TECHNICAL REPORT
Review of Impacts on Fish and Fisheries as Presented in the SEPA DEIS Evaluation of Flood Protection in the Chehalis Basin

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May 7, 2020

Executive Summary

The draft Environmental Impact Statement (DEIS) determines that the construction and operation of the Proposed Project would significantly impact salmon and steelhead (collectively referred to as salmon for convenience) produced by spawning populations upstream of Rainbow Falls, which is located approximately 11 miles downstream of the proposed dam site.

The Proposed Project includes a flood retention facility and temporary reservoir, referred to as the Flood Retention Expandable (FRE) facility, and changes to the Chehalis-Centralia airport levee.

While we agree with those conclusions, we further conclude that the actual impacts of the Proposed Project are understated and under-reported compared to the likely overall impacts that would occur to the salmon populations of the Chehalis Basin, to the ecological integrity of the Chehalis Basin ecosystem, and to the treaty-protected fishing rights of the Quinault Indian Nation (QIN).

We found that the analyses were insufficient to assess the expected total effects on salmon populations due to:

- Flawed salmon population modeling;
- Inadequate analyses of effects on watershed and ecological processes;
- Inadequate analyses of effects on population performance and viability;
- Inadequate analyses of cumulative effects; and
- Inadequate analyses of the compounding effects of climate change.

We further found that the DEIS does not address harvest, particularly impacts on treaty-protected fishing rights of the QIN. Those rights are essential for the maintenance of economy, human health, and cultural survival. The Proposed Project would have significant impacts on these treaty-protected rights.

We also found that the DEIS, while addressing certain likely impacts on spring Chinook, does not adequately account for the importance of this population either in the Chehalis Basin or within the Washington coastal region. We summarize the special significance of this population, its current status, the potential for being listed as threatened or endangered under the Endangered Species Act (ESA), and likely impacts of the Proposed Project.

Due to the severity and extent of likely impacts of the Proposed Project, the DEIS characterizes impacts on fish, tribal and cultural resources as significant and unavoidable "unless mitigation is technically feasible and economically practicable." We conclude that the impacts would not be biologically fully mitigable.

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[1] Both authors have extensive experience in assessing the effects of habitat, harvest, climate change, and restoration actions on the performance of salmon and steelhead populations. Each author has over 45 years of experience involving a wide range of topics related to issues covered in the DEIS.

Introduction

This technical report reviews the findings presented in the State Environmental Policy Act (SEPA) February 27, 2020 Draft Environmental Impact Statement (DEIS) regarding Chehalis Flood Protection as related to impacts on the salmon and steelhead populations[2] (collectively referred to as salmon hereafter) of the Chehalis Basin. We review the various ways that the DEIS reports that the Proposed Project might impact these fish populations and present our conclusions whether the analyses were adequate in assessing expected impacts. In doing so, we identify where there were gaps in the analyses presented in the DEIS with respect to potential impacts on the fish populations.

This report is not focused on the fish and habitat models employed in the DEIS to evaluate impacts on salmon populations, though we briefly summarize here our conclusions regarding the use of those models. We provided a detailed review of the models in a companion technical report entitled "Salmon Population Modeling for the SEPA DEIS". This report is focused on key topics contained within the DEIS that relate to how the DEIS analyses were performed to assess impacts on these populations.

This report is organized into the following major sections:

- Framework for Evaluation;
- DEIS Conclusions Regarding Impacts;
- Comments and Evaluation; and
- Spring Chinook Significance

In the final section of this report, Spring Chinook Significance, we describe the biological, ecological, and cultural importance of spring Chinook salmon in the basin. The DEIS, while addressing certain likely impacts on this species, does not adequately account for the importance of this population either in the Chehalis Basin or within the Washington coastal region. We summarize the special significance of the species, its current status, the potential for being listed as threatened or endangered under the Endangered Species Act (ESA), and likely impacts of the Proposed Project.

Framework for Evaluation

Our evaluation of the DEIS considered these major topics related to how the DEIS assessed impacts of the Proposed Project on the relevant fish populations:

- Important characteristics of the fish populations and how the action would affect those characteristics (abundance, productivity, diversity, and spatial structure—based Viable Salmonid Population (VSP) concepts from McElhany et al. 2000);
- Effects on watershed processes that form and maintain habitat characteristics;
- Effects on relevant habitats, based on understanding about the relationships of habitat characteristics to life stages of fish populations;
- Incorporation of other factors to assess cumulative effects;
- Compounding effects of climate change on habitats and fish populations;
- Methods used in the DEIS to assess impacts;

[2] Steelhead trout are classified within the genus *Oncorhynchus* along with the Pacific salmon species. Collectively, these species are often referred to as salmon (Waples 1991, Quinn 2018).

- Determination of significant adverse impacts; and
- Effects on treaty-protected rights to maintain the ability to harvest fish needed for economy, human health, and cultural survival.

DEIS Conclusions Regarding Impacts

The DEIS concludes that:

- Construction and operation of the Proposed Project would have a significant adverse impact on aquatic habitat from the headwaters of the Chehalis River to the middle mainstem. The removal of vegetation, increase in temperature, and reduced water quality would negatively affect aquatic habitat and species. (p70 in main report)
- Construction and operation would have significant adverse impacts on spring-run Chinook salmon, fall-run Chinook salmon, coho salmon, and steelhead from degraded habitat, noise, and fewer fish surviving passage around the FRE facility. (p70 in main report)
- These significant impacts on fish and aquatic species and habitat would be unavoidable unless the Fish and Aquatic Species and Habitat Management Plan and other mitigation plans meet regulatory requirements and implementation is feasible. (p70 in main report)

Comments and Evaluation

We considered the conclusions of the DEIS by evaluating various issues and topics that the DEIS incorporated into its analyses. We have organized our evaluation into the following categories of conclusions:

- Inadequate Analyses of Effects on Salmon Populations;
- Inadequate Analyses of Effects on the Ecological Integrity of the Chehalis Basin;
- Impacts on Harvest Opportunity (i.e., particularly on treaty-protected fishing rights); and
- Inadequate Discussion of Mitigation and Related Conclusions.

Inadequate Analyses of Effects on Salmon Populations

The DEIS presents an incomplete and inadequate assessment of the likely impacts on the salmon populations of the Chehalis Basin. We present our findings under the following topics/issues related to the analyses in the DEIS:

- Flawed salmon population modeling;
- Inadequate analyses of effects on watershed and ecological processes;
- Inadequate analyses of effects on population performance and viability;
- Inadequate analyses of cumulative effects; and
- Inadequate analyses of the compounding effects of climate change.

<u>Issue:</u> Flawed salmon population modeling

This issue was described and addressed in a companion technical report by the authors, entitled "Salmon Population Modeling for the SEPA DEIS." That document examined the use of two computer models within the DEIS to make quantitative and qualitative projections of the effects of the Proposed Project on populations of spring Chinook, fall Chinook, coho, and steelhead: (1) the Ecosystem Diagnosis and Treatment (EDT) Model and (2) the Integrated EDT-LCM Model (hereafter referred as the Hybrid Model).

We concluded that the information provided in the DEIS does not provide sufficient, specific information and data to permit thorough scientific evaluation. There are substantial uncertainties regarding the models, methods, and parameters employed in the DEIS modeling. However, our review of available information regarding how the modeling was performed revealed numerous errors in modeling inputs and configuration, which suggest a failure of Quality Assurance and Quality Control (QA/QC) measures to provide adequate review and oversight of the modeling process.

We concluded that the application of both the EDT Model and the Hybrid Model in the DEIS is flawed. However, we do not disagree that the genetic diversity and abundance of populations of spring and fall Chinook, coho, and steelhead originating in the subbasins above the proposed dam site (near Crim Creek) and from Rainbow Falls to Crim Creek would be significantly and adversely affected by project construction and operations, which would worsen further in late century (DEIS, Exhibit 5-6, Fish and Aquatic Species Habitat pS-14 and Tribal Resources p5-15; section 5.3, p70; Exhibit 5-3-2, p74).

We agree with those conclusions under the assumptions prescribed by the DEIS, including those relating to climate change and development, implementation of the Proposed Project, and exclusion of habitat restoration efforts within the upper Chehalis subbasin prioritized under the Aquatic Species Restoration Plan (ASRP).

<u>Issue:</u> Inadequate analyses of effects on watershed and ecological processes

The freshwater and estuarine habitats used by salmon, as well as other aquatic species, are produced by landscape scale watershed processes that have occurred over millennia. With development of the Chehalis Basin, flood damage to property has increased and salmon have been reduced to a small fraction of their former abundances by changes in the environment and disruptions of watershed and ecological processes.

The Proposed Project, including both the FRE and the raising of the Airport Levee near Chehalis-Centralia, will further disrupt watershed and ecological processes, reducing the ability of current habitat conditions to support salmon populations.

The Chehalis Basin Strategy has twin objectives to reduce flood damage and restore aquatic species. The effects of the Proposed Project must be examined within a foundational understanding of how the habitats of these species and their ecological functions are formed and maintained. This understanding is essential to the ability of the Chehalis Basin Strategy to accomplish its twin objectives of reducing damage from flooding and restoring aquatic species (ASRP Steering Committee 2019).

Beechie and Bolton (1999) describe why this landscape-scale context is critical for salmon recovery work and watershed restoration plans:

1. Spatial and temporal variations in landscape (watershed) processes create a dynamic mosaic of habitat conditions within the river network; and

2. Salmonid populations and their subpopulations are adapted to the local environmental conditions that were formed and maintained by these processes over long time periods.

It is important to recognize that the habitats of aquatic species continue to be affected by dynamic processes. Disruptions or alterations to these processes can adversely affect the quality and quantity of habitats, which in turn can adversely impact salmon populations that depend upon them. The Chehalis Basin salmon populations have declined sharply from their historical levels—with dramatic declines in each of the VSP characteristics (abundance, productivity, diversity, and spatial structure)—as a result of many factors, especially those related to land and water uses that have altered watershed and ecological processes (Smith and Wenger 2001; Mobrand Biometrics 2003; McConnaha et al. 2017; ASRP Steering Committee 2019; Beechie et al. 2020).

The Proposed Project would continue the pattern of altering watershed processes vital to the long-term sustainability of salmon populations. Richards et al. (2002), commenting on flood control efforts, described the cascade of effects that subsequently occur to riverine and riparian processes:

> *"River regulation (by channelization or flood control) results in terrestrialization of the vegetation, associated with a reduced rate of turnover of the fluvial landscape, reduced rates of ecosystem change, reductions of channel and ecosystem dynamics and of mosaic detail, reduced flood frequency, and loss of habitat and age diversity."*

The DEIS does not adequately address how the Proposed Project will fundamentally alter watershed and ecological processes critical to salmon habitats in the upper river, as well as throughout the entirety of the river corridor downstream extending into the estuary.

<u>Conclusions of the DEIS:</u>

The DEIS concludes that the following impacts would occur to habitats and watershed processes:

- In the upper Chehalis River (upstream of dam site): Impacts to be SIGNIFICANT to aquatic habitat function from increase in temperature (2°C to 3°C increases in summer) due to lack of large trees in the temporary reservoir, degraded riparian function, recurring inundation events affecting up to 847 acres of vegetation, reduced fish passage, bed scour affecting spawning grounds, degraded habitat, reduction in channel-forming flows and large woody material, and reduced nutrient contributions to the river (pE-v).
- In the upper and middle Chehalis River (downstream of the dam to the South Fork): Impacts to be SIGNIFICANT to aquatic habitat function from change in substrate transport process, reduced large woody material, reduced channel-forming flows, increase in temperature (2°C to 3°C increases in summer) due to lack of large trees in the temporary reservoir down to confluence with South Fork, increased turbidity from reservoir releases (pE-vi).
- In the lower and middle Chehalis River (downstream of the dam): Impacts to be SIGNIFICANT with respect to changes to floodplain inundation extents and creation of new habitat from reduction in peak flows (pE-vi).
- In the lower and middle Chehalis (downstream of the South Fork): Impacts to be MODERATE to aquatic habitats (pE-vi).
- In summary: Construction and operation of the Proposed Project would have a SIGNIFICANT adverse impact on aquatic habitat from the headwaters of the Chehalis River to the middle mainstem (p70 in main report).

However, as part of the fish and habitat modeling analysis presented, the DEIS called out as uncertainties what the effects of the FRE facility would be on watershed processes within the mainstem river corridor downstream of the facility, stating (pE2-35):

- Uncertainty associated with aspects of the project that were not considered in the modeling approach for areas downstream of the FRE facility include
    - Broad, long-term effects of a lack of channel-forming flows during floods; and
    - How a lack of flooding would impact channel width, fine sediment levels, floodplain maintenance and formation, and riparian structure and function.

Comments and Evaluation:

We agree with the overall conclusions that the Proposed Project would significantly adversely affect habitats and watershed and ecological processes. However, we also find that the DEIS presents an entirely superficial, inadequate, and even contradictory in places, analysis of the effects of the Proposed Project on watershed and ecological processes. Despite those conclusions of significant impacts, the DEIS also identified the impacts as uncertain, and therefore, did not include them as part of the fish and habitat modeling analysis (as noted on pE2-35). The DEIS leaves largely unexplained the basis, both with respect to rationale and criteria applied, for all of these findings.

In a separate technical report submitted by QIN (see NSD (2020a) entitled "Earth Discipline Report - Geology Technical Analyses Review"), the authors concluded:

> *"Landslides and landslide potential are underrepresented in the DEIS, and thereby the estimated 840,500 cubic yards of sediment delivered by landslides over the life of the project is underestimated in the impact analyses; actual sediment volumes will be much higher(potentially 16 million cubic yards or higher over the life of the project). A significant portion of landslide sediment inputs will be fine grained, that will adversely impact salmonid egg survival. This error is propagated in the sediment transport impact analyses and habitat impact analyses, and not considered in the FRE Operations Plan."* (page 1)
>
> *"The loss of topsoil and mature vegetation in the reservoir will decrease the function and benefit they provide for preventing erosion and enhancing slope stability. Landslides and mass wasting will also expose disturbed ground to accelerated erosion. It is our opinion that the erosion process will deliver additional fine-grained sediment (75,092 tons/year after clearing and 23,292tons/year as willow cover establishes) to the reservoir over the volumes delivered by landslides where it will be mobilized from the reservoir to the downstream reaches and will result in downstream habitat impacts. The addition of fine-grained sediment from erosion processes was not properly characterized, quantified or adequately considered in the DEIS. This error is propagated in the sediment transport impact analyses and habitat impact analyses. This condition will be exacerbated by an increase in landslides."* (page 1)

Further, that technical report found:

> *"The DEIS acknowledges that reservoir operations will increase fine sediment inputs to the river from hillslopes and landslides that will impact water quality. However, predictions of fine sediment inputs are grossly under-estimated, and no fine sediment transport modeling or aquatic habitat impact assessment was conducted. Increase in fine sediment inputs will increase salmonid egg mortality by infiltrating redds within the reservoir and far downstream."* (page 2)

In stark contrast to the conclusions in that technical report, it bears noting that in our separate technical report "Salmon Population Modeling for the SEPA DEIS", we found that the EDT modeling used to analyze FRE impacts to salmon incorporated gross errors in how the attribute "Fine Sediment" was characterized in the model. The model assumed that spawning gravels within the footprint of the FRE, as well as all stream reaches downstream to the confluence with Newaukum River (total distance of 39 miles) would remain exceptionally clean of fine sediments under FRE operations, even in late century with a 100-year flood flow.

In another technical report submitted by QIN (see NSD (2020b) entitled "Cascade of FRE Facility Ecosystems Effects Technical Memo"), the authors found:

> *"The DEIS fails to consider, analyze or characterize the physical and ecologic process linkages inherent in riverine ecosystems and thus fails to consider the consequent indirect impacts of the cascade of ecosystem effects and the amplification of those effects over time that will result from the proposed project. The proposed project will result in a cascade of impacts to both existing floodplain/off-channel water bodies and wetlands, as well as a loss of the physical processes that create and sustain the future formation of floodplain wetlands and floodplain/off-channel water bodies, resulting in a significant, unmitigable amplification of impacts over time."* (page 2)

Further, that technical report concluded:

> *"Overall, we find that numerous individual impacts have been underestimated or insufficiently analyzed. Furthermore, we find that no meaningful analysis has considered or acknowledged the interaction of these impaired processes in an ecosystem framework. Given the well-established interactions between geomorphic, hydrologic, and ecological processes that form and maintain high quality aquatic habitat, the impairment of several of these individual processes will set in motion a much larger "cascade" of impacts. The synchronous alteration to multiple, connected natural processes that sustain aquatic habitat sets up a positive feedback loop in which the overall impact to ecosystems is amplified relative to the alteration of any one process. These indirect impacts are not adequately or appropriately analyzed in the DEIS and its associated discipline reports."* (page 3)

Conclusions

We conclude that numerous individual impacts of the Proposed Project have been underestimated or insufficiently analyzed to adequately address the full scale and scope of impacts on watershed and ecological processes. As a result, the full extent of potential impacts on salmon populations within the Chehalis Basin have not been adequately assessed.

Issue: Inadequate analyses of effects on population performance and viability

Salmon population performance is determined by the spatial-temporal mosaic of habitats, both their quality and quantities, throughout the life cycle of the species.[3] The ability of populations to withstand stress and to sustain themselves over time is termed "viability."

NOAA Fisheries relies upon the concept of a viable salmonid population (VSP) to guide assessment and recovery under the Endangered Species Act (ESA) (McElhany et al. 2000). A viable salmonid population is defined as an independent population "of any Pacific salmonid (genus *Oncorhynchus*) that has a

[3] / In addition to the role of habitat, population performance is also affected by the genetic composition of the population, which can be affected by introgression with domesticated hatchery fish. The DEIS does not consider interactions between hatchery and wild fish of the same species or interspecies effects.

negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100- year time frame." NOAA employs a VSP framework consisting of four characteristics or parameters: abundance, intrinsic productivity, population spatial structure, and diversity. These four parameters are often referred to as the VSP parameters.

All of the VSP parameters combined provide information about the relative risk of extinction under historical, current, or future conditions, such as those expected in the future due to climate change or the Proposed Project.

To its credit, the DEIS is transparent in correctly identifying many of the major uncertainties in the analyses and findings related to projecting impacts on salmon population performance (e.g. pE2-33 to E2-35). These uncertainties are many, varied, and large, which calls into question whether the information that was used in the DEIS was sufficient and methods comprehensive enough to assess potential impacts with reasonable confidence.

<u>Conclusions of the DEIS:</u>

The key findings and conclusions of the DEIS with respect to impacts on the salmon populations are summarized below:

- Construction and operation of the Proposed Project would have a significant adverse impact on aquatic habitat from the headwaters of the Chehalis River to the middle mainstem. The removal of vegetation, increase in temperature, and reduced water quality would negatively affect aquatic habitat and species. (p70 in main report)
- Construction and operation would have significant adverse impacts on spring-run Chinook salmon, fall-run Chinook salmon, coho salmon, and steelhead from degraded habitat, noise, and fewer fish surviving passage around the FRE facility. (p70 in main report)
- These significant impacts on fish and aquatic species and habitat would be unavoidable unless the Fish and Aquatic Species and Habitat Management Plan and other mitigation plans meet regulatory requirements and implementation is feasible. (p70 in main report)
- The subbasin upstream of Crim Creek supports populations of salmon and steelhead that are genetically unique from salmon and steelhead in other subbasins of the Chehalis River Basin. The analysis predicts that the Proposed Project would reduce the genetic diversity within and among salmon populations of each species across the Chehalis Basin. (pS-8 in summary document)
- Spring-run Chinook spawn in three primary areas within the Chehalis Basin. The Proposed Project would significantly affect one of these three important spawning areas. (pS-8 in summary document)
- Reductions in the number of salmon and steelhead in the late-century from the Proposed Project are significant because they bring population abundances even further below 70% of historical abundance than the reductions predicted from climate change alone. (pS-8 in summary document)
- The Proposed Project could reduce future restoration options in the subbasins above and below Crim Creek and within the larger basin for the fish species and habitats they rely on. (pS-8 in summary document)

But even with that determination, substantial uncertainties with the analyses were identified in the DEIS. Listed below are some of those uncertainties (from pE2-33, 34, and 35), some of which indicate that projected impacts are underestimated:

- How would habitat conditions above and below the FRE facility during construction and operation change, including:
  - How fast will habitat recover from an FRE facility closure event?
  - What will habitat above the FRE facility look like through time?
  - How will downstream conditions change?
  - Will fish recolonize habitat after an FRE facility event, and if so, how quickly?
  - Will fish self-distribute downstream from the FRE facility during a closure and spawn successfully?
- Uncertainty exists associated with 10- or 100-year floods occurring during FRE facility construction (rather than 2-year floods, which is what is currently modeled). A 10- or 100-year flood during this construction period could have greater impacts on fish species and habitat.
- Uncertainty associated with fish passage estimates.
- The effect of climate change on conditions in Grays Harbor and the ocean is uncertain. Inclusion of these factors would affect the numeric estimates of fish performance under both alternatives. Annual variation in ocean conditions and ocean survival is a significant contributor to annual variation in spawner abundance for salmon and steelhead. It is not clear how climate change will affect salmon and steelhead survival in Grays Harbor and the ocean, although climate models suggest that ocean temperatures will likely increase in the future and increasing ocean temperatures may lead to reduced adult returns (Logerwell et al. 2003). For small or declining populations, this annual variation may result in populations going to very low numbers (or zero in some years), possibly resulting in earlier functional extirpation.
- Effects of peak flow outside the project area were not modeled so that effects of the Proposed Action were easier to detect. This results in an underestimation of the functional extirpation of weak species, especially spring Chinook. Inclusion of flood effects outside the project area may result in earlier functional extirpation of small populations (e.g., spring Chinook) if that was to be modeled.
- Uncertainty exists in flooding impacts to flow and channel width because the EDT model is structured based on monthly (not daily) increments of time. The impacts of the flood events are diminished when daily flows are incorporated into a monthly time step in the analysis.
- Uncertainties exist associated with lack of variation in timing and duration of the flood events in 2-, 10-, and 100-year flood years; no variation in flow conditions at other, non-flood event, times of the year were incorporated; and no variation in the life stage of the salmon and steelhead being affected by the flood event was incorporated. Additionally, uncertainties due to actual differences in 2-, 10-, and 100-year flood conditions in the future have not been captured since specific water years were chosen as representative in the models.

<u>Comments and Evaluation</u>

The DEIS does not adequately address the four VSP characteristics to evaluate the overall impact of the proposed project on the affected populations. The major focus of the DEIS analysis, using modeling, is on equilibrium abundance under the different scenarios evaluated. Only brief, superficial evaluation is given to the other characteristics, namely productivity, diversity, and spatial structure.

The DEIS acknowledges that the genetic structure and diversity of coho and steelhead are unique in the upper Chehalis Basin and that the Proposed Project will significantly impact those aspects of population performance—this recognition is based on findings in Seamons et al. (2017 and 2019).

Page E-145:

> *"As described above, coho salmon and steelhead found at and upstream of the proposed FRE facility are genetically distinct from coho salmon and steelhead in lower river areas."*

And further (same page):

> *"Any decline of Chinook salmon, coho salmon, or steelhead in the upper basin due to the Proposed Action would be a significant loss of genetic diversity from Chehalis Basin populations."*

Still, the DEIS suggests that such losses may not be that important to the aggregate populations in the Chehalis Basin, for example, in the following (pE-141):

> *"The salmon and steelhead in the two subbasins of the Chehalis River evaluated in this report represent only a fraction of the entire Chehalis Basin population (approximately 1.2% of spring-run Chinook salmon, 3.4% of fall-run Chinook salmon, 2.7% of coho salmon and 15.8% of steelhead; Ronne 2019)."*

We disagree. Such a characterization implies that abundance should be the major consideration when determining importance, ignoring other characteristics that are seminal to the concept of a VSP. With the exception of steelhead, this statement implies that the losses that would occur as a result of the Proposed Project would be very small compared to the overall population sizes (in aggregate) across the Chehalis Basin. However, the significance of component populations within the Chehalis Basin should not be viewed from the standpoint of the proportion of basin-wide abundance, but rather from perspective of the need to provide the suite of characteristics necessary to support viability and sustainability (see guidelines in McElhaney 2000, p126). In large part, this suite of characteristics revolves around the seminal concept of resiliency, the ability to withstand and adapt to stresses. Component populations are extremely important because they represent genetic adaptions to different local environmental conditions, the foundation necessary for resiliency. Their loss would reduce diversity and diminish the ability to sustain species in a variable and changing environment.

Important points that were missed in the presentation of DEIS results include the following:

- Several Chehalis Basin salmon populations have been in a state of decline over at least the past two decades, as illustrated in the patterns seen for spring Chinook and winter steelhead (Figures 1 and 2). When viewed over the past century, the losses are even much more significant (Mobrand Biometrics 2003; EDT modeling outputs from Chip McConnaha received September 2018). The Proposed Project would accelerate the declines.
- The productivities and diversity of Chehalis salmon populations have already been severely reduced from levels that formerly supported the populations, indicating that resiliency of the populations in aggregate (by species) is weakened, making them more vulnerable to further loss of resiliency from the Proposed Project (Mobrand Biometrics 2003; EDT modeling outputs from Chip McConnaha received September 2018).

- Each of the populations produced upstream of Rainbow Falls, with the possible exception of steelhead, currently perform at low levels (reflected in low abundances, productivities, and diversity) due to intensive land use practices in that area over the past century resulting in poor habitat conditions—habitat restoration projects suited to that area (upstream of Pe Ell) were identified as a high priority within the ASRP.
- The spatial range of spring Chinook in the Chehalis Basin was once greater than it is now—and it appears to be contracting due to the decline in the population (see final section of this report). The Proposed Project would accelerate contraction. Loss of spatial structure to the population would further erode population viability.
- The upper Chehalis subbasin (upstream of the proposed dam site) has been a stronghold for steelhead production relative to other parts of the Chehalis Basin, based on findings from intensive spawner surveys over the past six years (Ronne et al. 2018; Ronne et al. 2020). The decline that is occurring in the spawning escapements in the Chehalis River system upstream of Aberdeen (Figure 2) suggests that the upper Chehalis subbasin is particularly important to protect for the aggregate population in the Chehalis River system. Effects of the Proposed Project as presented in the DEIS to this population segment are substantial, causing significant loss in abundance, productivity, and diversity (pE-117, 141, 143, 144, 146). These losses would be further magnified as losses to the overall aggregate population.
- A viability analysis that considers productivity, abundance (or capacity), and interannual variability should be performed to assess the potential impacts of the Proposed Project on the viability of the populations produced in the upper basin. Special types of models that incorporate a quasi-extinction threshold (QET) are normally used to perform viability analyses. It bears noting that the modeling that was done using the Hybrid Model did not incorporate any kind of QET such that the model allowed population levels to drop to near zero, then unrealistically rebound. Page E-41 notes:

    "Over the mid- and late-century time frames, spring-run Chinook salmon abundance was estimated to be zero and fall-run Chinook salmon abundance ranged as low as 2 fish in the Above Crim Creek Subbasin. This highlights the increased year-to-year variability and subsequent vulnerability of these species to stressors under the Proposed Action."

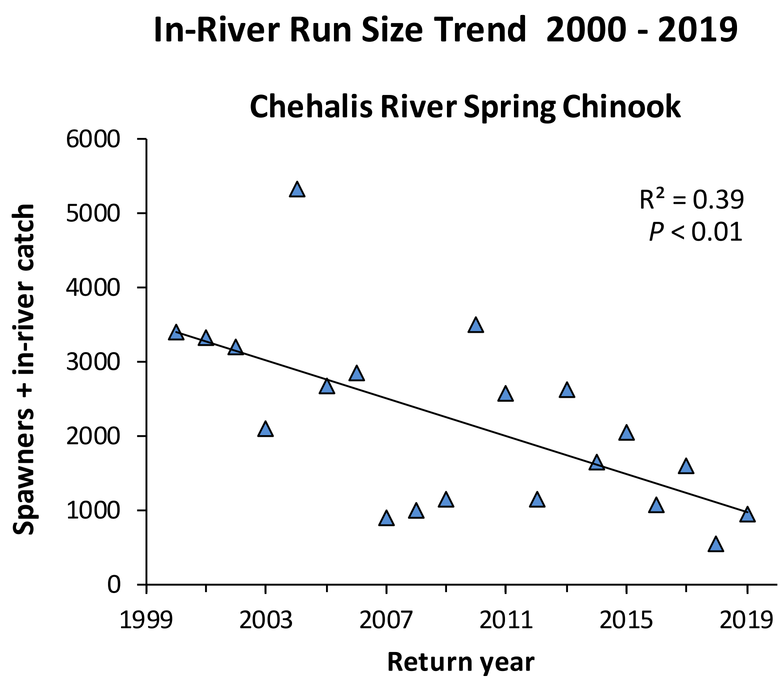

Figure 1. Estimated run sizes of spring Chinook returning to the Chehalis Basin, 2000-2019. The figure is from Lestelle et al. (2019) but it has been updated with provisional data for 2019 from Curt Holt (WDFW, personal communications).

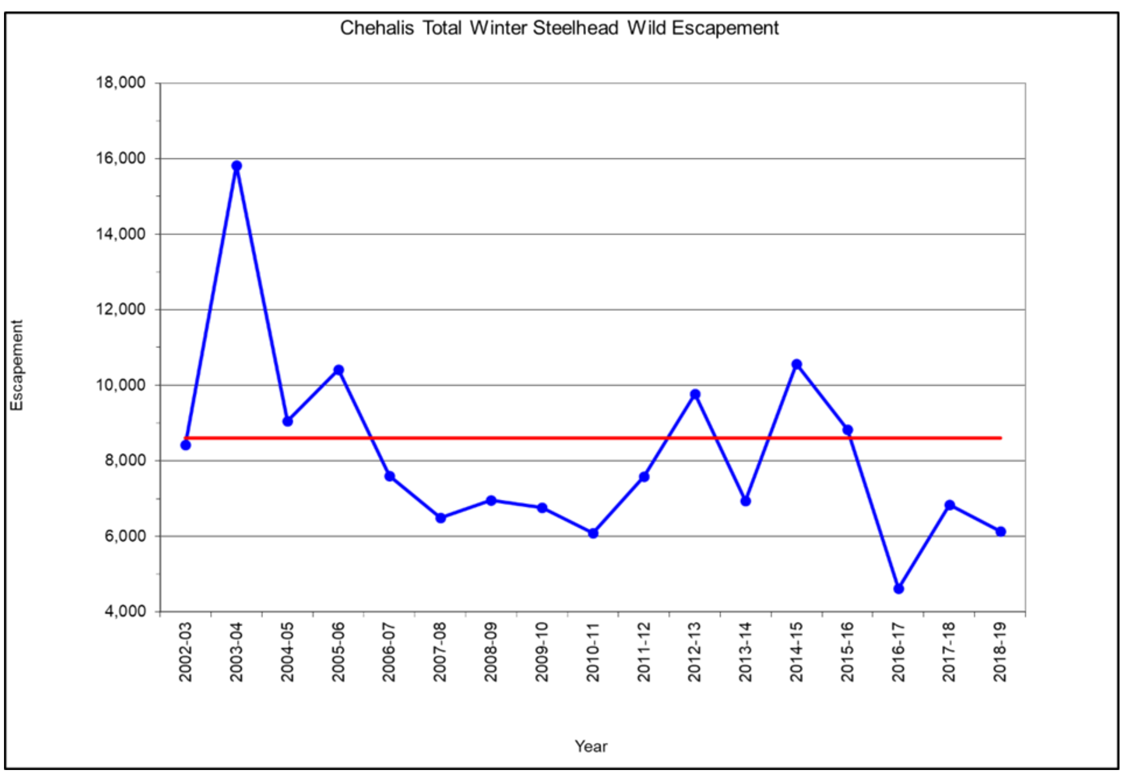

Figure 2. Estimated spawning escapements of wild winter steelhead in the Chehalis River system upstream of Aberdeen from 2002-03 to 2018-19. The horizontal red line is the spawning escapement goal for the population. Chart was provided by Curt Holt (WDFW, personal communications) to Larry Lestelle on February 18, 2020.

The DEIS also did not adequately address a large number of uncertainties that were identified in the report (see p.E2-33, 34, 35). An example of one of those uncertainties that needed much greater attention is fish passage that would be required at the FRE facility. The DEIS acknowledges uncertainty with both upstream and downstream fish passage design, but then relies on a number of unsubstantiated assumptions.

A key supporting document for the fish passage analysis (CBS 2018, p31) states with regard to the construction period: *"Due to the extended period of diversion and the impact to salmon populations, for the following fish passage alternatives during construction, **it is assumed that the full fish passage criteria required by NMFS and WDFW must be met for the entire period of construction**."* Page E-76 (Appendix E of DEIS) states: *"The Applicant's fish passage design for the FRE facility must meet state and federal regulations and optimize fish passage **during construction and during operation**, including non-flood conditions and during flood retention events. NOAA Fisheries requires fish passage to be provided between the 95% and 5% exceedance flow values, or in other words the middle 90% of the streamflow of record when migrating fish are normally present at a site (NMFS 2011). The Revised Code of Washington (RCW) 77.57.030 requires provision for passage of all fish and fish life stages believed to be present in the system."*

The fish passage assumptions applied in the DEIS analysis are based on the preliminary designs applied in the Programmatic EIS (PEIS), which were intended for the Flood Retention Only (FRO) structure as it was then envisioned. Although the FRE design differs from the FRO, the actual design of the fish passage has not been revised for the FRE. The DEIS assumes that fish passage effectiveness for the FRE facility remains the same as was assumed for the FRO.

A major difference in the analysis for the PEIS regarding fish passage than for the FRE is that a construction period, requiring temporary fish passage facilities, was not evaluated under the PEIS. This introduces a major uncertainty into the DEIS that was not adequately addressed. It is critical to recognize that fish passage criteria for temporary facilities (i.e., during construction) is intended to be the same as during implementation following construction. NMFS (2011) states in its document entitled "Anadromous Salmonid Passage Facility Design" the following:

> *"Criteria listed previously in this document also apply to the interim passage plan. Where this is not possible, project owners must seek NMFS approval of alternate interim fish passage design criteria, and a final interim passage plan."*

Page 20 of the DEIS states with regard to passage during the construction period: *"The temporary bypass tunnel and temporary trap-and-transport process would be required to meet National Marine Fisheries Service and WDFW criteria for fish passage. The fish passage information provided by the Applicant is preliminary and has not been approved; more details would be required during permitting."*

The annual duration of the in-water construction window period is uncertain and of concern. The DEIS states:

> *"Work in the river channel would take place over three separate in-water work windows, which are the time periods approved by regulatory agencies that avoid fish migration periods. The Washington Department of Fish and Wildlife (WDFW) approved in-water work window for the upper Chehalis River includes the month of August and the Corps window is from July to August. To meet the 5-year schedule, the Applicant stated they would request extensions to these work windows to September 30." DEIS Section 2.3.2.1 p13.*

If the requested extension of the annual construction period is granted, in-water construction would occur when spring Chinook are holding prior to spawning, and during active spawning, adult fall Chinook and coho are actively migrating, steelhead eggs are incubating, and juvenile coho and steelhead are rearing and moving to suitable habitats. High temperatures and low flows which occur during this construction period would heighten physiological stress and susceptibility to disease, increasing mortality and reducing fitness of cold water species like salmon. If the requested extension is not approved, construction activity would take longer to complete, impacting more years of salmon passage and production.

While passage requirements during the construction period should be just as rigorous as in post-construction, we are concerned that the criteria would be relaxed during the 5-year construction period when a river by-pass tunnel and trap and haul activities would be employed. The fish passage team as part of the DEIS concluded that it would be unlikely to achieve the same criteria during construction (Appendix E3 p.E-10-11). The fish passage team assumed that passage effectiveness **would be substantially lower during construction** than during post-construction for all species but particularly for coho and steelhead (Tables E3-4 and E3-5 p.E3-12 and p.E3-14). Note that overall upstream passage effectiveness ranges between 0.09 and 0.65, depending on species during construction. Passage values this low have very significant adverse effects on salmonid populations.

Table E3-4

Estimated Passage Effectiveness for Adult Salmonids Upstream and Steelhead Kelts Downstream During FRE Facility Construction (2025 to 2030)

SPECIES/RUN	TRAPPING EFFICIENCY[1]	HANDLING AND TRANSPORT TRUCK LOADING SURVIVAL	TRANSPORT, RELEASE, AND DELAYED MORTALITY	CUMULATIVE FISH PASSAGE EFFECTIVENESS (SURVIVAL)[1]
Spring-run Chinook Salmon	0.85	0.90	0.80	0.61
Fall-run Chinook Salmon	0.80	0.95	0.85	0.65
Coho Salmon	0.35	0.95	0.95	0.32
Steelhead	0.50	0.95	0.95	0.45
Steelhead (kelts)	0.60	0.90	0.90	0.49
Cutthroat	0.10	0.95	0.95	0.09

Notes:
Cumulative fish passage effectiveness is the product of trapping efficiency, handling and transport survival, and release and delayed mortality.
1. Includes effects of fish moving downstream from weir.

Table E3-5

Estimated Adult Salmonid Upstream Passage Effectiveness During FRE Facility Operations at Mid-Century (2030 to 2080)

SPECIES/RUN	NON-FLOOD RETENTION	FLOOD RETENTION
Spring-run Chinook Salmon	94%	91%
Fall-run Chinook Salmon	94%	91%
Coho Salmon	94%	91%
Steelhead	96%	91%

Source: Tables 11-4 and 11-5 (CBS 2017a).

Based on the documentation provided in Appendix E3 (p.E-10, 11) of the process used to develop the fish passage assumptions that were applied, we conclude that the estimates for effectiveness of fish passage provisions were simply educated guesses unsupported by rigorous analysis. The upstream passage facility would consist of a picket weir in conjunction with a temporary trap and haul facility. Picket weirs for collecting upstream adult salmon and steelhead are extremely difficult to maintain and operate during elevated flows in Western Washington rivers—they frequently fail. It is evident that high uncertainty exists in fish passage analysis, which was not incorporated into the DEIS analysis of impacts.

We also note that it is very likely that post-construction passage effectiveness will be highly uncertain and vary by year as the dam operator and support teams learn to operate the facilities to meet the passage requirements. The DEIS ignores the challenges of evaluation, monitoring, and accurately reporting the effectiveness of fish passage to meet these requirements.

<u>Issue:</u> Inadequate analyses of cumulative effects

The DEIS provides only a superficial analysis of cumulative effects on four salmon species that originate within the general vicinity of the FRE, i.e., from spawning that occurs upstream of Rainbow Falls. Rainbow Falls is located approximately 11 miles downstream of the proposed dam site. To understand the overall impact of the Proposed Project, it is imperative to assess the cumulative impacts of other known or likely factors that could reasonably be expected to compound the adverse impacts of the project, but were not adequately addressed in the DEIS.

The magnitude of the projected impacts of the Proposed Project on the limited set of salmon populations that were analyzed are very likely significantly underestimated when the full scope of cumulative impacts are considered.

Page 2-2 of Appendix 2 states:

> *"SEPA requires cumulative effects to be considered in an DEIS (WAC 197‑11‑792). Although SEPA does not specifically define "cumulative effects," the term is defined under NEPA as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time." (40 Code of Federal Regulations 1508.7)"*

The DEIS considers only a very narrow scope of other factors in its consideration of cumulative impacts.

<u>Conclusions of the DEIS:</u>

Table 2-1 on page 2-ii lists sources of cumulative impacts that were considered in the overall DEIS analysis.

With regard to cumulative effects on fish populations, page 2-20 identifies the major source of cumulative impacts briefly treated in the DEIS:

> "Indirect impacts from the Proposed Action include the potential for increased development in areas predicted to experience no flooding or less severe flooding as a result of the Proposed Action (see Section 3.7). The potential for future expansion of agriculture, rural, residential, and commercial development in the floodplain could contribute impacts on fish habitat and species from pollution, habitat degradation, and habitat disconnection."

Page 2-20 further states:

> "A number of projects throughout the Chehalis Basin are anticipated to improve conditions for fish species and aquatic habitats in the study area. These projects include the ASRP, Berwick

Creek Flood Reduction and Restoration, Chehalis Basin Partnership Watershed Plan Update, Chehalis Flood Storage and Habitat Enhancement Master Plan implementation, China Creek Flood Habitat Enhancement Master Plan, RCO Salmon Recovery Funding Board Projects, Voluntary Stewardship Program implementation, and WSDOT culvert replacement and fish barrier removal projects."

Comments and Evaluation

Although the DEIS acknowledges that potential cumulative impacts might occur from "future expansion of agriculture, rural, residential, and commercial development in the floodplain", little or no attention is given to describing the nature and extent of those developments or assessing their impacts.

Similarly, the DEIS recognizes that some benefits might be accrued due to restoration actions in the basin, but how these might combine with expected impacts of the Proposed Project is left unanswered and open to considerable conjecture.

Five major sources of cumulative impacts are completely ignored or are only superficially incorporated into the DEIS. Each of these sources would likely severely reduce population performance in conjunction with the Proposed Project. These sources are:

1. Variability in freshwater survival unrelated to effects of the Proposed Project;
2. Variability in estuarine and marine survival and effects of climate change on marine survival;
3. Fishing mortalities;
4. Effects of increased abundances of exotic fishes within the mainstem Chehalis River corridor; and
5. Hatchery fish and interspecies impacts.

We briefly describe the importance of considering cumulative effects from each of these sources to the overall analysis.

Variability in freshwater survival

The DEIS does not adequately address how significant cumulative effects can occur as a result of natural variability in survival conditions encountered by salmon populations.

The DEIS acknowledges the importance of addressing variability in survival and how it can affect population performance—still the DEIS deals with it insufficiently. Page E2-35 states:

> "*Variability refers to natural variability in habitat conditions or life-stage parameters, such as annual variation in flood magnitude and its effect on bed scour and incubation survival. Annual variation in habitat conditions affected by peak flows is currently incorporated into the model (e.g., the influence of annual variation in peak flow on incubation survival). Effects of the Proposed Action also vary as a function of peak flow (e.g., the dam is modeled as closed in years with 10-year and 100-year floods, but not the 2-year flow). Where such stochastic factors are included, such as these flow conditions, the integrated model results reflect the influence of these factors on variation in annual abundance and equilibrium population size and on the variation around the equilibrium population size. However, variability in other factors, including estimated FRE facility passage survival, freshwater life-stage survival (e.g., egg-to-fry survival), and varying ocean conditions affecting marine survival were not included in the models.*" (emphasis added)

Further, page E-41 also acknowledges the effects of variability, even though only partial variability was incorporated into the modeling:

> *"Integrated model results also show increased variability in estimated salmonid abundance among model run iterations associated with the flow scenarios modeled, primarily for spring-run and fall-run Chinook salmon. Over the mid- and late-century time frames, spring-run Chinook salmon abundance was estimated to be zero and fall-run Chinook salmon abundance ranged as low as 2 fish in the Above Crim Creek Subbasin. This highlights the increased year-to-year variability and subsequent vulnerability of these species to stressors under the Proposed Action. Such variability also impacts access to fishing (economic and cultural consequences) and the ecology of the basin for numerous other species, including Southern Resident killer whales that depend on the presence of Chehalis Basin salmon and steelhead."*

Variability in survival is a critical determinant of population viability, especially when populations are at low abundance (Morris and Doak 2002; Lestelle et al. 2018). As variability in survival increases, a salmon population requires either greater intrinsic productivity or abundance, or both, to maintain viability (Sands et al. 2009; Lestelle et al. 2018).

Although the Hybrid Model used in the DEIS incorporates some degree of random environmental variability on survival through the random selection of water year types, no other variability in freshwater survival is incorporated. All other sources of variation in freshwater survival are fixed in the model, since EDT is a deterministic model without any stochastic variability applied to survival (Blair et al. 2009). (With respect to the random selection of water year types, there was no consideration of variability in precipitation patterns across the Chehalis Basin because of the selection of three specific water flow year events.)

The Hybrid Model incorporates some variability in egg incubation survival associated with the 10-year and 100-year flood flow events, but the amount of variation appears limited and underestimated compared to expected effects at 10-year and 100-year flood flows, especially in late century (see companion technical report "Salmon Population Modeling for the SEPA DEIS"). Variability in salmon egg incubation survival can be extremely high when considering the effects of flood events (Kinsel et al. 2007; Zimmerman et al. 2015; Weinheimer et al. 2017).

Other environmental factors that can produce significant variability in freshwater salmon survival as a result of interannual variations include fine sediment, water temperature, and summer low flows (Lestelle 2005; Lestelle et al. 2019). The temporal patterns of these factors (particularly temperature and flow) can also affect species phenology – i.e., the timing of seasonal life history events such as breeding and fry emergence, and in turn, survival (Walther et al. 2002; Crozier et al. 2008).

With the FRE, the DEIS also recognizes that there is uncertainty in the fish passage values being applied in the modeling (pE2-35), and the passage values in actuality would likely be subject to considerable variability, particularly while the dam operator would be trying to adjust operations to achieve the fish passage requirements while contending with variability in water flows and drawdown constraints. The FRE presents unique challenges since it would not be a conventional dam with conventional operations and proven designs for fish passage facilities.

This issue of cumulative effects being compounded through variability in survival factors should be addressed through a viability analysis for the populations at greatest risk (i.e., those with low productivities and abundances). It needs to also be recognized that climate change will likely result in increased variability in freshwater survival responses due to greater variation in climate-related factors (Lestelle et al. 2014).

Variability in marine survival and effects of climate change on marine survival

Another major source of variability in survival occurs once juvenile salmon and steelhead enter the estuary and then the ocean. The DEIS acknowledges that marine survival can fluctuate widely but the modeling employed to assess impacts of the Proposed Project assumes constant survival (pE2-35).

It is not uncommon for interannual variability in marine survival (estuarine and ocean combined) to vary by a factor of 10 or more over a period of one or more decades (Beamish et al. 2000; Lawson 1993; Lestelle et al. 2018). The effect of such a range of variation in marine survival on salmon population viability is significant (Lestelle et al. 2018). The survival pattern for Queets River Fall Chinook, illustrated in Figure 3, is an example of how marine survival varies for Washington coastal Fall Chinook (from TCCHINOOK 2019); the Queets stock is a coded-wire-tag indicator stock used by the Pacific Salmon Commission's Chinook Technical Committee to represent Washington Coastal Fall Chinook.

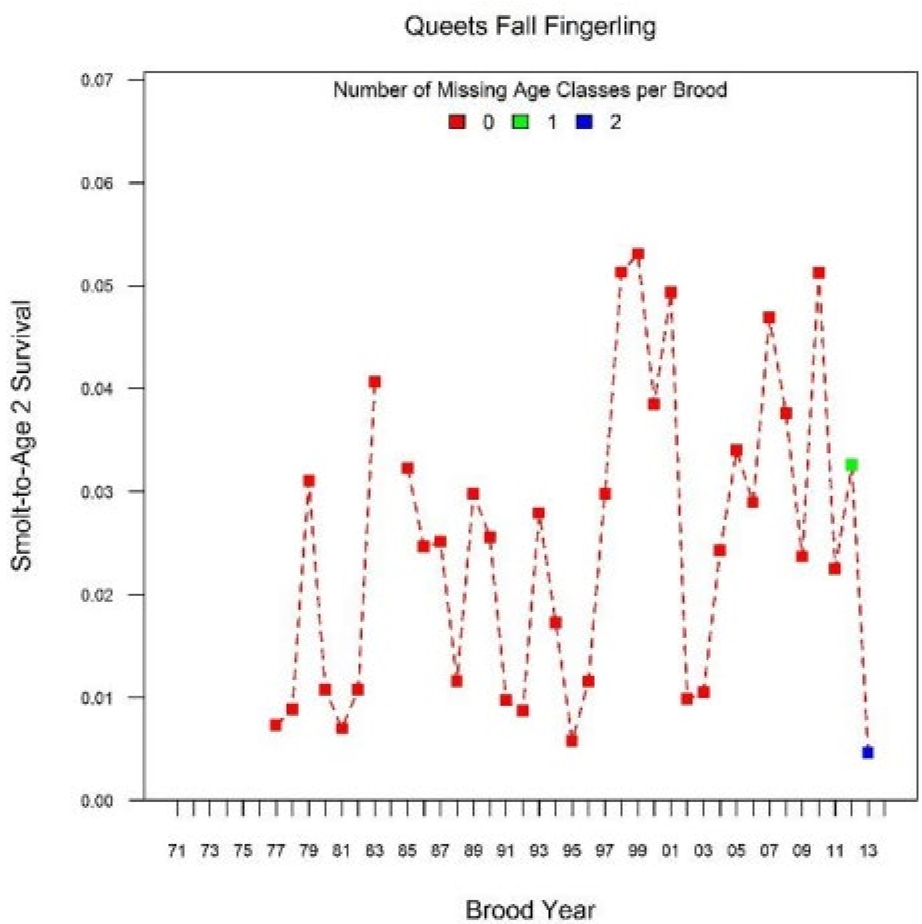

Figure 3. Estimated survival from smolt to age-2 of Queets River fall Chinook based on coded wire tagging analysis for fish produced from brood years 1977 to 2013 (from TCCHINOOK 2019).

The full effects of climate change on marine survival patterns of salmon remain uncertain but available information indicates that survivals will be adversely impacted (Crozier 2015; Cheung et al. 2020). It is likely, therefore, that interannual variability will increase. Marine heatwaves (MHWs) - persistent extremely warm ocean temperatures - are already impacting ecosystems worldwide, but recent studies suggest the impacts will be much greater than previously thought (Cheung et al. 2020). Globally, the frequency of MHWs has doubled since 1982, and is projected to increase further under continued global warming (Oliver et al. 2019; Figure 4). The lead author on a recent article addressing MHWs (Cheung et al. 2020) said that previous estimates of declines in fish populations assumed that the waters would warm at a steady rate as a result of climate change. But the impacts are much greater, he said, when one considers the occasional shocks to the system caused by rapid warming. Climate-change models predict at least four additional “blobs” before the end of the century, although nobody can predict when exactly they will occur (as reported in the Puget Sound Institute blog April 25, 2020 by Christopher Dunagan).

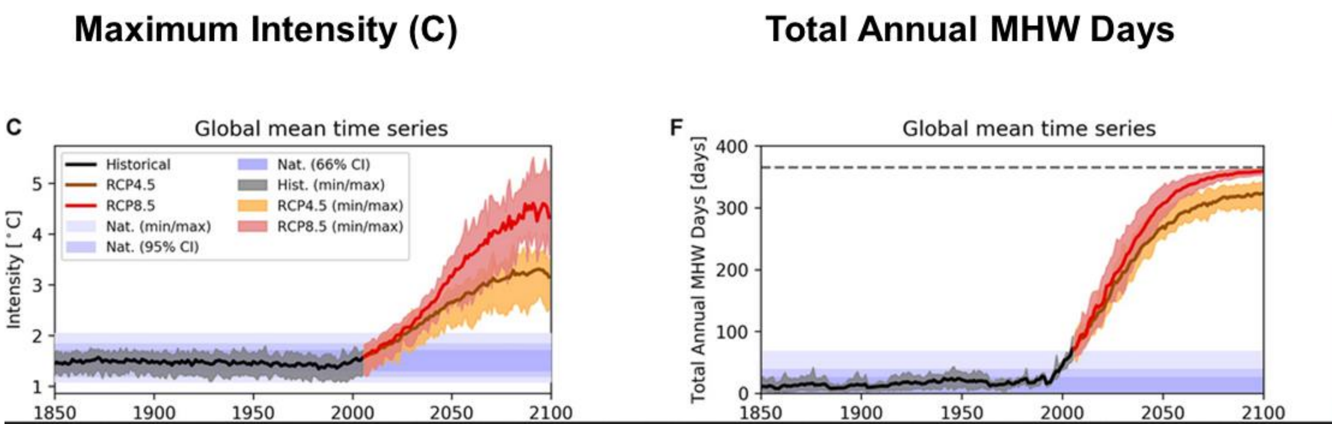

Figure 4. Projected changes to marine heatwaves (MHWs). From Oliver et al. 2019.

When prospective decreases in estuarine and marine survivals to salmon populations are considered, it will be even more important to protect and restore freshwater habitats (Lawson 1993). MHWs and increased variability in marine survival are important factors that should he included when evaluating cumulative effects on affected populations. These patterns in marine survival also further point to the need to include viability analysis to help address cumulative effects of the Proposed Project.

Fishing mortalities

Another source of cumulative impacts not included in the DEIS is mortality associated with on-going fisheries (see also section "Impacts on Harvest Opportunity"). Chinook and coho salmon originating in the Chehalis Basin are harvested by commercial, recreational, and subsistence fisheries on mature fish within the Chehalis Basin and the Grays Harbor estuary. Additionally, these species are harvested over an extensive marine geographic area. Chehalis fall Chinook are predominantly north migrating and are harvested at various stages of maturity over an area ranging from the Washington Coast to Southeast Alaska. Little information is available on marine harvest of Chehalis spring Chinook but their ocean distribution is believed to be similar to that of Washington coastal fall Chinook. Chehalis coho salmon are harvested by marine fisheries primarily during the last few months of life in offshore fisheries over a geographic area ranging from Southern Oregon through the mid-British Columbia coast.

Exploitation rates on these populations vary annually depending on a variety of local and international management constraints and the status of certain key populations. Historically (circa 1970s) total exploitation rates typically exceeded 60%. The combined effects of contemporary fisheries across the relevant geographic range produce exploitation rates typically in the 20-40% range.

Current exploitation rates add significant mortality to the populations that would be impacted by the Proposed Project. As a result, the projected spawning abundances, productivities, and diversities of the populations in the DEIS are too high by substantial amounts compared to levels if harvest had been accounted for. All modeling in the DEIS was done assuming no harvest impacts (pE-68).

The importance of the effect of variability as well as harvest on population viability is illustrated in Figures 5 and 6 below. The figures are from Lestelle et al. (2018) and were intended to illustrate how viability of summer chum populations in the Hood Canal region are affected by harvest. Viability is expressed through what is called a “viability curve”, which is defined by the levels of capacity (which is highly correlated with equilibrium abundance) and productivity that a population needs to perform at to achieve a low risk of extinction. NOAA Fisheries defines low risk as being <5% over a 100 year time frame (McElhany et al. 2000). Recovery of an ESA-listed population is achieved when risk of extinction is <5%.

Figure 6 shows the effect of incorporating an exploitation rate of 30% in the viability analysis compared to the situation where harvest does not occur. The viability curve is raised significantly at an exploitation rate of 30%.

The lack of addressing harvest as a part of a cumulative impacts analysis is a major gap in the DEIS. It also further points out the need to include a viability analysis to help address cumulative effects of the Proposed Project.

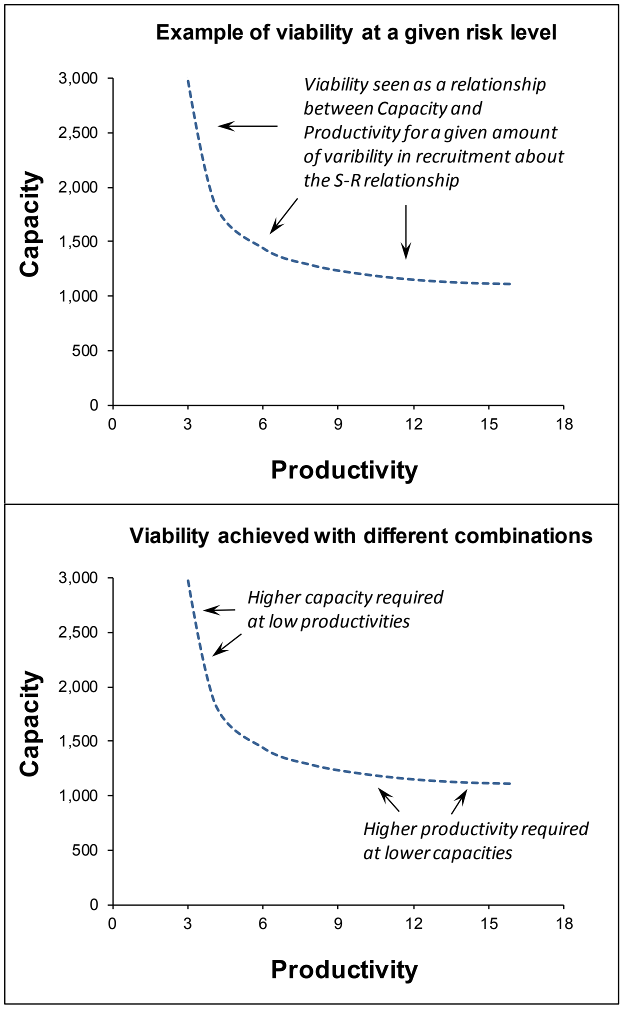

Figure 5. Example of a viability curve showing a relationship between capacity and productivity that defines a performance threshold for a salmon population associated with given level of extinction risk (e.g., <5% risk). The shape and location of the viability curve in relation to a population's capacity and productivity is determined by the amount of variability of recruitment around the underlying stock-recruitment relationship for the population. At relatively low productivities, a higher capacity is required to maintain low extinction risk, whereas at higher productivities a lower capacity is required for the same level of extinction risk. The example is based on a viability analysis for the Hood Canal Summer Chum ESU (from Lestelle et al. 2018).

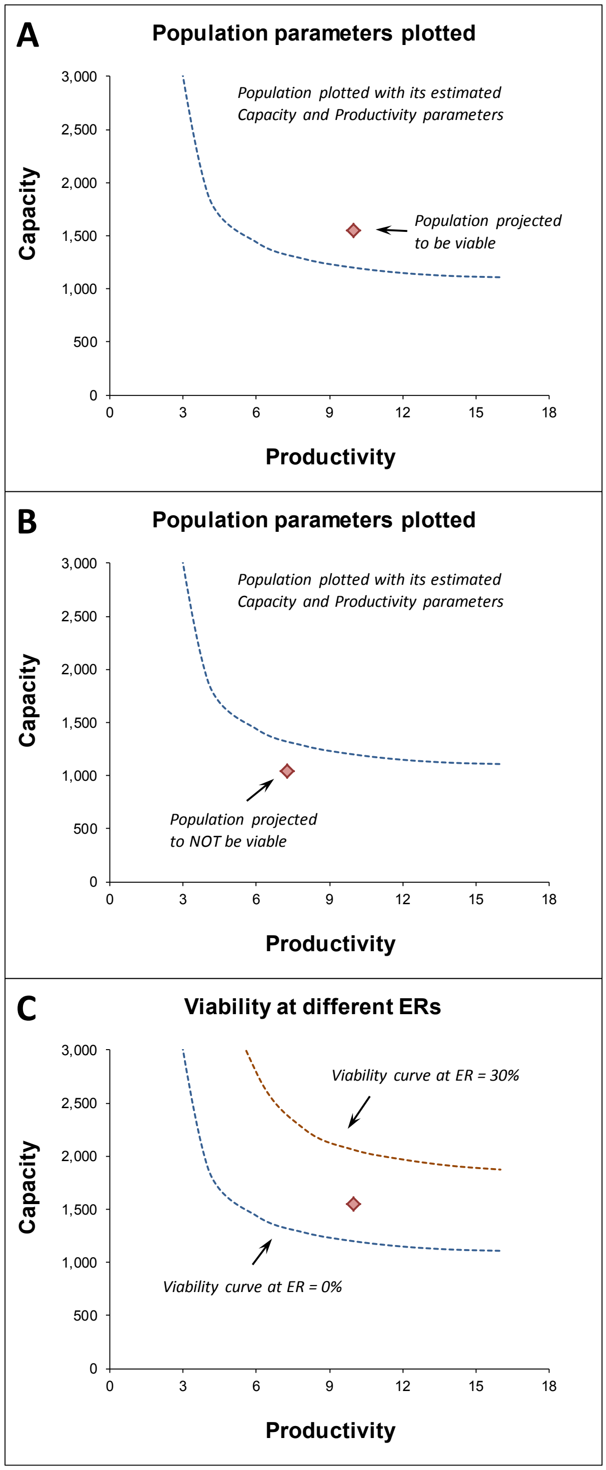

Figure 6. Example of salmon population performance plotted in relation to viability curves. A – The population is at low risk of extinction relative to the viability curve. B – The population is at high risk relative to the viability curve. C – The population is at low risk relative to the viability curve with an exploitation rate (ER) of 0 % but at high risk with an ER of 30%. The example is taken from a viability analysis of summer chum populations in Hood Canal (Lestelle et al. 2018).

Effects of increased abundances of exotic fishes

Exotic fish species (e.g., bass species) that can prey on juvenile salmon are a growing concern in the Chehalis Basin, and particularly within the mainstem Chehalis River corridor.

The EDT model incorporates some amount of predation mortality on juvenile salmon by exotic fishes (Lestelle 2005) but the effect is very small. Lestelle is aware of the level of effect since he was the author of the biological rules used in the model. The Science Review Team (SRT) for the Chehalis Basin Aquatic Species Restoration Plan has discussed the issue during its regular meetings and recognizes that the effect in EDT is nominal. Discussions of the potential effects of exotic fish species are continuing in the SRT since it is recognized that adverse effects may be significant and impede restoration progress.

Page E-21 in the DEIS states:

> *"Exotic species make up half of the vertebrate species in extensive surveys of floodplain off-channel habitats and commonly include species that prefer slow-moving water (e.g., basses, bullhead catfish, yellow perch and common carp)."*

During field trips to review Chehalis Basin areas in 2018, the SRT was briefed by long-time WDFW employee Curt Holt based in the Region 6 Offices in Montesano. Holt conducts the helicopter spawning surveys on the Chehalis River, oversees all other spawning survey work, and interacts regularly with recreational fishers on the river. He described the populations of both small and largemouth bass within the mainstem Chehalis River as being abundant and having many large fish, rivaling what a recreational fisher could catch in Eastern Washington. He showed the SRT many photos of large fish caught in the mainstem Chehalis River. Holt told the SRT that when he conducts helicopter surveys of the mainstem river, groups of largemouth bass are routinely startled by the helicopter and flushed from logjams into the open where they are easily spotted. Holt reported that he believes the abundance of bass has increased in the river since he began work for WDFW in 2000.

Crozier (2015) has reported a similar situation occurring in the Columbia River Basin. She reported that the threat from increasing predation by introduced bass is a management concern. Smallmouth bass is a particular concern in the John Day River subbasin, where bass were found feeding at the maximum consumption rate expected. Since bass were introduced in 1971 to the John Day River for recreational fishing, the population has been steadily expanding its range of distribution.

We conclude that the cumulative effects analysis should address what may be a significant source of mortality to juvenile salmon within the mainstem Chehalis River corridor, that is, from exotic fish predators. Predation by bass species on juvenile salmonids has been documented to be high in the Columbia River system (Sanderson et al. 2009). Moreover, it is likely that the effects being modeled as part of the EDT analysis are too low, perhaps by a substantial margin.

Hatchery fish

Hatchery fish released into streams can adversely impact the performance of co-mingled wild fish through competition for limited resources, predation by the hatchery fish on wild fish, and loss of genetic characteristics of wild fish through interbreeding with hatchery fish (HSRG 2004). The EDT model incorporates some amount of adverse effects of hatchery fish on wild salmon (Lestelle 2005), but similar to how the effects of exotic fish are addressed, the level of impact is very small and interactions between salmon and exotic species are not explicitly modeled.

The EDT model incorporates an attribute that identifies that juvenile hatchery fish can be present, but it does not consider the magnitude, fish size, or species of the hatchery releases. It is used in the modeling process as only a crude way to incorporate some risk that wild fish would be impacted by hatchery fish through competitive interactions or predation during juvenile life stages. The model does not address the effects of interbreeding between hatchery and wild fish.

Large numbers of juvenile hatchery coho and steelhead are released into Elk Creek, a tributary to the upper Chehalis River, entering the river approximately 8 miles downstream of the proposed dam site. Further downstream, hatchery coho and steelhead are released into the South Fork Newaukum River. The Newaukum River enters the Chehalis River approximately 35 miles downstream of the proposed dam site. Still larger numbers of hatchery fish are released into tributaries further downstream from the Newaukum River—notably in the Skookumchuck and Satsop rivers. Although the potential adverse effects of these programs are uncertain, a cumulative effects analysis should address them in conjunction with the other cumulative effects.

Interspecies interactions

In addition to hatchery-wild interactions, interspecies interactions of one salmonid species with other co-occurring species can affect survival, thereby compounding cumulative effects of the Proposed Project. Such effects warrant consideration as part of the cumulative effects assessment as their significance can be impacted by alteration of habitats, such as construction and operation of the FRE. Interspecific effects include nutrient transfer (Harding et al. 2019), multi-year nutrient subsidies (Nelson and Reynolds 2014), density-dependence in the ocean (Morita and Fukuwaka 2019), and competition and predation (Allee 1974; Fresh 1997).

Conclusions

The DEIS only addresses cumulative impacts of very limited potential mortality sources on the salmon populations in an extremely simplistic and superficial way. Other, more important mortality sources are ignored. Particularly lacking is consideration of how variability in freshwater and marine waters would combine with impacts of the Proposed Project, potentially producing much greater impacts than recognized in the DEIS. Climate change is also expected to increase interannual variability in survival, thereby greatly increasing the risk of extinction of the populations produced in the upper basin when considered in conjunction with impacts of the proposed project.

Also glaring in its absence is any consideration of how harvest would combine with impacts from the Proposed Project to reduce overall abundance, productivity, and diversity. A viability analysis of the populations produced in the upper Chehalis basin would need to incorporate harvest in the analysis.

Issue: Inadequate analyses of climate change

The DEIS does not present a separate evaluation of climate change. Rather, assumptions regarding future conditions are incorporated into analyses of the alternatives considered.

Page 5-3 of the DEIS states:

> *"The DEIS incorporates climate change projections for precipitation, temperature, flood peak flows, streamflow, and sea level rise throughout the analyses and modeling as part of the future conditions for all scenarios and for all resource areas. Climate change predictions are included in the baseline conditions for the Proposed Project, No Action Alternative, and Local Actions Alternative and are consistent between those. No separate impact findings for climate change or quantitative comparisons between the Proposed Project and alternatives related to climate change are made in this DEIS."*

A number of other factors, including, but not limited to assumptions involving development and tree growth, sedimentation, woody debris accumulation, and habitat improvement actions, are also included as part of future conditions; therefore, it is not possible to discern from the DEIS the effects of climate impacts alone.

Because details of the Local Actions alternative are uncertain and the DEIS assumes that local actions are “mainly non-structural”, the DEIS presents quantitative estimates only for FRE and the No Action alternatives; results were assumed to apply to the Local Actions alternative (DEIS p32).

Comments and Evaluation

The basis for climate projections within the DEIS is outdated and does not reflect current climate science.

Representative Concentration Pathways (RCPs)

Projections for mid and late century impacts on salmon under the FRE and No Action alternatives are based on downscaled information derived from simulation of two Representative Concentration Pathways (RCPs 4.5 and 8.5) by two Global Climate Models (GCMs).

RCPs are scenarios that have been developed to facilitate comparative simulations by alternative Global Climate Change Models by providing a common and consistent set of data representing starting conditions, historical data and projections of greenhouse gas concentrations.

> *"The name “representative concentration pathways” was chosen to emphasize the rationale behind their use. RCPs are referred to as pathways in order to emphasize that their primary purpose is to provide time-dependent projections of atmospheric greenhouse gas (GHG) concentrations. In addition, the term pathway is meant to emphasize that it is not only a specific long-term concentration or radiative forcing outcome, such as a stabilization level, that is, of interest, but also the trajectory that is taken over time to reach that outcome. They are representative in that they are one of several different scenarios that have similar radiative forcing and emissions characteristics".*
>
> *Source: IPCC Expert Meeting Report, Towards New Scenarios For Analysis Of Emissions, Climate Change, Impacts, And Response Strategies, IPCC 2007*

RCPs are identified by numbers that represent the expected change in radiative forcing[4] under average global concentrations of greenhouse gases (GHGs) by the year 2100. RCPs are not predictions, but rather datasets that are comprised of time-dependent estimates of major physical, ecological, and socio-economic driving forces (e.g., economic activity, energy sources, population growth) that determine GHG concentrations. These datasets, which cover historic and current periods, starting values for GCM simulations, and estimates for driving forces until the year 2100, are designed to enable GCMs to understand and characterize the robustness of alternative future climate change policies in the face of GCM uncertainties and sensitivities to data values. RCPs 8.5 (Riahi et al. 2007, 2011) and 4.5 (Clarke et al. 2007; Wise et al. 2009; Thomson et al. 2011) were employed for the DEIS. Under RCP 8.5,

[4] Radiative forcing is the balance between absorbed and radiated energy at the top of the Earth-atmosphere system that determines average global temperature. The RCP numbers represent the watts per square meter of change in that balance as measured from preindustrial conditions (defined as 1750) resulting from external (non-natural) factors, such as accumulation of greenhouse gases. The magnitude of radiative forcing serves as an index that reflects the importance of this imbalance in driving environmental change. The higher the number, the greater the radiative forcing, and hence temperature. For example RCP 8.5 indicates that the balance between incoming and outgoing energy at the top of the atmosphere is expected to increase by 8.5 watts per square meter (this change would increase global temperature by 4.9 degrees Celsius).

greenhouse gas emissions increase over time, resulting in high greenhouse gas concentration levels by 2100; under RCP 4.5, GHG emissions stabilize so total radiative forcing becomes relatively constant by or shortly after 2100 (Wayne 2009).[5]

Global Climate Models (GCMs)

RCP datasets are employed by GCMs to generate future projections using complex, stochastic mathematical algorithms representing climate forcing mechanisms. Individual GCMs can differ substantially due to their purposes, software designs, programming approaches, spatial and temporal resolutions, and representations of physical, chemical and biological processes. As a result GCMs produce a range of possible futures under RCPs.

GCMs involve intensive calculations and algorithms to solve mathematical equations to calculate how energy is transferred using the laws of thermodynamics and factors that influence radiative forcing to simulate how energy is cycled. GCMs can produce projections for dozens of environmental variables (winds, temperature, moisture, etc.) at a resolution of 150- to 200-square-kilometer computational blocks. Downscaling[6] procedures are employed to bring large-scale information at finer resolution to produce projections at local scales. There are only a handful of points with data available for downscaling within GCM grids that encompass the Chehalis Basin.

The DEIS relies upon GCM projections under RCPs 4.5 and 8.5. RCP 4.5 represents a future scenario that stabilizes radiative forcing at 4.5 watts per meter squared in the year 2100 without ever exceeding that value (Thompson et al. 2011). RCP 8.5 is commonly referred to as representing a "business as usual" scenario (because it incorporates no specific climate policy, the likely outcome if concerted, collective global efforts are not undertaken to curb emissions of greenhouse gases), a "high emissions" scenario, or a "worst-case" scenario, but in reality refers to the concentration of carbon that delivers global warming at an average of 8.5 watts per square meter across the planet, resulting in a temperature increase of about 4.3˚C by 2100, relative to pre-industrial levels.[7]

Current climate science uses an ensemble of multiple GCMs to help understand and evaluate uncertainties and their effects on the sensitivity and robustness of alternative climate policies. In

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[5] See Wayne, G.P. 2013. RCP 8.5 is commonly referred to as representing a "business as usual" scenario (because it incorporates no specific climate policy, the likely outcome if concerted, collective global efforts are not undertaken to curb emissions of greenhouse gases), a "high emissions" scenario, or a "worst-case" scenario, but in reality refers to the concentration of carbon that delivers global warming at an average of 8.5 watts per square meter across the planet, resulting in a temperature increase of about 4.3˚C by 2100, relative to pre-industrial levels. For further information, see: https://climatenexus.org/climate-change-news/rcp-8-5-business-as-usual-or-a-worst-case-scenario/ and Carbon Brief Explainer: "The High Emissions RCP 8.5 Global Warming Scenario" https://www.carbonbrief.org/explainer-the-high-emissions-rcp8-5-global-warming-scenario.

[6] The two main approaches to downscaling climate information are dynamical and statistical. Dynamical downscaling requires running high-resolution climate models on a regional sub-domain, using observational data or lower-resolution climate model output as a boundary condition. These models use physical principles to reproduce local climates, but are computationally intensive. Statistical downscaling is a two-step process consisting of i) the development of statistical relationships between local climate variables (e.g., surface air temperature and precipitation) and large-scale predictors (e.g., pressure fields), and ii) the application of such relationships to the output of global climate model experiments to simulate local climate characteristics in the future.

[7] For further information, see: https://climatenexus.org/climate-change-news/rcp-8-5-business-as-usual-or-a-worst-case-scenario/ and Carbon Brief Explainer: "The High Emissions RCP 8.5 Global Warming Scenario" https://www.carbonbrief.org/explainer-the-high-emissions-rcp8-5-global-warming-scenario.

contrast to DEIS' reliance on projections provided by only two GCMs, the Intergovernmental Panel on Climate Change (IPCC) utilizes ensembles of dozens of GCMs (Coupled Model Intercomparison Project, CMIP) to perform its periodic assessments of climate change (Massoud et al. 2019).

<u>Other Models</u>

The DEIS utilizes hydrologic, hydraulic, geomorphic, fish population, and fish lifecycle models to evaluate alternatives (DEIS p32). For impacts on salmon the DEIS replies on mid-century (2030-2060) and late-century (2060-2080) projections produced by the EDT Model (Lestelle and Morishima 2020).

Input parameters for habitat quality related to climate factors in EDT primarily consist of modelers' interpretative, qualitative conversions of outputs produced by other models (DEIS p32 and exhibit 3-2):

> *"The process for the DEIS used the results of one model to provide information for the next (Exhibit 3-2). First, the changes in water flows were identified using the hydrologic and hydraulic models. This included climate change projections and was used to help determine the study areas. This model showed the extent of the flooding for the Proposed Project and the No Action Alternative in the future. The water model results were then used in the geomorphology model to show changes in sedimentation in the Chehalis River. Both of these models were used for the fish population and fish lifecycle models for salmonid impacts. The results of these models were used throughout the preparation of technical Discipline Reports and the Draft DEIS chapters."*

Hydrologic models are of particular significance because assessment of impacts rely so heavily on alteration of flow regimes resulting from impacts of climate change. These models have notable deficiencies. For example, in their evaluation of hydrologic modeling, Mauger et.al. (2016) stated at p.47:

> *"The climate projections used in this study were an "ensemble of opportunity", meaning that they were not optimized for the Chehalis basin. Currently, there simply are not enough WRF simulations available to accurately characterize the range among projections – new regional model simulations could be produced based on a selection of global models that better captures the range among projections for the watershed. In addition, these simulations could be optimized to ensure that the mechanisms governing precipitation change are well represented."*

In Appendix C of their 2/18/19 memo on hydrologic modeling of the Chehalis Basin, Mauger and Karpack noted the importance of using a larger ensemble of GCMs and hydrologic models at p. 3:

> *"The primary limitation of this study is the lack of sufficient climate projections to reliably estimate the range among projections: two global climate models is simply not sufficient to do this…studies generally indicate that 6-10 different model projections are needed in order to develop a representative estimate of the mean and range among projections"*

They further noted the need for additional hydrologic modeling (p. 4):

> *"There are also several reasons that the latest results for the Chehalis River basin may change with further study. First, the results are based on just two global climate models. This is not enough: studies generally indicate that 6-10 different model projections are needed in order to develop a representative estimate of the mean and range among projections. Second, there are outstanding questions about how to address biases in the meteorological data and the optimal way to configure and calibrate the hydrologic model; both could be improved with additional investigation."*

Habitat-Drivers

The primary climate-related habitat characteristics evaluated in the DEIS using the EDT and Hybrid models are fine sediment, bed scour, wetted channel width, stream flow descriptors and water temperature. The flow characteristics are associated with annual peak flows, summer low flows, and rate of runoff (or flashiness). Fine sediment and bed scour primarily affect incubating salmon eggs. Wetted channel width is a determinant in the quantity of habitat available for different salmon life stages. Peak flows, which typically occur during periods of primary spawning activity and survival of eggs during incubation, strongly affect the rate of sediment supply and transport. Low flows affect spawning migrations of spring and fall Chinook (and holding habitat for spring Chinook), rearing conditions for juvenile coho and steelhead. Temperatures directly affect mortality due to metabolism and risk to disease for all species, and are especially important for prespawning spring Chinook during migration and holding periods.

Because of the methods and metrics employed, the DEIS analyses do not include consideration of other major impacts of climate change, such as changes in phenology, e.g., alteration of spawning and emergence timing of salmon, insects, pollination, migration, etc. The DEIS provides an estimate of greenhouse gas emissions in section 5.11.2.1 p144, but does not explicitly present impacts on salmon, ecological processes, or other species of plants and animals. The DEIS mentions at p41 that *"Sea level rise was also included in the analysis"*, but does not present information regarding these impacts.

Lack of Sufficient Information Regarding Climate-Related Impacts

The DEIS does not present sufficient information regarding climate-related impacts relating to:

- Alteration of atmospheric and ocean currents that will affect the frequency and intensity (severity) of water flow and storm events; although at p28, the DEIS indicates that the frequency of a major flood event would increase from 1 in 7 years to 1 in 4 years and a catastrophic flood event from 1 in 100 years to 1 in 27 years p29 (Exhibit 3-1). At p41, the DEIS acknowledges that *"During operations, impacts on surface and groundwater would occur over the long term and could result from either the FRE facility or the Airport Levee Changes."* Failure to consider how flood frequencies will change over time, thereby increasing the frequency of dam closure and reservoir filling, is conspicuously missing in the use of the Hybrid Model to assess effects of dam operations. We note that this failure is not made clear in the DEIS, but it was made clear to us in our meeting with Department of Ecology on February 10, 2020.
- Increased variability of precipitation patterns, changes in delta-bay (below RM 9) and marine environments (major sources of uncertainty with implications for diversity and capacity to sustain ability to exercise reserved treaty rights), and alteration of peak and low water flows and precipitation patterns implications for productivity, capacity, and ability to sustain harvest of aquatic species
- Changes in peak flows; although the DEIS analysis is dominated by certain kinds of physical effects of peak flows, it addresses impacts of the Proposed Project on ecological function within and outside the dam footprint only superficially. This is illustrated by the superficial treatment of alteration of geologic processes and biological processes that affect food webs (e.g., insects, molluscs, predation, algal blooms, etc.) on aquatic species. See also p81 "*Over the long term, the FRE facility would create a significant adverse impact on shellfish due to loss of habitat, impacts on mussel beds, changes in host fish abundance and distribution, and their inability to re-establish colonies between flood events. Macroinvertebrates are likely to recolonize disturbed areas and take advantage of newly deposited substrates but would likely have lower*

species diversity and different community composition. Over the long term, the FRE facility would create a significant to moderate adverse impact on aquatic macroinvertebrates due to loss of habitat, loss of food sources, and changes to water temperature, flow, and substrates."

Although the DEIS mentions consideration of low flows, for the DEIS the main focus of climate change analysis was centered on peak flood water flows and temperature. Peak flood flows were projected to increase by 12% in mid-century and 26% in late-century. Temperatures were projected to increase at the same rate as increasing air temperatures, 3.6° F to 5.4° F for most areas by late-century. DEIS p41.

EDT climate change modeling was limited to two geographic areas, above Crim Creek and from Pe Ell to Elk Creek, with respect to how the modeled populations were delineated for spawning. Monthly average flows and temperatures were reported in Table E-18 from Appendix E Fish Species and Habitats Discipline Report, pE-150.

The 26% increase in peak flow by the end of century does not represent sound science. The UW CIG (Mauger et.al. 2016) and PSU analyses (Van Glubt et al. 2017) utilized a very limited set of models, performed analyses that were designed and undertaken for different purposes, and relied upon tenuous assumptions regarding the adequacy and applicability of the models that were relied upon to generate projected environmental changes.

The DEIS uses only two GCMs and two emissions scenarios that indicates the modeling team employed what Mauger et al. (2016) referred to as an *"ensemble of opportunity, meaning that they were not optimized for the Chehalis basin. Currently, there simply are not enough WRF simulations available to accurately characterize the range among projections – new regional model simulations could be produced based on a selection of global models that better captures the range among projections for the watershed. In addition, these simulations could be optimized to ensure that the mechanisms governing precipitation change are well represented."*

Mauger and Karpack make a similar statement (App C in memo dated 28 Feb 2019 from WSE), stating:

> *"The primary limitation of this study is the lack of sufficient climate projections to reliably estimate the range among projections: two global climate models is simply not sufficient to do this…studies generally indicate that 6-10 different model projections are needed in order to develop a representative estimate of the mean and range among projections."*

Projected Climate Change Impacts

Projected climate change impacts on salmon abundance were graphically summarized for salmon originating in two areas near the proposed project in the memo of March 31, 2020[8]. The limited information provided in the DEIS regarding impacts on productivity (Appendix E, pE-143/144, E-188), diversity (Appendix E, pE-146), or spatial structure does not permit effects of climate change to be distinguished from effects of the Proposed Project.

Effects of climate change on productivity and diversity are not highlighted in the DEIS, but some information is available in the discipline reports or through examination of detailed EDT outputs. Inadequate treatment and presentation of these important metrics obscure their significance and importance in understanding and interpreting EDT results. Unfortunately, presentation and

[8] To: Chehalis Basin Board From: Andrea McNamara Doyle, Office of Chehalis Basin Director Cc: Gordon White and Diane Butorac, Department of Ecology; Michael Garrity and Celina Abercrombie, Department of Fish and Wildlife; Stephen Bernath, Department of Natural Resources; Bart Gerhart, Washington State Department of Transportation Re: Response to Chehalis Basin Board Questions on the Chehalis River Basin Flood Damage Reduction Project.

communication to the public the tables on pages 20-21 of the March 31 memo are incorrectly labelled. These tables are not extracts from the referenced sources, but appear to be reconstituted and incorrectly interpreted from information in the DEIS and appendices. The values in these tables do not represent model projections of "productivity", but rather reflect metrics pertaining to "diversity" (Note that the values for Spring Chinook No Action Alternative are not correct for diversity). Consideration of productivity is important to address some of the questions on p24 regarding recolonization (the way that populations are modeled and assumptions regarding independence and lack of consideration for meta populations).

Effects of the FRE and No Action alternatives are reported in DEIS, Exhibits 5.3-3, 5.3-4, 5.3-6, and 5.3-7. For the area above Crim Creek, there is an early and substantial decline in no harvest abundance (at equilibrium) of coho and steelhead projected to result from construction activity. The partial recovery of these species in mid-century is due to improved upstream passage during operation of the proposed project. Under the No Action alternative, no harvest abundances for both the No Action and Proposed Project alternatives spring and fall Chinook are projected to decline gradually through mid-century and continue to be reduced by late century due to projected increases in peak flows and temperature to lethal levels. For the area from Crim Creek to Rainbow Falls, the no harvest abundances of coho, steelhead, spring and fall Chinook are projected to decline gradually through mid-century, but accelerate by late century due to increases in peak flows and projected temperatures reaching lethal levels.

The DEIS, however, does not discuss other important differences between the projected impacts of the Proposed Project and No Action alternatives. Adverse impacts may occur under the FRE earlier than under the No Action alternative. Due to its steady-state nature of the EDT modeling employed, the DEIS provides mid and late century information on salmon population impacts, but does not provide information on timing of when adverse effects would be expected to occur or their duration. Under the Proposed Project, adverse impacts will occur during initial 2025-2030 period of construction and subsequent operation of the FRE facility; accelerated impacts would reduce the time available for potential mitigation or restoration actions to take effect. The framing of purpose, objective, and metrics for the DEIS precludes the possibility that other alternatives could be developed to meet the twin objectives of the Chehalis Basin Strategy, i.e., reducing damage from flooding throughout the Chehalis Basin and restoring aquatic species.

Appendix E, pE2-33 to E2-35 list limitations of the modeling and acknowledges areas of uncertainty, including substantial uncertainties associated with climate change projections, but do not describe the potential significance of those uncertainties on projected impacts of the Proposed Project or the No Action alternative.

Because of the manner in which steady state results of EDT is presented in the DEIS, it is not possible to separate impacts of the components of the proposed project (FRE and levee) separately or untangle impacts of climate change from other assumed conditions or restoration actions. The difference between the No Action alternative and the proposed FRE is presented as being attributable to FRE effects, but there is no discussion of the confounding effects of interactions between assumptions regarding future development, or other changes anticipated to occur over time. No information is presented regarding separation of effects of construction activities or operation. Biological damage that would occur during construction[9] is uncertain due to uncertainties regarding the annual period of

[9] Construction is proposed to occur over five years and the applicant has requested that annual construction period be permitted to run from July through September, a time period encompassing active migration of salmon

construction activity and the total number of years required to complete construction. No information is presented as to timing (i.e., differences in when impacts of climate change would be projected with dam/levee and without) of impacts on fish and wildlife.

Uncertainties

There is substantial uncertainty regarding the parameterization that was employed to configure EDT and other models to produce the results presented in the DEIS. The appendices, and discipline reports do not provide explicit and necessary detail.

An area of particular significance is the failure to consider and evaluate the increase in uncertainties as the projection horizon extends further into the future. GCMs produce projections of environmental outcomes that become increasingly uncertain over the simulation period. Consequently, there is greater uncertainty over late-century than mid-century timeframes. The increase in the degree of uncertainty in GCM projections over time is striking as illustrated by Figure 7, extracted from Arnell et.al. (2014). The different colors represent projections for temperature using an ensemble of GCMs for different RCPs. The heavy lines represent GCM means, showing markedly different and divergent trajectories for RCPs 8.5 (blue) and 4.5 (red).

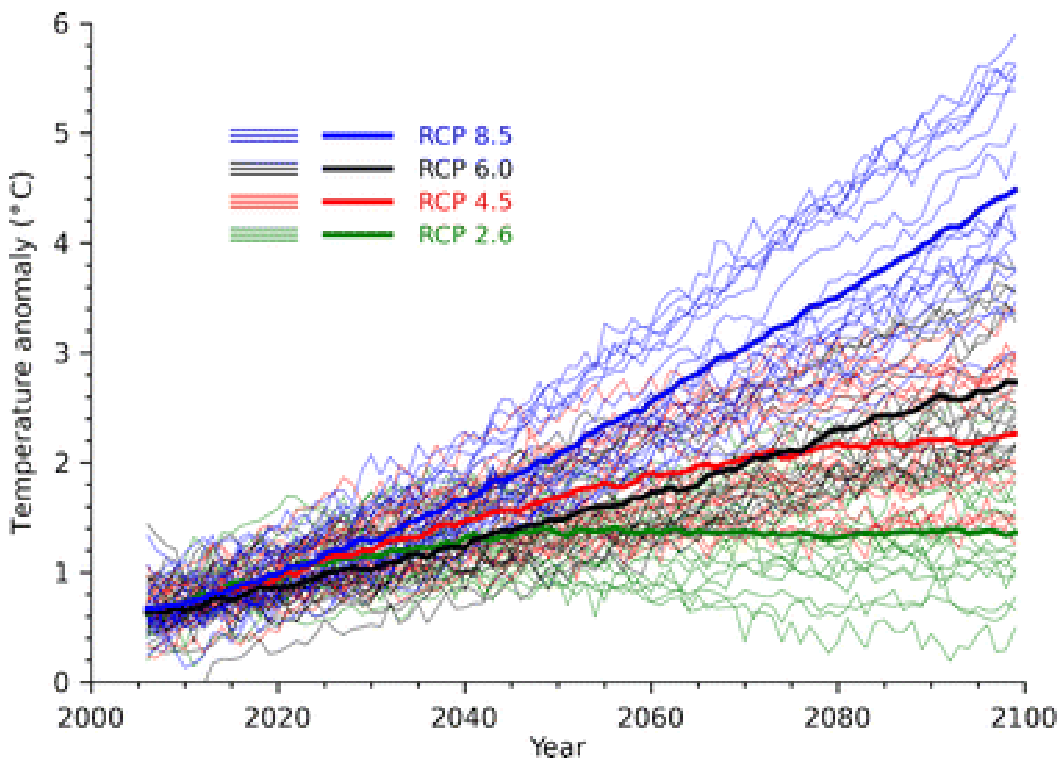

Figure 7. Projections of temperature uncertainty using different Global Climate Models (GCMs). Projections become increasingly uncertain over the simulation period. Different colors represent projections for temperature using an ensemble of GCMs with different RCPs. The heavy lines represent GCM means, showing markedly different and divergent trajectories for RCPs 8.5 (blue) and 4.5 (red). From Arnell et al. (2014).

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species. The DEIS does not provide information on magnitude or duration of likely adverse impacts on salmon (particularly Chinook and coho) which may occur during construction.

The DEIS Relies on Outdated GCMs and RCPs.

GCMs have been and continue to be continually refined. The Figure 8 illustrates how GCMs evolved from fuzzy, simple models of climate forcing mechanisms to encompass more and more components (from Fahys 2019). The DEIS relies on fifth generation of GCMs, Coupled Model Intercomparison Project (CMIP5), which was used to produce the fifth Intergovernmental Panel on Climate Change (IPCC) assessment report (IPCC 2014). The current generation of GCMs (CMIP6), includes over 100 GCMs being developed by about 50 research groups; these next generation models represent substantial advancements in representation of ecological processes and GHS forcing mechanisms with higher resolution (Carbon Brief, December 22, 2019).

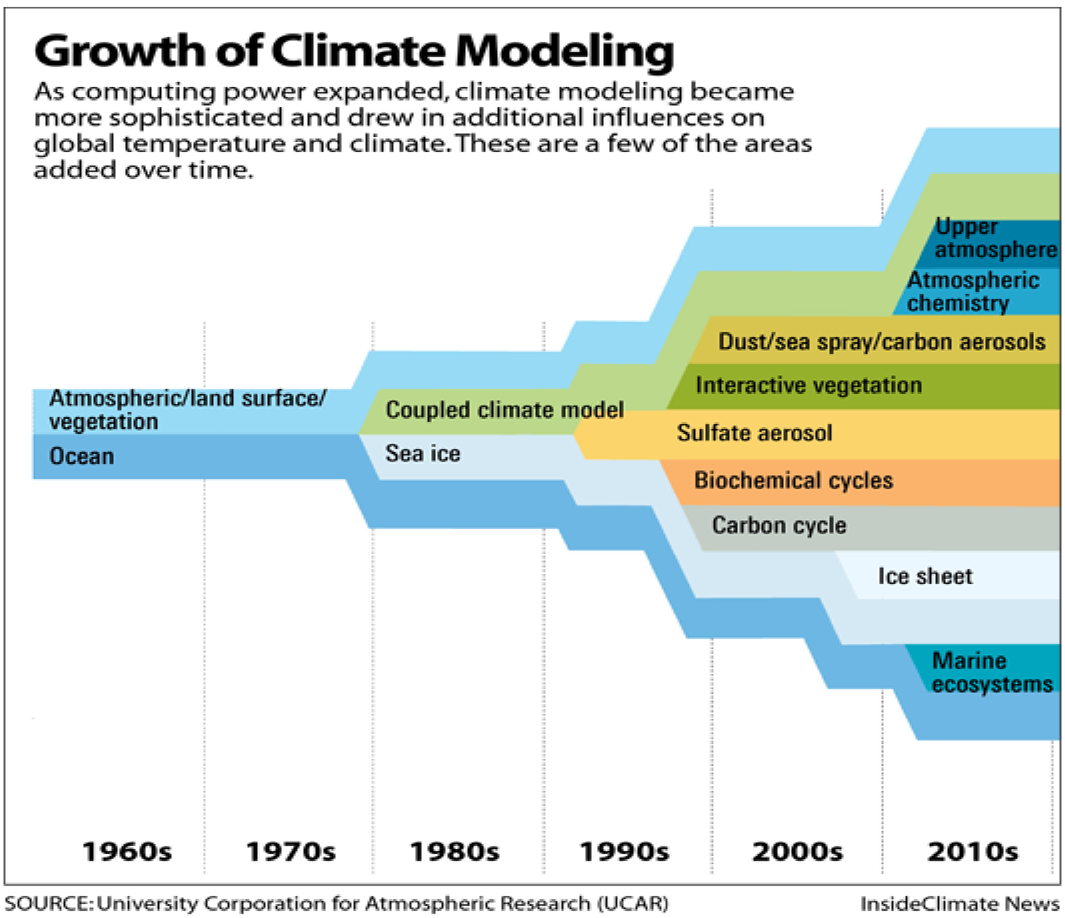


Figure 8. Growth of climate modeling since the 1960, illustrating how different components have been incorporated over time. From Fahys (2019).

Representative Concentration Pathways (RCPs) 4.5 and 8.5 were used for the 4th National Climate Assessment. The next generation of global climate models (https://www.carbonbrief.org/cmip6-the-next-generation-of-climate-models-explained) and Shared Socioeconomic Pathways (SSPs; https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change) are well under development. Results from the next generation of climate models (Coupled Model Intercomparison Projects- CMIP6 – approximately 100 global climate models being developed by some 49 groups of researchers) reflect substantially larger increases in temperature and changes in peak/low flows than previous versions.

RCPs have been replaced by a set of five Shared Socio-Economic Pathways (SSPs), which provide specifics regarding alternative global futures of societal development (Kriegler et al. 2012; van Vuuren et al. 2012; O'Neil et al. 2017). SSP are being augmented by a new set of global, spatially explicit population scenarios for the period 2010-2100 in ten-year time steps at a spatial resolution of 1 kilometer (Spatial Population Scenarios) (Jones et al. 2016; Gao 217).

Conclusions

We conclude that the consideration of climate change in the DEIS is inadequate and flawed. It is simplistic, does not reflect increasing uncertainty over time, based on an insufficient ensemble of outmoded GCMs, and utilizes an average of two RCPs without scientific basis. In short, the climate change methods employed by the DEIS to project mid and late century environmental conditions and their effects on salmon populations do not represent best science.

Summary:

- The DEIS Climate change analyses do not reflect current climate science. They are based on outdated models, fail to employ an adequate ensemble of GCM and hydrologic models, and do not include substantive treatment of major factors that would affect future salmon populations, including changes in estuarine and marine conditions, and environmental stochasticity and uncertainty. Variability and uncertainty in freshwater, estuarine or marine environments is high and the DEIS fails to discuss their potential significance of projected effects of the proposed project or alternatives.
- The DEIS climate change evaluation is overly focused on peak flows and temperatures on the "no harvest" abundances of salmon populations originating in the immediate vicinity of the Proposed Project and No Action alternatives. Impacts of the Local Action alternative are not substantively evaluated. Information on effects on productivity, diversity, and spatial structure is sparse with inadequate discussion of implications for resilience or long-term sustainability. The DEIS does not present adequate information on impacts of low water flows, impacts of changes in base flows from operation of the proposed project, or groundwater recharge and discharge rates, and hence baseflows[10]. Groundwater recharge rates appear to be underestimated by a factor >4. A multi-year groundwater/surface water model is needed to characterize effects of baseflows and their importance for determining extreme low flows.
- Projected changes in flows and temperatures are likely underestimates of the frequency of flows greater than the FRE reservoir outflow rate, the magnitude of late century annual peak flows, and future temperature increases.
- The DEIS does not discuss implications of population changes for potential harvest, important considerations for commercial, subsistence, and recreational in-river and marine fisheries over a broad geographic area.

[10] Baseflow is the portion of streamflow that is sustained between precipitation events, fed to streams by delayed pathways. Also called drought flow, groundwater recession flow, low flow, low-water flow, low-water discharge and sustained or fair-weather runoff, baseflow represents "the sum of deep subsurface flow and delayed shallow subsurface flow." For policy-level discussion, it is likely more useful to utilize the concept of *"Environmental flows"* instead of the hydraulic science term baseflows. Environmental flows refer to the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems, i.e., flow regimes, or patterns, that provides for human uses and maintains the essential processes required to support healthy river ecosystems.

- The limitations imposed by the framing of the DEIS (purpose, objectives, and metrics) preclude consideration of other actions for reducing damage from flooding and restoring aquatic species.
- The DEIS does not provide specific information on how projected impacts would affect the Chehalis Basin Strategy's twin goals of reducing flood damage throughout the Chehalis Basin and restoring aquatic species.
- The DEIS mentions that certain restoration actions are assumed, but does not provide specific information on location, timing, or scope of such actions or their effects, nor on what restoration program these might be associated with. Potential effects of actions taken pursuant to the Aquatic Species Restoration Plan, an integral part of the Chehalis Basin Strategy in addition to the goal of reducing flood damage throughout the Chehalis Basin, are not evaluated.
- Construction and operation of the proposed project would affect environmental conditions in the Chehalis Bain and estuary area below the immediate vicinity, which would be important to the ability to sustain ecological processes that affect the abundance and productivity of fish, wildlife, and plants essential to the ability of QIN to exercise its treaty-protected rights and protect cultural resources. Additionally, habitats of these species would be adversely affected by the anticipated increased demand for development of the floodplain following reduction of flood risk; however the DEIS fails to provide information on the location, magnitude, and type of development or attempt to quantify impacts. The DEIS does not consider impacts on salmon populations originating in areas other than the mainstem reaches, but which utilize common below the study area.
- The DEIS does not provide adequate treatment of effects of reservoir drawdown rates water saturation and groundwater flows on slope stability within the FRE reservoir area and hence consequential impacts on sediment and debris accumulation.

Inadequate Analyses of Effects on the Ecological Integrity of the Chehalis Basin

The Chehalis is large and diverse in geology, hydrology, habitat characteristics, and ecology. At 2,700 square miles, it is the second largest watershed in Washington. Recognizing this diversity, the Science Review Team (SRT) in developing the Aquatic Species Restoration Plan (ASRP) delineated separate regions within the basin based on distinct geologic, hydrologic, and ecological characteristics and related watershed and landscape-scale processes. These regions were called Ecological Diversity Regions, or simply Ecological Regions for brevity. The concept fundamentally recognized that diversity within the basin is important for the long-term resiliency and sustainability of the natural ecosystem and its flora and fauna. This concept of distinct ecological regions is a core foundational concept of the ASRP. A total of ten separate regions were delineated.

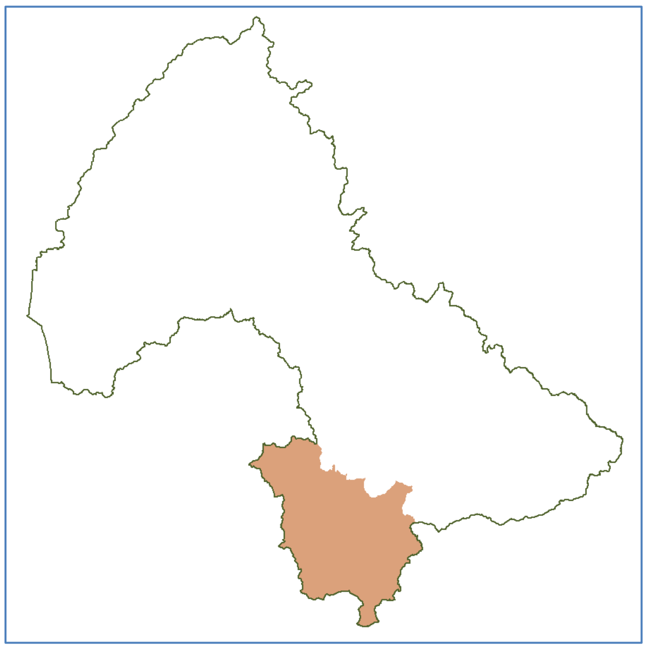
Page A-24 of the ASRP (ASRP Steering Committee 2019) states with regard to the approach taken in developing the ASRP:

> *"The central premise of the approach is that protecting or restoring all ecological regions to some degree is important to achieve the ASRP's vision, although the restoration needs are not equal in every region. The long-term health of the basin requires restoration to improve ecological health within each ecological region. The level of effort in each ecological region will vary due to differences in land use and habitat degradation among ecological regions. Also, the potential gain in species performance from restoration will result in differences in restoration needs and strategic priorities among regions. Some level of restoration effort would be committed to each region, but the intensity of efforts will vary among regions."*

One of these ecological regions is called the Willapa Hills Region. It encompasses the most upper parts of the Chehalis Basin, containing all of the South Fork and the upper basin upstream of the South Fork. The ASRP Phase 1 document described the region as follows:

> *"The Willapa Hills Ecological Region encompasses the upper Chehalis River (above Rainbow Falls) and tributaries, including East Fork and West Fork Chehalis rivers, Elk Creek, and the South Fork Chehalis River and its tributaries (Figure 5-1). This ecological region encompasses 316 square miles (greater than 200,000 acres) and represents approximately 12% of the overall Chehalis Basin. The maximum elevation in the watershed is 3,113 feet at Boistfort Peak (also called Bawfaw). The Chehalis River arises in the East Fork and West Fork, and primary tributaries to the upper Chehalis River include Thrash, Crim, Rock, and Elk creeks and the South Fork Chehalis River."*

The area encompassed by this region within the basin is shown below



The ASRP Phase 1 document listed the important features and functions of this region as follows (page 72):

- Willapa Hills was a former stronghold of spring-run Chinook salmon, but species occurrence has been highly variable and notably decreasing in recent years, leading to concerns about local extirpation.
- The upper Chehalis River supports a relatively large number of wild winter-run steelhead (Ashcraft et al. 2017).
- This ecological region anchors the location in the watershed where anadromous fish life histories have the longest distance in their migrations upstream of the estuary (promoting substantial life history diversity).
- The greatest diversity of amphibians is in this ecological region. It is the only region with Dunn's salamander, has the highest densities of Western toad in the basin, and is an important area for both coastal tailed frog and Van Dyke's salamander.

Large parts of this ecological region were prioritized for action under the ASRP, given prominence as part of Scenario 1 within the plan (signifying high priority). The plan stated:

> *"Priority restoration areas in the Willapa Hills Ecological Region include the mainstem Chehalis River above Rainbow Falls; East Fork and West Fork Chehalis rivers; upper South Fork Chehalis River; and Stillman, Lake, Big, Crim, Thrash, and Elk creeks."*

Notably, much of the area that was assigned as high priority for restoration in this ecological region is within the area that would be directly impacted by the construction and operation of the FRE facility.

We conclude that key ecological processes, species and life histories within this ecological region would be effectively devastated if the FRE facility was constructed and operated. If that happened, it would adversely affect the overall ecological integrity of the basin as envisioned under the ASRP. The DEIS did not adequately address such effects on the overall ecological integrity of the Chehalis Basin.

Impacts on Harvest Opportunity

A critical shortcoming of the DEIS is the failure to consider impacts of the Proposed Project on treaty-protected rights of QIN to harvest salmon produced by the Chehalis Basin. For QIN, the ability to harvest both naturally and artificially produced fish is central to its ability to exercise treaty-reserved rights, maintain human health, and ensure cultural survival. The DEIS does not provide information regarding the potential impacts of the Proposed Project on harvest.

The abundance and productivity of Chehalis Basin salmon affect harvest opportunity not only within the Chehalis Basin, but also for offshore commercial and recreational mixed-stock fisheries from California to Southeast Alaska.

In article 3 of the Treaty of Olympia with the United States[11], ancestors of the Quinault people reserved the right to take fish at usual and accustomed grounds and stations and the privilege of hunting and gathering. Securing the fishing right[12] in the treaty was critical to the Quinault signatories because fish and fishing served as the core of their culture, economy, and way of life. The Quinault Indian Nation is the only federally recognized tribe with reserved treaty fishing rights in the Chehalis River Basin, which includes the entirety of Grays Harbor. Its usual and accustomed fishing grounds and stations also include the marine area extending offshore for several miles and northward to Destruction Island. The treaty fishing right encompasses the right to co-manage resources shared with the citizens of the United States and to ensure that the State of Washington does not authorize activities or measures that threaten the ability to conserve fish, wildlife, or plant resources. The Quinault Indian Nation is one of only three tribes with self-regulatory status, that is, it has the authority to enact and enforce regulations pertaining to its fisheries and conduct its management activities free of interference by State and Federal entities so long as conservation of the resource is protected.

Although salmon remains central, the treaty reserved rights of the Quinault Nation are not limited to salmon, but rather cover all species. Today, Quinault fisheries harvest salmon (steelhead is a species of salmon), crab, clams and other shellfish, and multiple finfish species offshore. Fish are harvested for commercial, subsistence, ceremonial and cultural use, but hunting and gathering also remains vital to Quinault way of life. For the Quinault to be able to exercise their treaty rights, protected as the supreme law of the United States, the environment must be capable of producing harvestable quantities of resources sufficient to meet their needs.

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[11] Signed on 1 July 1855, at the Quinault River, and on 25 January 1856 at Olympia, the territorial capital. Ratified by Congress on 8 March 1859, and proclaimed law on April 11, 1859. 12 Stats., 971 .

[12] The use of the term "right" is particularly important because it distinguishes what was secured from the privilege of fishing, hunting, and gathering enjoyed by non-Indians, which would eventually be regulated by territorial and state governments.

The Treaty of Olympia was one of several treaties that opened the territory for settlement and development, which would take their toll over time with increased pressures for exploitation of resources and degradation and loss of habitats essential for continued production of fish, wildlife, and plants. The loss of salmon habitat due to land, water, and hydropower development has led to widespread reliance on artificial propagation (hatcheries) to mitigate or compensate for loss of production from naturally spawning fish.

When the treaty was signed, salmon were predominantly harvested as mature fish returning to rivers to spawn. As settlement proceeded, fisheries developed with the capability to harvest salmon far from their rivers of origin, posing new conservation challenges for resource conservation. Over decades, domestic and international processes and agreements for constraining harvest were put in place (Morishima and Henry 1999).

Chinook and coho salmon originating in the Chehalis Basin are harvested by commercial, recreational, and subsistence fisheries on mature fish within the Chehalis Basin and the Grays Harbor estuary. Additionally, these species are harvested over an extensive marine geographic area. Chehalis Basin fall Chinook are predominantly north migrating and are harvested at various stages of maturity over an area ranging from the Washington Coast to Southeast Alaska. Little information is available on marine harvest of Chehalis Basin spring Chinook. Chehalis Basin coho salmon are harvested by marine fisheries primarily during the last few months of life from offshore fisheries over a geographic area ranging from Southern Oregon through mid-British Columbia.

Several species of salmon are expected to be significantly and adversely affected if the Proposed Project proceeds. The status (abundance relative to conservation requirements for escapement, productivity which affects the ability to recover from short stress, and diversity which pertains to the inherent capability to sustain production and adapt under unstable environmental conditions) of Chehalis Basin salmon can affect fisheries over an extensive geographic area over an extended period of time.

Fisheries in marine waters are regulated by multiple jurisdictions, including states, tribes and first nations, Regional Councils established by the Magnuson-Stevens Fishery Conservation and Management Act, and international agreements such as the Pacific Salmon Treaty. These regulations provide for sharing of available harvest by hook-and-line fisheries and conservation responsibilities in accordance with framework and annual management plans, international and domestic statutory and legal requirements and fishery planning processes. Since the mid 1970's, annual fishery planning processes of the Pacific Fishery Management Council established under the Magnuson Stevens Fishery Conservation and Management Act produce plans for sharing harvest and conservation responsibility by commercial and recreational fisheries in the Exclusive Economic Zone off the coasts of Washington, Oregon and California and in state territorial waters. Since the mid 1980's, Alaskan and Canadian fisheries have been constrained by agreements between the United States and Canada pursuant to the Pacific Salmon Treaty.

For coho, marine fisheries harvest complex mixtures of natural and hatchery fish that originate in rivers coast-wide; annual planning processes are managed on a weak stock basis, that is, conservation constraints for the stock that can sustain the smallest rate of exploitation. For Chinook, weak stock management applies within state waters; harvests by Canadian and Alaskan fisheries are constrained by the 1985 Pacific Salmon Treaty agreement, which is based on variable harvest rates depending on aggregate abundance of all comingled hatchery and natural origin fish.

In the Chehalis River and Grays Harbor, gillnet fisheries account for the vast majority of commercial and tribal harvest of mature fish while hook-and-line fisheries account for recreational fishery harvest.

Commercial, subsistence, ceremonial, and recreational harvests are constrained by escapement goals for fish originating in the rivers and streams draining into Grays Harbor.

The distribution of mortalities of Chinook and coho originating from the Chehalis Basin is annually reported by Technical Committees of the Pacific Salmon Commission established by treaty between the United States and Canada in 1985.

Economic value of commercial harvests are commonly expressed in terms of ex-vessel values. Recreational fishery values are derived from expenditures for economic activities associated with recreational experience.

Salmon are important sources of food, providing protein, vitamins, and oils for consumption and nutrients to support aquatic and terrestrial ecosystem functions. For the Quinault peoples, the consumption of salmon is vital to dietary health and community well-being, affecting susceptibility to debilitating diseases like diabetes, and providing food for sharing in ceremonial and cultural events.

Section 5.3 p70 of the DEIS acknowledges the importance of harvest, yet the analysis of impacts of the proposed project does not consider impacts on the ability to harvest (pE2-2).

Moreover, the information presented in the DEIS is centered on abundance; projections of effects on productivity, diversity, and spatial structure are sparse and not clearly presented for public review and are only summarily presented in Section 3.2.3.2. Effects of harvest on salmon populations are not substantively evaluated, and discussion of implications for harvest opportunity is missing entirely.

Harvest affects both the sustainable abundance of salmon and the productivity of individual populations (or stocks) (see also discussion in this report under Cumulative Effects). Although the salmon resource is comprised of several individual stocks that originate and utilize different habitats within the Chehalis Basin, harvest is predominantly conducted on aggregate mixtures of stocks. Consequently, the effects of harvest activity must be evaluated on the basis of the suite of Chehalis Basin stocks.

The EDT analyses of impacts on salmon are almost entirely limited to consideration of populations originating in the Chehalis River mainstem areas originating in the immediate vicinity of the proposed FRE, or upstream of that point. These populations are only components of the aggregate salmon populations produced by the Chehalis Basin. Salmon stocks originating elsewhere within the Chehalis Basin will utilize freshwater, estuarine, and marine habitats affected by the Proposed Project, yet impact information on those other population components is missing.

The scope and content of the DEIS is centered on the Proposed Project. Substantive quantification of impacts on estuarine and marine environments affecting the availability of fish, shellfish, wildlife and plant resources for harvest for commercial, recreational, or cultural use are not provided.

The EDT model projections provided in the DEIS represent impacts on stock aggregates; no information on the productivities of individual stock components is provided. "Productivities" reflect the average productivities of the life stage trajectories (randomly sampled life histories and associated habitats) with productivities exceeding the value 1, i.e., that are capable of being sustained in the absence of harvest. EDT also produces projections of a metric termed "diversity" that refers to the proportion of trajectories having productivities that exceed the value 1. As harvest increases, more and more of the least productive stocks will be lost over time, decreasing spatial structure of the aggregate population. For statistics reported by the EDT model, the loss of less productive trajectories can result in an increase in productivity and a decrease in diversity.[13]

In practice, harvest impacts would not be expected to become immediately apparent, absent extremely high rates of exploitation. Instead, as exploitation exceeds the productivities of individual stocks, their abundance would decrease over time. When reviewing the DEIS projections of impacts of the Proposed Project on salmon, it is important to recognize that EDT produces projections under steady state conditions; while it is capable of producing "snapshot" of expected population performance under steady state conditions, it is not capable of generating projections of population response over time.

For harvest opportunities, abundance, productivity, diversity and spatial structure are all important considerations, but for different time scales. For constraining annual harvest, abundance in relation to escapement needed for propagation is the driving factor. Over a longer time scale, changes in abundance will be driven by productivities of aggregate populations Aggregate populations will depend on the productivities and abundance of individual component stocks. Salmon sustainability and viability over the long term need to incorporate concepts of diversity and stock structure (McElhany et al. 2000).

Quinault and other fisheries are increasingly reliant on the ability to access fish with harvestable fish (abundance above that needed for reproduction)—this can also affect whether available hatchery fish can be harvested. The DEIS does not address how the harvest of available hatchery fish could be impacted by the Proposed Project. The ability to harvest hatchery fish is limited by constraints resulting from the need to provide adequate spawning escapements for naturally produced salmon. As naturally-produced fish decline in abundance, as would happen under the Proposed Project, constraints on harvesting available hatchery fish would be increased, making it more difficult for QIN to access those hatchery fish. The DEIS mentions mitigation as potential measures to reduce adverse impacts of the Proposed Project, but provides no specifics, deferring to future development of mitigation plans and assessments of technical and financial feasibility. Nor does the DEIS identify opportunities for restoration of aquatic species, a co-equal objective of the Chehalis Basin Strategy along with reducing flood damage throughout the Chehalis Basin.

The Proposed Project would affect salmon, other species of fish, and ecological processes that also affect wildlife and plants (e.g., beargrass for basketry, aesthetic and recreational enjoyment). The DEIS does not include information regarding how the Proposed Project would be expected to affect the quantities of salmon, shellfish, wildlife, or plant resources available for harvest or the ability to access those resources.

In conclusion, the capacity of Chehalis Basin salmon to sustain harvest is of seminal importance to the Quinault Nation and to other fisheries off the coasts of Oregon to Southeast Alaska. The ability of QIN to harvest both naturally and artificially produced fish is central to its ability to exercise treaty-reserved rights, maintain human health, and ensure cultural survival. However, the DEIS is devoid of substantive discussion of potential impacts of the Proposed Project on harvest opportunity on salmon, shellfish, wildlife, or plants of concern to the QIN and its members.

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[13] In such case, the increase in productivity is small but in combination with the loss of diversity results in an overall loss of resilience to the population. This can happen when the population has been reduced to relatively small size and there has been a substantial loss in diversity so that the segment of the population remaining is very small—any further loss in diversity often leads to extinction in the model.

Inadequate Discussion of Mitigation and Related Conclusions

The DEIS provides no meaningful substance or related discussion on the scope of mitigation that is contemplated to offset the impacts that are projected to occur as a result of the Proposed Project.

Page S-14 very briefly summarizes the needed scope of mitigation, stating that the impact finding regarding fish, aquatic species and habitat would be significant and unavoidable, unless mitigation is feasible for:

- Aquatic habitat in the reservoir area and from the facility site to the confluence with the South Fork Chehalis River
- Spring-run and fall-run Chinook salmon, coho salmon, and steelhead in the Above Crim Creek and Rainbow Falls to Crim Creek subbasins
- Non-salmon native fish, including lamprey
- Migratory non-salmon native fish, including minnows and sculpin
- Freshwater mussels
- Macroinvertebrates

The DEIS then states that mitigation plans would be developed for the following (pS-14):

- Fish and Aquatic Species and Habitat Plan
- Large Woody Material Management Plan
- Riparian Habitat Mitigation Plan
- Stream and Stream Buffer Mitigation Plan
- Surface Water Quality Mitigation Plan
- Vegetation Management Plan
- Wetland and Wetland Buffer Mitigation Plan
- Wildlife Species and Habitat Management Plan

We find that the lack of the scope and substance of proposed mitigation does not permit full evaluation of the impacts of the Proposed Project. The types, locations, and timing of actions to be taken under any of these mitigation plans are not identified; instead the DEIS leaves the determination of technical and financial feasibility of mitigation to consultation and permitting processes that would be undertaken should permitting of the Proposed Project proceed. Therefore, it is not possible to fully and adequately evaluate the degree to which significant and adverse impacts of the Proposed Project can be mitigated.

Most importantly, we do not believe that the extent and types of expected impacts are biologically fully mitigable, particularly those associated with loss of genetic resources important for VSP considerations relating to biological and spatial diversity. We conclude that the Proposed Project poses a critical threat to the future sustainability of salmon and related resources in the upper Chehalis Basin.

Spring Chinook Significance

This section of our review draws special attention to the spring Chinook population in the Chehalis Basin and to the significance of the impacts that the FRE would have on this species. The DEIS, while addressing certain likely impacts on this species, does not adequately account for the importance of this species either in the Chehalis Basin or within the Washington coastal region. We summarize here the special significance that this species provides, its current status, the potential for being listed as threatened or endangered under the ESA, and likely impacts of the Proposed Project.

Importance of Spring Chinook

Spring Chinook have special importance for biological, ecological, and cultural reasons. They are distinguished from fall-run Chinook by their river entry timing, other life history characteristics, and genetics.

Chinook salmon are commonly classified by run-type based on their season of entry into freshwater during their spawning migration (Quinn et al. 2015). Along the Washington Coast, both spring and fall Chinook exist in the Chehalis, Quinault, Queets, Hoh, and Quillayute rivers.

Adult spring Chinook leave the ocean and return to their natal rivers in the spring and early summer in a sexually immature state, and then move up the river, holding in various locations while they mature sexually before spawning. In contrast, fall Chinook leave the ocean and enter their natal rivers in late summer or fall either fully sexually mature or very close to being fully mature. Both run-types generally spawn in late summer or fall.

Spring Chinook, because of their early river-entry timing, have a very high fat content upon leaving the ocean, which enables them to survive without eating over an extended period before spawning. Consequently, they have high importance to the both freshwater ecosystems because they provide high caloric food when other foods are less available. Within river systems, the migration timing of spring Chinook has supported recreational opportunity and provided a food source for human consumption and wildlife when other returning adult salmon are absent. In the ocean, spring Chinook are also eaten by Southern Resident Killer Whales (SRKW) along the Washington Coast during a time when other species of salmon are not yet returning to the mouths of their rivers of origin. Giles et al. (2018) described their importance to the SRKW as follows:

> *"Spring Chinook populations in Northwest watersheds have played a critical role in diet and range of Southern Resident orca due to their historically large numbers, large size, high fat content, and the timing of their return in the winter and early spring months when other Chinook populations are unavailable. These are foremost among the salmon that Southern Residents leave the Salish Sea to hunt for along the west coast in the winter and spring months."*

Because of their run timing and high fat content, spring Chinook are highly coveted by both tribal and non-tribal fishers. They have special cultural significance to Indian people groups (Netboy 1973), including the Quinault and Chehalis tribes, because these salmon are the first to return to their rivers of origin.

Geneticists have now identified a genetic basis for differentiating spring and fall Chinook. The implications of this finding are critical to understand with regard to the DEIS. Prince et al. (2107) concluded that the early migration of adults to their natal rivers is the result of a single mutational event associated with one allele within the genome of Chinook salmon. That event likely occurred hundreds of thousands of years ago and the allele for this migration pattern was subsequently spread to distant populations through straying and positive selection. Thus, such a mutational event is so exceptionally rare that if the allele is lost it cannot be expected to readily re-evolve. In other words, if spring Chinook are extirpated, they would be effectively gone.

Historical Population Structure and Distribution

Historically, spring Chinook were produced in several subbasins of the Chehalis Basin, including the Wynoochee, Skookumchuck, Newaukum, South Fork Chehalis, and upper Chehalis rivers (Phinney and Bucknell 1975). Their distribution in the upper Chehalis River was extensive based on mapping seen in Weyerhaeuser (1994). Run timing into the Chehalis River and upstream past Oakville is described in Lestelle et al. (2019).

Current Status and Projections

Spring Chinook are particularly vulnerable to land-use effects, watershed alterations—including construction and operation of dams, and climate change because of their early river entry and the length of time that they need to survive within freshwater (Busby et al. 1996; Quinn et al. 2015). The early entry timing by the adults requires that they hold in the river prior to spawning during the period of low summer flows and high water temperatures—both factors make these fish particularly vulnerable to high temperatures, predators, disease, poaching, and stress (Liedtke et al. 2016, 2017).

The distribution of spring Chinook within the Chehalis Basin has been much reduced over the past several decades. They are no longer present in the Wynoochee subbasin, and the Wynoochee Dam now blocks access to historical spawning reaches. Their distribution in the Skookumchuck River has been sharply reduced with construction of the Skookumchuck Dam, which does not allow for fish passage and inundated prime habitat. Spring Chinook now appear to be entirely or mostly absent from the South Fork Chehalis River (briefing by Curt Holt, WDFW, to the SRT in 2018). Their distribution in the upper Chehalis River appears to also have been sharply reduced, comparing distribution maps in Weyerhaeuser (1994) to those in Ashcraft et al. (2017), Ronne et al. (2018) and Ronne et al. (2020).

Estimates of the spawner abundance of spring Chinook in the Chehalis Basin are shown in Figure 1. The figure reveals a precipitous decline since 2000. The trend is alarming and suggests that the future of the population is precarious.

It bears noting that there is growing evidence that currently available estimates of Chehalis spring Chinook abundance may be biased high due to protocols for assigning spawning redds (nests) to Chinook run-type (Campbell et al. 2017; Thompson et al. 2019b) and alteration of freshwater environments. Spawning timing of spring Chinook appears to be getting later—likely due to deterioration in habitat quality, resulting in more overlap with fish believed to be fall Chinook. As a result it has become more difficult for surveyors to assign run-type to the redds at the time they are observed by the surveyors (Ronne et al. 2020). This overlap in spawning timing has apparently become a major threat to Chehalis spring Chinook as it is resulting in hybridization with fall Chinook (Thompson et al. 2019b). A likely reason for an increase in hybridization is that the reduced and declining abundance of spring Chinook is being swamped by more abundant fall Chinook. Concern is warranted that the status of spring Chinook is more precarious than managers had believed.

Estimates of future run sizes with climate change based on modeling show continued decline of spring Chinook and projected extirpation of populations affected by the FRE. Projections produced in conjunction with development of the ASRP indicate to us that the run in the upper Chehalis River will be extirpated by mid-century—if not earlier—without significant intervention and restoration actions.

Priorities Given to Spring Chinook in the ASRP

There is ample reason to believe that FRE would exacerbate climate and other pressures on Chehalis spring Chinook. Some form of stop-gap measures may be required to prevent extirpation in the relatively near future.

The ASRP Phase 1 draft gave high priority to restoration actions that would particularly benefit spring Chinook. This priority was embedded within Scenario 1 of the plan, calling for attention to be given to the core production areas of spring Chinook as they existed in the relatively recent past. One of these areas called out in the plan is the upper Chehalis subbasin and notably those areas that would be most affected by the Proposed Project (see Figure S-2 in ASRP Steering Committee 2019).

Potential for ESA Listing

The future viability of spring Chinook along the coast of California, Oregon, and Washington is of increasing concern. The recently published research by Prince et al. (2017) and Thompson et al. (2019a) raised significant concerns about population viability and the extent of efforts being taken by state and federal agencies to protect and recover the populations.

It is now known that the spring- and fall-run types are genetically distinct along the Pacific Coast (Prince et al. 2017; Thompson et al. 2019a) and in the Chehalis Basin (Thompson et al. 2019b). Until recently, spring and fall Chinook were placed within the same Evolutionarily Significant Units (ESU) based on how those geographic areas were delineated by NOAA Fisheries along the coast of California, Oregon, and Washington. Under the framework for evaluating population status as it was developed in the early 1990s by NOAA Fisheries, the presence of robust fall Chinook populations within an ESU was adequate for protecting any spring Chinook populations within the same ESU—even if the spring Chinook populations were severely diminished (Waples et al. 2004). NOAA Fisheries essentially argued that even if the spring-run migrating phenotype was to be extirpated by flow diversions, barriers, or other factors, that it could easily reemerge from the fall-run migration phenotype, perhaps over a time frame of a century or so. At that time, it was believed that there was essentially no distinguishable genetic difference between the spring and fall populations within a river basin like Chehalis. The Prince et al. (2017) and Thompson et al. (2019a) studies indicate the status of these populations need to be considered separately because the two run-types are genetically distinct. As noted earlier, these papers concluded that if spring Chinook are extirpated, they would be effectively gone.

Two petitions have been submitted to NOAA Fisheries requesting that the agency list populations of coastal spring Chinook in Northern California and along the Oregon Coast as threatened or endangered under the ESA. The most recent petition was submitted in September, 2019 regarding the Oregon coastal populations. Both petitions are pending.

On April 13, 2020, NOAA Fisheries announced a 90-day finding on the petition to list Oregon coastal spring Chinook as a threatened or endangered Evolutionarily Significant Unit (ESU) under the ESA and to designate critical habitat concurrently with the listing (Federal Register, April 13, 2020). The agency found that the petition presented substantial scientific information indicating the petitioned action may be warranted. The agency, therefore, has undertaken a status review of Oregon coastal spring Chinook to determine whether the petitioned action is warranted.

A similar trend with similar threats as seen on the Oregon Coast for spring Chinook exists in the Chehalis Basin. The Proposed Action presented in the DEIS will significantly worsen conditions for Chehalis Basin spring Chinook.

Impacts of the Proposed Project

The DEIS concludes that the Proposed Project would have significant and adverse impacts on the spring Chinook population in the Chehalis Basin. Modeling results demonstrate that the population component produced in the upper Chehalis Basin, i.e., upstream of the South Fork, would be driven to extinction, likely during the period of construction but no later than mid-century.

We conclude that these effects would likely result in the complete demise of the aggregate spring Chinook population in the Chehalis Basin due to the contraction of spawning distribution (i.e., reduction in spatial structure), loss of genetic diversity, and foreclosing the possibility of restoring the upper basin through habitat restoration measures.

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Attachments

CVs

Gary S. Morishima

Summary Vitae

Education:

- Ph.D. Quantitative Science & Environmental Management, University of Washington (major subjects include fisheries population dynamics, operations research, resource economics, numerical analysis, mathematical statistics)
- B.S., Mathematics, University of Washington

Professional Experience:

- Over forty years of experience in computer simulation modeling, natural resource management (forestry, fisheries, economics), legislative processes, policy analysis, mathematical statistics, workshop organization and conduct, conflict resolution, and meeting facilitation.
- Technical Advisor, Natural Resources, Quinault Nation, since 1979.
- CEO, MORI-ko L.L.C., Natural Resource Consulting Firm, since 1969
- Affiliate Professor, University of Washington School of Environmental and Forest Sciences
- Forest Manager, Quinault Nation, 1974-1979.
- Ford Fellow, Center for Quantitative Science in Fisheries, Forestry, and Wildlife, University of Washington
- Systems Analyst, Boeing Company

Current activities:

- Pacific Salmon Commission Technical Committees (since 1985):
  - Coho (U.S. Section Chair)
  - Joint Interceptions (U.S. Section Chair, now disbanded)
  - Selective Fishery Evaluation
  - Chinook
  - Data Sharing
- Other
  - Washington State Department of Natural Resources Carbon Sequestration Advisory Group
  - National Wildlife Health Center and the USGS Climate Adaptation Science Center Network Workgroup on Climate Change and Wildlife Health
  - National Congress of American Indians Climate Action Task Force
  - University of Oregon Landscape Carbon Sequestration for Atmospheric Recovery (LCSAR) Workgroup
  - Chehalis Basin Science Review Team
  - Intertribal Timber Council Operations Committee
  - Invited speaker at the 2020 Society for Applied Anthropology
  - Invited speaker at the 2020 North American Carbon Program Open Science Conference
  - Invited speaker at the 2020 Eighth Rising Voices Workshop (National Center for Atmospheric Research/University Corporation for Atmospheric Research)
  - Invited speaker at the 2020 University of Arizona School of Natural Resources Fall Seminar Series

Past Activities:

- Author Team, NW Chapter Fourth National Climate Assessment, 2017.
- Member National Academy of Sciences Review Team, State of the Carbon Cycle 2 Report, 2017.
- Member, Washington State Governor’s Chehalis Basin Task Force, 2017.
- Member, Advisory Committee on Climate Change and Natural Resources Science, appointed by the U.S. Secretary of the Interior (2013-2016).
- Member, Native American Policy Team, appointed by the U.S. Fish & Wildlife Service of the Department of the Interior (2013-2016).
- Executive Board, Intertribal Timber Council (1977-2016)
- Member, Washington State Climate Change Preparation and Adaptation Work Group.

- Member, Department of the Interior Climate Change Task Teams on Adaptation and Sequestration.
- Member, Coded Wire Tag Workgroup. Action Plan to Implement Recommendations of the CWT Expert Panel. Pacific Salmon Commission.
- Member, Expert Panel on the Future of the Coded Wire Tag Program for Pacific Salmon. Pacific Salmon Commission.
- Member, Expert Panel on Application of Genetic Stock Identification Methods to Ocean Salmon Fisheries. Pacific Salmon Commission.
- Participant, Independent Science Advisory Board, Harvest Management of Columbia Basin Salmon and Steelhead. Northwest Power and Conservation Council.
- Salmon Technical Team, Pacific Fishery Management Council (1981-2007, including past chair)
- Member, National Task Force on Tribal-Federal Relations, U.S. Forest Service (1999-2003)
- Technical Advisor, Tribal Leaders Task Force on Trust Reform (2002-2004)
- Intergovernmental Advisory Committee (appointed by the U.S. Secretary of Agriculture) to provide advice in implementing the Northwest Forest Plan (1993-2000)
- Member, Drafting Team on Secretarial Order on American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act (signed by the Secretaries of Interior and Commerce in 1999).
- Salmon & Steelhead Advisory Commission (appointed by the U.S. Secretary of Commerce), from 1982-1985.
- Various Task Forces on Indian Self-Determination and Education Assistance Act, Self-Governance, Fiscal Management systems of the Bureau of Indian Affairs, American Indian Policy Review Commission.
- Chair, Task Force for developing regulations to implement the National Indian Forest Resources Management Act.
- Policy Advisory Team for Natural Resources for former Washington State Governor Booth Gardner

Publications: List available upon request

Awards:

- National Earle Wilcox Award for Outstanding Contributions to Indian Forestry, Intertribal Timber Council
- Pride in Excellence Award, Boeing Company

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Lawrence C. Lestelle

Senior Fisheries and Aquatic Scientist

Education and Training

2006-2010
Enrolled in Ph.D. program, Fisheries Science, University of Washington

1988
Graduate, Washington Agriculture and Forestry Education Leadership Program

1978
M.S., Fisheries Science, University of Washington

1972
B.S., Fisheries Science, University of Washington

Employment History

Biostream Environmental, Principal and Sr. Scientist
2004 - Present

Mobrand Biometrics, Inc.
Sr. Biologist
1992 - 2004

MJM Research
Sr. Biologist
1991 - 1992

Quinault Indian Nation
Biologist and Program Manager
1974 - 1991

Fisheries Research Institute, University of Washington, Research Assistant
1972 – 1974

Professional Affiliations

American Fisheries Society
1976 - Present

Awards

Professional of the Year in 1989
Conservationist of the Year in 1989
Awards by the Grays Harbor Chapter of Trout Unlimited

Larry Lestelle has over 40 years of experience in salmon and aquatic resources research, management, and conservation in the Pacific Northwest. He has expertise in a wide variety of issues related to population dynamics and modeling, salmonid ecology, resource assessment and enhancement, fisheries management and environmental impacts. He was one of the lead architects of the Ecosystem Diagnosis and Treatment (EDT) Model, now widely used across the Pacific Northwest to assist managers and planners in salmon recovery and environmental impact assessment.

Habitat Modeling and EDT Design
Larry was one of the principal scientists in developing the EDT Model as part of the Mobrand Biometrics, both in regards to technical components and its application to salmon recovery planning. He formulated the biological rules that enable the model to assess species-specific responses to environmental change (species include Chinook, coho, chum, steelhead, cutthroat, and bull trout) in freshwater, estuarine, and marine environments. He has facilitated hundreds of hours of workshops and seminars on EDT applications. He has developed a variety of other fisheries and aquatic resources models, including water balance models, fisheries harvest models, and population assessment models.

Salmon Recovery Planning
Larry has had lead or supporting roles in salmon recovery planning and related population assessments aimed at numerous salmonid populations in the Pacific Northwest. These have been conducted on a wide variety of rivers throughout Washington, in Central and Eastern Oregon, and in Northern California. He has served as scientific advisor to several tribal agencies involved in recovery research and planning in their rivers (Klamath River in California and the Skokomish, Queets, Quinault, and Chehalis rivers in Washington).

Assessment of Environmental Impacts
Larry has provided key technical analysis of fisheries issues on relicensing projects on the Skokomish, Cowlitz, Deschutes (OR), and Lewis rivers, forest management and agricultural impacts in Washington, Oregon, and California, and mining impacts in Alaska and Montana. Has provided technical expertise on many other types of land use effects on fish populations, including urbanization, floodplain development, and dam operations.

Aquatic Ecology Research
Larry has planned and carried out extensive research aimed at improving understanding of salmonid ecology, effects of land uses and flow regulation on salmonid performance, and results of salmon supplementation.

Selected Projects

Review of NOAA Fisheries Life Cycle Model used in the Chehalis River Basin, WA

Principal role in a multi-year review of a new model (LCM) being built by NOAA Fisheries for the Washington Department of Fish and Wildlife for use in developing a basin-wide restoration plan for aquatic species in the Chehalis River Basin in Western Washington. As part of this review, smaller versions of the LCM were built to simulate the larger more complex model to serve in testing and evaluating modeling performance. The LCM is being developed to model the effects of various habitat scenarios on coho, spring and fall Chinook, and steelhead.

Analysis of Recovery Actions for Mid-Columbia Steelhead

Analyzed suites of recovery actions using the EDT model, including those associated with freshwater habitat, hydro, harvest, and hatcheries, for the recovery of steelhead populations in Fifteen Mile Creek, Deschutes River, John Day River, Umatilla River, and Walla Walla River. Prepared report materials to be incorporated into Oregon State's recovery plan for the affected populations.

Analysis of Recovery Actions for Grande Ronde Chinook and Steelhead

Analyzed suites of recovery actions using the EDT model, including those associated with freshwater habitat, hydro, harvest, and hatcheries, aimed at the recovery of spring chinook and steelhead populations in the Grande Ronde watershed, Oregon. Prepared summary report materials to be incorporated into NOAA's recovery plan for the affected populations.

Analysis of Effects of Changes in Regulated Flow Regimes on Salmonids in the Yakima River, WA

Developed updated biological rules for use in EDT modeling to assess effects of various alternatives for regulated flows in the mainstem Yakima River. Modifications to regulated flows were under consideration as part of potential new reservoirs (proposed Black Rock Project by U.S. Bureau of Reclamation).

Extension of EDT Rules to Estuarine and Marine Environments for Recovery Planning

Developed biological rules for analysis of ESA-listed summer chum salmon using the EDT model. The rules were developed to assess the effects of habitat conditions within estuarine and marine nearshore waters. Applied EDT modeling in developing recovery actions for summer chum in Hood Canal (part of the Puget Sound complex). Provided technical analysis to the Hood Canal Coordinating Council (lead author of the summer chum recovery plan) for updating the recovery plan.

Selected Publications and Reports

Lestelle, L.C., L.E. Mobrand, J.A. Lichatowich, and T.S. Vogel. 1996. Applied ecosystem analysis - a primer, EDT: the Ecosystem Diagnosis and Treatment Method. Project number 9404600, Bonneville Power Administration, Portland, Oregon.

Lichatowich, J., L.E. Mobrand, L. Lestelle, and T. Vogel. 1995. An approach to the diagnosis and treatment of depleted Pacific salmon populations in freshwater ecosystems. Fisheries 20(1): 10-18.

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Lestelle, L.C., L.E. Mobrand, and W.E. McConnaha. 2004. Information structure of Ecosystem Diagnosis and Treatment (EDT) and habitat rating rules for Chinook salmon, coho salmon, and steelhead trout. Report prepared for Northwest Power Planning Council. Mobrand Biometrics, Inc. Vashon, WA.

Lestelle, L.C., B. Watson, and G. Blair. 2006. Species-habitat rules: supporting documentation for updated flow rules for application in EDT—Supplemental report to information structure of Ecosystem Diagnosis and Treatment (EDT) and habitat rules for chinook salmon, coho salmon, and steelhead trout. Report prepared for U.S. Bureau of Reclamation. Mobrand-Jones and Stokes, Inc. Vashon, WA.

Blair, G.R., L.C. Lestelle, and L.E. Mobrand. 2009. The Ecosystem Diagnosis and Treatment model: a tool for evaluating habitat potential for salmonids. Pages 289-309 *in* E.E. Knudsen and J.H. Michael Jr. (eds.) Pacific Salmon Environment and Life History Models: Advancing Science for Sustainable Salmon in the Future. American Fisheries Society. Bethesda, MD.