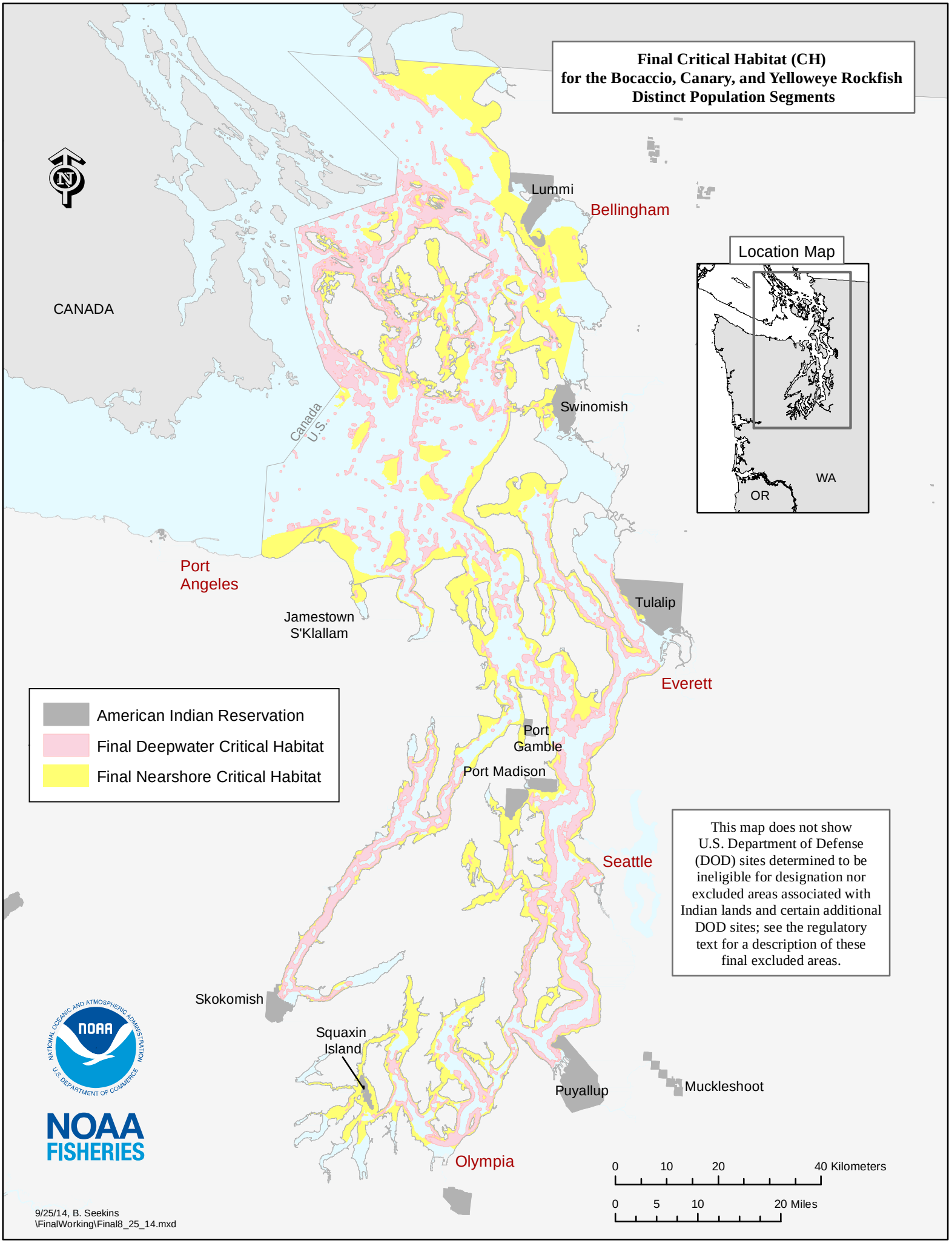
Final Critical Habitat
Puget Sound Steelhead



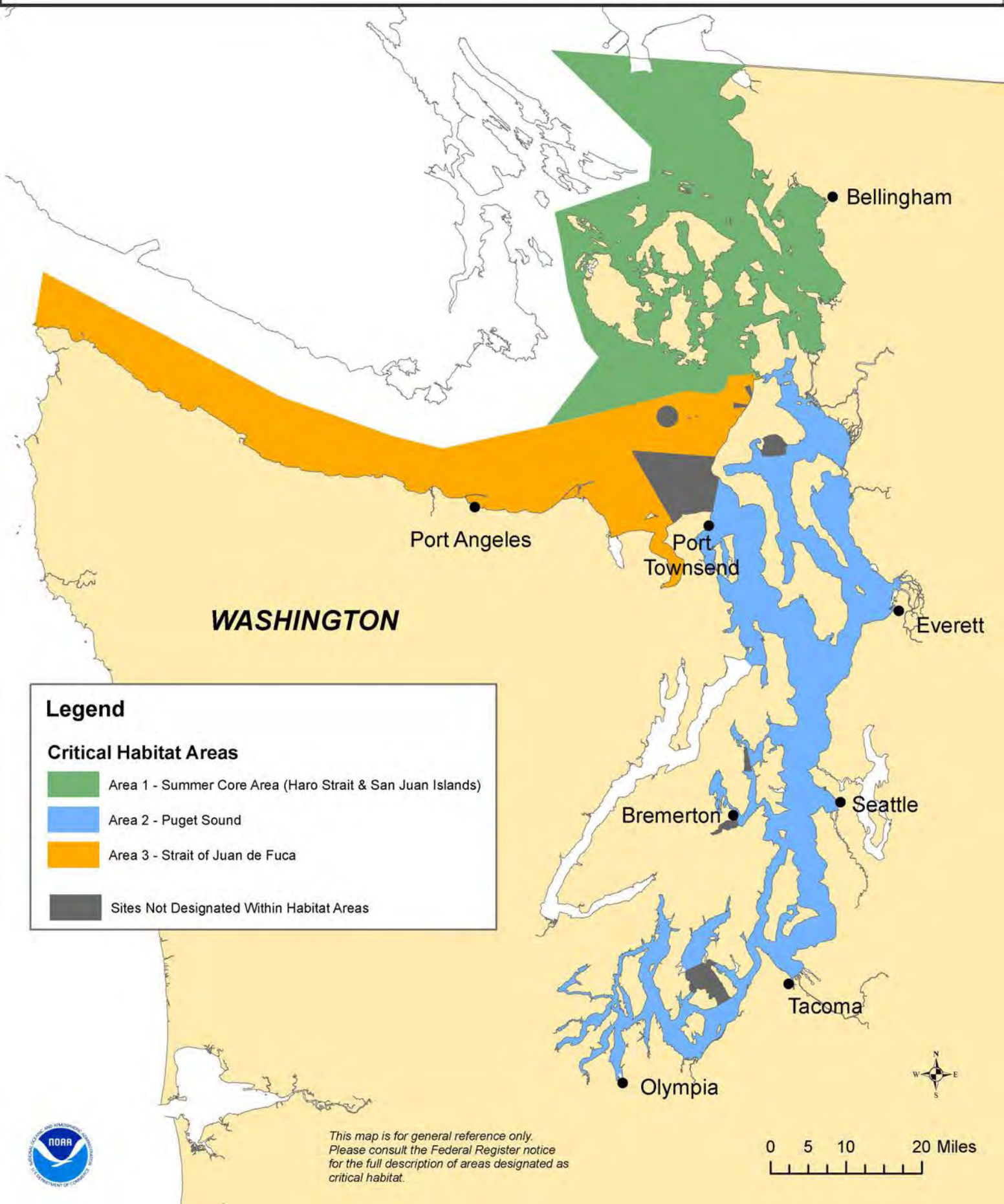
N

0 3.5 7 14 Miles

See Federal Register notice for detailed description of critical habitat (81 FR 9252, February 24, 2016)
DOC-NOAA Fisheries-West Coast Region


Final Critical Habitat (CH)
for the Bocaccio, Canary, and Yelloweye Rockfish
Distinct Population Segments
CANADA
Lummi
Bellingham
Location Map
WA
OR
Swinomish
Canada
U.S.
Port
Angeles
Jamestown
S'Klallam
Tulalip
Everett
American Indian Reservation
Final Deepwater Critical Habitat
Final Nearshore Critical Habitat
Port
Gamble
Port Madison
Seattle
This map does not show U.S. Department of Defense (DOD) sites determined to be ineligible for designation nor excluded areas associated with Indian lands and certain additional DOD sites; see the regulatory text for a description of these final excluded areas.
Skokomish
Squaxin
Island
Puyallup
Muckleshoot
Olympia
NOAA
FISHERIES
0 10 20 40 Kilometers
0 5 10 20 Miles
9/25/14, B. Seekins
\FinalWorking\Final8_25_14.mxd

Designated Critical Habitat for Southern Resident Killer Whales
November 2006
NOAA Fisheries, Northwest Region



This map is for general reference only. Please consult the Federal Register notice for the full description of areas designated as critical habitat.

Appendix B

SEA Water Quality Compliance Monitoring

IWS
PERMIT LIMITS

NPDES LIMITS

TABLE S1-1. IWS FLOW EFFLUENT LIMITS

OUTFALL 001 DISCHARGE TO PUGET SOUND		
Parameter	**Monthly Average**	**Maximum Daily**
Biochemical Oxygen Demand (BOD_5) November through March	45 mg/L	2665 lbs/day
Biochemical Oxygen Demand (BOD_5) April through October	25 mg/L	1480 lbs/day
Total Suspended Solids (TSS)	21 mg/L	33 mg/L
Oil and Grease as NWTPH-Dx	8 mg/L	15 mg/L
pH [b]	Daily minimum is equal to or greater than 6, and the daily maximum is less than 9.	

Footnotes:

[a] The monthly average effluent limits is based on the arithmetic mean of the samples taken during a calendar month.

[b] Indicates the range of permitted values. When pH is continuously monitored, excursions between 5.0 and 6.0, or 9.0 and 10.0 shall not be considered violations provided no single excursion exceeds 60 minutes in length and total excursions do not exceed 7 hours and 30 minutes per month. Any excursions below 5.0 and above 10.0 are violations. The instantaneous maximum and minimum pH must be reported monthly

S7. FACILITY LOADING

A. Design Criteria

Flows or waste loadings of the following design criteria for the permitted treatment facility must not be exceeded:

Daily Peak Flow @ Maximum Overflow Rate of 4.1 GPM/SF of Dissolved Air Flotation Surface Area	**7.1 MGD**

SANITARY SEWER
PERMIT LIMITS

Midway Sewer Discharge

TABLE S1-2: EFFLUENT LIMITS FOR MIDWAY SEWER DISCHARGE

Parameter	Average Monthly [a]	Maximum Daily [b]
Flow – GPD		
Boiler Blowdown - MBBD	1,000	15,000
Cooling Tower Blowdown - MTBD	18,000	250,000
Equipment Wash Rack Blowdown - EWBD	20,000	20,000
Bus Maintenance Facility Bus Wash & Chassis Blowdown - BWBD	4380	17,260
Oil and Grease – Equipment Wash Rack Blowdown, Bus Maintenance Facility Bus Wash & Chassis Blowdown	**N/A**	100 mg/L
pH – Equipment Wash Rack, Bus Maintenance Facility Bus Wash & Chassis Blowdown	Daily minimum is equal to or greater than 6, and the daily maximum is less than 9 standard units.	

[a] Daily flows averaged over a month.

[b] The maximum daily effluent limitation is defined as the highest allowable daily discharge. The daily discharge means the discharge of a pollutant measured during a calendar day. For pollutants with limits expressed in units of mass, the daily discharge is calculated as the total mass of the pollutant discharged over the day. For other units of measurement, the daily discharge is the average measurement of the pollutant over the day.

SDS
PERMIT LIMITS

TABLE 2S1-2: EFFLUENT LIMITS FOR INDUSTRIAL STORMWATER COMMON TO ALL OUTFALLS.

PARAMETER	DAILY MAXIMUM LIMITS - All Outfalls	SAMPLING FREQUENCY[1]		SAMPLING TYPE
		SDE4/S1, SDD05A, SDD05B	All Other Outfalls	
Turbidity[3]	25 NTU	2/Qtr	1/Qtr	Grab
pH	Between 6.5 - 8.5 S.U.	2/Qtr	1/Qtr	Grab
pH[4]	6.3 to 9.0 S.U. for outfalls SDN3A, SDW1A, SDW1B and SDW2	2/Qtr	1/Qtr	Grab
Oil and Grease (by NWTPH-Dx)	15 mg/L	2/Qtr	1/Qtr	Grab
Oil and Grease	No Visible Sheen	2/Qtr	1/Qtr	Visual
Ammonia[5]	14.7 mg/L	2/Qtr	1/Qtr	Comp[2]
Nitrate/Nitrite as N[5]	0.68 mg/L	2/Qtr	1/Qtr	Comp[2]
Priority Pollutants[6]	Report	2/year in year 3 of the permit		Comp[2]

TABLE 2S1-3: SITE SPECIFIC EFFLUENT LIMITS FOR INDUSTRIAL STORMWATER

PARAMETER	DAILY MAXIMUM LIMITS - Outfalls by Receiving Water						SAMPLING FREQUENCY[1]		SAMPLING TYPE
	Des Moines Creek - East Branch	Lake Reba	Northwest Ponds		Miller Creek	Walker Creek			
	SDE4/S1, SDD06A, SDD05A, SDD05B	SDN1, SDN2/3/4	SDS3/5, SDS6/7	SDS4	SDN3A, SDW1A, SDW1B	SDW2	SDE4/S1, SDD05A, SDD05B	All Other Outfalls	
Total Copper (µg/L)	25.6	28.5	32.2	32.2	59.2	47.9	2/Qtr	1/Qtr	Comp[2]
Total Zinc (µg/L)	117	117	117	71.4	117	117	2/Qtr	1/Qtr	Comp[2]

[1] Sampling frequency for new outfalls SDD05A and SDD05B (upon activation) is 2 storms/quarter, the second sample is required for a discharge at least 24 hours after the first. Sampling frequency for outfall SDE4/S1) is 2 storms/quarter for period (October – June) and 1 storm/quarter for period (July – September).

[2] Flow-weighted composite

[3] Turbidity effluent limits are at the end of the pipe. When this limit is exceeded, Permittee may conduct in-stream sampling (i.e., upstream and downstream) to assess turbidity and evaluate its compliance with water quality criteria.

[4] pH as low as 6.3 and as high as 9.0 shall not be considered a violation if results of concurrent sampling at the point of complete mix within the receiving water indicates pH range of 6.5 - 8.5 S.U.

[5] Required only if urea is applied. If urea is not applied, Permittee must certify it.

[6] See Appendix A to identify the specific pollutants in the priority pollutant groups listed. The Permittee must take samples twice per year, once during wet season and once during dry season in year 3 of the permit cycle, and submit the report to Ecology 180 days prior to permit expiration in conjunction with permit application.

CSW
PERMIT LIMITS

TABLE 2

EFFLUENT LIMITS	
Parameter	**Maximum Daily [a]**
Turbidity	**Turbidity in the** receiving water **must not exceed 5 nephelometric turbidity units (NTU) over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU.**[b]
Turbidity [c] (Batch or Continuous Treatment)	The maximum daily average must not exceed 5 NTU. [d]
Total Petroleum Hydrocarbons	5 mg/L - No visible sheen at any time [e]
pH (Batch or Continuous Treatment)	In the range of 6.5 to 8.5
pH [f]	In the range of 6.5 to 8.5 – With the human-caused variation within the above range of less than 0.2 units.

[a] The maximum daily effluent limitation is defined as the highest allowable daily discharge.

[b] In the **receiving water** here means at the point of complete mix to be determined by the Permittee.

[c] The treatment referred here is for batch or continuous treatment as specified by the DOE-SWMM, DOE Stormwater Treatment Technologies Approved through TAPE or CTAPE.

The average daily effluent limitation is based on the arithmetic mean of number of samples taken per day from the continuous discharge, or in case of batch treatment, based on the number of batch discharged per day.

[d] The maximum daily average is defined as maximum value of daily averages taken during a calendar month.

[e] TPH numerical limit must be applied and a sample must be taken only when visible sheen is observed. The numerical limit will not apply when there is no visible sheen observed.

[f] Indicates the range of permitted values. In the receiving water here means at the point of complete mix to be determined by the Permittee.

Footnotes:

(1) The method detection level (MDL) for turbidity is 1 NTU using a turbidimeter and Method Number 180.1 from 40 CFR Part 136 or *Standard Methods for the Examination of Water and Wastewater*, 18th Edition, 2130.

(2) The MDL for total petroleum hydrocarbons in 0.1 mg/L using Gas Chromatography and Flame Ionization Detector (FID) and method number Northwest Diesel (WTPH-D) from Washington State Department of Ecology Method WTPH-D. The quantitation level (QL) for TPH-D is 0.5 mg/L (5 x MDL).

Appendix C

Impacts Assessment for Aquatic Critical Areas

Parametrix
let's create tomorrow, together

Technical Memorandum

DATE:	May 22, 2024
TO:	Adele Pozzuto and Steve Rybolt, Port of Seattle
FROM:	Kaylee Moser, PWS and Josh Wozniak, PWS
SUBJECT:	Sustainable Airport Master Plan (SAMP) Impacts Assessment for Aquatic Critical Areas
CC:	Sarah Potter and Erik Schwenke, Landrum & Brown
PROJECT NUMBER:	553-2912-002
PROJECT NAME:	Sustainable Airport Master Plan (SAMP)

This memo describes estimated project impacts to aquatic critical areas based on the current designs for the Near-Term Projects (NTP). Impacts were calculated by overlaying the footprint of these NTPs and associated utility features provided by Landrum & Brown with mapped aquatic critical areas. Sources of mapped aquatic critical areas used in this analysis include:

- Wetland and streams delineated within the study areas (Parametrix 2024).
- Wetland and stream mapping provided by the Port for areas outside of the delineation study areas.
- Wetland and stream buffers created in compliance with SeaTac Municipal Code
- Wellhead protection areas and floodplains sourced from King County, City of SeaTac (SeaTac) and the Federal Emergency Management Agency (FEMA).

Impact assessments are based on the overlap between these GIS datasets and the NTP footprints. This memo provides only the spatial overlay of the projects with these features, pending further design refinement or technical studies. This memo and impact assessment provides information to the planning and design team, alerting them to potential aquatic critical area issues within certain portions of the NTP footprints.

Critical Areas Jurisdiction

The Port has its own jurisdiction over critical areas, and activities that affect critical areas at the Airport are not subject to municipal permit review. However, the Port substantially complies with local critical area codes to the extent practicable. The 2018 Port-SeaTac Interlocal Agreement (ILA) states that the City of SeaTac critical area regulations and standards shall apply to Port projects on Port property within the Airport Activity Area (AAA), with the exception of certain situations listed within the ILA (Port of Seattle 2018). The major exception is that if 401/404 or Hydraulic Project Act permitting is required for a project, the City's critical area regulations shall not apply. The Port administers permitting under these provisions for projects within the AAA as indicated by the 2018 Port-SeaTac ILA. The City implements critical area standards for Port projects on property outside the AAA. The Port will administer all of the critical areas permits except for projects in the North Study Area Zone, which is within City of SeaTac jurisdiction. This portion of the study area is directly north of State Route (SR) 518 (See Figure 1-1 Vicinity Map in Attachment A).

The City of SeaTac regulates the following aquatic critical areas under Chapter 15.700:

- Flood hazard areas
- Wetlands
- Stream
- Wellhead protection areas (WHPAs)
- Fish and wildlife habitat conservation areas

Overview of Project Impacts to Aquatic Critical Areas

The mapped aquatic critical areas within the study area include wetland, stream, floodways, WHPAs, and fish and wildlife habitat conservation areas. These layers were mapped by Parametrix or downloaded from the GIS data sites of government agencies, including the City of SeaTac, King County, and FEMA. The NTP footprints do not have any impacts on the mapped floodway or 100-year floodplain, nor are impacts to fish and wildlife habitat conservation areas anticipated to occur. The NTP footprints, utility lines, and stormwater ponds do have impacts to WHPAs, jurisdictional tributaries, wetlands, streams, and their associated buffers. Three WHPAs are mapped within the study area. The impacts to WHPAs were calculated based on a 10- year contaminant travel time. Wetlands and streams mapped within the study area were delineated between September and December 2019 and in March 2020, with a wetland and waters verification in January 2024. The mapped wetlands and streams within the study area drain into the Miller/Walker Creek, Gilliam Creek/Lower Green River, and Des Moines Creek drainage basins.

The NTPs are divided into five project groups: Airfield Operational Efficiency Projects, Airfield Safety/Standards Projects, Cargo Expansion Projects, North Terminal Projects, and Sustainable Aviation Fuel Projects. There is also associated utility infrastructure, including new stormwater ponds and 10 types of utility lines to be installed for the projects. Only the project elements that have impacts to aquatic critical areas are discussed in this memorandum. Permanent impacts to aquatic critical areas from utility line installation were calculated based on a 20- foot-wide buffer polygon applied to individual utility lines. Access roads are assumed to be 30 feet wide, with 5 feet of temporary disturbance on each side during construction, except in the vicinity of the Miller Creek crossing, where temporary disturbance extends to the limits of a covenant boundary that restricts impacts (20-50 feet). Temporary construction impact areas to critical areas were calculated based on a 50-foot buffer polygon applied to NTP footprints and stormwater ponds.

Impacts were specifically calculated so that there was no double counting for project elements that overlap spatially. In particular, for areas where permanent impacts from NTPs and utility lines overlapped, permanent “impact values” (acreages of impact) were assigned to the NTPs. As an example, consider a theoretical NTP served by an upgraded water line. The NTP would impact 0.5 acres of wetland. The new theoretical water line would impact 0.1 acre of the wetland inside the NTP footprint. Therefore, the water line impact would not be counted because it has already been included as an NTP impact. For areas where permanent impacts from new stormwater ponds and utility lines overlapped, permanent impact values were assigned to stormwater ponds. Where permanent and temporary buffer impacts overlapped, impact values were assigned to the project element that was permanent.

Table 1 summarizes the total permanent and temporary construction impacts for the NTP footprints, utility lines, and stormwater ponds within critical areas and associated buffers. Tables 2, 3, and 4 provide further details on permanent and temporary impacts for NTP footprints, utility lines, and stormwater ponds. In Tables 1 and 4 stream buffer impacts overlap wetland buffer impacts in some

areas but are accounted for separately. Also, all buffers have existing development such as buildings and impervious surfaces clipped out for the impact analysis.

See Attachment A for Figures 1-1 through 1-6d, displaying a vicinity map and the location of NTP footprints, utilities, stormwater ponds, and impacts to aquatic critical areas.

Table 1. Overview of Impacts to Aquatic Critical Areas and Buffers (acres)

Aquatic Critical Areas and Buffers	Permanent Impacts	Temporary Impacts
Stream/Jurisdictional Tributaries	0.02	0.08
Stream Buffer	0.12	0.20
Wetland	0.79	0.21
Wetland Buffer	2.66	3.43
Wetland, Stream and Buffer Total	**3.59**	**3.92**
Wellhead Protection Area	52.10	7.55

The current project design results in a total of 0.79 acres of permanent wetland impacts for all NTP footprints, utility lines, and stormwater ponds. Permanent stream/ jurisdictional tributary impacts—associated with the West Maintenance Campus access road—total 0.02 acre. Permanent wetland and stream buffer impacts total 2.66 acres and 0.12 acre, respectively. Temporary construction impacts, which would be restored after construction is complete, total 3.92 acres for wetland, stream, and buffer. Projects would protect WHPAs from groundwater contamination, as required by the State of Washington Department of Health. Based on the current spatial analysis, permanent WHPA impacts are estimated at 52.10 acres, with temporary construction impacts totaling 7.56 acres. Additional analysis of WHPA impacts will be conducted during design development for individual projects, and specific measures to protect WHPAs will be integrated into project designs as appropriate.

Permanent Impacts

Permanent project impacts are a result of excavation and fill to construct the NTPs, associated utility lines, and stormwater ponds. Permanent impacts for utility lines were calculated based on an assumption of a 20-foot-wide buffer polygon, as discussed with Landrum & Brown. Project impacts are a combination of impacts from the NTPs, as well as associated infrastructure. Impacts for NTP projects and associated infrastructure are broken down and described below.

The NTP footprints permanently impact a total of 0.23 acre of wetland and 2.31 acres of wetland buffer. Additionally, the NTP footprints permanently impact 0.01 acre of stream and impact 0.07 acre of stream buffer.

Associated infrastructure improvements (utility lines and stormwater ponds) permanently impact 0.56 acres of wetlands and 0.35 acres of wetland buffer. The infrastructure projects permanently impact 0.05 acre of stream buffer and 0.01 acre of streams/ jurisdictional tributaries. See Figure 1-4 for locations of permanent NTP impacts and Figure 1-5 for permanent utility/stormwater impacts.

Table 2 details the impacts to critical areas and buffers for individual project elements and sums up permanent impacts. Only the individual projects that have impacts to aquatic critical areas are listed.

Table 2. Permanent Impacts to Aquatic Critical Areas and Buffers (acres)

Project Element	Streams/ Jurisdictional Tributaries	Stream Buffer	Wetland	Wetland Buffer	WHPAs
Employee Parking Structure	--	--	0.02	0.60	--
Fuel Farm Expansion	--	--	0.21	0.01	--
North GT Holding Lot	--	--	--	--	5.02
Off-site Cargo PH 1 (L-Shape)	--	--	--	--	34.08
Off-site Cargo PH 2 (L-Shape)	--	--	--	--	3.17
Taxiway A/B Extension	--	--	--	--	6.12
Westside Maintenance Campus	0.01	0.07	<0.01	1.70	--
NTP Projects Subtotal	***0.01***	***0.07***	***0.23***	***2.31***	***48.39***
Stormwater Pond (Miller Creek detention pond)	--	--	0.55**	--	--
Stormwater Pond (Pond M)	--	--	--	0.11	--
Stormwater Pond (Pond F detention pond)	--	--	--	<0.01	--
Stormwater Pond (SDS4 pond)	--	--	--	<0.01	0.13
Sanitary Sewer Lines	--	--	--	0.01	2.24
Storm Lines	0.01	0.05	0.01	0.23	1.33
Water Lines	--	--	--	--	--
Infrastructure Improvements Subtotal	***0.01***	***0.05***	***0.56***	***0.35***	***3.71***
Grand Total*	***0.02***	***0.12***	***0.79***	***2.66***	***52.10***

Impacts values in the table are rounded from more detailed calculations. The grand total is rounded from the calculated grand total, not the sum of the individualrounded values presented in the table.
** Future design may include a vault, reducing or eliminating this impact.

Table 3 below summarizes all permanent wetland impacts by project element and Wetland ID (as identified in the Port wetland GIS layers and the 2024 Parametrix report).

Table 3. Permanently Impacted Wetlands

Project Element	Wetland Impact (acre)	Wetland ID	2014 Ecology Rating [a]
Employee Parking Structure	0.02	Wetland A	III
Westside Maintenance Campus	<0.01	Wetland 39	III
Stormwater Pond (Miller Creek detention pond)	0.55**	Wetland A20	III
Fuel Farm Expansion	0.21	Wetland E1	III
Storm (UMP Line)	<0.01	Wetland A14	III
	0.01	Wetland 44	II
	<0.01	Wetland A20	III
	<0.01	Wetland R13	II
	<0.01	Wetland R14a	II
Grand Total*	***0.79***		

[a] Hruby and Yahnke 2023
* Impacts values in the table are rounded from more detailed calculations. The grand total is rounded from the calculated grand total, not the sum of theindividual rounded values presented in the table.** Future design may include a vault, reducing or eliminating this impact.

Wetlands having the greatest permanent impact include Wetland E1, Wetland A20, and Wetland A. Wetland E1 is a Category III wetland permanently impacted by the Fuel Farm Expansion project within the Sustainable Aviation Fuel Project group (See Figure 1-6c in Attachment A). This wetland would be entirely impacted. Wetland A20 is a Category III wetland located near the WMC project and is fully permanently impacted by UMP projects including a stormwater pond (See Figure 1-6d in

Attachment A). Wetland A is a Category III wetland also located at the north end of the study area and is permanently impacted by the Employee Parking Structure (See Figure 1-6a in Attachment A).

More detailed information on these wetlands can be found within the Seattle-Tacoma International Airport Sustainable Airport Master Plan (SAMP) Near Term Projects Wetlands and Streams Report (Parametrix 2024).

Temporary Construction Impacts

Temporary construction impacts would occur where aquatic critical areas or buffers are affected by clearing and ground-disturbing work but are revegetated following construction. Temporary construction impacts were calculated based on the assumption of a 50-foot buffer polygon applied to NTP footprints and stormwater ponds, as discussed with Landrum & Brown. The temporary construction impacts for the WMC access road were calculated based on a 5- foot buffer from the edge of the road. At the Miller Creek stream crossing, the temporary construction impacts were extended to meet the boundaries of the restrictive covenant on either side of the road. The duration of temporary construction impacts is unknown at this time, and, therefore, temporary construction impacts are not further divided into short-term versus long-term.

The temporary construction impacts for wetlands are 0.21 acre for NTP footprints. The utility infrastructure projects would have 0.70 acre of temporary wetland buffer impacts. Additionally, 130 linear feet of jurisdictional tributaries would be permanently impacted for the WMC, Miller Creek detention pond, and some proposed utility lines.

Table 4 details the impacts to critical areas and buffers for individual project elements and sums up the temporary construction impacts. Only the individual projects that have temporary impacts to critical areas and/or associated buffers are listed in this table.

Table 4. Temporary NTP Construction Impacts to Aquatic Critical Areas and Buffers (acres)

Project Element	Stream	Stream Buffer	Wetland	Wetland Buffer	WHPAs
Employee Parking Structure	--	--	0.04	0.55	0.31
Fuel Farm Expansion	0.07	--	0.07	0.35	--
North GT Holding Lot	--	--	--	--	0.24
Off-site Cargo PH 1 (L-Shape)	--	--	--	--	1.79
Taxiway A/B Extension	--	--	--	0.42	4.58
Westside Maintenance Campus	0.01	0.20	0.10	1.41	--
NTP Projects Subtotal	*0.08*	*0.20*	*0.21*	*2.73*	*6.92*
Stormwater Pond (Miller Creek detention pond)	--	--		--	--
Stormwater Pond (Pond F detentionpond)	--	--	--	0.11	--
Stormwater Pond (SDS4 Pond)	--	--	--	0.06	0.63
Stormwater Pond buffer (Pond M)	--	--	--	0.53	--
Infrastructure Improvements Subtotal	*–*	*–*		*0.70*	*0.63*
Grand Total*	*0.08*	*0.20*	*0.21*	*3.43*	*7.55*

* Impact values in the table are rounded from more detailed calculations. The grand total is rounded from the calculated grand total, not the sum of the individual rounded values presented in the table.

Discussion of Impacts by Project Element

The following sections describe impacts for each NTP group and detail individual projects within each group that impact aquatic critical areas and/or buffers. Details on the use and purpose of these individual projects were extracted from the SAMP Facilities Implementation and Financial Feasibility

Technical Memorandum No. 7 and Environmental Overview Technical Memorandum No. 8 (Leigh-Fisher 2018a, 2018b). Utility line and stormwater pond project impacts are also discussed in this section.

Cargo Expansion Projects

The Cargo Expansion Projects group contains three individual projects with impacts to aquatic critical areas and/or associated buffers. Construction of these projects could permanently and temporarily impact WHPAs, wetlands, and wetland/stream buffers.

Land use conversion within a WHPA presents the potential for impact if construction or operation of new projects could result in a release of contaminants to groundwater. However, these impacts can be avoided by project design and operational measures that minimize the risk of contamination. During the project design and permitting phase, detailed geotechnical and hydrogeological assessments will be developed to characterize the potential for groundwater contamination from the proposed projects. The potential of the proposed uses to release contaminants will then be assessed, and appropriate measures applied to minimize any risk of contaminant release. The City of SeaTac requires non-residential developments within WHPAs to submit hazardous material inventory sheets to the respective water district at a minimum of once every two years. In addition, a critical area report may be required with details regarding geologic and hydrogeologic characteristics of the site, groundwater depth, and available historic water quality data. The Port will work with the relevant authorities to comply with all applicable requirements to avoid and/or minimize the potential for contamination.

- Off-site Cargo Phase 1 (L-Shape) – The building would provide warehouse and office space, truck terminals, and parking for visitors and employees. This NTP is located within the WHPA in the northern portion of the Port property. The project results in 34.08 acres of permanent land use conversion in the WHPA and 1.79 acres of temporary construction impacts to the WHPA.
- Off-site Cargo Phase 2 (L-Shape) – The building would provide warehouse and office space, truck terminals, and parking for visitors and employees. This NTP is located within the WHPA in the northern portion of the Airport. The project would result in 3.17 acres of permanent land use conversion in the WHPA.
- Westside Maintenance Campus – This project would relocate the Aviation Maintenance Facility from its current location in the North Cargo area to allow for construction of the Hardstand (north) project. This project would result in 0.01 acre of permanent wetland impact to Wetland 39 and 1.70 acre of permanent wetland buffer impact. The access road into the WMC crosses over Miller Creek and would result in 0.01 acre of permanent stream impact and 0.07 acre of permanent stream buffer impact. Temporary wetland impacts would be 0.1 acre, and temporary wetland buffer impacts would be 1.41 acre (See Figure 1-6d in Attachment A). Temporary stream impact would be 0.01 acre, and temporary stream buffer impact would be 0.20 acre.

North Terminal Projects

The North Terminal Projects group contains two individual projects with impacts to critical areas and/or associated buffers. Construction of these projects could permanently and temporarily impact WHPAs, wetland, and wetland/stream buffer.

- Employee Parking Structure – A large new parking structure would be constructed on Port property adjacent to and west of the North Employee Parking Lot, directly north of SR 518. Construction of this project would result in impacts to Wetland A. Permanent wetland

impacts are 0.02 acre and permanent wetland buffer impacts are 0.60 acre. Temporary construction impacts to the wetland are 0.04 acre and temporary wetland buffer impacts are 0.55 acre. This project is directly adjacent to the WHPA in the northern portion of the Port property and would result in 0.31 acre of temporary construction impacts to the WHPA.

- North Ground Holding (GT) Lot – A new GT lot is needed replace the current lot displaced by the Elevated Busway. This project is located within the WHPA in the northern portion of the Airport. The project results in 5.02 acres of permanent impacts and 0.24 acre of temporary construction impacts to the WHPA.

Fuel Farm Expansion Projects

The Fuel Farm Expansion Projects group includes the Fuel Farm Expansion project, which would have impacts to critical areas and/or associated buffers. Construction of this project would permanently and temporarily impact wetland, stream, and wetland/stream buffer.

Fuel Expansion of the fuel farm would include four new settling tanks, 10 million additional gallons of storage capacity, an approximately 500,000 gallon blending tank, an approximately 100,000-gallon Sustainable Aviation Fuel receipt tank, and infrastructure to support these improvements. The project is located in the southeast portion of the Airport, near the East Fork of Des Moines Creek. Construction would permanently impact the entirety of Wetland E1. Permanent impacts would include 0.21 acre of wetland and 0.01 acre of wetland buffer (See Figure 1-6c in Attachment A).

Taxiway A/B Projects

The Taxiway A/B Projects group contains the Taxiway A/B Extension project, which would have impacts to critical areas and/or associated buffers. Construction of this project would temporarily impact wetland buffers and would require protecting wellhead areas from impacts of contaminant discharge.

The extension of Taxiways A and B to provide access to the south end of Runway 16L/34R includes construction of parallel taxiway connectors from Taxiway B to Runway 16L/34R and the relocation of Taxiway S by 310 feet southward. The project would also include glideslope modifications the construction of a new vehicle service road bridge over S 188th St. Construction would result in 6.12 acres of permanent land use conversion within WHPAs. Temporary impacts would include 0.42 acre of wetland buffer associated with Wetland G12 and 4.58 acres of WHPA.

Utility Lines

As currently designed, the project would result in 0.01 acre of permanent wetland impacts and 0.01 acre of permanent stream impacts associated with stormwater utility lines. Wetlands impacted would include Wetland 44, Wetland A14a, and Wetland A20, all located on the west side of the airport. Additionally, utility lines would result in 0.24 acre of permanent wetland buffer impact for storm and water lines, and 3.57 acres of permanent land use conversion within WHPAs for sanitary sewer and storm lines (See Figure 1-6d in Attachment A).

Stormwater Ponds

The current design for stormwater ponds would result in 0.55 acre of permanent wetland impact. Wetland A20 near the WMC footprint would be entirely impacted by the Miller Creek detention pond (See Figure 1-6d in Attachment A). As the design evolves, it is possible that a vault rather than a stormwater pond will be proposed, reducing or eliminating this impact. New stormwater ponds would result in 0.70 acre of temporary wetland buffer impacts. Stormwater ponds would result in 0.13 acre of permanent land use conversion within WHPAs and would temporarily impact 0.63 acres.

Indirect Impacts

Indirect impacts from construction of the NTPs listed previously may result in long-term wetland degradation from stormwater discharges and alteration in wetland hydrology; however, stormwater detention and treatment activities would minimize long-term indirect water quality impacts on wetlands. Indirect impacts from stormwater ponds may also result in minimal wetland hydrology alteration. For aquatic habitat, indirect impacts would be minimal given the surrounding areas near project impacts are heavily developed.

Mitigation, Avoidance, And Minimization Measures

The avoidance and minimization of impacts to wetlands, streams and buffers was a guiding principle for the preliminary project design. Additional avoidance and minimization measures would be implemented, as practical, as the project design continues to develop. The Port is exploring options to reduce permanent wetland and stream impacts associated with utility lines and to minimize buffer impacts. Additional strategies include minimizing vegetation clearing and restoring temporarily affected areas as soon after the initial impact as possible.

The Port would comply with standard specifications, best management practices (BMPs),[1] and applicable federal and state mitigation requirements during design, construction, and post-construction activities. The Port would meet all regulatory requirements and continue to meet or exceed avoidance and minimization measures related to these BMPs in adherence with federal and state regulations.

[1] BMPs include various methods and devices to control, remove, or reduce pollution, and are listed in the Airport's Stormwater Pollution Prevention Plan (https://www.portseattle.org/file-documents/sea-tac-stormwater-pollution-prevention-plan). BMPs include operational practices (e.g. training and spill prevention), structural controls (e.g. stormwater ponds and oil/water separators), and erosion and sediment controls (e.g. silt fence and filter strips).

For unavoidable permanent impacts to wetlands, streams, temporary impacts to wetlands lasting more than one year, and permanent impacts to associated buffers, the Port would develop a compensatory mitigation plan during the permitting phase in accordance with applicable federal and state requirements and guidelines. These guidelines are listed in the U.S. Army Corps of Engineers and EPA's Compensatory Mitigation for Losses of Aquatic Resources[2], and Ecology's interagency guidance contained in Wetland Mitigation in Washington State: Parts 1 and 2[3]. The Port anticipates that it is has capacity on its current property to construct all or most of the mitigation, while acknowledging that other mechanisms, such as purchasing mitigation credits from banks or in-lieu fee programs, ensure capacity is available to provide the required quantity of mitigation.

The mitigation plan would be developed following a mitigation sequencing approach based on a hierarchy of avoiding and minimizing adverse impacts through careful design, rectifying temporary impacts, and compensating for unavoidable adverse impacts. The specific portfolio of mitigation, including location, design, and timing of permitting and construction, would be developed concurrent with the progression of NTP construction designs, which would be required to adhere to mitigation sequencing guidelines.

In cooperation with resource agencies and tribes, the Port would develop plans to mitigate unavoidable effects of the project on wetlands, streams, and regulatory buffers on a watershed basis. To the extent possible, compensatory mitigation sites would be identified and compensated for lost values in kind. It may be necessary to use several sites and mitigation approaches, given the project size, complexity of identifying mitigation opportunities, and mitigation requirements. The project would adhere to the mitigation requirements, including replacement ratios, specified by federal regulators, state resource agencies, and local critical area codes. Stream impacts are included in the wetland mitigation calculations below.

The Port has seven sites within its ownership identified as being suitable for compensatory mitigation. Proposed mitigation approaches have been evaluated and described based on each sites' opportunities and potential (Anchor 2019). Six sites are within the airport and one site is located along the Green River in Auburn. They encompass over 150 acres and include potential for greater than 40 acres of wetland re-establishment, 11 acres of wetland enhancement, almost 8 acres of preservation, and 80 acres of buffer enhancement (Anchor QEA 2019).

The area needed for compensatory mitigation is dictated by federal and state guidance, with a minimum 1:1 compensation ratio required by the Corps. Some agencies use the credit/debit system (Hruby 2012) to evaluate mitigation is some situations. Table 5 provides a summary of the compensatory mitigation ratios recommended by an interagency review committee composed of the Corps, EPA, and Ecology (Ecology, et al 2021).

Table 5. Interagency Recommended Compensatory Mitigation Ratios for Wetland Impacts

Category and Type of Wetland	Creation or Reestablishment	Rehabilitation	Enhancement
Category I: Mature Forested	6:1	12:1	24:1
Category I: Based on Functions	4:1	8:1	16:1
Category II	3:1	6:1	12:1
Category III	2:1	4:1	8:1
Category IV	1.5:1	3:1	6:1

[2] 33 CFR Parts 325 and 332/ 40 CFR Part 230

[3] *Wetland Mitigation in Washington State Part 1: Agency Policies and Guidance (2021),* and *Part 2: Developing Mitigation Plans* (2006)

Table 6 provides a summary of the compensatory wetland mitigation area calculation anticipated to be requiredby the current preliminary design, based on the unavoidable, permanent impacts to wetlands and the required mitigation ratios. Buffer impacts are mitigated at a 1:1 ratio and would require 2.66 acres.

Table 6. Compensatory Wetland Mitigation Area Calculations

Project Element	Wetland Impact (acre/Rating)	Re-establishment Area Needed (acres)	Rehabilitation Area Needed (acres)	Enhancement Area Needed (acres)
Facilities	0.23/III	0.46	0.92	1.84
UMP Line	0.01/III	0.02	0.04	0.08
Utility Lines	0.01/II	0.03	0.06	0.12
StormwaterPonds	0.55/III	1.10	2.75	4.40
	Total Areas	**1.61**	**3.77**	**6.44**

Based on these calculations, the mitigation areas identified by the Port have sufficient capacity to provide theneeded compensatory mitigation for the anticipated impacts of the proposed action.

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Attachment A

Figures

West Study Area Zone

Runway Study Area Zone

South RSA Study Area Zone

East Study Area Zone

North RSA Study Area Zone

North Study Area Zone

Des Moines Creek

Miller Creek/ Walker Creek

Gilliam Creek/ Lower Green River

509

518

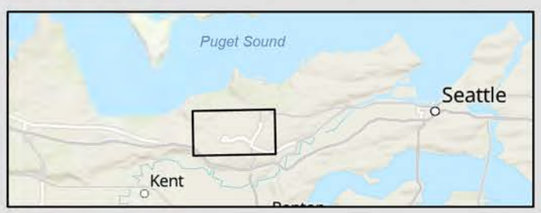
99

5

Parametrix

Date: 2/12/2024
Sources: King County, King County Aerial (2021)
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 0.13 0.25 0.38 0.5 Miles



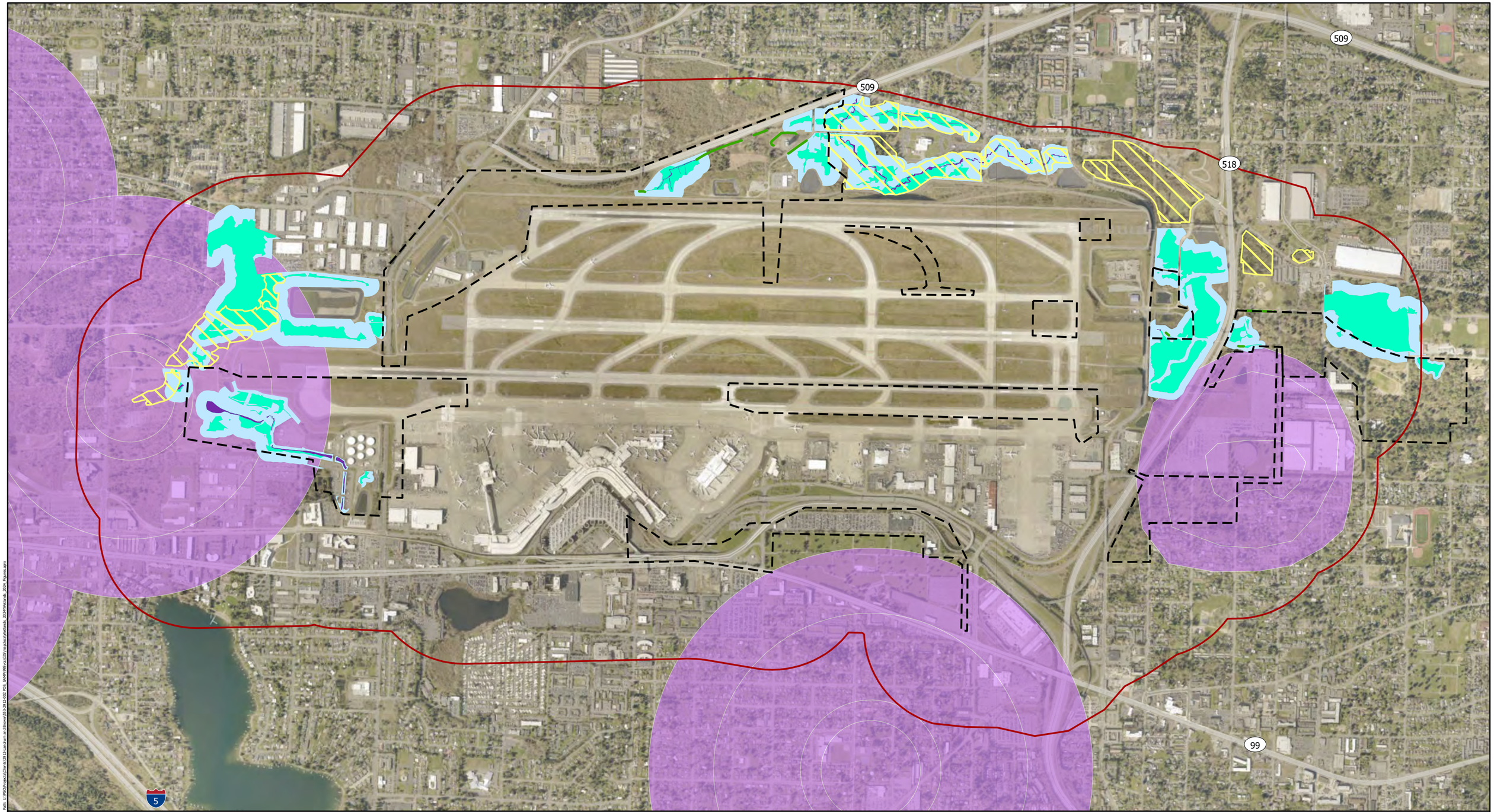
General Study Area
Field Survey Area

Drainage Basins
Des Moines Creek
Gilliam Creek/Lower Green River
Miller Creek/Walker Creek

Study Area Zones
East Zone
North RSA Zone
North Zone
Runway Zone
South RSA Zone
West Zone

Figure 1-1
Vicinity Map
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



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Parametrix

Date: 2/12/2024
Sources: King County, King County Aerial (2021)
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

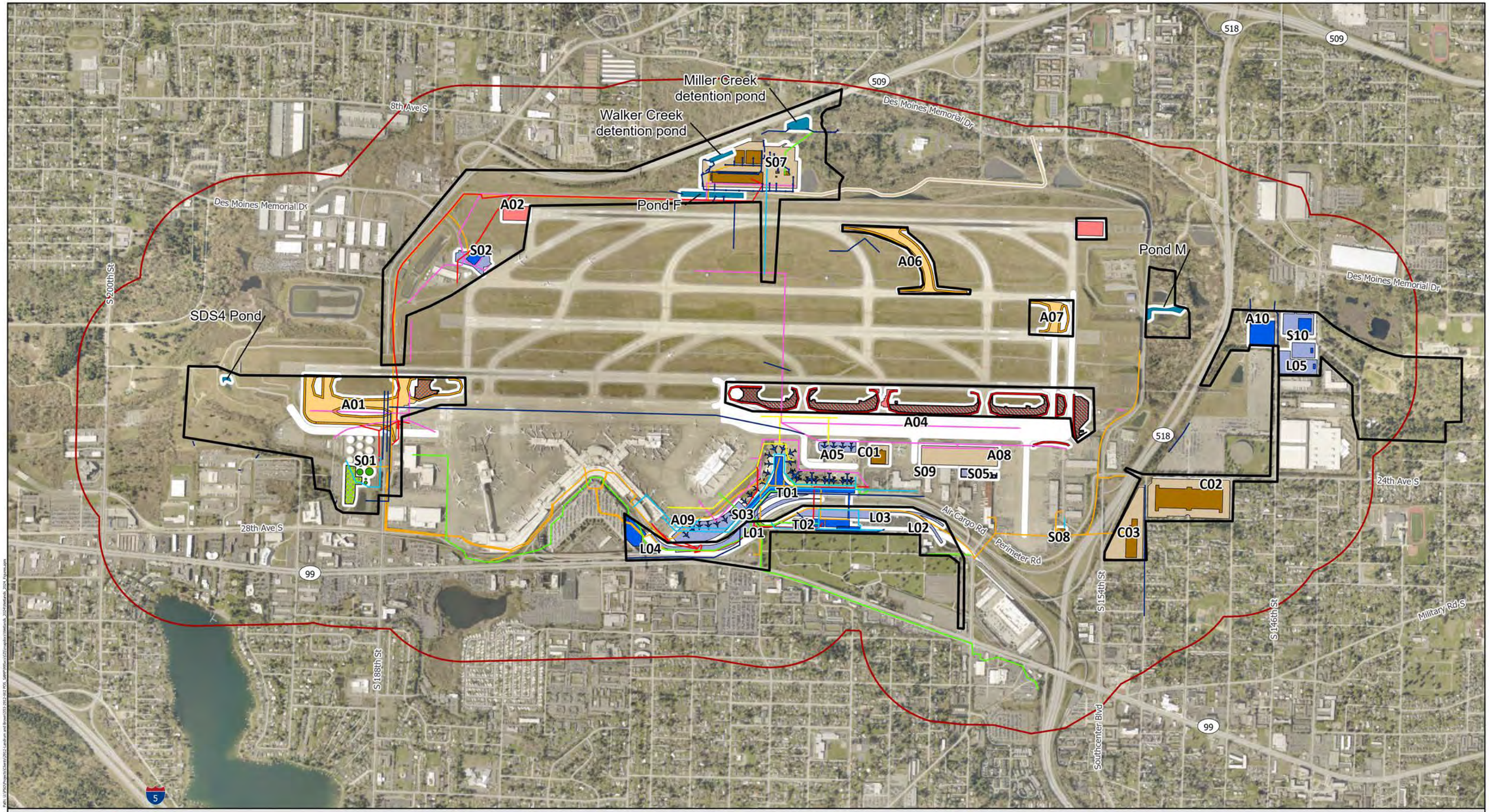
0 0.13 0.25 0.38 0.5 Miles

Tributaries
General Study Area
Field Survey Area
Restrictive Covenant

Critical Area Type
Stream
Wetland
Stream/Wetland Buffer
Wellhead Protection Area

Figure 1-2
Aquatic Critical Areas within the Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



Parametrix

Date: 2/12/2024
Sources: King County, King County Aerial (2021)
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 0.13 0.25 0.38 0.5 Miles

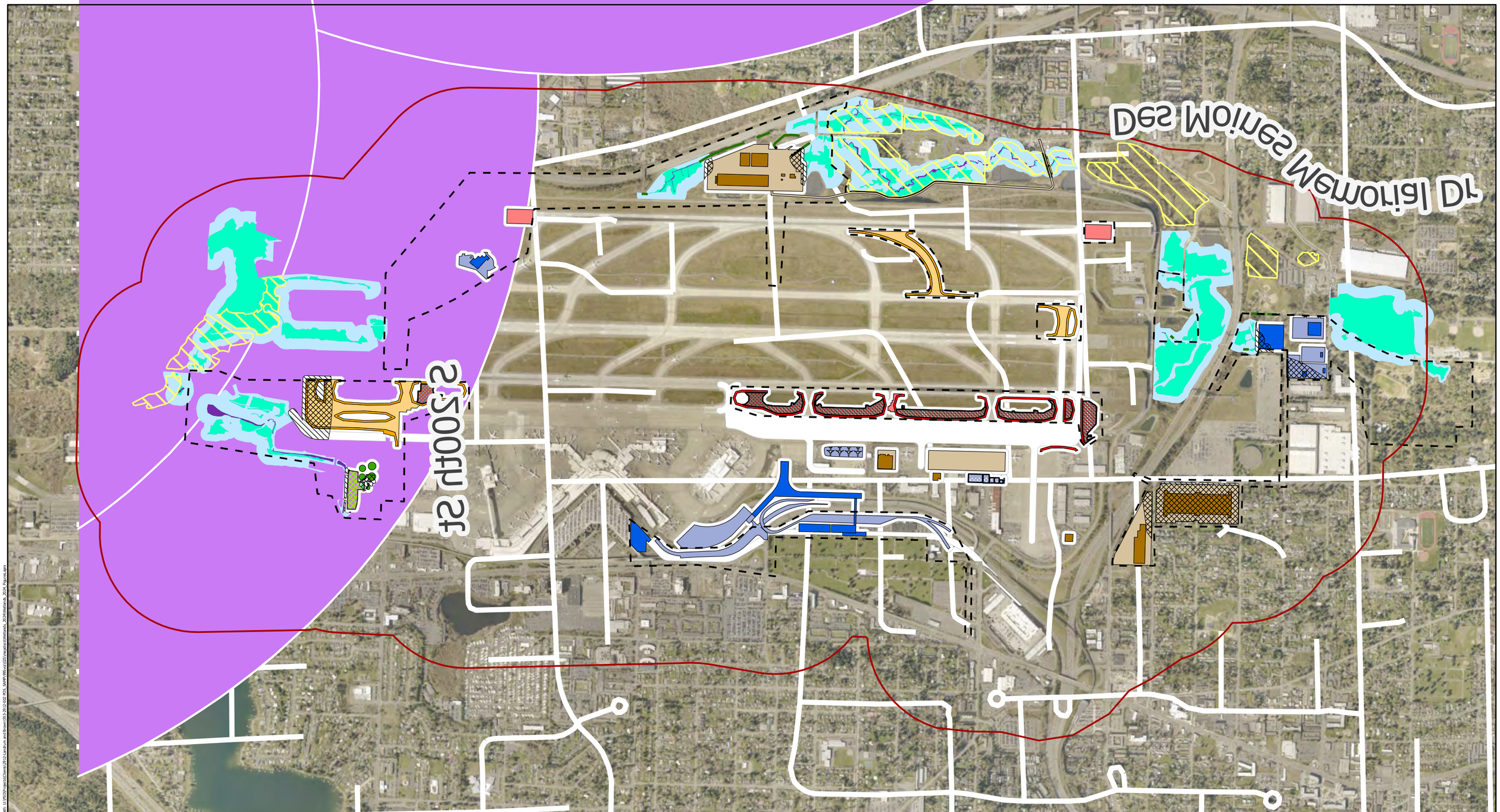
- Field Survey Area
- General Study Area
- Construction Area (50-ft buffer)
- Stormwater Pond (UMP Polygon)

Proposed Utilities (UMP Line)
- ICT
- IWS
- Jet Fuel
- Power
- Sanitary Sewer
- Storm
- Water

Near Term Project (NTP) Type
- Airfield Operational Efficiency Projects
- Airfield Operational Efficiency Projects, Structure
- Airfield Operational Efficiency Projects, Surface
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects, Structure
- Airfield Safety/Standards Projects, Surface
- Cargo Expansion Projects, Structure
- Cargo Expansion Projects, Surface
- North Terminal Projects
- North Terminal Projects, Structure
- North Terminal Projects, Surface
- Sustainable Aviation Fuel Projects
- Sustainable Aviation Fuel Projects, Structure

Figure 1-3
Project Elements within the Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA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General Study Area
Field Survey Area
Restrictive Covenant
Critical Area Type
Stream
Wetland
Stream/Wetland Buffer
Wellhead Protection Area
Near Term Project (NTP) Type
Airfield Operational Efficiency Projects
Airfield Operational Efficiency Projects, Structure
Airfield Operational Efficiency Projects, Surface
Airfield Safety/Standards Projects
Airfield Safety/Standards Projects, Structure
Airfield Safety/Standards Projects, Surface
Cargo Expansion Projects, Structure
Cargo Expansion Projects, Surface
North Terminal Projects
North Terminal Projects, Structure
North Terminal Projects, Surface
Sustainable Aviation Fuel Projects
Sustainable Aviation Fuel Projects, Structure
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Date: 2/12/2024
Sources: King County, King County Aerial (2021)
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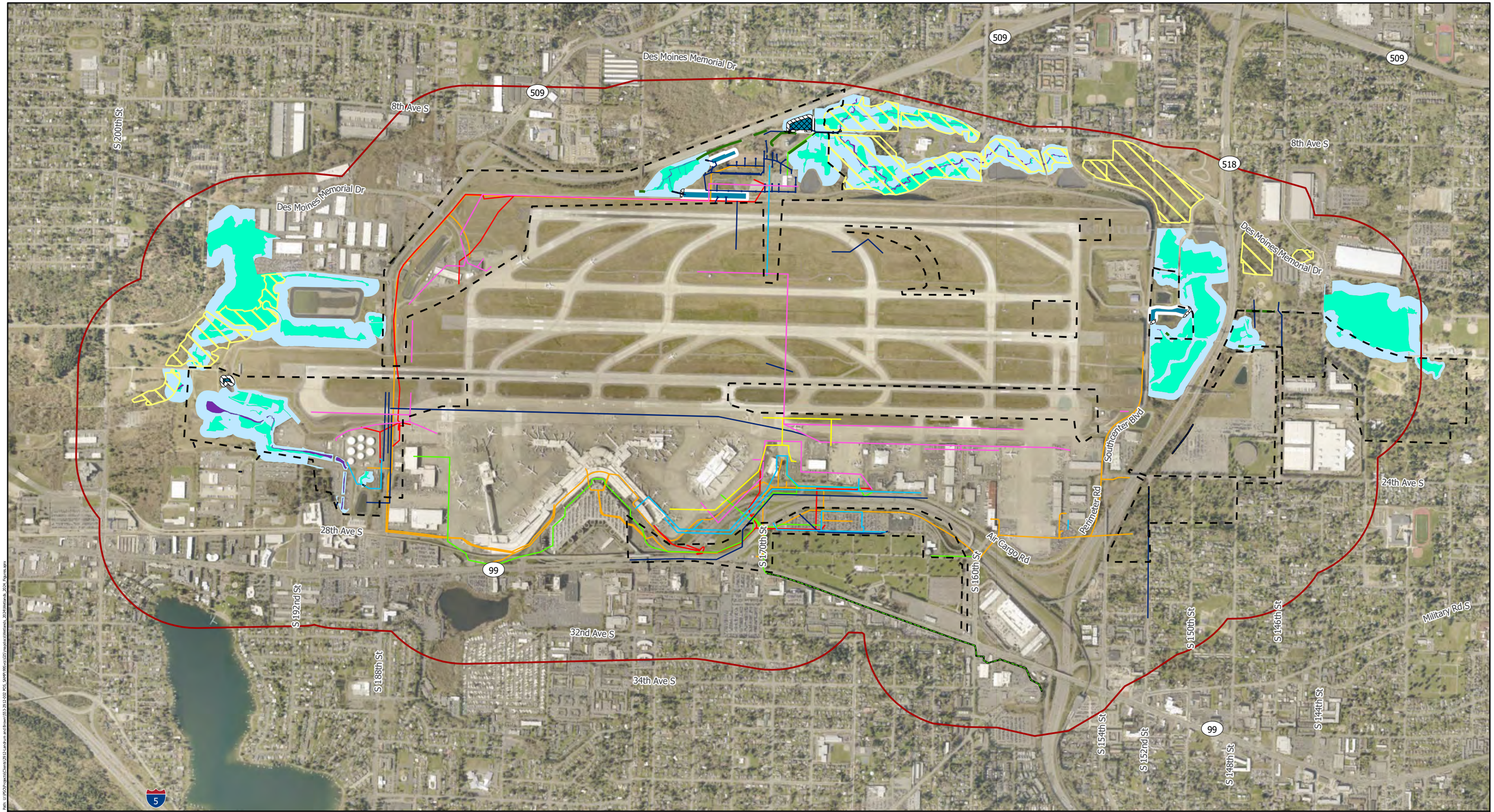
Figure 1-4
NTP Impacts to Aquatic Critical Areas within the Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)
King County, WA



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Sources: King County, King County Aerial (2021)
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0 0.13 0.25 0.38 0.5 Miles

- Tributaries
- Tributaries Impact
- Permanent Impact Area
- Temporary Impact Area
- Construction Area (50-ft buffer)
- Field Survey Area
- General Study Area
- Restrictive Covenant

Critical Area Type

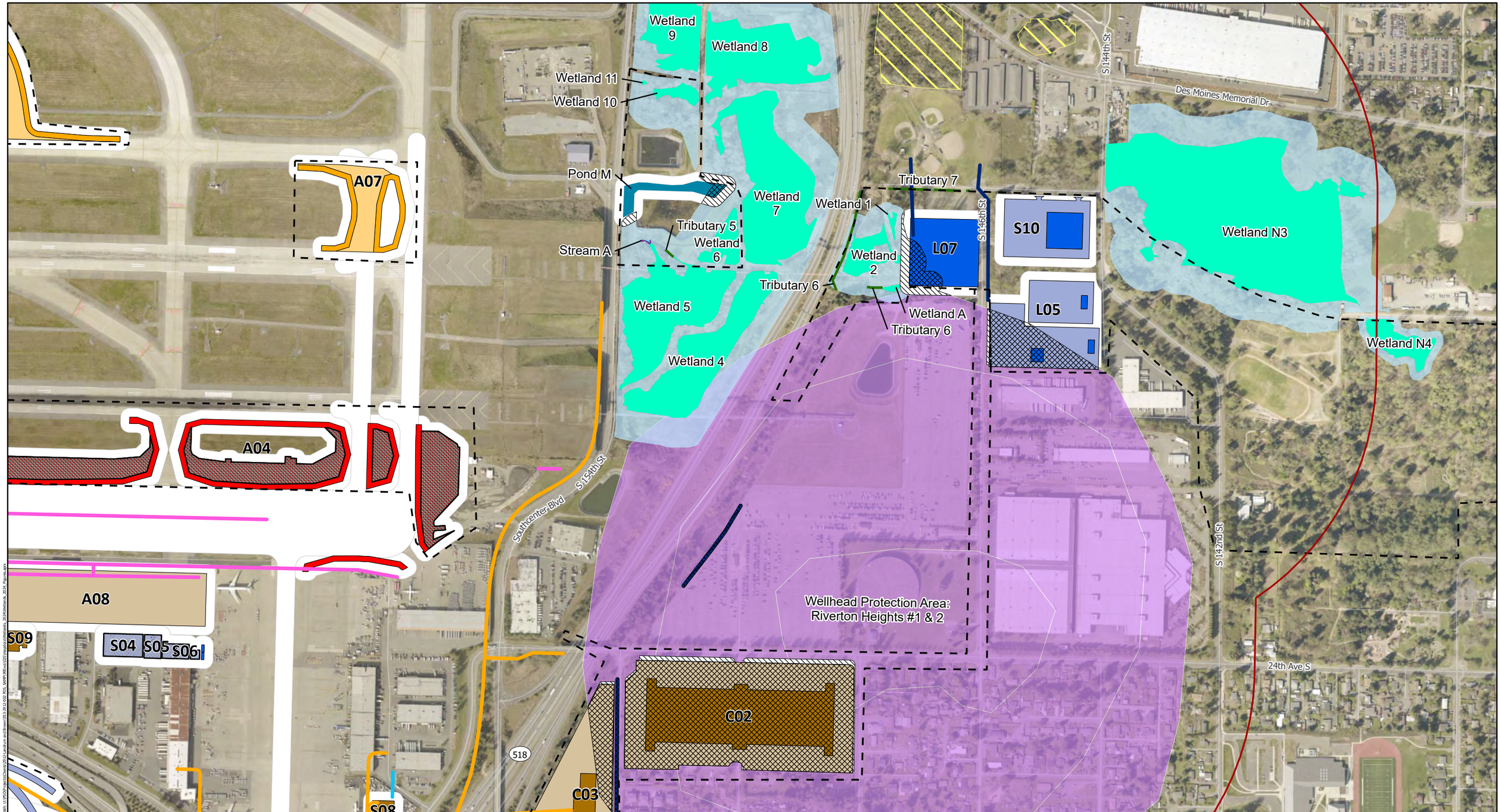
- Stream
- Wetland
- Stream/Wetland Buffer
- Wellhead Protection Area

Utility Master Plan (UMP) Type

- ICT
- IWS
- Jet Fuel
- Power
- Sanitary Sewer
- Storm
- Water

Figure 1-5
UMP Impacts to Aquatic Critical Areas within the Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



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Date: 2/12/2024
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0 250 500 1,000 Feet

- Tributaries
- Tributaries Impact
- General Study Area
- Field Survey Area
- Permanent Impact Area
- Temporary Impact Area
- Stormwater Pond
- Construction Area (50-ft buffer)
- Restrictive Covenant

Critical Area Type

- Stream
- Wetland
- Stream/Wetland Buffer
- Wellhead Protection Area

Utility Master Plan (UMP) Type

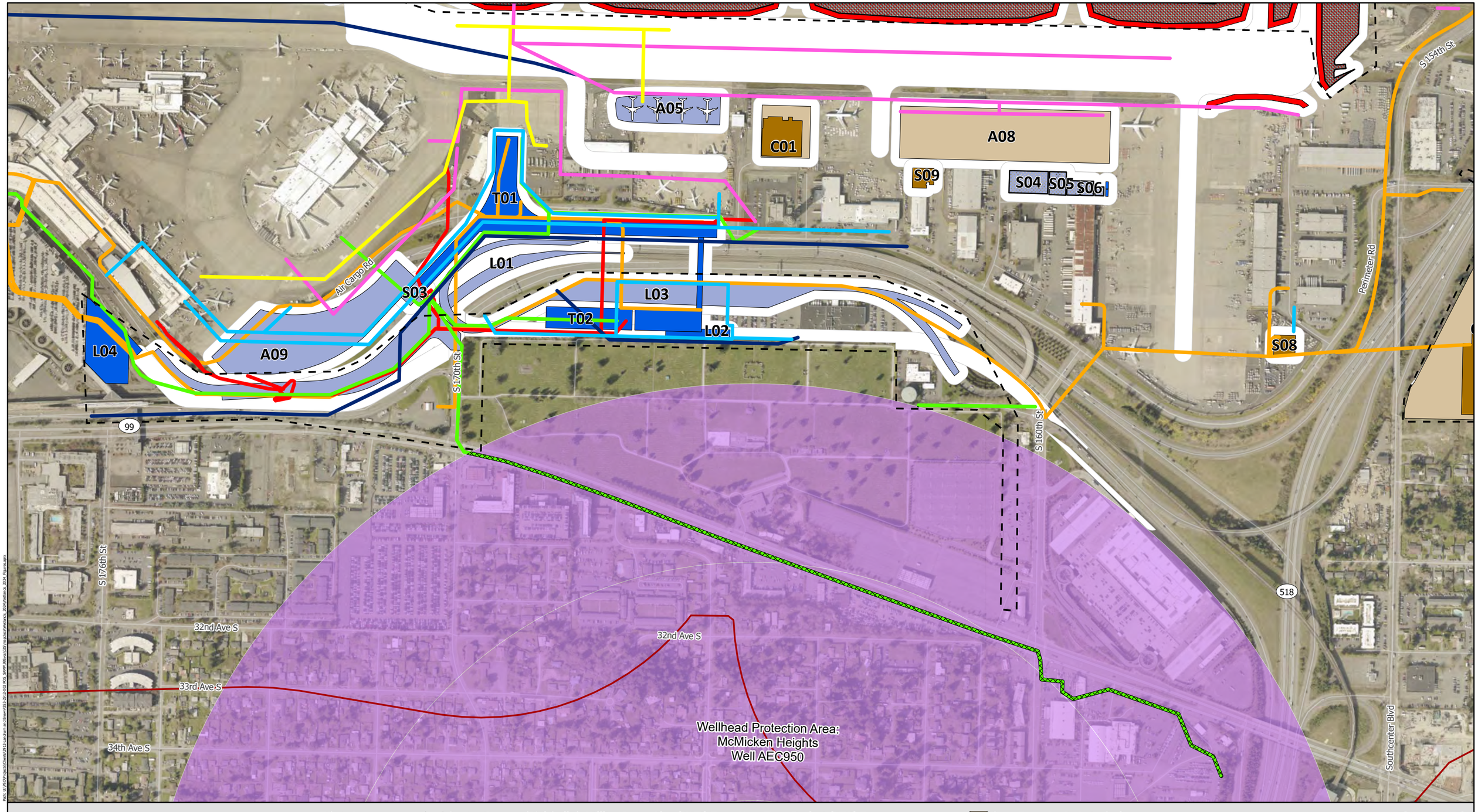
- ICT
- IWS
- Jet Fuel
- Power
- Sanitary Sewer
- Storm
- Water

Near Term Project (NTP) Type

- Airfield Operational Efficiency Projects
- Airfield Operational Efficiency Projects, Structure
- Airfield Operational Efficiency Projects, Surface
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects, Structure
- Airfield Safety/Standards Projects, Surface
- Cargo Expansion Projects, Structure
- Cargo Expansion Projects, Surface
- North Terminal Projects
- North Terminal Projects, Structure
- North Terminal Projects, Surface
- Sustainable Aviation Fuel Projects
- Sustainable Aviation Fuel Projects, Structure

Figure 1-6a
Project Impacts to Aquatic Critical Areas in North Portion of Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



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Date: 2/12/2024
Sources: King County, King County Aerial (2021)
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0 250 500 1,000 Feet

- Tributaries
- Tributaries Impact
- General Study Area
- Field Survey Area
- Permanent Impact Area
- Temporary Impact Area
- Stormwater Pond
- Construction Area (50-ft buffer)
- Restrictive Covenant

Critical Area Type

- Stream
- Wetland
- Stream/Wetland Buffer
- Wellhead Protection Area

Utility Master Plan (UMP) Type

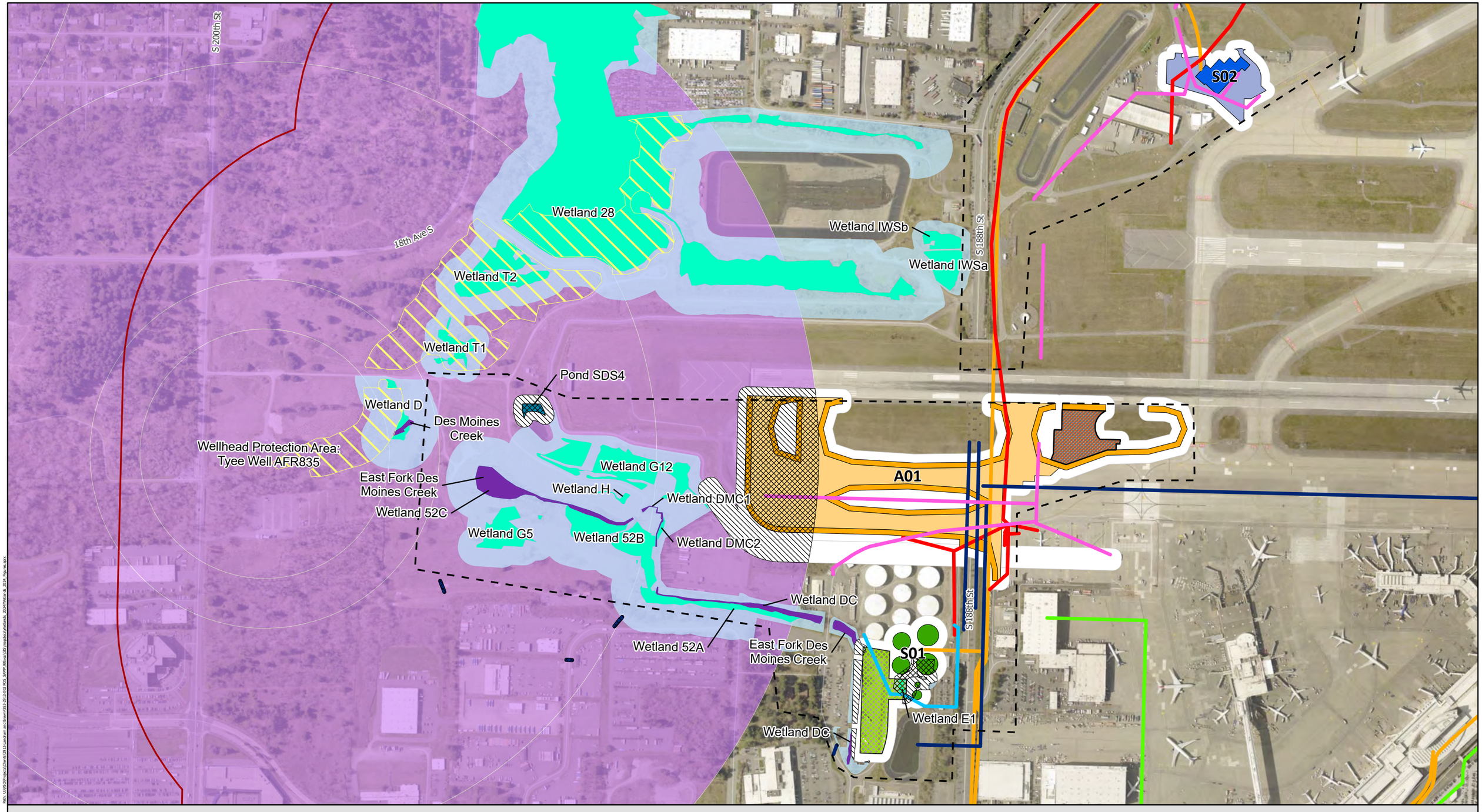
- ICT
- IWS
- Jet Fuel
- Power
- Sanitary Sewer
- Storm
- Water

Near Term Project (NTP) Type

- Airfield Operational Efficiency Projects
- Airfield Operational Efficiency Projects, Structure
- Airfield Operational Efficiency Projects, Surface
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects, Structure
- Airfield Safety/Standards Projects, Surface
- Cargo Expansion Projects, Structure
- Cargo Expansion Projects, Surface
- North Terminal Projects
- North Terminal Projects, Structure
- North Terminal Projects, Surface
- Sustainable Aviation Fuel Projects
- Sustainable Aviation Fuel Projects, Structure

Figure 1-6b
Project Impacts to Aquatic Critical Areas in North Portion of Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



Parametrix

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0 250 500 1,000 Feet

- Tributaries
- Tributaries Impact
- General Study Area
- Field Survey Area
- Permanent Impact Area
- Temporary Impact Area
- Stormwater Pond
- Construction Area (50-ft buffer)
- Restrictive Covenant

Critical Area Type

- Stream
- Wetland
- Stream/Wetland Buffer
- Wellhead Protection Area

Utility Master Plan (UMP) Type

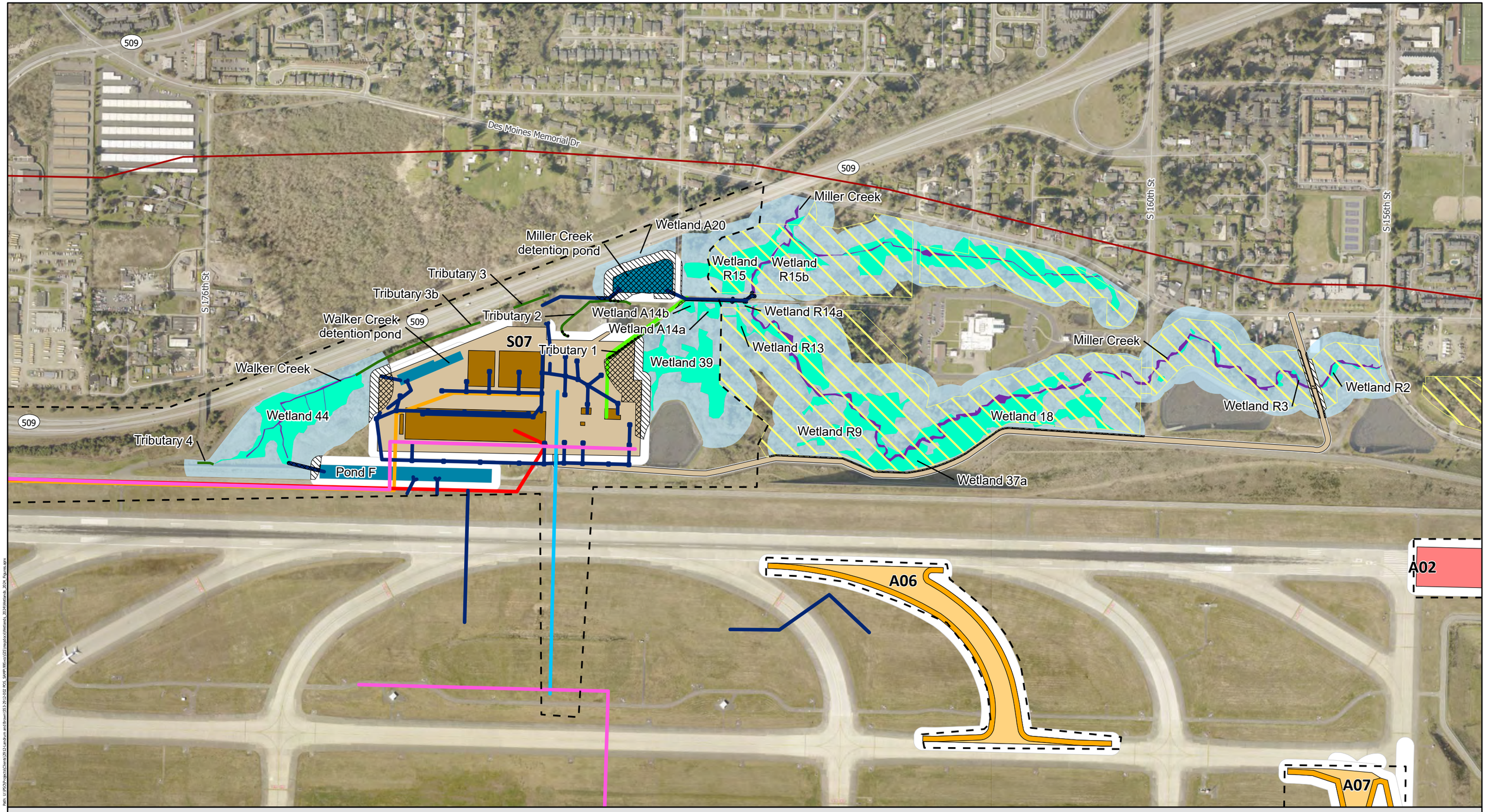
- ICT
- IWS
- Jet Fuel
- Power
- Sanitary Sewer
- Storm
- Water

Near Term Project (NTP) Type

- Airfield Operational Efficiency Projects
- Airfield Operational Efficiency Projects, Structure
- Airfield Operational Efficiency Projects, Surface
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects, Structure
- Airfield Safety/Standards Projects, Surface
- Cargo Expansion Projects, Structure
- Cargo Expansion Projects, Surface
- North Terminal Projects
- North Terminal Projects, Structure
- North Terminal Projects, Surface
- Sustainable Aviation Fuel Projects
- Sustainable Aviation Fuel Projects, Structure

Figure 1-6c
Project Impacts to Aquatic Critical Areas in North Portion of Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



Parametrix

Date: 2/12/2024
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0 250 500 1,000 Feet

- Tributaries
- Tributaries Impact
- General Study Area
- Field Survey Area
- Permanent Impact Area
- Temporary Impact Area
- Stormwater Pond
- Construction Area (50-ft buffer)
- Restrictive Covenant

Critical Area Type

- Stream
- Wetland
- Stream/Wetland Buffer
- Wellhead Protection Area

Utility Master Plan (UMP) Type

- ICT
- IWS
- Jet Fuel
- Power
- Sanitary Sewer
- Storm
- Water

Near Term Project (NTP) Type

- Airfield Operational Efficiency Projects
- Airfield Operational Efficiency Projects, Structure
- Airfield Operational Efficiency Projects, Surface
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects, Structure
- Airfield Safety/Standards Projects, Surface
- Cargo Expansion Projects, Structure
- Cargo Expansion Projects, Surface
- North Terminal Projects
- North Terminal Projects, Structure
- North Terminal Projects, Surface
- Sustainable Aviation Fuel Projects
- Sustainable Aviation Fuel Projects, Structure

Figure 1-6d
Project Impacts to Aquatic Critical Areas in North Portion of Survey Area
Impact Analysis Memorandum
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King County, WA

Appendix D
Species Life Histories

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1.0 INTRODUCTION

The information in this appendix is meant to accompany and complement the more detailed environmental baseline and effect analysis information provided in the main body of the *Seattle-Tacoma International Airport Sustainable Airport Master Plan Near Term Projects Biological Assessment* (BA). The following sections discuss the Endangered Species Act (ESA) listing status, critical habitat status, and general life history information for each ESA-listed species addressed in the BA for the Proposed Action:

- Chinook salmon, Puget Sound Evolutionarily Significant Unit (ESU) (*Oncorhynchus tshawytscha)*
- Steelhead, Puget Sound Distinct Population Segment (DPS) (*O. mykiss)*
- Bull trout, Coastal-Puget Sound DPS (*Salvelinus confluentus)*
- Bocaccio rockfish, Puget Sound/Georgia Basin DPS (*Sebastes paucispinis*)
- Yelloweye rockfish, Puget Sound/Georgia Basin DPS (*S. ruberrimus*)
- Killer whale, Southern Resident DPS (SRKW) (*Orcinus orca*)
- Humpback whale, Central America and Western North Pacific DPS (*Megaptera novaeangliae*)
- Marbled murrelet (*Brachyramphus marmoratus*)

2.0 PUGET SOUND CHINOOK SALMON

The Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*) ESU was listed as threatened under the ESA on March 24, 1999 (64 FR 14308), and its threatened status was reaffirmed on June 28, 2005 (70 FR 37160). The 2016 5-year review of Puget Sound Chinook salmon concluded that this species should remain listed as threatened (80 FR 6695, NMFS 2017a).

Critical habitat for Puget Sound Chinook salmon was designated on September 2, 2005 (70 FR 52629). It includes 1,683 miles of stream/riverine habitat, 41 square miles of lake habitat, and 2,182 miles of nearshore habitat within Washington and Puget Sound.

2.1 Life History and Population Trajectory

Like most other salmonids, Chinook salmon exhibit an anadromous (meaning they migrate from saltwater to freshwater to spawn) and semelparous (meaning they die after their first reproductive event) life history, thereby occurring in both freshwater river systems as well as the brackish and saltwater waterways of the Puget Sound and Pacific Ocean (USEPA 2021). A Chinook salmon hatches in fresh water, rears in fresh and/or salt water, matures in the ocean,

and returns to its natal freshwater streams to breed. Chinook salmon can be separated into 2 distinct life history strategies: ocean-type and stream-type fish. Ocean-type Chinook salmon spend a limited amount of time (i.e., weeks or months) rearing in fresh water before migrating to the ocean, while stream-type fish spend approximately 1-year rearing in fresh water (COSEWIC 2019). Upon entering estuaries, stream-type Chinook salmon are much larger than ocean-type Chinook salmon (COSEWIC 2019). Adult Chinook salmon weigh 40 pounds on average, although as the largest of the west-coast salmon, they may grow up to 120 pounds (NOAA 2024a). Chinook salmon are a cold-water species that rely on clean waters no warmer than 25°C (COSEWIC 2019).

The Chinook salmon population in the Salish Sea (i.e., the larger Puget Sound region including the Strait of Georgia has declined "60% since the Pacific Salmon Commission began tracking salmon abundance in 1984" (EPA 2021). This drastic decline has been due to multiple anthropogenic factors, including reduced habitat quality and accessibility, over-harvesting, and reduced water quality. Recent stock assessments show that most Puget Sound Chinook salmon stocks remain well below population recovery thresholds (NMFS 2006; Pacific Salmon Commission 2022; Puget Sound Indian Tribes and WDFW 2022; Puget Sound Info 2023a). There is little indication that Puget Sound Chinook salmon will recover in the near future, although most populations have not significantly decreased over the last few years (Puget Sound Info 2023a).

2.2 Regional and Local Abundance

The Puget Sound ESU for Chinook salmon includes all naturally occurring Chinook salmon originating in rivers that flow into the Puget Sound. Currently 22 independent populations of naturally occurring Chinook salmon exist within the ESU (NMFS 2017a; Puget Sound Info 2023a). In addition to these 22 populations, 26 artificial propagation hatchery programs across the Puget Sound augment Chinook salmon escapement numbers by artificially increasing egg survivorship and the number of juveniles hatched (NMFS 2017a).

The population of Salish Sea Chinook salmon was estimated to be over 473,000 in 2018 (EPA 2021). Estimates of total Chinook salmon abundance across the Puget Sound are not conducted by the Pacific Salmon Commission due in part to the lack of long-term tag data for naturally occurring stocks (Pacific Salmon Commission 2018). However, escapement trends for various indicator stocks of Chinook salmon in the Puget Sound are available. Escapement indicator stocks for the Puget Sound include the Nooksack, Skagit, Stillaguamish, Snohomish, Lake Washington, and Green River stocks (Pacific Salmon Commission 2022). In the years from 1975 to 2021, the collective Puget Sound Chinook salmon indicator stock escapement for summer and fall stocks ranged from a low of approximately 10,300 individuals in 2011 to a high of 45,000 in 2004. The combined escapement was approximately 30,000 in 2021 (Pacific Salmon Commission

2022). Spawning abundance estimates for most populations have therefore not experienced significant change between 1999 and 2021 (Puget Sound Info 2023a).

2.3 Sensitivity to Environmental Stressors

Chinook salmon are sensitive to many environmental stressors and threats. These include exclusion from upstream habitat and spawning grounds by impassible barriers (i.e., culverts, dams, etc.), and habitat degradation due to human development, including increased sedimentation, water temperatures, and decreased water qualities (NOAA 2024a). The diverse environmental stressors that impact Chinook salmon can be summarized in 4 main factors (EPA 2021):

- Habitat loss and degradation: Chinook salmon require a vast area of diverse habitat over the span of their lives. Additionally, these habitats must meet specific requirements for Chinook salmon survival and reproduction, including high water quality, low water temperatures, overhanging vegetation and in-stream wood, appropriately sized and clean spawning gravels, etc. With these many requirements, Chinook is especially sensitive to upland development and other human activities that disturb the nearshore, estuarine, or riverine habitats, including agriculture, timber harvest, and coastal modification.
- Harvest Rates: Despite the protection under ESA for some ESU of Chinook salmon, almost 22 million Chinook have been harvested between 1975 and 2018. Harvest rates have decreased since the Puget Sound ESA-listing in 1999; however, harvest above sustainable limits outside of the Puget Sound may still occur.
- Hatchery Influence: Although hatcheries intend to bolster failing Chinook salmon stocks that are near extinction, they may also have negative impacts on the remaining wild stocks through increased competition, introduction of diseases, dilution of superior wild genetics, and impediment of wild stock migration.
- Water infrastructure that impedes migrations: Culverts, dams, and floodgates can all impact salmonid species by causing fish passage barriers, water quality impairments, loss of habitat, and hydrological changes.

Additionally, global climate change is impacting Chinook salmon stocks by further altering their habitat, increasing water temperatures, and decreasing water quality (EPA 2021).

Impacts or effect mechanisms that Puget Sound Chinook salmon would be especially sensitive to include the following:

- Turbidity/suspended sediment
- Water temperature
- Physical disturbance of organisms
- Shading
- Dissolved oxygen and pH
- Water quality/contaminants
- Change in habitat type

Direct effects to lower levels of the food web or other parts of the ecosystem are not expected to indirectly affect Puget Sound Chinook salmon.

3.0 PUGET SOUND STEELHEAD

The Puget Sound steelhead (*Oncorhynchus mykiss*) Distinct Population Segment (DPS) was listed as threatened under the ESA on May 11, 2007 (72 FR 26722). This listing was subsequently updated and reaffirmed on April 14, 2014 (79 FR 20802). The DPS includes naturally spawned steelhead within the Puget Sound, along with steelhead from 6 hatchery programs.

Critical habitat was designated for Puget Sound steelhead on February 24, 2016 (81 FR 9251). It includes approximately 2,031 miles of freshwater and estuarine habitat in Puget Sound.

3.1 Life History and Population Trajectory

The Puget Sound steelhead ESU is primarily composed of winter-run fish, with a few stocks of summer-run steelhead.

The population of Puget Sound steelhead has generally been in decline for more than a hundred years. Historical catch data suggests return sizes of 409,000 to 930,000 adult steelhead each year in the Puget Sound towards the end of the 19th century (NMFS 2019). The current run size is less than 5% to 10% of these historic numbers (Puget Sound Info 2023b).

3.2 Regional and Local Abundance

Puget Sound steelhead populations are found in all of the major river systems within the Puget Sound, including the Nooksack, Skagit, Stillaguamish, Skykomish, Green, Puyallup, and Nisqually Rivers (NMFS 2019). The Puget Sound DPS of steelhead also includes artificial propagation programs within Hood Canal. Thus, Puget Sound steelhead are well distributed throughout the Puget Sound. Due to the lack of regional abundance and distribution information, details are provided here at the scale of the entire Puget Sound.

Winter-run and ocean-maturing steelhead return as adults to Puget Sound tributaries from December to April (Hard et al. 2007). Spawning occurs from January to mid-June, with peak spawning occurring from mid-April through May. Most steelhead juveniles reside in fresh

water for 2 years prior to migrating to marine habitats, with limited numbers migrating as 1- or 3-year-old smolts. Smoltification and seaward migration occur principally from April to mid-May (Hard et al. 2007). The inshore migration pattern of steelhead in Puget Sound is not well understood; it is generally thought that steelhead smolts move quickly offshore (Hard et al. 2007).

3.3 Sensitivity to Environmental Stressors

Environmental stressors like those presented for Chinook salmon are also applicable to steelhead. However, since juvenile steelhead spend more time in freshwater than other species (2-5 years), steelhead are more affected by habitat conditions within a given stream. Puget Sound summer-run steelhead also spend more time in freshwater than other salmon (including winter-run steelhead), as they "return to freshwater during early summer in an immature condition and do not spawn until the following spring" (WDFW 2011). Thus, degraded watershed habitats and processes have a greater cumulative impact on steelhead. Steelhead can also survive to spawn in multiple years, meaning they require adequate downstream passage as well as upstream passage. (WDFW 2011)

Impacts or effect mechanisms that Puget Sound steelhead would be especially sensitive to include the following:

- Turbidity/suspended sediment
- Water temperature
- Physical disturbance of organisms
- Shading
- Dissolved oxygen and pH
- Water quality/contaminants
- Change in habitat type
- Downstream passage at dams or other obstructions

Direct effects to lower levels of the food web or other parts of the ecosystem are not expected to indirectly affect Puget Sound steelhead.

4.0 COASTAL-PUGET SOUND BULL TROUT

The Coastal-Puget Sound DPS of bull trout (*Salvelinus confluentus*) was listed as threatened under the ESA on June 10, 1998 (64 FR 58910). This DPS includes individuals in Idaho, Montana, Nevada, Oregon, and Washington. Critical habitat was subsequently designated in 2005 (70 FR 56212). The most recent version of critical habitat for bull trout was designated on September 30, 2010 (75 FR 63898). It includes approximately 18,795 miles of streams and 488,252 acres of lakes and reservoirs in Idaho, Oregon, Washington, Montana, and Nevada, along with 754 miles of marine shoreline in Washington. Bull trout are federally managed by the U.S. Fish and Wildlife Service (USFWS). Dolly Varden (*S. malma*) are listed as threatened under the ESA due to their similarity to bull trout.

4.1 Life History and Population Trajectory

Bull trout exhibit 2 main life history strategies: resident and migratory. Resident fish spend their entire life within the stream or tributary in which they were born. Migratory fish spawn in tributary streams but then migrate to either a lake (adfluvial form), river (fluvial form), or marine ecosystem (anadromous) (USFWS 2015). The form that occurs within the Puget Sound is the anadromous form. The different life history forms may be found together, and one can produce offspring of another type. Bull trout typically reach sexual maturity at ages of 4-7 years and usually live to be about 10 years old (USFWS 2015).

Bull trout have very specific habitat requirements, often referred to as "the four Cs": Cold, Clean, Complex, and Connected habitat (Rieman and McIntyre 1993). Water temperatures typically need to be less than 54°F and habitat should include complex elements like deep pools, overhanging banks, and large woody debris. Suitable habitat must also be connected to spawning and rearing areas.

Spawning typically occurs between August and November, when water temperatures are decreasing. Bull trout often build redds in stream reaches near springs or other sources of cold groundwater. Migratory bull trout can travel as far as 250 kilometers to reach spawning grounds (USFWS 2015).

Bull trout are opportunistic feeders, relying on a variety of terrestrial and aquatic insects, macro-zooplankton, and small fish. Their food habits primarily depend on their life stage and size. Within the Puget Sound, bull trout often feed on forage fish, like Pacific herring, Pacific sand lance, and surf smelt (USFWS 2015).

A status review of bull trout was completed in 2008, and it was determined that the listing of "threatened" was still warranted (USFWS 2008). Of the 121 core areas that were assessed, 75 had substantial threats to the success and survival of the population. Bull trout have been largely extirpated from about 60% of their historic range (USFWS 2015).

4.2 Regional and Local Abundance

The Chilliwack, Nooksack, lower and upper Skagit, Snohomish-Skykomish, Stillaguamish, upper Cedar, and Puyallup river basins all support populations of bull trout (USFWS 2020). Except for the Chilliwack and upper Cedar River basins, all these basins contain anadromous bull trout that also use the marine waters of the Puget Sound. Thus, bull trout are well distributed throughout the Puget Sound. Acoustic telemetry data on tagged bull trout between 2002 and 2008 showed significant migration distances within the Puget Sound (up to 95 km 1-way) and some use of non-spawning river systems (Goetz et al. 2012). During migrations, most fish stayed close to the shoreline, relying heavily on nearshore habitats.

Juvenile and sub-adult bull trout generally exit rivers and migrate downstream between mid-February to early September, with peak migration periods between April and July. When juvenile bull trout enter salt water, their time of residence is variable (1 day to more than 4 months). Upon entry into salt water, juveniles may rear in tidal delta marshes or tributary channels, or they may pass through into nearshore marine areas. Larger juveniles may migrate through the nearshore from the natal river to adjacent river basins (Goetz et al. 2012).

4.3 Sensitivity to Environmental Stressors

The recovery plan for bull trout published in 2015 laid out 5 main factors affecting the success and survival of the species (USFWS 2015):

- Present or threatened destruction, modification, or curtailment of its habitat or range
- Overutilization for commercial, scientific, or educational purposes
- Disease or predation
- Inadequacy of existing regulatory mechanisms
- Other natural or manmade factors affecting its continued existence

Habitat threats make up a large proportion of the overall factors threatening the population of bull trout within the Puget Sound. However, these threats primarily occur within the freshwater habitats used by bull trout for spawning and rearing. Overfishing and disease are generally minor threats to bull trout success, especially since the time of listing. Since listing, regulatory mechanisms to protect bull trout populations have improved and other factors are continuing to be assessed.

In the marine habitats of the Puget Sound, the main factors that could affect the success of bull trout populations include specific threats to nearshore resources. Nonetheless, major habitat concerns relate to fish barriers and changes to water quality in rivers and streams that preclude bull trout use (USFWS 2015).

Impacts or effect mechanisms that bull trout would be especially sensitive to include the following:

- Turbidity/suspended sediment
- Water temperature
- Physical disturbance of organisms
- Shading
- Dissolved oxygen and pH
- Water quality/contaminants
- Change in habitat type

Direct effects to lower levels of the food web or other parts of the ecosystem are not expected to indirectly affect bull trout.

5.0 ROCKFISH

Two species of rockfish are included here because of their listing under the ESA: bocaccio (*Sebastes paucispinis*) and yelloweye (*Sebastes ruberrimus*). Bocaccio were listed as endangered on April 28, 2010 and yelloweye were listed as threatened on the same date (75 FR 22276). This listing is specific to the Puget Sound/Georgia Basin DPS of each species. This includes all "yelloweye rockfish and bocaccio (listed rockfish) in the Puget Sound, the Strait of Georgia…and the Strait of Juan de Fuca east of Victoria Sill (approximately east of Port Angeles)" (NMFS 2017b).

Critical habitat was designated for these species in 2014 (79 FR 68041). It includes 590.4 square miles of nearshore habitat and 414.1 square miles of deepwater habitat within Puget Sound and the Salish Sea.

5.1 Life History and Population Trajectory

Rockfish are long-lived, iteroparous (have multiple reproductive cycles) species that bear live young, in contrast to most other bony fishes (Drake et al. 2010). Rockfish larvae typically spend several months in a pelagic state before settling to demersal habitat. The iteroparity of rockfish is believed to allow populations to persist through many years of poor production.

5.1.1 Puget Sound/Georgia Basin Bocaccio Rockfish

In northern and central Californian waters, bocaccio were found to mature typically around 3 years of age (Drake et al. 2010). Bocaccio females produce between 20,000 and 2,298,000 eggs annually (Love et al. 2002). Off the coasts of Washington and Oregon, larval release typically occurs between January and April (Drake et al. 2010). Most larvae remain in a pelagic state for about 3.5 months before settling into shallower habitats. Females typically grow more quickly than males and can reach larger sizes, which a maximum of 91 cm and 6.8 kg (Love et al. 2002; MacCall 2003). The maximum age has been estimated at 54 years.

Bocaccio rely on shallower habitats as juveniles but move out to deeper waters as they age. They typically remain within home ranges for most of their adult lives (Drake et al. 2010).

Bocaccio prey base changes as they grow. Bocaccio larvae feed on larval krill, diatoms, and dinoflagellates. Juveniles are opportunistic feeders, relying on fish larvae, copepods, and krill. As adults, their prey base shifts to primarily other fish, including hake, sablefish, anchovies, lanternfishes, squid, and other rockfish (Love et al. 2002). Predators of smaller bocaccio include Chinook salmon, terns, and harbor seals (Love et al. 2002).

The population of Puget Sound/Georgia Basin bocaccio has generally been in decline, warranting a listing under the ESA. Between 1975 and 1979, bocaccio were reported as 4.63% of rockfish catch on average, while no bocaccio were observed between 1996 and 2007 out of 2,238 rockfish identified from recreational catches (Drake et al. 2010).

5.1.2 *Puget Sound/Georgia Basin Yelloweye Rockfish*

Yelloweye rockfish are commonly found associated with rocky, high-relief zones, both as juveniles and adults (Drake et al. 2010). Juveniles are typically found in shallower habitats than adults. Adults have been found to have a high affiliation with caves and crevices in deepwater habitats (Drake et al. 2010). Yelloweye inhabit a wide depth range throughout their lives, with depths recorded between 15 and 549m (Drake et al. 2010). The lifespan of yelloweye can reach up to 150 years (NOAA 2023). As with other rockfish, yelloweye are internally fertilized and store sperm for several months prior to fertilization. In the Puget Sound, fertilization is believed to occur in the winter to summer months and birth in the early spring to late summer (Washington et al. 1978). Female yelloweye can produce 1.2 million to 2.7 million eggs in a given reproductive season.

Yelloweye larvae typically remain in a pelagic state for about 2 months prior to settlement. As they grow, they move towards deeper habitats, but generally associate with crevices and other rocky substrates. Throughout their lives, yelloweye are opportunistic feeders, with their prey resources depending on size and life stage. Adult yelloweye rockfish typically rely on sand lance, gadids, flatfishes, shrimp, crabs, and gastropods for prey (Love et al. 2002; Yamanaka et al. 2006).

The population of yelloweye rockfish in the Puget Sound/Georgia Basin has generally been in decline, warranting a listing under the ESA.

5.2 Regional and Local Abundance

The following sections describe specifics of the distribution and abundance of bocaccio and yelloweye rockfish throughout the Puget Sound and within the regions of interest identified in Section 1.

Bocaccio used to be relatively common along steep walls within the Puget Sound but have become more rare (Love et al. 2002). Yelloweye are also generally rare within the Puget Sound (Drake et al. 2010). Habitats within the Puget Sound (e.g., eelgrass, kelp, drift vegetation, and cobble fields) are more commonly used by juvenile rockfish following settlement (Puget Sound Institute 2011). As adults, when present in the Puget Sound, bocaccio and yelloweye rockfish are generally associated with deepwater habitats.

5.3 Sensitivity to Environmental Stressors

Rockfish are sensitive to a variety of environmental threats, including loss of habitat and overfishing. They are especially vulnerable to overfishing because most species do not start reproducing until 5-20 years of age, and very few young survive to adulthood (NOAA 2023). Habitat threats within the Puget Sound include loss of kelp forests and eelgrass beds. These habitats are especially important for juvenile rockfish.

Impacts or effect mechanisms that yelloweye rockfish and bocaccio would be especially sensitive to include:

- Turbidity/suspended sediment
- Water temperature
- Physical disturbance of organisms
- Shading
- Dissolved oxygen and pH
- Water Quality/contaminants
- Change in habitat type

Direct effects to lower levels of the food web or other parts of the ecosystem are not expected to indirectly affect yelloweye rockfish or bocaccio.

6.0 SOUTHERN RESIDENT KILLER WHALE

The Southern Resident Killer Whale (SRKW) (*Orcinus orca*) DPS was listed as endangered under the ESA on November 18, 2005 (70 FR 69903), and its endangered status was reaffirmed on April 4, 2007 (72 FR 16284). The final rule designating critical habitat for SRKW took effect in December of 2006 and includes the North Puget Sound (NPS), South Puget Sound, San Juan Islands, and Strait of Juan de Fuca (71 FR 69054).

6.1 Life History and Population Trajectory

While both resident and transient forms of killer whales occur in Puget Sound, resident whales of the SRKW DPS have historically been the most commonly observed in Puget Sound (Wiles 2004). The SRKW DPS is known to occupy the NPS at variable times of the year. This group consists of 3 pods (J, K, and L) and is considered a distinct stock under the Marine Mammal Protection Act. Whales of the J pod are seen year-round in the inland waterways of Puget Sound, the Strait of Juan de Fuca, and the Strait of Georgia (Wiles 2004; NMFS 2008). From late spring through midwinter, the K and L pods are also present in these waters. Individuals from all 3 pods have also been seen, albeit infrequently, at all times of the year in coastal waters from central California north to Vancouver Island (Ford et al. 1996; NMFS 2008). Whales of the SRKW DPS tend to remain outside of relatively confined bays or shallow water areas as they move through the central Puget Sound area.

Killer whales are social animals that live and hunt in pods of up to 20 individuals. Members of the pod rely on sound to communicate, navigate, and forage. Killer whales make a variety of noises, included clicks and pulsed calls. Male killer whales live for an average of 30 years, but may reach 60-years-old. Female killer whales live for an average of 50 years, but may reach 90 years of age. Females reach sexual maturity between 10 and 13 years old. Gestation occurs for 15 to 18 months, and once the calf is born, it nurses for a year or longer. The birthrate for killer whales is estimated at every 5 years, although birthrate is not well documented (NOAA 2024b).

The SRKW population is genetically isolated and rarely interbreeds with other killer whale populations (Hoelzel et al. 1998; Barrett-Lennard 2000; Barrett-Lennard and Ellis 2001). Whales of the SRKW DPS also differ behaviorally from transient killer whales in that they rely almost exclusively on fish as a food source. Observations in northern Puget Sound indicate that salmon are preferred prey for killer whales, representing over 96 percent of the prey during the summer and fall (Ford and Ellis 2005). This study also indicated that Chinook salmon constitutes over 70 percent of the identified salmonids taken in the summer and fall, although extensive feeding on chum salmon was also observed in the fall. While salmon appear to be a preferred prey item, 22 other species of fish and 1 species of squid (*Gonatopsis borealis*) are known to be eaten (Ford et al. 1996, 1998). Species such as rockfish (*Sebastes spp.*), Pacific halibut (*Hippoglossus stenolepis*), a number of flatfish, lingcod (*Ophiodon elongatus*), and greenling (*Hexagrammos* spp.) are likely consumed regularly by SRKWs (Ford et al. 1998).

The historical population size for SRKW in the Pacific Northwest has been estimated at no less than 140 individuals (NOAA 2024b). However, populations declined in the 1960s due to a live-capture SRKW fishery for use in marine mammal parks, and only 71 individuals of this DPS remained in the wild in 1974 (NOAA 2024b). While SRKW populations increased thereafter and peaked in 1995 with 98 individuals, recent whale census in 2023 has documented only 75 individuals (Center for Whale Research 2023).

6.2 Regional and Local Abundance

The following sections outline the regional SRKW abundance at the scale of the entire Puget Sound, including the San Juan Islands and the Strait of Juan de Fuca, when appropriate. The local abundance is also included for NPS.

From late spring to fall, most whales of the SRKW DPS can be found in the waters around the San Juan Islands, including Haro Strait, Boundary Passage, and the northeastern portion of the Strait of Juan de Fuca (Ford et al. 1996; Krahn et al. 2004). During this period, whales are also present in smaller numbers in Rosario Strait, the interior waters of the San Juan Islands, the southern portions of Georgia Strait and the Strait of Juan de Fuca, Admiralty Inlet, Puget Sound, and the outer coast. Individuals or groups from this population may also be seen at various locations in central Puget Sound each summer, typically for periods of a few days, but occasionally remaining in the area for more than a month. During early autumn, SRKW pods (especially the J pod) expand their movements into Puget Sound, likely to feed on returning adult chum and Chinook salmon (Osborne 1999). Considerably less is known about the wintertime movements of this stock. Whales from the J pod are commonly sighted in inshore waters in winter, while the K and L pods apparently spend more time offshore (Ford et al. 1996; Krahn et al. 2004).

As of July 1, 2023, the SRKW population totals 75 whales, including 25 in J Pod, 16 in K Pod, and 34 in L Pod (Center for Whale Research 2023).

Table 1. Summary of monthly killer whale sightings in North Puget Sound from 1990-2013

Month	Sightings
January	160
February	136
March	71
April	105
May	634
June	1,479
July	1,705
August	1,096
September	982
October	408
November	266
December	328
Source: (Olson 2014)	

Based on a review of Whale Museum data from 1948 through 2017, SRKWs are most likely to occur within the Puget Sound during the months of August through January. The months of February through July have relatively fewer sightings (Olson 2018). Guidance from the NMFS Northwest Region office defines SRKWs as extremely unlikely to occur in a particular area during a particular month if the Whale Museum data set includes a total of fewer than 6 sightings in that area during that month. However, given the highly mobile nature of this species, the current 75 members of the SRKW DPS could be present within the NPS at any time of the year.

6.3 Sensitivity to Environmental Stressors

The Federal Register (70 FR 69908) has put forth 5 reasons for SRKW decline as justification for the 2005 ESA listing, including present destruction of habitat or range, overuse for human gain, disease or predation, inadequacy of existing regulatory mechanisms, and other natural or human-caused factors affecting their continued existence. SRKW habitat modification and destruction has occurred with increases in pollution, vessel traffic, and decreases in prey availability (i.e., Chinook salmon). Commercial shipping, whale watching, ferry, and recreational boat traffic have all increased within the Puget Sound in recent years, all of which impact SRKW short-term behaviors and provide additional in-water sound that may reduce SRKW foraging efficiency and communication, thereby increasing energy expenditures. Increases in pollution, urbanization, and fisheries have also drastically reduced Chinook salmon stocks, the main prey for SRKW.

Although a reduction in prey and behavioral disturbance from underwater sound are major environmental stressors for SRKW, contaminants and oil spills are also factors in their recent declines. Contaminants in sea water can range from increased sediments from upland or intertidal disturbance, pathogens and bacteria from water treatment plants and sewer outfalls, and chemicals from agricultural practices or industrial uses. As top predators, SRKW take in bioaccumulated contaminants in their diet. These toxins may accumulate in the bodies of SRKW in blubber and cause harm to immune and reproductive systems, thereby reducing individuals' viability and reproductive success. Additionally, oil spills such as the 1989 Exxon Valdez oil spill in Prince William Sound caused the direct death of individual SRKW, and oil spills can also indirectly impact SRKW by decreasing prey populations (NOAA 2024b).

The impact or effect mechanism that SRKW would be especially sensitive to is sound/noise.

7.0 HUMPBACK WHALE

The Central America and Mexico DPS's of humpback whales (*Megaptera novaeangliae*) were listed as endangered under the Endangered Species Conservation Act, the precursor to the Endangered Species Act, on December 2, 1970 (NOAA 2024c). In September 2016, the Central America was reaffirmed as endangered, and the Mexico DPS was listed as threatened (81 FR 62259). Critical habitat for both was designated on April 21, 2021 (86 FR 21082). The current designation includes marine habitat in the North Pacific Ocean, with approximately 48,521 nmi^2 designated for the Central America DPS and approximately 116,098 nmi^2 designated for the Mexico DPS of humpback whales.

7.1 Life History and Population Trajectory

Humpback whales are found through all the world's major oceans. During the summer months, they feed on krill and small fish to build up stores of blubber for the winter. They can consume up to 3,000 pounds of food per day. Humpbacks can live about 80 to 90 years, reaching sexual maturity between ages 4 and 10. Females typically produce a single calf every 2 to 3 years.

The 2016 revision to the original listing of humpback whales determined that 9 of the 14 populations have recovered enough that they do not warrant listing (NOAA 2024c). Thus, the global population of humpbacks is largely recovering and expanding. However, the Central America DPS is still listed as endangered, and the Mexico DPS is still listed as threatened. Aerial surveys of marine mammals in Alaska in 2018 recorded 53 sightings of 79 humpback whales, including 2 calves (Clarke et al. 2019).

7.2 Regional and Local Abundance

Humpback whales have not been known to typically inhabit inland and coastal waters, but sightings have become more common within the Puget Sound.

The Puget Sound is now experiencing what has been termed a "humpback comeback", as humpbacks are being spotted more frequently in the inland and coastal waters (Banse 2019). This is largely believed to be related to the overall population expansion, as well as potential shifts in oceanographic conditions and prey availability (Puget Sound Express 2019). Cascadia Research Collective estimates that about 1,600 whales feed off the west coast of North America, and about 500 off Washington and British Columbia specifically (Puget Sound Express 2019).

7.3 Sensitivity to Environmental Stressors

Humpback whale populations were largely decimated by commercial whaling practices, prior to the moratorium in 1985 (NOAA 2024c). Primary threats continue to be from human and boat disturbance, including vessel strikes, entanglements, and harassment by vessels. These threats are of rising concern within the Puget Sound as numbers have increased in recent years (Boiko-Weyrauch 2019; Banse 2019).

The impact or effect mechanism that humpback whales would be especially sensitive to is sound/noise.

8.0 MARBLED MURRELET

Marbled murrelet (*Brachyramphus marmoratus*) are listed as threatened at the federal level, with defined critical habitat in nesting locations along the west coast of the United States (USFWS 2024a). Marbled murrelet were initially listed on October 1, 1992 (57 FR 45328). Critical habitat for the marbled murrelet was originally designated on May 24, 1996 (61 FR 26256) and further revised on October 5, 2011 (76 FR 61599). The current designation includes approximately 3,698,100 acres in Washington, Oregon, and California.

8.1 Life History and Population Trajectory

Marbled murrelets spend most of their lives in the marine environment, but nest in old-growth forests within range of the coast. Both males and females have a sooty-brown upperpart with dark bars and light, mottled brown underparts. Their breeding range extends from Bristol Bay, Alaska in the north to Monterey Bay, California in the south (USFWS 2024a). They breed in the early spring, laying one egg per nest and usually only nesting once per year (DNR 2014). Nesting birds typically forage more closely to the nesting habitats than do non-nesters, with a range size of 240 km^2 compared to 655 km^2, as measured on radio marked murrelets in northern California (Hébert and Golightly 2008). However, home range size was found to vary more greatly by year in Washington: 2,098 km^2 in 2005 compared to 469 km^2 in 2004 (Bloxton and Raphael 2008). In the marine environment, their preferred habitats include sheltered, nearshore waters within 3 miles of the shore (USFWS 2024b).

These seabirds are primarily opportunistic feeders, relying on small schooling fish (e.g. Pacific sand lance (*Ammodytes hexapterus*), northern anchovy (*Engraulis mordax*), and Pacific herring (*Clupea pallasii*), rockfish, and marine invertebrates like squid and shrimp (DNR 2014). Feeding primarily occurs in shallow, nearshore water that is less than 100 feet deep (USFWS 2024b). Foraging murrelets do not typically form groups but may collect around schools of fish or other food resources (Speich and Wahl 1989).

General population models and trends suggest that the marbled murrelet population is on a long-term downward trajectory (WDFW 2024). Past demographic models suggest losses of about 3 to 7 percent per year (McShane et al. 2004). However, a USFWS's 2019 5-year status review found that "while there continue to be significant declines in the murrelet population in Washington State, there does not appear to be a trend (negative or positive) at the listed-range scale" (USFWS 2019a), which is a change from their 2009 5-year status review.

8.2 Regional and Local Abundance

The following sections outline the regional abundance of marbled murrelets at the scale of the entire Puget Sound and North Puget Sound.

Puget Sound is encompassed by Conservation Zone 1, as defined in the original Marbled Murrelet Recovery Plan (USFWS 1997). According to at-sea population surveys conducted for annual monitoring, murrelets are estimated to have had an annual rate of change of -4.9% between the years of 2001-2016 within Conservation Zone 1 (USFWS 2019a). Nonetheless, marbled murrelets are considered to be fairly common within the Puget Sound throughout the year (Seattle Audubon Society 2019a).

8.3 Sensitivity to Environmental Stressors

Because marbled murrelets rely on both marine and terrestrial environments, they are sensitive to a variety of stressors. Threats discussed in this section will be divided into factors specific to terrestrial, nesting habitats and those affecting marbled murrelets in general.

The primary stressor within the marbled murrelet terrestrial range is loss of nesting habitat. Nesting habitat is threatened by commercial logging and other human disturbance, and climate change is likely to exacerbate habitat loss and fragmentation (USFWS 2019a). For this reason, much of the existing old-growth forest suitable for marbled murrelet nesting has been designated as critical habitat to limit the allowable actions within these areas (61 FR 26256).

Other threats impact marbled murrelets during the portion of their lives when they are in the marine environment. These factors include the following ((USFWS 2019b):

- Loss of habitat
- Predation

- Gill-net fishing operations
- Oil spills
- Marine pollution
- Disease

Impacts or effect mechanisms that marbled murrelets would be especially sensitive to include:

- Sound/noise
- Physical disturbance of organisms
- Stranding

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Appendix E

Rainbow Trout Early Life Stages in situ Monitoring

Nautilus Environmental

Port of Seattle- Seattle-Tacoma International Airport

Rainbow Trout Early Life Stages *In Situ* Monitoring Testing

Phase 1: Development and Demonstration - Fall 2011 and Spring 2012 Testing Events

Final Report

Report date: September 20, 2012

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1.0 INTRODUCTION

This report presents the results of the rainbow trout (RBT) early life stages (ELS) *in situ* monitoring tests conducted in the Fall 2011 and Spring 2012, as described in the Port of Seattle's Seattle-Tacoma International Airport *In situ* Monitoring Plan, Phase 1: Development and Demonstration (Nautilus 2010). Results for studies conducted in Fall 2010 and Spring 2011 were presented previously (Nautilus 2011). The objective of this program is to demonstrate the feasibility of using salmonid ELS as an *in situ* monitoring tool to assess the quality of receiving waters potentially affected by stormwater discharges from the Seattle-Tacoma International Airport (STIA), as well as a multitude of other discharges from the surrounding urban environment. The *in situ* bioassay and supporting analytical data are intended to serve as an indication of attainment of receiving water quality standards and associated beneficial uses related to salmonid spawning and rearing. Thus, the overall goal of Phase 1 is to validate the *in situ* approach, particularly with respect to determining if the selected sites and exposure methodologies are appropriate, or if they need to be modified to compensate for confounding variables (e.g., deposition of fine sediments, mobilization of anoxic sediments during storm events, etc.). Applied under the appropriate conditions, it is anticipated that the RBT *in situ* ELS bioassay will be an effective instream biological monitoring tool for assessing the potential effects of stormwater discharges on the receiving environment. In addition to continued evaluation of the *in situ* testing methodology, this report also compares the results of the current year's monitoring to results obtained the previous year to determine the extent to which they were consistent between years.

Phase I (i.e., Development and Demonstration) was originally intended to last for one year and include testing during the Spring and Fall seasons. However, this Phase is being extended to allow for additional comparison with the sublethal testing currently being conducted by the STIA at sites downstream of Port outfalls as identified in Part II, Special Condition S8 of their NPDES permit. The laboratory sublethal toxicity testing is used for permit compliance purposes, and has been conducted concurrently with *in situ* deployments when feasible to facilitate validation of the *in situ* methodology. Part II, Special Condition S9 of the permit allows for substitution of the laboratory sublethal test with *in situ* testing, but, because the *in situ* testing has been implemented on a watershed approach, direct substitution of the *in situ* test in place of the laboratory sublethal test is not appropriate at this time.

For the remainder of the permit cycle (through March 2014), *in situ* testing will continue to focus on the watershed-based sites identified in the monitoring plan, along with continued concurrent laboratory sublethal testing. Extended implementation of Phase I through the remainder of the current permit cycle will create a valuable dataset for use in comparing the *in situ* methodology with the laboratory sublethal test.

2.0 TEST METHODS

Guidance for conducting *in situ* ELS exposures with salmonids is available from a number of sources. For example, the British Columbia Ministry of Environment has a protocol for an *in situ* ELS salmonid test (BC MoE, 2003). In addition, Environment Canada has developed both laboratory and *in situ* test procedures for early lifestages of rainbow trout (Environment Canada, 1998). In the U.S., there are two general laboratory protocols for conducting fish early life stage toxicity tests (EPA, 1996; ASTM, 2005).

2.1 Design

The study design used for the Fall 2011 and Spring 2012 *in situ* testing involved exposure of eyed-embryos at three sampling sites, using four replicates per site. The locations of the sites are shown in Figure 1. The Study Design was consistent with the methodology used in the Spring 2011 monitoring event in which the two sites located downstream of all Airport discharges were augmented by an additional site on Des Moines Creek located upstream (Des Moines Creek Upstream) of any Airport discharges. The additional site was included to determine the extent to which sources upstream of any STIA inputs may contribute to adverse effects observed at the downstream site on Des Moines Creek. The study design for both events is summarized in Table 1.

The exposure period used in the *in situ* tests covers the major salmonid early life stage developmental milestones, beginning with the eyed egg stage, proceeding through hatching and alevin (yolk sac present and residing in gravel) stages, and ending with the early fry stage (also known as swim-up fry). At this point, the yolk sac is absorbed and, under natural conditions, the fish would leave the gravel to feed independently. The duration of the exposure period was expected to include multiple rain/runoff events, and corresponding fluctuations in flow, contaminant concentrations, temperature, water chemistry, etc. Collectively, these

attributes of the *in situ* approach provide highly relevant information regarding the suitability of the streams to support salmonids.

The eyed eggs for both *in situ* events were supplied locally by TroutLodge (Sumner, WA), which supplies these same organisms for the laboratory toxicity tests required in STIA's NPDES stormwater permit. The status of the *in situ* organisms was routinely monitored during the exposure, as well as at specific developmental stages and after significant storm events. Data were obtained on hatching, survival, development and growth. A subset of embryos was also reared in the laboratory to assess organism quality. Weekly temperature measurements from the field were used to adjust rearing temperatures for the laboratory controls so that development in the controls could be used to trigger field inspections at specific times (e.g., hatch, swim-up).

Table 1: Summary of the *in situ* ELS test study design.

Names of Sites	No. of Replicates	No. of Embryos per replicate
Miller Creek (MC8th)	4	30
Des Moines Creek at S 200th	4	30
Des Moines Creek Upstream	4	30
Laboratory Control	4	30

2.2 Monitoring Locations and Site Preparation

The exposures were conducted in two streams within STIA property boundaries, Miller Creek and Des Moines Creek, Figure 1. Two of the sites, Miller Creek and Des Moines Creek at S 200th, are located downstream of STIA inputs into their respective drainages. An additional site (Des Moines Creek Upstream) is located upstream of STIA stormwater outfalls into Des Moines Creek. This site is used to assess water quality in Des Moines Creek prior to receiving any STIA stormwater discharges; the Des Moines Creek basin upstream of STIA is heavily urbanized and potentially impacted by a variety of pollutant sources.

The chosen sampling sites generally do not have ideal substrate conditions, and are subjected to heavy sediment flow during storm events. Consequently, based on results obtained during the previous year, all four exposure replicates at each site were placed above the substrate in gravel contained within PVC crate frames (see Figure 2). The stakes and associated crates were placed so that replicate crates rested on the streambed in a row from upstream to downstream, at a sufficient distance apart such that flow patterns were reestablished between each crate. This

approach allowed for passage of water through the exposure chambers, but prevented smothering of embryos and fry by sediment.



Port of Seattle

Figure 1
Receiving Water Monitoring Locations

2.3 Field Exposure Apparatus

The trout embryos were contained in modified Whitlock-Vibert hatchboxes (Federation of Flyfishers, MO), which are comprised of two rectangular chambers located one above the other; the upper chamber is for embryo development and the lower chamber for rearing of hatched fish. The external sides of the hatchbox are plastic mesh that allows passage of water through the box, but prevents loss of embryos. The divider between the embryo chamber and the rearing chamber is comprised of slots that are narrow enough to prevent transfer of unhatched embryos, but wide enough to permit migration of hatched fish into the lower rearing chamber. Thus, upon hatch, alevins are able to migrate through the slots from the embryo chamber into the larger rearing chamber. To prevent escape of the hatched fry into the streams upon swim-up, plastic screening material (Darice® size 7 mesh) was attached to the external faces of the rearing chamber and held in place using small plastic zip ties.

The hatchboxes were contained within flexible plastic mesh bags surrounded by 1 – 2 inch diameter gravel, with the hatchbox placed centrally within the rocks in the bag. The gravel surrounding the hatchboxes acts to diffuse the current and prevent exposure of the embryos to sunlight. The bags were then placed within the PVC crates, which were held in place in the stream by stakes anchored in the substrate (Figure 2). Figure 3 shows the eyed eggs within the hatchbox, while Figure 4 is of fry within the hatchbox.

Figure 2: Photograph of the crate set up, Des Moines Creek at S 200th.



Figure 3: Photograph of eyed eggs in the upper chamber within the hatchbox.

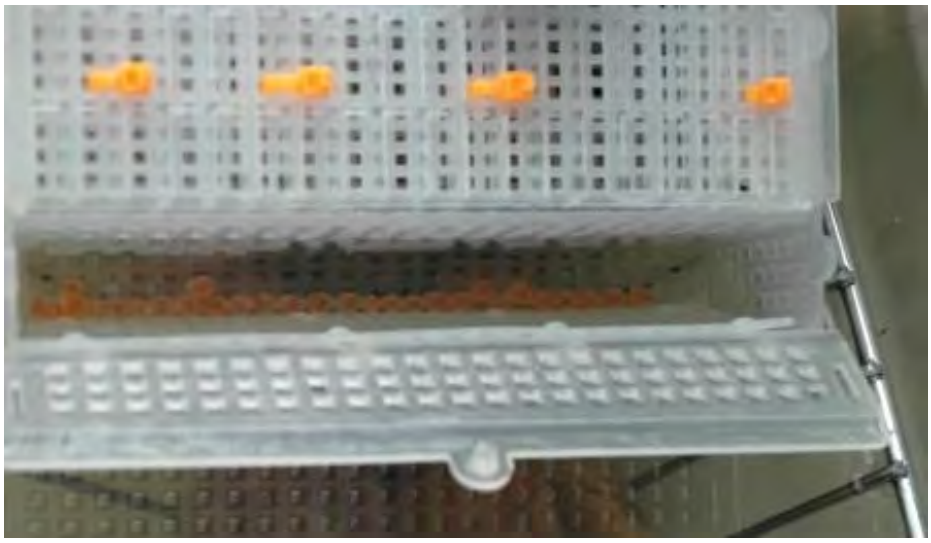


Figure 4: Photograph of fry within the hatchbox.



2.4 Test Organisms

Eyed-egg stage rainbow trout embryos were obtained from TroutLodge in Sumner, WA, on November 30, 2011 and March 27, 2012 for the Fall and Spring events, respectively. As supplied, the eyed embryos had developed for approximately 245 degree-days[1], as noted in communication with TroutLodge staff. The embryos were transported to the Airport Stormwater Laboratory or the Rainier Environmental Laboratory (Fife, WA), for the Fall and Spring monitoring events, respectively, where they were randomly counted into replicate units of 30 embryos apiece in individual opaque plastic food-storage containers (i.e., 450-mL opaque Ziploc plastic tubs). The containers were then placed in a cooler containing ice packs, and transported to the sites where the embryos were transferred into the hatchboxes in the creek on the same day. The embryos were transferred to the sites in laboratory control water, and all embryos were installed at the sites between 13:00 and 14:30 on November 30, 2011 for the Fall event, and between 14:45 and 15:45 on March 27, 2012 for the Spring event.

All personnel handling the embryos wore nitrile gloves. Containers were pre-cleaned with Liqui-nox soap (Alconox, Jersey City, NJ) and rinsed with deionized water.

2.5 Controls

Controls were used to assess the influence of the following factors on test results:

1. Quality (health and viability) of supplied organisms,
2. Transport and handling of organisms, and
3. Ambient stream temperatures, which affect the time to developmental milestones (e.g., hatch).

The controls consisted of a laboratory exposure (four replicates of 30 organisms each) conducted concurrently with each field exposure in clean laboratory water (moderately hard synthetic water [MHSW]) to monitor organism health and developmental milestones using a subset of the same batch of embryos used to begin the field exposures. These embryos were also counted out and placed in individual plastic containers filled with MHSW and transported to the sites with the other replicates; thus, they also served as transport controls. Upon returning to the

[1] Degree-days are used to standardize descriptions of fish development, regardless of rearing temperature. For example, it takes rainbow trout approximately 340 degree-days to reach hatch (Quinn, 2005). Thus, at 8°C, it takes approximately 42 days to reach hatch.

laboratory after deployment of all field organisms, the control replicates were transferred to 4-L plastic containers in the laboratory containing 2 liters of MHSW at the average site water temperature, ± 1°C. Gentle aeration was applied (100-200 bubbles per minute) to the control chambers. The controls were monitored daily for mortalities, and dead organisms removed. Temperature was adjusted on a weekly basis to correspond to temperatures measured in the field. Water renewals were conducted three times per week (Monday, Wednesday, Friday) using clean MHSW. Dissolved oxygen, pH, conductivity, and temperature were measured before and after water renewals. Developmental milestones (e.g., hatch and swim-up) were also recorded.

2.6 Monitoring of Field Exposures

The sites were visited approximately every week to assess the condition of the test organisms. During these checks, survival was recorded, as well as qualitative observations of organism health, site conditions, and sedimentation within the boxes. All dead organisms observed were removed on each visit. These observations were recorded on standard field data sheets included in Appendix A. In addition, temperature, pH, and dissolved oxygen (DO) and conductivity were measured during the site visits.

Monitoring of the installations required removal of the substrate overlying the hatchboxes from the mesh bag in the crate. The embryos or alevins in each hatchbox were then poured into a white plastic dishpan containing site water where they were enumerated. They were then returned to the hatchbox, which was placed back into the mesh-net bag of gravel, and the bag returned to its respective crate. Care was taken to minimize disturbance and damage to the test organisms.

2.7 Test Termination

The field exposures and laboratory controls were terminated when the field organisms reached the swim-up fry stage (i.e., yolk sac absorbed). This occurred on February 14th, 2012 for the Fall 2011 exposure, and on April 25th, 2012 for the Spring 2012 exposure. Surviving organisms were placed in their original plastic replicate containers, which were filled with site water, transported back to the laboratory and terminated. The fish were then wet-weighed (to the nearest 0.001 gram) on an analytical balance, and measured (total length, from tip of the snout to the end of the tail for the Fall exposure, and standard length, from tip of snout to caudal

peduncle for the Spring exposure) to the nearest 0.5 mm. Obvious external malformations were noted, including the affected body part (e.g., head, eye, spine) and type of abnormality (e.g., edema). Abnormality data were recorded on standard data sheets (Appendix A). The laboratory control fish were evaluated similarly on the same day.

2.8 Data Analysis

All test data were entered in CETIS (Comprehensive Environmental Toxicity Information System, Tidepool Scientific, McKinleyville, CA). Differences among the exposure sites and laboratory controls were evaluated using pair-wise multiple comparison tests according to the USEPA flow chart (USEPA 2002); significant differences were identified at p=0.05.

One interim and five terminal endpoints were evaluated; the endpoints are described below:

1. Hatching success – an interim measure of the percentage of embryos hatched the day of the hatch inspection, or determined to have hatched based on the number of alevins present at the subsequent inspection, relative to the total number of embryos originally added;
2. Post-hatch survival - the percentage of organisms surviving at test termination relative to the number of embryos that hatched (these data help determine whether the majority of mortalities occurred pre- or post-hatch, or were distributed throughout the exposure period);
3. Cumulative survival - the percentage of surviving organisms at test termination relative to the number of embryos in each replicate at the beginning of the exposure;
4. Abnormality – the percentage of abnormal organisms at test termination relative to the number of surviving organisms;
5. Length – to the nearest 0.5 mm;
6. Weight – to the nearest 0.001 g.

3.0 QA/QC

The QA/QC program for the field exposure involved the following:

- Consistent field staff leader throughout all visits;
- Field documentation of all primary data; i.e., the names of individuals collecting the samples, sampling location, time of sampling, site conditions (e.g., degree of

sedimentation), and other relevant observations, such as weather and any unusual conditions;

- Calibrated field meters;
- Use of pre-cleaned containers, with appropriate labels;
- Storing and transporting organisms in sealed containers in a cold, dark environment; cooling sample containers using ice or gel packs;
- Including transport controls to ascertain the extent of any transport-induced stress;
- Checking field organisms every week to monitor developmental progress, mortality and abnormality.

The QA/QC program for the laboratory portion of the study involved:

- Checks and maintenance of control organisms at regular intervals, including recording primary observations and water quality data on standardized data sheets;
- Review of datasheets by senior laboratory staff;
- Test termination activities (measurements, health assessment) conducted by qualified staff members using standardized datasheets to ensure consistent assessment of abnormalities and growth across all test sites and controls;
- Use of standard laboratory water and environmental chambers to maintain test organisms.

4.0 RESULTS

4.1 Water Quality Measurements

Water quality measurements are summarized in Tables 2 and 3 for the Fall 2011 and Spring 2012 monitoring events, respectively.

Table 2: Fall 2011 summary of water quality measurements collected during site visits and control renewals.

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	5.3 (1.2)	9.7 (0.6)	7.49 (0.19)	261.3 (19.4)
	[Min-Max]	[3.1 – 7.6]	[7.1 – 10.6]	[7.04 – 7.82]	[220 – 298]
Miller Creek		5.5 (1.2)	10.7 (2.2)	7.53 (0.17)	198.5 (51.5)
		[4.1 – 7.2]	[6.5 – 12.6]	[7.24 – 7.78]	[132 – 293]
Des Moines Creek		5.7 (1.3)	10.0 (1.3)	7.42 (0.26)	168.6 (69.1)
at S 200th		[3.4 – 7.3]	[7.1 – 11.5]	[7.12 – 7.81]	[93 – 327]
Des Moines Creek		5.5 (1.4)	10.9 (1.9)	7.40 (0.39)	114.6 (66.6)
Upstream		[3.0 – 7.9]	[6.9 – 13.1]	[6.48 – 7.9]	[27 – 214]

Data include average, (standard deviation) and [minimum - maximum]

Table 3: Spring 2012 summary of water quality measurements collected during site visits and control renewals.

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	10.6 (0.7)	10.9 (0.4)	7.87 (0.08)	353.1 (6.6)
	[Min-Max]	[9.5 – 12.0]	[10.2 – 11.6]	[7.70 – 8.00]	[341 – 365]
Miller Creek		10.5 (1.2)	10.1 (0.6)	7.60 (0.10)	211.4 (29.9)
		[9.3 – 12.3]	[9.4 – 10.7]	[7.47 – 7.74]	[170 – 247]
Des Moines Creek		11.1 (1.6)	9.5 (0.5)	7.45 (0.19)	178.6 (17.7)
at S 200th		[9.5 – 13.5]	[8.7 – 9.9]	[7.31 – 7.78]	[151 – 193]
Des Moines Creek		11.2 (1.6)	9.4 (0.3)	7.65 (0.31)	118.3 (6.7)
Upstream		[9.7 – 12.8]	[9.0 – 9.7]	[7.40 – 8.07]	[109 – 125]

Data include average, (standard deviation) and [minimum - maximum]

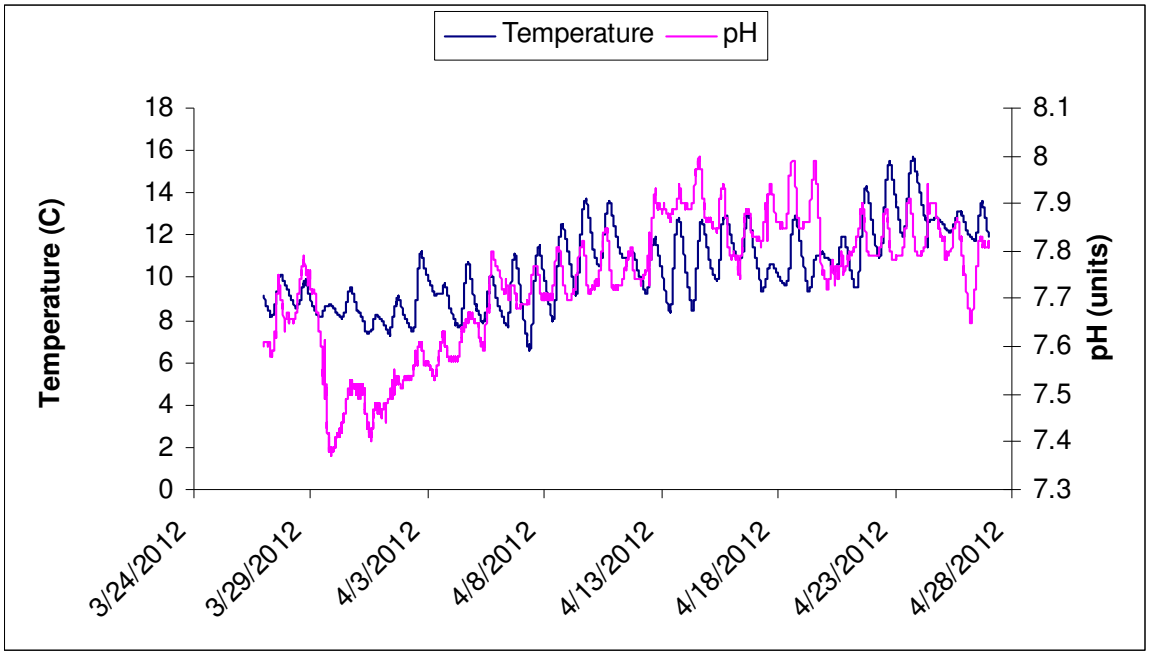
In the Fall 2011 *in situ* tests, temperatures for the three field sites and the control ranged from 3.0 to 7.9ºC. The field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays (60-100% saturation, and 6-9 pH units, respectively). The pH values were circumneutral, and DO ranged from 6.5 to 13.1 mg/L among all stream measurements. Although limited to weekly measurements, the field DO and pH data suggested generally good water quality conditions, with no indication of potential for adverse effects on organism survival and development. The conductivity measurements for all three sites exhibited some

variability throughout the exposure period, but the values remained well-within ranges tolerated by early life stages of salmonids.

In the Spring 2012 *in situ* tests, temperatures between the three field sites and the control ranged from 9.3 to 13.5ºC. These temperatures were about 5 degrees warmer than fall temperatures, which accounts for the difference in test durations between the two events (i.e., 77 days for the Fall event and 30 days for the Spring event). The field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays. The pH values were circumneutral, and DO ranged from 8.7 to 10.7 mg/L among all stream measurements. Consequently, the weekly field measurements of DO and pH suggested generally good water quality conditions, with no indication of potential for adverse effects on organism survival and development. As observed in the Fall event, the conductivity measurements for all three sites exhibited some variability throughout the exposure period, but the values remained well-within ranges tolerated by early life stages of salmonids.

Continuous measurements of pH and temperature were collected by CardnoTEC using data sondes at the Miller Creek site during the Spring 2012 monitoring event. These data are shown in Figure 5. The data generally agreed with the values collected during the weekly checks at the site, although temperature readings occasionally reached higher levels throughout the day than measured at a single weekly time point. Regardless, the average temperature over the exposure period was similar between methodologies (i.e., 10.5ºC with both continuous and weekly checks). pH readings obtained with continuous monitoring averaged 7.74 compared with an average of 7.60 calculated from the weekly checks. Data from both methodologies suggest that temperature and pH were well-within water quality ranges appropriate for survival and growth of local salmonids.

Figure 5: Continuous pH and temperature data from Miller Creek, Spring 2012



4.2 Precipitation During the Monitoring Events

Precipitation data were provided by STIA. Figure 6 shows the daily precipitation for the duration of the exposure for the Fall 2011 test. A number of storm events occurred during testing, with a total of 10.0 inches of rain/snow over 11 weeks, and the largest storm occurring on January 20th.

Figure 6: Daily precipitation for the duration of fall exposure

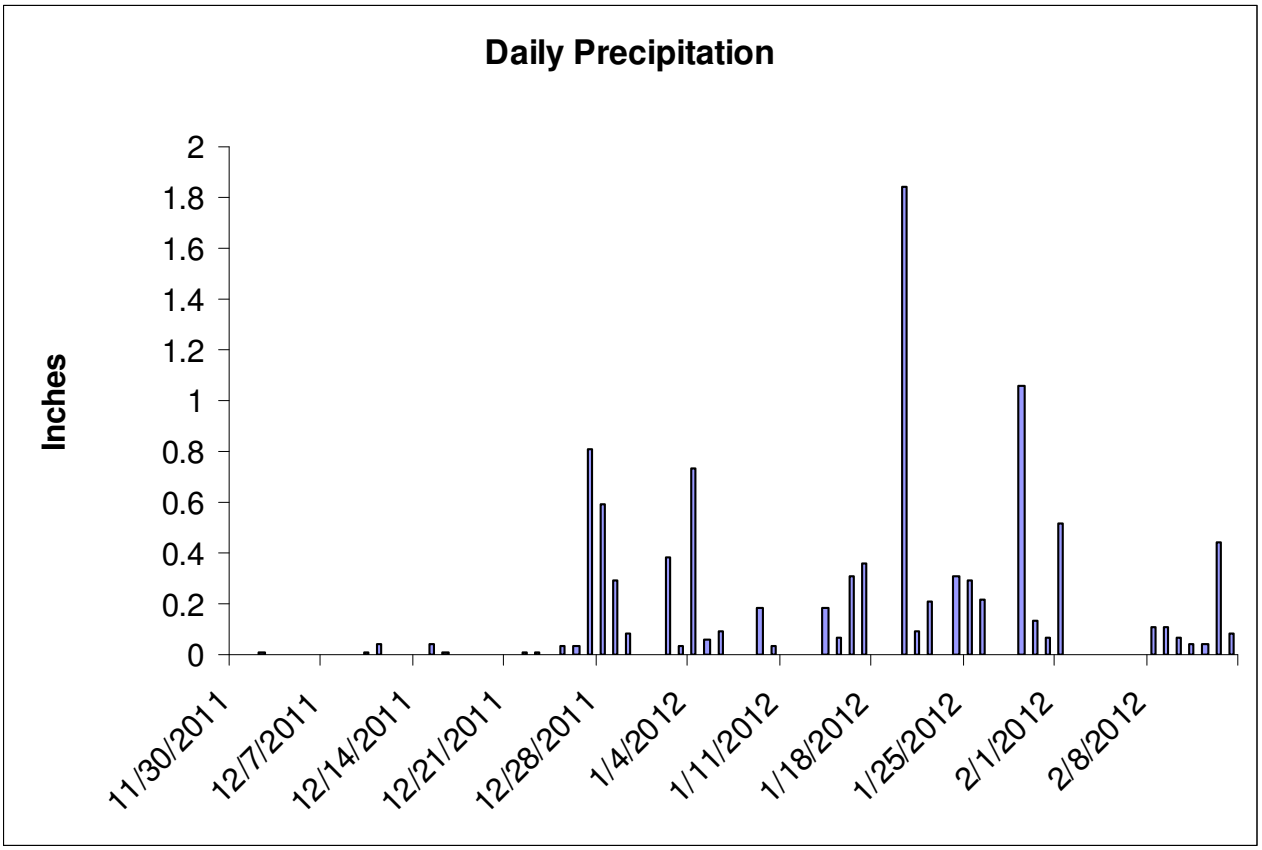
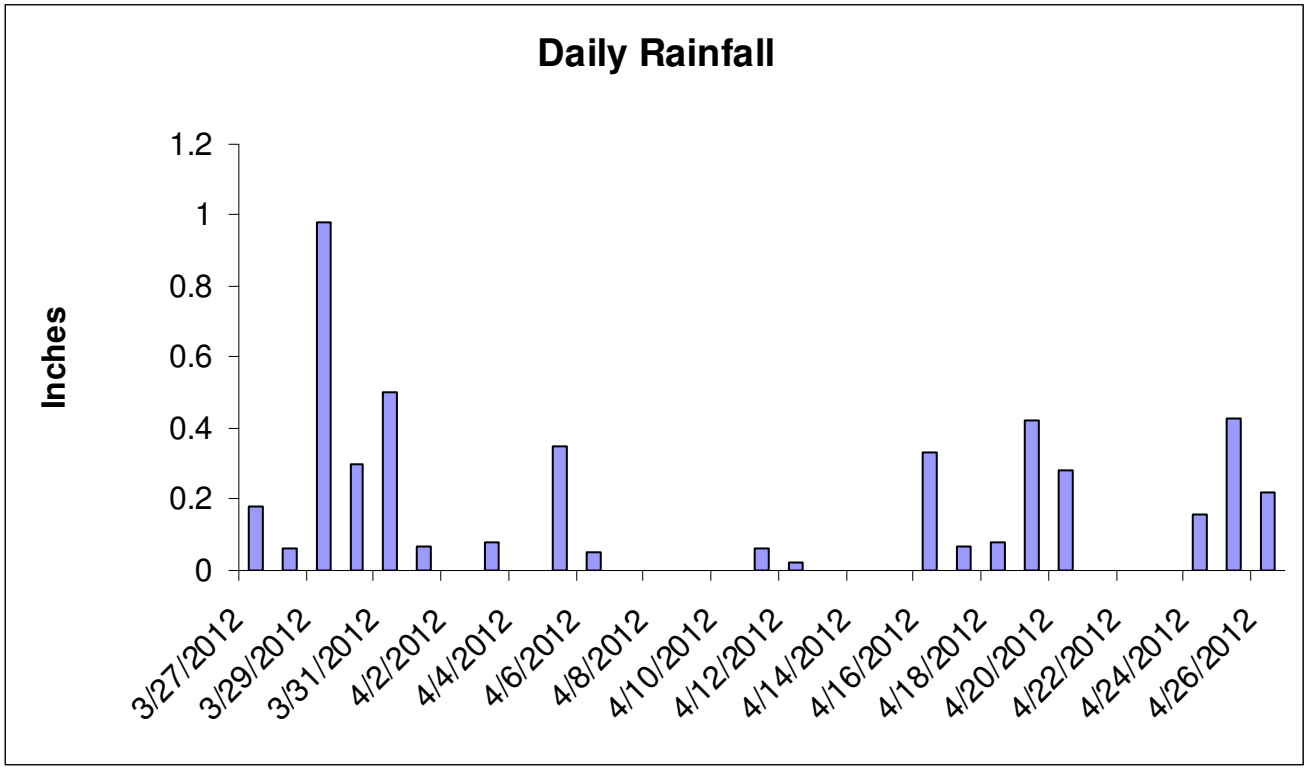


Figure 7 contains the daily rainfall for the duration of the exposure for the Spring 2012 test. Much less total precipitation (4.6 inches) and fewer storms occurred during this exposure period, compared with the fall. No snow occurred during the exposure period, and the largest storm was on March 29th.

Figure 7: Daily rainfall for the duration of the spring exposure



4.3 *In situ* Exposures

4.3.1 Fall 2011

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 4. Table 5 presents the growth endpoints. These same data are presented graphically in Figures 8 through 10 for ease of comparison.

At termination, fish in the controls had developed to 655 degree-days, while the site fish reached approximately 659 degree-days at Miller Creek, 676 degree-days at Des Moines Creek at S 200th, and 660 degree-days at the Des Moines Creek Upstream site.

Hatching success – Mean hatching success for the controls was 99.2%. The Miller Creek replicates exhibited 90.0% mean hatching success, the Des Moines Creek at S 200th replicates had 90.8% mean hatching success, while the Des Moines Creek Upstream replicates averaged 89.2% mean hatching success. Hatching success at Miller Creek, Des Moines Creek at S 200th and Des

Moines Creek Upstream were not statistically different from the controls, and there was no significant difference between the two Des Moines Creek sites.

Post-hatch survival – Control survival of alevins post-hatch was 93.3%. The Miller Creek replicates exhibited 68.0% post-hatch survival, and the Des Moines Creek at S 200th replicates exhibited 56.2% post-hatch survival, while the Des Moines Creek Upstream replicates averaged 50.3%. Post-hatch survival at Miller Creek was not significantly different from the controls. However, the two Des Moines Creek sites were significantly different from the controls, but not from each other.

Cumulative survival – Control survival from the initiation of the test to termination averaged 92.5%. The Miller Creek replicates exhibited an average survival of 63.3% through the duration of the exposure, whereas the Des Moines Creek at S 200th replicates exhibited an average survival of 50.0% compared with an average survival of 45.0% at the Des Moines Creek Upstream site. Statistically, these results were similar to post-hatch survival; thus, Miller Creek was not statistically different from the controls, and the two Des Moines Creek sites were significantly different from the controls, but not from each other.

Abnormalities – There were no abnormalities observed in any of the fish at termination. Some edema was noted during a field visit at both the Des Moines Creek Upstream site and Miller Creek, but these fish either died subsequent to that visit, or the edema had resolved itself by the end of the exposure.

Growth – Average weight in the controls was 119.7 mg, and length averaged 21.1 mm. Miller Creek fish averaged 111.7 mg and 21.7 mm, Des Moines Creek at S 200th fish averaged 104.1 mg and 21.8 mm, and Des Moines Creek Upstream fish averaged 107.4 mg and 21.7 mm. None of the differences in length or weight were significant among sites and controls.

Table 4: Fall 2011 results for hatching success, survival and abnormality in the control and field treatment groups[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	99.2 (1.6)	93.3 (5.4)	92.5 (4.2)	0
Miller Creek	90.0 (11.5)	68.0 (29.0)	63.3 (31.4)	0
Des Moines Creek at S 200th	90.8 (7.4)	56.2 (36.1)	50.0 (31.4)	0
Des Moines Creek Upstream	89.2 (11.0)	50.3 (13.8)	45.0 (12.9)	0

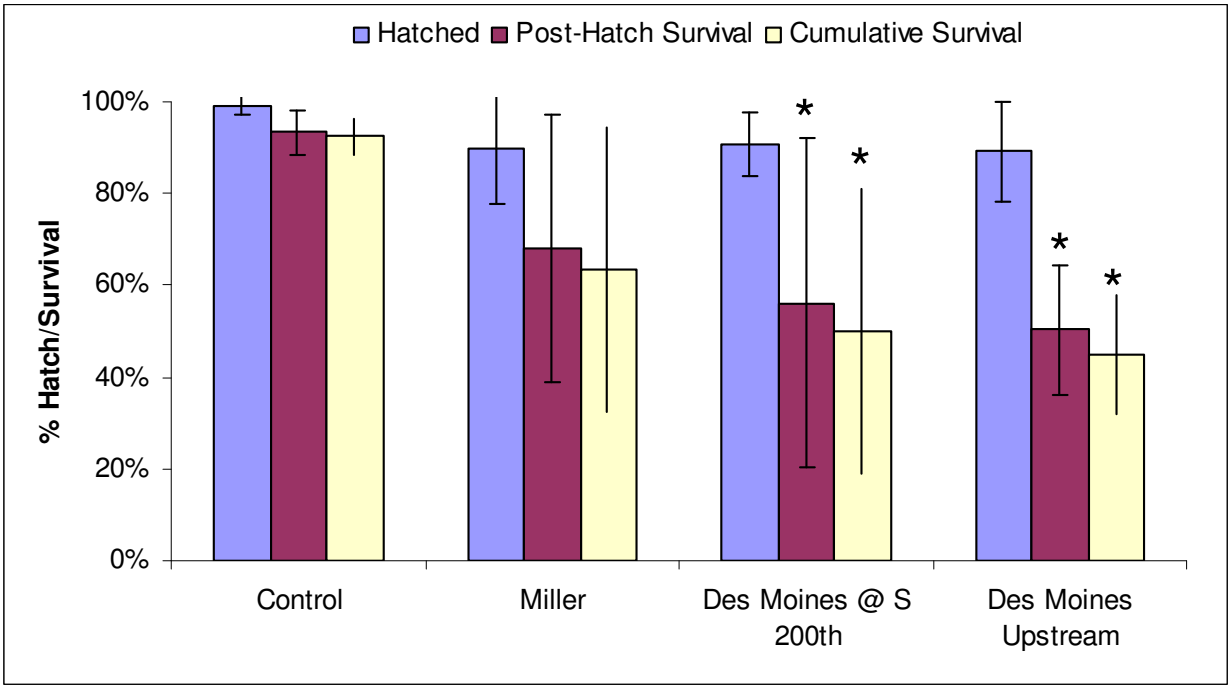
Notes:
1. Results are presented as mean and standard deviation
2. Gray shaded values are significantly different from the control

Table 5: Fall 2011 results for growth in the control and field treatment groups [1].

Site	Length (mm)	Weight (mg)
Control	21.1 (1.0)	119.7 (7.6)
Miller Creek	21.7 (0.49)	111.7 (8.3)
Des Moines Creek at South 200th	21.8 (0.55)	104.1 (17.0)
Des Moines Creek Upstream	21.7 (0.88)	107.4 (7.0)

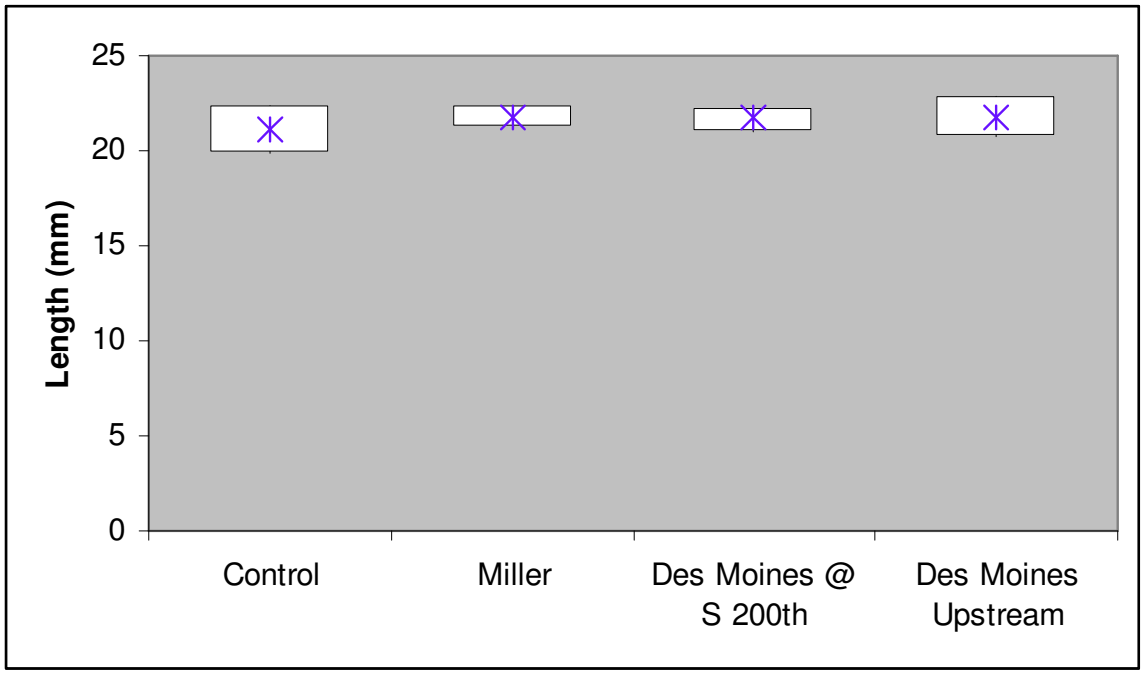
Notes:
1. Results are presented as mean and standard deviation
2. There were no statistical differences compared to the control

Figure 8: Fall 2011 hatching success, post-hatch survival and cumulative survival in the field and control treatment groups.



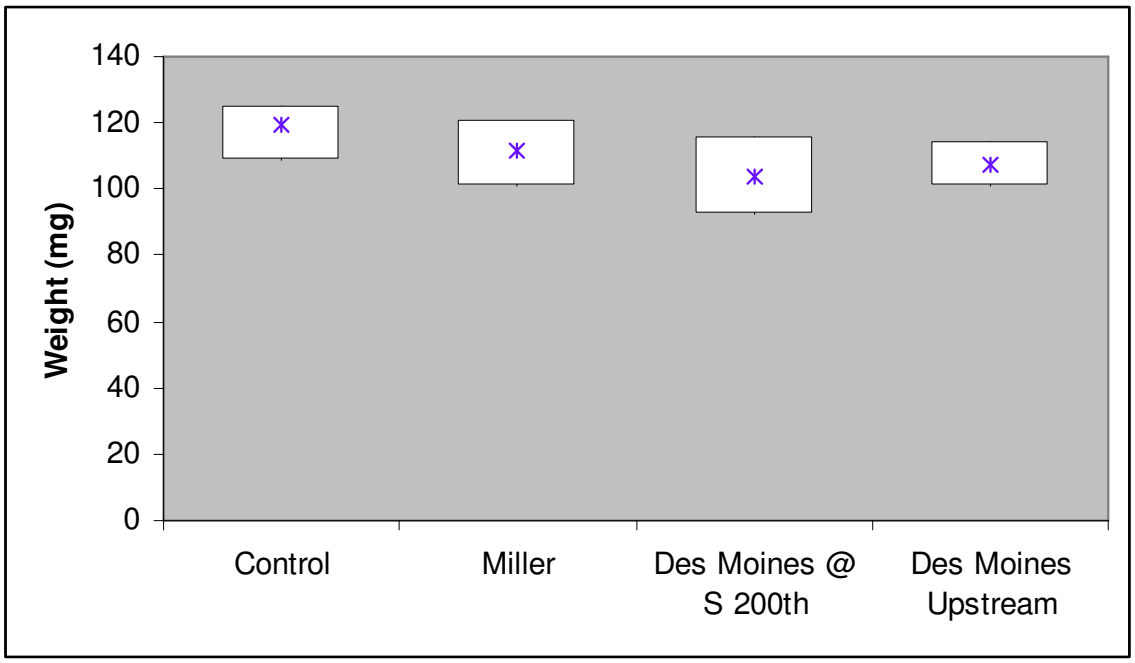
Error bars are standard deviations; asterisks denote significant difference from controls.

Figure 9: Fall 2011 average lengths for the laboratory control and exposure sites.



Data point is average, box is minimum to maximum values

Figure 10: Fall 2011 average weights for the laboratory control and exposure sites.



Data point is average, box is minimum to maximum values

4.3.2 Spring 2011

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 6. Table 7 presents the growth endpoints. These same data are presented graphically in Figures 11 through 13 for ease of comparison.

At termination, fish in the controls had developed for 552 degree-days, while the site fish developed to approximately 549 degree-days at Miller Creek, 564 degree-days at Des Moines Creek at S 200th, and 585 degree-days at the Des Moines Upstream site.

Hatching success – Mean hatching success for the controls was 100%. The Miller Creek replicates exhibited 95.0% mean hatching success, the Des Moines Creek at S 200th replicates had 100% hatching success, and the Des Moines Creek Upstream replicates averaged 94.2% hatching success. There were no significant differences in hatching success among the treatment and control groups.

Post-hatch survival – Control survival of alevins post-hatch was 100%. The Miller Creek replicates averaged 96.5% post-hatch survival, compared with 96.7% survival at Des Moines Creek at S 200th. Post-hatch survival at Miller Creek and Des Moines Creek at S 200th was not

significantly different from the controls. Conversely, fish in the Des Moines Creek Upstream replicates exhibited 0% post-hatch survival, which was significantly different from the controls and the other two exposure sites.

Cumulative survival – Control survival from the initiation of the test to termination averaged 100%. The Miller Creek replicates exhibited an average survival of 91.7% through the duration of the exposure, while Des Moines Creek at S 200th replicates averaged 96.7% survival; both of these values were not significantly different from the controls. The Des Moines Upstream replicates exhibited 0% survival at the end of the exposure, which was significantly different from the controls, as well as the other sites.

Abnormalities -- The incidence of abnormalities at termination was 0.83% in controls. The Miller Creek replicates averaged 1.1% abnormality, and there were no abnormalities at the Des Moines Creek at S 200th site, (complete mortality prevented determination of this endpoint for the Des Moines Creek Upstream site). The abnormal control fish exhibited a malformed head, while the abnormal Miller Creek fish was suffering from edema. There were no significant differences between the controls and the two sites.

Growth – Average weight in the controls was 127.4 mg, and length averaged 24.2 mm. Miller Creek fish averaged 137.3 mg and 24.5 mm for weight and length, respectively, and Des Moines Creek at S 200th fish averaged 134.2 mg and 24.3 mm. None of the differences in length or weight were significant between sites with surviving organisms and controls. Complete mortality prevented determination of these endpoints for the Des Moines Creek Upstream site.

Table 6: Spring 2012 results for hatching success, survival and abnormality in the control and field treatment groups[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	100 (0)	100 (0)	100 (0)	0.83 (1.7)
Miller Creek	95.0 (10)	96.5 (4.7)	91.7 (11.1)	1.1 (2.2)
Des Moines Creek at S 200th	100 (0)	96.7 (4.7)	96.7 (4.7)	0 (0)
Des Moines Upstream	94.2 (5.7)	0 (0)	0 (0)	NC

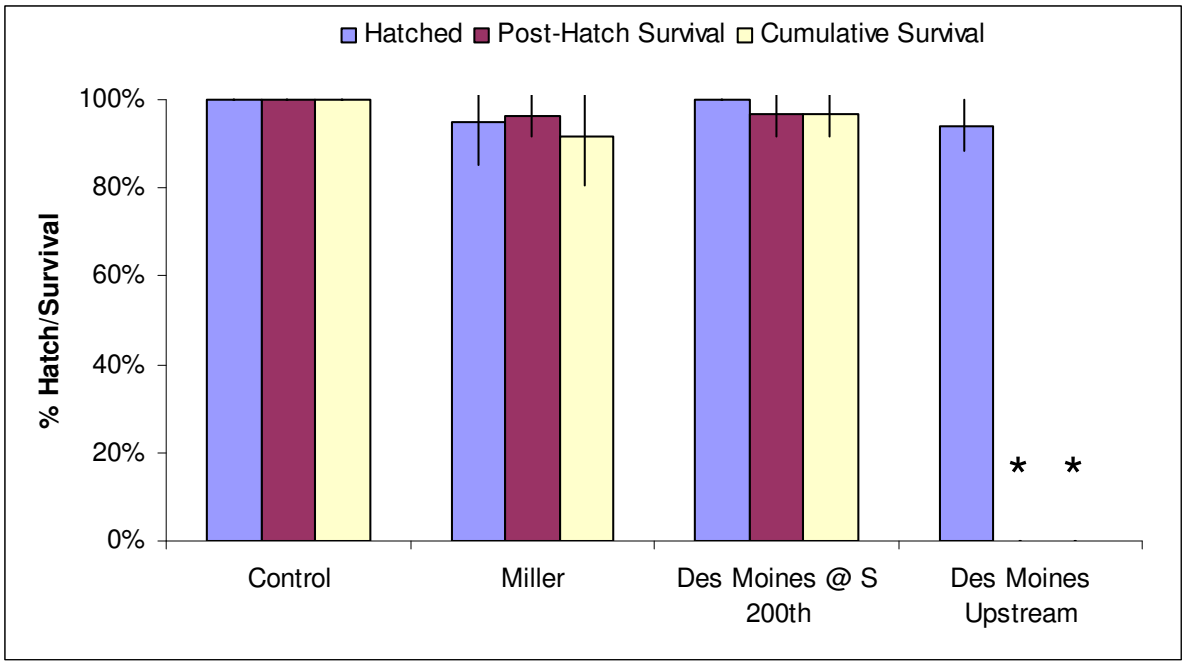
Notes:
1. Results are presented as mean and standard deviation
2. Gray shaded values are significantly different from control
3. NC- Not calculable

Table 7: Spring 2012 results for growth in the control and field treatment groups.

Site	Length (mm)	Weight (mg)
Control	24.2 (0.33)	127.4 (4.8)
Miller Creek	24.5 (0.51)	137.3 (4.9)
Des Moines Creek at S 200th	24.3 (0.13)	134.2 (6.8)
Des Moines Upstream	NC	NC

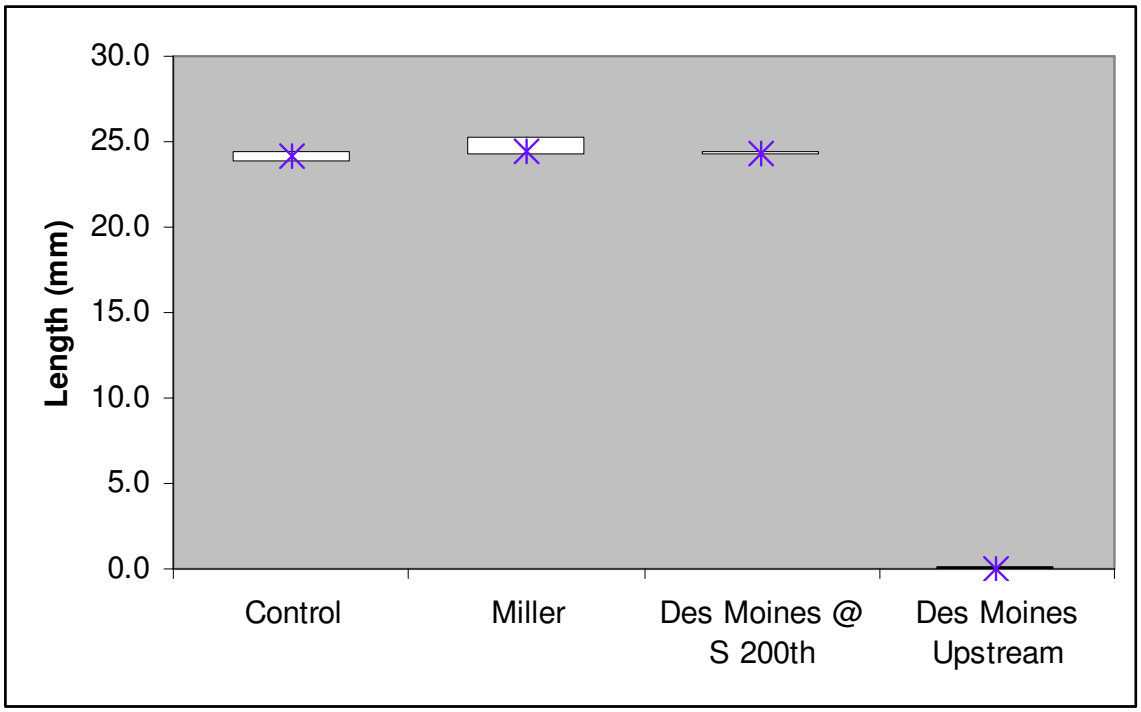
Notes:
1. Results are presented as mean and standard deviation
2. NC- Not calculable

Figure 11: Spring 2012 hatching success, post-hatch survival and cumulative survival in the field and control treatment groups.



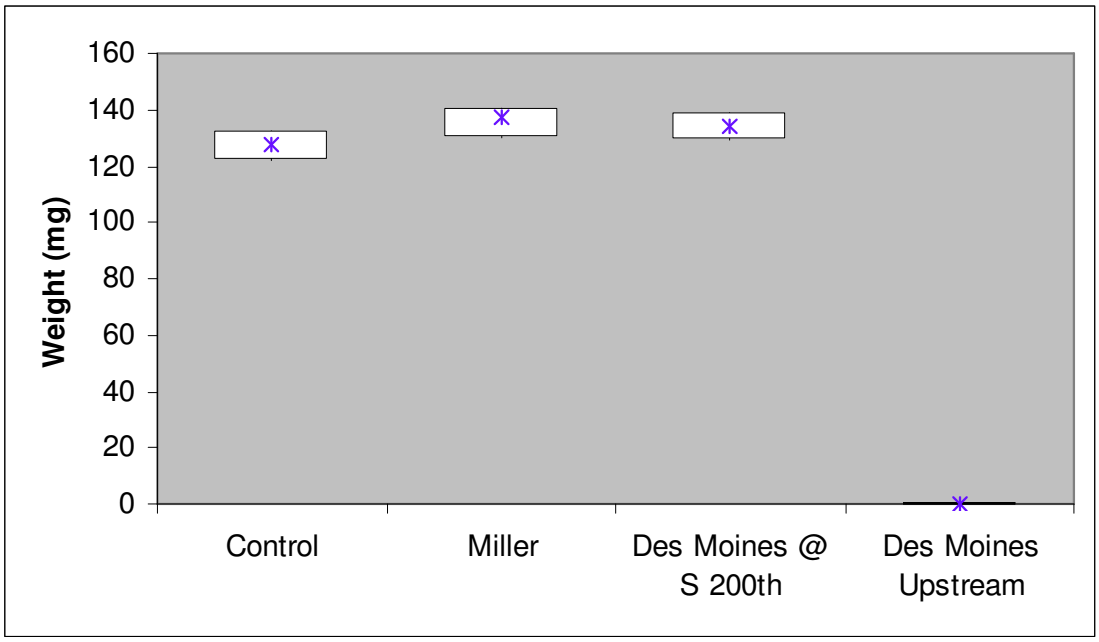
Error bars are standard deviations, asterisks denotes significant difference from controls.

Figure 12: Spring 2012 average lengths for the control and exposure groups.



Data point is average, box is minimum to maximum values. No data for Des Moines Upstream due to complete mortality.

Figure 13: Spring 2012 average weights for the control and exposure groups.

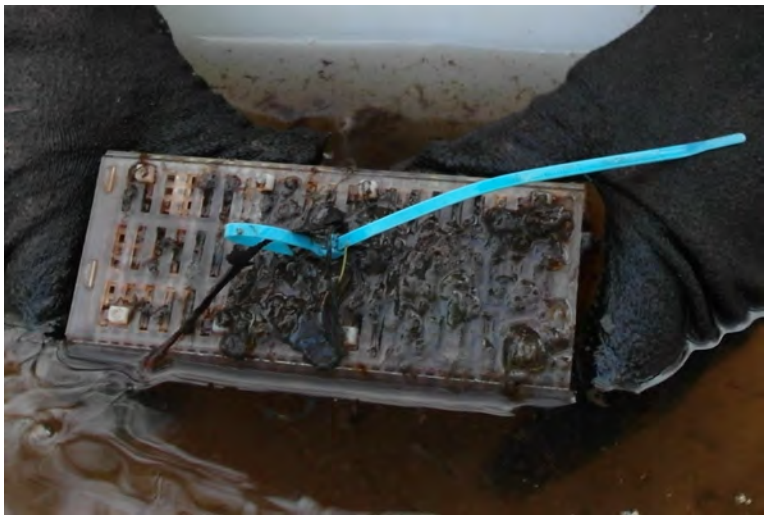


Data point is average, box is minimum to maximum values. No data for Des Moines Upstream due to complete mortality.

4.4 Field Observations

In the Fall 2011 event, all replicates at the Des Moines Creek at S 200th site were subject to biofouling, consisting of a brown filamentous substance (biofilm). This was also observed during the Fall 2010 monitoring event. The substance has not been identified, although it appeared to consist of a mixture of diatoms, bacteria, and possibly fungus. The biofilm was first noted 7 weeks (January 23, 2012) after test initiation, and the onset coincided with the first snow event of the year. In some cases, the growth was extensive (Figure 14). The biofilm did not appear to prevent flow of water into and through the crates. The biofilm was also found to a lesser degree at the Des Moines Upstream site. Miller Creek was also observed to have some biofilm on the hatchboxes, although the initial observation was made a week prior to when it was found in Des Moines Creek. The biofilm at Miller Creek was lighter in color and a different consistency, suggesting a different mixture of organisms. All hatchboxes were replaced the week the biofilm was found at all three sites. Des Moines Creek at S 200th was the only site to see new growth of the biofilm after the initial discovery; however, the texture of the film in the following weeks was different from the initial discovery, and the thickness of the coating was never as severe. Unlike the Fall 2010 event, the appearance of the biofilm did not coincide with mortality at Des Moines Creek at S 200th.

Figure 14: Photograph of hatchbox colonized by biofilm



As the biofilm was also found at the Des Moines Creek Upstream site the same week it appeared downstream, the source of the biofilm appears to be located outside of the area associated with Airport operations.

A biofilm was also observed during the Spring 2012 exposure, but was not present the previous spring. On the day of test termination, both Miller Creek and Des Moines Creek at S 200th replicates were found to be covered in brown algae. The appearance of the biofilm was different than the biofilm observed during the Fall event. Thus, these observations may reflect seasonal differences in composition of the biofilm. Unfortunately, the Des Moines Creek Upstream replicates had already been removed because of complete mortality, so it was not possible to establish the extent to which the biofilm originated upstream of STIA operations based on growth of biofilm on the hatchboxes.

5.0 DISCUSSION

The results of the Fall 2011 rainbow trout *in situ* early life stage exposure indicated that adverse effects on survival were found in Des Moines Creek at S 200th, compared with the laboratory controls. However, as similar effects were also seen at the Des Moines Creek Upstream location, these effects appear to be from an upstream source and not caused by Airport activities. While the Des Moines Creek Upstream location was not included in the Fall 2010 sampling event, results from Des Moines Creek at S 200th show improvement, although not statistically significant, when compared between the Fall 2010 and 2011 monitoring events (i.e., cumulative survival of 18.3% in Fall 2010 vs 50.0% in Fall 2011).

While average survival at Miller Creek was reduced during the Fall 2011 event, although not statistically different from controls, the distribution of the reduced survival is of potential interest. The two middle replicates at Miller Creek showed similar results to the controls with 90% and 86.6% survival in the second and third replicates, respectively. In comparison, the first replicate exhibited 53.3% survival and the fourth replicate only 23.3% survival. Water quality effects are unlikely to be observed in a pattern where only the furthest upstream and most downstream replicates are affected. Thus, the results instead suggest a potential replicate location issue. The downstream-most replicate is subjected to significant amounts of sediment being washed into the creek, especially during rain events. This may lead to smothering of the eggs or alevins between site visits. A similar explanation for why the first replicate had lower survival is unclear at this time and may simply reflect variability within the system or response. Survival in Miller Creek in Fall 2010 averaged 81.7%, compared with 63.3% in Fall 2011. However, there was no statistical difference between the two years, suggesting a relatively consistent pattern in water quality. Neither year exhibited significant differences from the control.

Sedimentation can be an issue at the Miller Creek site, especially after large storm events have washed fine particles into the creek. During one such storm in the Fall 2011, most of the boxes were almost completely full of sediment. While the alevins were able to stay on top of the sediment in the boxes, this might not have been the case if the check been delayed a day or two. This observation emphasizes the importance of checking the boxes soon after major storm events.

The results of the Spring 2012 *in situ* exposure indicated that adverse effects were associated only with the Des Moines Creek Upstream site, compared with the laboratory controls and Des

Moines Creek at S 200th. The large difference in survival between the two locations on Des Moines Creek suggests that the effects were relatively localized, and did not extend to lower reaches of the Creek. On two occasions, while at the Des Moines Creek Upstream site, the field crew observed that the water became extremely murky over the course of the visit, which coincided with a rising water level. It was actually raining on only one of these occasions, suggesting that a release of water was occurring further upstream.

The results for Spring monitoring events for both Miller and Des Moines Creeks at S 200th exhibited a statistical improvement from 2011 to 2012, as cumulative survival increased from 73.3% to 91.7% at Miller Creek, and from 76.7% to 96.7% at Des Moines Creek at S 200th. Conversely, survival at the Des Moines Creek Upstream site was lower in 2012 compared with 2011, with no survival occurring in 2012, compared with 42.5% survival in 2011.

Overall, cumulative survival was the primary endpoint affected, with reduced survival clearly associated with the post-hatch period. The fact that mortality was not observed until after hatching continues to suggest that the subsequent early juvenile development period is the most critical life stage for these exposures.

Seasonal differences in response are of interest, as preliminary data suggest that adverse effects are more consistently observed during the Fall exposure. Part of the difference could be the difference in duration of the exposure, which is dictated by the temperature in the creeks. The Fall event in 2011 required 11 weeks for eggs to develop from the eyed stage to swim up, compared with just 5 weeks in the Spring. Precipitation amounts also differed between seasons, with the Fall season receiving substantially more precipitation than the Spring. It should be noted, however, that the Fall events of the past two years have extended into the Winter months, and the effects may be more related to snow events and winter conditions than to Fall.

Regardless of seasonal differences, perhaps the most notable observation associated with these tests is the continued level of adverse effects found at the Des Moines Creek Upstream site. Adverse effects have been observed at this site during all monitoring events, and are present during both Spring and Fall. Since this site is located near the headwaters of Des Moines Creek, causes of impacts at this site arise outside of STIA property and have the potential to extend further downstream. The results of this study have been communicated to the City of Sea-Tac, who are working on determining the cause through the City's illicit discharge and elimination program.

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Nautilus Environmental

Port of Seattle- Seattle-Tacoma International Airport

Rainbow Trout Early Life Stages *In Situ* Monitoring Testing

Phase 1: Development and Demonstration - Fall 2012 and Spring 2013 Testing Events

Final Report

Report date: September 16, 2013

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1.0 INTRODUCTION

This report presents the results of the rainbow trout (RBT) early life stage (ELS) *in situ* monitoring tests conducted in the Fall 2012 and Spring 2013, as described in the Port of Seattle's Seattle-Tacoma International Airport *In situ* Monitoring Plan, Phase 1: Development and Demonstration (Nautilus 2010). Results for studies conducted in Fall 2010/Spring 2011 and Fall 2011/Spring 2012 have been presented previously (Nautilus 2011 and Nautilus 2012, respectively). The objective of this program is to demonstrate the feasibility of using salmonid ELS as an *in situ* monitoring tool to assess the quality of receiving waters potentially affected by stormwater discharges from the Seattle-Tacoma International Airport (STIA), as well as a multitude of other discharges from the surrounding urban environment. The *in situ* bioassay and supporting analytical data are intended to provide an indication of attainment of receiving water quality standards and associated beneficial uses related to salmonid spawning and rearing. Thus, the overall goal of Phase 1 is to validate the *in situ* approach, particularly with respect to determining if the selected sites and exposure methodologies are appropriate, or if they need to be modified to compensate for confounding variables (e.g., deposition of fine sediments, mobilization of anoxic sediments during storm events, etc.). Applied under the appropriate conditions, it is anticipated that the RBT *in situ* ELS bioassay will be an effective instream biological monitoring tool for assessing the potential effects of stormwater discharges on the receiving environment. In addition to continued evaluation of the *in situ* testing methodology, this report also compares the results of the current year's monitoring to results obtained the previous years to determine the extent to which they were consistent between years.

Phase I of the *In situ* Monitoring Plan (i.e., Development and Demonstration) was originally intended to last for one year and include testing during the Spring and Fall seasons. However, this Phase was extended to allow for additional comparison with the laboratory sublethal testing being conducted by the STIA at sites downstream of Port outfalls as identified in Part II, Special Condition S8 of their NPDES permit. The laboratory sublethal toxicity testing is used for permit compliance purposes, and has been conducted concurrently with *in situ* deployments (when feasible) to facilitate validation of the *in situ* methodology. Comparison of the two methods is conducted in the Combined Acute, Sublethal, In Situ Report (Nautilus 2013) as well as in Section 4.5 of this document. Notably, Part II, Special Condition S9, of the permit allows for substitution of the laboratory sublethal test with *in situ* testing but, because the *in situ* testing has been implemented at the watershed level, direct substitution of the *in situ* test in place of the

laboratory sublethal test was not considered appropriate until parallel testing could be performed.

For the remainder of the permit cycle (through March 2014), *in situ* testing will continue to focus on the watershed-based sites identified in the monitoring plan, along with continued concurrent laboratory sublethal testing. Extended implementation of Phase I through the remainder of the current permit cycle will create a valuable dataset for comparing the *in situ* methodology with the laboratory sublethal test.

2.0 TEST METHODS

Guidance for conducting *in situ* ELS exposures with salmonids is available from a number of sources. For example, the British Columbia Ministry of Environment has a protocol for an *in situ* ELS salmonid test (BCMOE, 2003). In addition, Environment Canada has developed both laboratory and *in situ* test procedures for early lifestages of rainbow trout (Environment Canada, 1998). In the U.S., there are two general laboratory protocols for conducting fish early life stage toxicity tests (EPA, 1996; ASTM, 2005). The procedures used in this study reflect refinements made to the general guidance provided in the documents above (Chalmers et al *in press*), and have been used successfully at a number of sites in both Canada and the United States. Additional refinements specific to applying the method to waterways present on Airport property are included in the descriptions below.

2.1 Design

The study design used for the Fall 2012 and Spring 2013 *in situ* testing involved exposure of eyed-embryos at three sampling sites, using four replicates per site with 30 embryos per replicate. The locations of the sites are shown in Figure 1. The Study Design was consistent with the methodology used in the three previous monitoring events in which the two sites located downstream of all Airport discharges were augmented by an additional site on Des Moines Creek located upstream (Des Moines Creek Upstream) of any Airport discharges. The additional site was included to determine the extent to which sources upstream of any STIA inputs may contribute to adverse effects observed at the downstream site on Des Moines Creek.

The exposure period used in the *in situ* tests covers the major salmonid early life stage developmental milestones, beginning with the eyed egg stage, proceeding through hatching and alevin (yolk sac present and residing in gravel) stages, and ending with the early fry stage (also known as swim-up fry). At this point, the yolk sac is absorbed and, under natural conditions, the fish would leave the gravel to feed independently. The duration of the exposure period is expected to include multiple rain/runoff events, and corresponding fluctuations in flow, contaminant concentrations, temperature, water chemistry, etc. Collectively, these attributes of the *in situ* approach provide highly relevant information regarding the suitability of waterbodies to support salmonids (Chalmers et al, *in press*).

The eyed eggs for both *in situ* events were supplied locally by TroutLodge (Sumner, WA), which supplies these same organisms for the laboratory toxicity tests required in STIA's NPDES

stormwater permit. The status of the *in situ* organisms was routinely monitored during the exposure, as well as at specific developmental stages and after significant storm events. Data were obtained on hatching, survival, development and growth. A subset of embryos was also reared in the laboratory to assess organism quality. Weekly temperature measurements from the field were used to adjust rearing temperatures for the laboratory controls so that development in the controls could be used to trigger field inspections at specific times (e.g., hatch, swim-up).

2.2 Monitoring Locations and Site Preparation

The exposures were conducted in two streams within the STIA property boundaries: Miller Creek and Des Moines Creek (Figure 1). Two of the sites, Miller Creek and Des Moines Creek at S 200th, are located downstream of STIA inputs into their respective drainages. An additional site (Des Moines Creek Upstream) is located upstream of STIA stormwater outfalls into Des Moines Creek. This site is used to assess water quality in Des Moines Creek prior to receiving any STIA stormwater discharges; the Des Moines Creek basin upstream of STIA is heavily urbanized and potentially impacted by a variety of pollutant sources.

Results from 2010 concluded that the chosen sampling sites generally do not have ideal substrate conditions and are subjected to heavy sediment flow during storm events. Consequently, all four exposure replicates at each site were placed above the substrate in gravel contained within PVC crate frames (see Figure 2) anchored to the substrate with steel stakes. The crates were placed so that replicate crates rested on the streambed in a row from upstream to downstream, at a sufficient distance apart such that flow patterns were re-established between each crate. This approach allowed for passage of water through the exposure chambers, but prevented smothering of embryos and fry by sediment.

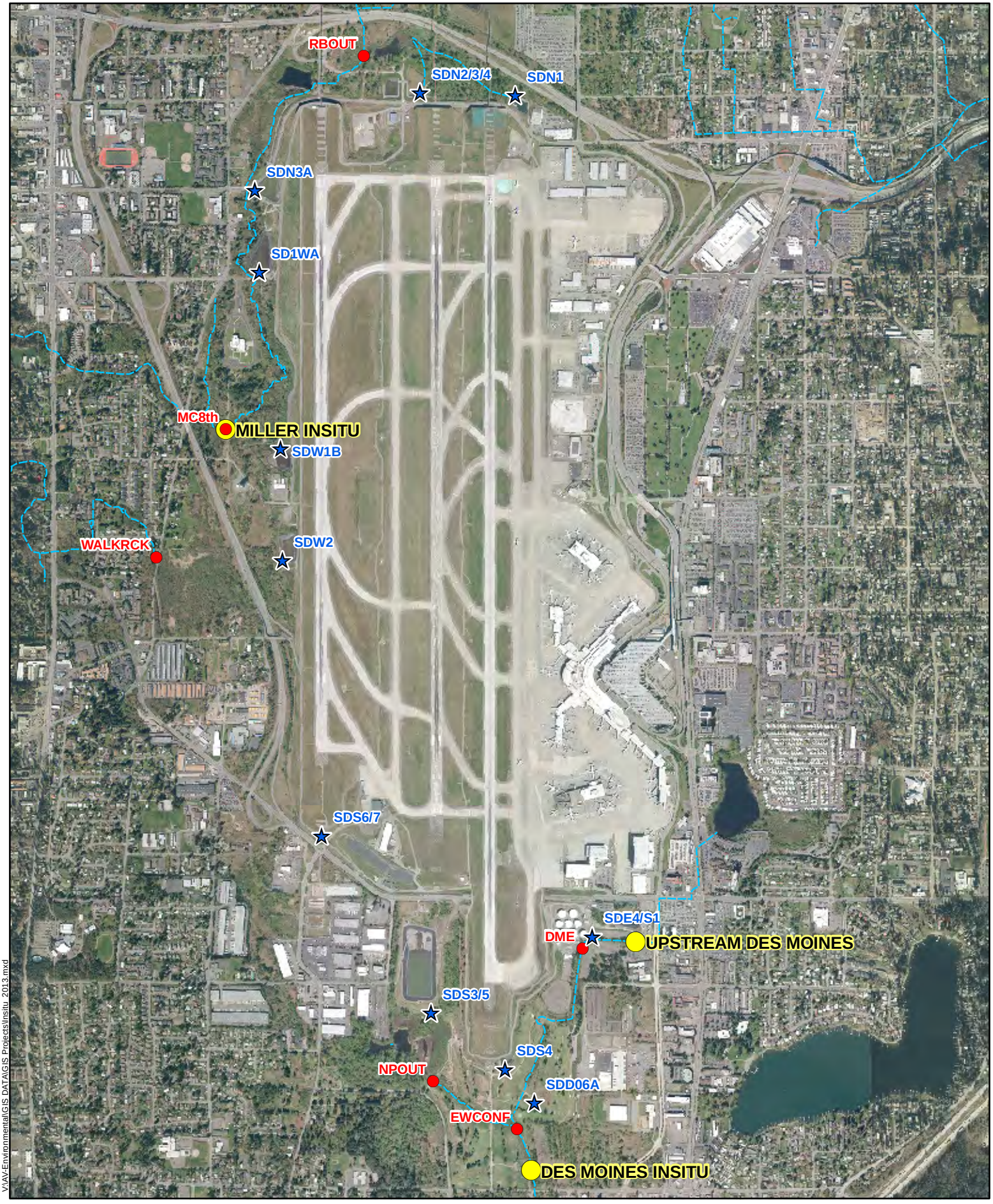

Figure 1

Port of Seattle

2.3 Field Exposure Apparatus

The trout embryos were contained in modified Whitlock-Vibert hatchboxes (Federation of Flyfishers, MO), which are comprised of two rectangular chambers located one above the other; the upper chamber is for embryo development and the lower chamber for rearing of hatched fish. The external sides of the hatchbox are plastic mesh that allows passage of water through the box, but prevents loss of embryos. The divider between the embryo chamber and the rearing chamber is comprised of slots that are narrow enough to prevent transfer of unhatched embryos, but wide enough to permit migration of hatched fish into the lower rearing chamber. Thus, upon hatch, alevins are able to migrate through the slots from the embryo chamber into the larger rearing chamber. To prevent escape of the hatched fry into the streams upon swim-up, plastic screening material (Darice® size 7 mesh) was attached to the external faces of the rearing chamber and held in place using small plastic zip ties.

The hatchboxes were contained within flexible plastic mesh bags surrounded by 1 – 2 inch diameter gravel, with the hatchbox placed centrally within the rocks in the bag. The gravel surrounding the hatchboxes acts to diffuse the current and prevent exposure of the embryos to sunlight. The bags were then placed within the PVC crates, which were held in place in the stream by stakes anchored in the substrate (Figure 2). Figure 3 shows the eyed eggs within the hatchbox, while Figure 4 is of fry within the hatchbox.

Figure 2: Photograph of the crate set up, Des Moines Creek at S 200th.



2.4 Test Organisms

Eyed-egg stage rainbow trout embryos were obtained from TroutLodge in Sumner, WA, on October 17, 2012 for the Fall event. As supplied, the eyed embryos had developed for approximately 245 degree-days[1], as noted in communication with TroutLodge staff. For the Spring event, green eggs and sperm were collected from TroutLodge on March 27, 2013, brought to Rainier Environmental Laboratory (REL; Fife, WA) where the eggs were fertilized and raised to approximately 252 degree-days. On the day of test initiation for both events, eggs were brought to REL, or collected from there, and randomly counted into replicate units of 30 embryos apiece in individual opaque plastic food-storage containers (i.e., 450-mL Ziploc plastic tubs). These containers were then placed in a cooler containing ice packs, and transported to the sites where the embryos were transferred into the hatchboxes in the creek on the same day. The embryos were transferred to the sites in laboratory control water, and all embryos were installed at the sites between 14:00 and 15:30 on October 17th, 2012 for the Fall event, and between 12:00 and 13:30 on April 17th, 2013 for the Spring event.

All personnel handling the embryos wore nitrile gloves. Containers were pre-cleaned with Liqui-nox soap (Alconox, Jersey City, NJ) and rinsed with deionized water.

2.5 Controls

Controls were used to assess the influence of the following factors on test results:

1. Quality (health and viability) of supplied organisms,
2. Transport and handling of organisms, and
3. Ambient stream temperatures, which affect the time to developmental milestones (e.g., hatch).

The controls consisted of a laboratory exposure (four replicates of 30 organisms each) conducted concurrently with each field exposure in clean laboratory water (moderately hard synthetic water [MHSW]) using a subset of the same batch of embryos used to initiate the field exposures. These embryos were also counted out, placed into individual plastic containers filled with MHSW and transported to the sites with the other replicates; thus, they also served as transport

[1] Degree-days are used to standardize descriptions of fish development, regardless of rearing temperature. For example, it takes rainbow trout approximately 340 degree-days to reach hatch (Quinn, 2005). Thus, at 8°C, it takes approximately 42 days to reach hatch.

controls. Upon returning to the laboratory after deployment of all field organisms, the control replicates were transferred to 4-L plastic containers in the laboratory containing 2 liters of MHSW at the average site water temperature, ± 1°C. Gentle aeration was applied (100-200 bubbles per minute) to the control chambers. The controls were monitored daily for mortalities, and dead organisms removed. Temperature was adjusted on a weekly basis to correspond to temperatures measured in the field. Water renewals were conducted three times per week (Monday, Wednesday, Friday) using clean MHSW. Dissolved oxygen, pH, conductivity, and temperature were measured before and after water renewals. Developmental milestones (e.g., hatch and swim-up) were also recorded.

2.6 Monitoring of Field Exposures

The sites were visited approximately every week to assess the condition of the test organisms. During these checks, survival was recorded, as well as qualitative observations of organism health, site conditions, and sedimentation within the boxes. All dead organisms observed were removed on each visit. These observations were recorded on standard field data sheets included in Appendix A. In addition, temperature, pH, dissolved oxygen (DO) and conductivity were measured during the site visits.

Monitoring of the installations required removal of the substrate overlying the hatchboxes in the crate. The embryos or alevins in each hatchbox were then poured into a white plastic dishpan containing site water where they were enumerated. They were then returned to the hatchbox, which was placed back into the mesh-net bag of gravel, the overlying gravel replaced, and the bag returned to its respective crate. Care was taken to minimize disturbance and damage to the test organisms.

2.7 Test Termination

The field exposures and laboratory controls were terminated when the field organisms reached the swim-up fry stage (i.e., yolk sac absorbed). This occurred on November 14th, 2012 for the Fall 2012 exposure, and on May 9th, 2013 for the Spring 2013 exposure. Surviving organisms were placed in their original plastic replicate containers filled with site water, transported back to the laboratory, and terminated. The fish were then wet-weighed (to the nearest 0.001 gram) on an analytical balance, and measured (total length, from tip of the snout to the end of the tail) to the nearest 0.5 mm. Obvious external malformations were noted, including the affected body

part (e.g., head, eye, spine) and type of abnormality (e.g., edema). Abnormality data were recorded on standard data sheets (Appendix A). The laboratory control fish were evaluated similarly on the same day.

2.8 Data Analysis

All test data were entered in CETIS (Comprehensive Environmental Toxicity Information System, Tidepool Scientific, McKinleyville, CA). Differences among the exposure sites and laboratory controls were evaluated using pair-wise multiple comparison tests according to the USEPA flow chart (USEPA 2002); significant differences were identified at p=0.05.

One interim and five terminal endpoints were evaluated; the endpoints are described below:

1. Hatching success – an interim measure of the percentage of embryos hatched the day of the hatch inspection, or determined to have hatched based on the number of alevins present at the subsequent inspection, relative to the total number of embryos originally added;
2. Post-hatch survival - the percentage of organisms surviving at test termination relative to the number of embryos that hatched (these data help determine whether the majority of mortalities occurred pre- or post-hatch, or were distributed throughout the exposure period);
3. Cumulative survival - the percentage of surviving organisms at test termination relative to the number of embryos in each replicate at the beginning of the exposure;
4. Abnormality – the percentage of abnormal organisms at test termination relative to the number of surviving organisms;
5. Length – to the nearest 0.5 mm;
6. Weight – to the nearest 0.001 g.

3.0 QA/QC

The QA/QC program for the field exposure involved the following:

- Consistent field staff leader throughout all visits;
- Field documentation of all primary data; i.e., the names of individuals collecting the samples, sampling location, time of sampling, site conditions (e.g., degree of sedimentation), and other relevant observations, such as weather and any unusual conditions;
- Calibrated field meters;
- Use of pre-cleaned containers, with appropriate labels;
- Storing and transporting organisms in sealed containers in a cold, dark environment; cooling sample containers using ice or gel packs;
- Including transport controls to ascertain the extent of any transport-induced stress;
- Checking field organisms every week to monitor developmental progress, mortality and abnormality.

The QA/QC program for the laboratory portion of the study involved:

- Checks and maintenance of control organisms at regular intervals, including recording primary observations and water quality data on standardized data sheets;
- Review of datasheets by senior laboratory staff;
- Test termination activities (measurements, health assessment) conducted by qualified staff members using standardized datasheets to ensure consistent assessment of abnormalities and growth across all test sites and controls;
- Use of standard laboratory water and environmental chambers to maintain test organisms.

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4.0 RESULTS

4.1 Water Quality Measurements

Water quality measurements are summarized in Tables 1 and 2 for the Fall 2012 and Spring 2013 monitoring events, respectively.

Table 1: Summary of water quality measurements collected during site visits and control renewals (Fall 2012).

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	11.9 (1.1)	9.5 (0.6)	7.96 (0.10)	299.8 (5.0)
	[Min-Max]	[9.4 – 12.8]	[8.6 – 10.0]	[7.75 – 8.21]	[292 - 315]
Miller Creek		10.7 (1.2)	10.9 (1.1)	7.31 (0.19)	183.5 (35.8)
		[9.3 – 12.2]	[9.3-12.0]	[7.09 – 7.62]	[126 - 216]
Des Moines Creek		11.2 (1.2)	10.5 (1.2)	7.24 (0.12)	134.6 (27.3)
at S 200th		[9.7 - 12.5]	[9.0 – 11.4]	[7.12 – 7.42]	[93 - 160]
Des Moines Creek		12.0 (1.6)	10.2 (0.8)	7.34 (0.34)	105.2 (12.7)
Upstream		[9.7 – 14.2]	[9.1 – 11.2]	[6.87 – 7.68]	[85 - 117]

Table 2: Summary of water quality measurements collected during site visits and control renewals (Spring 2013).

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	12.0 (0.2)	9.7 (0.4)	7.38 (0.1)	263.1 (15.2)
	[Min-Max]	[11.6 – 12.3]	[8.8 – 10.5]	[7.15 – 7.55]	[237 - 282]
Miller Creek		11.7 (2.0)	10.2 (0.9)	7.58 (0.17)	250.6 (45.6)
		[10.0 – 14.0]	[8.9 – 11.0]	[7.40 – 7.77]	[183 - 294]
Des Moines Creek		12.4 (1.4)	9.9 (0.5)	7.43 (0.07)	187.8 (54.7)
at S 200th		[11.3 – 14.4]	[9.0 – 10.4]	[7.37 – 7.54]	[103 - 235]
Des Moines Creek		14.0 (1.9)	8.6 (1.2)	7.09 (0.24)	126.4 (30.2)
Upstream		[12.0 – 16.2]	[6.9 – 9.8]	[6.70 – 7.34]	[100 - 174]

In the Fall 2012 *in situ* tests, temperatures for the three field sites and the control ranged from 9.3 to 14.2°C. The field measurements of DO and pH were within acceptable ranges for rainbow

trout laboratory bioassays (60-100% saturation, and 6-9 pH units, respectively). The pH values were between 6.8 and 7.7, and DO ranged from 9.0 to 12.0 mg/L among all stream measurements. Although limited to weekly measurements, the field DO and pH data suggested good water quality conditions, with no indication of potential for adverse effects on organism survival and development. The conductivity measurements for all three sites exhibited some variability throughout the exposure period, but the values remained well-within ranges tolerated by early life stages of salmonids.

In the Spring 2013 *in situ* tests, temperatures among the three field sites and the control ranged from 10.0 to 16.2°C. These temperatures were similar, though slightly warmer than Fall temperatures. The field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays. The pH values were between 6.7 and 7.8, and DO ranged from 8.9 to 11.0 mg/L among all stream measurements. Consequently, the weekly field measurements of DO and pH suggested good water quality conditions, with no indication of potential for adverse effects on organism survival and development. As observed in the Fall event, the conductivity measurements for all three sites exhibited some variability throughout the exposure period, but the values remained well-within ranges tolerated by early life stages of salmonids.

During limited periods of both the fall and spring monitoring events, continuous measurements of pH and temperature were collected by CardnoTEC using data sondes at the Miller Creek site. This data was collected as part of another program and only covered limited portions of the exposure periods for the Fall and Spring. Nonetheless, the continuous monitoring data was in general agreement with the values collected during the weekly checks at the site, and are presented in Figures 5 and 6 for the Fall and Spring testing events, respectively.

Figure 5: Continuous pH and temperature data from Miller Creek, Fall 2012

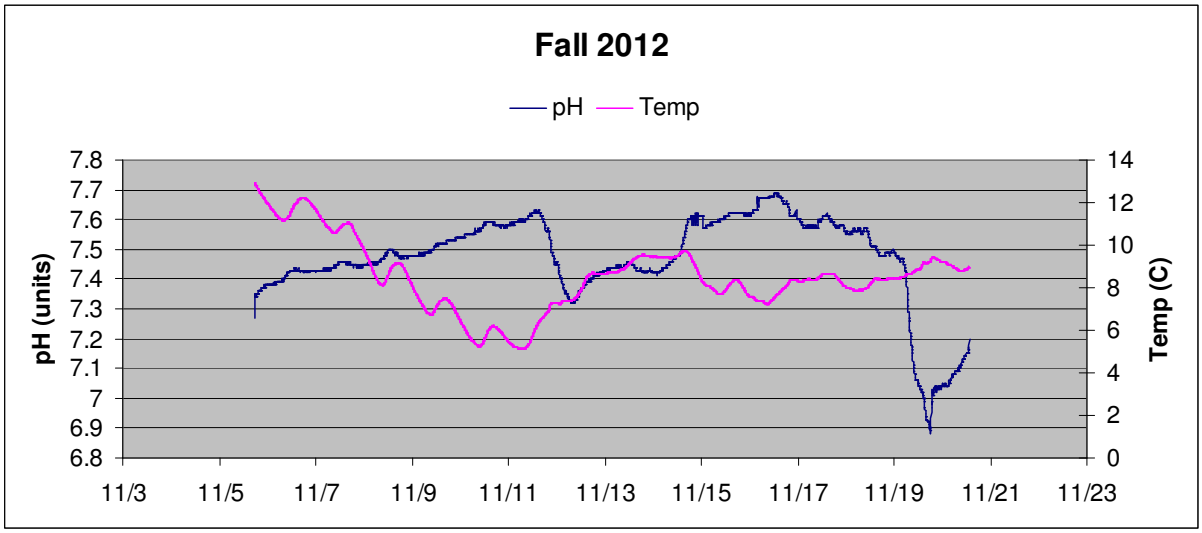
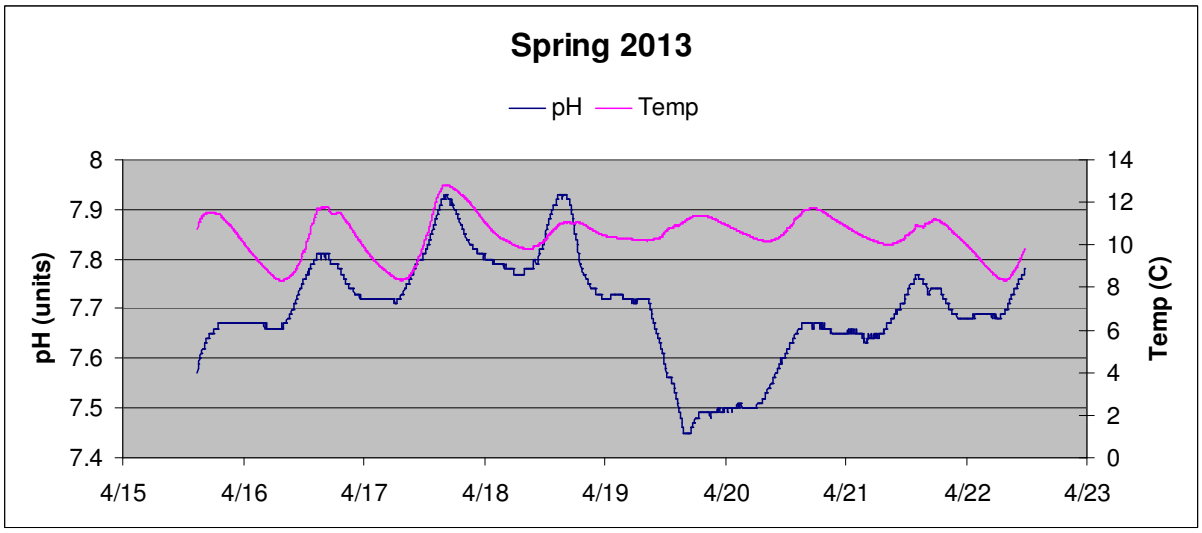


Figure 6: Continuous pH and temperature data from Miller Creek, Spring 2013



4.2 Precipitation During the Monitoring Events

Precipitation data were provided by STIA. Figure 7 shows the daily rainfall for the duration of the exposure for the Fall 2012 test. A number of storm events occurred during testing, with a total of 6.96 inches of rain over 4 weeks, and the largest storm occurring on October 30th. There was no snow during this testing event.

Figure 7: Daily rainfall for the duration of Fall exposure

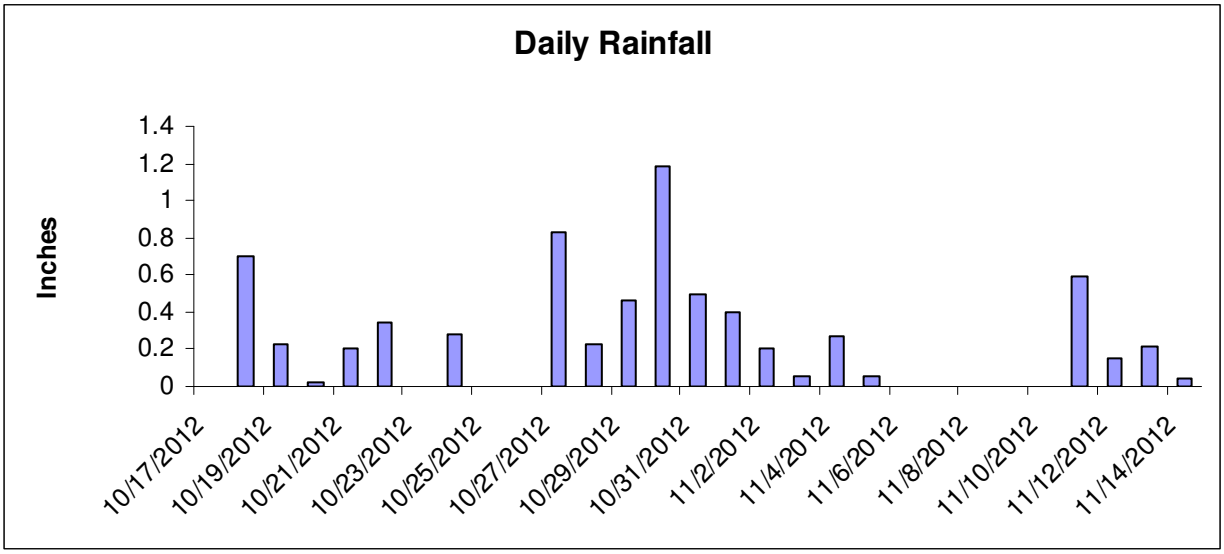
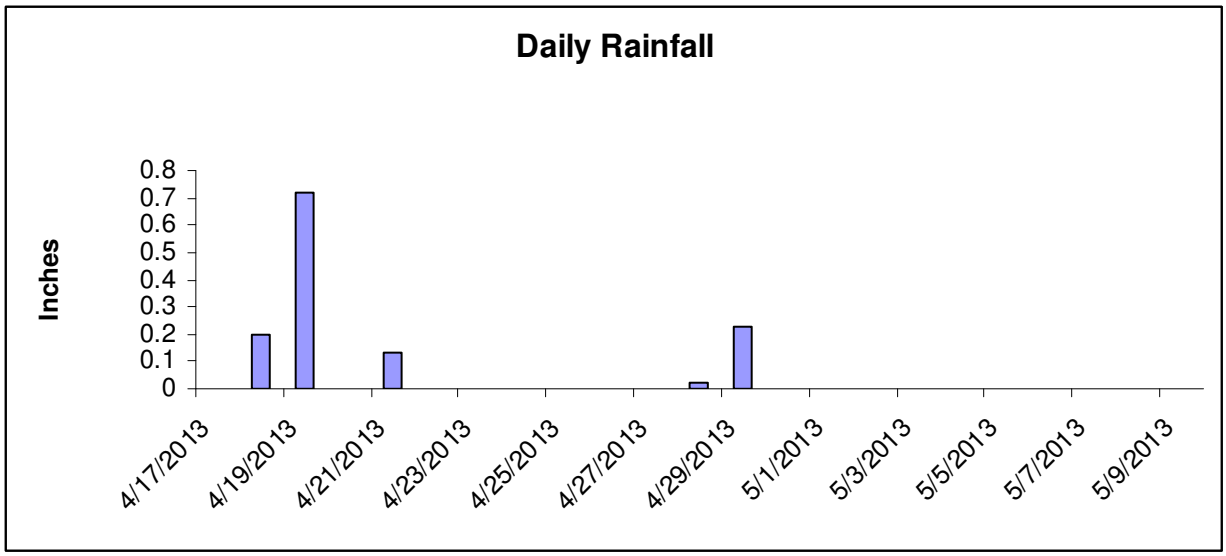


Figure 8 contains the daily rainfall for the duration of the exposure for the Spring 2013 test. Much less total precipitation (1.3 inches) and fewer storms occurred during this exposure period, compared with the Fall. No snow occurred during the exposure period, and the largest storm was on April 19th.

Figure 8: Daily rainfall for the duration of the spring exposure



4.3 *In situ* Exposures

4.3.1 Fall 2012

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 3. Table 4 presents the growth endpoints. These same data are presented graphically in Figures 9 through 11 for ease of comparison.

Hatching success – Mean hatching success for the controls was 99.2%. The Miller Creek replicates exhibited 71.7% mean hatching success, the Des Moines Creek at S 200th replicates had 85.8% mean hatching success, while the Des Moines Creek Upstream replicates averaged 60.0% mean hatching success. Hatching success at Des Moines Creek at S 200th was not statistically different from the controls; however, hatching success at Miller Creek and Des Moines Creek Upstream were significantly reduced relative to the control.

Post-hatch survival – Control survival of alevins post-hatch was 98.3%. The Miller Creek replicates exhibited 40.6% post-hatch survival, and the Des Moines Creek at S 200th replicates exhibited 90.1% post-hatch survival, while the Des Moines Creek Upstream replicates averaged 84.3%. Post-hatch survival at the two Des Moines Creek sites were not significantly different from the controls. However, the Miller Creek site was significantly different from the controls.

Cumulative survival – Control survival from the initiation of the test to termination averaged 97.5%. The Miller Creek replicates exhibited an average survival of 28.3% through the duration of the exposure, whereas the Des Moines Creek at S 200th replicates exhibited an average survival of 77.5% compared with an average survival of 55.0% at the Des Moines Creek Upstream site. Des Moines Creek at S 200th was not statistically different from the controls, whereas both Des Moines Upstream and Miller Creek were significantly reduced compared with the controls.

Abnormalities – There were few abnormalities over all, with just one in the controls, one at Miller Creek, and none at Des Moines Creek at S 200th; however, there were 4 total, (2 each in 2 replicates) at Des Moines Creek Upstream. The abnormalities at Des Moines Upstream were 2 spinal curvatures, one misshapen head, and one case of edema. These finding were not significantly different from the control. The abnormalities in both the control and Miller Creek fish were spinal curvatures.

Growth – Average weight in the controls was 84.6 mg, and length averaged 22.6 mm. Miller Creek fish averaged 80.4 mg and 22.0 mm, Des Moines Creek at S 200th fish averaged 81.0 mg and 21.9 mm, and Des Moines Creek Upstream fish averaged 78.4 mg and 22.1 mm. None of the differences in length were significant between sites and controls. Only Des Moines Upstream was significantly different from controls for weight.

Table 3: Results for hatching success, survival and abnormality in the control and field treatment groups (Fall 2012)[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	99.2 (1.7)	98.3 (1.9)	97.5 (1.7)	0.9 (1.7)
Miller Creek	71.7 (9.6)	40.6 (20.0)	28.3 (12.3)	8.3 (16.7)
Des Moines Creek at S 200th	85.8 (8.3)	90.1 (5.1)	77.5 (10.7)	0 (0)
Des Moines Creek Upstream	60.0 (25.4)	84.3 (23.8)	55.0 (32.2)	4.4 (5.1)

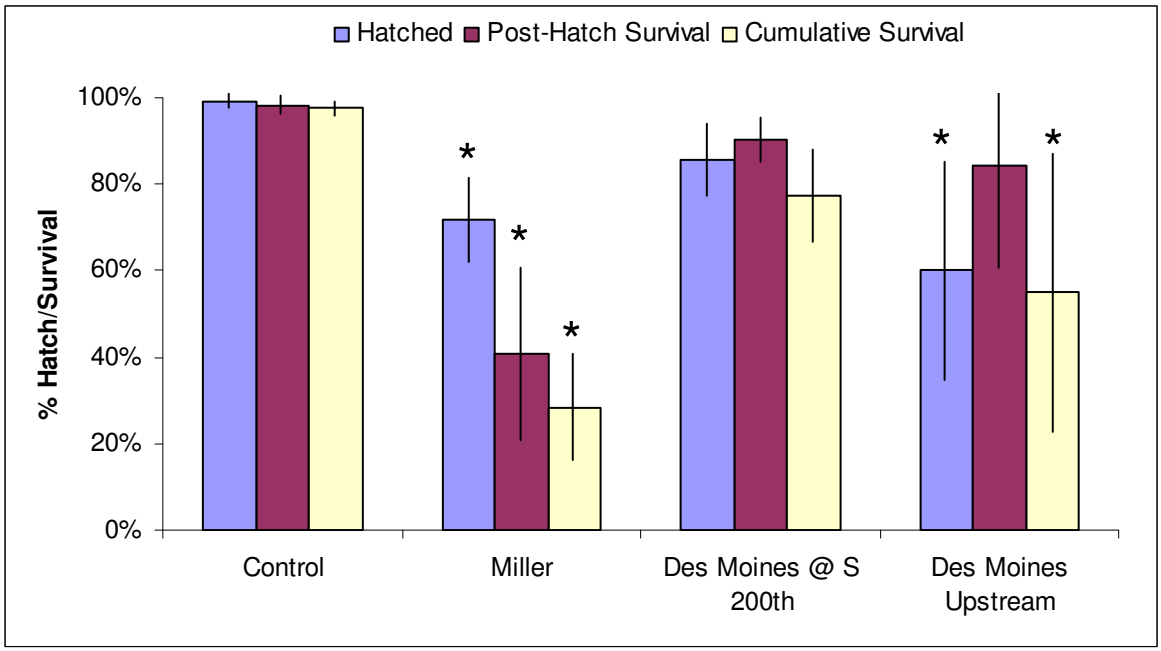
Notes:
1. Results are presented as mean and standard deviation
2. Gray shaded values are significantly different from the control

Table 4: Comparison of growth in the control and field treatment groups (Fall 2012)[1].

Site	Length (mm)	Weight (mg)
Control	22.6 (0.30)	84.6 (2.46)
Miller Creek	22.0 (0.71)	80.4 (5.42)
Des Moines Creek at South 200th	21.9 (0.26)	81.0 (1.22)
Des Moines Creek Upstream	22.1 (0.61)	78.4 (2.17)

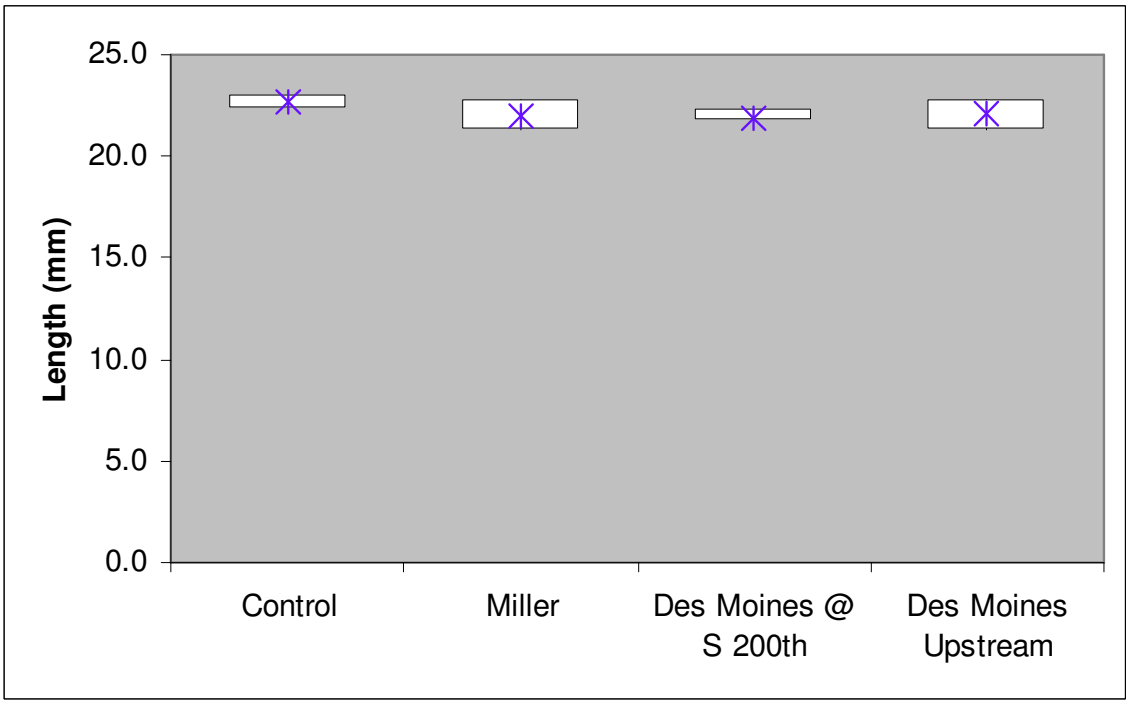
Notes:
1. Results are presented as mean and standard deviation
2. Gray shaded values are significantly different from the control

Figure 9: Hatching success, post-hatch survival and cumulative survival in the field and control treatment groups (Fall 2012).



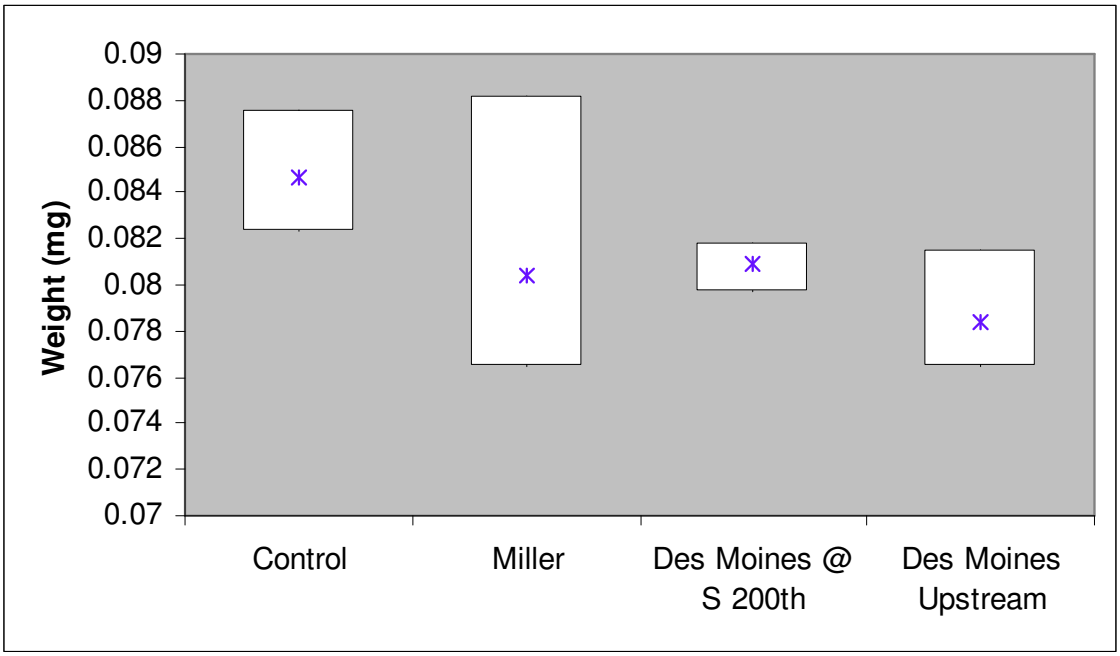
Error bars are standard deviations; asterisks denote significant difference from controls.

Figure 10: Average lengths for the laboratory control and exposure sites (Fall 2012).



Data point is the average; box represents range of minimum to maximum values

Figure 11: Average weights for the laboratory control and exposure sites (Fall 2012).



Data point is the average; box represents range of minimum to maximum values.

4.3.2 Spring 2013

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 5. Table 6 presents the growth endpoints. These same data are presented graphically in Figures 12 through 14 for ease of comparison.

Hatching success – Mean hatching success for the controls was 100%. The Miller Creek replicates exhibited 98.3% mean hatching success, the Des Moines Creek at S 200th replicates had 95.0% hatching success, and the Des Moines Creek Upstream replicates averaged 90.8% hatching success. There were no significant differences in hatching success among the treatment and control groups.

Post-hatch survival – Control survival of alevins post-hatch was 97.5%. The Miller Creek replicates averaged 90.8% post-hatch survival, compared with 90.7% survival at Des Moines Creek at S 200th, and 77.2% at Des Moines Upstream. Only Des Moines Upstream was significantly different from controls.

Cumulative survival – Control survival from the initiation of the test to termination averaged 97.5%. The Miller Creek replicates exhibited an average survival of 89.2% through the duration

of the exposure, while Des Moines Creek at S 200th replicates averaged 85.8% survival; both of these values were not significantly different from the controls. The Des Moines Upstream replicates exhibited 70.0% survival at the end of the exposure, which was significantly different from the controls.

Abnormalities -- There were few abnormalities over all, with just two in the controls, none at Miller Creek, and one at Des Moines Creek at S 200th, and one at Des Moines Creek Upstream. The abnormalities were one head shape, and three cases of edema. There were no significant differences from the controls.

Growth – Average weight in the controls was 156.2 mg, and length averaged 27.0 mm. Miller Creek fish averaged 153.4 mg and 26.6 mm, Des Moines Creek at S 200th fish averaged 152.8 mg and 26.5 mm, and Des Moines Creek Upstream fish averaged 152.0 mg and 26.6 mm. None of the differences in length were significant between sites and controls. Des Moines Upstream was significantly different from controls for weight.

Table 5: Hatching success, survival and abnormality in the control and field treatment groups (Spring 2013)[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	100 (0)	97.5 (3.2)	97.5 (3.2)	1.7 (3.5)
Miller Creek	98.3 (1.9)	90.7 (10.3)	89.2 (9.6)	0 (0)
Des Moines Creek at S 200th	95.0 (7.9)	90.7 (10.9)	85.8 (10.0)	1.0 (2.0)
Des Moines Upstream	90.8 (10.7)	77.2 (5.4)	70.0 (8.6)	1.3 (2.5)

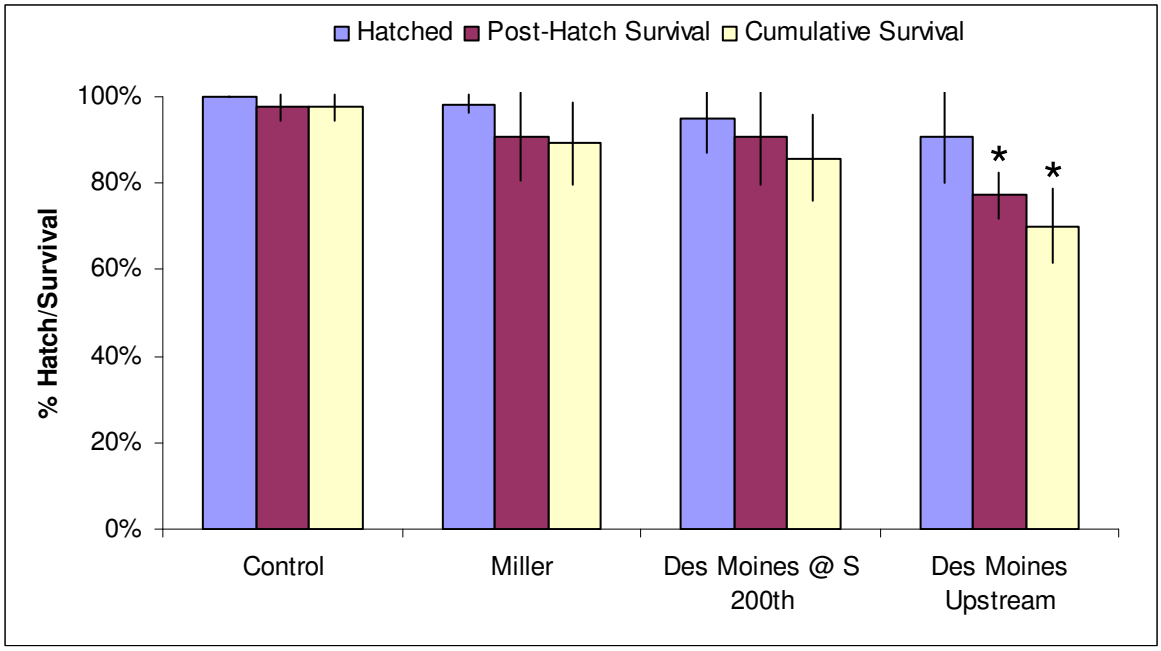
Notes:
1. Results are presented as mean and standard deviation
2. Gray shaded values are significantly different from the control

Table 6: Comparison of growth in the control and field treatment groups (Spring 2013).

Site	Length (mm)	Weight (mg)
Control	27.0 (0.31)	156.2 (1.7)
Miller Creek	26.6 (0.75)	153.4 (1.9)
Des Moines Creek at S 200th	26.5 (0.65)	152.8 (4.0)
Des Moines Upstream	26.6 (0.39)	152.0 (2.6)

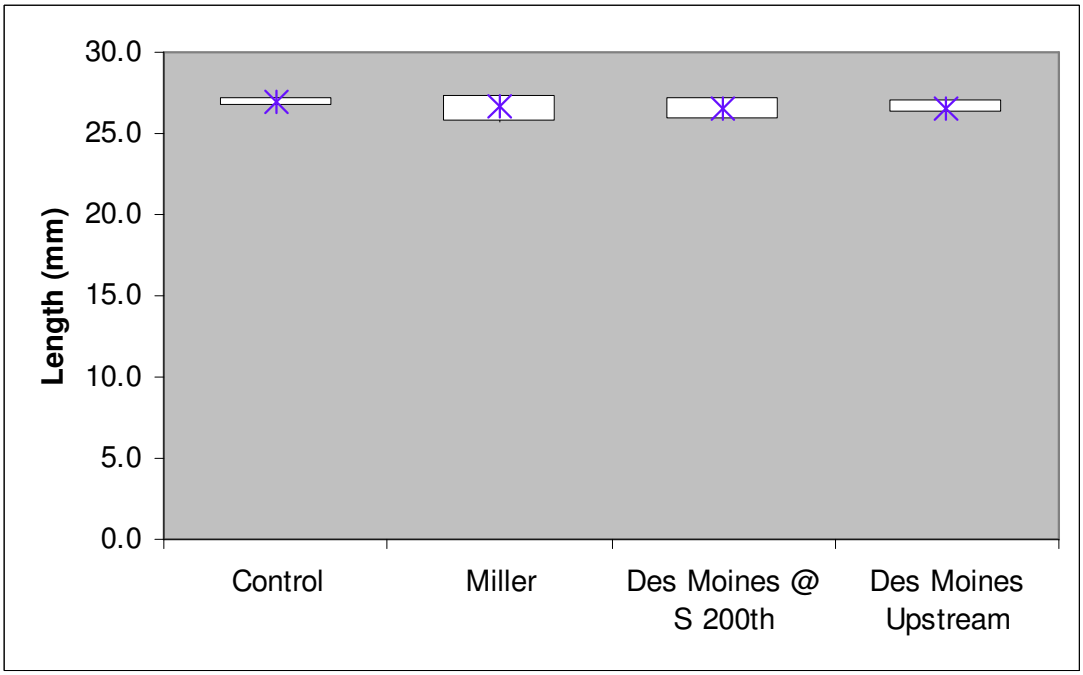
Notes:
1. Results are presented as mean and standard deviation
2. Gray shaded values are significantly different from the control

Figure 12: Hatching success, post-hatch survival and cumulative survival in the field and control treatment groups (Spring 2013).



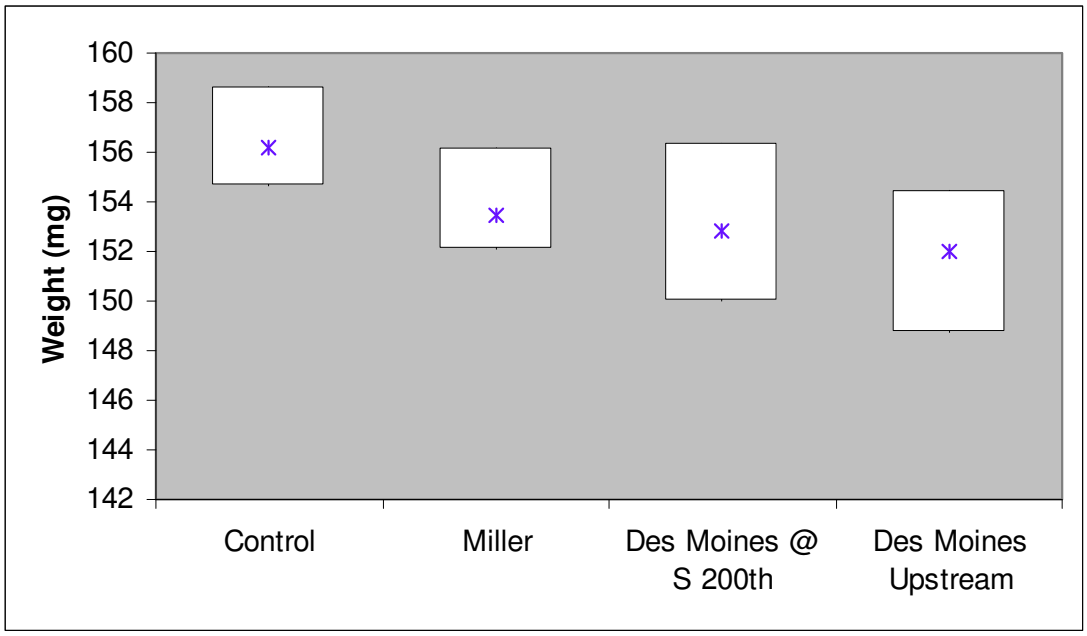
Error bars are standard deviations, asterisks denotes significant difference from controls.

Figure 13: Average lengths for the control and exposure groups (Spring 2013).



Data point is the average; box represents range of minimum to maximum values.

Figure 14: Average weights for the control and exposure groups (Spring 2013).



Data point is the average; box is minimum to maximum values.

4.4 Field Observations

During both testing events, hatch boxes were observed to be free of accumulating biofilm or other accumulation of organic material. During the Fall 2012 event, spawning salmon were observed in Miller Creek and in Des Moines Creek at S 200th. During both events, crayfish were often found within the crates at all sites, but not within the hatchboxes. Accumulation of sediments within the hatch boxes was observed during the Fall 2012 event at the Miller Creek site, with sediment volume reaching 80% and greater within the boxes.

4.5 Comparison of *in situ* and sublethal tests

In addition to the *in situ* testing, STIA also collects samples from the receiving water downstream of stormwater outfalls for sublethal toxicity testing with rainbow trout embryos during storm events: once in the fall, once in the spring, and once during deicing conditions each year. Including the initial first attempt in Fall 2010, there were 4 sampling periods for sublethal testing that overlapped with the *in situ* deployments (Table 7). As the upstream Des Moines Creek station is above any Airport outfalls, it is not included in the sublethal testing, so discussion here is limited to comparisons of Miller Creek (*in situ*) with MC8th (sublethal), and

Des Moines Creek at S 200th (*in situ*), with DME and EWCONF (sublethal). The Fall 2010 sublethal samples overlapped with the initial deployment of the *in situ* tests (i.e., the in-gravel portion of the exposures only). There was no toxicity in the laboratory tests, but the *in situ* replicates in both creeks were buried by a major precipitation event and needed to be restarted. The deicing sublethal samples in 2011 overlapped with the repeated Fall/Winter 2010 *in situ* testing; the DME and EWCONF sublethal samples exhibited toxicity in the laboratory, and toxicity was also observed in the *in situ* Des Moines Creek at S 200th site. There was no toxicity in Miller Creek or MC8th. There was no overlap in tests during either the Spring 2011 and Fall/Winter 2011 testing periods. The Spring 2012 sublethal tests coincided with the *in situ* exposures, and neither test type exhibited toxicity at the downstream locations. The two test types also overlapped during the Fall 2012 exposure period; adverse effects were observed in the Miller Creek *in situ* exposure, but not in any of the laboratory tests or at the downstream *in situ* exposure conducted on Des Moines Creek.

Table 7: Comparison of responses in sublethal and *in situ* tests.

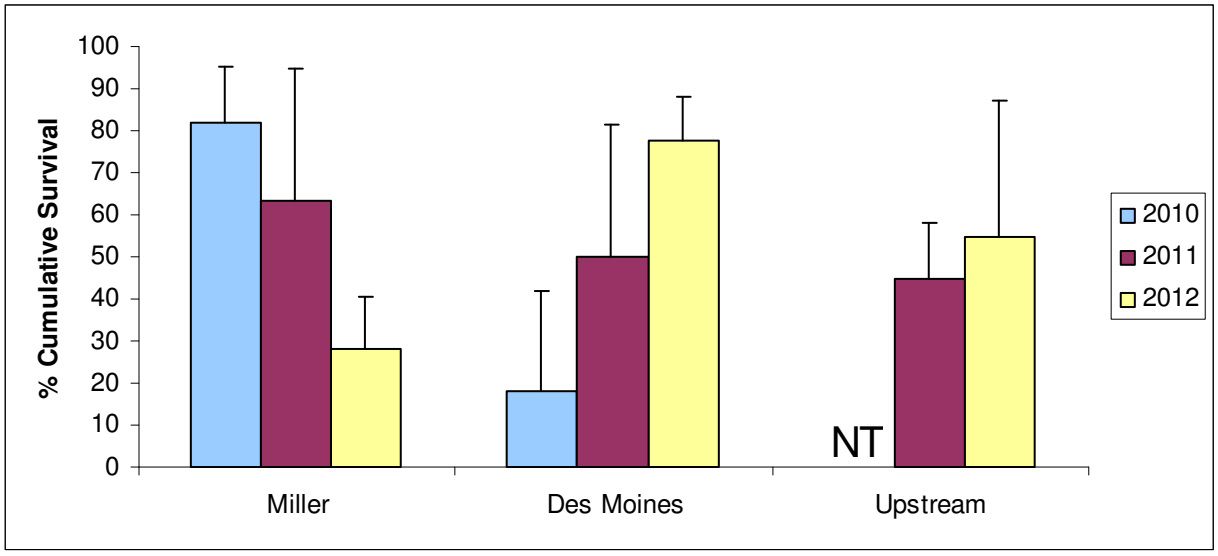
	***In situ* test results**	**Sublethal test results**
Fall 2010- 1st Attempt	Restart due to burial of replicates	Non-toxic
Fall/Winter 2010	Effects observed at Des Moines at S 200th	Toxicity in DME and EWCONF
Spring 2011	No overlap	
Fall/Winter 2011	No overlap	
Spring 2012	No effects observed	Non-toxic
Fall 2012	Effects observed at Miller Creek	Non-toxic
Spring 2013	No overlap	

5.0 DISCUSSION

The results of the Fall and Spring testing events that have been conducted to date are shown in Figures 15 and 16, respectively. Review of these data suggest that adverse effects are more consistently observed during the Fall exposure period, with the Fall season tending to receive substantially more precipitation than the Spring. It should also be noted, however, that the Fall events of the previous two years (2010 and 2011) extended into the Winter months and therefore, would have also reflected the effects of snow and winter conditions.

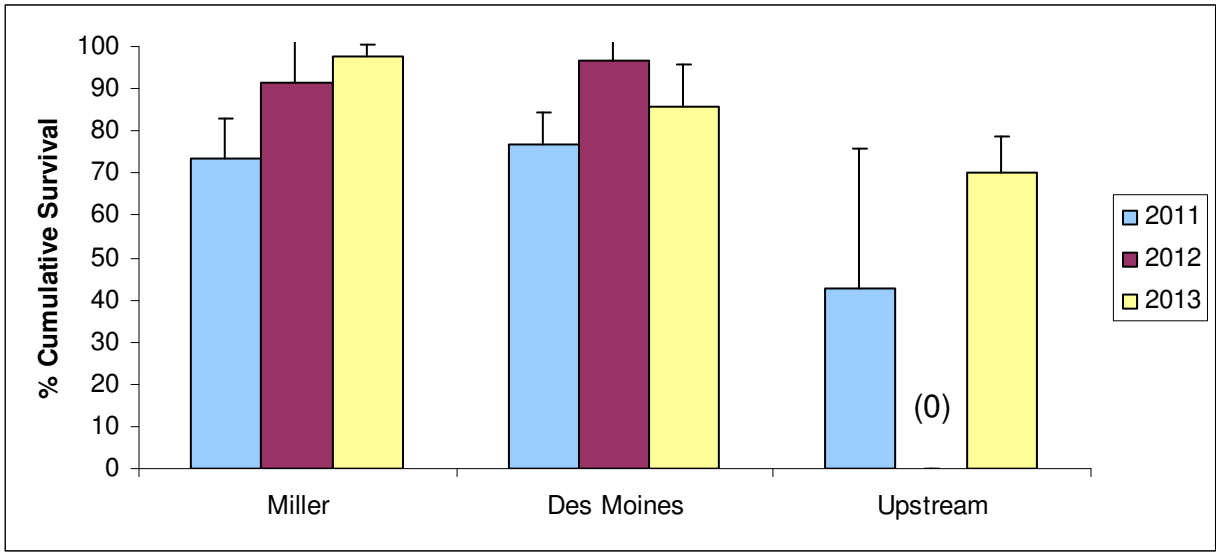
In Fall 2012, adverse effects on survival were observed in Miller Creek, with both hatching success and post-hatch survival significantly reduced compared to the controls. Sedimentation can be an issue at the Miller Creek site, particularly in the Fall after large storm events, and was again observed during the Fall 2012 event. The sedimentation is likely the result of comparatively large precipitation events and corresponding elevations in stream flow that lead to channel erosion and bedload movement, resulting in suspended sediments that tend to settle in the hatchboxes. Salmonid early life stages are known to be sensitive to suspended sediments, with concentrations as low as 7 mg/L resulting in reduced egg survival (BCMOE 1997). Notably, toxicity and chemistry data from STIA outfalls discharging upstream of the Miller Creek exposure location indicate no toxicity and low levels of turbidity and metals, suggesting that STIA inputs are not related to adverse effects observed in the *in situ* exposures.

Figure 15: Year to year comparisons of cumulative survival across sites during Fall events.



NT- Not tested

Figure 16: Year to year comparisons of cumulative survival across sites during Spring testing events.



Regardless of seasonal differences, perhaps the most notable observation associated with these tests is the continued level of adverse effects found at the Upstream Des Moines Creek site. Adverse effects have been observed at this site during all monitoring events, and are present during both Spring and Fall. Since this site is located near the headwaters of Des Moines Creek, causes of impacts at this site arise outside of STIA property and have the potential to extend further downstream. The results of this study have been previously communicated to the City of SeaTac, who are working to identify and remove illicit discharges and connections in the watershed through the City's illicit discharge detection and elimination program, which appears to be working, given the improvement in this site in Fall 2012 and Spring 2013 compared to previous years.

Overall, there has been general good agreement with results in the field and laboratory, with the laboratory tests helping to provide additional insight into the results of the field (i.e., *in situ*) tests. For example, lack of toxicity in the laboratory exposures may be helpful in terms of interpreting whether dissolved contaminants or suspended sediments are causing toxicity in the *in situ* exposures.

Finally, over the course of developing the *in situ* approach for use in the Airport's monitoring program, adjustments have been made in sampling location and methodology to address sedimentation impacts to the hatchboxes. However, sedimentation within the hatchboxes, even

with "above-gravel" installation, is still being observed at Miller Creek. Consequently, future testing will explore additional options for altering the exposure methodology and/or exposure sites in a manner that will more fully address this question.

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Nautilus Environmental

Port of Seattle- Seattle-Tacoma International Airport

Rainbow Trout Early Life Stages *In Situ* Monitoring Testing

Phase 1: Development and Demonstration - Fall 2013 and Spring 2014 Testing Events

Final Report

Report date: October 3, 2014

Submitted to:

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1.0 INFORMATION

This report presents the results of the rainbow trout (RBT) early life stage (ELS) *in situ* monitoring tests conducted in the Fall 2013 and Spring 2014, as described in the Port of Seattle's Seattle-Tacoma International Airport *In situ* Monitoring Plan, Phase 1: Development and Demonstration (Nautilus 2010). The objective of this program is to demonstrate the feasibility of using salmonid ELS as an *in situ* monitoring tool to assess the quality of receiving waters potentially affected by stormwater discharges from the Seattle-Tacoma International Airport (STIA), as well as a multitude of other discharges from the surrounding urban environment. Results for studies conducted in Fall 2010/Spring 2011, Fall 2011/Spring 2012, and Fall 2014/Spring 2013 have been presented previously (Nautilus 2011, Nautilus 2012, and Nautilus 2013, respectively).

Results from the *in situ* bioassays and supporting analytical data are intended to provide an indication of attainment of receiving water quality standards and associated beneficial uses related to salmonid spawning and rearing. Thus, the overall goal of Phase 1 is to validate the *in situ* approach, particularly with respect to determining if the selected sites and exposure methodologies are appropriate, or if they need to be modified to compensate for confounding variables (e.g., deposition of fine sediments, mobilization of anoxic sediments during storm events, etc.). Applied under the appropriate conditions, it is anticipated that the RBT *in situ* ELS bioassay will be an effective instream biological monitoring tool for assessing the potential effects of stormwater discharges on the receiving environment.

Phase I of the *In Situ* Monitoring Plan (i.e., Development and Demonstration) was originally intended to last for one year and include testing during the Spring and Fall seasons. However, this Phase was extended to allow for additional comparisons with the laboratory sublethal testing being conducted by the STIA at sites downstream of Port outfalls, as specified in Part II, Special Condition S8 of NPDES Permit No. WA-002465-1. The laboratory sublethal toxicity testing is used for permit compliance purposes, and has been conducted concurrently with *in situ* deployments (when feasible) to facilitate validation of the *in situ* methodology. A comparison of the two methods is presented in the Combined Acute, Sublethal, and *In Situ* Report (Nautilus 2013).

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2.0 TEST METHODS

Guidance for conducting *in situ* ELS exposures with salmonids is available from a number of sources. For example, the British Columbia Ministry of Environment has a protocol for an *in situ* ELS salmonid test (BCMOE, 2003). In addition, Environment Canada has developed both laboratory and *in situ* test procedures for early life stages of rainbow trout (Environment Canada, 1998). In the U.S., there are two general laboratory protocols for conducting fish early life stage toxicity tests (EPA, 1996; ASTM, 2005). The procedures used in this study reflect refinements made to the general guidance provided in the documents above (Chalmers *et al*, 2014), and have been used successfully at a number of sites in both Canada and the United States. Additional refinements specific to applying the method to waterways present on Airport property are included in the descriptions below.

2.1 Design

The study design used for the Fall 2013 and Spring 2014 *in situ* testing involved exposure of eyed-embryos at three sampling sites, using four replicates per site with 30 embryos per replicate. The locations of the sites are shown in Figure 1. The Study Design was consistent with the methodology used in the five previous monitoring events in which the sites located on Miller and Des Moines Creeks downstream of all Airport discharges were augmented by an additional site on Des Moines Creek located upstream of any Airport discharges. The additional site (i.e., Des Moines Creek Upstream) was included to determine the extent to which sources upstream of any STIA inputs may contribute to adverse effects observed at the downstream site on Des Moines Creek.

The exposure duration used in the *in situ* tests covers the major salmonid early life stage developmental milestones, beginning with the eyed egg stage, proceeding through hatching and alevin stages (yolk sac present and residing in the gravel), and ending with the early fry stage (also known as swim-up fry). At this point, the yolk sac is absorbed and, under natural conditions, the fish would leave the gravel to feed independently. The duration of the exposure period is expected to include multiple rain/runoff events, and corresponding fluctuations in flow, contaminant concentrations, temperature, water chemistry, etc. Collectively, these attributes of the *in situ* approach provide highly relevant information regarding the suitability of waterbodies to support salmonids (Chalmers *et al*, 2014).

The eyed eggs for both *in situ* events were supplied locally by TroutLodge (Sumner, WA), which supplies RBT eggs and sperm for the laboratory sublethal toxicity tests required in STIA's NPDES stormwater permit. The status of the *in situ* organisms was routinely monitored during the exposure, as well as at specific developmental stages and after significant storm events. Data were obtained on hatching, survival, development and growth. A subset of embryos was also reared in the laboratory to assess organism quality. Weekly temperature measurements from the field were used to adjust rearing temperatures for the laboratory controls so that development in the controls could be used to trigger field inspections at specific times (e.g., hatch, swim-up).

2.2 Monitoring Locations and Site Preparations

The exposures were conducted in two streams within the STIA property boundaries: Miller Creek and Des Moines Creek (Figure 1). Two of the sites, Miller Creek and Des Moines Creek at S 200th, are located downstream of STIA inputs into their respective drainages. An additional site (Des Moines Creek Upstream) is located upstream of STIA stormwater outfalls into Des Moines Creek. This site is used to assess water quality in Des Moines Creek prior to receiving any STIA stormwater discharges; the Des Moines Creek basin upstream of STIA is heavily urbanized and potentially impacted by a variety of pollutant sources.

Results from 2010 concluded that the chosen sampling sites generally do not have ideal substrate conditions and are subjected to heavy sediment flow during storm events. Consequently, all four exposure replicates at each site were placed above the substrate in gravel contained within PVC crate frames (see Figure 2) anchored to the substrate with steel stakes. The replicate crates at each site were placed in a row on the streambed, from upstream to downstream, at a sufficient distance apart so that flow patterns were re-established between each crate. This approach allowed for passage of water through the exposure chambers, but prevented smothering of embryos and fry by sediment.

2.3 Field Exposure Apparatus

The trout embryos were contained in modified Whitlock-Vibert hatchboxes (Federation of Flyfishers, MO), which are comprised of two rectangular chambers located one above the other; the upper chamber is for embryo development and the lower chamber for rearing of hatched fish. The external sides of the hatchbox are plastic mesh that allows passage of water through the box, but prevents loss of embryos. The divider between the embryo chamber and the rearing chamber is comprised of slots that are narrow enough to prevent transfer of unhatched embryos, but wide enough to permit migration of hatched fish into the lower rearing chamber. Thus, upon hatch, alevins are able to migrate through the slots from the embryo chamber into the larger rearing chamber. To prevent escape of the hatched fry into the streams upon swim-up, plastic screening material (Darice® size 7 mesh) was attached to the external faces of the rearing chamber and held in place using small plastic zip ties.

The hatchboxes were contained within flexible plastic mesh bags surrounded by 1 – 2 inch diameter gravel, with the hatchbox placed centrally within the rocks in the bag. The gravel surrounding the hatchboxes acts to diffuse the current and prevent exposure of the embryos to sunlight. The bags were then placed within the PVC crates, which were held in place in the stream by stakes anchored in the substrate (Figure 2). Figure 3 shows the eyed eggs within the hatchbox, while Figure 4 is of fry within the hatchbox.

Figure 2: Photograph of the crate set up, Des Moines Creek at S 200th.



2.4 Test Organisms

Eyed-egg stage rainbow trout embryos were obtained from TroutLodge on October 9, 2013 for the Fall event and April 9, 2014 for the Spring event. As supplied, the eyed embryos had developed for approximately 245 degree-days[1], as noted in communication with TroutLodge staff. On the day of test initiation for both events, eggs were brought to Rainier Environmental Laboratory (REL; Fife, WA), and randomly counted into replicate units of 30 embryos apiece in individual opaque plastic food-storage containers (i.e., 450-mL Ziploc plastic tubs). These containers were then placed in a cooler containing ice packs, and transported to the sites where the embryos were transferred into the hatchboxes in the creek on the same day. The embryos were transferred to the sites in laboratory control water, and all embryos were installed at the sites between 14:00 and 15:15 on October 9, 2013 for the Fall event, and between 13:45 and 15:45 on April 9, 2014 for the Spring event.

All personnel handling the embryos wore nitrile gloves. Containers were pre-cleaned with Liqui-nox soap (Alconox, Jersey City, NJ) and rinsed with deionized water.

2.5 Controls

Controls were used to assess the influence of the following factors on test results:

1. Quality (health and viability) of supplied organisms,
2. Transport and handling of organisms, and
3. Ambient stream temperatures, which affect the time to developmental milestones (e.g., hatch).

The controls consisted of a laboratory exposure (four replicates of 30 organisms each) conducted concurrently with each field exposure in clean laboratory water (moderately hard synthetic water [MHSW]) using a subset of the same batch of embryos used to initiate the field exposures. These embryos were also counted out, placed into individual plastic containers filled with MHSW and transported to the sites with the other replicates; thus, they also served as transport

[1] Degree-days are used to standardize descriptions of fish development, regardless of rearing temperature. For example, it takes rainbow trout approximately 340 degree-days to reach hatch (Quinn, 2005). Thus, at 8°C, it takes approximately 42 days to reach hatch.

controls. Upon returning to the laboratory after deployment of all field organisms, the control replicates were transferred to 4-L plastic containers in the laboratory containing 2 liters of MHSW at the average site water temperature, ±1°C. The control chambers are held in the dark, and gentle aeration was applied (100-200 bubbles per minute). The controls were monitored daily for mortalities, and dead organisms removed. Temperature was adjusted on a weekly basis to correspond to temperatures measured in the field. Water renewals were conducted three times per week (Monday, Wednesday, Friday) using clean MHSW. Dissolved oxygen, pH, conductivity, and temperature were measured before and after water renewals. Developmental milestones (e.g., hatch and swim-up) were also recorded.

2.6 Monitoring of Field Exposures

The sites were visited at approximately weekly intervals to assess the condition of the test organisms. During these checks, survival was recorded, as well as qualitative observations of organism health, site conditions, and sedimentation within the boxes. All dead organisms observed were removed on each visit. These observations were recorded on standard field data sheets included in Appendix A. In addition, temperature, pH, dissolved oxygen (DO) and conductivity were measured during the site visits.

Monitoring of the installations required removal of the substrate overlying the hatchboxes in the crate. The embryos or alevins in each hatchbox were then poured into a plastic dishpan containing site water where they were enumerated. They were then returned to the hatchbox, which was placed back into the mesh-net bag of gravel, the overlying gravel replaced, and the bag returned to its respective crate. Care was taken to minimize disturbance and damage to the test organisms.

2.7 Test Termination

The field exposures and laboratory controls were terminated when the field organisms reached the swim-up fry stage (i.e., yolk sac absorbed). This occurred on November 6, 2013 for the Fall exposure, and on May 6, 2014 for the Spring exposure. Surviving organisms were placed in their original plastic replicate containers filled with site water, transported back to the laboratory, and terminated. The fish were then wet-weighed (to the nearest 0.001 gram) on an analytical balance, and measured (total length, from tip of the snout to the end of the tail) to the nearest 0.5 mm. Obvious external malformations were noted, including the affected body part (e.g., head, eye, spine) and type of abnormality (e.g., edema). Abnormality data were recorded

on standard data sheets (Appendix A). The laboratory control fish were evaluated similarly on the same day.

2.8 Data Analysis

All test data were entered in CETIS (Comprehensive Environmental Toxicity Information System, Tidepool Scientific, McKinleyville, CA). Differences among the exposure sites and laboratory controls were evaluated using pair-wise multiple comparison tests according to the USEPA flow chart (USEPA 2002); significant differences were identified at $p \leq 0.05$.

One interim and five terminal endpoints were evaluated; the endpoints are described below:

1. Hatching success – an interim measure of the percentage of embryos hatched the day of the hatch inspection, or determined to have hatched based on the number of alevins present at the subsequent inspection, relative to the total number of embryos originally added;
2. Post-hatch survival - the percentage of organisms surviving at test termination relative to the number of embryos that hatched (these data help determine whether the majority of mortalities occurred pre- or post-hatch, or were distributed throughout the exposure period);
3. Cumulative survival - the percentage of surviving organisms at test termination relative to the number of embryos in each replicate at the beginning of the exposure;
4. Abnormality – the percentage of abnormal organisms at test termination relative to the number of surviving organisms;
5. Length – to the nearest 0.5 mm;
6. Weight – to the nearest 0.001 g.

3.0 QA/QC

The QA/QC program for the field exposure involved the following:

- Consistent field staff leader throughout all visits;
- Field documentation of all primary data; i.e., the names of individuals collecting the samples, sampling location, time of sampling, site conditions (e.g., degree of sedimentation), and other relevant observations, such as weather and any unusual conditions;
- Calibrated field meters;
- Use of pre-cleaned containers, with appropriate labels;
- Storing and transporting organisms in sealed containers in a cold, dark environment; cooling sample containers using ice or gel packs;
- Including transport controls to ascertain the extent of any transport-induced stress;
- Checking field organisms every week to monitor developmental progress, mortality and abnormality.

The QA/QC program for the laboratory portion of the study involved:

- Checks and maintenance of control organisms at regular intervals, including recording primary observations and water quality data on standardized data sheets;
- Review of datasheets by senior laboratory staff;
- Test termination activities (measurements, health assessment) conducted by qualified staff members using standardized datasheets to ensure consistent assessment of abnormalities and growth across all test sites and controls;
- Use of standard laboratory water and environmental chambers to maintain test organisms.

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4.0 RESULTS

4.1 Water Quality Measurements

Water quality measurements are summarized in Tables 1 and 2 for the Fall 2013 and Spring 2014 monitoring events, respectively.

Table 1: Summary of water quality measurements collected during site visits and control renewals (Fall 2013).

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	11.3 (1.2)	9.3 (0.2)	7.38 (0.14)	264.4 (3.5)
	[Min-Max]	[8.6 – 12.4]	[8.9– 9.7]	[7.19 – 7.67]	[257 - 271]
Miller Creek		9.8 (1.4)	10.4 (0.5)	7.31 (0.13)	271.8 (53.4)
		[8.0 – 11.7]	[9.8-10.9]	[7.14 – 7.50]	[182 - 307]
Des Moines		10.2 (1.2)	10.7 (1.4)	7.08 (0.36)	187.8 (32.8)
Creek at S 200th		[8.5 – 11.9]	[9.1 – 12.9]	[6.74 – 7.54]	[141 - 224]
Des Moines		12.3 (1.4)	9.9 (0.3)	6.87 (0.29)	107.2 (13.3)
Creek Upstream		[10.5– 14.1]	[9.4 – 10.2]	[6.50 – 7.19]	[94 - 126]

Table 2: Summary of water quality measurements collected during site visits and control renewals (Spring 2014).

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	12.0 (0.2)	9.1 (0.3)	7.45 (0.13)	284.9 (22.4)
	[Min-Max]	[11.5 – 12.4]	[8.3 – 9.4]	[7.17 – 7.67]	[244 - 312]
Miller Creek		11.9 (1.0)	11.3 (1.1)	6.96 (0.62)	201.2 (46.8)
		[10.7 – 13.3]	[10.5 – 13.1]	[6.05 – 7.78]	[148 - 270]
Des Moines		12.6 (1.0)	9.9 (0.6)	6.89 (0.39)	140.4 (30.8)
Creek at S 200th		[11.3 – 13.8]	[9.1 – 10.72]	[6.34 – 7.44]	[98 - 168]
Des Moines		12.8 (0.3)	10.2 (0.5)	6.77 (0.44)	92.0 (11.3)
Creek Upstream		[12.5 – 13.1]	[9.7 – 10.7]	[6.26 – 7.03]	[79 - 99]

In the Fall 2013 *in situ* tests, temperatures for the three field sites and the control ranged from 8.0 to 14.1^{0}C. The field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays (60-100% saturation, and 6-9 pH units, respectively). The pH values were between 6.5 and 7.7, and DO ranged from 9.1 to 12.9 mg/L among all stream measurements. Although limited to weekly measurements, the field DO and pH data suggested good water quality conditions, with no indication of potential for adverse effects on organism survival and development. The conductivity measurements for all three sites exhibited some variability throughout the exposure period, but the values remained well-within ranges tolerated by early life stages of salmonids.

In the Spring 2014 *in situ* tests, temperatures among the three field sites and the control ranged from 10.7 to 13.8^{0}C. These temperatures were similar to Fall temperatures. The field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays. The pH values were between 6.1 and 7.8, and DO ranged from 9.1 to 13.1 mg/L among all stream measurements. Consequently, the weekly field measurements of DO and pH suggested good water quality conditions, with no indication of potential for adverse effects on organism survival and development. As observed in the Fall event, the conductivity measurements for all three sites exhibited some variability throughout the exposure period, but the values remained well-within ranges tolerated by early life stages of salmonids.

Continuous measurements of pH were collected by CardnoTEC at the Miller Creek site using data sondes for limited periods primarily during the Fall 2013 monitoring event. These data were collected as part of another program, and show short-term variability in pH. The data are presented in Figure 5 for the Fall 2013 testing event.

Figure 5: Continuous pH data from Miller Creek, Fall 2013.



4.2 Precipitation During the Monitoring Events

Precipitation data were provided by STIA. Figure 6 shows the daily rainfall for the duration of the exposure for the Fall 2013 test. A limited number of storm events occurred during the *in situ* deployment, with a total of 1.53 inches of rain over 4 weeks. There was no snow during this testing event. Figure 7 shows the daily rainfall for the duration of the Spring 2014 exposure. Appreciably more rain (5.37 in) fell during the Spring event compared with the Fall. No snow occurred during the exposure period, and the largest storm was May 3rd.

Figure 6: Daily rainfall for the duration of Fall 2013 exposure.

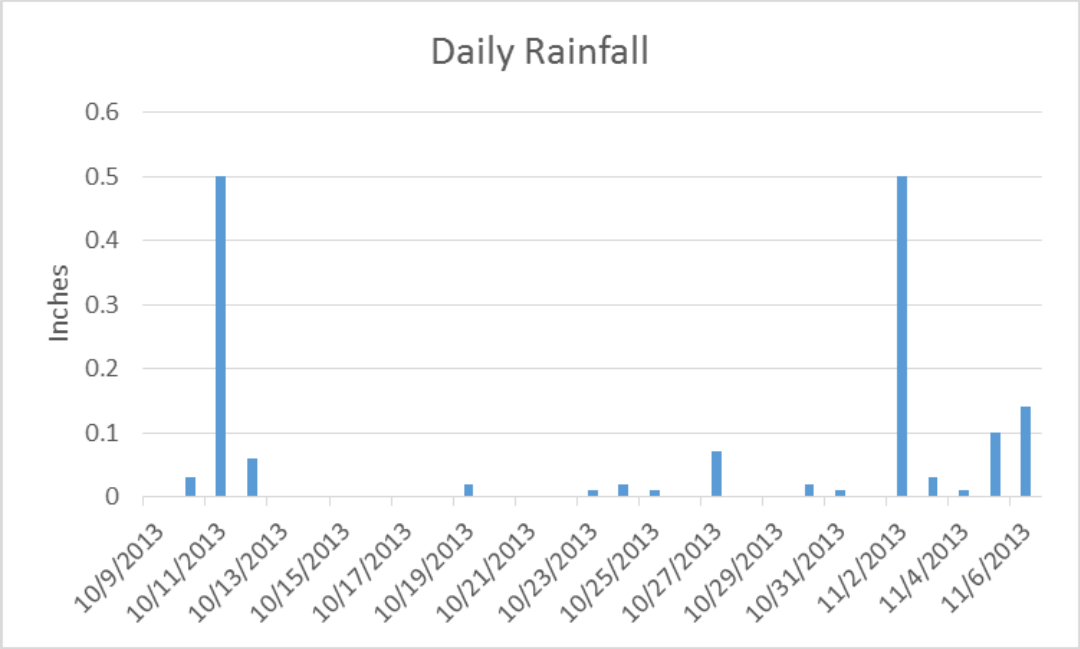
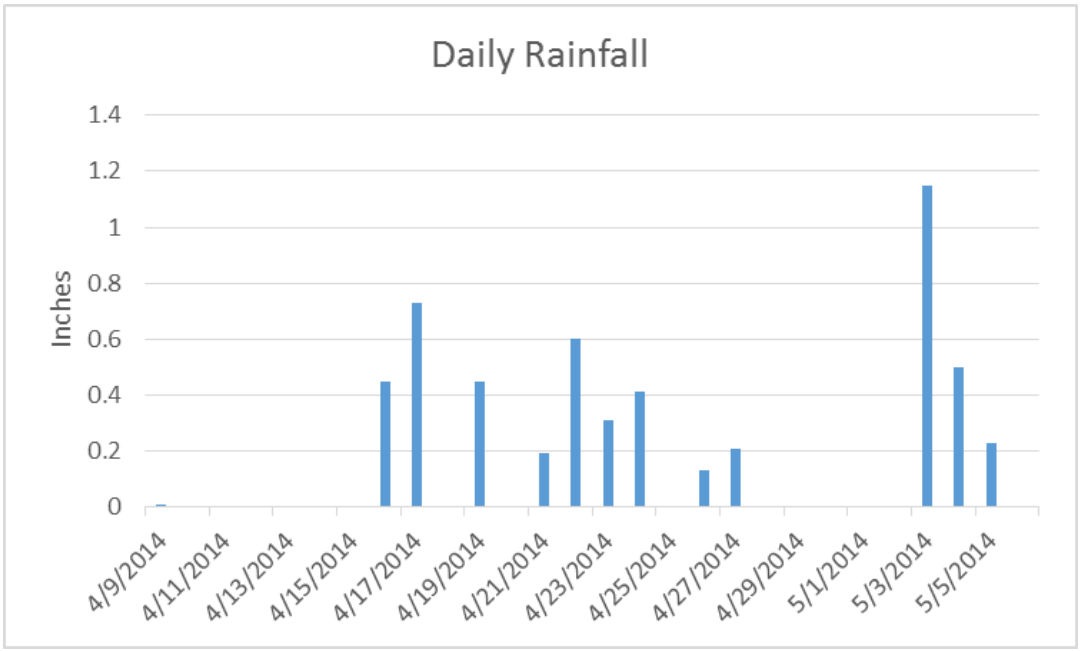


Figure 7: Daily rainfall for the duration of the Spring 2014 exposure.



4.3 *In situ* exposures

4.3.1 Fall 2013

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 3. Table 4 presents the growth endpoints. These same data are presented graphically in Figures 9 through 11 for ease of comparison.

During an interim check after the embryos had hatched, one of the replicates at Miller Creek was found without alive or dead alevins. As there is normally evidence of fish mortality in a replicate, the lack of any carcasses suggests escapement. Therefore, this replicate was removed from statistical analysis for all endpoints except hatching success.

Hatching success – Mean hatching success for the controls was 99.2%, compared with 58.3% at Miller Creek, 95.0% at Des Moines Creek at S 200th, and 44.2% at Des Moines Creek Upstream. Hatching success at Des Moines Creek at S 200th was not statistically different from the controls; however, hatching success at Miller Creek and Des Moines Creek Upstream were significantly reduced relative to the controls.

Post-hatch survival – Control survival of alevins post-hatch was 100%, compared with 61.6% at Miller Creek, 93.8% at Des Moines Creek at S 200th, and 11.2% Des Moines Creek Upstream. Post-hatch survival at Des Moines Creek Upstream and Miller Creek sites were significantly different from the controls. However, there was no difference in post-hatch survival between the controls and Des Moines Creek at S 200th.

Cumulative survival – Control survival from the initiation of the test to termination averaged 99.2%. For comparison, cumulative survival at the exposure sites averaged 45.6% at Miller Creek, 89.2% at Des Moines Creek at S 200th, and 5.8% at the Des Moines Creek Upstream site. Survival at Des Moines Creek at S 200th was not statistically different from the controls, whereas both Des Moines Upstream and Miller Creek were significantly reduced compared with the controls.

Abnormalities – There were few abnormalities observed across all treatments, with just one in the controls, one at Miller Creek, and one at Des Moines Creek at S 200th. The control fish exhibited edema, while the abnormal fish at Miller Creek was missing its tail, and the fish at Des Moines Creek at S 200th had small and misshapen eyes.

Growth – Average weight in the controls was 80.0 mg, and length averaged 22.4 mm. For comparison, Miller Creek fish averaged 64.2 mg and 20.8 mm, fish exposed at Des Moines Creek at S 200th averaged 76.7 mg and 21.9 mm, and Des Moines Creek Upstream fish averaged 76.0 mg and 21.7 mm, for weight and length, respectively. Growth of fish from Des Moines Creek Upstream (length only) and Miller Creek (length and weight) was significantly less than observed in the controls.

Table 3: Results for hatching success, survival and abnormality in the control and field treatment groups (Fall 2013)[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	99.2 (1.7)	100 (0.0)	99.2 (1.7)	0.9 (1.7)
Miller Creek	58.3 (22.9)	61.6 (36.4)	45.6 (31.5)	2.0 (3.4)
Des Moines Creek at S 200th	95.0 (7.9)	93.8 (2.0)	89.2 (8.8)	0.9 (1.7)
Des Moines Creek Upstream	44.2 (15.0)	11.2 (14.1)	5.8 (7.9)	0 (0)

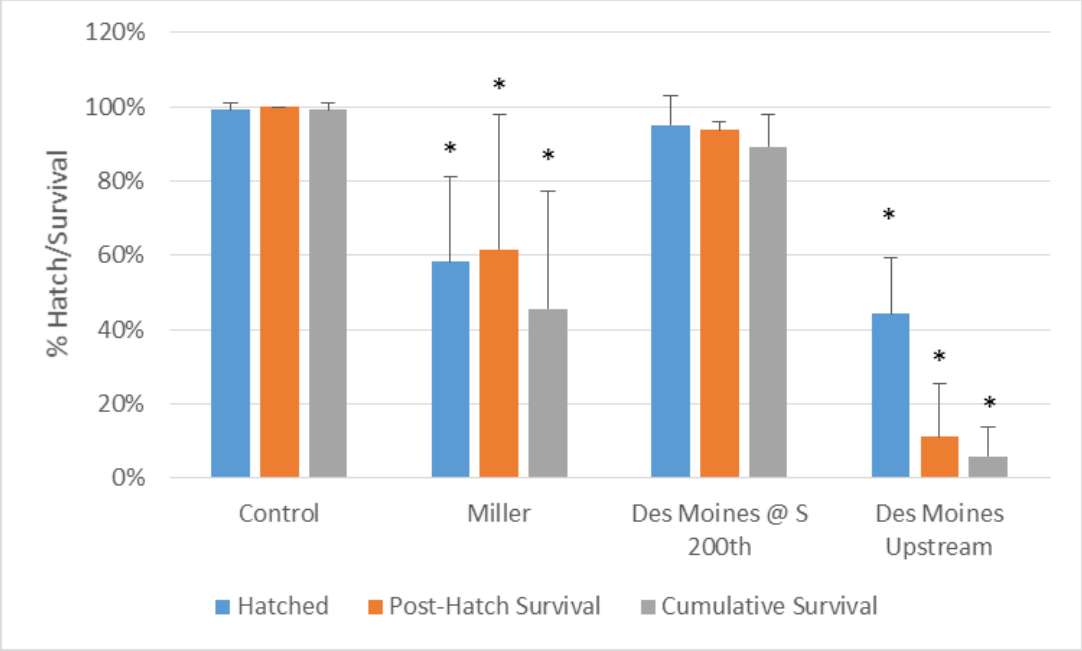
Notes:
1. Results are presented as mean and standard deviation.
2. Shaded values are significantly different from the control.

Table 4: Comparison of growth in the control and field treatment groups (Fall 2013)[1].

Site	Length (mm)	Weight (mg)
Control	22.4 (0.64)	80.0 (1.81)
Miller Creek	20.8 (0.47)	64.2 (4.55)
Des Moines Creek at South 200th	21.9 (0.39)	76.7 (0.93)
Des Moines Creek Upstream	21.7 (0.42)	76.0 (8.49)

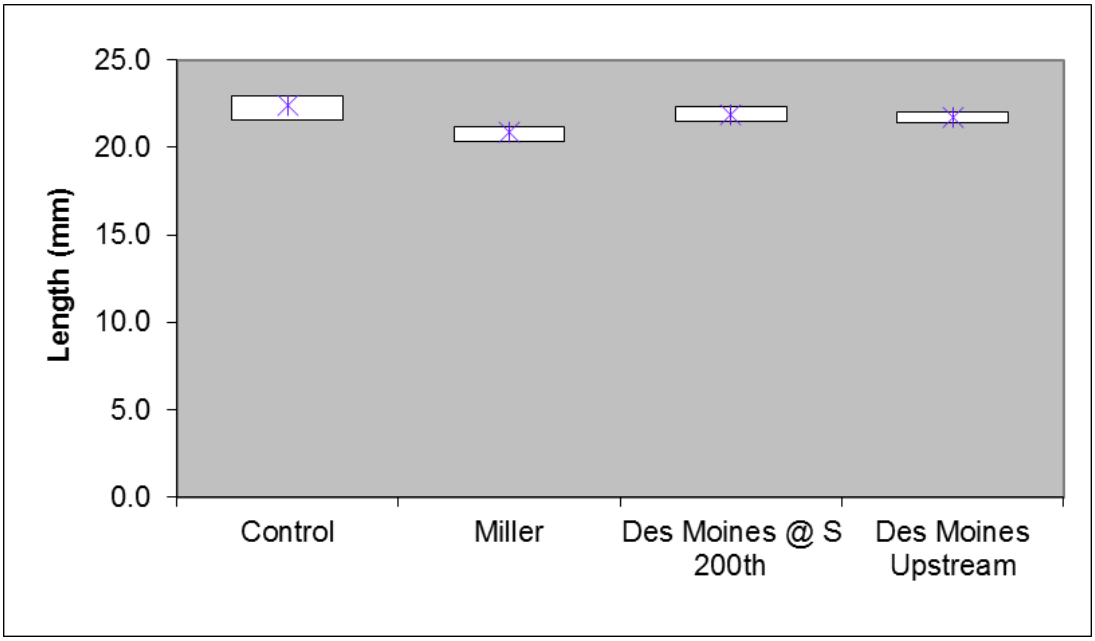
Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control

Figure 8: Hatching success, post-hatch survival and cumulative survival in the field and control treatment groups (Fall 2013).



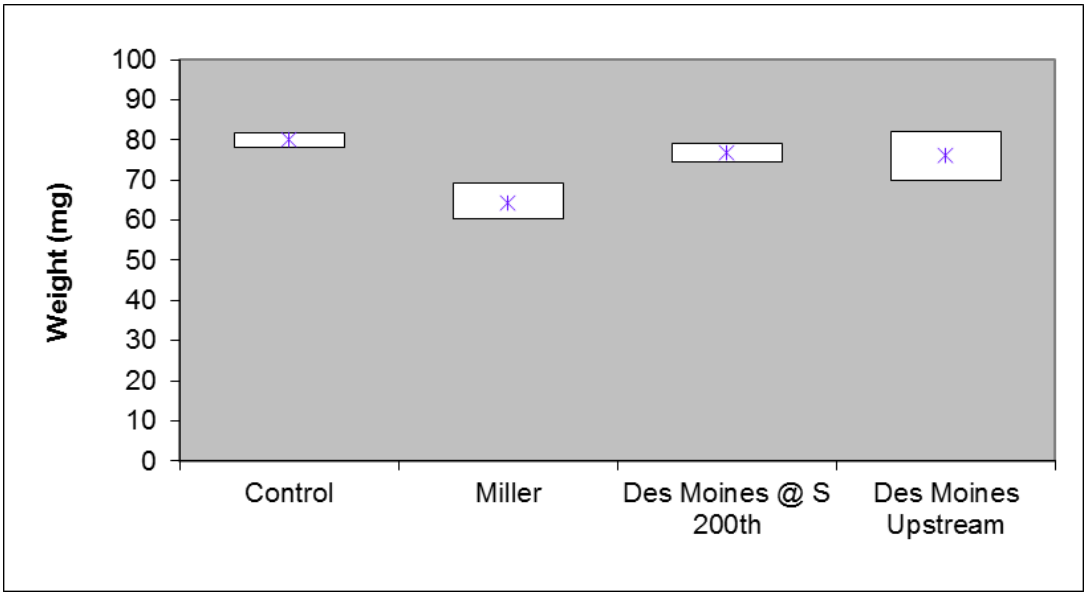
Error bars are standard deviations; asterisks denote significant difference from controls.

Figure 9: Average lengths for the laboratory control and exposure sites (Fall 2013).



Data point is the average; box represents range of minimum to maximum values.

Figure 10: Average weights for the laboratory control and exposure sites (Fall 2013).



Data point is the average; box represents range of minimum to maximum values.

4.3.2 Spring 2014

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 5. Table 6 presents the growth endpoints. These same data are presented graphically in Figures 12 through 14 for ease of comparison.

Hatching success – Mean hatching success for the controls was 100%, compared with 98.3% at Miller Creek, 92.5% at Des Moines Creek at S 200th, and 0.8% at Des Moines Creek Upstream. Hatching success at both Des Moines Creek sites was significantly less than the controls ($p \leq 0.05$); however, since the effect size at Des Moines Creek at S 200th was <10%, the p-value was changed to 0.01, per the WDOE guidance document (WDOE 2008), which removed the significance.

Post-hatch survival – Control survival of alevins post-hatch was 97.5%, compared with 96.6% at Miller Creek, 97.2% at Des Moines Creek at S 200th, and 0% at Des Moines Upstream. Only Des Moines Upstream was significantly different from controls.

Cumulative survival – Control survival from the initiation of the test to termination averaged 97.5%, compared with 94.4% at Miller Creek, and 90.0% at Des Moines Creek at S 200th. Neither of these sites differed significantly from the controls. No survival was observed at test

termination at the Des Moines Upstream site, which was significantly different from the controls.

Abnormalities -- There were few abnormalities observed in any of the treatments, with just one in the controls, and one at Miller Creek. Both abnormalities were misshapen jaws.

Growth – Average weight in the controls was 124.1 mg, compared with 129.2 mg at Miller Creek, and 127.1 mg at Des Moines Creek at S 200th. Surviving fish averaged 26.6 and 26.5 mm at Miller and Des Moines Creek at S 200th, respectively, compared with an average of 26.7 mm in the controls. There were no statistical differences in growth among sites.

Table 5: Hatching success, survival and abnormality in the control and field treatment groups (Spring 2014)[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	100 (0)	97.5 (3.2)	97.5 (3.2)	0.8 (1.7)
Miller Creek	98.3 (1.9)	96.6 (3.3)	94.4 (1.9)	1.2 (2.1)
Des Moines Creek at S 200th	92.5 (8.8)	97.2 (1.9)	90.0 (9.4)	0 (0.0)
Des Moines Upstream	0.8 (1.7)	0 (0.0)	0 (0.0)	NA

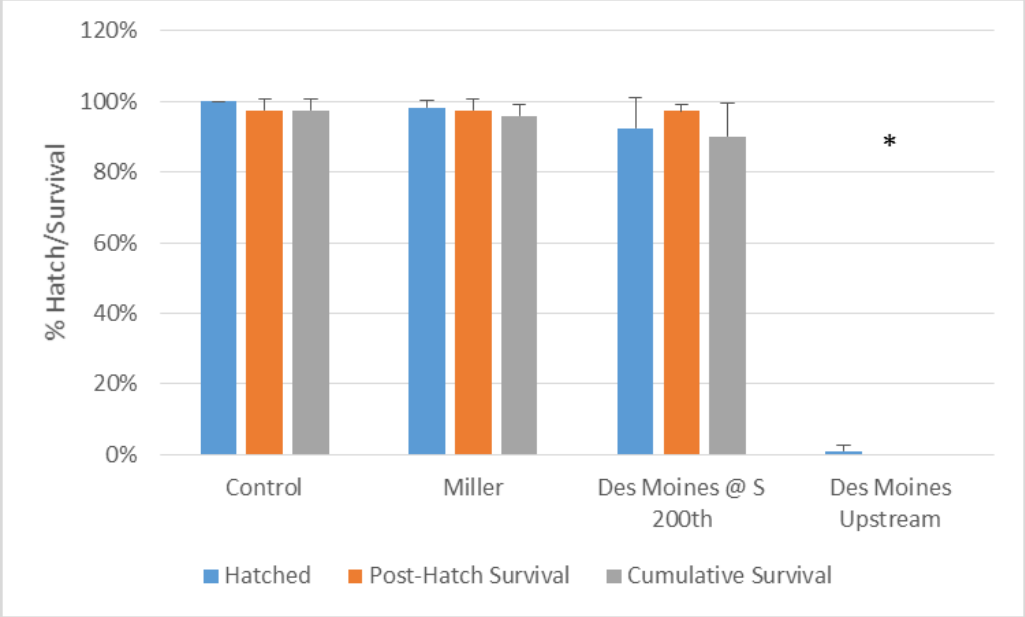
Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control
3. NA- Not applicable

Table 6: Comparison of growth in the control and field treatment groups (Spring 2014)[1].

Site	Length (mm)	Weight (mg)
Control	26.7 (0.14)	124.1 (2.5)
Miller Creek	26.6 (0.3)	129.2 (3.3)
Des Moines Creek at S 200th	26.5 (0.11)	127.1 (2.7)
Des Moines Upstream	NA	NA

Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control
3. NA- Not applicable

Figure 11: Hatching success, post-hatch survival and cumulative survival in the field and control treatment groups (Spring 2014).



Error bars are standard deviations; asterisks denote significant difference from controls.

Figure 12: Average length for the control and exposure group (Spring 2014).



Data point is the average; box represents range of minimum to maximum values.

Figure 13: Average weights for the control and exposure groups (Spring 2014).



Data point is the average; box represents range of minimum to maximum values.

4.4 Field Observations

During both testing events, hatch boxes were observed to be free of biofilm or other accumulation of organic material. During both events, crayfish were often found within the crates at all sites, but not within the hatchboxes. Tadpoles were observed in the Spring at the Miller Creek site. Accumulation of sediments within the hatch boxes was observed during the Spring 2014 event at the Miller Creek site, with sediment volume reaching 80% and greater within the boxes. Interestingly, no adverse effects were observed despite the relatively high level of sedimentation.

4.5 Relationships Between *In Situ* and Sublethal Tests

There were no overlaps between the Fall 2013 and Spring 2014 *in situ* deployments, and laboratory sublethal tests.

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5.0 DISCUSSION

In Fall 2013, adverse effects on survival were observed in Miller Creek, with hatching success, post-hatch survival and cumulative survival significantly reduced compared to the controls. The rainfall total for Fall 2013 was one of the smallest amounts recorded during an *in situ* exposure over the last 4 years, regardless of season. Therefore, the amount of discharge from STIA was limited; the stormwater outfall located immediately upstream of the site was only seen discharging on the day of termination. Thus, test conditions during the Fall may have been more representative of seasonal base flow conditions. No evidence of adverse effects were observed in the hatch boxes deployed at Miller Creek in Spring 2014, which experienced appreciably more discharge during the exposure period.

Adverse effects were not observed at Des Moines at S 200th during the Fall or Spring deployments. Conversely, significant effects were observed at the Upstream Des Moines Creek site in both events. This result is consistent with previous testing events, and continues to suggest that there are concerns with water quality at this site. Notably, this site is located near the headwaters of Des Moines Creek, upstream of inputs from STIA property. These findings have been communicated to the City of SeaTac, who are working to identify and remove illicit discharges and connections in the watershed through the City's illicit discharge detection and elimination program.

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Port of Seattle

September 2, 2014

Mr. Bobb Nolan
Washington Department of Ecology
Northwest Regional Office
3190 160th Ave SE
Bellevue, Washington 98008

Re: Storm Drainage System *In Situ* Monitoring– Fall 2014 and Spring 2015 Testing Events Final Report
Seattle-Tacoma International Airport
NPDES Permit WA-002465-1, Part II Special Condition S9

Dear Mr. Abbasi:

Please find attached the Nautilus Environmental *Phase 1: Development and Demonstration – Fall 2014 and Spring 2015 Testing Events Final Report* dated August 17, 2015. This report presents the results of the rainbow trout early life stages *in situ* bioassay, as described in the Port of Seattle's Seattle-Tacoma International Airport *In situ* Monitoring Plan, Phase 1: Development and Demonstration.

Deicing season sublethal laboratory testing was not able to be completed during the 2014/2015 season because trout embryos were not available for testing during the time when ground deicing occurred. The *in situ* bioassay was completed during both Fall and Spring seasons which continues to support the reliability of the *in situ* test in comparison to the laboratory sublethal test which is often encumbered by the timing of rainfall events and embryo availability.

If you have any questions regarding this letter, please contact me at 206/787-5528.

Sincerely,

Bob Duffner
Environmental Compliance Programs Manager, Aviation

Cc: Randy Marshall, Department of Ecology

Attachment: Nautilus Environmental, *Port of Seattle – Seattle Tacoma International Airport, Rainbow Trout Early Life Stages In Situ Monitoring Testing, Phase I: Development and Demonstration – Fall 2014 and Spring 2015 Testing Events, Final Report*, August 17, 2015.

Seattle-Tacoma
International Airport
P.O. Box 68727
Seattle, WA 98168-0727

Nautilus Environmental

Port of Seattle- Seattle-Tacoma International Airport

Rainbow Trout Early Life Stages *In Situ* Monitoring Testing

Phase 1: Development and Demonstration - Fall 2014 and Spring 2015 Testing Events

Final Report

Report date: August 17, 2015

Submitted to:

Port of Seattle
Seattle-Tacoma International Airport
PO Box 68727
Seattle, WA 98168

8663 Commerce Court
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1.0 INFORMATION

This report presents the results of the rainbow trout (RBT) early life stage (ELS) *in situ* monitoring tests conducted in the Fall 2014 and Spring 2015, as described in the Port of Seattle's Seattle-Tacoma International Airport *In situ* Monitoring Plan, Phase 1: Development and Demonstration (Nautilus 2010). The objective of this program is to demonstrate the feasibility of using salmonid ELS as an *in situ* monitoring tool to assess the quality of receiving waters potentially affected by stormwater discharges from the Seattle-Tacoma International Airport (STIA), as well as a multitude of other discharges from the surrounding urban environment. Results for studies conducted in Fall 2010/Spring 2011, Fall 2011/Spring 2012, Fall 2014/Spring 2013, and Fall 2013/Spring 2014 have been presented previously (Nautilus 2011, Nautilus 2012, Nautilus 2013, and Nautilus 2014, respectively).

Results from the *in situ* bioassays and supporting analytical data are intended to provide an indication of attainment of receiving water quality standards and associated beneficial uses related to salmonid spawning and rearing. Thus, the overall goal of Phase 1 is to validate the *in situ* approach, particularly with respect to determining if the selected sites and exposure methodologies are appropriate, or if they need to be modified to compensate for confounding variables (e.g., deposition of fine sediments, mobilization of anoxic sediments during storm events, etc.). Applied under the appropriate conditions, it is anticipated that the RBT *in situ* ELS bioassay will be an effective instream biological monitoring tool for assessing the potential effects of stormwater discharges on the receiving environment.

Phase I of the *In Situ* Monitoring Plan (i.e., Development and Demonstration) was originally intended to last for one year and include testing during the Spring and Fall seasons. However, this Phase was extended to allow for additional comparisons with the laboratory sublethal testing being conducted by the STIA at sites downstream of Port outfalls, as specified in Part II, Special Condition S8 of NPDES Permit No. WA-002465-1. The laboratory sublethal toxicity testing is used for permit compliance purposes, and has been conducted concurrently with *in situ* deployments (when feasible) to facilitate validation of the *in situ* methodology. A comparison of the two methods is presented in the Combined Acute, Sublethal, and *In Situ* Report (Nautilus 2013).

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2.0 TEST METHODS

Guidance for conducting *in situ* ELS exposures with salmonids is available from a number of sources. For example, the British Columbia Ministry of Environment has a protocol for an *in situ* ELS salmonid test (BCMOE, 2003). In addition, Environment Canada has developed both laboratory and *in situ* test procedures for early life stages of rainbow trout (Environment Canada, 1998). In the U.S., there are two general laboratory protocols for conducting fish early life stage toxicity tests (EPA, 1996; ASTM, 2005). The procedures used in this study reflect refinements made to the general guidance provided in the documents above (Chalmers *et al*, 2014), and have been used successfully at a number of sites in both Canada and the United States. Additional refinements specific to applying the method to waterways present on Airport property are included in the descriptions below.

2.1 Design

The study design used for the Fall 2014 and Spring 2015 *in situ* testing involved exposure of eyed-embryos at three sampling sites, using four replicates per site with 30 embryos per replicate. The locations of the sites are shown in Figure 1. The Study Design was consistent with the methodology used in the seven previous monitoring events in which the sites located on Miller and Des Moines Creeks downstream of all Airport discharges were augmented by an additional site on Des Moines Creek located upstream of any Airport discharges. The additional site (i.e., Des Moines Creek Upstream) was included to determine the extent to which sources upstream of any STIA inputs may contribute to adverse effects observed at the downstream site on Des Moines Creek.

The exposure duration used in the *in situ* tests covers the major salmonid early life stage developmental milestones, beginning with the eyed egg stage, proceeding through hatching and alevin stages (yolk sac present and residing in the gravel), and ending with the early fry stage (also known as swim-up fry). At this point, the yolk sac is absorbed and, under natural conditions, the fish would leave the gravel to feed independently. The duration of the exposure period is expected to include multiple rain/runoff events, and corresponding fluctuations in flow, contaminant concentrations, temperature, water chemistry, etc. Collectively, these attributes of the *in situ* approach provide highly relevant information regarding the suitability of waterbodies to support salmonids (Chalmers *et al*, 2014).

The eyed eggs for both *in situ* events were supplied locally by TroutLodge (Sumner, WA), which supplies RBT eggs and sperm for the laboratory sublethal toxicity tests required in STIA's NPDES stormwater permit. The status of the *in situ* organisms was routinely monitored during the exposure, as well as at specific developmental stages and after significant storm events. Data were obtained on hatching, survival, development and growth. A subset of embryos was also reared in the laboratory to assess organism quality. Weekly temperature measurements from the field were used to adjust rearing temperatures for the laboratory controls so that development in the controls could be used to trigger field inspections at specific times (e.g., hatch, swim-up).

2.2 Monitoring Locations and Site Preparations

The exposures were conducted in two streams within the STIA property boundaries: Miller Creek and Des Moines Creek (Figure 1). Two of the sites, Miller Creek and Des Moines Creek at S 200th, are located downstream of STIA inputs into their respective drainages. An additional site (Des Moines Creek Upstream) is located upstream of STIA stormwater outfalls into Des Moines Creek. This site is used to assess water quality in Des Moines Creek prior to receiving any STIA stormwater discharges; the Des Moines Creek basin upstream of STIA is heavily urbanized and potentially impacted by a variety of pollutant sources.

Results from 2010 concluded that the chosen sampling sites generally do not have ideal substrate conditions and are subjected to heavy sediment flow during storm events. Consequently, all four exposure replicates at each site were placed above the substrate in gravel contained within PVC crates anchored to the substrate with steel stakes. The replicate crates at each site were placed in a row on the streambed, from upstream to downstream, at a sufficient distance apart so that flow patterns were re-established between each crate. This approach allowed for passage of water through the exposure chambers, but prevented smothering of embryos and fry by sediment.

2.3 Field Exposure Apparatus

The trout embryos were contained in modified Whitlock-Vibert hatchboxes (Federation of Flyfishers, MO), which are comprised of two rectangular chambers located one above the other; the upper chamber is for embryo development and the lower chamber for rearing of hatched fish. The external sides of the hatchbox are plastic mesh that allows passage of water through the box, but prevents loss of embryos. The divider between the embryo chamber and the rearing chamber is comprised of slots that are narrow enough to prevent transfer of unhatched embryos, but wide enough to permit migration of hatched fish into the lower rearing chamber. Thus, upon hatch, alevins are able to migrate through the slots from the embryo chamber into the larger rearing chamber. To prevent escape of the hatched fry into the streams upon swim-up, plastic screening material (Darice® size 7 mesh) was attached to the external faces of each rearing chamber and held in place using small plastic zip ties.

The hatchboxes were contained within flexible plastic mesh bags surrounded by 1 – 2 inch diameter gravel, with the hatchbox placed centrally within the rocks in the bag. The gravel surrounding the hatchboxes acts to diffuse the current and prevent exposure of the embryos to sunlight. The bags were then placed within the PVC crates, which were held in place in the stream by stakes anchored in the substrate (Figure 2). Figure 3 shows the eyed eggs within the hatchbox, while Figure 4 is of fry within the hatchbox.

Figure 2: Photograph of the crate set up, Des Moines Creek at S 200th.



2.4 Test Organisms

Eyed-egg stage rainbow trout embryos were obtained from TroutLodge on October 9, 2014 for the Fall event and March 27, 2015 for the Spring event. According to TroutLodge staff, the eyed embryos had already developed for approximately 245 degree-days[1]. On the day of test initiation, eggs were brought to Rainier Environmental Laboratory (REL; Fife, WA), and randomly counted into replicate units of 30 embryos apiece in individual opaque plastic food-storage containers (i.e., 450-mL Ziploc plastic tubs). These containers were then placed in a cooler containing ice packs, and transported to the sites where the embryos were transferred into the hatchboxes in the creek on the same day. The embryos were transferred to the sites in laboratory control water, and all embryos were installed at the sites between 14:15 and 15:40 on October 9, 2014 for the Fall event, and between 13:45 and 15:00 on March 27, 2015 for the Spring event.

2.5 Controls

Controls were used to assess the influence of the following factors on test results:

1. Quality (health and viability) of supplied organisms,
2. Transport and handling of organisms, and
3. Ambient stream temperatures, which affect the time to developmental milestones (e.g., hatch).

The controls consisted of a laboratory exposure (four replicates of 30 organisms each) conducted concurrently with each field exposure in clean laboratory water (moderately hard synthetic water [MHSW]) using a subset of the same batch of embryos used to initiate the field exposures. These embryos were also counted out, placed into individual plastic containers filled with MHSW and transported to the sites with the other replicates; thus, they also served as transport controls. Upon returning to the laboratory after deployment of all field organisms, the control replicates were transferred to 4-L plastic containers in the laboratory containing 2 liters of MHSW at the average site water temperature, ±1°C. The control chambers are held in the dark, and gentle aeration was applied (100-200 bubbles per minute). The controls were monitored daily for

[1] Degree-days are used to standardize descriptions of fish development, regardless of rearing temperature. For example, it takes rainbow trout approximately 340 degree-days to reach hatch (Quinn, 2005). Thus, at 8°C, it takes approximately 42 days to reach hatch.

mortalities, and dead organisms removed. Temperature was adjusted on a weekly basis, as needed, to correspond to temperatures measured in the field. Water renewals were conducted three times per week (Monday, Wednesday, Friday) using clean MHSW. Dissolved oxygen (DO), pH, conductivity and temperature were measured before and after water renewals. Developmental milestones (e.g., hatch and swim-up) were also recorded.

2.6 Monitoring of Field Exposures

The sites were visited at approximately weekly intervals to assess the condition of the test organisms. During these checks, survival was recorded, as well as qualitative observations of organism health, site conditions and sedimentation within the boxes. All dead organisms observed were removed on each visit. These observations were recorded on standard field data sheets included in Appendix A. In addition, temperature, pH, DO and conductivity were measured during the site visits.

Monitoring of the installations required removal of the substrate overlying the hatchboxes in the crate. The embryos or alevins in each hatchbox were then poured into a plastic dishpan containing site water where they were enumerated. They were then returned to the hatchbox, which was placed back into the mesh-net bag of gravel, the overlying gravel replaced, and the bag returned to its respective crate. Care was taken to minimize disturbance and damage to the test organisms.

2.7 Test Termination

The field exposures and laboratory controls were terminated when the field organisms reached the swim-up fry stage (i.e., yolk sac absorbed). This occurred on November 5, 2014 for the Fall exposure, and on April 15, 2015 for the Spring exposure. Surviving organisms were placed in their original plastic replicate containers filled with site water, transported back to the laboratory, and terminated. The fish were then wet-weighed (to the nearest 0.001 gram) on an analytical balance, and measured (total length, from tip of the snout to the end of the tail) to the nearest 0.5 mm. Obvious external malformations were noted, including the affected body part (e.g., head, eye, spine) and type of abnormality (e.g., edema). Abnormality data were recorded on standard data sheets (Appendix A). The laboratory control fish were evaluated similarly on the same day.

2.8 Data Analysis

All test data were entered in CETIS (Comprehensive Environmental Toxicity Information System, Tidepool Scientific, McKinleyville, CA). Differences among the exposure sites and laboratory controls were evaluated using pair-wise multiple comparison tests according to the USEPA flow chart (USEPA 2002); significant differences were identified at $p \leq 0.05$.

One interim and five terminal endpoints were evaluated; the endpoints are described below:

1. Hatching success – an interim measure of the percentage of embryos hatched the day of the hatch inspection, or determined to have hatched based on the number of alevins present at the subsequent inspection, relative to the total number of embryos originally added;
2. Post-hatch survival - the percentage of organisms surviving at test termination relative to the number of embryos that hatched (these data help determine whether the majority of mortalities occurred pre- or post-hatch, or were distributed throughout the exposure period);
3. Cumulative survival - the percentage of surviving organisms at test termination relative to the number of embryos in each replicate at the beginning of the exposure;
4. Abnormality – the percentage of abnormal organisms at test termination relative to the number of surviving organisms;
5. Length – to the nearest 0.5 mm;
6. Weight – to the nearest 0.001 g.

3.0 QA/QC

The QA/QC program for the field exposure involved the following:

- Consistent field staff leader throughout all visits;
- Field documentation of all primary data; i.e., the names of individuals collecting the samples, sampling location, time of sampling, site conditions (e.g., degree of sedimentation), and other relevant observations, such as weather and any unusual conditions;
- Calibrated field meters;
- Use of pre-cleaned containers, with appropriate labels;
- Storing and transporting organisms in sealed containers in a cold, dark environment; cooling sample containers using ice or gel packs;
- Including transport controls to ascertain the extent of any transport-induced stress;
- Checking field organisms every week to monitor developmental progress, mortality and abnormality.

The QA/QC program for the laboratory portion of the study involved:

- Checks and maintenance of control organisms at regular intervals, including recording primary observations and water quality data on standardized data sheets;
- Review of datasheets by senior laboratory staff;
- Test termination activities (measurements, health assessment) conducted by qualified staff members using standardized datasheets to ensure consistent assessment of abnormalities and growth across all test sites and controls;
- Use of standard laboratory water and environmental chambers to maintain test organisms.

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4.0 RESULTS

4.1 Water Quality Measurements

Water quality measurements are summarized in Tables 1 and 2 for the Fall 2014 and Spring 2015 monitoring events, respectively.

Table 1: Summary of water quality measurements collected during site visits and control renewals (Fall 2014).

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	14.7 (1.0)	9.6 (0.4)	7.80 (0.25)	291.5 (18.1)
	[Min-Max]	[12.5 – 16.2]	[8.8 – 10.4]	[7.37 – 8.23]	[260 - 326]
Miller Creek		13.4 (1.0)	9.8 (0.4)	7.61 (0.17)	159.5 (61.7)
		[12.3 – 14.8]	[9.2-10.1]	[7.44 – 7.90]	[128 - 270]
Des Moines		16 (0.9)	9.8 (2.6)	7.18 (0.05)	101.0 (41.9)
Creek at S 200th		[12.4 – 14.4]	[8.2 – 14.3]	[7.13 – 7.24]	[58 - 171]
Des Moines		14.6 (2.1)	8.7 (0.9)	7.09 (0.20)	79.1 (30.4)
Creek Upstream		[12.6 – 17.7]	[7.4 – 9.8]	[7.24 – 7.36]	[44 - 127]

Table 2: Summary of water quality measurements collected during site visits and control renewals (Spring 2015).

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	12.2 (0.2)	9.2 (0.6)	7.41 (0.17)	283.5 (19.5)
	[Min-Max]	[11.6 – 12.5]	[8.2 – 10.1]	[7.15 – 7.85]	[246 - 311]
Miller Creek		10.6 (1.7)	11.1 (0.5)	7.29 (0.15)	212.8 (20.5)
		[8.9 – 13.3]	[10.3 – 11.5]	[7.10 – 7.45]	[187 - 236]
Des Moines		11.3 (1.3)	10.0 (0.5)	6.94 (0.11)	171.8 (21.7)
Creek at S 200th		[10.1 – 13.1]	[9.4 – 10.7]	[6.82 – 7.09]	[145 - 205]
Des Moines		12.9 (1.2)	10.0 (0.4)	6.81 (0.25)	107.0 (9.4)
Creek Upstream		[12.0 – 15.0]	[9.4 – 10.3]	[6.42 – 7.04]	[96 - 122]

In the Fall 2014, temperatures for the three field sites and the control ranged from 12.3 to 17.7^{0}C. The field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays (60-100% saturation, and 6-9 pH units, respectively). The pH values were between 7.1 and 7.9, and DO ranged from 7.4 to 14.3 mg/L. Although limited to weekly measurements, the field DO and pH data suggested good water quality conditions, with no indication of potential for adverse effects on organism survival and development. The conductivity measurements for all three sites exhibited some variability throughout the exposure period, but the values remained well-within ranges tolerated by early life stages of salmonids.

In the Spring 2015 *in situ* tests, temperatures among the three field sites and the control ranged from 8.9 to 15.0^{0}C. The field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays; specifically, the pH values were between 6.4 and 7.9, and DO ranged from 9.4 to 11.5 mg/L. These data suggested good water quality conditions, with no indication of potential for adverse effects on organism survival and development. As observed in the Fall event, the conductivity measurements remained well-within ranges tolerated by early life stages of salmonids.

4.2 Precipitation During the Monitoring Events

Precipitation data were provided by STIA. Figure 5 shows the daily rainfall for the duration of the exposure for the Fall 2014 test. Above average rainfall for October was recorded, with 7.66 inches of total rainfall. There was no snow during this testing event. Figure 6 shows the daily rainfall for the duration of the Spring 2015 exposure. Much less rain (total 1.5 in) fell during this event compared with the Fall, and no snow occurred during the exposure period. Approximately 35% of the total rainfall during this event was associated with a single day (13 April).

Figure 5: Daily rainfall for the duration of Fall 2014 exposure.

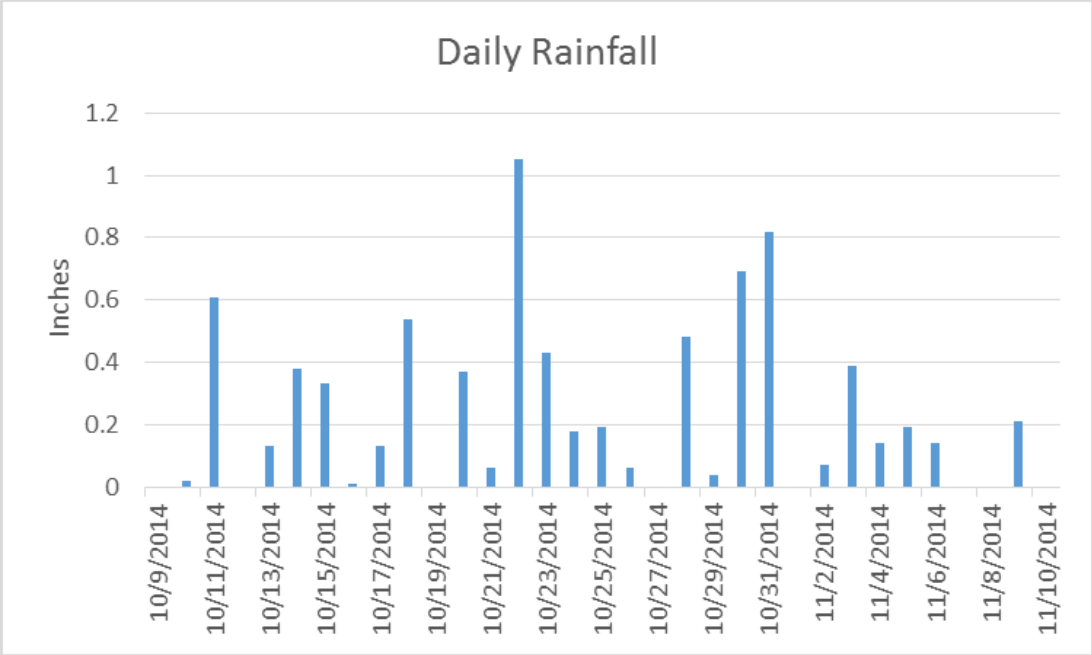
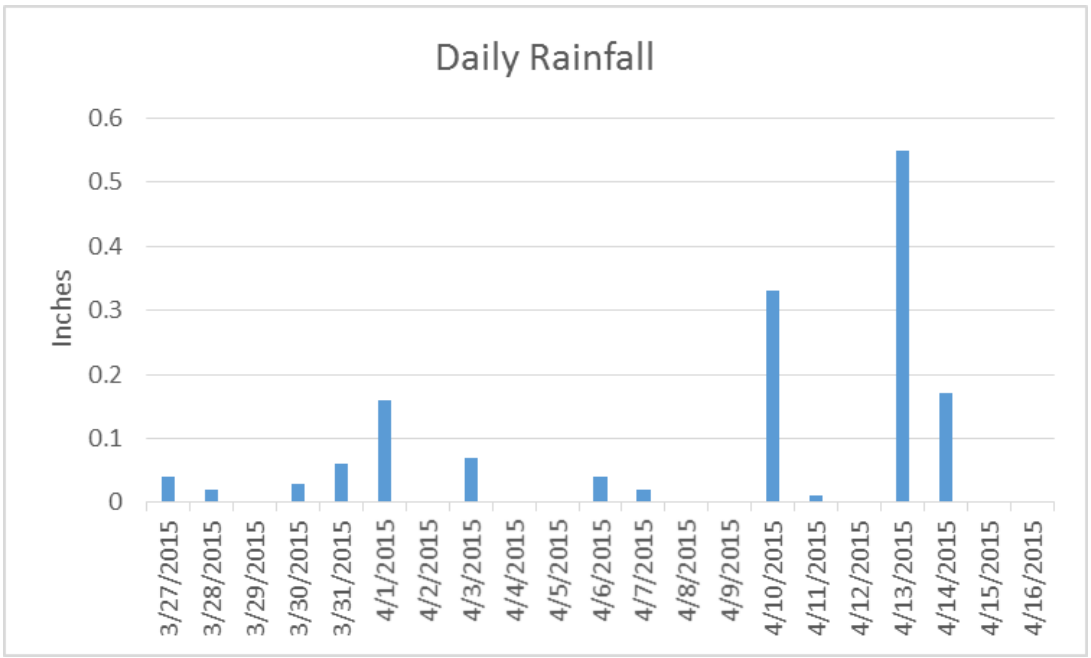


Figure 6: Daily rainfall for the duration of the Spring 2015 exposure.



4.3 *In situ* exposures

4.3.1 Fall 2014

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 3. Table 4 presents the growth endpoints. These same data are presented graphically in Figures 7 through 9 for ease of comparison.

Hatching success – Mean hatching success for the laboratory controls was 100%, compared with 60.8% at Miller Creek, 65.0% at Des Moines Creek at S 200th, and 53.3% at Des Moines Creek Upstream. Hatching success at all three sites was significantly reduced relative to the controls.

Post-hatch survival – Control survival of alevins post-hatch was 100%, compared with 77.3% at Miller Creek, 83.1% at Des Moines Creek at S 200th, and 2.4% Des Moines Creek Upstream. Post-hatch survival at Des Moines Creek Upstream was significantly different from the controls; however, there were no differences in post-hatch survival between the controls, Miller Creek and Des Moines Creek at S 200th.

Cumulative survival – Control survival from the initiation of the test to termination averaged 100%. For comparison, cumulative survival at the exposure sites averaged 38.9% at Miller Creek, 58.3% at Des Moines Creek at S 200th, and 1.7% at the Des Moines Creek Upstream site. Survival at all three sites was significantly reduced compared with the controls.

Abnormalities – There were few abnormalities observed across all treatments, with just one in the controls, and one at Des Moines Creek at S 200th. The control fish was missing its tail, while the abnormal fish at Des Moines Creek at S 200th exhibited edema.

Growth – Average weight in the controls was 89.7 mg, and length averaged 23.4 mm. For comparison, Miller Creek fish averaged 95.8 mg and 22.9 mm, fish exposed at Des Moines Creek at S 200th averaged 85.4 mg and 22.8 mm, and Des Moines Creek Upstream fish averaged 81.0 mg and 22.0 mm, for weight and length, respectively. Growth of fish from Des Moines Creek Upstream (length only) was significantly less than observed in the controls.

Table 3: Results for hatching success, survival and abnormality in the control and field treatment groups (Fall 2014)[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	100 (0)	100 (0.0)	100 (0)	0.8 (1.7)
Miller Creek	60.8 (12.9)	77.3 (45.5)	38.9 (30.2)	0 (0)
Des Moines Creek at S 200th	65.0 (25.9)	83.1 (23.6)	58.3 (33.8)	1.1 (2.2)
Des Moines Creek Upstream	53.3 (16.6)	2.4 (4.8)	1.7 (3.3)	0 (0)

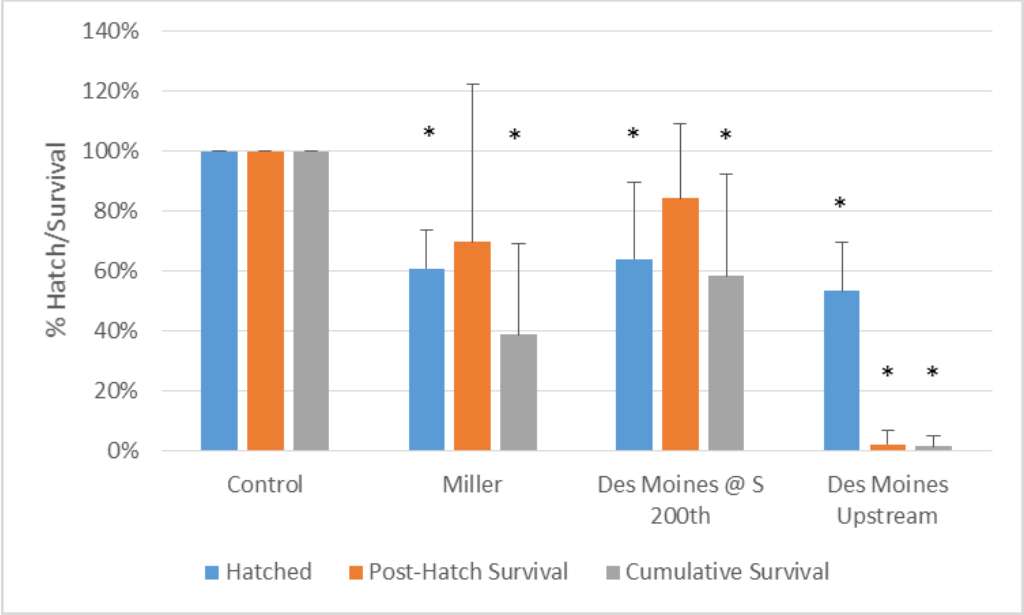
Notes:
1. Results are presented as mean and standard deviation.
2. Shaded values are significantly different from the control.

Table 4: Comparison of growth in the control and field treatment groups (Fall 2014)[1].

Site	Length (mm)	Weight (mg)
Control	23.4 (0.29)	89.7 (1.75)
Miller Creek	22.9 (0.61)	95.8 (2.94)
Des Moines Creek at South 200th	22.8 (0.26)	85.4 (5.42)
Des Moines Creek Upstream	22.0 (NC)	81.0 (NC)

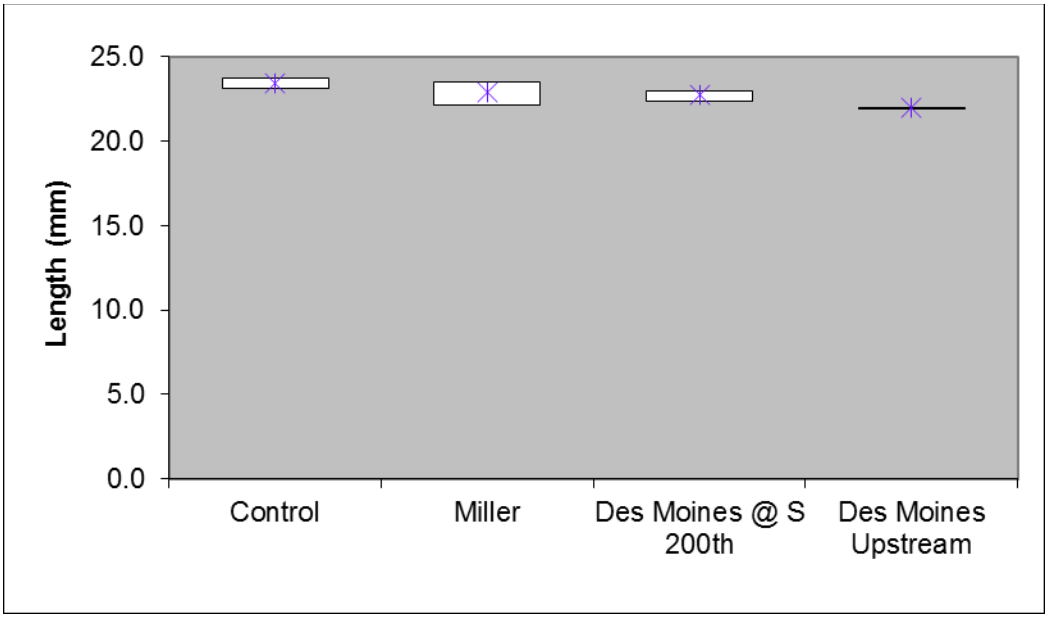
Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control
3. NC – Not calculable as only one replicate survived

Figure 7: Hatching success, post-hatch survival and cumulative survival in the field and control treatment groups (Fall 2014).



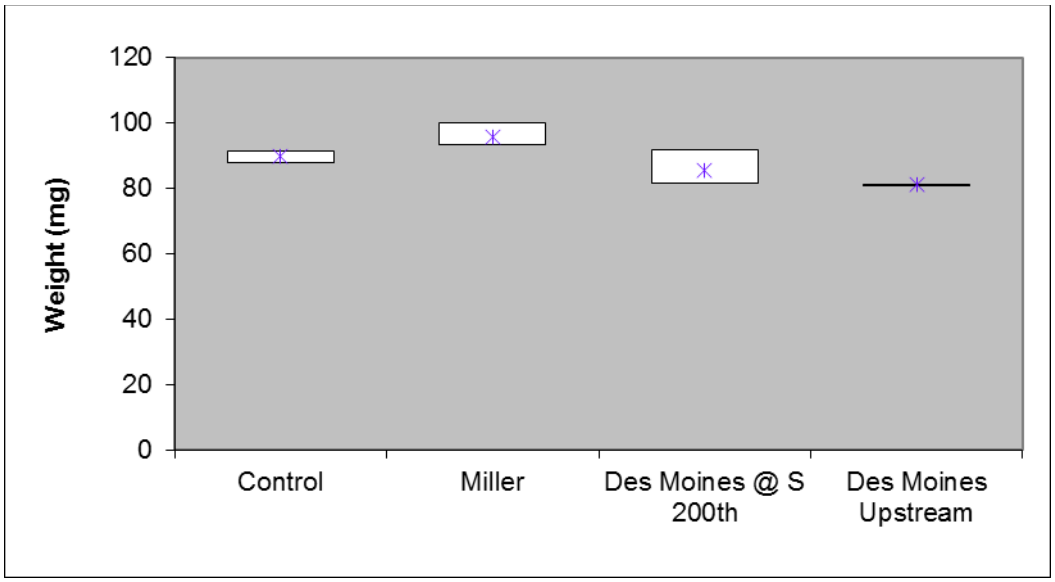
Error bars are standard deviations; asterisks denote significant difference from controls.

Figure 8: Average lengths for the laboratory control and exposure sites (Fall 2014).



Data point is the average; box represents range of minimum to maximum values.

Figure 9: Average weights for the laboratory control and exposure sites (Fall 2014).



Data point is the average; box represents range of minimum to maximum values.

4.3.2 Spring 2015

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 5. Table 6 presents the growth endpoints. These same data are presented graphically in Figures 10 through 12 for ease of comparison.

Hatching success – Mean hatching success for the controls was 98.3%, compared with 98.3% at Miller Creek, 95.0% at Des Moines Creek at S 200th, and 97.5% at Des Moines Creek Upstream. None of these differences were significantly different from the controls.

Post-hatch survival – Control survival of alevins post-hatch was 98.3%, compared with 99.2% at Miller Creek, 94.6% at Des Moines Creek at S 200th, and 94.9% at Des Moines Upstream. None of these differences were significantly different from the controls.

Cumulative survival – Control survival from the initiation of the test to termination averaged 96.6%, compared with 97.5% at Miller Creek, 90.0% at Des Moines Creek at S 200th, and 92.5% at Des Moines Creek Upstream. None of these differences were significantly different from the controls.

Abnormalities -- There were few abnormalities observed in any of the treatments, with just two abnormalities at Miller Creek. Both abnormalities were misshapen spines.

Growth – Average weight in the controls was 162.6 mg, and length averaged 26.6 mm. For comparison, Miller Creek fish averaged 154.1 mg and 26.2 mm, fish exposed at Des Moines Creek at S 200th averaged 153.3 mg and 26.2 mm, and Des Moines Creek Upstream fish averaged 157.2 mg and 26.9 mm, for weight and length, respectively. Weight for all field sites was significantly reduced compared to the controls ($p \leq 0.05$); however, since the effect size was <10%, the p-value was changed to 0.01, per the WDOE guidance document (WDOE 2008), which removed the significance for Des Moines Creek Upstream. Length was only significantly different from the controls at Miller Creek ($p \leq 0.05$); however, the effect size was <10% and changing the p-value removed the significance.

Table 5: Hatching success, survival and abnormality in the control and field treatment groups (Spring 2015)[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	98.3 (3.3)	98.3 (1.9)	96.7 (2.7)	0 (0.0)
Miller Creek	98.3 (1.9)	99.2 (1.7)	97.5 (1.7)	1.7 (3.4)
Des Moines Creek at S 200th	95.0 (5.8)	94.6 (7.0)	90.0 (9.8)	0 (0.0)
Des Moines Upstream	97.5 (1.7)	94.9 (4.4)	92.5 (4.2)	0 (0.0)

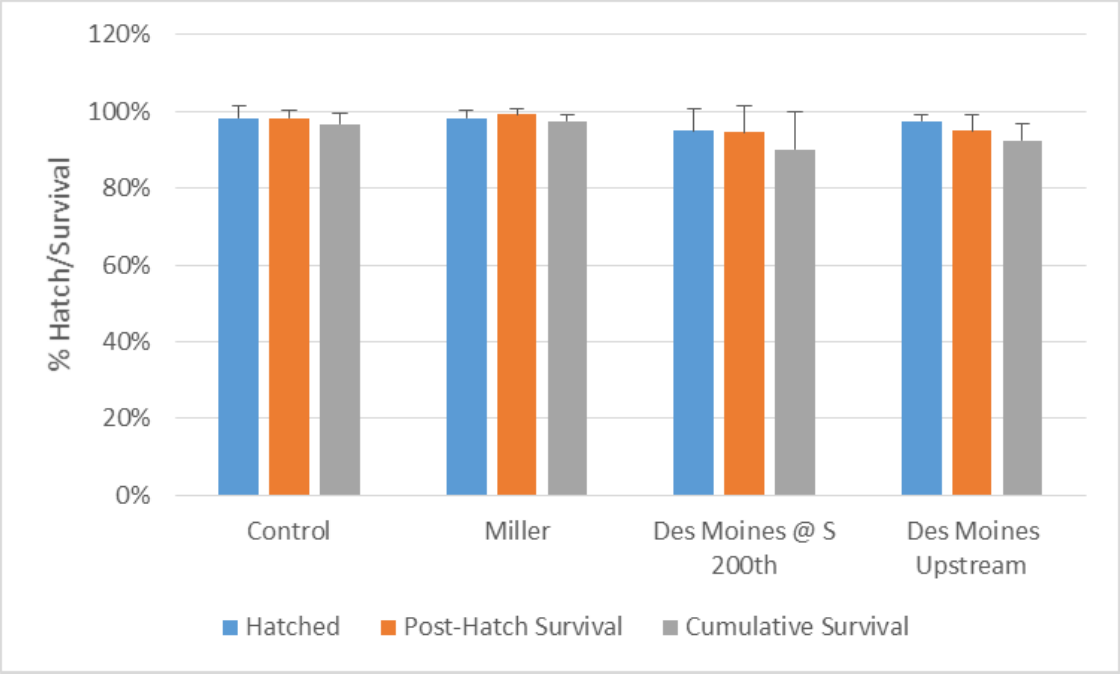
Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly lower than the control

Table 6: Comparison of growth in the control and field treatment groups (Spring 2015)[1].

Site	Length (mm)	Weight (mg)
Control	26.59 (0.26)	162.6 (2.7)
Miller Creek	26.16 (0.39)	154.1 (3.2)
Des Moines Creek at S 200th	26.24 (0.16)	153.3 (1.0)
Des Moines Upstream	26.90 (0.09)	157.2 (3.9)

Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly lower than the control
3. NA- Not applicable

Figure 10: Hatching success, post-hatch survival and cumulative survival in the field and control treatment groups (Spring 2015).



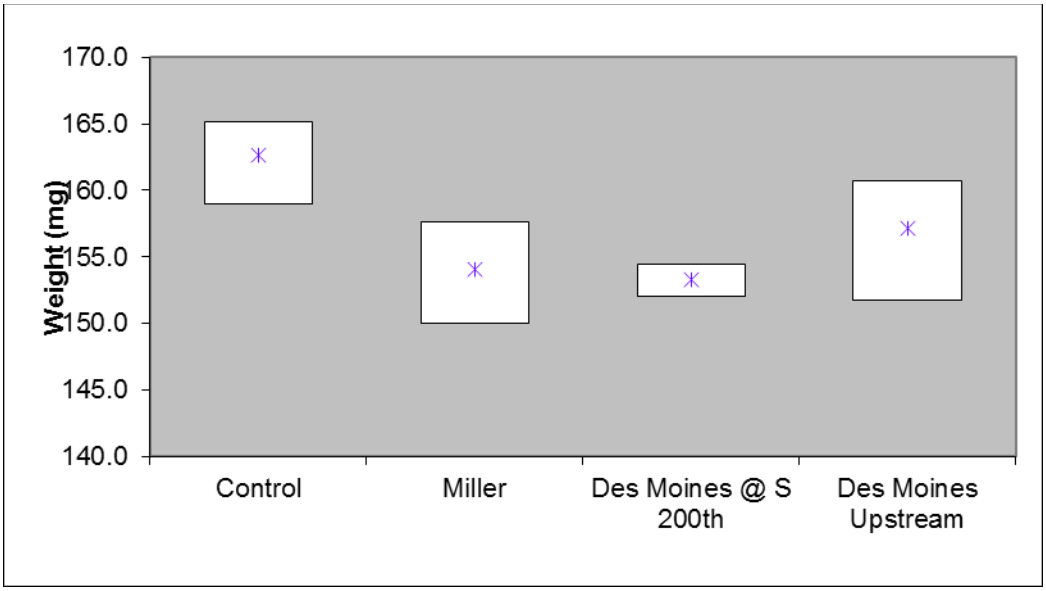
Error bars are standard deviations; asterisks denote significant difference from controls.

Figure 11: Average length for the control and exposure group (Spring 2015).



Data point is the average; box represents range of minimum to maximum values.

Figure 12: Average weights for the control and exposure groups (Spring 2015).



Data point is the average; box represents range of minimum to maximum values.

4.4 Field Observations

During both testing events, hatchboxes were observed to be free of biofilm or other accumulation of organic material. During both events, crayfish were often found within the crates at all sites, but not within the hatchboxes. A tadpole was observed in the Fall at the Miller Creek site. Accumulation of sediments within the hatchboxes was observed during the Fall 2014 event at the Miller Creek site, with sediment volume reaching 80% and greater within the boxes. Effects of sedimentation have shown variable results to date. While high sedimentation has been seen during testing events with significant mortality, other events have shown no effect despite high sedimentation rates. A number of factors likely play a role in the effects of sedimentation, including the size of the particles, the age of the fish, the duration between accumulation and our check, and amount of sediment.

4.5 Relationships Between *In Situ* and Sublethal Tests

Sublethal tests (i.e., 7-day trout embryo tests) overlapped with both the Fall and Spring testing events. There was no toxicity documented in any of the samples collected for the sublethal tests.

5.0 DISCUSSION

In Miller Creek, adverse effects on survival were observed in Fall 2014, with hatching success and cumulative survival significantly reduced compared to the controls. Limited evidence of adverse effects were observed in the hatchboxes deployed at Miller Creek in Spring 2014, with only weight differing from the control and an effect size of <10%.

Adverse effects were observed at Des Moines at S 200th during the Fall and Spring deployment. Hatching success and cumulative survival were significantly reduced compared to the controls in the Fall, compared with only small (<10%) effects on weight observed in the Spring.

Notably, significant adverse effects were observed at the Upstream Des Moines Creek site in Fall 2014, with reduced hatching success, increased mortality and reduced growth, suggesting that effects observed at the downstream site could be related to inputs originating upstream of STIA. Conversely, no adverse effects were observed at Upstream Des Moines Creek during the Spring 2015 event; this is the first time that Des Moines Creek Upstream has not exhibited significant adverse effects since testing at this site began in 2011.

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Rainbow Trout Early Life Stages *In Situ* Monitoring Testing

Fall 2015 and Spring 2016 Testing Events

Draft Report

September 16, 2016

Submitted to: **Port of Seattle**
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APPENDIX A – Raw Data
APPENDIX B – Statistical Output

SIGNATURE PAGE

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This report has been prepared by Nautilus Environmental Company Inc. based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

1.0 INTRODUCTION

This report presents the results of the rainbow trout (RBT) early life stages (ELS) *in situ* monitoring tests conducted in the Fall 2015 and Spring 2016. The objective of this program is to use salmonid ELS as an *in situ* monitoring tool to assess the quality of receiving waters potentially affected by stormwater discharges from the Seattle-Tacoma International Airport (STIA), as well as a multitude of other discharges from the surrounding urban environment. Results for studies conducted in Fall 2010/Spring 2011, Fall 2011/Spring 2012, Fall 2014/Spring 2013, Fall 2013/Spring 2014, and Fall 2014/Spring 2015 have been presented previously (Nautilus 2011, Nautilus 2012, Nautilus 2013, Nautilus 2014, and Nautilus 2015 respectively).

Results from the *in situ* bioassays and supporting analytical data are intended to provide an indication of attainment of receiving water quality standards and associated beneficial uses related to salmonid spawning and rearing. Initial Phase 1 testing conducted previously demonstrated that the RBT *in situ* ELS bioassay is an effective instream biological monitoring tool for assessing the potential effects of stormwater discharges on the receiving environment.

The sampling events presented herein were conducted under NPDES Permit No. WA-002465-1, which was reissued in January 1, 2016. The Fall 2015 event was conducted under Phase I of the *In Situ* Monitoring Plan (i.e., Development and Demonstration), that was originally intended to last for one year (2010-2011) and include testing during the Spring and Fall seasons. However, this Phase was extended to allow for additional comparisons with the laboratory sublethal testing being conducted by the STIA at sites downstream of Port outfalls, as specified in Part II, Special Condition S8 of the NPDES permit. The laboratory sublethal toxicity testing is used for permit compliance purposes, and has been conducted concurrently with *in situ* deployments (when feasible) to facilitate validation of the in situ methodology. A comparison of the two methods was presented in the Combined Acute, Sublethal, and In Situ Report (Nautilus 2013).

The Spring 2016 event falls under the new Permit and is now required to be conducted biannually in the fall and spring, corresponding to the spawning regimes of local salmonid species. In addition to the locations used during Phase 1 testing, an additional site representing Walker Creek has been added to the sampling program. Details of the location are described in Section 2.2 below.

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2.0 METHODS

Guidance for conducting *in situ* ELS exposures with salmonids is available from a number of sources. For example, the British Columbia Ministry of Environment has a protocol for an *in situ* ELS salmonid test (BCMOE, 2003). In addition, Environment Canada has developed both laboratory and *in situ* test procedures for early life stages of rainbow trout (Environment Canada, 1998). In the U.S., there are two general laboratory protocols for conducting fish early life stage toxicity tests (EPA, 1996; ASTM, 2005). The procedures used in this study reflect refinements made to the general guidance provided in the documents above (Chalmers et al, 2014), and have been used successfully at a number of sites in both Canada and the United States. Additional refinements specific to applying the method to waterways present on Airport property are included in the descriptions below.

2.1 Design

The study design used for the Fall 2015 and Spring 2016 *in situ* testing involved exposure of eyed-embryos at four sampling sites, using four replicates per site with 30 embryos per replicate. The locations of the sites are shown in Figure 1. The Study Design was consistent with the methodology used in the nine previous monitoring events in which the sites located on Miller and Des Moines Creeks downstream of all Airport discharges were augmented by an additional site on Des Moines Creek located upstream of any Airport discharges. The additional site (i.e., Des Moines Creek Upstream) was included to determine the extent to which sources upstream of any STIA inputs may contribute to adverse effects observed at the downstream site on Des Moines Creek. New in 2016 is a site located in the headwaters of Walker Creek.

The exposure duration used in the *in situ* tests covers the major salmonid early life stage developmental milestones, beginning with the eyed egg stage, proceeding through hatching and alevin stages (yolk sac present and residing in the gravel), and ending with the early fry stage (also known as swim-up fry). At this point, the yolk sac is absorbed and, under natural conditions, the fish would leave the gravel to feed independently. The duration of the exposure period is expected to include multiple rain/runoff events, and corresponding fluctuations in flow, contaminant concentrations, temperature, water chemistry, etc. Collectively, these attributes of the in situ approach provide highly relevant information regarding the suitability of waterbodies to support salmonids (Chalmers et al, 2014).

The eyed eggs for both in situ events were supplied locally by TroutLodge (Sumner, WA), which also supplied RBT eggs and sperm for the laboratory sublethal toxicity tests required in STIA's expired NPDES stormwater permit. The status of the *in situ* organisms was routinely monitored

during the exposure, as well as at specific developmental stages and after significant storm events. Data were obtained on hatching, survival, development and growth. A subset of embryos was also reared in the laboratory to assess organism quality. Weekly temperature measurements from the field were used to adjust rearing temperatures for the laboratory controls so that development in the controls could be used to trigger field inspections at specific times (e.g., hatch, swim-up).

2.2 Monitoring Locations and Site Preparation

The Fall 2015 exposures were conducted in two streams within the STIA property boundaries: Miller Creek and Des Moines Creek (Figure 1). Two of the sites, Miller Creek and Des Moines Creek at S 200th, are located downstream of STIA inputs into their respective drainages. An additional site (Des Moines Creek Upstream) is located upstream of STIA stormwater outfalls into Des Moines Creek. This site is used to assess water quality in Des Moines Creek prior to receiving any STIA stormwater discharges; the Des Moines Creek basin upstream of STIA is heavily urbanized and potentially impacted by a variety of pollutant sources. For Spring 2016, a site in the headwaters of Walker Creek was added in addition to the three sites above. INSERT LOCATION info from Josh.

Results from 2010 concluded that the chosen sampling sites generally do not have ideal substrate conditions and are subjected to heavy sediment flow during storm events. Consequently, all four exposure replicates at each site were placed above the substrate in gravel contained within PVC crates anchored to the substrate with steel stakes. The replicate crates at each site were placed in a row on the streambed, from upstream to downstream, at a sufficient distance apart so that flow patterns were re-established between each crate. This approach allows passage of water through the exposure chambers, but prevents smothering of embryos and fry by sediment. This approach was also applied to the new Walker Creek site, as it also lacks appropriate substrate conditions.

Figure 1. Map of STIA with receiving monitoring stations.

2.3 Field Exposure Apparatus

The trout embryos were contained in modified Whitlock-Vibert hatchboxes (Federation of Flyfishers, MO), which are comprised of two rectangular chambers located one above the other; the upper chamber is for embryo development and the lower chamber for rearing of hatched fish. The external sides of the hatchbox are plastic mesh that allows passage of water through the box, but prevents loss of embryos. The divider between the embryo chamber and the rearing chamber is comprised of slots that are narrow enough to prevent transfer of unhatched embryos, but wide enough to permit migration of hatched fish into the lower rearing chamber. Thus, upon hatch, alevins are able to migrate through the slots from the embryo chamber into the larger rearing chamber. To prevent escape of the hatched fry into the streams upon swim-up, plastic screening material (Darice® size 7 mesh) was attached to the external faces of each rearing chamber and held in place using small plastic zip ties.

The hatchboxes were contained within flexible plastic mesh bags surrounded by 1 – 2 inch diameter gravel, with the hatchbox placed centrally within the rocks in the bag. The gravel surrounding the hatchboxes acts to diffuse the current and prevent exposure of the embryos to sunlight. The bags were then placed within the PVC crates, which were held in place in the stream by stakes anchored in the substrate (Figure 2). Figure 3 shows the eyed eggs within the hatchbox, while Figure 4 is of fry within the hatchbox.

Figure 2. Photograph of the crate set up, Des Moines Creek at S 200th.



2.4 Test Organisms

Eyed-egg stage rainbow trout embryos were obtained from TroutLodge on November 4, 2015 for the Fall event and March 23, 2016 for the Spring event. According to TroutLodge staff, the eyed embryos had already developed for approximately 245 degree-days[1]. On the day of test initiation, eggs were brought to Rainier Environmental Laboratory (REL; Fife, WA), and randomly counted into replicate units of 30 embryos apiece in individual opaque plastic food-storage containers (i.e., 450-mL Ziploc plastic tubs). These containers were then placed in a cooler containing ice packs, and transported to the sites where the embryos were transferred into the hatchboxes in the creek on the same day. The embryos were transferred to the sites in laboratory control water, and all embryos were installed at the sites between 13:30 and 14:30 on November 4, 2015 for the Fall event, and between 15:15 and 17:00 on March 23, 2016 for the Spring event.

2.5 Controls

Controls were used to assess the influence of the following factors on test results:

1. Quality (health and viability) of supplied organisms,
2. Transport and handling of organisms, and
3. Ambient stream temperatures, which affect the time to developmental milestones (e.g., hatch).

The controls consisted of a laboratory exposure (four replicates of 30 organisms each) conducted concurrently with each field exposure in clean laboratory water (moderately hard synthetic water [MHSW]) using a subset of the same batch of embryos used to initiate the field exposures. These embryos were also counted out, placed into individual plastic containers filled with MHSW and transported to the sites with the other replicates; thus, they also served as transport controls. Upon returning to the laboratory after deployment of all field organisms, the control replicates were transferred to 4-L plastic containers in the laboratory containing 2 liters of MHSW at the average site water temperature, ±1°C. The control chambers are held in the dark, and gentle aeration was applied (100-200 bubbles per minute). The controls were monitored daily for

[1] Degree-days are used to standardize descriptions of fish development, regardless of rearing temperature. For example, it takes rainbow trout approximately 340 degree-days to reach hatch (Quinn, 2005). Thus, at 8°C, it takes approximately 42 days to reach hatch.

mortalities, and dead organisms removed. Temperature was adjusted on a weekly basis, as needed, to correspond to temperatures measured in the field. Water renewals were conducted three times per week (Monday, Wednesday, Friday) using fresh MHSW. Dissolved oxygen (DO), pH, conductivity and temperature were measured before and after water renewals. Developmental milestones (e.g., hatch and swim-up) were also recorded.

2.6 Monitoring of Field Exposures

The sites were visited at approximately weekly intervals to assess the condition of the test organisms. During these checks, survival was recorded, as well as qualitative observations of organism health, site conditions and sedimentation within the boxes. All dead organisms observed were removed on each visit. These observations were recorded on standard field data sheets included in Appendix A. In addition, temperature, pH, DO and conductivity were measured during the site visits.

Monitoring of the installations required removal of the substrate overlying the hatchboxes in the crates. The embryos or alevins in each hatchbox were then poured into a plastic dishpan containing site water where they were enumerated. They were then returned to the hatchbox, which was placed back into the mesh-net bag of gravel, the overlying gravel replaced, and the bag returned to its respective crate. Care was taken to minimize disturbance and damage to the test organisms.

2.7 Test Termination

The field exposures and laboratory controls were terminated when the field organisms reached the swim-up fry stage (i.e., yolk sac absorbed). This occurred on December 16, 2015 for the Fall exposure, and on April 19, 2016 for the Spring exposure. Surviving organisms were placed in their original plastic replicate containers filled with site water, transported back to the laboratory, and terminated. The fish were then wet-weighed (to the nearest 0.001 gram) on an analytical balance, and measured (total length, from tip of the snout to the end of the tail) to the nearest 0.5 mm. Obvious external malformations were noted, including the affected body part (e.g., head, eye, spine) and type of abnormality (e.g., edema). Abnormality data were recorded on standard data sheets (Appendix A). The laboratory control fish were evaluated similarly on the same day.

2.8 Data Analysis

All test data were entered in CETIS (Comprehensive Environmental Toxicity Information System, Tidepool Scientific, McKinleyville, CA). Differences among the exposure sites and laboratory

controls were evaluated using pair-wise multiple comparison tests according to the USEPA flow chart (USEPA 2002); significant differences were identified at $p \leq 0.05$.

One interim and five terminal endpoints were evaluated; the endpoints are described below:

1. Hatching success – an interim measure of the percentage of embryos hatched the day of the hatch inspection, or determined to have hatched based on the number of alevins present at the subsequent inspection, relative to the total number of embryos originally added;
2. Post-hatch survival - the percentage of organisms surviving at test termination relative to the number of embryos that hatched (these data help determine whether the majority of mortalities occurred pre- or post-hatch, or were distributed throughout the exposure period);
3. Cumulative survival - the percentage of surviving organisms at test termination relative to the number of embryos in each replicate at the beginning of the exposure;
4. Abnormality – the percentage of abnormal organisms at test termination relative to the number of surviving organisms;
5. Length – to the nearest 0.5 mm;
6. Weight – to the nearest 0.001 g.

3.0 QA/QC

The QA/QC program for the field exposure involved the following:

- Consistent field staff leader throughout all visits;
- Field documentation of all primary data; i.e., the names of individuals collecting the samples, sampling location, time of sampling, site conditions (e.g., degree of sedimentation), and other relevant observations, such as weather and any unusual conditions;
- Calibrated field meters;
- Use of pre-cleaned containers, with appropriate labels;
- Storing and transporting organisms in sealed containers in a cold, dark environment; cooling sample containers using ice or gel packs;
- Including transport controls to ascertain the extent of any transport-induced stress;
- Checking field organisms every week to monitor developmental progress, mortality and abnormality.

The QA/QC program for the laboratory portion of the study involved:

- Checks and maintenance of control organisms at regular intervals, including recording primary observations and water quality data on standardized data sheets;
- Review of datasheets by senior laboratory staff;
- Test termination activities (measurements, health assessment) conducted by qualified staff members using standardized datasheets to ensure consistent assessment of abnormalities and growth across all test sites and controls;

Use of standard laboratory water and environmental chambers to maintain test organisms.

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4.0 RESULTS

4.1 Water Quality Measurements

Water quality measurements are summarized in Tables 1 and 2 for the Fall 2015 and Spring 2016 monitoring events, respectively.

Table 1. Summary of water quality measurements collected during site visits and control renewals (Fall 2015).

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	8.1 (2.4)	9.4 (0.5)	7.48 (0.22)	256.0(23.91)
	[Min-Max]	[4.8 – 11.5]	[8.4 – 10.1]	[7.12 – 8.03]	[212 - 322]
Miller Creek		7.5 (2.1)	11.4 (0.6)	7.18 (0.18)	160.5 (20.7)
		[4.7 – 9.8]	[10.5 -12.1]	[6.98 – 7.48]	[135 - 191]
Des Moines Creek at S 200th		7.8 (2.3)	9.3 (0.8)	6.82 (0.12)	148.5 (26.7)
		[5.4 – 10.5]	[7.7 – 9.8]	[6.68 – 7.04]	[106 - 174]
Des Moines Creek Upstream		7.5 (2.1)	10.2 (0.9)	6.43 (0.44)	96.7 (10.2)
		[5.0 – 11.8]	[8.8 – 11.2]	[5.81 – 6.96]	[80 - 111]

Table 2. Summary of water quality measurements collected during site visits and control renewals (Spring 2016).

Creek		Temperature (°C)	DO (mg/L)	pH (units)	Specific Conductance (uS/cm)
Control	$\overline{X}$ (SD)	11.1 (0.3)	9.3 (0.4)	7.53 (0.28)	269.0 (26.1)
	[Min-Max]	[10.7 – 11.8]	[8.7 – 10.2]	[7.05 – 8.01]	[211 – 299]
Miller Creek		11.3 (1.9)	10.9 (0.7)	7.58 (0.16)	225.4 (45.6)
		[8.7 – 13.7]	[9.9 – 11.6]	[7.44 – 7.85]	[178 – 271]
Walker Creek		11.8 (0.4)	10.7 (0.2)	6.93 (0.13)	268.8 (14.2)
		[11.4 – 12.3]	[10.5 – 10.9]	[6.75 – 7.06]	[248 – 280]
Des Moines Creek at S 200th		12.0 (1.7)	9.4 (0.4)	6.89 (0.15)	199.8 (33.8)
		[10.2 – 14.3]	[9.1 – 10.1]	[6.63 – 7.00]	[158 – 238]
Des Moines Creek Upstream		11.7 (1.8)	10.0 (0.6)	6.85 (0.17)	105.7 (11.5)
		[10.5 – 13.8]	[9.4 – 10.5]	[6.67 – 7.01)	[99 – 119]

In the Fall 2015, temperatures for the three field sites and the control ranged from 4.7 to 11.8^{0}C. Almost all field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays (60-100% saturation, and 6-9 pH units, respectively). One check at Des Moines Creek Upstream measured a pH of 5.81, which was confirmed by calibration recheck upon returning to the stormwater laboratory. All other pH values were between 6.68 and 8.03, and DO ranged from 7.7 to 12.1 mg/L. Although limited to weekly measurements, the field DO and pH data suggested overall good water quality conditions, with limited indication of potential for adverse effects on organism survival and development. The conductivity measurements for all three sites exhibited some variability throughout the exposure period, but the values remained well-within ranges tolerated by early life stages of salmonids.

In the Spring 2016 *in situ* tests, temperatures among the three field sites and the control ranged from 8.7 to 14.3^{0}C. The field measurements of DO and pH were within acceptable ranges for rainbow trout laboratory bioassays; specifically, the pH values were between 6.63 and 8.01, and DO ranged from 8.7 to 11.6 mg/L. These data suggested good water quality conditions, with no indication of potential for adverse effects on organism survival and development. As observed in the Fall event, the conductivity measurements remained well-within ranges tolerated by early life stages of salmonids.

4.2 Precipitation during the Monitoring Events

Precipitation data were provided by STIA. Figure 5 shows the daily rainfall for the duration of the exposure for the Fall 2015 test. A total of 13.06 inches of total rainfall fell during the Fall event. There was no snow during this testing event. Figure 6 shows the daily rainfall for the duration of the Spring 2016 exposure. Much less rain (total 1.1 in) fell during this event compared with the Fall, and no snow occurred during the exposure period.

Figure 5. Daily rainfall for the duration of Fall 2015 exposure.

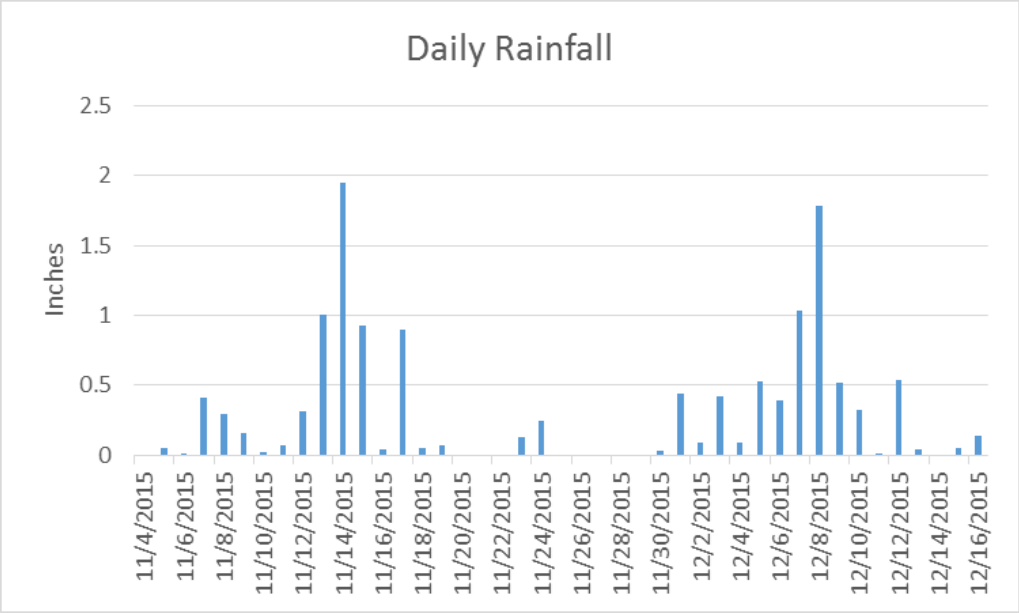
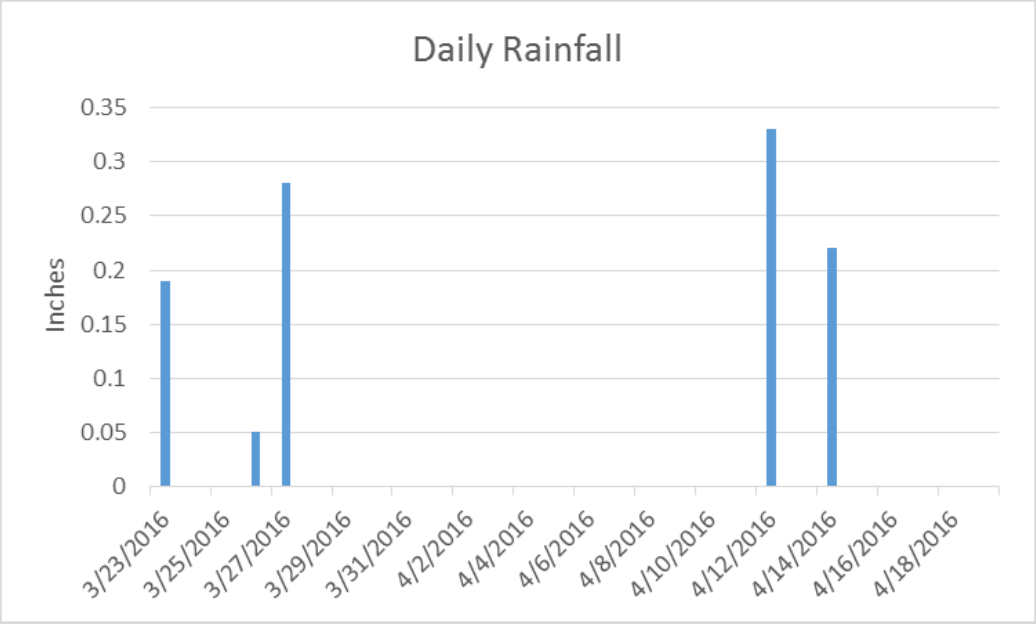


Figure 6. Daily rainfall for the duration of the Spring 2016 exposure.



4.3 *In situ* exposures

4.3.1 Fall 2015

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 3. Table 4 presents the growth endpoints. These same data are presented graphically in Figures 7 through 9 to facilitate comparisons.

Hatching success – Mean hatching success for the laboratory controls was 99.2%, compared with 100% at Miller Creek, 98.3% at Des Moines Creek at S 200th, and 72.5% at Des Moines Creek Upstream. Hatching success was significantly reduced (Steel Many-One Rank Sum Test) relative to the controls at the Des Moines Creek Upstream site, and there were no differences in hatching success between the controls and Miller Creek or Des Moines Creek at S 200th.

Post-hatch survival – Control survival of alevins post-hatch was 98.3%, compared with 96.7% at Miller Creek, 72.5% at Des Moines Creek at S 200th, and 33.1% Des Moines Creek Upstream. Post-hatch survival at Des Moines Creek Upstream was significantly different (Steel Many-One Rank Sum Test) from the controls; however, there were no differences in post-hatch survival between the controls, Miller Creek and Des Moines Creek at S 200th.

Cumulative survival – Control survival from the initiation of the test to termination averaged 97.5%. For comparison, cumulative survival at the exposure sites averaged 96.7% at Miller Creek, 71.7% at Des Moines Creek at S 200th, and 28.3% at the Des Moines Creek Upstream site. Survival was significantly reduced (Steel Many-One Rank Sum Test) relative to the controls at the Des Moines Creek Upstream site, and there were no differences in survival between the controls and Miller Creek or Des Moines Creek at S 200th.

Abnormalities – There were few abnormalities observed across all treatments, with just two in the controls. Both control fish had edema.

Growth – Average weight in the controls was 141.4 mg, and length averaged 26.4 mm. For comparison, Miller Creek fish averaged 140.0 mg and 25.6 mm, fish exposed at Des Moines Creek at S 200th averaged 138.7 mg and 25.7 mm, and Des Moines Creek Upstream fish averaged 127.0 mg and 25.0 mm, for weight and length, respectively. While length was significantly different (Bonferroni Adjusted T test) between the field sites and the controls for all locations, the largest difference was only 5%. The WDOE guidance document (WDOE 2016) allows alpha to be changed to 0.01 in cases of small differences, which removed the significance for Des Moines Creek at S 200th, but not for Miller Creek or Des Moines Creek Upstream. The Des Moines Creek Upstream site was the only site significantly different (Bonferroni Adjusted T test) from the control for weight, with a 10% effect.

Table 3. Results for hatching success, survival, and abnormality in the control and field treatment groups (Fall 2015)[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	99.2 (1.7)	98.3 (1.9)	97.5 (1.7)	1.7 (3.4)
Miller Creek	100 (0)	96.7 (4.7)	96.7 (4.7)	0 (0)
Des Moines Creek at S 200th	98.3 (1.9)	72.5 (37.5)	71.7 (37.6)	0 (0)
Des Moines Creek Upstream	72.5 (21.8)	33.1 (42.3)	28.3 (36.6)	0 (0)

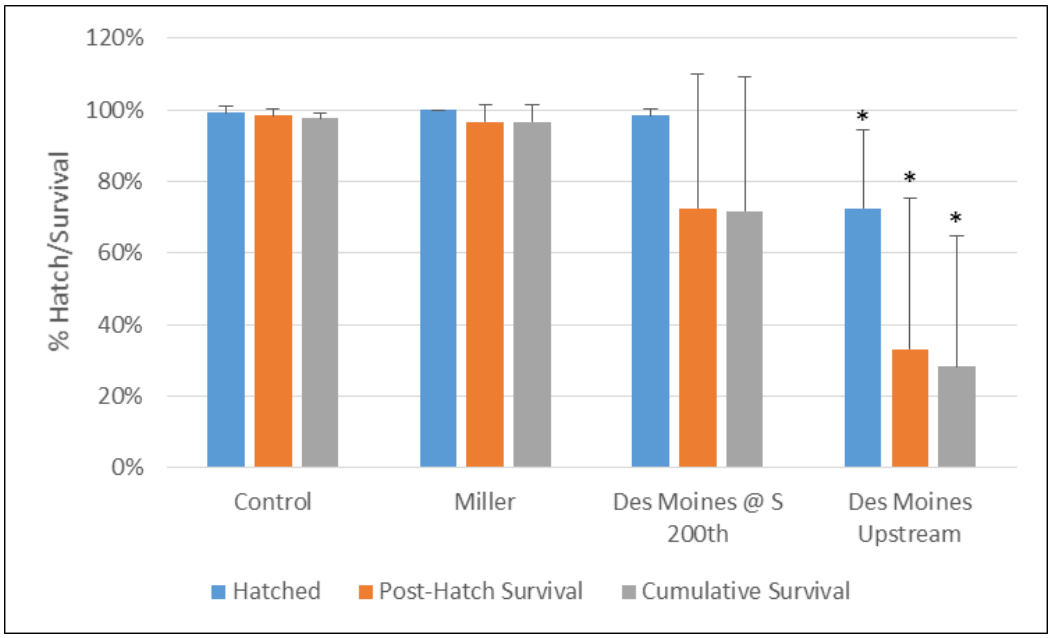
Notes:
1. Results are presented as mean and standard deviation.
2. Shaded values are significantly different from the control.

Table 4. Comparison of growth in the control and field treatment groups (Fall 2015)[1].

Site	Length (mm)	Weight (mg)
Control	26.4 (0.41)	141.4 (1.69)
Miller Creek	25.6 (0.28)	140.0 (1.86)
Des Moines Creek at South 200th	25.7 (0.26)	138.7 (8.27)
Des Moines Creek Upstream	25.0 (0.28)	127.0 (0.82)

Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control

Figure 7. Hatching success, post-hatch survival, and cumulative survival in the field and control treatment groups (Fall 2015).



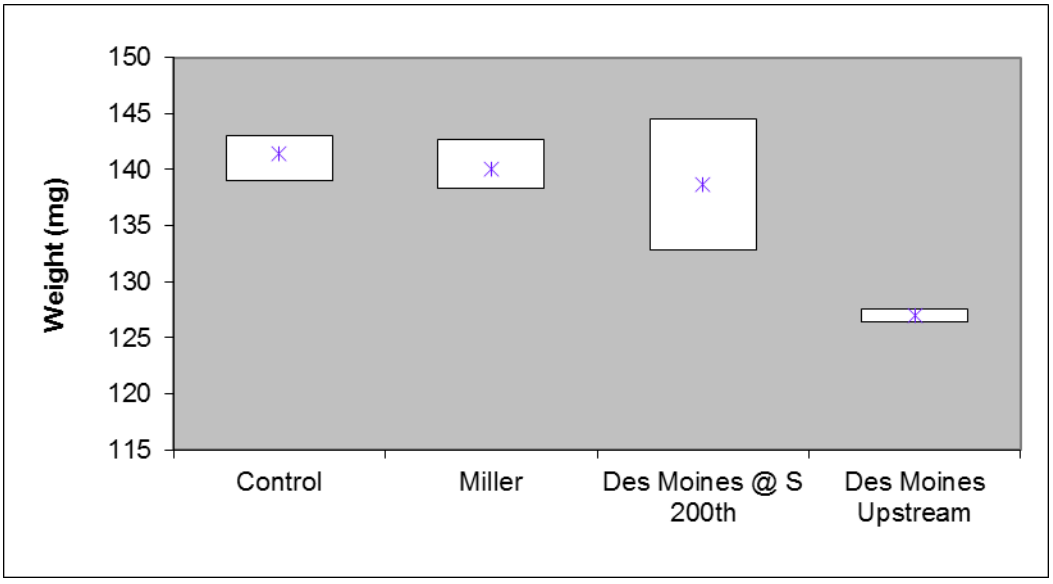
Error bars are standard deviations; asterisks denote significant difference from control.

Figure 8. Average lengths for the laboratory control and exposure sites (Fall 2015).



Data point is the average; box represents range of minimum to maximum values.

Figure 9. Average weights for the laboratory control and exposure site (Fall 2015).



Data point is the average; box represents range of minimum to maximum values.

4.3.2 Spring 2016

The results for hatching success, post-hatch survival, cumulative survival and abnormalities are summarized in Table 5. Table 6 presents the growth endpoints. These same data are also presented graphically in Figures 10 through 12.

Hatching success – Mean hatching success for the controls was 100%, compared with 96.7% at Miller Creek, 89.2% at Walker Creek, 96.7% at Des Moines Creek at S 200th, and 21.7% at Des Moines Creek Upstream. Both Walker Creek and Des Moines Creek Upstream were significantly different (Dunnett Multiple Comparison Test) from the controls, while Miller Creek and Des Moines at S 200th were not. Changing alpha for the small difference in effect does not remove the significance.

Post-hatch survival – Control survival of alevins post-hatch was 96.7%, compared with 98.2% at Miller Creek, 100% at Walker Creek, 98.2% at Des Moines Creek at S 200th, and 0% at Des Moines Upstream. Only Des Moines Creek Upstream was significantly different (Steel Many-One Rank Sum Test) from controls.

Cumulative survival – Control survival from the initiation of the test to termination averaged 96.7%, compared with 95.0% at Miller Creek, 89.2% at Walker Creek, 94.2% at Des Moines Creek at S 200th, and 0% at Des Moines Creek Upstream. Both Walker Creek and Des Moines Creek Upstream were significantly different (Dunnett Multiple Comparison Test) from controls. However, since the effect size was <10% at Walker Creek, and changing alpha removed the significance.

Abnormalities -- There were few abnormalities observed in any of the treatments, with one control abnormality, and two abnormalities at Miller Creek. Both abnormalities at Miller Creek were misshapen heads, while the control fish exhibited edema.

Growth – Average weight in the controls was 113.4 mg, and length averaged 25.2 mm. For comparison, Miller Creek fish averaged 115.0 mg and 25.1 mm, fish at Walker Creek averaged 115.9 mg and 25.6 mm, fish exposed at Des Moines Creek at S 200th averaged 115.5 mg and 25.3 mm. The lack of surviving fish at Des Moines Creek Upstream precluded growth assessments for this site. Neither weight nor length was significantly different (Dunnett Multiple Comparison Test) from controls in the sites with surviving fish.

Table 5. Hatching success, survival and abnormality in the control and field treatment groups (Spring 2016)[1].

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	100 (0)	96.7 (2.7)	96.7 (2.7)	0.8 (1.7)
Miller Creek	96.7 (2.7)	98.2 (2.0)	95.0 (4.3)	1.8 (2.1)
Walker Creek	89.2 (4.2)	100 (0)	89.2 (4.2)	0 (0)
Des Moines Creek at S 200th	96.7 (4.7)	96.7 (4.7)	94.2 (5.7)	0 (0)
Des Moines Upstream	21.7 (11.4)	0 (0)	0 (0)	NC

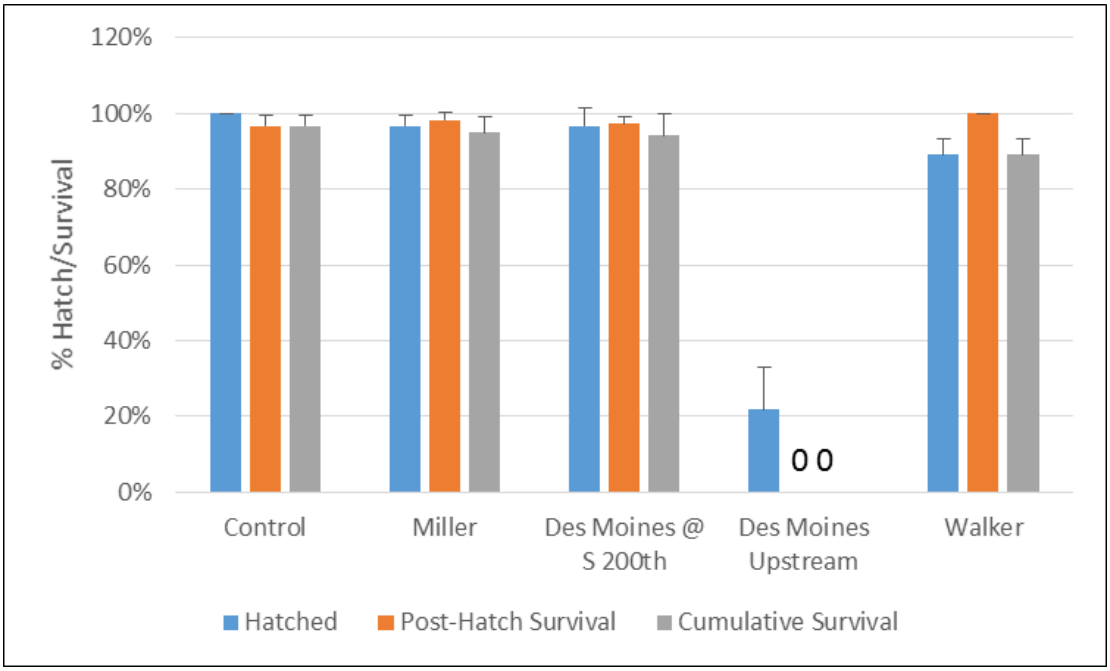
Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly lower than the control
3. NC – not calculable as there was no survival

Table 6. Comparison of growth in the control and field treatment groups (Spring 2016)[1].

Site	Length (mm)	Weight (mg)
Control	25.15 (0.26)	113.4 (3.1)
Miller Creek	25.11 (0.39)	115.0 (1.5)
Walker Creek	25.60 (0.14)	115.9 (2.5)
Des Moines Creek at S 200th	25.32 (0.46)	115.5 (4.8)
Des Moines Upstream	NC	NC

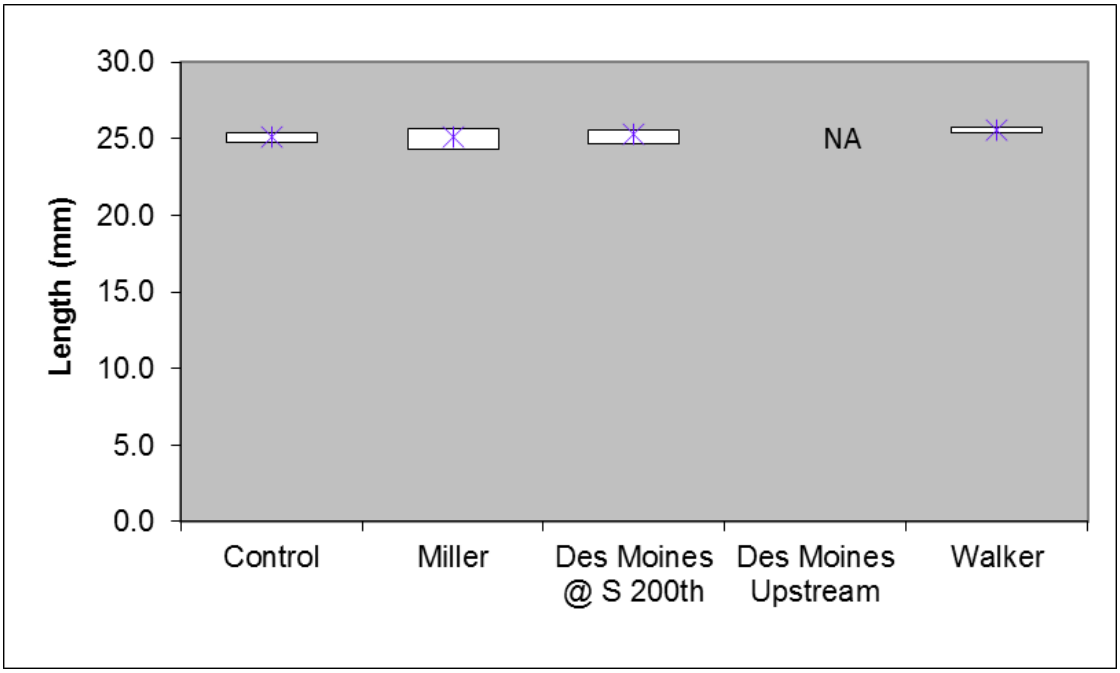
Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly lower than the control
3. NC – Not calculable, as there was no survival

Figure 10. Hatching success, post-hatch survival, and cumulative survival in the field and control treatment groups (Spring 2016).



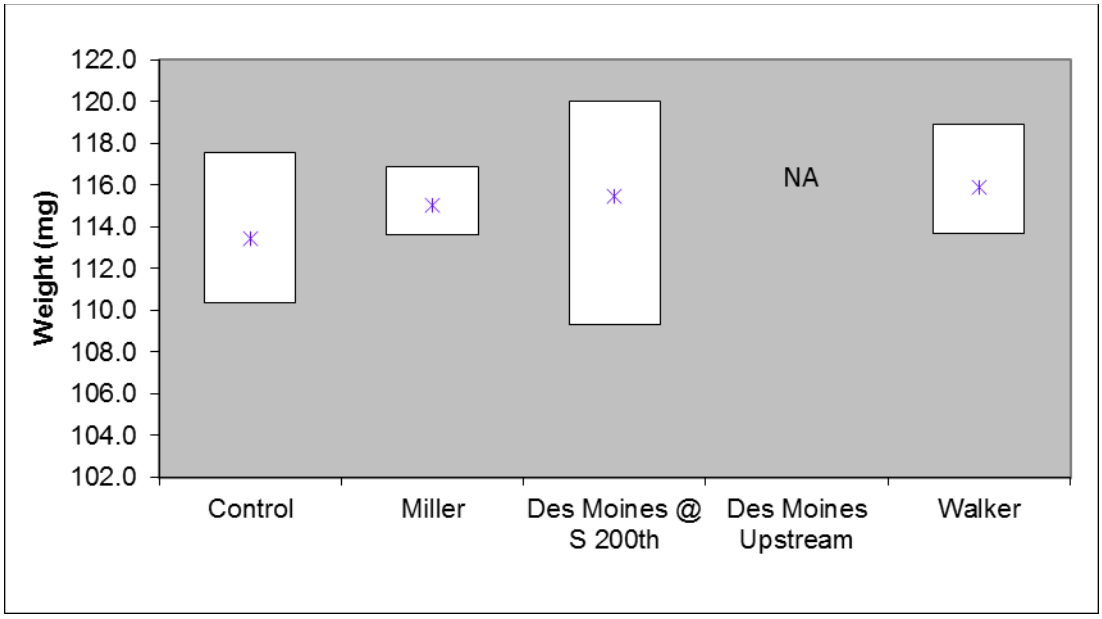
Error bars are standard deviations; asterisks denote significant differences from control.

Figure 11. Average length for the controls and exposure group (Spring 2016).



Data point is the average; box represents range of minimum to maximum values; NA – not applicable as there were not surviving fish.

Figure 12. Average weight for the control and exposure groups (Spring 2016).



Data point is the average; box represents range of minimum to maximum values; NA – not applicable as there were no surviving fish.

4.4 Field Observations

Towards the end of the Fall event, biofilm was observed on crates and hatchboxes at Des Moines at S 200th, and some at Des Moines Upstream. There did not appear to be a link between the occurrence of biofilm and the onset of mortality. During both events, crayfish were often found within the crates at all sites, but not within the hatchboxes. Accumulation of sediments within the hatchboxes was observed during the Fall 2015 event at all three sites, with sediment volume reaching 80% and greater within the boxes. Effects of sedimentation have shown variable results to date. While high sedimentation has been seen during testing events with significant mortality, other events have shown no effect despite high sedimentation rates. A number of factors likely play a role in the effects of sedimentation, including the size of the particles, the age of the fish, the duration between accumulation and our check, as well as the amount of sediment. There were no notable field observations for the Spring event.

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5.0 DISCUSSION

There were limited adverse effects observed at Miller Creek and Des Moines Creek at S 200th compared with controls in both testing events. Only length during the Fall 2015 event was significantly different ($p \leq 0.01$) with reductions in length of less than 5% relative to controls.

The addition of Walker Creek in the Spring 2016 event went smoothly. The only adverse effect observed was on hatching success, which was significantly different but only a 10% effect relative to controls.

Notably, significant adverse effects were observed at the Upstream Des Moines Creek site during both testing events, with reduced hatching success, increased mortality and reduced growth. With the exception of the Spring 2015 testing event (Nautilus Environmental 2015), this site has consistently exhibited evidence of adverse effects, suggesting an ongoing pattern of impaired water quality.

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Rainbow Trout Early Life Stages *In Situ* Monitoring Testing

Fall 2020 and Spring 2021

Final Report

September 23, 2021

Submitted to: **Port of Seattle**
Seattle-Tacoma International Airport

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SIGNATURE PAGE



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This report has been prepared by Nautilus Environmental Company Inc. based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

EXECUTIVE SUMMARY

The Port of Seattle monitors the potential effects of stormwater discharges from the Seattle-Tacoma International Airport (STIA) on the receiving environment as part of their National Pollutant Discharge Elimination System (NPDES) permit, which requires that *in situ* rainbow trout (RBT) early-life stage (ELS) tests be conducted biannually in the fall and spring. The testing program was initiated in Fall 2010; exposure sites include Miller Creek, Des Moines Creek Lower and Des Moines Creek Upstream, with Walker Creek being added to the study beginning Spring 2016. The creeks flow through STIA property boundaries, with monitoring points generally located downstream of STIA inputs; however, one site (Des Moines Creek Upstream) is located upstream of STIA stormwater outfalls to monitor for potential impacts originating upstream of Airport property. Results are compared to a laboratory control conducted concurrently with the *in-situ* tests.

During the Fall 2020 event, post-hatch and cumulative survival were both significantly reduced at all sites compared to the laboratory control, with the exception of Walker Creek. Des Moines Creek Upstream also had reduced hatching rates. During the Spring 2021 event, cumulative survival was significantly reduced at all sites except Walker Creek compared to the laboratory control; the hatching success was also significantly reduced at Miller Creek and Des Moines Creek Upstream; and the post-hatch success was significantly reduced at both Des Moines Creek Lower and Upstream. In terms of sublethal effects, adverse effects on length and weights were observed at Miller Creek and Des Moines Creek Lower during the Fall event; no adverse effects on growth were observed at any of the sites during the Spring event. Developmental abnormalities were minimal across all sites and controls during both events (i.e., ≤ 5%). Of note, with the exception of Spring 2015, Spring 2018 and Spring 2020 testing events, Des Moines Creek Upstream has historically exhibited adverse effects since the testing program began in 2010, which may be related to results observed further downstream at Des Moines Lower. Thus, inputs upstream of the STIA boundaries could be impairing water quality in the Des Moines Creek basin.

1.0 INTRODUCTION

This report presents the results of the rainbow trout (RBT) early life stages (ELS) *in situ* monitoring tests conducted in the Fall of 2020 and Spring of 2021. The objective of this program is to use salmonid ELS as an *in situ* monitoring tool to assess the quality of receiving waters potentially affected by stormwater discharges from the Seattle-Tacoma International Airport (STIA), as well as a multitude of other potential sources from the surrounding urban environment. Results for studies conducted in Fall 2010/Spring 2011, Fall 2011/Spring 2012, Fall 2012/Spring 2013, Fall 2013/Spring 2014, Fall 2014/Spring 2015, Fall 2015/Spring 2016, Fall 2016/Spring 2017, Fall 2017/Spring 2018, Fall 2018/Spring 2019, and Fall 2019/Spring 2020 have been presented previously (Nautilus Environmental 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019 and 2020, respectively), and have demonstrated that the RBT *in situ* ELS bioassay is an effective biological monitoring tool for assessing the potential effects of stormwater discharges on the receiving environment.

The sampling events presented herein were conducted under NPDES Permit No. WA-002465-1, which requires that *in situ* tests be conducted biannually in the fall and spring, corresponding to the spawning regimes of local salmonid species. Details of the locations tested are described in Section 2.2 below.

2.0 METHODS

Guidance for conducting *in situ* ELS exposures with salmonids is available from a number of sources. The British Columbia Ministry of Environment has a protocol for an *in situ* ELS salmonid test (BCMOE, 2003), and Environment Canada has developed laboratory test procedures for early life stages of rainbow trout (Environment Canada, 1998). In the USA, there are two general laboratory protocols for conducting fish early life stage toxicity tests (EPA, 1996; ASTM, 2005). The procedures used in this study reflect refinements made to the general guidance provided in the documents above (Chalmers et al., 2014), and have been used successfully at a number of sites in both Canada and the USA. Additional refinements specific to applying the method to waterways present on Airport property are included in the descriptions below.

2.1 Design

The study design used for the Fall 2020 and Spring 2021 *in situ* testing involved exposure of eyed-stage embryos at four sampling sites, using four replicates per site with 30 embryos per replicate. The locations of the sites are shown in Figure 1. The original sites were located on Miller and Des Moines Creeks downstream of all Airport discharges, and were subsequently augmented by an additional site on Des Moines Creek located upstream of any Airport discharges to determine the extent to which sources upstream of STIA inputs may contribute to adverse effects observed at the downstream site on Des Moines Creek. A site located in Walker Creek was also included in the study design beginning with the Spring 2016 testing event.

The exposure duration used in the *in situ* tests covers the major salmonid early life stage developmental milestones, beginning with the eyed egg stage, proceeding through hatching and alevin stages (yolk sac present, during which the fish reside in the gravel), and ending at the early fry stage (also known as swim-up fry). At this point, the yolk sac has been absorbed and, under natural conditions, the fish would leave the gravel to feed independently. The duration of the exposure period is expected to include multiple rain/runoff events, and corresponding fluctuations in flow, contaminant concentrations, temperature, water chemistry, etc. Collectively, these attributes of the *in situ* approach provide highly relevant information regarding the suitability of waterbodies to support salmonid development (Chalmers et al., 2014).

Eyed eggs for both *in situ* events were supplied by TroutLodge (Sumner, WA), which also supplies rainbow trout eggs and sperm for the laboratory sublethal toxicity tests required in the STIA NPDES stormwater permit. Following deployment, the status of the *in situ* organisms was routinely monitored during the exposure, as well as at specific developmental stages and after significant storm events. Data were obtained on hatching, survival, development and growth. A subset of embryos was also reared in the laboratory (Rainier Environmental, Fife, WA) to assess organism quality. Weekly temperature measurements from the field were used to adjust rearing temperatures for the laboratory controls so that development in the controls could be used to trigger field inspections at specific times (e.g., hatch, swim-up).

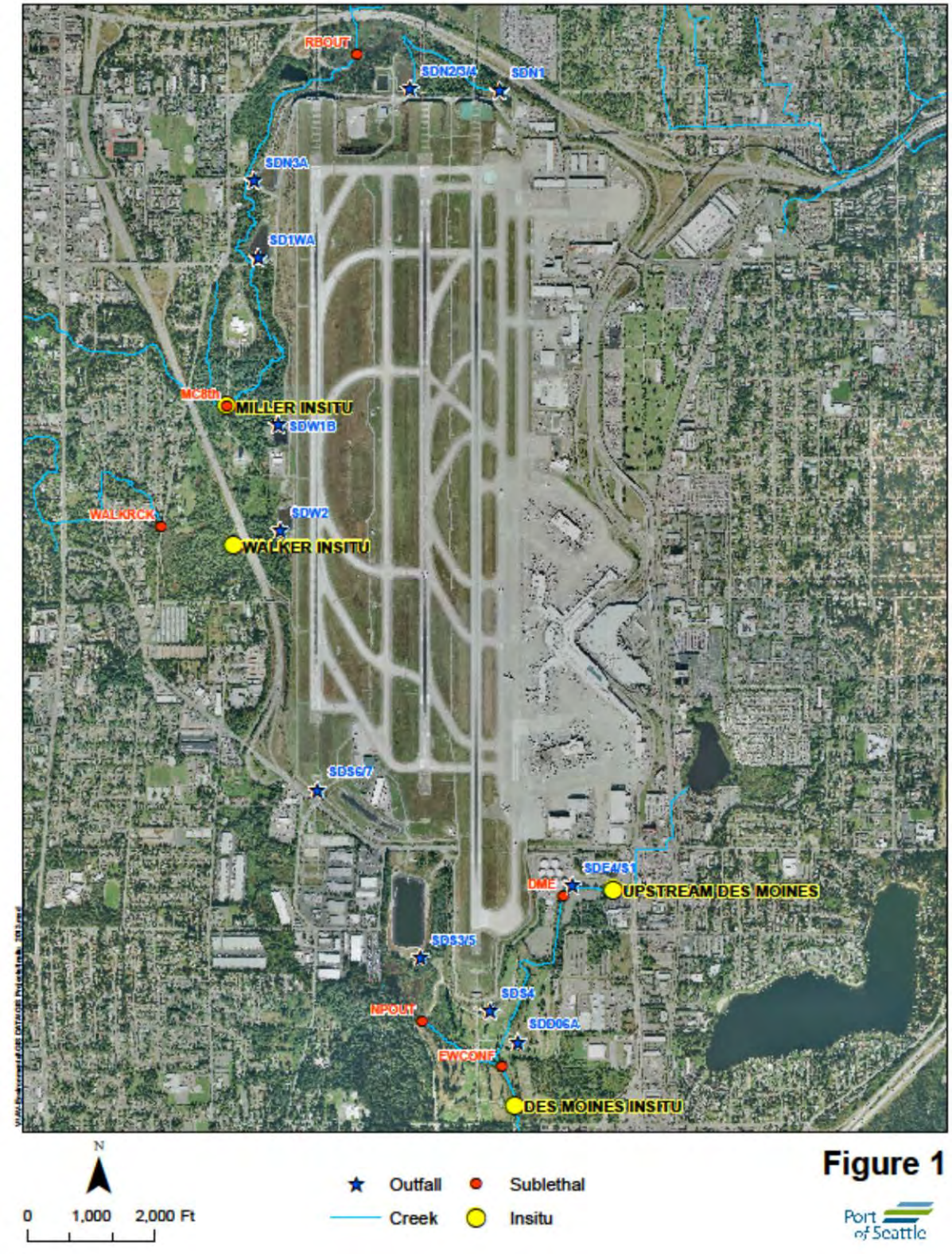
2.2 Monitoring Locations and Site Preparation

The exposures were conducted in three streams within the STIA property boundaries: Miller Creek, Walker Creek, and Des Moines Creek (Figure 1). Two sites are located on Des Moines Creek; Des Moines Creek Upstream is located on Airport property upstream of STIA stormwater outfalls into Des Moines Creek, and is used to assess water quality in Des Moines Creek prior to receiving any STIA stormwater discharges (the Des Moines Creek basin upstream of STIA is

heavily urbanized and potentially impacted by a variety of pollutant sources). The remaining sites, Miller Creek, Walker Creek and Des Moines Creek Lower, are located downstream of STIA inputs into their respective drainages (Figure 1).

Results from 2010 showed that the sampling sites generally do not have ideal substrate conditions for rearing salmonid ELS and are subjected to heavy sediment flow during storm events. Consequently, all four exposure replicates at each site were placed above the substrate in gravel contained within PVC crates which were anchored to the substrate with steel stakes. The replicate crates at each site were placed in a row on the streambed, from upstream to downstream, at a sufficient distance apart so that flow patterns were re-established between each crate. This approach allows passage of water through the exposure chambers, but prevents smothering of embryos and fry by sediment.

Figure 1. Map of STIA with receiving monitoring stations.



2.3 Exposure Apparatus

The RBT embryos were contained in modified Whitlock-Vibert hatchboxes (Federation of Flyfishers, MO), which are comprised of two rectangular chambers located one above the other; the upper chamber is for embryo development and the lower chamber for rearing of hatched fish. The external sides of the hatchbox are plastic mesh that allows passage of water through the box, but prevents loss of embryos. The divider between the embryo chamber and the rearing chamber is comprised of slots that are narrow enough to prevent transfer of unhatched embryos, but wide enough to permit migration of hatched fish into the lower rearing chamber. Thus, upon hatch, alevins are able to migrate through the slots from the embryo chamber into the larger rearing chamber. To prevent escape of the hatched fry into the streams upon swim-up, plastic screening material (Darice® size 7 mesh) was attached to the external faces of each rearing chamber and held in place using small plastic zip ties.

The hatchboxes were contained within flexible plastic mesh bags surrounded by 1 – 2 inch diameter gravel, with the hatchbox placed centrally within the rocks in the bag. The gravel surrounding the hatchboxes acts to diffuse the current and prevent exposure of the embryos to sunlight. The bags were then placed within the PVC crates, which were held in place in the stream by stakes anchored in the substrate (Figure 2). Figure 3 shows the eyed eggs within the hatchbox, and Figure 4 shows fry in the hatchbox.

Figure 2. Photograph of the crate set up, Des Moines Creek Lower.



2.4 Test Organisms

Eyed-egg stage rainbow trout embryos were obtained from TroutLodge on October 13, 2020 for the Fall event and March 23, 2021 for the Spring event. According to TroutLodge staff, the eyed embryos had developed to approximately 245 degree-days[1] for both testing events. On the day of test initiation, eggs were brought to Rainier Environmental Laboratory (REL; Fife, WA), and randomly counted into replicate units of 30 embryos each in individual opaque plastic food-storage containers (i.e., 450-mL Ziploc plastic tubs). These containers were then placed in a cooler containing ice packs, and transported to the sites where the embryos were transferred into the hatchboxes in the creek on the same day. The embryos were transferred to the sites in laboratory control water, and all embryos were installed at the sites between 15:00 and 18:00 on October 14, 2020 for the Fall event, and between 13:00 and 16:00 on March 24, 2021 for the Spring event.

2.5 Controls

Controls were used to assess the influence of the following factors on test results:

1. Quality (health and viability) of supplied organisms,
2. Transport and handling of organisms, and
3. Ambient stream temperatures, which affect the time to developmental milestones (e.g., hatch).

The controls consisted of a laboratory exposure (four replicates of 30 organisms each) conducted concurrently with each field exposure in clean laboratory water (moderately hard synthetic water [MHSW]) using a subset of the same batch of embryos used to initiate the field exposures. These embryos were distributed at the same time as the organisms used on site, placed into individual plastic containers filled with MHSW and transported to the sites with the other replicates; thus, they also served as transport controls. Upon returning to the laboratory after deployment of the field organisms, the control replicates were transferred to 4-L plastic

[1] Degree-days are used to standardize descriptions of fish development, regardless of rearing temperature, and reflects the sum of degrees during each day of development. For example, it takes rainbow trout approximately 340 degree-days to reach hatch (Quinn, 2005). Thus, at 8°C, it takes approximately 42 days to reach hatch.

containers in the laboratory containing 2 L of MHSW at ±1°C of the average site water temperature. The control chambers were held in the dark and gentle aeration was applied (100-200 bubbles per minute). The controls were monitored daily for mortalities, which were removed. Temperature was adjusted on a weekly basis, as needed, to correspond to temperatures measured in the field. Water renewals were conducted three times per week (Monday, Wednesday, Friday) using fresh MHSW. Dissolved oxygen (DO), pH, conductivity and temperature were measured before and after water renewals. Developmental milestones (e.g., hatch and swim-up) were also recorded.

2.6 Monitoring of Field Exposures

The sites were visited at approximately weekly intervals to assess the condition of the test organisms. During these checks, survival was recorded, as well as qualitative observations of organism health, site conditions and sedimentation within the boxes. Any dead organisms were removed during each visit. These observations were recorded on standard field data sheets, which are included in Appendix A. In addition, temperature, pH, DO and conductivity were measured during the site visits.

Monitoring of the installations required removal of the substrate overlying the hatchboxes in the crates. The embryos or alevins in each hatchbox were then poured into a plastic dishpan containing site water where they were enumerated. They were then returned to the hatchbox, which was placed back into the mesh-net bag of gravel, the overlying gravel replaced, and the bag returned to its respective crate. Care was taken to minimize disturbance and damage to the test organisms.

2.7 Test Termination

The field exposures and laboratory controls were terminated when the field organisms reached the swim-up fry stage (i.e., when the yolk sac was fully absorbed). This occurred on November 5, 2020, for the Fall exposure, and on April 20, 2021, for the Spring exposure. Surviving organisms were placed in their original plastic replicate containers filled with site water, transported back to the laboratory, and terminated. The fish were then weighed (to the nearest 0.001 gram) on an analytical balance, and measured (total length, from tip of the snout to the end of the tail) to the nearest 0.5 mm. Obvious external malformations were noted, including the affected body part (e.g., head, eye, spine) and type of abnormality (e.g., edema). Abnormality data were recorded on standard data sheets (Appendix A). The laboratory control fish were evaluated similarly on the same day.

2.8 Data Analysis

Test data were entered into CETIS (Comprehensive Environmental Toxicity Information System, Tidepool Scientific, McKinleyville, CA) for statistical analyses. Differences among the exposure sites and laboratory controls were evaluated using pair-wise multiple comparison tests according to the USEPA flow chart (USEPA 2002); significant differences were identified at $p \leq 0.05$.

One interim and five terminal endpoints were evaluated; the endpoints are described below:

1. Hatching success – an interim measure of the percentage of embryos hatched the day of the hatch inspection, or determined to have hatched based on the number of alevins present at the subsequent inspection, relative to the total number of embryos originally added;
2. Post-hatch survival - the percentage of organisms surviving at test termination relative to the number of embryos that hatched (these data help determine whether the majority of mortalities occurred pre- or post-hatch, or were distributed throughout the exposure period);
3. Cumulative survival - the percentage of surviving organisms at test termination relative to the number of embryos in each replicate at the beginning of the exposure;
4. Abnormality – the percentage of abnormal organisms at test termination relative to the number of surviving organisms;
5. Length – to the nearest 0.5 mm;
6. Weight – to the nearest 0.001 g.

3.0 QA/QC

The QA/QC program for the field exposure involved the following:

- Consistent field staff leader throughout all visits;
- Field documentation of all primary data; i.e., the names of individuals collecting the samples, sampling location, time of sampling, site conditions (e.g., degree of sedimentation), and other relevant observations, such as weather and any unusual conditions;
- Calibrated field meters;
- Use of pre-cleaned containers, with appropriate labels;
- Storing and transporting organisms in sealed containers in a cold, dark environment; cooling sample containers using ice or gel packs;
- Including transport controls to ascertain the extent of any transport-induced stress;
- Checking field organisms every week to monitor developmental progress, mortality and abnormality.

The QA/QC program for the laboratory portion of the study involved:

- Checks and maintenance of control organisms at regular intervals, including recording primary observations and water quality data on standardized data sheets;
- Review of datasheets by senior laboratory staff;
- Test termination activities (measurements, health assessment) conducted by qualified staff members using standardized datasheets to ensure consistent assessment of abnormalities and growth across all test sites and controls;
- Use of standard laboratory water and environmental chambers to maintain test organisms.

4.0 RESULTS

4.1 Fall 2020

4.1.1 Water Quality Measurements

Water quality measurements for the Fall 2020 monitoring event are summarized Table 1.

Table 1. Summary of mean, with (standard deviation) and [range], of water quality measurements collected during site visits and laboratory exposure (Fall 2020).

Creek	Temperature (°C)	Dissolved Oxygen (mg/L)	pH (units)	Specific Conductance (µS/cm)
Control	12.8 (0.9) [11.7 –14.0]	8.6 (0.4) [7.8 – 9.2]	7.78 (0.16) [7.52 – 8.01]	306.8 (9.9) [292 - 322]
Miller Creek	11.1 (1.9) [9.5 – 13.2]	10.4 (1.2) [9.2 – 12.0]	7.60 (0.14) [7.45 – 7.74]	226.8 (53.4) [173.8 – 290.0]
Walker Creek	12.4 (0.6) [11.9 – 13.2]	10.3 (1.1) [9.7 – 11.9]	7.20 (0.09) [7.09 – 7.30]	215.5 (19.2) [186.7 – 226.9]
Des Moines Creek Lower	11.4 (1.9) [9.6 – 13.8]	9.5 (1.2) [8.8 – 11.3]	6.81 (0.09) [6.72 – 6.93]	135.8 (36.3) [97 - 175]
Des Moines Creek Upstream	12.8 (1.6) [11.3 – 15.0]	9.0 (0.6) [8.4 – 9.5]	6.95 (0.04) [6.90 – 7.00]	100.8 (14.5) [79.8 – 112.4]

In the Fall 2020 *in situ* tests, temperatures for the four field sites and the control ranged from 9.5 to 15.0°C. Field measurements of pH were within acceptable ranges for rainbow trout laboratory bioassays (6-9 pH units); the pH values were between 6.72 and 8.01. Dissolved oxygen (DO) measurements were generally within acceptable ranges (60 – 100% saturation), although several readings during the test initiation and termination indicated super-saturation of between 102 and 110%; DO ranged from 7.8 to 12.0 mg/L.

Although limited to weekly measurements, the field temperature, DO and pH data suggested good water quality conditions overall, with limited indication of potential for adverse effects on organism survival and development. Supersaturation of dissolved oxygen recorded at Miller Creek on October 14 and 22 and at Walker Creek on October 22 are unusual but would not be expected to cause adverse effects unless total gas pressure was supersaturated.

The conductivity measurements for all four sites did not show much variability throughout the exposure period and remained within ranges tolerated by early life stages of salmonids; measurements ranged between 80 and 322 µS/cm.

4.1.2 Precipitation and Field Observations During the Fall 2020 Event

Field observations during each site visit are presented in Table 2. Precipitation data were provided by STIA. Figure 5 shows the daily precipitation over the duration of the exposure, in conjunction with monitoring milestones and associated observations. A total of 1.87 inches of rainfall fell during the Fall event, with no snow. Hatchboxes were installed on October 14 and the first site visit was on October 22, with weekly site visits thereafter. Conditions at all sites were good throughout the exposure.

At Miller Creek, alevins were observed to be escaping from gaps in hatchbox 4 during the October 22, 2020 site visit and the container was replaced with a new hatchbox. On October 28, the remains of a dead alevin was noted in hatchbox 1; shrimp were also present in the hatchbox. There was a gap in hatchbox 2 and was fixed. Leaf litter was observed on the bank during each site visit.

Algae was observed on all hatchboxes during each site visit at Walker Creek and leaf litter was on the bank. Amphipods were noted in hatchboxes 3 and 4 on October 28. All alevins appeared to have escaped hatchbox 2, despite the hatchbox being closed correctly. Consequently, this replicate was excluded from data analysis.

At the Des Moines Creek Lower site, there was consistent leaf litter covering the banks during each site visit. During the first site visit, algae was observed on hatchbox 2. On the following site visit on October 28, 2020, a flap on hatchbox 2 was exposed with fish trapped; a small gap was also noted on hatchbox 3. Both hatchboxes were repaired.

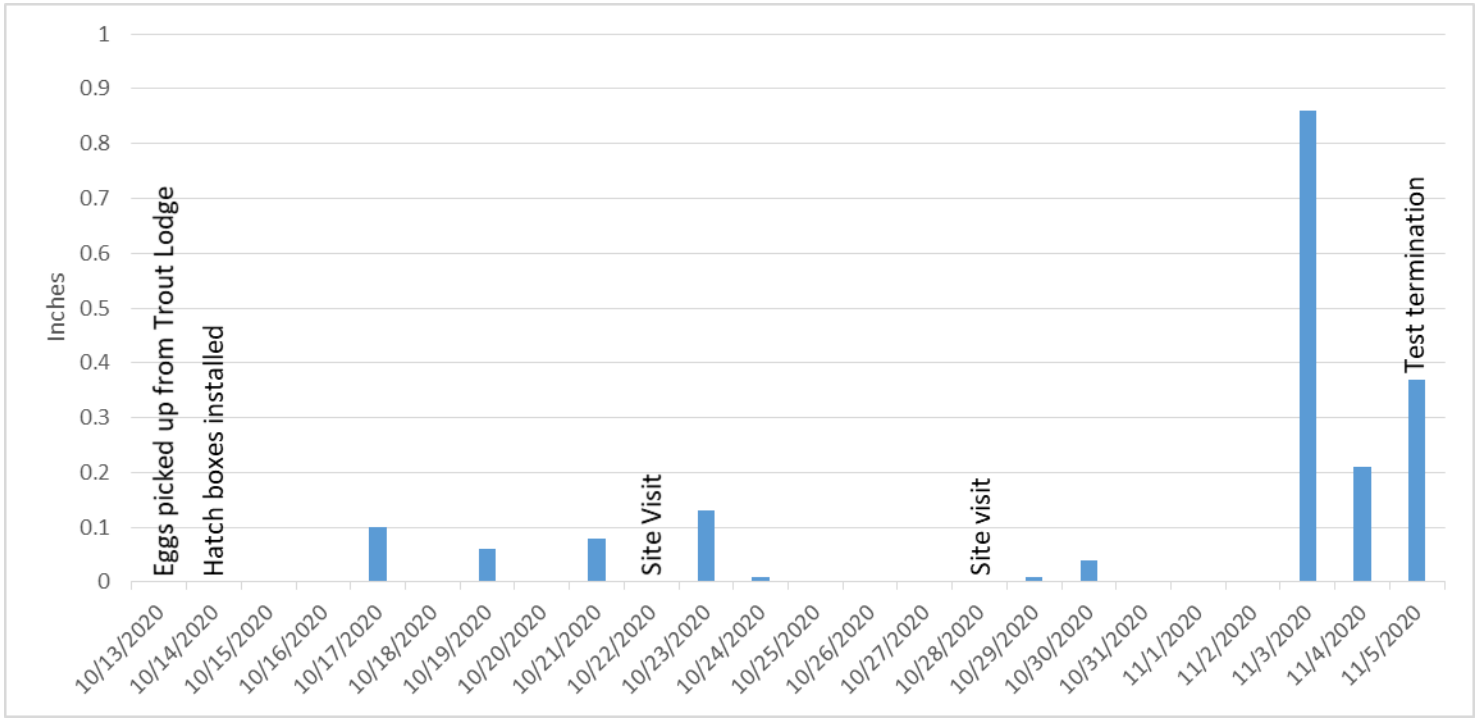
At the Des Moines Upstream site, snails, leeches or amphipods were observed in all hatchboxes on October 22 and 28, 2021. A small gap was noted in hatchbox 3 on October 28. Debris was caught around hatchbox 1 during the test termination. Leaf litter was observed on the bank during each site visit.

No sedimentation was observed in any of the hatchboxes for the duration of the exposure.

Table 2. Observations made during the Fall 2020 exposure.

Site	Observations			
	October 14, 2020	October 22, 2020	October 28, 2020	November 5, 2020
Des Moines Upstream	--	Leeches in hatchbox 1 and 3; snails in hatchbox 1; amphipods in hatchbox 4; leaf litter on bank	Amphipods in hatchbox 2, 3 and 4; leeches in hatchbox 3; leaf litter on bank	Debris around hatchbox; leaf litter on bank
Des Moines Lower	--	Algae on hatchbox 2; leaf litter on bank	Gaps in hatchbox 2 and 3 fixed; leaf litter on bank	Leaf litter on bank
Miller Creek	--	Leaf litter in crate 1; hatchbox 4 switched out due to alevins escaping through holes; leaf litter on bank	Gap in hatchbox 2 fixed; leaf litter on bank	Leaf litter on bank
Walker Creek	--	Algae on all hatchboxes; leaf litter on bank	Algae on all hatchboxes; amphipods in hatchbox 3 and 4; all alevins escaped hatchbox 2; Leaf litter on bank	Algae on all hatchboxes; leaf litter on bank

Figure 5. Daily rainfall during the Fall 2020 exposure.



4.1.3 Fall 2020 *In situ* exposure metrics

Data for the Fall sampling event are summarized in Tables 3 and 4, and are presented graphically in Figures 7 through 9.

Hatching success – Mean hatching success for the laboratory controls was 100%, compared with 90.8% at Miller Creek, 93.3% at Walker Creek, 95.8% at Des Moines Creek Lower, and 80.0% at Des Moines Creek Upstream. There was no significant differences in hatching success at any sites in comparison to the control except at Des Moines Creek Upstream (Bonferroni Adj t Test). There was no significant difference in hatching success between Des Moines Creek Lower compared to Des Moines Creek Upstream.

Post-hatch survival – Control survival of alevins post-hatch was 100%, compared with 82.3% at Miller Creek, 94.0% at Walker Creek, 87.8% at Des Moines Creek Lower, and 84.6% at Des Moines Creek Upstream. Post-hatch survival was significantly lower at Miller Creek, Des Moines Creek Lower and Des Moines Creek Upstream compared to the control (Bonferroni Adj t Test). There was no significant difference in post-hatch survival between Des Moines Creek Lower compared to Des Moines Creek Upstream.

Cumulative survival – Control survival from initiation to termination of the test averaged 100%. Cumulative survival at the exposure sites averaged 75.0% at Miller Creek, 87.8% at Walker Creek, 84.2% at Des Moines Creek Lower, and 68.3% at the Des Moines Creek Upstream site. Survival was significantly reduced relative to the controls at all sites (Bonferroni Adj t Test) except at Walker Creek. There was no significant difference in cumulative survival at Des Moines Creek Lower compared to Des Moines Creek Upstream.

Abnormalities – There were few abnormalities observed across treatments: two in Miller Creek; one at Walker Creek; and one at Des Moines Creek Lower. The fish in the Miller Creek and Des Moines Creek Lower were missing fins; in Walker Creek, the deformity was observed in the eyes.

Growth – Average weight and length in the controls was 103.5 mg and 23.2 mm, respectively. Miller Creek fish averaged 90.8 mg and 21.9 mm, fish exposed at Walker Creek averaged 107.9 mg and 23.9 mm, Des Moines Creek Lower averaged 93.0 mg and 22.2 mm, and Des Moines Creek Upstream fish averaged 111.0 mg and 23.9 mm, for weight and length, respectively. The length and weight of the fish in both Miller and Des Moines Creek Lower was significantly different compared to the control (Bonferroni Adj t Test). There was a significant difference in both growth endpoints at Des Moines Creek Lower compared to Des Moines Creek Upstream.

Table 3. Hatching success, survival and abnormality in the control and field treatment groups (Fall 2020).

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	100 (0.0)	100 (0.0)	100 (0.0)	0.0 (0.0)
Miller Creek	90.8 (8.3)	82.3 (10.9)	75.0 (14.0)	2.3 (2.8)
Walker Creek	93.3 (5.8)	94.0 (2.3)	87.8 (6.9)	1.2 (2.1)
Des Moines Creek Lower	95.8 (4.2)	87.8 (8.3)	84.2 (9.2)	1.1 (2.3)
Des Moines Creek Upstream	80.0 (13.6)	84.6 (11.5)	68.3 (18.2)	0.0 (0.0)

Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control

Table 4. Growth in the control and field treatment groups (Fall 2020).

Site	Length (mm)	Weight (mg)
Control	23.2 (0.2)	103.5 (2.7)
Miller Creek	21.9 (0.4)	90.8 (3.3)
Walker Creek	23.9 (0.6)	107.9 (9.3)
Des Moines Creek Lower	22.2 (0.4)	93.0 (2.9)
Des Moines Creek Upstream	23.9 (0.2)	111.0 (8.2)

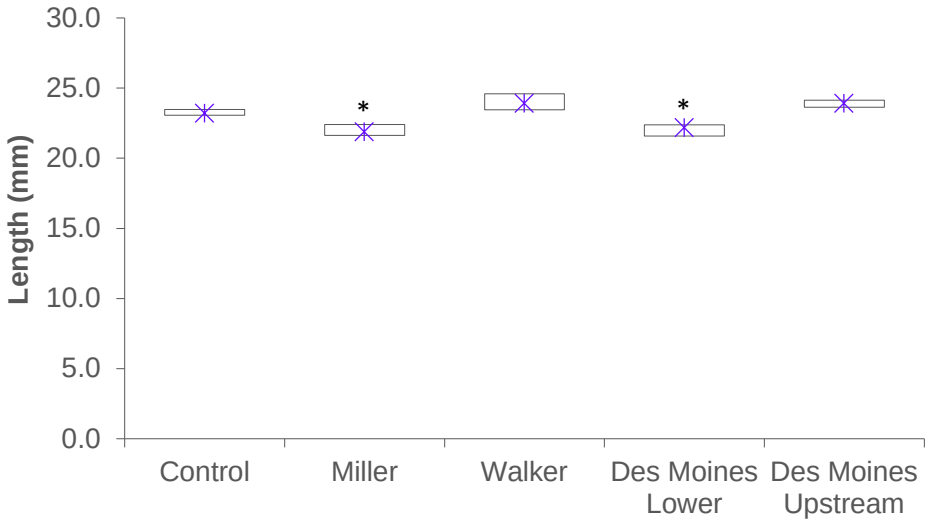
Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control

Figure 6. Hatching success, post-hatch survival, and cumulative survival in the field and control treatment groups (Fall 2020).



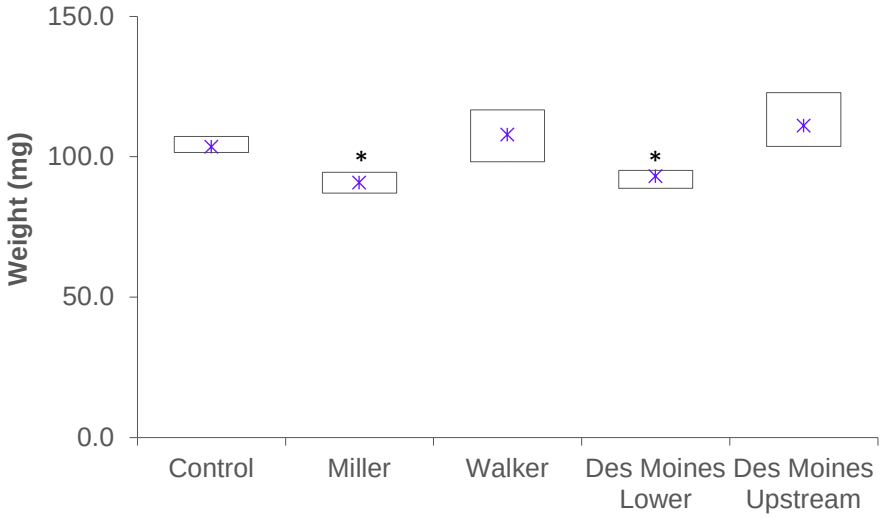
Error bars are standard deviations; asterisks denote significant difference from control.

Figure 7. Average lengths for the laboratory control and exposure sites (Fall 2020).



Data point is the average; box represents range of minimum to maximum values. Asterisks denote significant difference from control.

Figure 8. Average weights for the laboratory control and exposure sites (Fall 2020).



Data point is the average; box represents range of minimum to maximum values. Asterisks denote significant difference from control.

4.2 Spring 2021

4.2.1 Water Quality Measurements

Water quality measurements for the Spring 2021 monitoring event are summarized in Table 5.

Table 5. Summary of mean, with (standard deviation) and [range], of water quality measurements collected during site visits and laboratory exposure (Spring 2021).

Creek	Temperature (°C)	Dissolved Oxygen (mg/L)	pH (units)	Specific Conductance (µS/cm)
Control	10.2 (1.1) [8.4 – 11.7]	8.6 (0.4) [8.0 – 9.5]	7.64 (0.19) [7.3 – 8.0]	301.9 (8.9) [291 – 324]
Miller Creek	9.4 (1.2) [8.0 – 11.2]	11.1 (0.4) [10.4 – 11.4]	7.74 (0.09) [7.6 – 7.8]	261.6 (43.1) [202 – 316]
Walker Creek	11.4 (0.4) [10.7 – 11.7]	10.4 (0.2) [10.1 – 10.6]	7.12 (0.13) [7.0 – 7.3]	257.8 (21.2) [236 – 286]
Des Moines Creek Lower	10.1 (2.0) [7.4 – 11.9]	9.3 (0.8) [7.9 – 9.9]	7.06 (0.15) [6.9 – 7.2]	188.8 (23.6) [157 – 218]
Des Moines Creek Upstream	12.0 (2.1) [9.5 – 15.0]	9.0 (0.9) [7.9 – 10.2]	7.38 (0.11) [7.3 – 7.5]	171.4 (17.3) [148 – 195]

Temperatures among the four field sites and the control ranged from 7.4 to 15.0°C. The pH values were between 6.9 and 8.0, and DO ranged from 7.9 to 11.4 mg/L. All field measurements of pH and dissolved oxygen were within acceptable ranges for rainbow trout laboratory bioassays. Conductivity readings were similar at each site between each visit and ranged between 148 and 324 µS/cm.

4.2.2 Precipitation and Field Observations During the Spring 2021 Event

Field observations during each site visit are presented in Table 6. The daily rainfall for the duration of the Spring 2021 exposure is shown in Figure 9. The largest amount of rain (0.69 inches) was observed on March 25, 2021. A total of 1.63 in of rain fell and no snow occurred during the exposure period. Hatchboxes were installed on March 24, 2021, with weekly site visits thereafter.

At Miller Creek, woody debris was observed below crate 4 and recent plant trimmings were present nearby during the hatchbox installation; this debris was largely cleared prior to subsequent visits. Woody debris was observed on crates 2 and 3 on March 31, 2021; approximately 1 cm of sediment was also observed in hatchbox 3. Nymphs were observed in hatchboxes during the April 6 site visit and a brown biofilm was observed on hatchbox 1 on April 20, 2021.

At Walker Creek, organic debris was observed on crates 1 and 2 during the March 31, 2021 site visit. Two alevins were stuck in the corner of hatchbox 3 on April 6; the alevins were removed and the hatchbox replaced. Biofilm was observed on hatchbox 4 and there was an increase in algal growth noted on the stream substrate. Algae was growing on crate 4 the following week and nymphs were observed inside hatchbox 4 during termination on April 20, with the nymphs observed to be holding onto the live alevins.

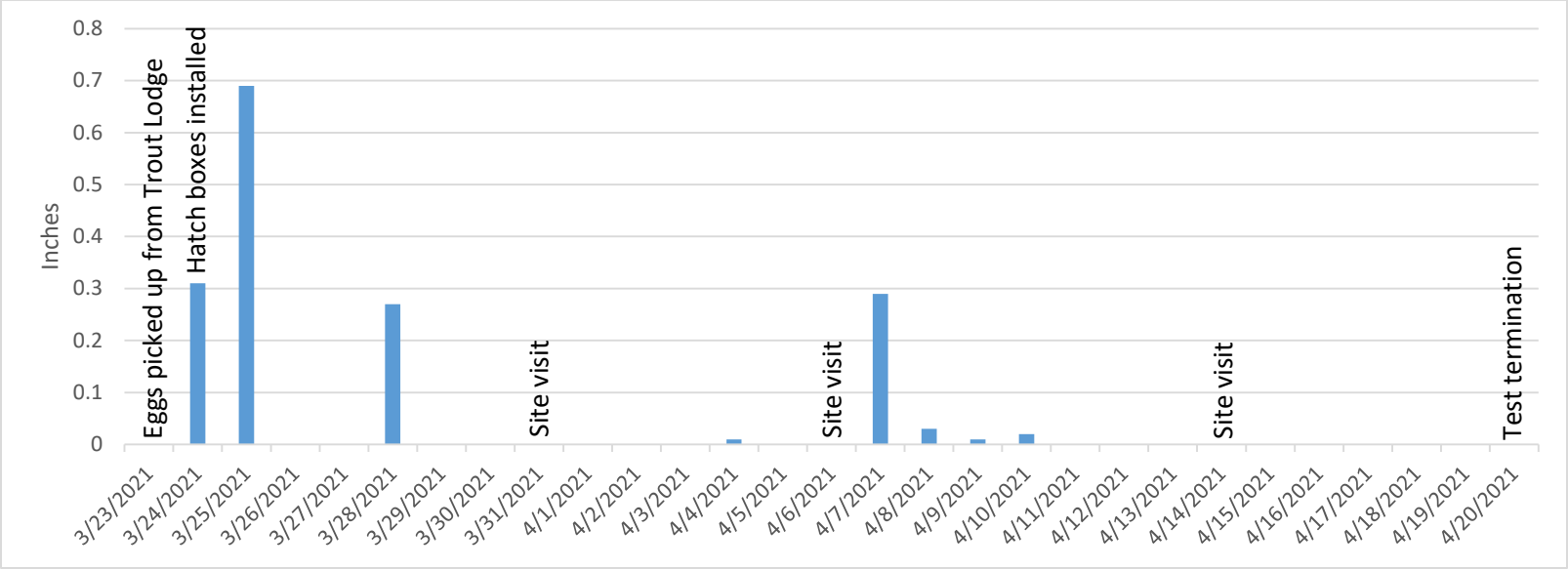
At Des Moines Lower, amphipods were observed in hatchboxes 3 and 4 during the site visit on April 6, 2021. Alevins were noted to have escaped hatchbox 1 on April 14 with only 4 remaining compared to 26 the week prior; consequently, this replicate was removed from analysis for all endpoints except hatching success. Two alevins were also noted to have lacerations in hatchbox 3. There was a brown tint observed in the water during the site visit on April 14 and during termination on April 20, 2021.

Brown biofilm was observed on all hatchboxes on April 6, 2021 at Des Moines Upstream. During the test termination, algal growth was noted in the stream. No sedimentation was observed in the hatchboxes at any of the sites at test termination.

Table 6. Observations made during the Spring 2021 exposure.

Site	Observations				
	March 24, 2021	March 31, 2021	April 6, 2021	April 14, 2021	April 20, 2021
Des Moines Upstream	--	Organic matter on rocks	Brown biofilm on all hatchboxes	--	Algae growth
Des Moines Lower	--	Small amount of biofilm on hatchbox 3	Amphipods in hatchboxes 3 and 4	Brownish tint to water; alevins escaped in hatchbox 1; 2 alevins with lacerations in hatchbox 2	Brownish tint to water
Miller Creek	Large woody debris below hatchbox 4; recent plant trimming nearby	Woody debris on crate 2; 1 cm sediment in hatchbox 3 and debris on crate	Nymphs in hatchboxes	Amphipods in hatchboxes	Brown biofilm on hatchbox 1
Walker Creek	--	Organic debris on crate 1 and 2	Biofilm on hatchbox 4; increased algae on substrate in stream	Algae on crate 4	Nymph holding onto live alevins in hatchbox 4; large amounts of green filamentous algae on stream substrate

Figure 9. Daily rainfall for the duration of the Spring 2021 exposure.



4.2.3 Spring 2021 *In situ* exposure metrics

Data for the spring sampling event are summarized in Tables 7 and 8, and presented graphically in Figures 10 through 12.

Hatching success – Mean hatching success for the controls was 99.2%, compared with 74.2% at Miller Creek, 94.2% at Walker Creek, 83.3% at Des Moines Creek Lower and 71.7% at Des Moines Creek Upstream. Hatching success at Miller and Des Moines Creek Upstream were significantly different from the control (Dunnett Multiple Comparison Test). There was no significant difference in hatching success at Des Moines Lower compared to Des Moines Creek Upstream.

Post-hatch survival – Control survival of alevins post-hatch was 99.1%, compared with 94.3% at Miller Creek, 93.0% at Walker Creek, 80.5% at Des Moines Creek Lower, and 85.0% at Des Moines Upstream. Des Moines Creek Lower and Des Moines Upstream were significantly different from the control (Dunnett Multiple Comparison Test), however, there was no significant difference observed between the two sites.

Cumulative survival – Control survival from initiation of the test to termination averaged 98.3%, compared with 70.0% at Miller Creek, 87.5% at Walker Creek, 67.8% at Des Moines Creek Lower, and 60.0% at Des Moines Creek Upstream. There was a significant difference at all of the sites compared to the control except at Walker Creek (Dunnett Multiple Comparison Test). There was no significant difference in cumulative survival between Des Moines Lower and Des Moines Creek Upstream.

Abnormalities – There were few abnormalities observed across treatments, with one each in the control, Walker Creek and Des Moines Creek Lower and two in Miller Creek. The abnormality of the fish in the control, Walker Creek and Des Moines Creek Lower were located in the spine and the abnormalities observed at Miller Creek were in the fins and spine.

Growth – Average weight in the controls was 104.5 mg, and length averaged 24.2 mm. In comparison, Miller Creek fish averaged 111.0 mg and 24.2 mm, fish from Walker Creek averaged 121.7 mg and 26.0 mm, fish exposed at Des Moines Creek Lower averaged 102.7 mg and 23.3 mm and fish from Des Moines Creek Upstream average 111.9 mg and 24.8 mm. Neither weight nor length were significantly different from the control at any sites (Dunnett Multiple Comparison Test). There was a significant difference in length between Des Moines Lower and Des Moines Creek Upstream.

Table 7. Hatching success, survival and abnormality in the control and field treatment groups (Spring 2021).

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	99.2 (1.7)	99.1 (1.7)	98.3 (3.3)	0.8 (1.7)
Miller Creek	74.2 (20.2)	94.3 (5.1)	70.0 (19.6)	1.7 (3.3)
Walker Creek	94.2 (4.2)	93.0 (4.9)	87.5 (3.2)	0.9 (1.8)
Des Moines Creek Lower	83.3 (20.7)	80.5 (10.6)	67.8 (26.9)	1.0 (2.0)
Des Moines Upstream	71.7 (17.7)	85.0 (9.3)	60.0 (11.9)	0.0 (0.0)

Notes:

1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control

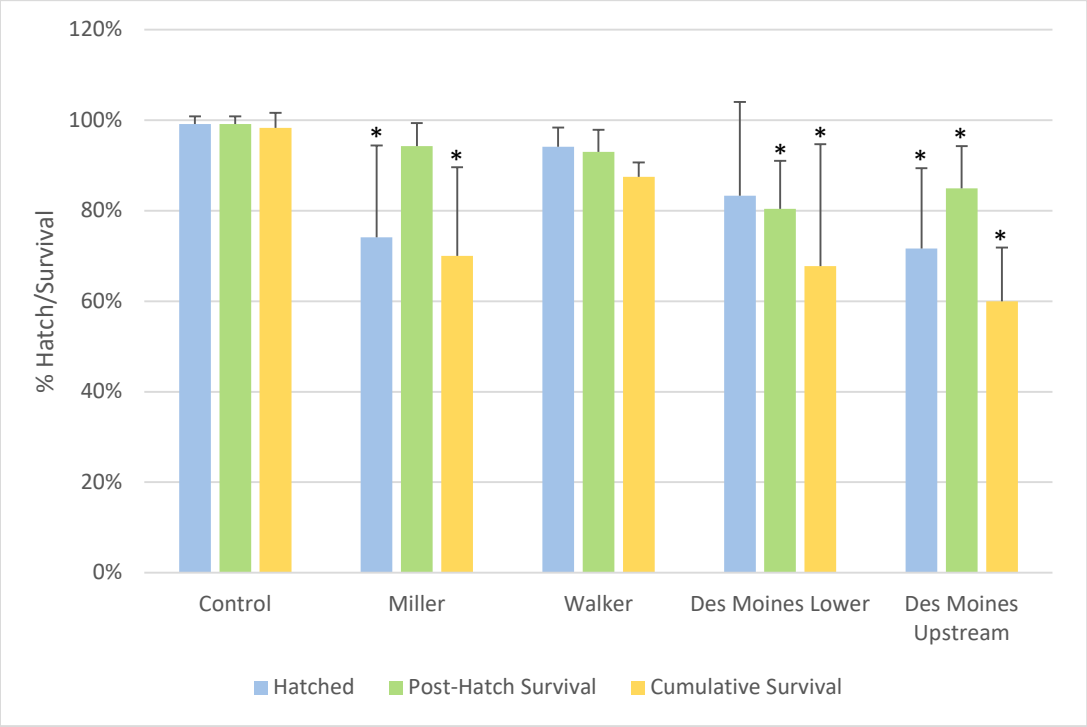
Table 8. Growth in the control and field treatment groups (Spring 2021).

Site	Length (mm)	Weight (mg)
Control	24.2 (0.5)	104.5 (2.6)
Miller Creek	24.2 (1.0)	111.0 (3.2)
Walker Creek	26.0 (0.0)	121.7 (8.4)
Des Moines Creek Lower	23.3 (0.6)	102.7 (9.5)
Des Moines Upstream	24.8 (0.5)	111.9 (2.6)

Notes:

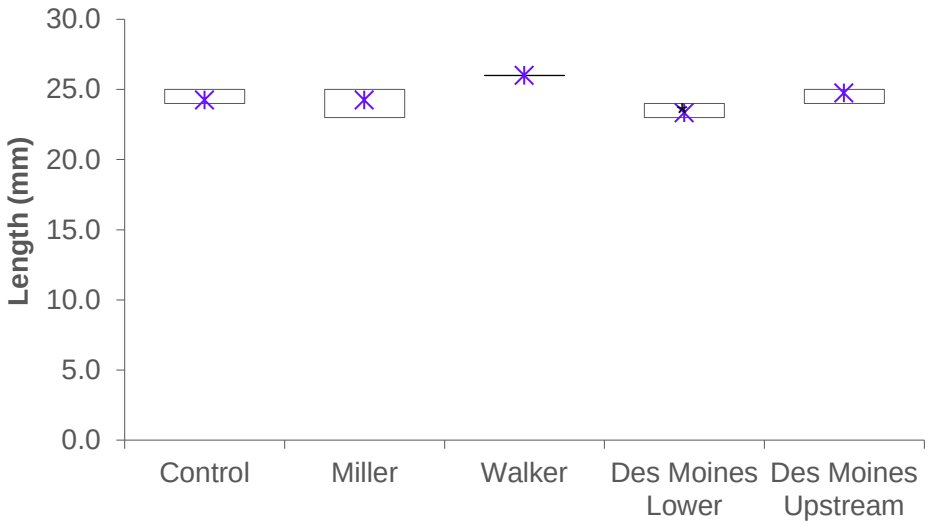
1. Results are presented as mean and standard deviation

Figure 10. Hatching success, post-hatch survival, and cumulative survival in the field and control treatment groups (Spring 2021).



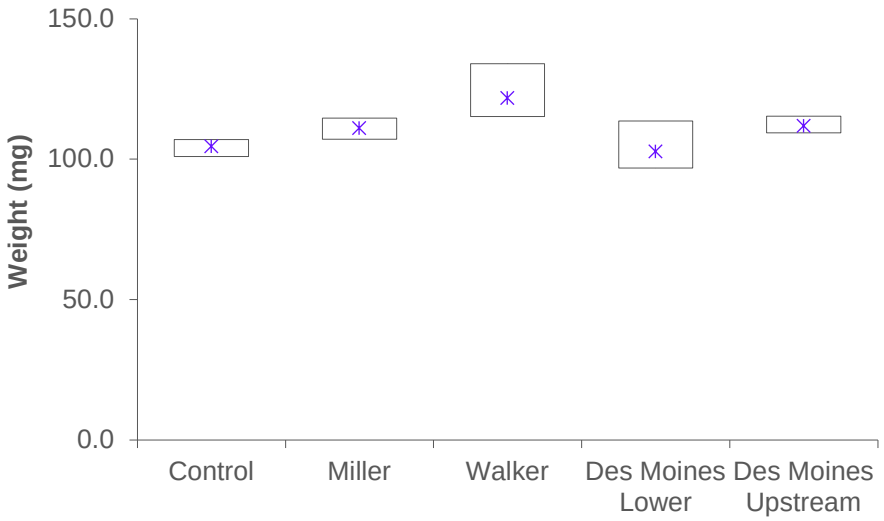
Error bars are standard deviations.

Figure 11. Average lengths for the laboratory control and exposure sites (Spring 2021).



Data point is the average; box represents range of minimum to maximum values.

Figure 12. Average weights for the laboratory control and exposure sites (Spring 2021).



Data point is the average; box represents range of minimum to maximum values.

5.0 DISCUSSION

There were only adverse effects associated with sublethal measurements, such as growth and incidence of deformities, for growth of alevins exposed in Miller Creek and Des Moines Creek Lower during the Fall event; there was a 5.6 and 4.4% reduction in length and 12.4 and 10.2 percent reduction in weight relative to the laboratory control at these two locations, respectively. In both cases, there was more residual yolk observed in these fish at test termination than at the other locations, indicating that the fish were developing more slowly at these sites. The temperature was lower at these locations by more than 1°C relative to the other locations and control exposure. Thus, the reduced growth at these locations may be reflective of the colder water temperatures causing slower growth, rather being indicative of a toxicological effect at these sites.

Survival of rainbow trout was relatively high in both test events at all locations, with the lowest cumulative survival occurring in Des Moines Upstream in both test periods (60.0 and 68.3% in the Fall and Spring events, respectively). A statistically significant reduction in survival was observed in Miller Creek and both Lower Des Moines Creek and Des Moines Upstream in both test events; however, the very high survival in the laboratory control (i.e., 100.0 and 98.3% respectively) resulted in a relatively high statistical sensitivity to detect adverse effects in these exposures.

Results for cumulative survival, incorporating both effects on hatch rate and survival post hatch, provided the best measure of adverse effects in the *in situ* exposures reported here. In the Fall 2020 event, cumulative survival in the exposure sites ranged from 68.3 to 87.8%, and was significantly decreased at all sites compared to the control (100% survival), with the exception of Walker Creek. In the Spring 2021 event, cumulative survival ranged from 60.0 to 87.5% across the sites, compared with 98.3% in the control, and similar to the Fall event, all sites were significantly lower than the control except at Walker Creek.

Of note, significant adverse effects were observed in both Fall 2020 and Spring 2021 events at the Des Moines Creek Lower and Des Moines Creek Upstream sites, with reduced post-hatch survival and cumulative survival at both locations; Des Moines Creek Upstream also had reduced hatching success during both events. During the Fall 2020 event, Des Moines Creek Lower had reduced growth, in both the length and weight endpoints. With the exception of the Spring 2015 (Nautilus Environmental 2015), Spring 2018 (Nautilus Environmental 2018) and the Spring 2020 (Nautilus Environmental 2020) testing events, Des Moines Upstream has generally exhibited evidence of adverse effects, suggesting an ongoing pattern of impaired water quality upstream of STIA inputs, which could also contribute to adverse effects observed further

downstream at Des Moines Creek Lower. In the present study, Des Moines Creek Lower produced results that were statistically significantly different from Des Moines Creek Upstream in length and weight of the exposed fish in Fall 2020 and in lengths in Spring 2021 suggesting the possibility of a localized impact at the downstream site, but there was no significant difference in cumulative survival between the upstream and downstream sites, and differences in growth may have resulted from different temperature profiles at these two locations.

In general, creek conditions and water quality parameters remained within suitable ranges for the duration of the both testing events and were unlikely to have contributed to any adverse effects observed. However, some exceedances were notable, including dissolved oxygen measurements that exceeded saturation during the Fall 2020 event. Elevated levels of total dissolved gas (TDG), which includes dissolved oxygen, can be harmful to salmonids (Carter 2008), and USEPA (1986) has set a criterion for TDG stating that levels should not exceed 110% of saturation. In all instances during the Fall event, dissolved oxygen was ≤110% saturation, and it is unknown if the supersaturated oxygen resulted in supersaturated TDG or not.

No sedimentation was observed in either event that may have affected embryo survival.

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Rainbow Trout Early Life Stages *In Situ* Monitoring Testing

Fall 2021 and Spring 2022

Final Report

June 30, 2022

Submitted to: **Port of Seattle**
Seattle-Tacoma International Airport

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SIGNATURE PAGE



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This report has been prepared by Nautilus Environmental Company Inc. based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

EXECUTIVE SUMMARY

The Port of Seattle monitors the potential effects of stormwater discharges from the Seattle-Tacoma International Airport (STIA) on the receiving environment as part of their National Pollutant Discharge Elimination System (NPDES) permit, which requires that *in situ* rainbow trout (RBT) early-life stage (ELS) tests be conducted biannually in the fall and spring. The testing program was initiated in Fall 2010; exposure sites include Miller Creek, Des Moines Creek Lower and Des Moines Creek Upstream, with Walker Creek being added to the study beginning Spring 2016. The creeks flow through STIA property boundaries, with monitoring points generally located downstream of STIA inputs; however, one site (Des Moines Creek Upstream) is located upstream of STIA stormwater outfalls to monitor for potential impacts originating upstream of Airport property. Results are compared to a laboratory control conducted concurrently with the *in situ* tests.

During the Fall 2021 event, hatching success, post-hatch survival and cumulative survival were all significantly reduced at Miller Creek and Des Moines Creek Upstream compared to the laboratory control. During the Spring 2022 event, post-hatch and cumulative survival was significantly reduced at Des Moines Creek Upstream compared to the laboratory control. In terms of sublethal effects, no effects were observed on length or weights at any site during either the Fall or Spring events. Developmental abnormalities were minimal across all sites and controls during both events (i.e., ≤ 5%). Of note, with the exception of Spring 2015, Spring 2018 and Spring 2020 testing events, Des Moines Creek Upstream has historically exhibited adverse effects since the testing program began in 2010.

1.0 INTRODUCTION

This report presents the results of the rainbow trout (RBT) early life stages (ELS) *in situ* monitoring tests conducted in the Fall of 2021 and Spring of 2022. The objective of this program is to use salmonid ELS as an *in situ* monitoring tool to assess the quality of receiving waters potentially affected by stormwater discharges from the Seattle-Tacoma International Airport (STIA), as well as a multitude of other potential sources from the surrounding urban environment. Results for studies conducted in Fall 2010/Spring 2011, Fall 2011/Spring 2012, Fall 2012/Spring 2013, Fall 2013/Spring 2014, Fall 2014/Spring 2015, Fall 2015/Spring 2016, Fall 2016/Spring 2017, Fall 2017/Spring 2018, Fall 2018/Spring 2019, Fall 2019/Spring 2020 and Fall 2020/2021 have been presented previously (Nautilus Environmental 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020 and 2021, respectively), and have demonstrated that the RBT *in situ* ELS bioassay is an effective biological monitoring tool for assessing the potential effects of stormwater discharges on the receiving environment.

The sampling events presented herein were conducted under NPDES Permit No. WA-002465-1, which requires that *in situ* tests be conducted biannually in the fall and spring, corresponding to the spawning regimes of local salmonid species.

2.0 METHODS

Guidance for conducting *in situ* ELS exposures with salmonids is available from a number of sources. The British Columbia Ministry of Environment has a protocol for an *in situ* ELS salmonid test (BCMOE, 2003), and Environment Canada has developed laboratory test procedures for early life stages of rainbow trout (Environment Canada, 1998). In the USA, there are two general laboratory protocols for conducting fish early life stage toxicity tests (EPA, 1996; ASTM, 2005). The procedures used in this study reflect refinements made to the general guidance provided in the documents above (Chalmers et al., 2014), and have been used successfully at a number of sites in both Canada and the USA. Additional refinements specific to applying the method to waterways present on Airport property are included in the descriptions below.

2.1 Design

The study design used for the Fall 2021 and Spring 2022 *in situ* testing involved exposure of eyed-stage embryos at four sampling sites, using four replicates per site with 30 embryos per replicate. The locations of the sites are shown in Figure 1. The original sites were located on Miller and Des Moines Creeks downstream of all Airport discharges, and were subsequently augmented by an additional site on Des Moines Creek located upstream of any Airport discharges to determine the extent to which sources upstream of STIA inputs may contribute to adverse effects observed at the downstream site on Des Moines Creek. A site located in Walker Creek was also included in the study design beginning with the Spring 2016 testing event.

The exposure duration used in the *in situ* tests covers the major salmonid early life stage developmental milestones, beginning with the eyed egg stage, proceeding through hatching and alevin stages (yolk sac present, during which the fish reside in the gravel), and ending at the early fry stage (also known as swim-up fry). At this point, the yolk sac has been absorbed and, under natural conditions, the fish would leave the gravel to feed independently. The duration of the exposure period is expected to include multiple rain/runoff events, and corresponding fluctuations in flow, contaminant concentrations, temperature, water chemistry, etc. Collectively, these attributes of the *in situ* approach provide highly relevant information regarding the suitability of waterbodies to support salmonid development (Chalmers et al., 2014).

Eyed eggs for both *in situ* events were supplied by TroutLodge (Sumner, WA), which also supplies rainbow trout eggs and sperm for the laboratory sublethal toxicity tests required in the STIA NPDES stormwater permit. Following deployment, the status of the *in situ* organisms was routinely monitored during the exposure, as well as at specific developmental stages and after significant storm events. Data were obtained on hatching, survival, development and growth. A subset of embryos was also reared in the laboratory (Rainier Environmental, Fife, WA) to assess organism quality. Weekly temperature measurements from the field were used to adjust rearing temperatures for the laboratory controls so that development in the controls could be used to trigger field inspections at specific times (e.g., hatch, swim-up).

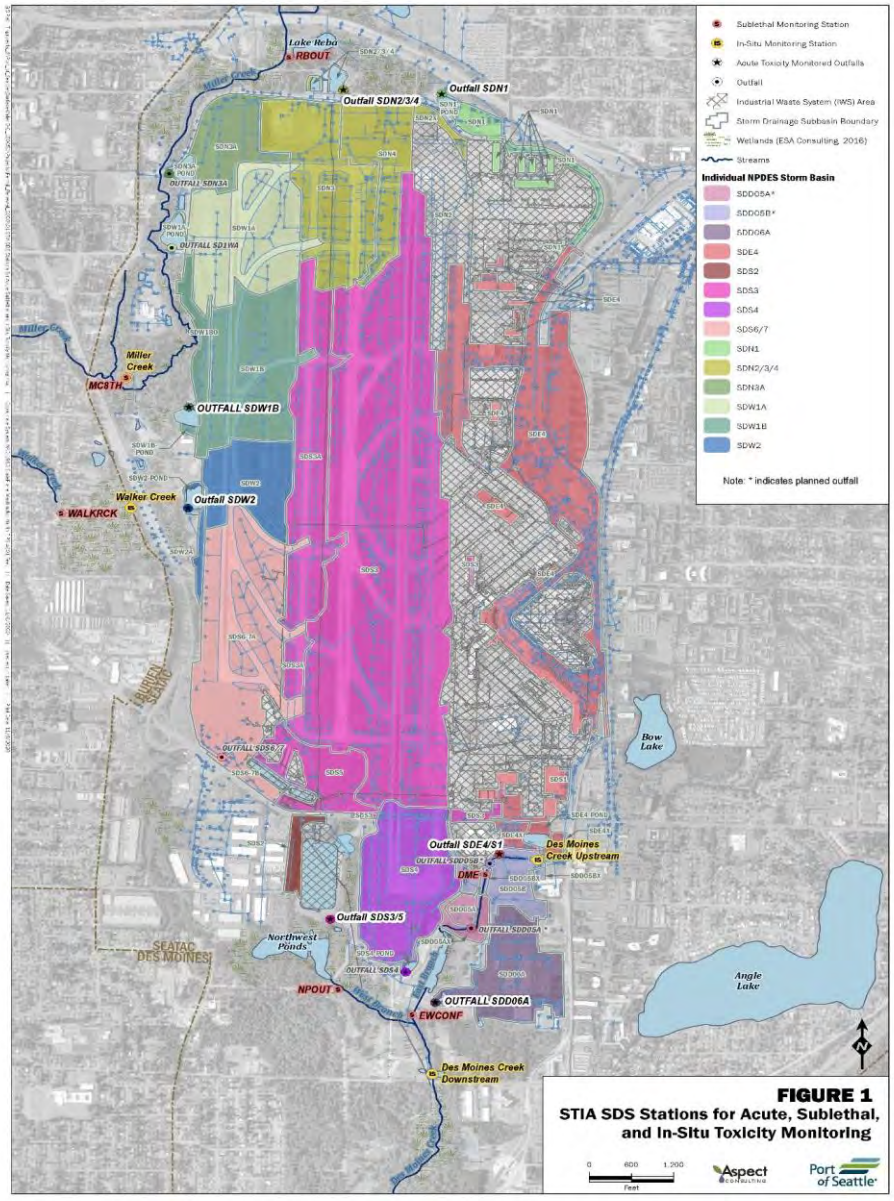
2.2 Monitoring Locations and Site Preparation

The exposures were conducted in three streams within the STIA property boundaries: Miller Creek, Walker Creek, and Des Moines Creek (Figure 1). Two sites are located on Des Moines Creek; Des Moines Creek Upstream is located on Airport property upstream of STIA stormwater outfalls into Des Moines Creek, and is used to assess water quality in Des Moines Creek prior to receiving any STIA stormwater discharges (the Des Moines Creek basin upstream of STIA is heavily urbanized

and potentially impacted by a variety of pollutant sources). The remaining sites, Miller Creek, Walker Creek and Des Moines Creek Lower, are located downstream of STIA inputs into their respective drainages (Figure 1).

Results from 2010 showed that the sampling sites generally do not have ideal substrate conditions for rearing salmonid ELS and are subjected to heavy sediment flow during storm events. Consequently, all four exposure replicates at each site were placed above the substrate in gravel contained within PVC crates which were anchored to the substrate with steel stakes. The replicate crates at each site were placed in a row on the streambed, from upstream to downstream, at a sufficient distance apart so that flow patterns were re-established between each crate. This approach allows passage of water through the exposure chambers, but prevents smothering of embryos and fry by sediment.

Figure 1. Map of STIA with receiving monitoring stations.



2.3 Exposure Apparatus

The RBT embryos were contained in hatchboxes comprised of 4 inch x 6 inch cylindrical stainless steel strainer. The external sides of the hatchbox are perforated to allow passage of water through the box, but prevents loss of embryos. These stainless streel hatchboxes replaced a former Whitlock-Vibert style box that at times allowed alevins to escape due to deformations in the plastic mesh chambers. With the new hatchboxes, embryos hatch and remain through alevin stage in a large (~100 square inch) rearing chamber.

The hatchboxes were contained within flexible plastic mesh bags surrounded by 1 – 2 inch diameter gravel, with the hatchbox placed centrally within the rocks in the bag. The gravel surrounding the hatchboxes acts to diffuse the current and prevent exposure of the embryos to sunlight. The bags were then placed within the PVC crates, which were held in place in the stream by stakes anchored in the substrate (Figure 2). Figure 3 and 4 shows top-down and side-view images of the stainless steel hatchboxes.

Figure 2. Photograph of the crate set up, Des Moines Creek Lower.



2.4 Test Organisms

Eyed-egg stage rainbow trout embryos were obtained from TroutLodge on October 18, 2021 for the Fall event and April 5, 2022 for the Spring event. According to TroutLodge staff, the eyed embryos had developed to approximately 245 degree-days[1] for both testing events. On the day of test initiation, eggs were brought to Rainier Environmental Laboratory (REL; Fife, WA), and randomly counted into replicate units of 30 embryos each in individual opaque plastic food-storage containers (i.e., 450-mL Ziploc plastic tubs). These containers were then placed in a cooler containing ice packs, and transported to the sites where the embryos were transferred into the hatchboxes in the creek on the same day. The embryos were transferred to the sites in laboratory control water, and all embryos were installed at the sites between 11:00 and 14:00 on October 19, 2021 for the Fall event, and between 8:00 and 13:00 on April 6, 2022 for the Spring event.

2.5 Controls

Controls were used to assess the influence of the following factors on test results:

1. Quality (health and viability) of supplied organisms,
2. Transport and handling of organisms, and
3. Ambient stream temperatures, which affect the time to developmental milestones (e.g., hatch).

The controls consisted of a laboratory exposure (four replicates of 30 organisms each) conducted concurrently with each field exposure in clean laboratory water (moderately hard synthetic water [MHSW]) using a subset of the same batch of embryos used to initiate the field exposures. These embryos were distributed at the same time as the organisms used on site, placed into individual plastic containers filled with MHSW and transported to the sites with the other replicates; thus, they also served as transport controls. Upon returning to the laboratory after deployment of the field organisms, the control replicates were transferred to 4-L plastic containers in the laboratory containing 2 L of MHSW at ±1°C of the average site water temperature. The control chambers

[1] Degree-days are used to standardize descriptions of fish development, regardless of rearing temperature, and reflects the sum of degrees during each day of development. For example, it takes rainbow trout approximately 340 degree-days to reach hatch (Quinn, 2005). Thus, at 8°C, it takes approximately 42 days to reach hatch.

were held in the dark and gentle aeration was applied (100-200 bubbles per minute). The controls were monitored daily for mortalities, which were removed. Temperature was adjusted on a weekly basis, as needed, to correspond to temperatures measured in the field. Water renewals were conducted three times per week (Monday, Wednesday, Friday) using fresh MHSW. Dissolved oxygen (DO), pH, conductivity and temperature were measured before and after water renewals. Developmental milestones (e.g., hatch and swim-up) were also recorded.

2.6 Monitoring of Field Exposures

The sites were visited at approximately weekly intervals to assess the condition of the test organisms. During these checks, survival was recorded, as well as qualitative observations of organism health, site conditions and sedimentation within the boxes. Any dead organisms were removed during each visit. These observations were recorded on standard field data sheets, which are included in Appendix A. In addition, temperature, pH, DO and conductivity were measured during the site visits.

Monitoring of the installations required removal of the substrate overlying the hatchboxes in the crates. The embryos or alevins in each hatchbox were then poured into a plastic dishpan containing site water where they were enumerated. They were then returned to the hatchbox, which was placed back into the mesh-net bag of gravel, the overlying gravel replaced, and the bag returned to its respective crate. Care was taken to minimize disturbance and damage to the test organisms.

2.7 Test Termination

The field exposures and laboratory controls were terminated when the field organisms reached the swim-up fry stage (i.e., when the yolk sac was fully absorbed). This occurred on November 19, 2021, for the Fall exposure, and on May 4, 2022, for the Spring exposure. Surviving organisms were placed in their original plastic replicate containers filled with site water, transported back to the laboratory, and terminated. The fish were then weighed (to the nearest 0.001 gram) on an analytical balance, and measured (total length, from tip of the snout to the end of the tail) to the nearest 0.5 mm. Obvious external malformations were noted, including the affected body part (e.g., head, eye, spine) and type of abnormality (e.g., edema). Abnormality data were recorded on standard data sheets (Appendix A). The laboratory control fish were evaluated similarly on the same day.

2.8 Data Analysis

Test data were entered into CETIS (Comprehensive Environmental Toxicity Information System, Tidepool Scientific, McKinleyville, CA) for statistical analyses. Differences among the exposure sites and laboratory controls were evaluated using pair-wise multiple comparison tests according to the USEPA flow chart (USEPA 2002); significant differences were identified at $p \leq 0.05$.

One interim and five terminal endpoints were evaluated; the endpoints are described below:

1. Hatching success – an interim measure of the percentage of embryos hatched the day of the hatch inspection, or determined to have hatched based on the number of alevins present at the subsequent inspection, relative to the total number of embryos originally added;
2. Post-hatch survival - the percentage of organisms surviving at test termination relative to the number of embryos that hatched (these data help determine whether the majority of mortalities occurred pre- or post-hatch, or were distributed throughout the exposure period);
3. Cumulative survival - the percentage of surviving organisms at test termination relative to the number of embryos in each replicate at the beginning of the exposure;
4. Abnormality – the percentage of abnormal organisms at test termination relative to the number of surviving organisms;
5. Length – to the nearest 0.5 mm;
6. Weight – to the nearest 0.001 g.

3.0 QA/QC

The QA/QC program for the field exposure involved the following:

- Consistent field staff leader throughout all visits;
- Field documentation of all primary data; i.e., the names of individuals collecting the samples, sampling location, time of sampling, site conditions (e.g., degree of sedimentation), and other relevant observations, such as weather and any unusual conditions;
- Calibrated field meters;
- Use of pre-cleaned containers, with appropriate labels;
- Storing and transporting organisms in sealed containers in a cold, dark environment; cooling sample containers using ice or gel packs;
- Including transport controls to ascertain the extent of any transport-induced stress;
- Checking field organisms every week to monitor developmental progress, mortality and abnormality.

The QA/QC program for the laboratory portion of the study involved:

- Checks and maintenance of control organisms at regular intervals, including recording primary observations and water quality data on standardized data sheets;
- Review of datasheets by senior laboratory staff;
- Test termination activities (measurements, health assessment) conducted by qualified staff members using standardized datasheets to ensure consistent assessment of abnormalities and growth across all test sites and controls;
- Use of standard laboratory water and environmental chambers to maintain test organisms.

4.0 RESULTS

4.1 Fall 2021

4.1.1 Water Quality Measurements

Water quality measurements for the Fall 2021 monitoring event are summarized Table 1.

Table 1. Summary of mean, with (standard deviation) and [range], of water quality measurements collected during site visits and laboratory exposure (Fall 2021).

Creek	Temperature (°C)	Dissolved Oxygen (mg/L)	pH (units)	Specific Conductance (µS/cm)
Control	11.0 (1.0) [9.5 – 12.1]	8.3 (0.4) [7.7 – 9.2]	7.88 (0.13) [7.62 – 8.1]	296.3 (13.3) [275 - 315]
Miller Creek	9.9 (1.2) [9.0 – 11.1]	10.5 (0.4) [9.9 – 10.8]	7.33 (0.23) [7.21 – 7.66]	202.1 (74.4) [167.2 – 317.7]
Walker Creek	11.0 (1.0) [10.9 – 11.9]	10.0 (1.2) [8.7 – 11.5]	7.22 (0.14) [7.06 – 7.45]	213.0 (26.8) [212.0 – 238.8]
Des Moines Creek Lower	10.5 (1.4) [9.4 – 12.2]	9.1 (0.8) [8.4 – 10.0]	6.86 (0.19) [6.61 – 7.02]	120.2 (23.9) [105.3 – 156.7]
Des Moines Creek Upstream	10.5 (1.8) [9.2 – 12.8]	9.6 (0.9) [8.5 – 10.8]	6.83 (0.28) [6.53 – 7.01]	115.0 (31.1) [97.6 – 154.1]

In the Fall 2021 *in situ* tests, temperatures for the four field sites and the control ranged from 9.0 to 12.8°C. Field measurements of pH were within acceptable ranges for rainbow trout laboratory bioassays (6-9 pH units); the pH values were between 6.53 and 8.10. Dissolved oxygen (DO) measurements were within acceptable ranges (60 – 100% saturation); DO ranged from 7.7 to 11.5 mg/L.

Although limited to weekly measurements, the field temperature, DO and pH data suggested good water quality conditions overall, with no indication of potential for adverse effects on organism survival and development.

The conductivity measurements for all four sites did not show much variability throughout the exposure period and remained within ranges tolerated by early life stages of salmonids; measurements ranged between 98 and 318 µS/cm.

4.1.2 Precipitation and Field Observations During the Fall 2021 Event

Field observations during each site visit are presented in Table 2. Precipitation data were provided by STIA. Figure 5 shows the daily precipitation over the duration of the exposure, in conjunction with monitoring milestones and associated observations. A total of 12.82 inches of rainfall fell during the Fall event, with no snow. Hatchboxes were installed on October 19 and the first site visit was on October 27, with weekly site visits thereafter. Standard water quality conditions (temp, pH, and DO) at all sites were generally acceptable throughout the exposure.

At Miller Creek, leaf litter was observed on the bank and in the stream. During the first site visit on October 27, all remaining unhatched eggs in hatchbox 1, 2 and 3 were dead, with no surviving alevins in hatchbox 1, seventeen in hatchbox 2 and one in hatchbox 3; algae was present in hatchbox 3. On November 3, sediment was observed in hatchbox 2, with alevins buried; a worm was also observed in hatchbox 3. The following site visit on November 10, leaf litter and sand were coving all hatchboxes. During termination, sand was also noted on all hatchboxes.

During the first site visit at Walker Creek, eight flatworms were observed in hatchbox 4 and algae in the water. In the following visit, a small red worm was observed in hatchbox 3. On November 10, increased leaf litter was observed in the area. During termination, leaves were observed on hatchboxes 1 and 2 and heavy leaf litter observed in the area.

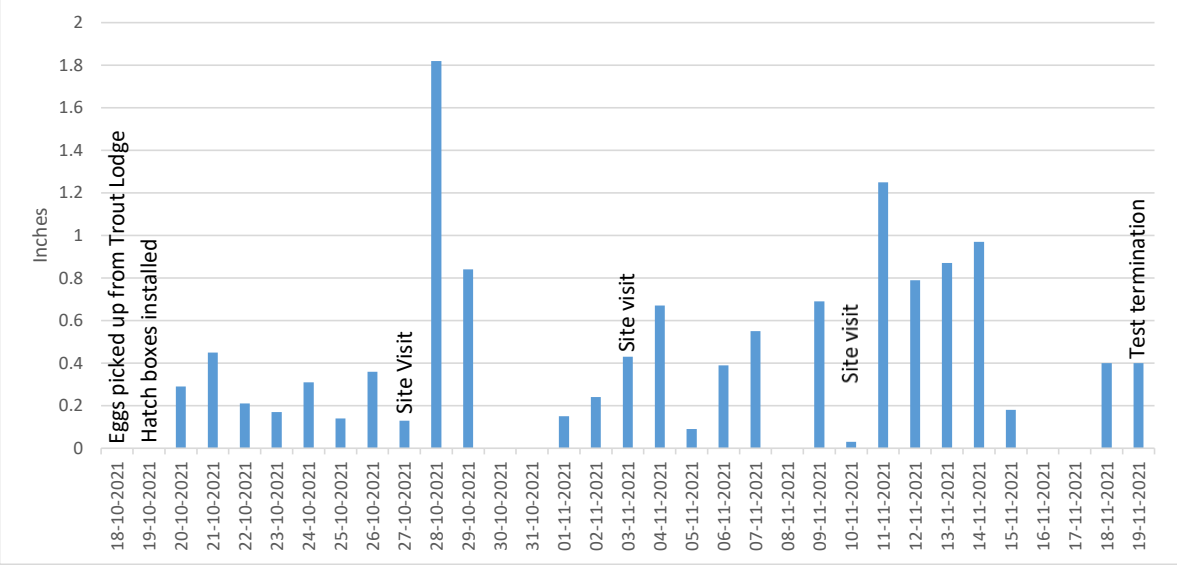
At the Des Moines Creek Lower site, a small amount of algae was observed on hatchbox 4 during the first site visit on October 27. Biofilm and iron associated bacterial growth coated hatchboxes 1 and 2 on November 3; sand was observed in hatchbox 3 and 4 and algae in hatchbox 3. On November 10, brown biofilm was observed on crate 1 and 2 and algae in hatchbox 4. Biological foam was observed in the stream. At termination, algae were present in all hatchboxes; leaf litter in hatchbox 2 and 4; and iron bacteria in hatchbox 2, 3 and 4. Foam was present in the stream.

At the Des Moines Upstream site, leaf litter was in the stream and anthropogenic waste was observed around the site on the initiation date of the test. Algae was present in the stream and on all hatch boxes during the following site visit on October 27, 2021; flatworms were also observed in hatchbox 1. On November 3, sand was observed in crates 1 and 4; leaf litter on crate 2 and some plastic insulation on crate 3. Algae was present on all crates. During the site visit on November 10, coarse sand was found in hatchbox 2 and 3 and algae in hatch box 1 and 4. Hatchbox 4 also had pine needles. During termination, hatchboxes 1, 2 and 4 had sand, leaves and/or branches covering the boxes.

Table 2. Observations made during the Fall 2021 exposure.

Site	Observations				
	October 19, 2021	October 27, 2021	November 3, 2021	November 10, 2021	November 19, 2021
Miller Creek	Leaf litter and branches on bank and stream	Algae present in water; all remaining eggs dead in hatchbox 1, 2 and 3	Sediment in crate and hatchbox 2; worm in hathbox 3; large amount of leaf litter on bank	Leaf litter and sand I hatchbox 2; leaf litter on bank and sand covering all hatchboxes	Sand on all crates and hatchboxes; stream is turbid, lots of down trees and branches
Walker Creek	Dense vegetation, leaf litter and plant debris on bank	Flatworms in hatchbox 4. Algae on alevins; algae in water	Red worm in hatchbox 2 and 3	Leaf litter on bank	Leaves on hatchbox 1 and 2; algae on hatchbox 2; heavy leaf litter on bank
Des Moines Lower	Lots of vegetation coverage on bank; minimal leaf litter	Algae on hatchbox 4	Biofilm and iron bacteria coating hatchbox; hatchbox 3; sand on/in hatchbox 3 and 4; leaf litter on bank	Brown biofilm on crate 1 and 2; algae in hatchbox 4; biological foam in stream	Algae on all hatchboxes; iron bacteria on hatchbox 2,3 and 4; leaves on hatchbox 2 and 4; lots of leaf litter and branches on bank; less foam in stream than previous week, near hatchbox 1
Des Moines Upstream	Leaf litter in stream; anthropogenic waste around site	Green algae present in water and on all hatchboxes; flatworm in hatchbox 1	Sand in crate 1 and 4; leaf litter on crate 2; plastic insulation on crate 3; green algae present on all crates	Algae coating hatchbox 3	Pine needles and sand in hatchbox 1; sand, leaf debris and branches covering hatchbox 2 and 4 and observed on bank

Figure 5. Daily rainfall during the Fall 2021 exposure.



4.1.3 Fall 2021 *In situ* exposure metrics

Data for the Fall sampling event are summarized in Tables 3 and 4, and are presented graphically in Figures 7 through 9.

Hatching success – Mean hatching success for the laboratory controls was 100%, compared with 39.2% at Miller Creek, 92.5% at Walker Creek, 87.5% at Des Moines Creek Lower, and 71.7% at Des Moines Creek Upstream. Significant differences in hatching success was observed at Miller Creek and Des Moines Creek Upstream in comparison to the control (Steel Many-One Rank Sum Test). There was no significant difference in hatching success between Des Moines Creek Lower compared to Des Moines Creek Upstream.

Post-hatch survival – Control survival of alevins post-hatch was 100%, compared with 57.0% at Miller Creek, 88.5% at Walker Creek, 91.9% at Des Moines Creek Lower, and 36.3% at Des Moines Creek Upstream. Post-hatch survival was significantly lower at Miller Creek and Des Moines Creek Upstream compared to the control (Bonferroni Adj t Test). There was a significant difference in post-hatch survival between Des Moines Creek Lower compared to Des Moines Creek Upstream, with the upstream site having lower survival.

Cumulative survival – Control survival from initiation to termination of the test averaged 100%. Cumulative survival at the exposure sites averaged 32.5% at Miller Creek, 82.5% at Walker Creek, 80.0% at Des Moines Creek Lower, and 26.7% at the Des Moines Creek Upstream site. Survival was significantly reduced relative to the controls at Miller Creek and Des Moines Creek Upstream (Dunnett Multiple Comparison Test). There was no significant difference in cumulative survival at Des Moines Creek Lower compared to Des Moines Creek Upstream.

Commented [BK1]: Is this true?

Abnormalities – There were few abnormalities observed across treatments: one occurred in Miller Creek and two at Des Moines Creek Lower. All the observed deformities were in the spine.

Growth – Average weight and length in the controls was 89.3 mg and 24.1 mm, respectively. Miller Creek fish averaged 110.2 mg and 24.6 mm, fish exposed at Walker Creek averaged 108.8 mg and 25.7 mm, Des Moines Creek Lower averaged 106.5 mg and 25.4 mm, and Des Moines Creek Upstream fish averaged 100.5 mg and 24.7 mm, for weight and length, respectively. No significance in either endpoint was observed when compared to the control (Bonferroni Adj t Test). There was no significant difference in either growth endpoints at Des Moines Creek Lower compared to Des Moines Creek Upstream.

Table 3. Hatching success, survival and abnormality in the control and field treatment groups (Fall 2021).

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	100 (0.0)	100 (0.0)	100 (0.0)	0.0 (0.0)
Miller Creek	39.2 (46.3)	57.0 (49.4)	32.5 (39.5)	2.2 (3.1)
Walker Creek	92.5 (8.8)	88.5 (10.4)	82.5 (16.6)	0.0 (0.0)
Des Moines Creek Lower	87.5 (14.5)	91.9 (7.6)	80.0 (12.5)	2.5 (2.8)
Des Moines Creek Upstream	71.7 (22.0)	36.3 (32.8)	26.7 (30.4)	0.0 (0.0)

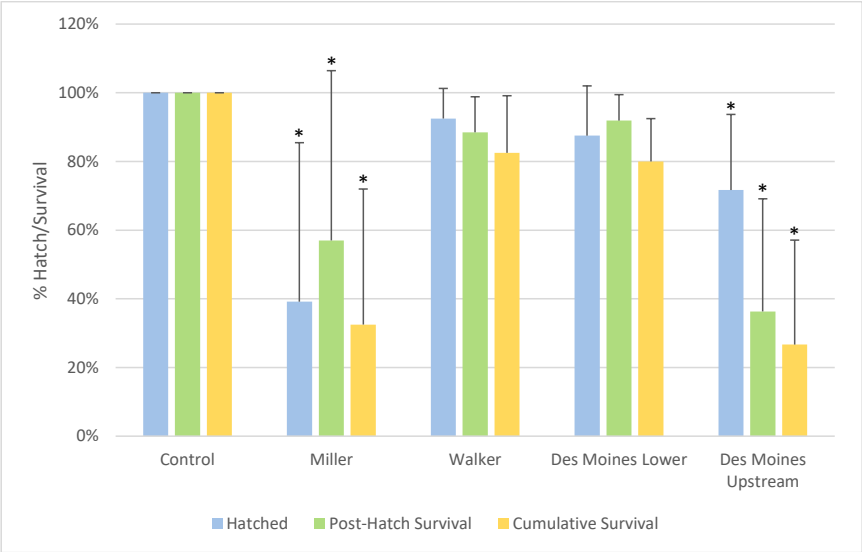
Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control

Table 4. Growth in the control and field treatment groups (Fall 2021).

Site	Length (mm)	Weight (mg)
Control	24.1 (0.9)	89.3 (2.7)
Miller Creek	24.6 (0.5)	110.2 (0.3)
Walker Creek	25.7 (0.3)	108.8 (2.9)
Des Moines Creek Lower	25.4 (0.4)	106.5 (2.6)
Des Moines Creek Upstream	24.7 (0.8)	100.5 (10.0)

Notes:
1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control

Figure 6. Hatching success, post-hatch survival, and cumulative survival in the field and control treatment groups (Fall 2021).



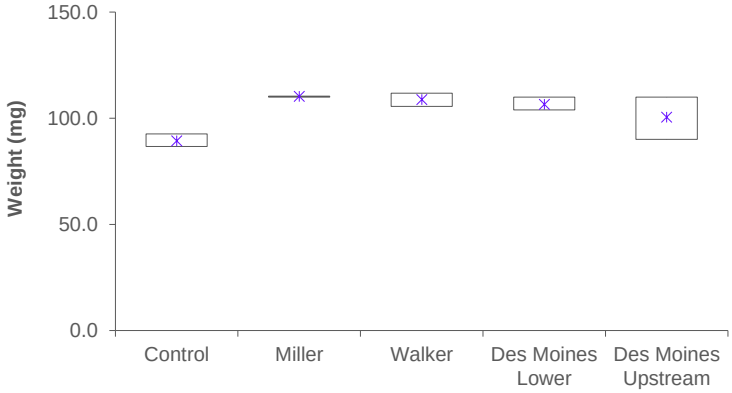
Error bars are standard deviations; asterisks denote significant difference from control.

Figure 7. Average lengths for the laboratory control and exposure sites (Fall 2021).



Data point is the average; box represents range of minimum to maximum values.

Figure 8. Average weights for the laboratory control and exposure sites (Fall 2021).



Data point is the average; box represents range of minimum to maximum values.

4.2 Spring 2022

4.2.1 Water Quality Measurements

Water quality measurements for the Spring 2022 monitoring event are summarized in Table 5.

Table 5. Summary of mean, with (standard deviation) and [range], of water quality measurements collected during site visits and laboratory exposure (Spring 2022).

Creek	Temperature (°C)	Dissolved Oxygen (mg/L)	pH (units)	Specific Conductance (µS/cm)
Control	9.7 (0.7) [8.9 – 11.9]	9.0 (0.3) [8.2 – 9.7]	7.86 (0.22) [7.1 – 8.2]	304.3 (23.7) [284 – 355]
Miller Creek	8.7 (1.1) [7.7 – 10.5]	11.4 (1.5) [9.7 – 13.5]	7.56 (0.35) [7.1 – 8.0]	257 (64.4) [154.8 – 327.9]
Walker Creek	10.3 (0.9) [9.3 – 11.6]	10.3 (1.2) [9.1 – 11.8]	7.41 (0.29) [7.0 – 7.7]	287.8 (21.7) [263.7 – 320.4]
Des Moines Creek Lower	10.2 (1.0) [9.4 – 11.9]	10.1 (0.7) [9.3 – 11.0]	7.04 (0.31) [6.6 – 7.4]	164.1 (20.5) [147.3 – 199.1]
Des Moines Creek Upstream	11.5 (1.6) [10.2 – 12.5]	10.4 (1.3) [9.7 – 12.1]	6.88 (0.41) [6.3 – 7.4]	152.3 (14.6) [147.6 – 175]

Temperatures among the four field sites and the control ranged from 7.7 to 12.5°C. Field measurements of pH were within acceptable ranges for rainbow trout laboratory bioassays (6-9 pH units); the pH values were between 6.3 and 8.2. Dissolved oxygen measurements were generally within acceptable ranges (80 – 100% saturation), although several readings during the test initiation and the third site visit indicated super-saturation of between 103 and 113%; dissolved oxygen ranged from 8.2 to 13.5 mg/L. Conductivity readings were similar at each site between each visit and ranged between 147 and 355 µS/cm.

The field temperature, dissolved oxygen and pH data suggested good water quality conditions overall, with limited indication of potential for adverse effects on organism survival and development. Supersaturation of dissolved oxygen recorded at Miller, Walker and Des Moines Creek Upstream on April 6 and Miller Creek on April 20 are unusual but would not be expected to cause adverse effects unless total gases were supersaturated.

4.2.2 Precipitation and Field Observations During the Spring 2022 Event

Field observations during each site visit are presented in Table 6. The daily rainfall for the duration of the Spring 2022 exposure is shown in Figure 9. The largest amount of rain (0.51 inches) was observed on April 30, 2022. A total of 2.58 of rain fell and no snow occurred during the exposure period. Hatchboxes were installed on April 6, 2022, with weekly site visits thereafter.

At Miller Creek, an earthworm was observed in the rocks in hatchbox 2 and mayflies in hatchbox 4 during the first site visit on April 12, 2022. A small amount of sedimentation was observed in hatchboxes at termination on May 4, 2022.

At Walker Creek, green algae was observed growing on the rocks and hatchboxes on April 12, 2022 and freshwater shrimp were found in hatchbox 2. The mesh screen on the bottom of hatchbox 3 was partially detached and the box was replaced to prevent loss of fish. During the following site visit on April 20, a small amount of algae was observed on hatchbox 2.

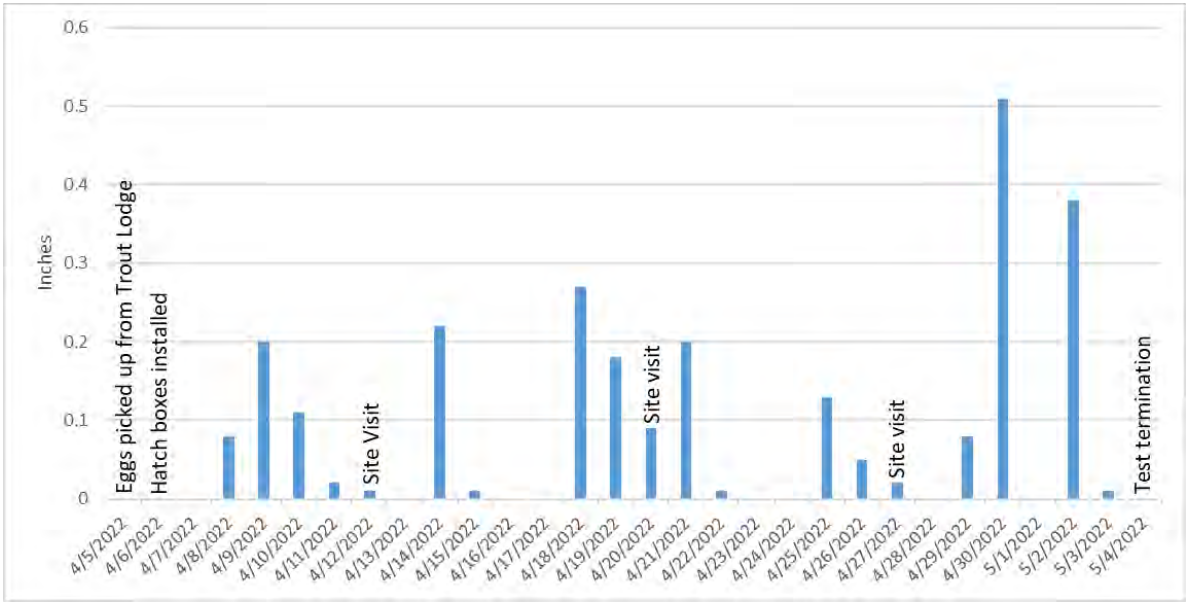
At Des Moines Lower, algal growth was observed in hatchboxes 1 and 2. A small amount of sediment was also observed in hatchbox 2. At termination, a foul odour was noted at the site for hatchboxes 1 and 2.

Brown algae was observed on the hatchboxes and in the water during the first site visit at Des Moines Upstream. During the following site visit on April 20, 2022, a plastic bag was removed from crate 1; a moderate amount of anthropogenic waste was also observed in the stream, including plastic bags and cigarette butts. On April 27 and May 4, algae was observed on all hatchboxes.

Table 6. Observations made during the Spring 2022 exposure.

Site	Observations				
	April 6, 2022	April 12, 2022	April 20, 2022	April 27, 2022	May 4, 2022
Miller Creek	Small amount of algal growth	Earthworm in rocks in hatchbox 2; mayflies in hatchbox 4	--	--	Some sedimentation in hatchboxes
Walker Creek	Small amount of algal growth	Green algae growing on rocks and hatchboxes; shrimp in hatchbox 2; hatchbox 3 not fully covered and replaced	Algae in hatchbox 2	--	Water clear
Des Moines Lower	No algal growth	Water very clear	Water very clear	Algae growth in hatchbox 1 and 2; a little sediment in hatchbox 2	Foul odour at site for hatchbox 1 and 2
Des Moines Upstream	Small amount of algal growth	Brown algae on hatchboxes and in water	Plastic bag on crate 1; moderate amount of anthropogenic waste in stream including plastic bags and cigarette butts	Algae in all hatchboxes	Algae in all hatchboxes

Figure 9. **Daily rainfall for the duration of the Spring 2022 exposure.**



4.2.3 Spring 2022 *In situ* exposure metrics

Data for the spring sampling event are summarized in Tables 7 and 8, and presented graphically in Figures 10 through 12.

Hatching success – Mean hatching success for the controls was 97.5%, compared with 95.0% at Miller Creek, 93.3% at Walker Creek, 99.2% at Des Moines Creek Lower and 90.8% at Des Moines Creek Upstream. There was no significant difference in hatching success at any site compared to the control (Dunnett Multiple Comparison Test). There was no significant difference in hatching success at Des Moines Lower compared to Des Moines Creek Upstream.

Post-hatch survival – Control survival of alevins post-hatch was 99.2%, compared with 96.5% at Miller Creek, 96.4% at Walker Creek, 95.8% at Des Moines Creek Lower, and 67.1% at Des Moines Upstream. A significant difference was observed at Des Moines Creek Upstream compared to the control (Dunnett Multiple Comparison Test); a significant difference was also observed between Des Moines Creek Lower and Upstream.

Cumulative survival – Control survival from initiation of the test to termination averaged 96.7%, compared with 91.7% at Miller Creek, 90.0% at Walker Creek, 95.0% at Des Moines Creek Lower, and 60.8% at Des Moines Creek Upstream. There was a significant difference at Des Moines Creek Upstream compared to the control (Dunnett Multiple Comparison Test) and a significant difference in cumulative survival between Des Moines Lower and Des Moines Creek Upstream.

Abnormalities – There were few abnormalities observed across treatments, with three in the control and one each in Miller Creek, Des Moines Creek Lower and Des Moines Creek Upstream. The abnormality of the fish in the control and Des Moines Creek Upstream were located in the spine, and the abnormality observed at Miller Creek was in the head.

Growth – Average weight in the controls was 101.9 mg, and length averaged 23.7 mm. In comparison, Miller Creek fish averaged 131.6 mg and 26.1 mm, fish from Walker Creek averaged 140.9 mg and 27.4 mm, fish exposed at Des Moines Creek Lower averaged 134.7 mg and 26.4 mm and fish from Des Moines Creek Upstream average 135.4 mg and 26.7 mm. Neither weight nor length were significantly lower than the control at any sites (Dunnett Multiple Comparison Test). There was also no significant difference in length or weight between Des Moines Lower and Des Moines Creek Upstream.

Table 7. Hatching success, survival and abnormality in the control and field treatment groups (Spring 2022).

Site	Hatch (%)	Post-Hatch Survival (%)	Cumulative Survival (%)	Abnormality (%)
Control	97.5 (3.2)	99.2 (1.7)	96.7 (2.7)	2.6 (3.2)
Miller Creek	95.0 (1.9)	96.5 (2.9)	91.7 (4.3)	0.9 (1.8)
Walker Creek	93.3 (6.1)	96.4 (2.7)	90.0 (6.1)	0.0 (0.0)
Des Moines Creek Lower	99.2 (1.7)	95.8 (6.3)	95.0 (5.8)	0.9 (1.7)
Des Moines Upstream	90.8 (7.4)	67.1 (23.6)	60.8 (20.4)	2.3 (4.6)

Notes:

1. Results are presented as mean and standard deviation
2. Shaded values are significantly different from the control

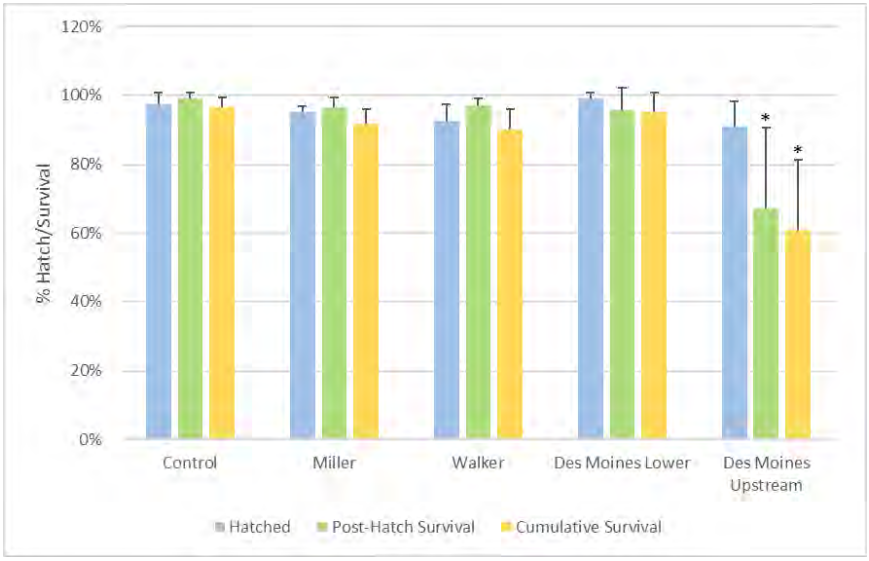
Table 8. Growth in the control and field treatment groups (Spring 2022).

Site	Length (mm)	Weight (mg)
Control	23.7 (0.7)	101.9 (6.6)
Miller Creek	26.1 (0.4)	131.6 (0.9)
Walker Creek	27.4 (0.4)	140.9 (7.6)
Des Moines Creek Lower	26.4 (0.5)	134.7 (6.2)
Des Moines Upstream	26.7 (0.4)	135.4 (5.1)

Notes:

1. Results are presented as mean and standard deviation

Figure 10. Hatching success, post-hatch survival, and cumulative survival in the field and control treatment groups (Spring 2022).



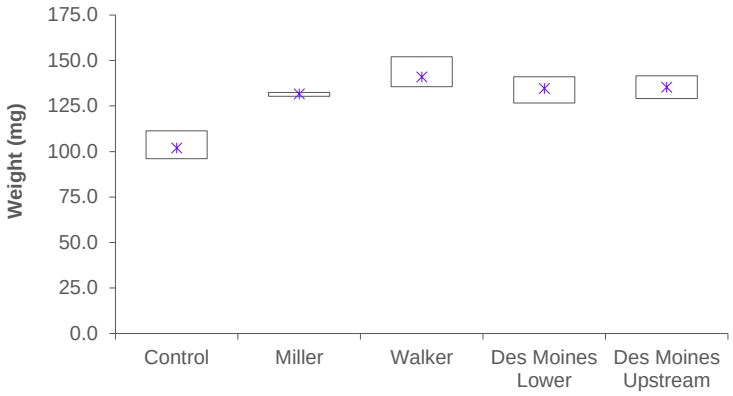
Error bars are standard deviations.

Figure 11. Average lengths for the laboratory control and exposure sites (Spring 2022).



Data point is the average; box represents range of minimum to maximum values.

Figure 12. Average weights for the laboratory control and exposure sites (Spring 2022).



Data point is the average; box represents range of minimum to maximum values.

5.0 DISCUSSION

There were only adverse effects associated with lethal measurements, such as hatching success and survival for alevins exposed in Miller Creek and Des Moines Creek Upstream during the Fall event and at Des Moines Creek Upstream during the Spring event. A statistically significant reduction in survival was observed in Miller Creek during the Fall event and in Des Moines Creek Upstream in both test events. Respectively, during the fall period there was a 60.8 and 28.3% reduction in hatching success and a 43 and 63.7% reduction in post-hatch survival relative to the laboratory control. At the remaining sites during the Fall event, survival was high (≥80%). With the exception of Des Moines Creek Upstream, post-hatch survival was high during the Spring event (≥90%); there was a 32.9% reduction in post-hatch survival at Des Moines Upstream relative to the laboratory control.

Results for cumulative survival, incorporating both effects on hatch rate and survival post hatch, provided the best measure of adverse effects in the *in situ* exposures reported here. In the Fall 2021 event, cumulative survival in the exposure sites ranged from 26.7 to 82.5%, and was significantly decreased at Miller (32.5%) and Des Moines Creek Upstream (26.7%) compared to the control (100% survival).

A high degree of egg and embryo mortality at Miller Creek and Des Moines was observed with the first site visit on October 27, 2021 during the Fall event, contributing to low cumulative survival numbers. Water quality measurements during the site visit were within acceptable ranges; therefore, the cause of mortality cannot be determined as water quality impairments, although observations are limited to the weekly site visits. No signs of predation or sedimentation were observed; however, a high degree of algae accumulation was observed within the hatchboxes at these locations during the initial visit and may have caused high mortality. Low overall cumulative survival through the remaining study period was likely impacted by a combination of high stream flows and sedimentation loads. Total rainfall through the 31 day fall study period was 12.82 inches, which is significantly higher than the Port's recorded long term monthly rainfall averages for October (4.24 inches) and November (6.36 inches). Both the overall volume and the moderate-high intensity of rainfall events throughout the study period lead to elevated streamflow conditions capable of carrying above average loads of late summer algae and sediment.

In the Spring 2021 event, cumulative survival ranged from 60.8 to 95.0% across the sites, compared with 96.7% in the control, with only Des Moines Creek Upstream being significantly lower than the control.

Of note, significant adverse effects were observed in both Fall 2021 and Spring 2022 events at the Des Moines Creek Upstream site, with reduced post-hatch survival and cumulative survival during both Fall and Spring events, and reduced hatching success in the Fall. With the exception of the Spring 2015 (Nautilus Environmental 2015), Spring 2018 (Nautilus Environmental 2018) and the Spring 2020 (Nautilus Environmental 2020) testing events, Des Moines Upstream has generally exhibited evidence of adverse effects, suggesting an ongoing pattern of impaired water quality upstream of STIA inputs, including anthropogenic waste often being observed at the site or in the creek.

In general, creek conditions and water quality parameters remained within suitable ranges for the duration of the both testing events and were unlikely to have contributed to any adverse effects observed. However, some exceedances were notable, including dissolved oxygen measurements that exceeded saturation during the Spring 2022 event. Elevated levels of total dissolved gas (TDG), which includes dissolved oxygen, can be harmful to salmonids (Carter 2008), and USEPA (1986) has set a criterion for TDG stating that levels should not exceed 110% of saturation. In most instances during the Spring event, dissolved oxygen was ≤110% saturation, and it is unknown if the supersaturated oxygen resulted in supersaturated TDG or not.

6.0 REFERENCES

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APPENDIX D

Biological Resources

ESA & Sensitive Species Memorandum

CONFLUENCE
ENVIRONMENTAL COMPANY

To: Erik Schwenke, Landrum & Brown
cc: Steve Rybolt, Port of Seattle | Sea-Tac International Airport

From: Eric Doyle

Date: September 11, 2023

Re: 2023 Revised SAMP Endangered Species Act and sensitive species field assessment and existing conditions review

Enclosures: Attachment 1

This document is the 2023 updated version of a previous memorandum prepared by Confluence Environmental Company (Confluence) on behalf of Landrum & Brown and the Port of Seattle (the Port) to support the Sustainable Airport Master Plan (SAMP) Near Term Projects (NTPs) Environmental Review. This memorandum was developed to support evaluation of federal and state protected species concerns related to Near Term Project development to inform future compliance with Endangered Species Act (ESA), Washington State Environmental Policy Act (SEPA), and other regulatory requirements. The prior version was provided to the Port on September 29, 2021, with revisions by Landrum & Brown in January 2022. This revised memorandum has been updated to include current ESA-listed species status and sensitive species occurrence information for the study area, referred to hereafter as the general study area (GSA).

1.0 REGULATORY FRAMEWORK

The regulatory framework for this review includes:

- Section 7(a)(2) of the federal ESA of 1973, as amended
- The Migratory Bird Treaty Act (MBTA) (16 U.S.C. 703-712)
- The Bald and Golden Eagle Protection Act (BGPA) (16 U.S.C. 668; 50 CFR 22)
- The Washington State Environmental Policy Act (SEPA) RCW 43.21C
- Washington Threatened, Endangered, and Sensitive Species as defined under WAC 220-610-110

This review considers the documented or potential presence of federally and state-protected species and habitats, including ESA critical habitat, in the vicinity of the GSA defined for this review, and the potential for measurable effects on these species or habitats resulting from

SAMP NTP development. The GSA includes the development footprint of SAMP NTP development, also referred to as the study area, and the anticipated extent of measurable stormwater effects from this future development.

2.0 RESEARCH METHODS

Confluence developed this review using the GSA developed for the SAMP Environmental Assessment and assembling the best available science and information on ESA-listed species occurrence within the GSA and vicinity. The information review was supported by vehicle and foot reconnaissance of affected habitats within the GSA, supplemented by site-specific knowledge of parts of the GSA from past projects, including environmental compliance for Sound Transit light rail development and SR-518 improvements.

The Confluence staff assigned to this project are knowledgeable biologists with years of experience conducting ESA Section 7 consultations in the region. We relied on this experience and available information to define the GSA, assess the likelihood of protected species occurrence, and characterize potential effects on those species and protected habitats resulting from SAMP NTP development.

2.1 General Study Area

The GSA encompasses the extent of SAMP NTP study area and surrounding areas that could measurably impacted by project development. This includes the headwaters of tributary streams potentially affected by changes in stormwater runoff from existing and new impervious surfaces and industrial discharges resulting from the SAMP. These are the headwaters of the Miller/Walker Creek and Des Moines Creek drainages to Puget Sound, and the Gilliam Creek drainage to the Green River. The GSA comprises:

1. The development footprint for the proposed SAMP NTPs and immediate surroundings within or adjacent to Seattle-Tacoma International Airport (see Exhibit 1), and;
2. The reasonably foreseeable extent of measurable direct and indirect effects resulting from project construction and operation, including stormwater discharge (see Appendix J, Environmental Assessment).[1]

The GSA is composed of currently developed areas (buildings, paved surfaces), as well as managed vegetated habitats within and adjacent to the airport boundary. Vegetated habitats include managed strips adjacent to runways and taxiways, open fields and shrublands, forested

[1] The Port has evaluated stormwater

areas, stormwater ponds, and wetlands. These habitats are managed for tree height and wildlife control to maintain aircraft safety. Many vegetated habitats around the outer edge of the GSA were previously developed for residential and recreational uses (e.g., city park lands). These properties were subsequently purchased and cleared for airport noise mitigation and other purposes and have revegetated over time.

2.2 Information Sources

Confluence relied on the following information sources to determine potential ESA-listed species and critical habitat occurrence in the GSA:

- The SAMP NTP GSA (Exhibit 1)
- An October 9, 2019 reconnaissance survey of affected habitats within the study area guided by Port of Seattle staff
- Knowledge of the Gilliam Creek drainage from a prior foot survey conducted by Confluence staff in 2009
- The Washington Department of Fish and Wildlife (WDFW 2019a, 2021a, 2023a) Priority Habitats and Species (PHS) database
- The WDFW SalmonScape database (WDFW 2019b, 2021b, 2023b)
- The WDFW state sensitive species list (WDFW 2019c, 2021c, 2023c)
- The U.S. Fish and Wildlife Service (USFWS 2019, 2021, 2023) iPac list of threatened and endangered species and designated critical habitat known or likely to occur in the GSA and vicinity
- National Oceanographic and Atmospheric Administration (NOAA Fisheries 2019, 2021, 2023) lists of threatened and endangered species and designated critical habitat known or likely to occur in the GSA and vicinity
- A list of wildlife species observed within the GSA from periodic monitoring activities and studies conducted by the Port of Seattle (2019, 2023)
- A 2014 review of potential ESA compliance concerns prepared for the Port of Seattle (Anchor QEA 2014)
- The Miller and Walker Creeks Basin Plan (Miller and Walker Creek Executive Committee 2006)
- Gray literature on the Miller Creek and Walker Creek drainages (Batcho 2009; King County 2011)
- The City of Tukwila Surface Water Comprehensive Plan (CH2MHill 2013)

3.0 RESULTS

The results of this review include:

- Identification of ESA-listed and proposed species, and designated proposed critical habitat that the USFWS and NOAA Fisheries identify as known or potentially occurring in the project vicinity;
- Identification of other federally protected species known or potentially occurring in the project vicinity;
- Identification of state protected species known or potentially occurring in the project vicinity
- Analysis of the likelihood of those species occurring in the GSA;
- The potential effects of SAMP NTP implementation on those species and their habitats.

3.1 ESA-Listed Species and Critical Habitat in GSA Vicinity

The USFWS and NOAA Fisheries lists obtained for this review indicate that several ESA-listed animal species and designated critical habitat occur in the vicinity of the GSA. These species lists are broadly defined and consider species presence within approximately 50 miles of a designated point of interest or are simply maps of regional listed species distribution and critical habitat designations. As such, they include several species that are not likely to occur in the GSA for a variety of reasons, including unsuitable habitat conditions, regional extirpation, and/or documented lack of occurrence over several years. ESA-listed animal species and designated critical habitat occurrence in the general vicinity and documented or potential occurrence in the GSA are summarized in Table 1.

One ESA-listed plant species have been documented in King County, the federally endangered swamp sandwort (*Arenaria paludicola*) (58 FR 41378). The swamp sandwort historically occurred in swamps and freshwater marshes in proximity to marine shorelines in Puget Sound. This species no longer occurs in King County and has most likely been extirpated from Washington State (Washington Natural Heritage Program 2021; WDNR 2021). Golden paintbrush, a previously ESA-listed species, was formally delisted on July 19, 2023. USFWS determined that delisting was warranted because all remaining populations are protected on appropriately managed public lands and the species has been successfully reintroduced at several sites within its native range (88 FR 46088). Golden paintbrush historically occurred in King County but is now exceedingly rare. This species is associated with open meadow and prairie habitats on glacial outwash plains in the Puget Sound Lowlands at 10 to 300 feet elevation (Washington Natural Heritage Program 2021; WDNR 2021). The GSA lacks suitable habitat for this species and it has not been documented in the vicinity.

Table 1. ESA-listed animal species and designated critical habitat occurring in the vicinity of the Airport and likelihood of occurrence in the GSA.

Species	Listing Status	Critical Habitat	Known or Likely to Occur in GSA		Rationale
			Species	Critical Habitat	
North American Wolverine	Proposed Threatened 10/08/2016 81 FR 71670	Not designated	No	No	The developed Puget Sound lowlands do not provide suitable habitat for this species.
Marbled murrelet – Washington, Oregon, and California	Threatened 10/01/1992 57 FR 45328	Designated 08/04/2016 81 FR 51348	No	No	This species is primarily marine but nests in large coniferous trees in mature, predominantly old growth, forests. These habitats do not occur in the GSA.
Yellow-billed cuckoo – Western U.S.	Threatened 11/03/2014 79 FR 59991	Designated 12/02/2014 79 FR 71373	No	No	This species has been extirpated from Washington State and occurs only as a periodic migrant. The GSA does not provide suitable habitat.
Bull trout – Coastal-Puget Sound	Threatened 11/01/1999 64 FR 58910	Designated 10/18/2010 75 FR 63898	No	No	Foraging adult and subadult bull trout may occur in the Green River and nearshore marine habitats of Puget Sound. The GSA is inaccessible to and does not contain suitable habitat for bull trout and is outside of designated critical habitat for this species.
Chinook Salmon – Puget Sound	Threatened 06/28/2005 70 FR 37160	Designated 09/02/2005 70 FR 52685	No	No	Chinook occur in proximity to the GSA in nearshore areas of Puget Sound and in migratory and rearing habitats the Green River. The GSA is inaccessible to and does not contain suitable habitat for Chinook salmon and is outside of designated critical habitat for this species.
Steelhead – Puget Sound	Threatened 05/11/2006 72 FR 26722	Designated 09/08/2008 73 FR 55451	No	No	Migrating adult and juvenile steelhead may occur in proximity to the GSA in migratory habitats in the Green River. The GSA is inaccessible to and does not contain suitable habitat for steelhead and is outside of designated critical habitat for this species.
Yelloweye Rockfish – Puget Sound/Georgia Basin	Endangered 3/24/2017 82 FR 7711	Designated 11/3/2014 79 FR 68042	No	No	The GSA is comprised entirely of terrestrial upland and freshwater habitats unsuitable for obligate marine species.
Bocaccio Rockfish – Puget Sound/Georgia Basin	Threatened 4/28/2010 75 FR 22276	Designated 11/3/2014 79 FR 68042	No	No	

Species	Listing Status	Critical Habitat	Known or Likely to Occur in GSA		Rationale
			Species	Critical Habitat	
Southern Resident Killer Whale	Endangered 11/18/2005 70 FR 69903	Proposed 10/19/2019 84 FR 55530	No	No	
Humpback Whale – Mexico and Central America	Mexico DPS Threatened Central America DPS Endangered 12/21/2016 81 FR 93639	Proposed 10/19/2019 84 FR 55530	No	No	

3.1.1 Likelihood of ESA-Listed Species Occurrence in the GSA

The best available science and information indicates that no ESA-listed species or designated critical habitat are present within the SAMP NTP GSA. This conclusion is supported by the fact that the developed areas of the Seattle-Tacoma International Airport and immediate surroundings do not provide suitable habitat for any listed species, with the possible exception of the streaked horned lark. This species relies on short grass prairie habitats and is known to occur in managed grasslands between runways and taxiways at other airports elsewhere in the Puget Sound region. However, streaked horned lark has not been observed in annual wildlife surveys conducted by the Port of Seattle (2019, 2023) and the Seattle-Tacoma International Airport lies is outside the range of currently occupied habitat (USFWS 2019). This indicates that the streaked horned lark is unlikely to occur in the GSA in the near-term. While the species range could conceivably expand in the future, the North Puget Lowlands, including the GSA, are not included in current recovery objectives (USFWS 2019). Therefore, the GSA should not be considered potential habitat for the purpose of ESA consultation.

The GSA does not overlap habitats known or potentially used by any ESA-listed fish species or designated critical habitats (NMFS 2021; USFWS 2021). While several listed species are known to occur in the general proximity, they have not been documented within the GSA boundary, cannot currently access the habitats therein, and would be unlikely to do so for the foreseeable future because these habitats are unsuitable. As stated, the Port of Seattle has identified and/or committed to sufficient stormwater and industrial wastewater controls to fully offset water quantity and water quality impacts from SAMP Near-Term Project development. No measurable stormwater impacts would occur within the Gilliam Creek, Miller/Walker Creek and Des Moines Creek systems, the only potentially suitable freshwater habitats for ESA-listed salmonids are located downstream of the GSA.

3.1.2 Potential SAMP Near Term Project Effects on ESA-Listed Species and Habitats

Based on the best available science and information and the conservative GSA boundary used in this assessment, the SAMP NTPs do not appear to trigger formal consultation requirements under Section 7 of the ESA. No ESA-listed species are documented or likely to occur within the GSA and no designated critical habitat occurs within this boundary. Therefore, no measurable effects on listed species or their habitats are likely to occur.

3.2 Other Federally Protected Species Occurring in the GSA

The other relevant federal regulations considered in this review are the MBTA and BGPA, which afford various protections to a broad range of native bird species. All bird species in Washington State, except for non-native European starlings, rock doves (pigeons) and English

house sparrows, are protected under the MBTA. Table 2 provides a list of MBTA-protected species observed on Seattle-Tacoma International Airport property in annual surveys conducted by Port of Seattle staff and their contractors. The Port of Seattle has documented bald eagle occurrences within the GSA. There are no bald eagle nesting or roosting sites documented in the GSA or surrounding proximity in the PHS database (WDFW 2023a). The golden eagle does not commonly occur west of the Cascades and has not been observed in the GSA (Port of Seattle 2019, 2023; WDFW 2023a).

Table 2. Federally protected bird species documented within the GSA.

Species	Observed in 2019	Observed 2020-2023	Federal Protection Status
American bittern	●	●	MBTA
American coot	●	●	MBTA
American crow	●	●	MBTA
American goldfinch	●	●	MBTA
American kestrel	●	●	MBTA
American pipet	●	●	MBTA
American robin	●	●	MBTA
American tree sparrow	--	●	MBTA
American wigeon	●	●	MBTA
Anna's hummingbird	●	●	MBTA
Bald eagle	●	●	MBTA, BGPA
Band-tailed pigeon	--	●	MBTA
Bank swallow	--	●	MBTA
Barn own	●	●	MBTA
Barn swallow	●	●	MBTA
Barred owl	●	●	MBTA
Barrow's goldeneye	--	●	MBTA
Belted kingfisher	●	●	MBTA
Bewick's wren	●	●	MBTA
Black swift	--	●	MBTA
Black-capped chickadee	●	●	MBTA

Species	Observed in 2019	Observed 2020-2023	Federal Protection Status
Black-headed grosbeak	●	--	MBTA
Black-throated gray warbler	●	--	MBTA
Blue-winged teal	●	--	MBTA
Broad-winged hawk	--	●	MBTA
Brown creeper	●	--	MBTA
Brown-headed cowbird	●	●	MBTA
Bufflehead	●	●	MBTA
Bushtit	●	●	MBTA
Cackling goose	●	●	MBTA
California gull	--	●	MBTA
California quail	●	●	MBTA
Canada goose	●	●	MBTA
Canvasback	--	●	MBTA
Caspian tern	--	●	MBTA
Cedar waxwing	●	●	MBTA
Chestnut-backed chickadee	●	--	MBTA
Chipping sparrow	--	●	MBTA
Cliff swallow	●	●	MBTA
Common goldeneye	●	--	MBTA
Common merganser	●	●	MBTA
Common nighthawk	--	●	MBTA
Common raven	●	●	MBTA
Common yellowthroat	●	●	MBTA
Cooper's hawk	●	●	MBTA
Dark-eyed junco	●	●	MBTA
Dickcissel	--	●	MBTA
Double-crested cormorant	●	●	MBTA
Dowitcher	●	--	MBTA

Species	Observed in 2019	Observed 2020-2023	Federal Protection Status
Downy woodpecker	●	●	MBTA
Dunlin	--	●	MBTA
Eared grebe	●	●	MBTA
Evening grosbeak	●	--	MBTA
Fox sparrow	--	●	MBTA
Gadwall	●	●	MBTA
Glaucous-winged gull	●	●	MBTA
Golden-crowned kinglet	●	●	MBTA
Golden-crowned sparrow	●	--	MBTA
Gray-cheeked thrush	--	●	MBTA
Great blue heron	●	●	MBTA
Great horned owl	●	●	MBTA
Greater scaup	--	●	MBTA
Greater white-fronted goose	●	●	MBTA
Greater yellowlegs	--	●	MBTA
Green heron	●	●	MBTA
Green-winged teal	●	●	MBTA
Hammond's flycatcher		●	MBTA
Hairy woodpecker	●	--	MBTA
Hermit thrush	--	●	MBTA
Herring gull	--	●	MBTA
Hooded merganser	●	●	MBTA
Horned grebe	--	●	MBTA
Horned lark ssp.	●	●	MBTA
House finch	●	●	MBTA
House wren	●	●	MBTA
Killdeer	●	●	MBTA
Lazuli bunting	●	●	MBTA

Species	Observed in 2019	Observed 2020-2023	Federal Protection Status
Least sandpiper	--	●	MBTA
Lesser nighthawk	--	●	MBTA
Lesser scaup	●	●	MBTA
Lincoln's sparrow	--	●	MBTA
Long-eared owl	--	●	MBTA
Macgillivray's warbler	--	●	MBTA
Mallard	●	●	MBTA
Marsh wren	●	--	MBTA
Merlin	●	●	MBTA
Mountain bluebird	--	●	MBTA
Mourning dove	●	●	MBTA
Northern flicker	●	●	MBTA
Northern harrier	●	●	MBTA
Northern pintail	●	●	MBTA
Northern shoveler	●	●	MBTA
Northern shrike	●	●	MBTA
Northwestern crow	●	●	MBTA
Orange-crowned warbler	--	●	MBTA
Osprey	●	●	MBTA
Ovenbird	--	●	MBTA
Pacific golden plover	--	●	MBTA
Pacific slope flycatcher	--	●	MBTA
Palm warbler	--	●	MBTA
Pectoral sandpiper	--	●	MBTA
Peregrine falcon	●	●	MBTA
Pied-billed grebe	●	●	MBTA
Pileated woodpecker	●	●	MBTA
Pine siskin	●	●	MBTA

Species	Observed in 2019	Observed 2020-2023	Federal Protection Status
Purple martin	--	●	MBTA
Red-breasted merganser	●	●	MBTA
Red-breasted nuthatch	●	--	MBTA
Red-breasted sapsucker	●	●	MBTA
Red-necked grebe	--	●	MBTA
Red-necked phalarope	--	●	MBTA
Red-shouldered hawk	●	--	MBTA
Red-tailed hawk	●	●	MBTA
Red-winged blackbird	●	●	MBTA
Ring-billed gull	--	●	MBTA
Ring-necked duck	●	●	MBTA
Rough-legged hawk		●	MBTA
Ruby-crowned kinglet	●	●	MBTA
Ruddy duck	●	●	MBTA
Rufous hummingbird	●	●	MBTA
Savannah sparrow	●	●	MBTA
Sharp-shinned hawk	●	●	MBTA
Short-eared owl	●	●	MBTA
Snow bunting	●	●	MBTA
Snow goose	●	●	MBTA
Snowy owl	--	●	MBTA
Song sparrow	●	●	MBTA
Sora	--	●	MBTA
Spotted sandpiper	●	--	MBTA
Spotted towhee	●	●	MBTA
Swainson's hawk	●	●	MBTA
Swainson's thrush	●	●	MBTA
Townsend's warbler	●	●	MBTA

Species	Observed in 2019	Observed 2020-2023	Federal Protection Status
Tree swallow	●	●	MBTA
Tundra swan	--	●	MBTA
Turkey vulture	●	●	MBTA
Varied thrush	●	●	MBTA
Vaux swift	--	●	MBTA
Violet-green swallow	●	●	MBTA
Warbling vireo	--	●	MBTA
Western grebe	--	●	MBTA
Western gull	--	●	MBTA
Western meadowlark	●	●	MBTA
Western sandpiper	●	●	MBTA
Western screech owl	--	●	MBTA
Western tanager	--	●	MBTA
Western wood pewee	●	--	MBTA
Whimbrel	●	●	MBTA
White-crowned sparrow	●	●	MBTA
White-throated sparrow	--	●	MBTA
White-throated swift	--	●	MBTA
Willow flycatcher	●	--	MBTA
Wilson's snipe	--	●	MBTA
Wilson's warbler	●	●	MBTA
Winter wren	●	●	MBTA
Wood duck	●	●	MBTA
Yellow warbler	●	●	MBTA
Yellow-headed blackbird	●	●	MBTA
Yellow-rumped warbler	●	●	MBTA

Notes: -- = No, ● = Yes

Based on the documented presence, the bird species listed in Table 2 and their habitats are likely to be affected by SAMP NTPs development. These effects would include temporary disturbance and disruption during construction activities, and the permanent alteration and loss of suitable habitat in currently undeveloped areas within the proposed development footprint. These likely include nesting, foraging, mating, and juvenile rearing habitats.

3.3 State Protected Species Occurring in the GSA

The Washington Threatened, Endangered, and Sensitive Species list includes species listed under the federal ESA, and other species that are state listed as endangered, threatened, or sensitive that require additional protection and/or management to ensure their survival. ESA-listed species known or likely to occur in the GSA are addressed in Section 3.1. This section addresses other state listed and sensitive species commonly found in terrestrial and freshwater habitats. These species and their likelihood of occurrence in the GSA are identified in Table 3. None of the state-protected species are likely to occur in the GSA based on their current known distribution and/or habitat associations.

Table 3. Washington state protected species not listed under the ESA and likelihood of occurrence in the GSA.

Species	State Status	Likely to Occur in GSA	Basis[a]
Birds			
Sandhill crane	Endangered	No	Seasonal distribution in Washington restricted to specific areas in Yakima and Klickitat counties
Upland sandpiper	Endangered	No	Historical distribution limited to eastern Washington, likely extirpated from state
Tufted puffin	Endangered	No	Distribution limited to coastal marine habitats with rocky outcrops on Washington coast and Strait of Juan de Fuca
Columbian sharp-tailed grouse	Endangered	No	Distribution restricted to eastern Washington
American white pelican	Threatened	No	Distribution restricted to eastern Washington
Ferruginous hawk	Threatened	No	Distribution restricted to southeastern Washington
Common loon	Sensitive	No	Found in association with protected marine waters and large inland waterbodies. These habitats do not occur within the GSA.
Oregon vesper sparrow	Endangered	No	Status review in progress, ESA listing is probable. Two breeding populations are currently documented in

Species	State Status	Likely to Occur in GSA	Basis[a]
			Washington State, one each in Pierce and Thurston Counties.
Mammals			
Western gray squirrel	Threatened	No	Current distribution limited to oak and mixed conifer woodlands in southern Puget Sound lowlands and eastern slopes of the Cascade Range. These habitats do not occur within the GSA.
Fisher	Endangered	No	Species distribution limited to mature/old growth coniferous forest. GSA does not provide suitable habitat.
Reptiles			
Northwestern pond turtle	Endangered	No	Current distribution in western Washington limited to two sites outside of the GSA (Hallock et al. 2017)
Amphibians			
Northern leopard frog	Endangered	No	Distribution restricted to eastern Washington.
Larch mountain salamander	Sensitive	No	Distribution limited to alpine habitats in Cascade Range.
Fish			
Pygmy whitefish	Sensitive	No	Found only in cold alpine streams and deep cold lakes. Suitable habitat does not occur in GSA.
Margined sculpin	Sensitive	No	Current distribution in Washington restricted to cold water streams in southeast corner of state.
Olympic mudminnow	Sensitive	No	GSA is outside of known species range and documented observations.
Invertebrates			
Mardon skipper	Endangered	No	Distribution limited to native grass meadows in southern Washington Cascade Range.
Plants			
Triangular-lobed moonwort	Sensitive	No	Occurs in King County. Distribution limited to elevations above 2,100 feet.
Western moonwort	Sensitive	No	Occurs in King County. Distribution limited to elevations above 2,500 feet.
Alaska harebell	Sensitive	No	Occurs in King County. Distribution limited to elevations above 2,000 feet.
Few-flowered sedge	Sensitive	No	Occurs in King County. Suitable habitat present in GSA (Tub Lake) but species has not been documented.
Long-styled sedge	Sensitive	No	Occurs in King County. Distribution limited to elevations above 2,700 feet.
Clubmoss cassiope	Threatened	No	One documented occurrence in WA at elevations above 1,900 feet.

Species	State Status	Likely to Occur in GSA	Basis[a]
Golden chinquapin	Sensitive	No	Rare in WA. Has not been documented in the GSA or vicinity.
Spleenwort-leaved goldthread	Sensitive	No	Old-growth forest obligate. Suitable habitat does not occur in GSA or vicinity.
Treelike clubmoss	Sensitive	No	Occurs in King County. Distribution limited to elevations above 800 feet.
Black lily	Threatened	No	Occurs in King County in moist, open meadow habitat. Suitable habitat does not occur in GSA or vicinity.
Oregon golden aster	Sensitive	No	Occurs in King County. Habitat limited to gravel bars adjacent to larger rivers. Suitable habitat does not occur in GSA or vicinity.
Canadian St. John's-wort	Sensitive	Possible	Occurs in King County. Wetland obligate species. Species has not been documented in GSA or vicinity but suitable habitat is present.
Pacific pea	Endangered	No	Occurs in King County. Associated with prairie habitat. Suitable habitat does not occur in GSA or vicinity.
One-cone clubmoss	Sensitive	No	Habitat in WA is limited to North Cascades.
Choris' bog-orchid	Threatened	No	Occurs in King County. Distribution in WA limited to elevations above 2,500 feet.
Flat-leaved bladderwort	Sensitive	Possible	Occurs in King County. Wetland obligate species. Species has not been documented in GSA or vicinity but suitable habitat is present.

a Information obtained from WDFW (2021b) and WDNR (2011, 2020) unless otherwise cited.

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CONFLUENCE
ENVIRONMENTAL COMPANY

EXHIBITS



Exhibit 1.
General Study Area

Document Path: J:\Landrum & Brown_001162\001162.004_SEA SAMP_SD12\GIS\Working\Overview Map.mxd --- 9/27/2021 --- by todd.nisley

APPENDIX D

Biological Resources

Species Lists

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Washington Fish And Wildlife Office
510 Desmond Drive Se, Suite 102
Lacey, WA 98503-1263
Phone: (360) 753-9440 Fax: (360) 753-9405

In Reply Refer To: August 17, 2023
Project Code: 2023-0118376
Project Name: Port of Seattle - Sustainable Airport Master Plan

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological

evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

https://www.fws.gov/sites/default/files/documents/endangered-species-consultation-handbook.pdf

Migratory Birds: In addition to responsibilities to protect threatened and endangered species under the Endangered Species Act (ESA), there are additional responsibilities under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA) to protect native birds from project-related impacts. Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). For more information regarding these Acts, see https://www.fws.gov/program/migratory-bird-permit/what-we-do.

The MBTA has no provision for allowing take of migratory birds that may be unintentionally killed or injured by otherwise lawful activities. It is the responsibility of the project proponent to comply with these Acts by identifying potential impacts to migratory birds and eagles within applicable NEPA documents (when there is a federal nexus) or a Bird/Eagle Conservation Plan (when there is no federal nexus). Proponents should implement conservation measures to avoid or minimize the production of project-related stressors or minimize the exposure of birds and their resources to the project-related stressors. For more information on avian stressors and recommended conservation measures, see https://www.fws.gov/library/collections/threats-birds.

In addition to MBTA and BGEPA, Executive Order 13186: *Responsibilities of Federal Agencies to Protect Migratory Birds*, obligates all Federal agencies that engage in or authorize activities that might affect migratory birds, to minimize those effects and encourage conservation measures that will improve bird populations. Executive Order 13186 provides for the protection of both migratory birds and migratory bird habitat. For information regarding the implementation of Executive Order 13186, please visit https://www.fws.gov/partner/council-conservation-migratory-birds.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Code in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List

OFFICIAL SPECIES LIST

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

Washington Fish And Wildlife Office
510 Desmond Drive Se, Suite 102
Lacey, WA 98503-1263
(360) 753-9440

PROJECT SUMMARY

Project Code: 2023-0118376
Project Name: Port of Seattle - Sustainable Airport Master Plan
Project Type: Airport - Maintenance/Modification
Project Description: This iPac project updates the project description and analysis area for the previous Sustainable Airport Master Plan species list request. The project includes a net increase of 75 acres of impervious surface area, with stormwater detention and treatment system improvements as needed to achieve no measurable change in water quality and quantity at points of discharge.

Project Location:

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@47.449925500000006,-122.30843349657927,14z



Counties: King County, Washington

ENDANGERED SPECIES ACT SPECIES

There is a total of 5 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

MAMMALS

NAME	STATUS
North American Wolverine *Gulo gulo luscus* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/5123	Proposed Threatened

BIRDS

NAME	STATUS
Marbled Murrelet *Brachyramphus marmoratus* Population: U.S.A. (CA, OR, WA) There is **final** critical habitat for this species. Your location does not overlap the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/4467	Threatened
Yellow-billed Cuckoo *Coccyzus americanus* Population: Western U.S. DPS There is **final** critical habitat for this species. Your location does not overlap the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/3911	Threatened

FISHES

NAME	STATUS
Bull Trout *Salvelinus confluentus* Population: U.S.A., conterminous, lower 48 states There is **final** critical habitat for this species. Your location does not overlap the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/8212	Threatened

INSECTS

NAME	STATUS
Monarch Butterfly *Danaus plexippus*	Candidate

No critical habitat has been designated for this species.
Species profile: https://ecos.fws.gov/ecp/species/9743

CRITICAL HABITATS

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

YOU ARE STILL REQUIRED TO DETERMINE IF YOUR PROJECT(S) MAY HAVE EFFECTS ON ALL ABOVE LISTED SPECIES.

IPAC USER CONTACT INFORMATION

Agency:	Federal Aviation Administration
Name:	Eric Doyle
Address:	146 N Canal St
Address Line 2:	Suite 111
City:	Seattle
State:	WA
Zip:	98103
Email	eric.doyle@confenv.com
Phone:	2063217314

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Washington Fish And Wildlife Office
510 Desmond Drive Se, Suite 102
Lacey, WA 98503-1263
Phone: (360) 753-9440 Fax: (360) 753-9405
http://www.fws.gov/wafwo/

In Reply Refer To: September 23, 2021
Consultation Code: 01EWFW00-2021-SLI-1776
Event Code: 01EWFW00-2021-E-03785
Project Name: Port of Seattle - Sustainable Airport Master Plan

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, and proposed species, designated and proposed critical habitat, and candidate species that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. The species list is currently compiled at the county level. Additional information is available from the Washington Department of Fish and Wildlife, Priority Habitats and Species website: http://wdfw.wa.gov/mapping/phs/ or at our office website: http://www.fws.gov/wafwo/species_new.html. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 et seq.), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether or not the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species, and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:
http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF

Please be aware that bald and golden eagles are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 et seq.). You may visit our website at http://www.fws.gov/pacific/eagle/for information on disturbance or take of the species and information on how to get a permit and what current guidelines and regulations are. Some projects affecting these species may require development of an eagle conservation plan: (http://www.fws.gov/windenergy/eagle_guidance.html). Additionally, wind energy projects should follow the wind energy guidelines (http://www.fws.gov/windenergy/) for minimizing impacts to migratory birds and bats.

Also be aware that all marine mammals are protected under the Marine Mammal Protection Act (MMPA). The MMPA prohibits, with certain exceptions, the "take" of marine mammals in U.S. waters and by U.S. citizens on the high seas. The importation of marine mammals and marine mammal products into the U.S. is also prohibited. More information can be found on the MMPA website: http://www.nmfs.noaa.gov/pr/laws/mmpa/.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Tracking Number in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Related website:
National Marine Fisheries Service: http://www.nwr.noaa.gov/protected_species/species_list/species_lists.html

Attachment(s):

- Official Species List

Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

Washington Fish And Wildlife Office
510 Desmond Drive Se, Suite 102
Lacey, WA 98503-1263
(360) 753-9440

Project Summary

Consultation Code: 01EWFW00-2021-SLI-1776
Event Code: Some(01EWFW00-2021-E-03785)
Project Name: Port of Seattle - Sustainable Airport Master Plan
Project Type: TRANSPORTATION
Project Description: This iPac project updates the project description and analysis area for the previous Sustainable Airport Master Plan species list request. The project includes a net increase of 75 acres of impervious surface area, with stormwater detention and treatment system improvements as needed to achieve no measurable change in water quality and quantity at points of discharge.

Project Location:

Approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@47.449925500000006,-122.30843349657927,14z



Counties: King County, Washington

Endangered Species Act Species

There is a total of 6 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

Mammals

NAME	STATUS
Gray Wolf *Canis lupus* Population: Western Distinct Population Segment No critical habitat has been designated for this species.	Proposed Endangered

Birds

NAME	STATUS
Marbled Murrelet *Brachyramphus marmoratus* Population: U.S.A. (CA, OR, WA) There is **final** critical habitat for this species. The location of the critical habitat is not available. Species profile: https://ecos.fws.gov/ecp/species/4467	Threatened
Streaked Horned Lark *Eremophila alpestris strigata* There is **final** critical habitat for this species. The location of the critical habitat is not available. Species profile: https://ecos.fws.gov/ecp/species/7268	Threatened
Yellow-billed Cuckoo *Coccyzus americanus* Population: Western U.S. DPS There is **final** critical habitat for this species. The location of the critical habitat is not available. Species profile: https://ecos.fws.gov/ecp/species/3911	Threatened

Fishes

NAME	STATUS
Bull Trout *Salvelinus confluentus*	Threatened

Population: U.S.A., conterminous, lower 48 states
There is **final** critical habitat for this species. The location of the critical habitat is not available.
Species profile: https://ecos.fws.gov/ecp/species/8212

Insects

NAME	STATUS
Monarch Butterfly *Danaus plexippus*	Candidate

No critical habitat has been designated for this species.
Species profile: https://ecos.fws.gov/ecp/species/9743

Critical habitats

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Washington Fish And Wildlife Office
510 Desmond Drive Se, Suite 102
Lacey, WA 98503-1263
Phone: (360) 753-9440 Fax: (360) 753-9405
http://www.fws.gov/wafwo/

In Reply Refer To: November 05, 2019
Consultation Code: 01EWFW00-2020-SLI-0150
Event Code: 01EWFW00-2020-E-00315
Project Name: Seattle-Tacoma International Airport - SAMP Near-Term Projects Environmental Review

Subject: List of threatened and endangered species that may occur in your proposed project location, and/or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, and proposed species, designated and proposed critical habitat, and candidate species that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. The species list is currently compiled at the county level. Additional information is available from the Washington Department of Fish and Wildlife, Priority Habitats and Species website: http://wdfw.wa.gov/mapping/phs/ or at our office website: http://www.fws.gov/wafwo/species_new.html. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 et seq.), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered

species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether or not the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species, and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:
http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF

Please be aware that bald and golden eagles are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 et seq.). You may visit our website at http://www.fws.gov/pacific/eagle/for information on disturbance or take of the species and information on how to get a permit and what current guidelines and regulations are. Some projects affecting these species may require development of an eagle conservation plan: (http://www.fws.gov/windenergy/eagle_guidance.html). Additionally, wind energy projects should follow the wind energy guidelines (http://www.fws.gov/windenergy/) for minimizing impacts to migratory birds and bats.

Also be aware that all marine mammals are protected under the Marine Mammal Protection Act (MMPA). The MMPA prohibits, with certain exceptions, the "take" of marine mammals in U.S. waters and by U.S. citizens on the high seas. The importation of marine mammals and marine mammal products into the U.S. is also prohibited. More information can be found on the MMPA website: http://www.nmfs.noaa.gov/pr/laws/mmpa/.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Tracking Number in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Related website:
National Marine Fisheries Service: http://www.nwr.noaa.gov/protected_species/species_list/species_lists.html

Attachment(s):

- Official Species List

Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

Washington Fish And Wildlife Office
510 Desmond Drive Se, Suite 102
Lacey, WA 98503-1263
(360) 753-9440

Project Summary

Consultation Code: 01EWFW00-2020-SLI-0150

Event Code: 01EWFW00-2020-E-00315

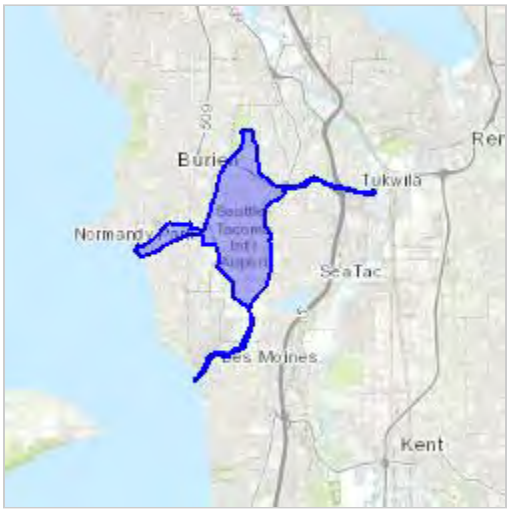
Project Name: Seattle-Tacoma International Airport - SAMP Near-Term Projects Environmental Review

Project Type: TRANSPORTATION

Project Description: The project includes development of new facilities on Port of Seattle property within and adjacent to Seattle-Tacoma International Airport to support capacity expansion. The project footprint considers the potential extent of stormwater-related effects on streams draining the affected areas and their receiving waters.

Project Location:

Approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/place/47.442064956500076N122.30887862068647W



Counties: King, WA

Endangered Species Act Species

There is a total of 6 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

Mammals

NAME	STATUS
Gray Wolf *Canis lupus* Population: Western Distinct Population Segment No critical habitat has been designated for this species.	Proposed Endangered
North American Wolverine *Gulo gulo luscus* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/5123	Proposed Threatened

Birds

NAME	STATUS
Marbled Murrelet *Brachyramphus marmoratus* Population: U.S.A. (CA, OR, WA) There is **final** critical habitat for this species. Your location is outside the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/4467	Threatened
Streaked Horned Lark *Eremophila alpestris strigata* There is **final** critical habitat for this species. Your location is outside the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/7268	Threatened
Yellow-billed Cuckoo *Coccyzus americanus* Population: Western U.S. DPS There is **proposed** critical habitat for this species. Your location is outside the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/3911	Threatened

Fishes

NAME	STATUS
Bull Trout *Salvelinus confluentus* Population: U.S.A., conterminous, lower 48 states There is **final** critical habitat for this species. Your location overlaps the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/8212	Threatened

Critical habitats

There is 1 critical habitat wholly or partially within your project area under this office's jurisdiction.

NAME	STATUS
Bull Trout *Salvelinus confluentus* https://ecos.fws.gov/ecp/species/8212#crithab	Final

STATE LISTED SPECIES

Revised February 2022

Washington Department of FISH and WILDLIFE

The Washington Fish and Wildlife Commission has classified the following 46 species as Endangered, Threatened, or Sensitive. The federal status of species under the Endangered Species Act differs in some cases from state status; federal status is indicated by: Federal Endangered (FE), Threatened (FT), Candidate (FC), USFWS has made a 90-day finding that listing may be warranted (90d), or a NOAA Species of Concern (FSC).

STATE ENDANGERED

A species native to the State of Washington that is seriously threatened with extinction throughout all or a significant portion of its range within the state.

The 35 State Endangered species listed below are designated in Washington Administrative Code 220-610-010

MAMMALS (14)

Fin Whale	FE
Sei Whale	FE
Blue Whale	FE
Humpback Whale	FT/FE[#]
[#]Mexico DPS=T; Central America DPS=E	
North Pacific Right Whale	FE
Sperm Whale	FE
Killer Whale	FE[#]
[#]Southern Residents only	
Gray Wolf	FE
Grizzly Bear	FT
Lynx	FT
Fisher	-
Columbian White-tailed Deer	FT
Woodland Caribou[x]	FE
Pygmy Rabbit	FE

BIRDS (12)

Sandhill Crane	-
Snowy Plover	FT
Upland Sandpiper[x]	-
Marbled Murrelet	FT
Tufted Puffin	-
Columbian Sharp-tailed Grouse	-
Greater Sage-Grouse	-
Ferruginous Hawk	-
Northern Spotted Owl	FT
Yellow-billed Cuckoo[x]	FT
Streaked Horned Lark	FT
Oregon Vesper Sparrow	90d

REPTILES (3)

Western Pond Turtle	90d
Leatherback Sea Turtle	FE
Loggerhead Sea Turtle	FE

AMPHIBIANS (2)

Oregon Spotted Frog	FT
Northern Leopard Frog	-

INVERTEBRATES (4)

Oregon Silverspot Butterfly[x]	FT
Taylor's Checkerspot	FE
Mardon Skipper	-
Pinto Abalone	-

STATE THREATENED

A species native to the state of Washington that is likely to become endangered within the foreseeable future throughout a significant portion of its range within the state without cooperative management or removal of threats.

The 5 State Threatened species are designated in Washington Administrative Code 220-200-100

MAMMALS (3)

Sea Otter	-
Western Gray Squirrel	-
Mazama Pocket Gopher	
subsp. *glacialis, pugetensis, tumuli, yelmensis*	FT
...subsp. *couchi, louiei[x], melanops*	-

BIRDS (1)

American White Pelican	-

REPTILES (1)

Green Sea Turtle	FT

[x]These species are, or may be, extirpated from all of their historical range in Washington

For more information, check our website:
https://wdfw.wa.gov/species-habitats/species

Or contact us at:
wildthing@dfw.wa.gov
or
Wildlife Program (360) 902-2515
Fish Program (360) 902-2700

For more information on federal status, check the US Fish and Wildlife Service or the NOAA National Marine Fisheries Service

STATE SENSITIVE

A species native to the state …that is vulnerable or declining and is likely to become endangered or threatened in a significant portion of its range within the state without cooperative management or removal of threats.

The 6 State Sensitive species are designated in Washington Administrative Code 220-200-100

MAMMALS (1)

Gray Whale	FE[#]
[#]Western North Pacific Stock	

BIRDS (1)

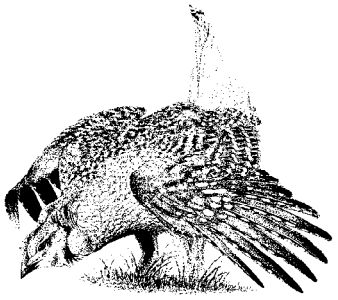
Common Loon	-

FISH (3)

Pygmy Whitefish	-
Margined Sculpin	-
Olympic Mudminnow	-

AMPHIBIAN (1)

Larch Mountain Salamander	-



STATE CANDIDATE SPECIES

Revised February 2022

Washington Department of FISH and WILDLIFE

The Washington Department of Fish and Wildlife has designated the following 71 species as Candidates for listing in Washington as State Endangered, Threatened, or Sensitive. The Department reviews species for listing following procedures in Washington Administrative Code 220-610-110. The federal status of species under the Endangered Species Act differs in some cases from state status; federal status is indicated by: Federal Endangered (FE), Threatened (FT), Candidate (FC), USFWS has made a 90-day finding that listing may be warranted (90d), or a NOAA Fisheries Species of Concern (FSC).

MAMMALS (10)

Townsend's Big-eared Bat	-
Keen's Myotis Bat	-
White-tailed Jackrabbit	-
Black-tailed Jackrabbit	-
Washington Ground Squirrel	-
Townsend's Ground Squirrel	
South of the Yakima River	-
Olympic Marmot	-
Cascade Red Fox	-
Wolverine	FC
Pacific Harbor Porpoise	-

BIRDS (14)

Western Grebe	-
Clark's Grebe	-
Short-tailed Albatross	FE
Northern Goshawk	-
Golden Eagle	-
Cassin's Auklet	-
Flammulated Owl	-
Burrowing Owl	-
White-headed Woodpecker	-
Black-backed Woodpecker	-
Loggerhead Shrike	-
Slender-billed White-breasted Nuthatch	-
Sage Thrasher	-
Sagebrush Sparrow	-

REPTILES and AMPHIBIANS (10)

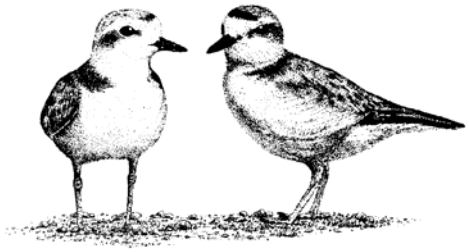
Sagebrush Lizard	-
Common Sharp-tailed Snake	-
California Mountain Kingsnake	-
Striped Whipsnake	-
Dunn's Salamander	-
Van Dyke's Salamander	-
Cascade Torrent Salamander	90d
Western Toad	-
Columbia Spotted Frog	-
Rocky Mountain Tailed Frog	-

FISH (10)

Mountain Sucker	-
Lake Chub	-
Leopard Dace	-
Umatilla Dace	-
River Lamprey	-
Steelhead	
Snake River	FT
Upper Columbia	FT
Middle Columbia	FT
Lower Columbia	FT
Bull Trout	FT

MOLLUSKS (7)

Shortface Lanx	-
Ashy (Columbia) Pebblesnail	-
California Floater	-
Columbia Oregonian (snail)	90d
Poplar Oregonian (snail)	-
Dalles Sideband (snail)	90d
Blue-gray Taildropper (slug)	-



Many species of uncertain conservation need are listed in our State Wildlife Action Plan:
https://wdfw.wa.gov/species-habitats/at-risk/swap

INSECTS (18)

Beller's Ground Beetle	-
Mann's Mollusk-eating Ground Beetle	
Columbia River Tiger Beetle	-
Hatch's Click Beetle	-
Columbia Clubtail (dragonfly)	-
Pacific Clubtail	-
Sand-verbena Moth	-
Yuma Skipper	-
Makah Copper	-
Chinquapin Hairstreak	-
Johnson's Hairstreak	-
Juniper Hairstreak	-
Puget Blue	-
Valley Silverspot	-
Silver-bordered Fritillary	-
Great Arctic	-
Island Marble	FE
Western Bumble Bee	90d

OTHER INVERTEBRATES (2)

Giant Palouse Earthworm	-
Leschi's Millipede	-

For more information, check our website:
https://wdfw.wa.gov/species-habitats/species
Or contact us:
Wildlife Program (360) 902-2515
Fish Program (360) 902-2700

APPENDIX D

Biological Resources

References

Nationwide Standard Conservation Measures
Title 21A.24

NATIONWIDE STANDARD CONSERVATION MEASURES

Listed below are effective measures that should be employed at all project development sites nationwide with the goal of reducing impacts to birds and their habitats. These measures are grouped into three categories: General, Habitat Protection, and Stressor Management. These measures may be updated through time. We recommend checking the Conservation Measures website regularly for the most up-to-date list.

1. General Measures

a. Educate all employees, contractors, and/or site visitors of relevant rules and regulations that protect wildlife. See the Service webpage on Regulations and Policies for more information on regulations that protect migratory birds.

b. Prior to removal of an inactive nest, ensure that the nest is not protected under the Endangered Species Act (ESA) or the Bald and Golden Eagle Protection Act (BGEPA). Nests protected under ESA or BGEPA cannot be removed without a valid permit.
   i. See the Service Nest Destruction Policy

c. Do not collect birds (live or dead) or their parts (e.g., feathers) or nests without a valid permit. Please visit the Service permits page for more information on permits and permit applications.

d. Provide enclosed solid waste receptacles at all project areas. Non-hazardous solid waste (trash) would be collected and deposited in the on-site receptacles. Solid waste would be collected and disposed of by a local waste disposal contractor. For more information about solid waste and how to properly dispose of it, see the EPA Non-Hazardous Waste website.

e. Report any incidental take of a migratory bird, to the local Service Office of Law Enforcement.

f. Consult and follow applicable Service industry guidance.

2. Habitat Protection

a. Minimize project creep by clearly delineating and maintaining project boundaries (including staging areas).

b. Consult all local, State, and Federal regulations for the development of an appropriate buffer distance between development site and any wetland or waterway. For more information on wetland protection regulations see the Clean Water Act sections 401 and 404.

c. Maximize use of disturbed land for all project activities (i.e., siting, lay-down areas, and construction).

d. Implement standard soil erosion and dust control measures. For example:
   i. Establish vegetation cover to stabilize soil
   ii. Use erosion blankets to prevent soil loss
   iii. Water bare soil to prevent wind erosion and dust issues

3. Stressor Management

Stressor: Vegetation Removal

Conservation Goal: Avoid direct take of adults, chicks, or eggs.

Conservation Measure 1: Schedule all vegetation removal, trimming, and grading of vegetated areas outside of the peak bird breeding season to the maximum extent practicable. Use available resources, such as internet-based tools (e.g., the FWS's Information, Planning and Conservation system and Avian Knowledge Network) to identify peak breeding months for local bird species; or, contact local Service Migratory Bird Program Office for breeding bird information.

Conservation Measure 2: When project activities cannot occur outside the bird nesting season, conduct surveys prior to scheduled activity to determine if active nests are present within the area of impact and buffer any nesting locations found during surveys.

1) Generally, the surveys should be conducted no more than five days prior to scheduled activity.
2) Timing and dimensions of the area to be surveyed vary and will depend on the nature of the project, location, and expected level of vegetation disturbance.
3) If active nests or breeding behavior (e.g., courtship, nest building, territorial defense, etc.) are detected during these surveys, no vegetation removal activities should be conducted until nestlings have fledged or the nest fails or breeding behaviors are no longer observed. If the activity must occur, establish a buffer zone around the nest and no activities will occur within that zone until nestlings have fledged and left the nest area. The dimension of the buffer zone will depend on the proposed activity, habitat type, and species present and should be coordinated with the local or regional Service office.
4) When establishing a buffer zone, construct a barrier (e.g., plastic fencing) to protect the area. If the fence is knocked down or destroyed, work will suspend wholly, or in part, until the fence is satisfactorily repaired.
5) When establishing a buffer zone, a qualified biologist will be present onsite to serve as a biological monitor during vegetation clearing and grading activities to ensure no take of migratory birds occurs. Prior to vegetation clearing, the monitor will ensure that the limits of construction have been properly staked and are readily identifiable. Any associated project activities that are inconsistent with the applicable conservation measures, and activities that may result in the take of migratory birds will be immediately halted and reported to the appropriate Service office within 24 hours.
6) If establishing a buffer zone is not feasible, contact the Service for guidance to minimize impacts to migratory birds associated with the proposed project or removal of an active nest. Active nests may only be removed if you receive a permit from your local Migratory Bird Permit Office. A permit may authorize active nest removal by a qualified biologist with bird handling experience or by a permitted bird rehabilitator.

Conservation Measure 3: Prepare a vegetation maintenance plan that outlines vegetation maintenance activities and schedules so that direct bird impacts do not occur.

Stressor: Invasive Species Introduction
Conservation Goal: Prevent the introduction of invasive plants.

Conservation Measure 1: Prepare a weed abatement plan that outlines the areas where weed abatement is required and the schedule and method of activities to ensure bird impacts are avoided.

Conservation Measure 2: For temporary and permanent habitat restoration/enhancement, use only native and local (when possible) seed and plant stock.

Conservation Measure 3: Consider creating vehicle wash stations prior to entering sensitive habitat areas to prevent accidental introduction of non-native plants.

Conservation Measure 4: Remove invasive/exotic species that pose an attractive nuisance to migratory birds.

Stressor: Artificial Lighting
Conservation Goal: Prevent increase in lighting of native habitats during the bird breeding season.

Conservation Measure 1: To the maximum extent practicable, limit construction activities to the time between dawn and dusk to avoid the illumination of adjacent habitat areas.

Conservation Measure 2: If construction activity time restrictions are not possible, use down shielding or directional lighting to avoid light trespass into bird habitat (i.e., use a 'Cobra' style light rather than an omnidirectional light system to direct light down to the roadbed). To the maximum extent practicable, while allowing for public safety, low intensity energy saving lighting (e.g. low pressure sodium lamps) will be used.

Conservation Measure 3: Minimize illumination of lighting on associated construction or operation structures by using motion sensors or heat sensors.

Conservation Measure 5: Bright white light, such as metal halide, halogen, fluorescent, mercury vapor and incandescent lamps should *not* be used.

Stressor: Human Disturbance
Conservation Goal: Minimize prolonged human presence near nesting birds during construction and maintenance actions.

Conservation Measure 1: Restrict unauthorized access to natural areas adjacent to the project site by erecting a barrier and/or avoidance buffers (e.g., gate, fence, wall) to minimize foot traffic and off-road vehicle uses.

Stressor: Collision

Conservation Goal: Minimize collision risk with project infrastructure and vehicles.

Conservation Measure 1: Minimize collision risk with project infrastructure (e.g., temporary and permanent) by increasing visibility through appropriate marking and design features (e.g., lighting, wire marking, etc.).

Conservation Measure 2: On bridge crossing areas with adjacent riparian, beach, estuary, or other bird habitat, use fencing or metal bridge poles (Sebastian Poles) that extend to the height of the tallest vehicles that will use the structure.

Conservation Measure 3: Install wildlife friendly culverts so rodents and small mammals can travel under any new roadways instead of over them. This may help reduce raptor deaths associated with being struck while tracking prey or scavenging road kill on the roadway.

Conservation Measure 4: Remove road-kill carcasses regularly to prevent scavenging and bird congregations along roadways.

Conservation Measure 5: Avoid planting "desirable" fruited or preferred nesting vegetation in medians or Rights of Way.

Conservation Measure 6: Eliminate use of steady burning lights on tall structures (e.g., >200 ft).

Stressor: Entrapment

Conservation Goal: Prevent birds from becoming trapped in project structures or perching and nesting in project areas that may endanger them.

Conservation Measure 1: Minimize entrapment and entanglement hazards through project design measures that may include:

1. Installing anti-perching devices on facilities/equipment where birds may commonly nest or perch
2. Covering or enclosing all potential nesting surfaces on the structure with mesh netting, chicken wire fencing, or other suitable exclusion material prior to the nesting season to prevent birds from establishing new nests. The netting, fencing, or other material must have no opening or mesh size greater than 19 mm and must be maintained until the structure is removed.
3. Cap pipes and cover/seal all small dark spaces where birds may enter and become trapped.

Conservation Measure 2: Use the appropriate deterrents to prevent birds from nesting on structures where they cause conflicts, may endanger themselves, or create a human health and safety hazard.

1. During the time that the birds are trying to build or occupy their nests (generally , between April and August, depending on the geographic location), potential nesting

surfaces should be monitored at least once every three days for any nesting activity, especially where bird use of structures is likely to cause take. It is permissible to remove non-active nests (without birds or eggs), partially completed nests, or new nests as they are built (prior to occupation). If birds have started to build any nests, the nests shall be removed before they are completed. Water shall not be used to remove the nests if nests are located within 50 feet of any surface waters.

2. If an active nest becomes established (i.e., there are eggs or young in the nest), all work that could result in abandonment or destruction of the nest shall be avoided until the young have fledged or the nest is unoccupied. Construction activities that may displace birds after they have laid their eggs and before the young have fledged should not be permitted. If the project continues into the following spring, this cycle shall be repeated. When work on the structure is complete, all netting shall be removed and properly disposed of.

Stressor: Noise

Conservation Goal: Prevent the increase in noise above ambient levels during the nesting bird breeding season.

Conservation Measure 1: Minimize an increase in noise above ambient levels during project construction by installing temporary structural barriers such as sand bags

Conservation Measure 2: Avoid permanent additions to ambient noise levels from the proposed project by using baffle boxes or sound walls.

Stressor: Chemical Contamination

Conservation Goal: Prevent the introduction of chemicals contaminants into the environment.

Conservation Measure 1: Avoid chemical contamination of the project area by implementing a Hazardous Materials Plan. For more information on hazardous waste and how to properly manage hazardous waste, see the EPA Hazardous Waste website.

Conservation Measure 2: Avoid soil contamination by using drip pans underneath equipment and containment zones at construction sites and when refueling vehicles or equipment.

Conservation Measure 3: Avoid contaminating natural aquatic and wetland systems with runoff by limiting all equipment maintenance, staging laydown, and dispensing of fuel, oil, etc., to designated upland areas.

Conservation Measure 4: Any use of pesticides or rodenticides shall comply with the applicable Federal and State laws.

1. Choose non-chemical alternatives when appropriate
2. Pesticides shall be used only in accordance with their registered uses and in accordance with the manufacturer's instructions to limit access to non-target species.

3. For general measures to reducing wildlife exposure to pesticides, see EPA's Pesticides: Environmental Effects website.

Stressor: Fire

Conservation Goal: Minimize fire potential from project-related activities.

Conservation Measure 1: Reduce fire hazards from vehicles and human activities (e.g., use spark arrestors on power equipment, avoid driving vehicles off road).

Conservation Measure 2: Consider fire potential when developing vegetation management plans by planting temporary impact areas with a palate of low-growing, sparse, fire resistant native species that meet with the approval of the County Fire Department and local FWS Office.

4. Is located in the same aquatic area drainage subbasin or marine shoreline and attains the following ratios of area of functional mitigation to area of alteration:

a. a 3:1 ratio for a type S or F aquatic area; and

b. a 2:1 ratio for a type N or O aquatic area;

D. For purposes of subsection C. of this section, a mitigation measure is in the same aquatic area reach if the length of aquatic area shoreline meets the following criteria:

1. Similar geomorphic conditions including slope, soil, aspect and substrate;

2. Similar processes including erosion and transport of sediment and woody debris;

3. Equivalent or better biological conditions including invertebrates, fish, wildlife and vegetation; and

4. Equivalent or better biological functions including mating, reproduction, rearing, migration and refuge; or

5. For tributary streams, a distance of no more than one-half mile;

E. The department may reduce the mitigation ratios in subsection C. of this section to 2:1 ratio for a type S or F aquatic area and 1.5:1 ratio for a type N or O aquatic area if the applicant provides a scientifically rigorous mitigation monitoring program that includes the following elements:

1. Monitoring methods that ensure that the mitigation meets the approved performance standards identified by the department;

2. Financing or funding guarantees for the duration of the monitoring program; and

3. Experienced, qualified staff to perform the monitoring;

F. For rectifying an illegal alteration to any type of aquatic area or its buffer, mitigation measures must meet the following standards:

1. Located on the site of the illegal alteration at a 1:1 ratio of area of mitigation to area of alteration; and

2. To the maximum extent practical, replicates the natural prealteration configuration at its natural prealteration location including the factors in subsection B. of this section; and

G. The department may modify the requirements in this section if the applicant demonstrates that, with respect to each aquatic area function, greater functions can be obtained in the affected hydrologic unit that the department may determine to be the drainage subbasin through alternative mitigation measures.

H. For temporary alterations to an aquatic area or its buffer that is predominately woody vegetation, the department may require mitigation in addition to restoration of the altered aquatic area or buffer. (Ord. 16267 § 58, 2008: Ord. 15051 § 197, 2004: Ord. 10870 § 485, 1993).

21A.24.381 Aquatic habitat restoration project approval. To ensure that agriculture will remain the predominate use in the agriculture production district, the department shall only approve an aquatic habitat restoration project, a floodplain restoration project or a project under the mitigation reserves program that is proposed for a site located within an agricultural production district, as follows:

A. The project shall be allowed only when supported by owners of the land where the proposed project is to be sited;

B. Except as provided in subsection C. of this section, the project shall be located on lands that the department of natural resources and parks determines are unsuitable for direct agricultural production purposes, such as portions of property that have not historically been farmed due to soil conditions or frequent flooding and that it determines cannot be returned to productivity by drainage maintenance; and

C. If the project is located on land determined by the department of natural resources and parks to be suitable for direct agriculture, then:

1. The applicant shall demonstrate to the satisfaction of the department that there are no unsuitable lands available within the agricultural production district that meet the technical or locational requirements of the project;

2. The applicant shall demonstrate to the satisfaction of the department of natural resources and parks that the project will not reduce the ability to farm in the area and that agriculture will remain the predominate use in the agricultural production district; and

3. The project must either:

a. be included in, or be consistent with, an approved Water Resources Inventory Area Plan, Farm Management Plan, Flood Hazard Management Plan or other similar watershed scale plan; or

b. not reduce the baseline agricultural productivity within the agricultural production district. (Ord. 17485 § 22, 2012: Ord. 16267 § 59, 2008).

21A.24.382 Wildlife habitat conservation areas - development standards.

The following development standards apply to development proposals and alterations on sites containing wildlife habitat conservation areas:

A. Unless allowed as an alteration exception under K.C.C. 21A.24.070, only the alterations identified in K.C.C. 21A.24.045 are allowed within a wildlife habitat conservation area;

B. For a bald eagle:

1. The wildlife habitat conservation area is an area with a four-hundred-foot radius from an active nest;

2. Between March 15 and April 30, alterations are not allowed within eight hundred feet of the nest; and

2. Between January 1 and August 31, land clearing machinery, such as bulldozers, graders or other heavy equipment, may not be operated within eight hundred feet of the nest;

C. For a great blue heron:

1. The wildlife habitat conservation area is an area with an eight-hundred-twenty-foot radius from the rookery. The department may increase the radius up to an additional one-hundred sixty-four feet if the department determines that the population of the rookery is declining; and

2. Between January 1 and July 31, clearing or grading are not allowed within nine-hundred-twenty-four feet of the rookery;

D. For a marbled murrelet, the wildlife habitat conservation area is an area with a one-half-mile radius around an active nest;

E. For a northern goshawk, the wildlife habitat conservation area is an area with a one-thousand-five-hundred-foot radius around an active nest located outside of the urban growth area;

F. For an osprey:

1. The wildlife habitat conservation area is an area with a two-hundred-thirty-foot radius around an active nest; and

2. Between April 1 and September 30, alterations are not allowed within six-hundred-sixty feet of the nest;

G. For a peregrine falcon:

1. The wildlife habitat conservation area is an area extending for a distance of one-thousand feet of an eyrie on a cliff face, the area immediately above the eyrie on the rim of the cliff, and the area immediately below the cliff;

2. Between March 1 and June 30, land-clearing activities that result in loud noises, such as from blasting, chainsaws or heavy machinery, are not allowed within one-half mile of the eyrie; and

3. New power lines may not be constructed within one-thousand feet of the eyrie;

H. For a spotted owl, the wildlife habitat conservation area is an area with a three-thousand-seven-hundred-foot radius from an active nest;

I. For a Townsend's big-eared bat:

1. Between June 1 and October 1, the wildlife habitat conservation area is an area with a four-hundred-fifty-foot radius from the entrance to a cave or mine, located outside of the urban area, with an active nursery colony

2. Between November 1 and March 31, the wildlife habitat conservation area is an area with a four-hundred-fifty-foot radius around the entrance to a cave or mine located outside the urban growth area serving as a winter hibernacula;

3. Between March 1 and November 30, a building, bridge, tunnel, or other structure used solely for day or night roosting may not be altered or destroyed;

4. Between May 1 and September 15, the entrance into a cave or mine that is protected because of bat presence is protected from human entry; and

5. A gate across the entrance to a cave or mine that is protected because of bat presence must be designed to allow bats to enter and exit the cave or mine;

J. For a Vaux's swift:

1. The wildlife habitat conservation area is an area with a three-hundred-foot radius around an active nest located outside of the urban growth areas;

2. Between April 1 and October 31, clearing, grading, or outdoor construction is not allowed within four hundred feet of an active or potential nest tree. The applicant may use a species survey to demonstrate that the potential nest tree does not contain an active nest;

K. The department shall require protection of an active breeding site of any federal or state listed endangered, threatened, sensitive and candidate species or King County species of local importance not listed in subsections B. through J. of this section. If the Washington state Department of Fish and Wildlife has adopted management recommendations for a species covered by this subsection, the department shall follow those management recommendations. If management recommendations have not been adopted, the department shall base protection decisions on best available science. (Ord. 17485 § 23, 2012: Ord. 15051 § 198, 2004).

21A.24.383 Wildlife habitat conservation areas - modification. Upon request of the applicant and based upon a site-specific critical areas report that includes, but is not limited to, an evaluation of the tolerance of the animals occupying the nest or rookery to the existing level of development in the vicinity of the nest or rookery, the department may approve a reduction of the wildlife habitat conservation area for the following species:

A. Bald eagle;

B. Great blue heron; and

C. Osprey. (Ord. 17485 § 24, 2012: Ord. 15051 § 199, 2004).

21A.24.385 Wildlife habitat networks - applicability. The department shall make certain that segments of the wildlife habitat network are set aside and protected along the designated wildlife habitat network adopted by the King County Comprehensive Plan as follows:

A. This section applies to the following development proposals on parcels that include a segment of the designated wildlife habitat network:

1. All urban planned developments, fully contained communities, binding site plans, subdivisions and short subdivisions; and

2. All development proposals on individual lots unless a segment of the wildlife habitat network in full compliance with K.C.C. 21A.24.386 already exists in a tract, easement or setback area, and a notice of the existence of the segment has been recorded;

B. Segments of the wildlife habitat network must be identified and protected in one of the following ways:

1. In urban planned developments, fully contained communities, binding site plans, subdivisions and short subdivisions, native vegetation is placed in a contiguous permanent open-space tract with all developable lots sited on the remaining portion of the project site, or the lots are designed so that required setback areas can form a contiguous setback covering the network segments; or

2. For individual lots, the network is placed in a county-approved setback area. To the maximum extent practical, existing native vegetation is included in the network. The notice required by K.C.C. 21A.27.170 is required; and

C. All wildlife habitat network tracts or setback areas must meet the design standards in K.C.C. 21A.24.386. (Ord. 15051 § 201, 2004: Ord. 13694 § 90, 1999: Ord. 11621 § 52, 1994. Formerly K.C.C. 21A.14.260).

21A.24.386 Wildlife habitat networks - development standards and alterations. The following standards apply to development proposals and alterations on sites containing wildlife habitat network:

A. Unless allowed as an alteration exception under K.C.C. 21A.24.070, only the alterations identified in K.C.C. 21A.24.045 are allowed in the wildlife habitat network;

B. The wildlife habitat network is sited to meet the following conditions:

1. The network forms one contiguous tract or setback area that enters and exits the property where the network crosses the property boundary;

2. To the maximum extent practical, the network maintains a width of three-hundred feet. The network width shall not be less than one-hundred-fifty feet at any point; and

3. The network is contiguous with and includes critical areas and their buffers;

4. To the maximum extent practical, the network connects isolated critical areas or habitat; and

5. To the maximum extent practical, the network connects with wildlife habitat network segments, open space tracts or wooded areas on adjacent properties, if present;

C. The wildlife habitat network tract must be permanently marked in accordance with this chapter;

D. An applicant proposing recreation, forestry or any other use compatible with preserving and enhancing the habitat value of the wildlife habitat network located within the site must have an approved management plan. The applicant shall include and record the approved management plan for a binding site plan or subdivision with the covenants, conditions and restrictions (CCRs), if any. Clearing within the wildlife habitat network in a tract or tracts is limited to that allowed by an approved management plan;

E. If the wildlife habitat network is contained in a setback area, a management plan is not required. Clearing is not allowed within a wildlife habitat network within a setback area on individual lots, unless the property owner has an approved management plan;

F. In urban planned developments, fully contained communities, binding site plans, subdivisions and short subdivisions a homeowners association or other entity capable of long term maintenance and operation shall monitor and assure compliance with any approved management plan;

G. Segments of the wildlife habitat network set aside in tracts, conservation easements or setback area must comply with K.C.C. 16.82.150;