Preliminary Chelan River Use Attainability Analysis and Site Specific Criteria

Technical Support Document

Water Quality Program

Washington State Department of Ecology
Olympia, Washington

March 2021, Publication 21-10-008

Publication Information

This document is available on the Department of Ecology's website at:
https://apps.ecology.gov/publications/summarypages/2110008.html

Contact Information

Water Quality Program

P.O. Box 47600
Olympia, WA 98504-7600
Phone: 360-407-6600
Website[1]: Washington State Department of Ecology

ADA Accessibility

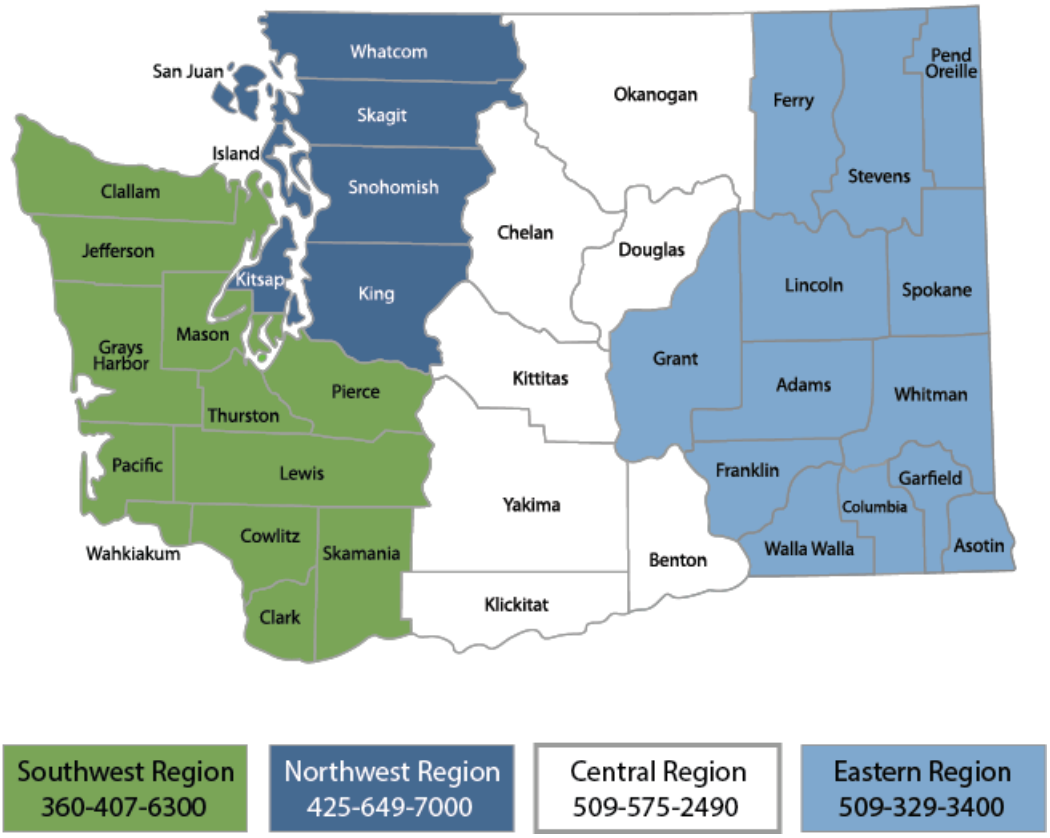
The Department of Ecology is committed to providing people with disabilities access to information and services by meeting or exceeding the requirements of the Americans with Disabilities Act (ADA), Section 504 and 508 of the Rehabilitation Act, and Washington State Policy #188.

To request an ADA accommodation, contact Ecology by phone at 360-407-6600 or email at swqs@ecy.wa.gov. For Washington Relay Service or TTY call 711 or 877-833-6341. Visit Ecology's website for more information.

[1] www.ecology.wa.gov/contact

Department of Ecology's Regional Offices

Map of Counties Served



Region	Counties served	Mailing Address	Phone
Southwest	Clallam, Clark, Cowlitz, Grays Harbor, Jefferson, Mason, Lewis, Pacific, Pierce, Skamania, Thurston, Wahkiakum	PO Box 47775 Olympia, WA 98504	360-407-6300
Northwest	Island, King, Kitsap, San Juan, Skagit, Snohomish, Whatcom	3190 160th Ave SE Bellevue, WA 98008	425-649-7000
Central	Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, Yakima	1250 W Alder St Union Gap, WA 98903	509-575-2490
Eastern	Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman	4601 N Monroe Spokane, WA 99205	509-329-3400
Headquarters	Across Washington	PO Box 46700 Olympia, WA 98504	360-407-6000

Chelan River Use Attainability Analysis and Site-Specific Criteria

Technical Support Document

Water Quality Program
Washington State Department of Ecology
Olympia, WA

March 2021 | Publication 21-10-008

DEPARTMENT OF
ECOLOGY
State of Washington

Table of Contents

List of Figures and Tables

Figures

Tables

List of Acronyms and Abbreviations

Acronym or abbreviation used	Description
7-DADMax	7-day average of the daily maximum temperatures
CWA	Clean Water Act
Chelan River Plan	Chelan River Biological Evaluation and Implementation Plan
DO	Dissolved oxygen
FERC	Federal Energy Regulatory Commission
LLO	Low level outlet
PUD	Public utility district
SSC	Site-specific criteria
UAA	Use attainability analysis
WQC	Water quality certification

Executive Summary

On December 20, 2019, the Department of Ecology (Ecology) received a request from the Public Utility District No. 1 of Chelan County (Chelan PUD) to modify the aquatic life designated use in the Chelan River. To support a change to the state surface water quality standards, Chelan PUD submitted a use attainability analysis (UAA) and proposed site-specific criteria (SSC) that would reflect the highest attainable aquatic life use. After determining that the UAA submittal met the requirements in Chapter 173-201A-440 to consider a change to the designated use, Ecology responded on February 18, 2020 indicating that Chelan PUD's request was sufficient to consider rulemaking. Ecology formally announced the start of the Chelan River UAA rulemaking on October 27, 2020. Since rulemaking commenced, Ecology staff have reviewed the information and analyses in the proposed UAA and SSC to determine if changes to Chelan PUD's submittal are necessary.

The Chelan River water quality is directly influenced by Lake Chelan. Lake Chelan forms the headwaters of the Chelan River. Data suggests that in the absence of the Lake Chelan Dam, water quality conditions in the river would be similar or worse. The Lake Chelan Dam has raised water levels in the Lake, allowing water to be drawn from the lower part of the water column in the forebay of the dam, resulting in the release of the coolest water available to feed the Chelan River.

The data presented by Chelan PUD indicates that a change in the aquatic life use in two segments of the Chelan River is appropriate. In Reaches 1-3 of the river, we are considering changing the aquatic life use from salmonid spawning, rearing, and migration to migration for naturally limited waters only due the lack of suitable habitat for salmonids, natural passage barriers, and low water quality driven by the natural conditions in Lake Chelan. In Reach 4 of the river, we are considering changing the aquatic life use from salmonid spawning, rearing, and migration to salmonid spawning, rearing, and migration for naturally limited waters. This change is supported by the suboptimal water quality driven by Lake Chelan that result in conditions less than what is considered fully protecting the current aquatic life use designation.

To protect the proposed highest attainable aquatic life uses, water quality criteria should reflect the unique characteristics of the river. Where naturally occurring pollutant concentrations preclude the full attainment of the designated uses, and those uses are being changed through the UAA process, it is appropriate to consider related changes to the numeric criteria that reflect the new use designations. After reviewing the Chelan PUD submittal, we agree that the water temperature criteria for the Chelan River should be changed to reflect the highest attainable conditions using SSC. Therefore, we are proposing new limits on the allowable warming in two river segments: warming along Reach 1 through 3 and warming within Reach 4. We are considering limiting river warming to a maximum increase of 3.75°C due to solar and atmospheric heating from the top of Reach 1 to the end of Reach 3, and a limited temperature increase of 1.25°C from the end of Reach 3 to the end of the habitat channel in Reach 4. The river warming is based on monitoring data collected from 2010-2018 as well as statistical analyses predicted the likelihood of an exceedance of a given temperature increase. This limited temperature warming within the specified river segments will apply when water

temperatures exceed 17.5°C. For dissolved oxygen (DO), we are considering SSC of 8.0 mg/L or 90% saturation for Reaches 1-3 and 8.0 mg/L or 95% saturation for Reach 4.

Given that the calculation of the SSC is meant to limit heat inputs to only natural heat sources, we are proposing that no anthropogenic heat inputs be allowed in the Chelan River. This ensures that the predicted temperature conditions calculated in the modeling assumptions made in the UAA and the natural thermal regime are not exceeded in the future and therefore, the highest attainable use is not degraded by future anthropogenic heat sources.

Background

On December 20, 2019, Ecology received a request from the Public Utility District No. 1 of Chelan County (Chelan PUD) to modify the aquatic life designated use in the Chelan River. (Chelan UAA Rulemaking Web Page[2]). On February 18, 2020, Ecology acknowledged that the request was complete and the information was sufficient to consider a rulemaking. Ecology formally announced the Chelan River UAA rulemaking on October 27, 2020. Since rulemaking commenced, Ecology staff have reviewed the information and analyses in the proposed UAA and SSC to determine if changes to Chelan PUD's submittal are necessary. As part of the rulemaking process, we will solicit and receive feedback on the rule being considered and Ecology's evaluation of the UAA.

Chelan PUD owns and operates the Lake Chelan hydropower project built at the headwaters of the Chelan River, and is currently under a 50-year Federal Energy Regulatory Commission (FERC) license (Figure 1). The hydropower project consists of a barrier dam that is now used to delineate Lake Chelan from Chelan River. The first dam on Lake Chelan became operational in 1903 and the Lake Chelan Dam and powerhouse as it exists today was built in 1926. Prior to 2009, all flows to the headwaters of the Chelan River were diverted several miles through a penstock to the powerhouse located near the river's natural confluence with the Columbia River. The Chelan River occasionally flowed, when surface flows exceeded the dam's capacity to generate, resulting in spill over the dam into the Chelan River riverbed. With the exception of these high flow events (12,000–15,000 cubic feet per second [cfs]), the Chelan River remained mostly dry for over 80 years. A recent regulatory timeline of the Lake Chelan hydropower project can be found in Table 1.

[2] https://ecology.wa.gov/Regulations-Permits/Laws-rules-rulemaking/Rulemaking/WAC173-201A-Chelan-UAA

Figure 1 Lake Chelan and the Lake Chelan Hydropower Project at the headwaters of the Chelan River. Photo: Chelan PUD

Table 1 Lake Chelan Hydroelectric Project Regulatory Timeline (adapted from PCHB 03-075, 2004)

Year	Event
1906	Dam and powerhouse are constructed (since 1892, five other dams have been constructed at project site).
May 12, 1981	FERC granted 30-year license, retroactive to 1974, when the original 50-year license expired. The 1981 license was scheduled to expire on March 31, 2004. To obtain a new license, Chelan PUD was required to obtain a § 401 Certification from Ecology, confirming that the Project meets the requirements of the Clean Water Act and state water quality laws.
April 21, 2003	Chelan PUD applied for a 401 Certification in March of 2002 and Ecology issued 401 Water Quality Certification one year later in April 2003. The certification sets up requirements designed to show how the dam will meet Water Quality standards and requires monitoring with the intent to show how biological objectives will be met.
May 21, 2003	Appeal filed with the Pollution Control Hearings Board contesting Ecology's issuance of the 401 Water Quality Certification challenging the adequacy of the Certification to meeting state water quality standards. Key issues:

Year	Event
	Whether biological objectives, when combined with an adaptive management plan, provide reasonable assurance water quality standards will be met where strict compliance with numeric water quality criteria fails to protect characteristic uses. Whether the 401 certification is unlawful where it allows non-compliance for the ten-year adaptive management period and contemplates a Use Attainability Analysis (UAA) at the end of this period, which could result in a new and less stringent standard.
April 21, 2004	PCHB issues decision concluding the Certification, with clarifications provided in the PCHB's decision, will provide reasonable assurance that state water quality standards will be met. With regard to the two items above: Ecology could have initiated a rule change to solve the compliance issues. However, Ecology also possessed information from biologists who believed a realistic possibility existed to develop a reasonable and feasible adaptive management program, which could create habitat for cold-water fish in the river. Therefore, Ecology agreed to the concept of developing an adaptive management plan that would address compliance with the state temperature standard by achieving the biological objectives that the temperature standard was intended to support. The Board finds there is reasonable assurance water quality standards with regard to temperature, are met by this § 401 Certification. The uses are adequately protected, and the numeric criteria, although not finally determined, will be established at the end of a 10-year period of extensive scientific study. Whether the numeric component will be changed at some point in the future is beyond the scope of this appeal, and any future change will be the subject of a different Ecology decision.
June 1, 2004 – November 3, 2017	Ecology issues amended 401 Water Quality Certification to include the PCHB's findings from their April 21, 2004 decision, and subsequently four other amendments were issued to address flows, deadlines for implementation, and non-capacity amendments that included turbine replacements for generation

Until the federal relicensing process, the aquatic life and habitat potential of the Chelan River was largely unknown due to the ephemeral nature of the River as a result of dam operations. The 401 Water Quality Certification (WQC) issued by Ecology under the Federal Clean Water Act

(CWA) during the FERC relicensing period required identification of the aquatic life and habitat potential of the Chelan River and to establish minimum instream flows. In 2009, the requirement to implement minimum instream flows for the Chelan River was completed, resulting in consistent year-round flows. The 401 WQC required Chelan PUD to implement reasonable and feasible measures to achieve a series of biological objectives over a 10-year period that involved monitoring, evaluation, and adaptive management to determine the potential for the Chelan River to support aquatic life.

The 401 WQC for Lake Chelan Dam states that at the end of the 10-year monitoring period if some biological objectives have not been met, but that all known, reasonable, and feasible measures have been implemented, then "Ecology intends to initiate a process to modify the applicable water quality standards to the extent necessary" to reflect the objectives achieved. The 10-year monitoring and evaluation program, which began in 2009, has concluded (Chelan PUD, 2019) and Ecology is taking the next steps to assess the results from this program to determine the highest attainable aquatic life uses and water quality conditions for the Chelan River. Ecology is using the monitoring data collected during the first 10 years of the FERC license, along with other applicable information, to evaluate the Chelan UAA application that considers changes to aquatic life uses and SSC criteria for the Chelan River.

Introduction

Water Quality Tools

Washington's Water Quality Standards include water quality tools that are intended to guide the process of restoration to reach the highest attainable water quality conditions. These water quality tools include variances, SCC, UAA, water quality offsets, and intake credits. The federal CWA regulations allows for the use of UAAs and SSC to revise water quality standards under limited circumstances.

We received a request from Chelan PUD to use the UAA and SSC water quality tools on the Chelan River. Therefore, the focus of this document will include review and evaluation of the scientific information available that can support the requested UAA and SSC.

What is a Use Attainability Analysis?

A UAA, as defined in WAC 173-201A-440 and 40 CFR 131.10, is a structured scientific assessment of the factors affecting the attainment of a designated use, which may include physical, chemical, biological, and economic factors. A use can only be removed through a UAA if it is not existing or attainable. A UAA proposing to remove a designated use on a water body must be submitted to Ecology in writing and include sufficient information to demonstrate that the use is neither existing nor attainable based on the following six factors described in 40 CFR 131.10(g)(1)-(6)):

1. Naturally occurring pollutant concentrations prevent the attainment of the use; or
2. Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or
3. Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or
4. Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use; or
5. Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or
6. Controls more stringent than those required by sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact.

What is a Site-Specific Criterion?

A criteria to establish site-specific conditions, as described in WAC 173-201-430 and 40 CFR 131.11, is established when the attainable condition of existing and designated uses for a water body would be fully protected using a criterion that reflects local conditions and key species. A SSC must be set in a manner that is scientifically justifiable and based on a demonstration that it will protect the existing and attainable uses of a water body.

Chelan River

The Chelan River is located in Chelan County, Washington, and its headwaters are fed by Lake Chelan. Lake Chelan is a 55-mile natural lake that contains two basins, the Lucerne Basin and the Wapato Basin (Figure 2). The two basins are separated by a sill, otherwise known as "the narrows." The Wapato Basin is the shallower of the two basins with depths ranging from 300 feet to less than 30 feet near the Lake outlet near the Lake Chelan Dam. The Wapato Basin surface area represents approximately one-quarter of Lake Chelan but the Wapato Basin holds less than 8% of the Lake Chelan's volume. The unique presence of a sill separating the basins coupled with the morphology of the Wapato Basin is a key factor in the water conditions of Chelan River.

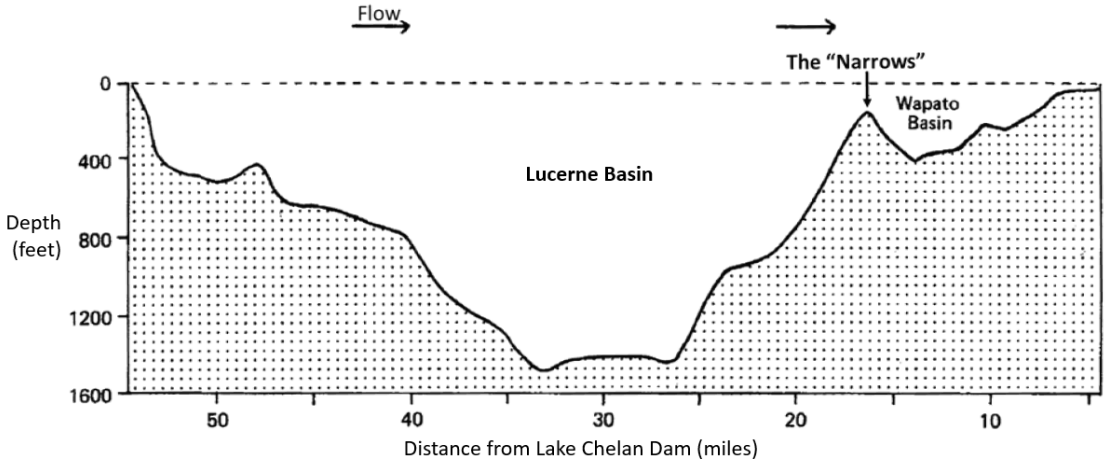


Figure 2 Depth and geological profile of Lake Chelan (adapted from Kendra and Singleton, 1987).

The depth of the Wapato Basin as it nears the outlet of Lake Chelan is noteworthy given that the water temperature in these shallow waters feed the headwaters of the Chelan River and the powerhouse of the Lake Chelan Dam. Water temperatures in the Wapato Basin often exceed 20°C and these warm temperatures can extend to depths of over 20 feet (Figure 3). In July and August in 2016-2018, and as early as June 2016, water temperatures exceeded 20°C (Figure 3). This is consistent with historical maximum surface temperatures in the Wapato Basin in August, which were reported to be over 21°C in August of 1987, 1995, and 1996 (Ecology, 1997). The water temperature of Lake Chelan directly relates to the Chelan River water temperatures and drives the downstream thermal regime.

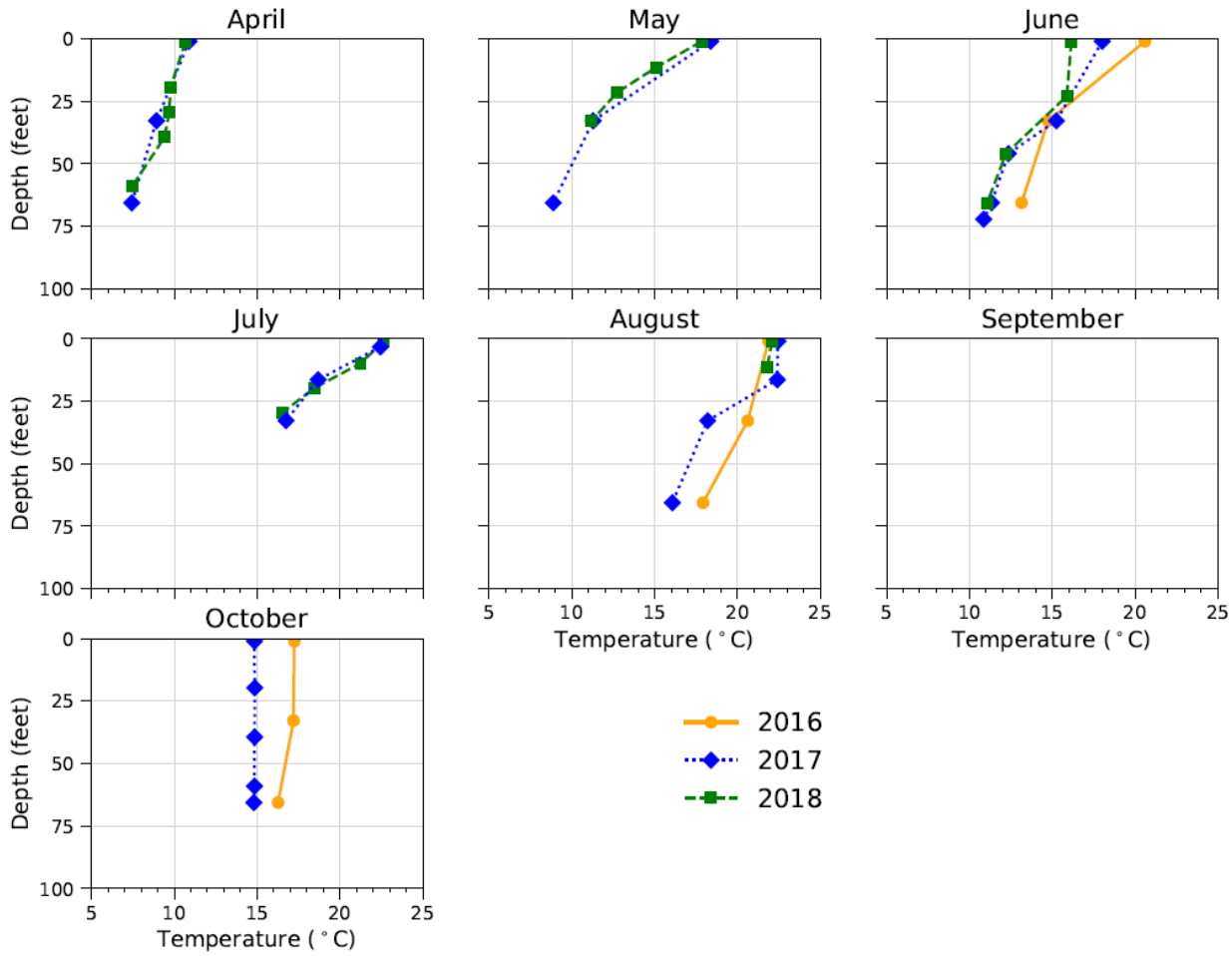


Figure 3 Temperature depth profile at the lower end of the Lucerne Basin before the Lake flows into Chelan River (adapted from Mugunthan et al. 2019).

Construction of the Lake Chelan Dam raised Lake Chelan by 21 feet at the maximum storage capacity. Chelan PUD constructed a low-level outlet (LLO) near the base of the dam that provides water flows for the Chelan River (Figure 4). A feasibility study examined the optimal location to construct the LLO to provide the coolest water to the Chelan River (Chelan PUD, 2005). In the absence of the dam, Wapato Basin and the branching arm of the basin that leads to the Chelan River would be shallower by approximately 21 feet (Kendra and Singleton, 1987), and therefore, the water would be more vulnerable to solar heating and less stratified. Thus, in the absence of the project, warmer surface waters of the lake would have resulted in naturally warmer water temperatures in the river. The additional water depth of the Wapato Basin, provided by the Chelan Dam, specifically where it connects to the Chelan River, allows for water to be drawn from the lower part of the water column, thereby using the coolest water possible to feed the Chelan River. Figure 4 demonstrates the slight cooling effect drawing water from depth in the forebay, recorded as LLO temperatures, compared with surface water temperatures in the Lake Chelan Wapato Basin. This cooling effect is most noticeable when thermal stratification occurs in the water column resulting in higher surface water temperatures than deeper waters.

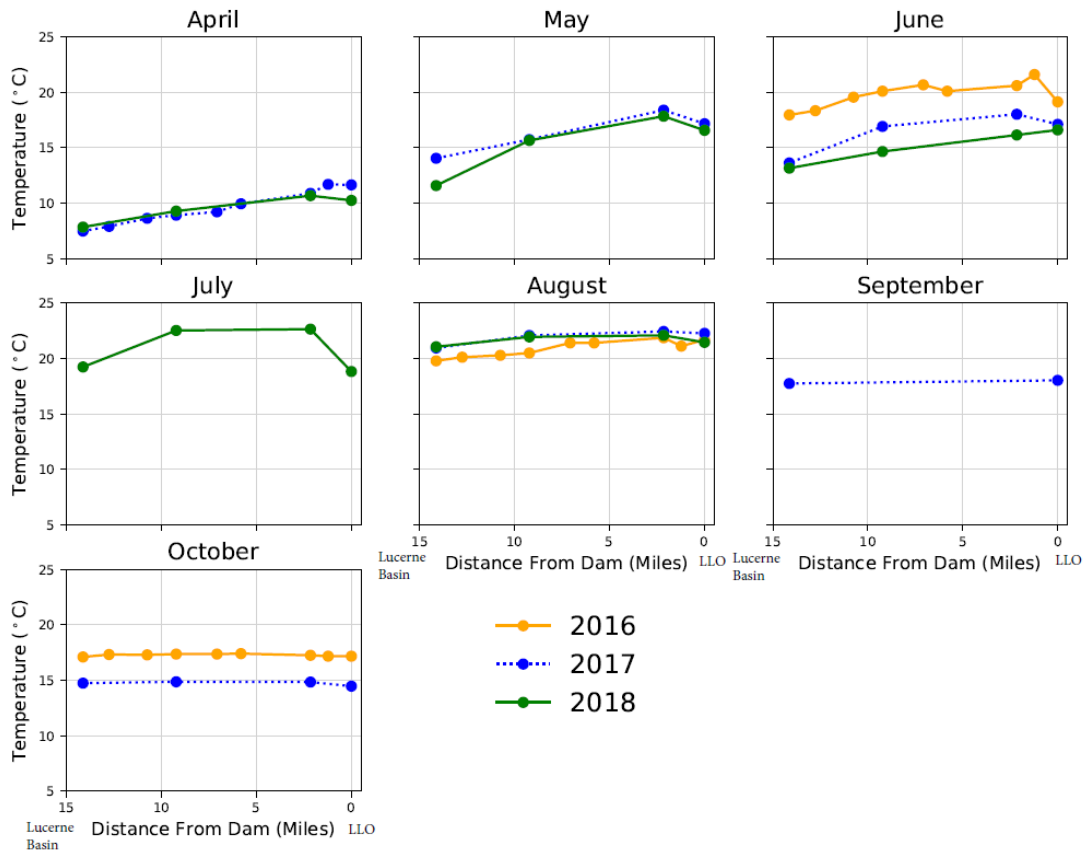


Figure 4 Longitudinal temperature profile demonstrating slightly lower temperatures at the LLO outlet (mile 0) compared with surface water temperatures within Lake Chelan. Each circle in the figures above represents surface water monitoring station ranging from the LLO to approximately 15 miles away from the Lake Chelan Dam.

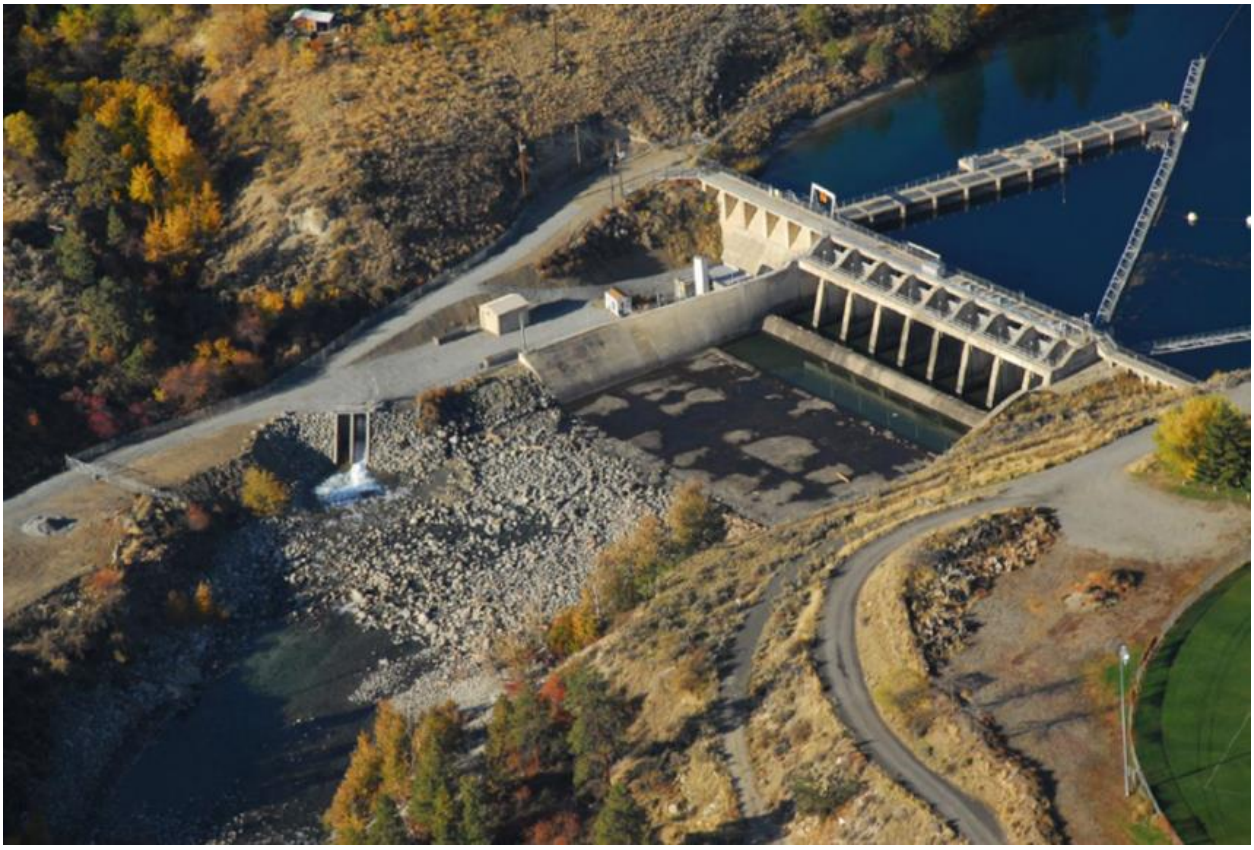


Figure 5 Aerial image of Lake Chelan Dam, lower level outlet, and the headwaters of Chelan River (adapted from Mugunthan et al. 2019)

The Chelan River in its entirety is 4 miles long to its confluence with the Columbia River. The River has four distinct reaches as described by Mugunthan et al. (2019) and shown in Figure 5:

Reach 1 – This reach extends from the Dam through the first 2.29 miles of the river, and has a gradient of about 1%. This reach is characterized by large cobbles and small boulders and is scarce in riparian vegetation. Upper sections of this reach are approximately 100 to 140 feet wide, with middle and lower sections narrowing down considerably. There is a braided section towards the lower end of the reach, which has the most significant riparian vegetation (Herrera, 2015).

Reach 2 – This reach is 0.75 miles long with a similar gradient and a narrower channel relative to Reach 1. The substrate is coarser than Reach 1.

Reach 3 – This reach is 0.38 miles long and is referred to as the "gorge" because of the steep, confined bedrock. The reach is characterized by a steep gradient of approximately 9%. This reach has several waterfalls with heights ranging from 5 to 20 feet, numerous cascades, bedrock chutes, and large deep pools. The steep gradient and waterfalls in this reach create a natural upstream passage barrier to anadromous salmonids and trout (R2 and IA, 2000). A review of the historical fish assemblages in the Chelan River and Lake Chelan concluded that the natural passage barrier in Reach 3 has effectively prevented anadromous salmonids from using habitats in Reaches 1-3 or Lake Chelan (BioAnalysts, 2000).

Reach 4 – This reach is 0.50 miles long and extends to the confluence of the Columbia River. This reach has a high flow channel that is characterized by large cobbles and boulders, and an engineered habitat channel that became operational in 2009. A pump station was constructed to withdraw water from the tailrace and provide additional flows to the habitat channel through the pump flow channel to meet incubation and spawning objectives. During spill conditions, higher flows that move down the Chelan River largely bypass the habitat channel and flow through the original high flow channel. The original channel was thought to be braided prior to 1995, based on older photographs (Stillwater Sciences, 2001). The lower end of the reach merges with the powerhouse tailrace before the confluence with the Columbia River. The tailrace extends from the powerhouse to the Columbia River and is approximately 0.32 miles long. The lower portion of the tailrace is nearly flat. Water depths in the tailrace range from 10 to 30 feet.

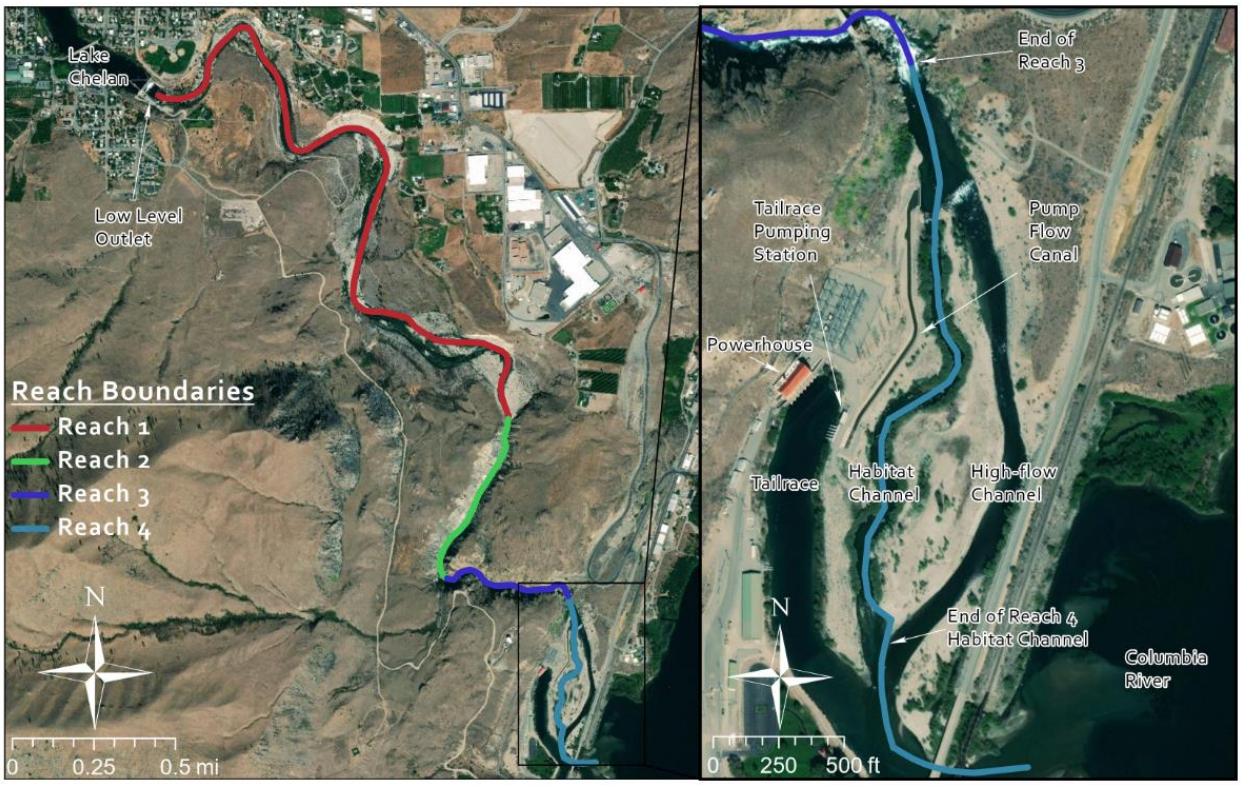


Figure 6 Aerial image of the Chelan River reaches in relation to Lake Chelan and the Columbia River.

Chelan River Biological Objectives

To determine the highest attainable use, we must consider the aquatic life potential for the Chelan River. This UAA focuses on the propagation and protection of the most sensitive fish species. The studies necessary to perform this review were established and completed during the relicensing process and though the adaptive management process described in the Chelan River Biological Evaluation and Implementation Plan (Chelan River Plan).

The Lake Chelan Hydroelectric Project Comprehensive Settlement Agreement was signed in 2003, representing the final agreement regarding the relicensing of the dam. Chelan PUD worked collaboratively with state and federal fishery managers, tribes, and stakeholders in a natural science work group to develop plans to restore ecosystem functions in the Chelan River. As part of the settlement agreement, Chelan PUD committed to implementing the Chelan River Plan. The implementation of the Chelan River Plan led to the evaluation of the aquatic life and habitat potential in the Chelan River.

The Chelan River Plan included species-specific biological objectives focused on Chinook salmon, steelhead, and cutthroat trout and a set of broader based biological objectives. The biological objectives are broadly described as the following (Chelan PUD, 2019):

- **Chinook salmon:** adult production from fish produced in Reach 4 of the Chelan River.
    - Areas developed to support spawning meet design habitat characteristics (depth, velocity, and substrate) at the designated instream flow.
    - Distribution of spawning use should reflect distribution of constructed spawning habitat.
    - Intragravel DO greater than 6.0 milligram per liter (mg/L).
    - Egg-to-emergence success greater than or equal to 80% of Methow River average or 70% survival, whichever is less.
    - Fry presence and use of available habitat.
- **Steelhead:** adult production from fish produced in Reach 4 of the Chelan River – net benefit to the Evolutionary Significant Unit.
    - Areas developed to support spawning meet design habitat characteristics (depth, velocity, and substrate) at the designated instream flow.
    - Distribution of spawning use should reflect distribution of constructed spawning habitat.
    - Intragravel DO greater than 6.0 milligram per liter (mg/L).
    - Egg-to-emergence success greater than or equal to 80% of Methow River average or 70% survival, whichever is less.
    - Fry presence and use of available habitat.
- **Cutthroat trout:** establish a viable population of cutthroat trout in Reaches 1-3 of the Chelan River.

- A viable population is one that is not limited by project operations. Viable is defined in the Chelan River Plan as "naturally produced (not stocked) fish, viable (population has representatives of several age classes), healthy (fish condition better than starvation), and of reasonable density (200 fish of various ages) consistent with the habitat conditions."
- Presence of 200 fish including various age classes.
- Habitat improvements for cutthroat trout, as related to water temperature, may include: new naturally evolved stream channel, riparian shade, thermal refugia/pumping studies, and increased flows.

- **Habitat protection and enhancement actions:**
  - Construction of a low-level outlet within the dam infrastructure to provide minimum instream flows year-round from colder subsurface withdrawals from the lake
  - Habitat improvements in Reach 4 including a river channel and planning riparian vegetation
  - Design a tailrace pump station to convey water from the powerhouse tailrace to the newly constructed habitat channel to supplement flows in the habitat channel
  - Establish year-round instream flows

The natural science workgroup group determined the following alternatives to be neither reasonable nor feasible (Chelan PUD, 2003):

- Increasing flow to maintain Chelan River water temperatures within 0.3°C of natural temperatures when water temperature exceeds 18°C. The higher flow option was eliminated because higher flows would not contribute to meeting biological objectives and would reduce useable habitat for native fish species.
- Building a pipeline to transport cool water several miles from deeper regions of Lake Chelan to provide flows to the Chelan River was eliminated due to limited ability to provide cool water within proximity to the Chelan Dam and excessively high costs.
- Pumping groundwater into Reach 1 of Chelan River was eliminated due to the limited availability of groundwater to provide meaningful reductions in water temperature to create thermal refugia.
- Pumping surface water from the Columbia River into Reach 4 of the Chelan River was eliminated due to the warmer water temperatures of the Columbia River during Chinook Salmon spawning and potential ecological consequences of mixing waters.

Water Quality Standards

The Chelan River is assigned water quality standards that describe the condition of the water body and the means by which that condition will be protected (Table 2). Surface Water Quality Standards (WQS) are comprised of three parts – designated uses, water quality criteria, and antidegradation.

- Simply put, designated uses consider "what we are trying to protect," and establish the water quality goals for a water body. Designated uses are specified in the water quality standard regulations for each water body or segment, regardless of whether or not the uses are currently attained. Existing uses, on the other hand, refer to uses a water body has actually attained on or after November 28, 1975, whether or not those uses are specifically included in water quality standards as a designated use.
- Water quality criteria are expressed as a constituent concentration, levels, or narrative statements, representing a quality of water that supports a particular use. When criteria are met, water quality will generally support the designated use. Water quality are set to protect the most sensitive use.
- Antidegradation is aimed at protecting waters with quality that is better than the water quality criteria from degradation.

Chelan River Aquatic Life Uses and Water Quality Criteria

All reaches of the Chelan River are currently designated for the salmonid spawning, rearing, and migration aquatic life use (WAC 173-201A-600). The applicable water quality criteria are shown in Table 2.

Table 2 Water quality criteria for the Chelan River (WAC 173-201A-200)

Parameter	Criteria	Duration	Frequency
Temperature	≤17.5° C Anthropogenic allowance of 0.3° C	7-day average of the daily minimum	No more than one exceedance every 10 years
Dissolved Oxygen	≥8.0 mg/L Anthropogenic allowance of 0.2 mg/L	1-day minimum	No more than one exceedance every 10 years
Turbidity	1. Change of ≤ 5 NTU if background ≤50 NTU 2. Change of ≤ 10 NTU if background > 50 NTU	Instantaneous	1-day maximum
Total Dissolved Gas	≤110% saturation	Instantaneous	1-day maximum
pH	6.5 to 8.5	Instantaneous	1-day maximum
Toxics	See WAC 173-201A-240	See WAC 173-201A-240	See WAC 173-201A-240

Chelan River Water Quality Monitoring Findings

Temperature Results

As part of the research of the biological objectives conducted under the Chelan River Plan, temperature data was collected from several locations on the Chelan River including the LLO, end of Reach 1, end of Reach 3, end of the Reach 4 habitat channel, and powerhouse tailrace. Figures 6 and 7 show the 7-DADMax temperatures for the LLO, end of Reach 1, and end of Reach 4 habitat channel from 2010 to 2018. The temperature measurements demonstrate that the Chelan River is directly influenced by the LLO, which is directly influenced by Lake Chelan water temperatures. The water temperatures exceeded the temperature criterion from mid to late spring through early fall in all years (Figure 7 and 8). The greatest temperature increase within a reach was observed in Reach 1, where temperatures increased up to 3°C during summer conditions (Figure 9). Warming in Reach 4 was typically less than 1°C as shown by the temperatures recorded at the end of Reach 3 compared with the end of Reach 4 (Figure 9). The LLO temperatures are similar to the dam tailrace temperatures, which is largely a consequence of the underground penstock that prevents solar heating (Mugunthan et al. 2019).

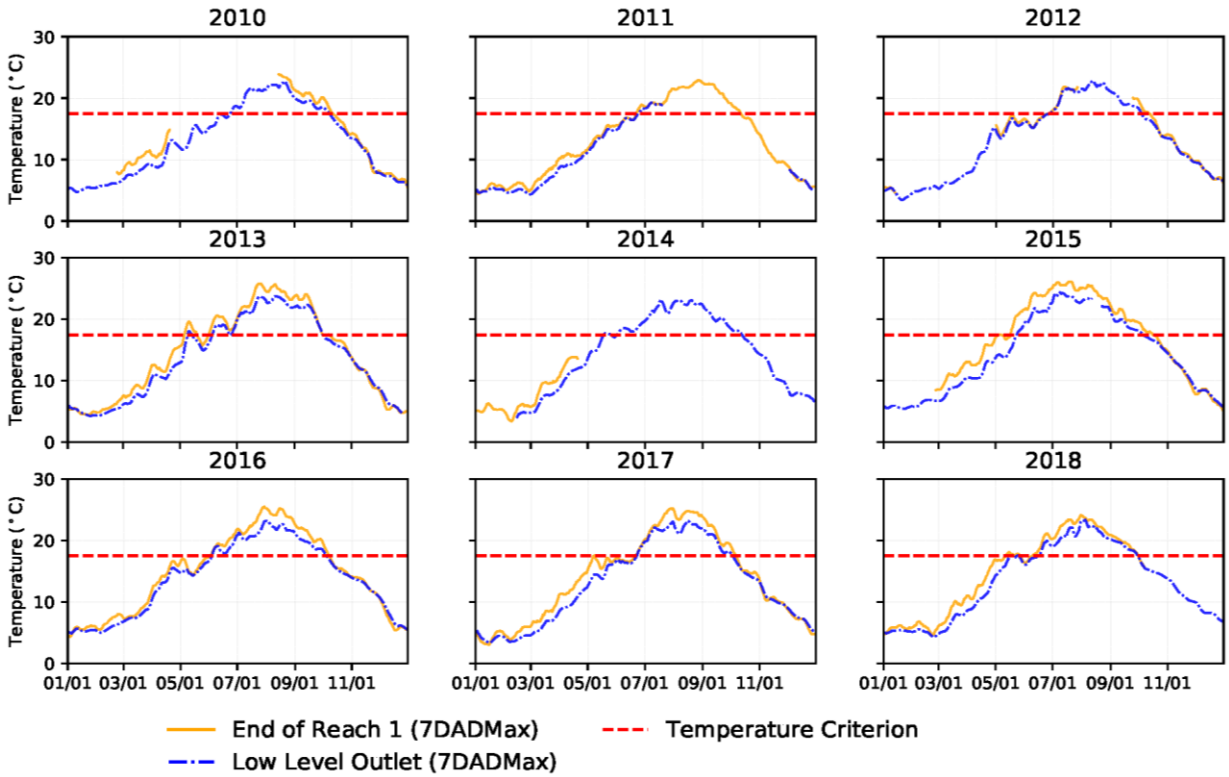


Figure 7 Chelan River water temperatures at the end of Reach 1 (adapted from Mugunthan et al. 2019)

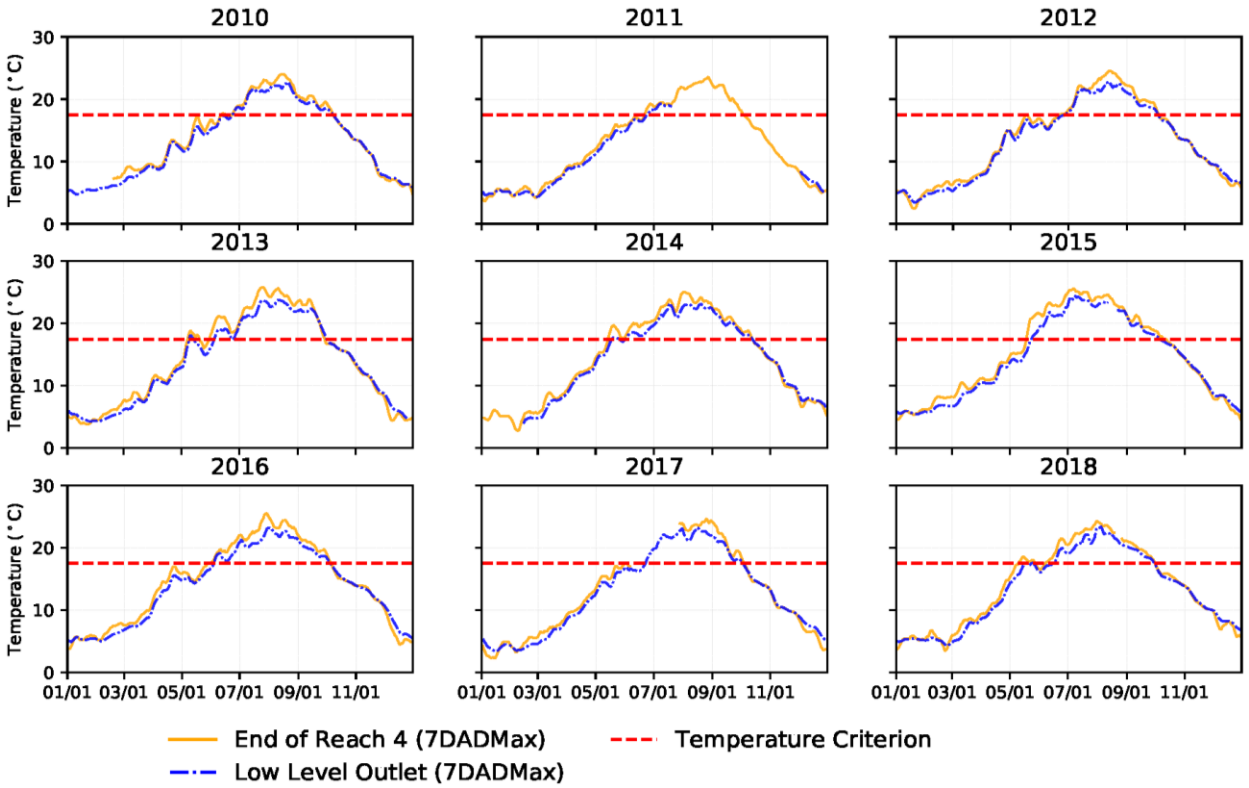


Figure 8 Chelan River water temperatures at the end of Reach 4 (adapted from Mugunthan et al. 2019)

Chelan PUD measured diurnal temperature fluctuations for average, wet, and dry years during the monitoring period. The greatest diurnal temperature fluctuations occurred in summer (Mugunthan et al. 2019). The diurnal fluctuations observed in the Chelan River can be largely be attributed to solar heating. The extent of solar heating was calculated for two sections of the Chelan River including from the top of Reach 1 to the end of Reach 3 and from the end of Reach 3 to the end of habitat channel in Reach 4. The 7-DADMax was calculated by measuring the temperature change from the upper and lower ends of these river segments from 2009 to 2018 using hourly temperature measures. The mean, range, and 90th percentile for each day over a 10-year record are shown in Figure 8.

The highest temperature change from the upper to the lower end of the segments examined occurred in late April and early May and then again in mid to late summer. The change in the 7-DADMax temperature in Reach 1-3 is within 1 to 2°C from spring to summer on average, but can reach as high as 3.5°C immediately before the high flows from snowmelt. These higher temperature changes occur in the spring when water temperature is approximately 18°C and not during peak summer temperatures. The habitat channel in Reach 4 shows similar seasonal warming patterns. However, the temperature change is typically less than 0.2°C on average, with maximum temperature swings of slightly over 1°C in the spring.

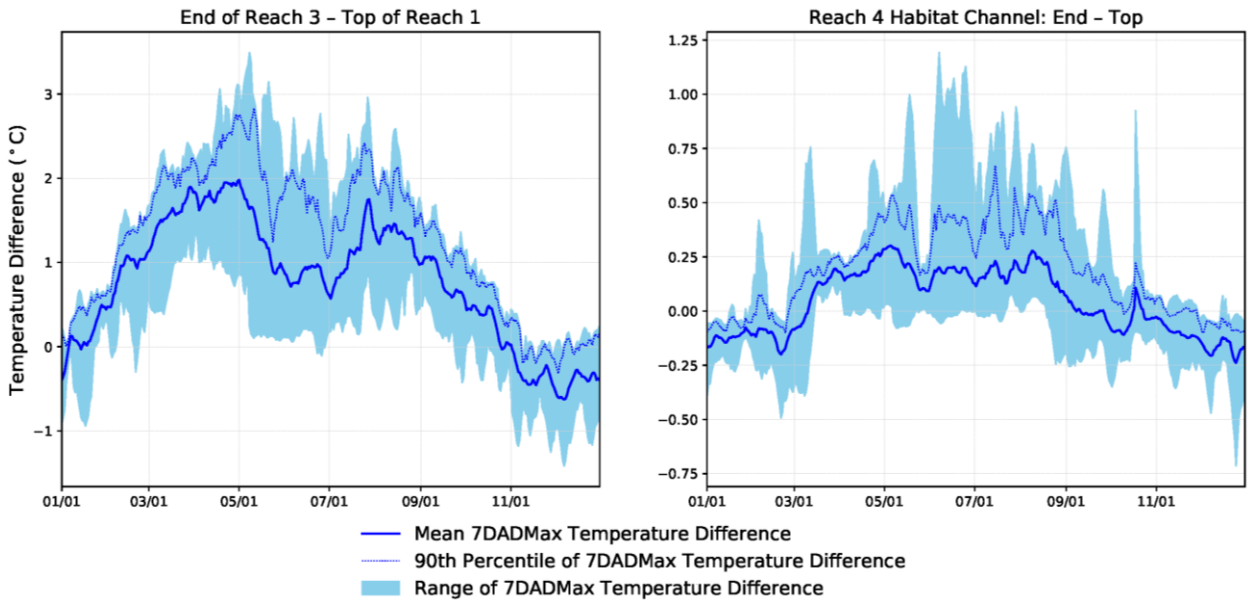


Figure 9 Temperature changes in the Chelan River determined from the Chelan River Plan data (adapted from Mugunthan et al. 2019)

Chelan PUD examined a range of higher flow releases to reduce water temperature in the Chelan River. A QUAL-2K model did find that the daily maximum temperatures would be reduced at 200 cfs (0.5°C) and 500 cfs (1.5°C). However, higher flows were eliminated as a possibility for thermal remediation in the Chelan River because it reduced the amount of useable habitat area in the Chelan River, produced greater scour under high flows, and limited the already minimal primary productivity that is essential to support aquatic life. Furthermore, higher flows would lead to more heat input into the Columbia River due to the increase volume of water (Chelan PUD, 2003). The increased flows would also increase nighttime temperatures and reduce cold-water refuges. The flow increases examined would not reduce water temperatures to levels that are optimal for salmonids and would reduce useable habitat.

Dissolved Oxygen Results

The DO levels in the Chelan River met the 8.0 mg/L criterion the majority of the monitoring period (Figure 9). When DO levels were observed below 8.0 mg/L, it was typically during peak summer conditions, at the top of Reach 4, most likely due to higher temperatures that inhibit the ability of oxygen to dissolve in water. DO levels declined in November 2015 and spring of 2016, but this was attributed to a malfunctioning sensor (Chelan PUD, 2011-2019; Chelan PUD 2017). During the monitoring period, DO saturation in the habitat channel of Reach 4 was at or near saturation, except during the previously explained sensor malfunction and during peak summer temperatures (Figure 10). The pH levels were generally found within the criteria of 6.5 to 8.5 units, except for some periods in 2016 and 2018 when the 8.5 criterion was exceeded. These exceedances were attributed to periphyton activity in 2018 and drifts in pH sensors (Chelan PUD, 2017, 2019).

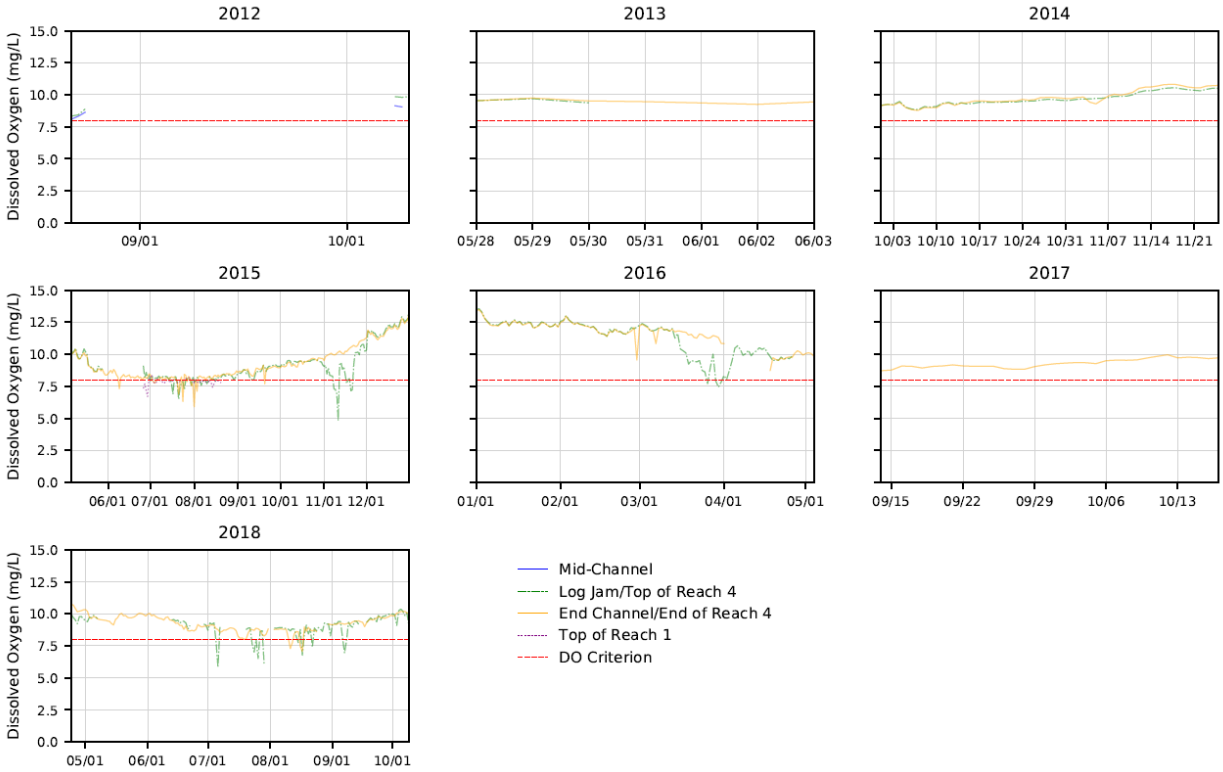


Figure 10 Daily minimum dissolved oxygen in the Chelan River from 2012-2018 (adapted from Mugunthan et al. 2019)

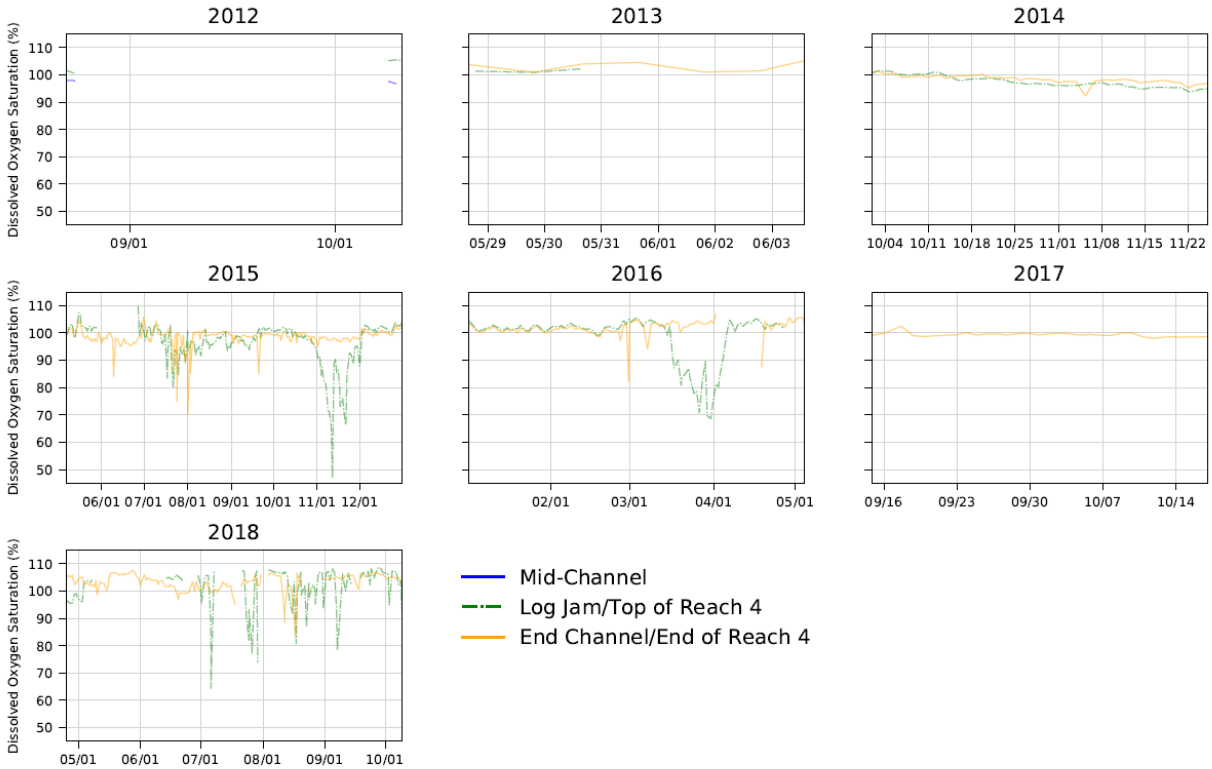


Figure 11 Calculated percent saturation from daily minimum dissolved oxygen, water temperature, and barometric pressure in the Chelan River habitat channel (adapted from Mugunthan et al. 2019)

Turbidity Results

Turbidity data collected at the beginning and end of Reach 4 showed compliance with the turbidity criterion over 99% of the time (Chelan PUD, 2019). Total dissolved gas (TDG) data met the standard of 110% under all spill conditions in 2016, with a max TDG level of 106.5% (Chelan PUD, 2017).

Chelan River Biological Survey Findings

Macroinvertebrates

Reaches 1-3

The macroinvertebrate community within the Chelan River was found to have a low benthic index of biological integrity (B-IBI), an index reflective of biological conditions of a stream. The low B-IBI score (15-24) suggests low productivity and/or poor water quality conditions. The macroinvertebrate community is representative of the low productivity conditions within Lake Chelan (Van der Broek et al. 2018). The macroinvertebrates observed within the Chelan River are typically not the preferred prey of stream dwelling salmonids, but rather representative of species tolerant to high temperatures (Van der Broek et al. 2018).

Reach 4

The habitat channel in Reach 4 and the tailrace of the powerhouse has been shown to have a relatively high abundance of zooplankton in the spring months. Zooplankton are a potential food source for salmonids present in Reach 4. The penstock intake is at a higher elevation in the water column than the LLO, possibility facilitating the transfer of pelagic zooplankton. Van der Broek et al. (2018) suggests that pelagic zooplankton could be transported through the penstock to the tailrace and habitat channel.

Fish

Reaches 1-3

Upstream movement of salmonids from Reach 4 of the Chelan River to Reaches 1-3 is obstructed by multiple natural passage barriers (Figure 11), limiting the ability of anadromous fish to enter the majority of the River (R2 and I2, 2000). Chelan PUD was unable to establish a salmonid population in Reach 1 through 3 after multiple attempts to stock cutthroat trout due to limited food availability, water quality conditions, and habitat. Occasional salmonid species were present in Reach 1 through 3, but their occurrence has been attributed to fish originating from Lake Chelan (Figure 12). These salmonids would reside only temporarily, and continue downstream into Reach 4 and presumably, into the Columbia River. The presence of salmonids in the upper reaches of the Chelan River coincided with high flow events and the annual stocking of fish in Lake Chelan (Figure 12).

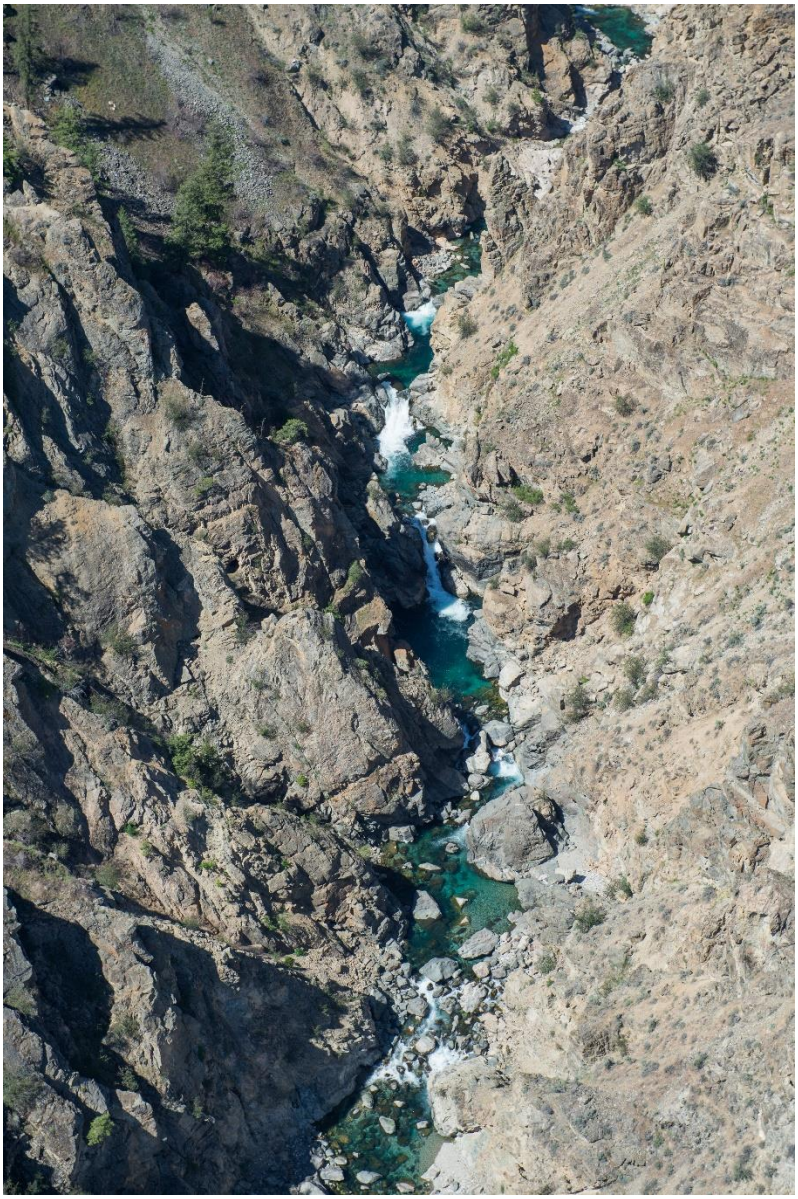


Figure 12 A series of natural passage barriers found in Reach 3 that limits upstream migration of salmonids. Photo credit: Chelan PUD

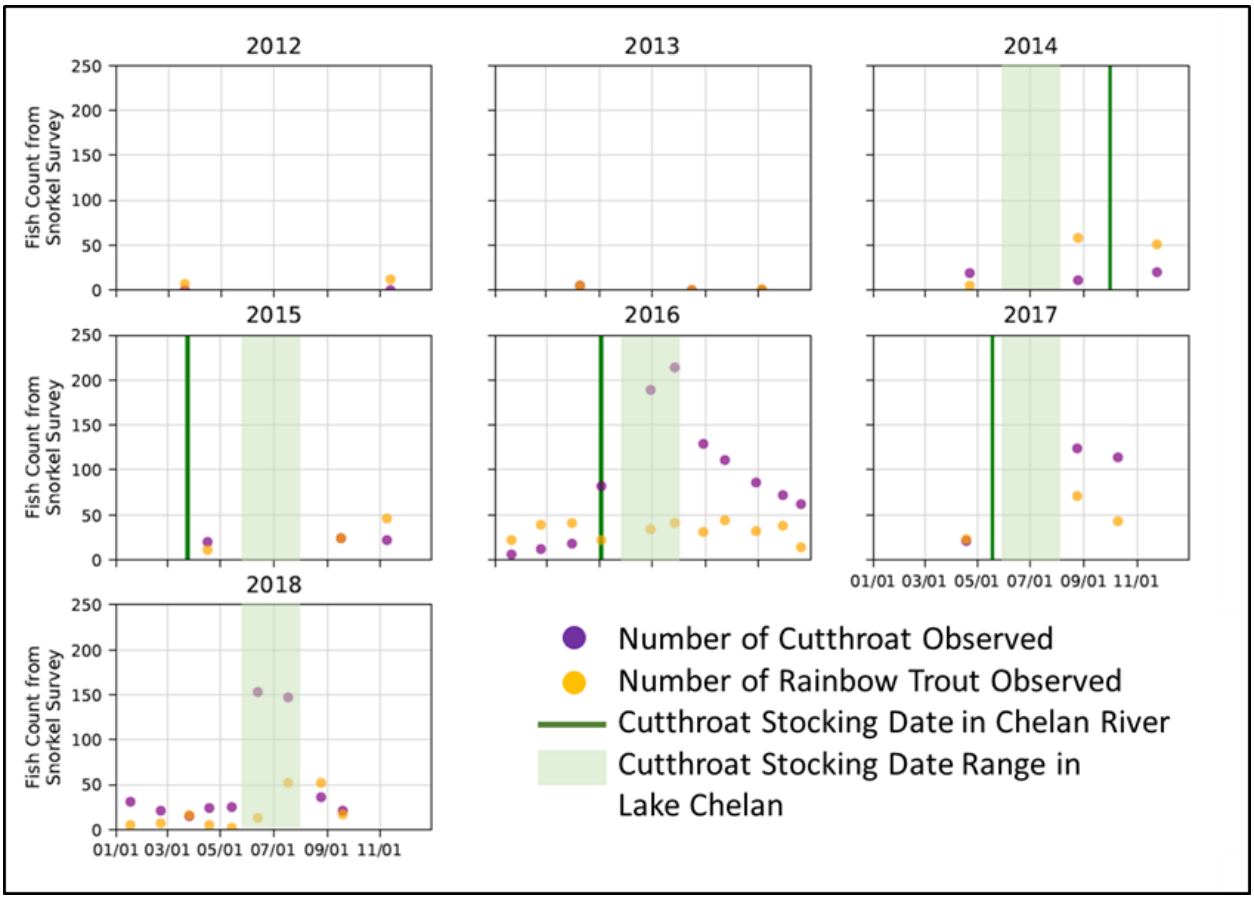


Figure 13 Cutthroat and rainbow trout abundance in Reaches 1-3 (adapted from Mugunthan et al. 2019)

Reaches 1 through 3 have been found to have little habitat potential, limited productivity, limited food available to aquatic life, and warm water temperatures that may preclude the establishment of year-round residence of salmonids. The Chelan River is ultraoligotrophic with limited presence of macroinvertebrates and productivity. It was found that non-native, temperature-tolerant smallmouth bass were the only fish that were represented by multiple age classes and appeared to be increasing in abundance over time.

The hydrology, habitat potential, water quality, and natural barriers preclude the salmonid spawning and rearing uses on this section of the Chelan River. However, salmonids have been demonstrated to use Reach 1 through 3 for purposes of downstream migration from Lake Chelan to lower reaches of the Chelan River and the Columbia River.

Reach 4

During fish surveys, summer Chinook salmon spawning has been documented in the engineered habitat channel and the tailrace of the dam in the fall from early October to late November, resulting in an overall increase in Chinook escapement compared with escapements prior to habitat restoration (Figure 13). Chinook salmon fry and rearing juveniles were observed in the habitat channel and tailrace in the spring months of each year, suggesting that flows and habitat improvements are providing adequate rearing habitat. Juvenile Chinook salmon

numbers peak from late April through early May, with numbers rapidly decreasing by mid-May (Figure 14). The emigration of juveniles coincides with increasing water temperatures in the Chelan River (Figure 14). The timing of the emigration reflects similar patterns observed in the nearby Methow and Wenatchee rivers (Figure 14) and the density of steelhead spawning in the Chelan River was high (16 redds/km) compared to other regional spawning areas (1-5 redds/km; Jacobsen et al. 2013; Snow et al. 2018).

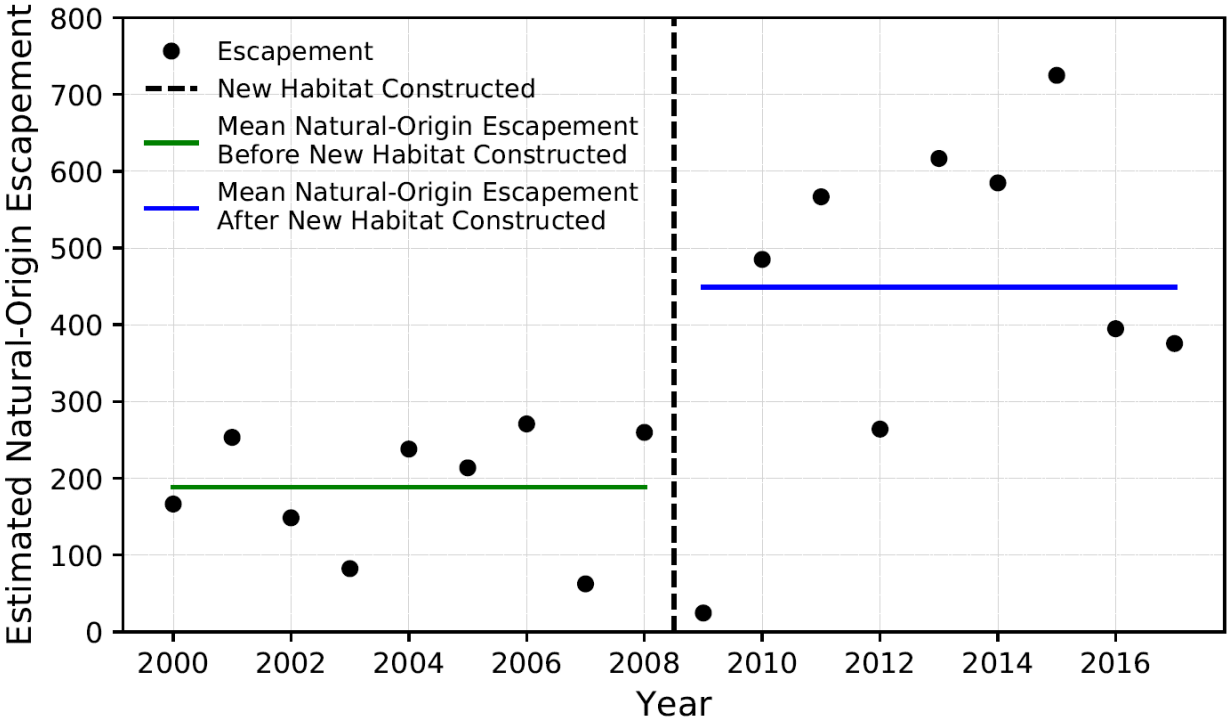


Figure 14 Estimated natural-origin Chinook salmon spawning escapement in the Chelan River from 2000-2017 (adapted from Mugunthan et al. 2019)

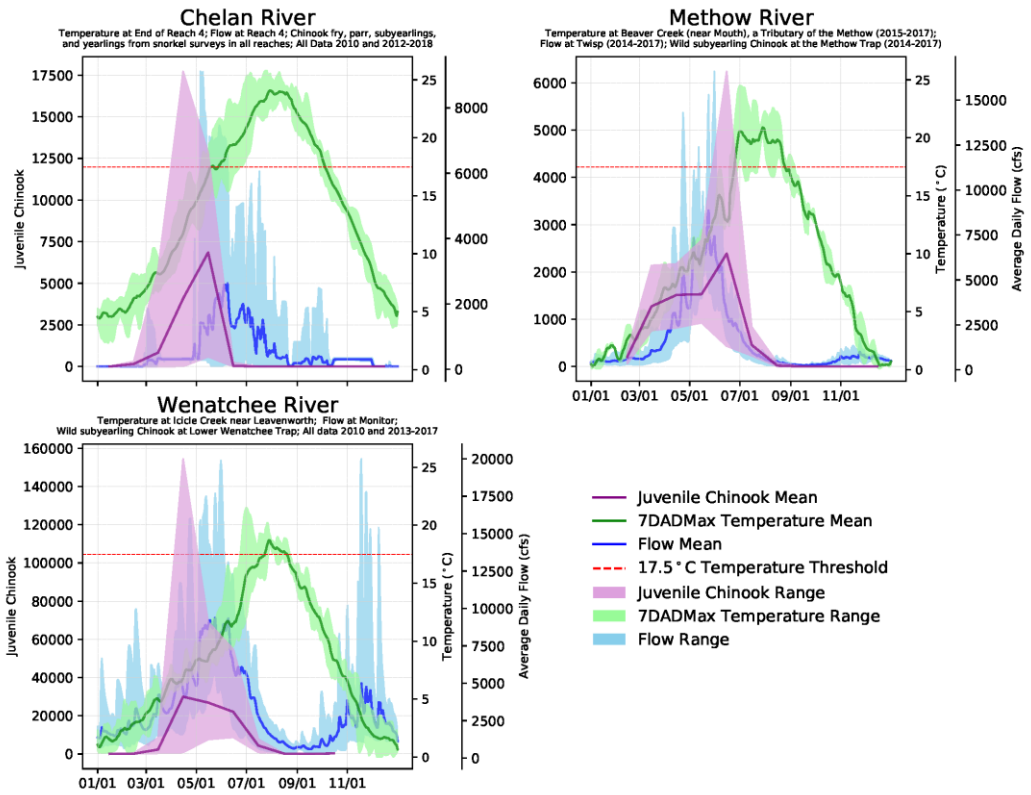


Figure 15 Timing of juvenile Chinook salmon presence in the Chelan River and timing of outmigration in the Methow and Wenatchee rivers (adapted from Mugunthan et al. 2019)

Steelhead spawning has also been observed in the habitat channel during spring, from early March to early May (Figure 15). Juvenile steelhead and rainbow trout were observed in the habitat channel through mid-summer. The abundance of trout in Reach 4 coincided with high flow periods in the Chelan River, and may represent either downstream migrants from the Lake or progeny from the spawning steelhead that were observed. As with Chinook salmon, steelhead and rainbow trout abundance decrease when water temperatures begin to increase rapidly in the early summer months (Figure 16). The timing of the emigration reflects similar patterns observed in the nearby Wenatchee and Twisp rivers (Figure 16).

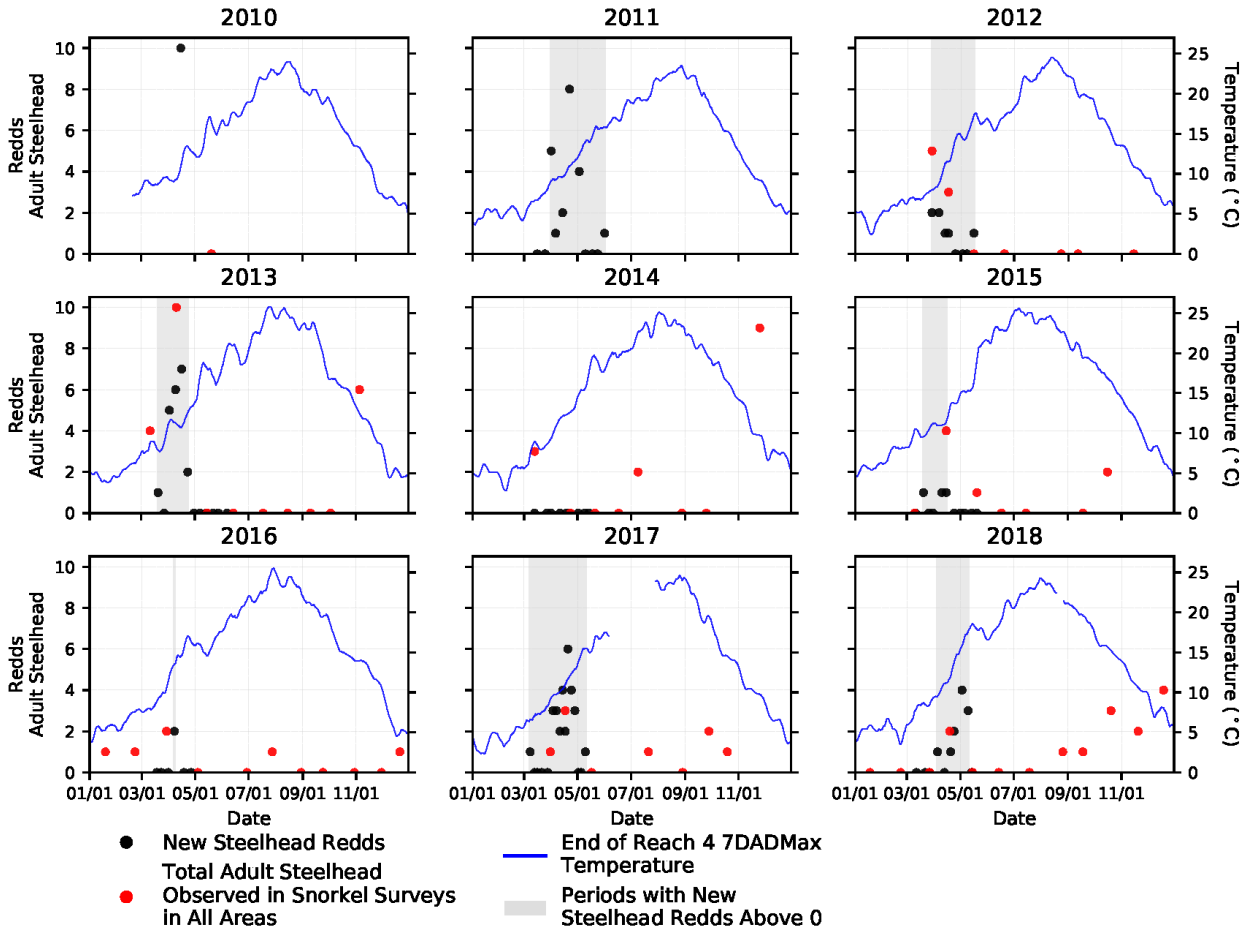


Figure 16 Steelhead adults and redds observed in Reach 4 habitat channel (adapted from Mugunthan et al. 2019)

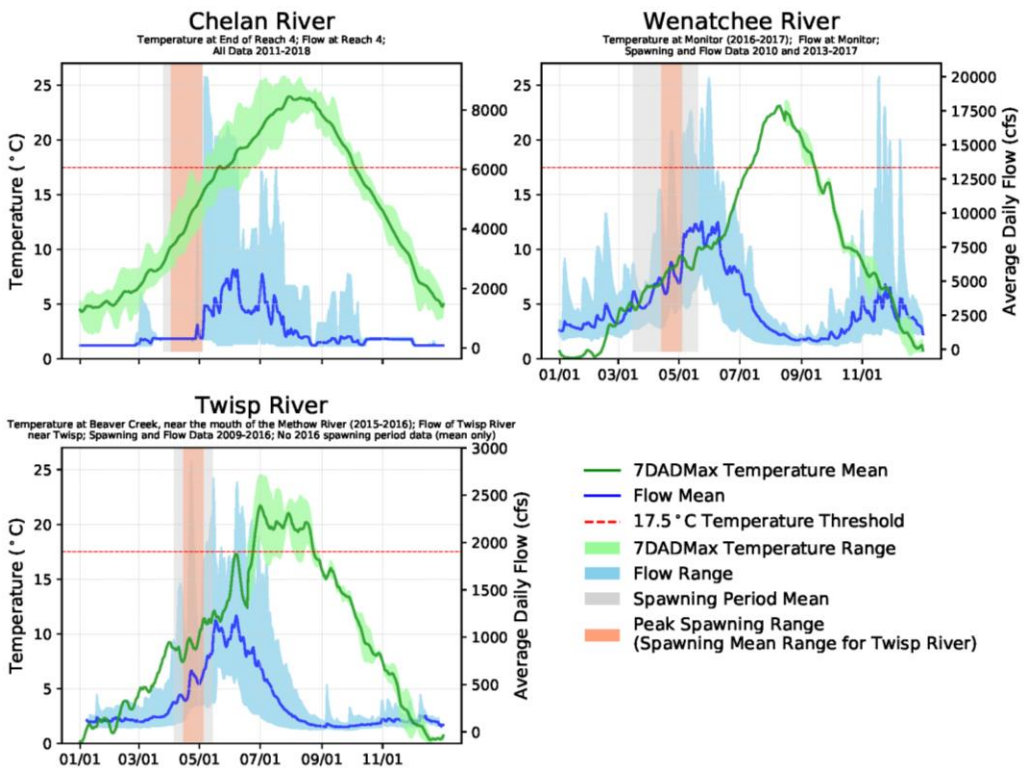


Figure 17 Timing of steelhead spawning in the Chelan River relative to adjacent watersheds (adapted from Mugunthan et al. 2019)

The 7-DADmax temperatures in the habitat channel and tailrace routinely exceed 17.5°C by mid- to late-May and 20°C by early-July (Figure 7) as a result of higher water temperatures in Lake Chelan. Reach 4 has demonstrated the ability to support the aquatic life use of salmonid spawning, rearing, and migration, but full protection of this use is not likely due to high water temperatures that naturally increase during seasonal warming in the Lake Chelan.

The salmonid spawning, rearing, and migration use designation is defined as salmon or trout spawning and emergence that only occurs outside of the summer season (September 16 – June 14). The rearing and migration components of this use must be supported throughout the year, including the summer season. As demonstrated in the Chelan PUD monitoring program, water quality does not fully support the salmonid spawning, rearing, and migration year-round in Reach 4, specifically from mid-May through mid-October, due to temperature related influences from Lake Chelan and solar heating (Figure 17).

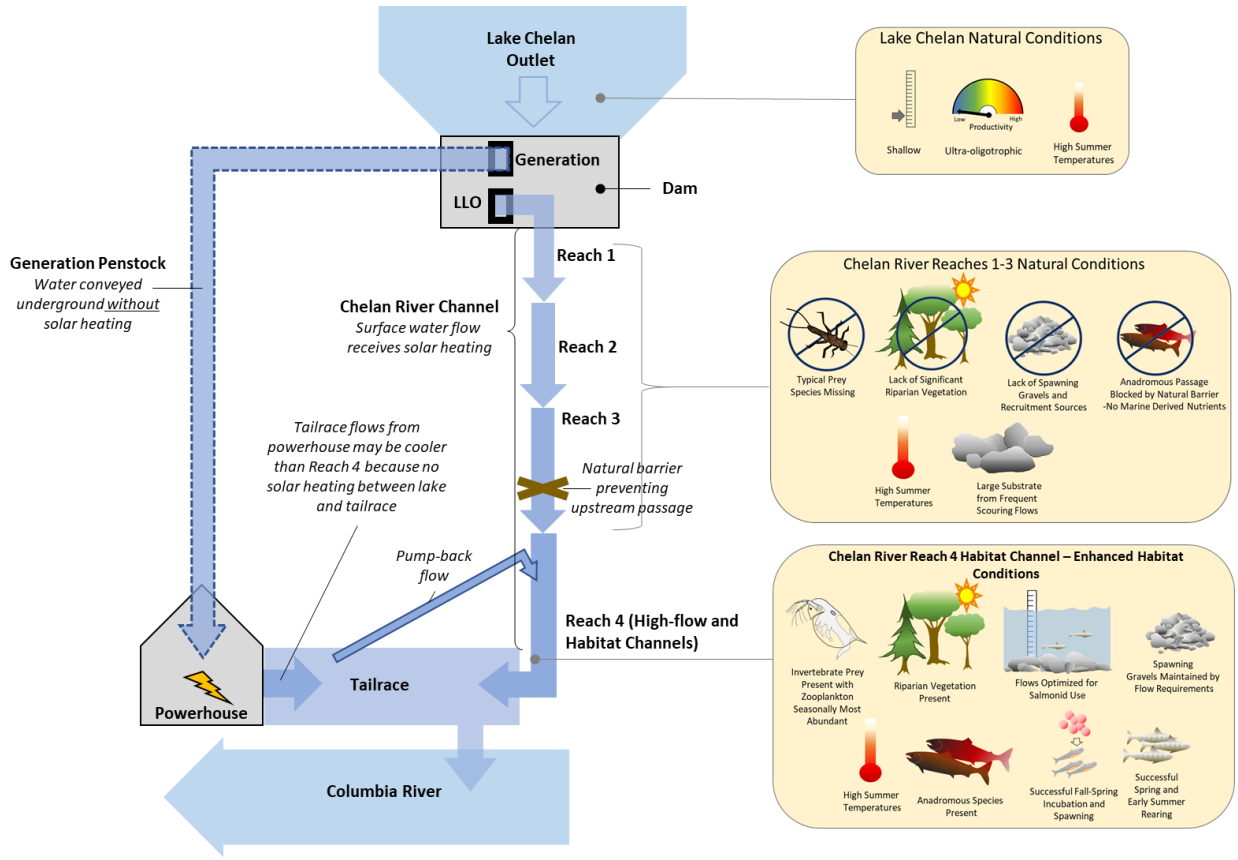


Figure 18 Illustration of flow routing and habitat conditions in the Chelan River (adapted from Mugunthan et al. 2019)

Habitat Assessment Findings

Reaches 1-3

The Chelan River is not supplied sediment from upstream due to the presence of Lake Chelan. The conveyance of materials from lakes to outflowing water bodies is generally known to be limited due to their slow moving or non-existing water currents and minimal perturbations in sediment. Rather, Chelan River receives sediment by erosion of the streambed and banks (Chelan PUD, 2000). Substrate has been described as very coarse and only transported during very high flow events. The substrate composition reflects a high-energy environment (Stillwater Sciences, 2001).

The geomorphology of the Chelan River is not favorable for spawning or incubation for salmonids based on their life history due to the lack of smaller spawning gravel and fast moving water in the upper reaches (Stillwater Sciences, 2001). The limited suitable habitat in the upper reaches of Chelan River is located in the channel margins and would likely be subject to dewatering (Stillwater Sciences, 2001). Furthermore, the limited riparian vegetation and large woody debris results in limited cover and habitat. The limitations in habitat coupled with high water temperatures and limited productivity preclude the ability to establish viable salmonid populations.

Reach 4

Habitat improvements in Reach 4 include re-establishing a river channel, providing sufficient water flows, and planting riparian vegetation to enhance the habitat available to salmonids for spawning and rearing. Reach 4 is shown before minimum instream flows (later required and implemented through the 401 WQC) when a defined channel did not exist (Figure 18), after minimum instream flows were enacted (Figure 19), and after the habitat construction and maturation (Figure 20).

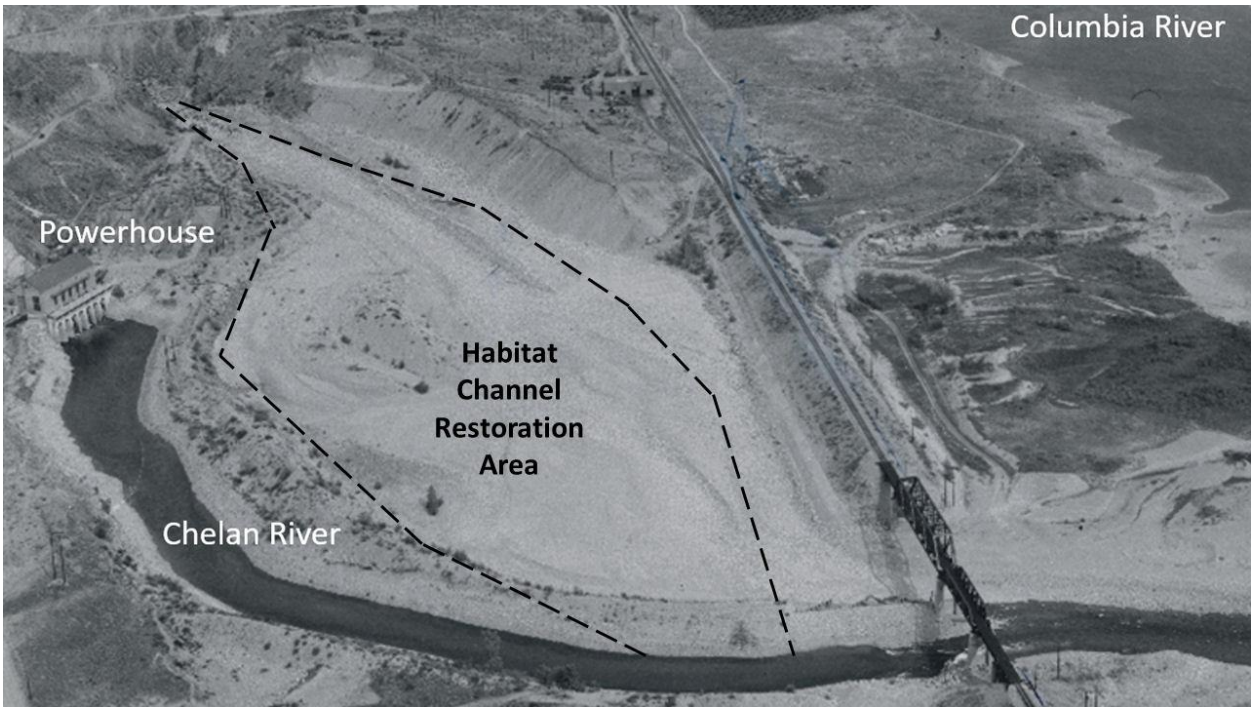


Figure 19 Reach 4 prior to habitat enhancement projects and restoration (1926) of water flows (adapted from Mugunthan et al. 2019).

Figure 20 Reach 4 after restoration of instream minimum flows and the construction of the habitat channel in 2009 (adapted from Mugunthan et al. 2019).

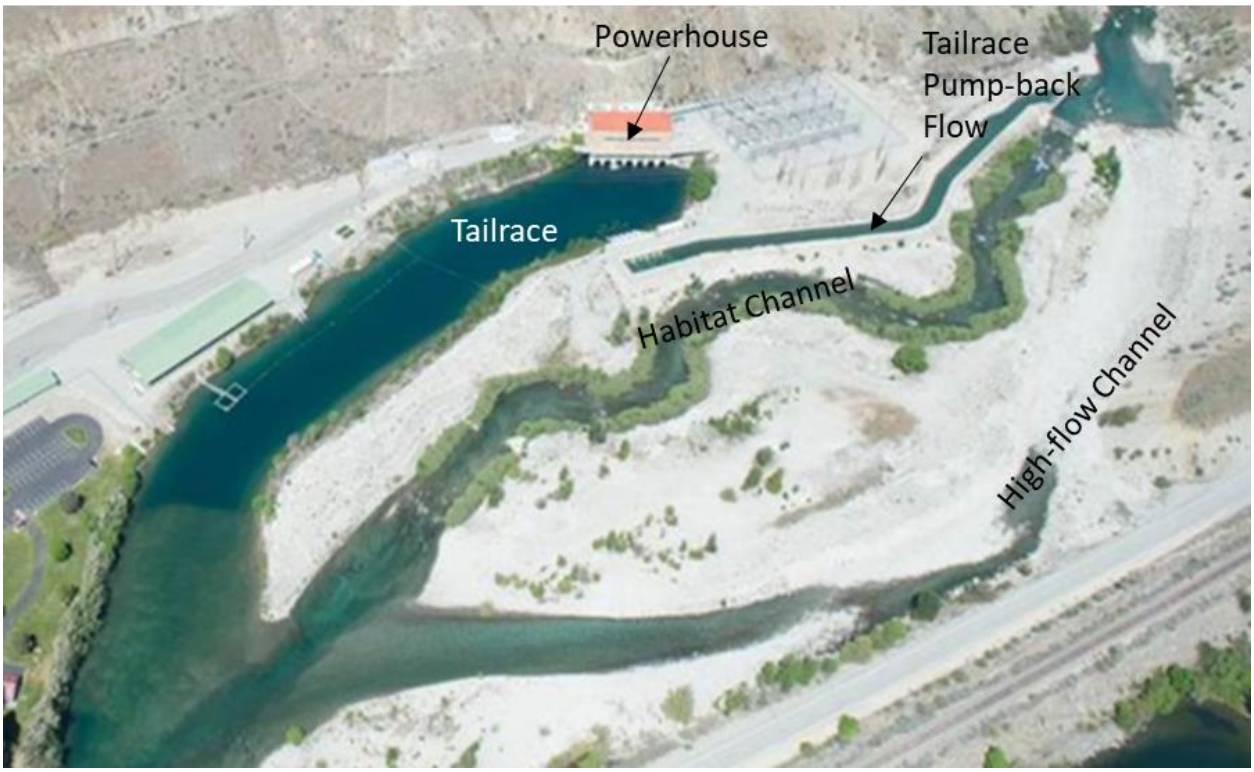


Figure 21 Reach 4 and the maturation of riparian vegetation in the habitat channel in 2017 (adapted from Mugunthan et al. 2019).

Use Attainability Analysis: Evaluation of Factors

Chelan PUD conducted a series of biological assessments and monitoring as required within their 401 WQC that enabled a determination of the highest attainable aquatic life use in the Chelan River. The current designated use for aquatic life is salmonid spawning, rearing, and migration. Chelan PUD has proposed changes to the designated uses on the Chelan River. Revisions to designated aquatic life uses that require less stringent water quality criteria based on a UAA must follow WAC 173-201A-440and 40 CFR 131.10(j)(2).

The federal CWA regulation 40 CFR 131.10(g) specifies that states may designate or remove a use that is not an existing use, if the state conducts a UAA that demonstrates that attaining the use in not feasible because of one of six factors outlined in 40 CFR 131.10(g)(1)-(6). One of the requirements of a UAA is a scientific assessment of the factors that are impacting the attainment of a designated use specified in Section 101(a)(2) of the Clean Water Act (fishable/swimmable uses). The factors that may be considered in reevaluating a use include physical, chemical, biological, and economic-based factors that preclude the ability to attain the designated use.

Reaches 1-3

Chelan PUD evaluated the default designated aquatic life use of salmonid spawning, rearing, and migration in Reaches 1 through 3. The results of these monitoring efforts suggest that the salmonid spawning, rearing, and migration use cannot be attained and has never existed. Upstream migration of salmonids above Reach 4 is obstructed by a natural passage barrier and attempts to establish resident salmonids in Reaches 1-3 were unsuccessful. Salmonids are present in Reaches 1-3 at times but likely originate from Lake Chelan. During high flow events, the number of salmonids detected increased due to flushing from Lake Chelan into the Chelan River. Salmonids appear to be using Reaches 1-3 for downstream migratory purposes but spawning and rearing has not been observed. The habitat and water quality conditions, specifically water temperature and food availability, prevents spawning, rearing, and year-round residence of salmonids in these upper reaches of the Chelan River.

Chelan PUD identified factor five under 40 CFR 131.10(g) to justify a UAA on the Chelan River. Factor five states that "physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses."

We agree that the presence of a natural passage barrier and limited habitat precludes the attainment of salmonid spawning, rearing, and migration for anadromous salmonids. Reach 3 is characterized by a naturally steep gradient, fast moving water leading to scouring, large boulders, and natural waterfalls that obstruct the movement of salmonids upstream. Furthermore, Reaches 1-3 have limited riparian habitat and poor substrate quality that is not sufficient to support spawning and rearing. The studies conducted by Chelan PUD describes the limitations of salmonids movement upstream and the inability of downstream migrating salmonids to spawn and rear due to insufficient habitat. In conclusion, we agree that factor five is appropriate to justify a designed use revision in Reaches 1-3.

We also agree with Chelan PUD that factor one is a secondary factor that supports a UAA for Reaches 1-3. Factor one states that "naturally occurring pollutant concentrations prevent the attainment of the use." Water quality conditions of Reaches 1-3 is limited and cannot support salmonid spawning and rearing under the best of circumstances. The non-anadromous salmonids that are seasonally observed in Reaches 1-3 appear to originate from Lake Chelan during high flow events and do not reside year-round. The high water temperatures and limited productivity, directly influenced by Lake Chelan, limit salmonid reproduction and food availability. Data suggests that in the absence of the dam, water temperature conditions would be similar or worse.

Reach 4

Chelan PUD evaluated the default designated aquatic life use of salmonid spawning, rearing, and migration in Reach 4. Prior to establishing minimum instream flows and engineering a habitat channel in Reach 4, salmonids spawned and reared in the tailrace of Lake Chelan Dam. However, salmonid spawning was not an existing use in former Chelan River fluvial formation due to the lack of perennial flows. Following the construction of the engineered habitat channel and the implementation of minimum instream flows in the Chelan River, salmonids have returned to the main channel. Chinook salmon and steelhead have been observed spawning, rearing, and migrating in Reach 4 since the creation of the habitat channel, resulting in the existing aquatic life use of salmonid spawning, rearing, and migration.

While salmonid spawning, rearing, and migration has been observed in Reach 4 since habitat enhancement activities, full attainment of this use does not exist due to suboptimal water quality caused by naturally low nutrients and natural seasonal warming conditions. Water quality conditions in Reach 4 are not representative of full protection of the use and may act to limit spawning and rearing success. We agree with Chelan PUD that factor one under 40 CFR 131.10(g), which states, "naturally occurring pollutant concentrations prevent the attainment of the use," aptly describes the basis for changing the designated aquatic life use. Water temperatures routinely exceed 20°C in all reaches of the Chelan River during the summer. The high temperatures thus limit the year-round attainment for full protection of the aquatic life use of salmonid spawning, rearing, and migration in Reach 4.

Furthermore, even at the estimated maximum riparian coverage in Reaches 1-3, shading is not predicted to significantly lower water temperatures compared with current conditions (Herrera, 2015). As mentioned previously, the water temperatures in the Chelan River are likely improved due to the presence of the Chelan Dam from raising Lake Chelan water elevation by 21 feet and the subsequent thermal stratification in the forebay of the Dam. Water is drawn from the lower water column than would otherwise occur in the absence of a dam, thereby resulting in use of the coolest water available to feed the Chelan River. However, even with this influx of cooler water, suboptimal water quality conditions still exist, as confirmed by the low abundance of salmonids in Reach 4 during the summer when water temperatures reach intolerable levels.

Revisions to Designated Uses

Reaches 1-3

We propose to designate aquatic life uses in Reaches 1-3 of the Chelan River to those that have been established by the return of perennial flows. The current general designated uses of salmonid spawning, rearing, and migration were not previously existing uses and were applied without review of local conditions. We propose the designated use of **migration for naturally limited waters,** which represents the highest attainable use in Reaches 1-3 as demonstrated by the occurrence of naturally-occurring pollutant concentrations (namely water temperature), limited habitat availability, and a natural passage barrier. This modification of the aquatic life use is justified under 40 CFR 131.10(g)(5), as well as 40 CFR 131.10(g)(1).

Reaches 4

We propose to designate aquatic life uses in Reach 4 of the Chelan River to those that have been established by the return of perennial flows. The current general designated uses of salmonid spawning, rearing, and migration were not previously existing uses and were applied without review of local conditions. We propose an aquatic life sub-category of **salmonid spawning, rearing, and migration for naturally limited waters**. This sub-category represents the established propagation of salmonids occurring in Reach 4 since flows were restored, while recognizing that the optimal biological criteria for salmonid spawning, rearing, and migration is not fully achievable due to local conditions. Naturally occurring pollutant concentrations (namely water temperature) limit optimal spawning and rearing success. This modification of the aquatic life use is justified under 40 CFR 131.10(g)(1) and meets the intent of the UAA und 40 CFR 131.10(j)(2) to designate a sub-category of a use that requires criteria less stringent than previously applicable.

Site-Specific Water Quality Criteria

Changing the designated uses through a UAA may also necessitate changes to site-specific criteria (SSC). To protect the proposed highest attainable aquatic life uses, water quality criteria that is specific to the Chelan River is needed that accounts for the unique characteristics of the waterbody. Furthermore, the SSC should account for variation in water conditions that can accompany different climatic conditions, including predominately wet and dry years. During the monitoring program, Chelan PUD characterized water quality during both dry and wet climatic years. These variations in climate can directly affect water quality conditions in the Chelan River and Lake Chelan.

Site-specific criteria must follow regulations set in WAC 173-201A-430 and 40 CFR 131.11(b)(1)(ii). Site-specific criteria must be based on sound scientific rationale and protect the designated uses. Site-specific criteria take into account a site's physical, chemical, and/or biological conditions. We are proposing SSC for water temperature and DO for Reaches 1-3 and Reach 4, primarily based on the influence of Lake Chelan on water temperatures in the Chelan River and the limited capacity of the surrounding habitat to reduce solar heating.

Site-specific criteria are dependent on maintaining the highest attainable conditions identified in Chelan PUDs monitoring program. The warmest water temperature conditions occur from mid-May through mid-October, when Lake Chelan experiences abrupt increases in water temperatures that result in reduced water quality in Chelan River. The proposed SSC will be based on Lake Chelan temperatures as well as warming that occurs due to solar heating over the distance of the Chelan River (Figure 21). The objective of the SSC is to maintain the extent of warming within the Chelan River to current conditions after accounting for the temperature of the source water (also referred as the background temperature).

The SSC developed for temperature accounts for warming of the Chelan River that occurs naturally through solar heating. Given that the calculation of the SSC is meant to limit heat inputs to only natural heat sources, we propose that no anthropogenic heat inputs be allowed in the Chelan River. This ensures that the predicted temperature conditions calculated in the modeling assumptions made in the UAA and the natural thermal regime are not exceeded in the future and the therefore, the highest attainable use is not degraded by future anthropogenic heat sources. A special provision in the rule language is included for Reaches 1-3 and Reach 4 to specify that no heat inputs from anthropogenic sources are allowed to warm the Chelan River.

To evaluate the warming of water within Reaches 1-3 and Reach 4, compliance points have been identified for water quality monitoring purposes. The compliance point for Reaches 1-3 is at the end of the canyon in Reach 3. The end of the canyon is the most downstream location in Reaches 1-3 and is representative of the highest water temperatures. The end of the canyon should be compared to background conditions identified as the water coming out of the dam outlet at the top of Reach 1. In Reach 4, the compliance point is the end of the habitat channel just upstream of the confluence with the powerhouse channel. The water temperature at the end of the canyon in Reach 3 is considered the background temperature for Reach 4.

Water from the Chelan River combines with the powerhouse channel that contains tailrace waters that are cooler than the water in the Chelan River. Therefore, to evaluate natural warming in Reach 4, it is appropriate to evaluate water temperature upstream of the confluence with tailrace waters. Tailrace waters cannot be considered part of the natural warming occurring in the Chelan River because water is drawn through the penstock of the Lake Chelan Dam and therefore not exposed to solar heating.

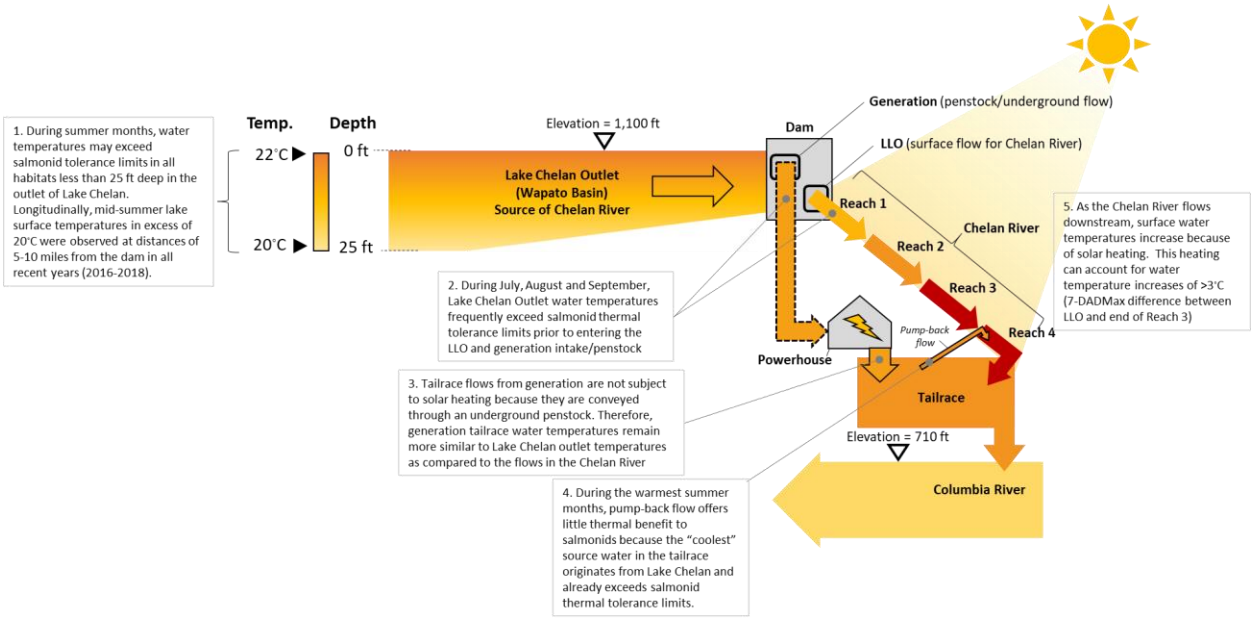


Figure 22 Site-specific conditions that result in high summer water temperatures (adapted from Mugunthan et al. 2019)

Statistical Analyses

A statistical bootstrapping approach was adopted for determining a reasonable worst-case temperature increase under current conditions for Reaches 1 through 3 and Reach 4. Mugunthan et al. (2019; Appendix A) provides a detailed discussion of the statistical analysis that was conducted to develop the proposed SSC. In summary, the bootstrapping analysis constructed 1,000 sets of paired, hypothetical 365-day time series of 7-DADMax temperatures at the background (upstream) and downstream extents by resampling from the daily maximum temperature data collected during the Chelan River Plan studies.

From the paired background and downstream 7-DADMax values, the numeric increase within Reaches 1 through 3 and the Reach 4 habitat channel were calculated for each day. For each 365-day period, numeric temperature increases of up to 5°C were evaluated at 0.25°C increments to identify what represents a reasonable worst-case under current conditions (Figures 22 and 23). Finally, the anticipated water temperature increases under projected air temperature increases from climate change was added to the reasonable worst-case estimates to derive the numeric criteria.

The results of the bootstrapping analyses demonstrate the simulated probability of exceedances for different allowable temperature increases in Reaches 1-3 (Figure 22) and Reach 4 (Figure 23) for two different definitions of an exceedance. The red line in Figure 22 and 23 represents the standard definition for determining an exceedance as one value greater than the 7-DADMax is considered out of compliance. The blue line in Figure 22 and 23 represents an alternative method of definition an exceedance, where compliance is determined by two more non-overlapping 7-DADMax values.

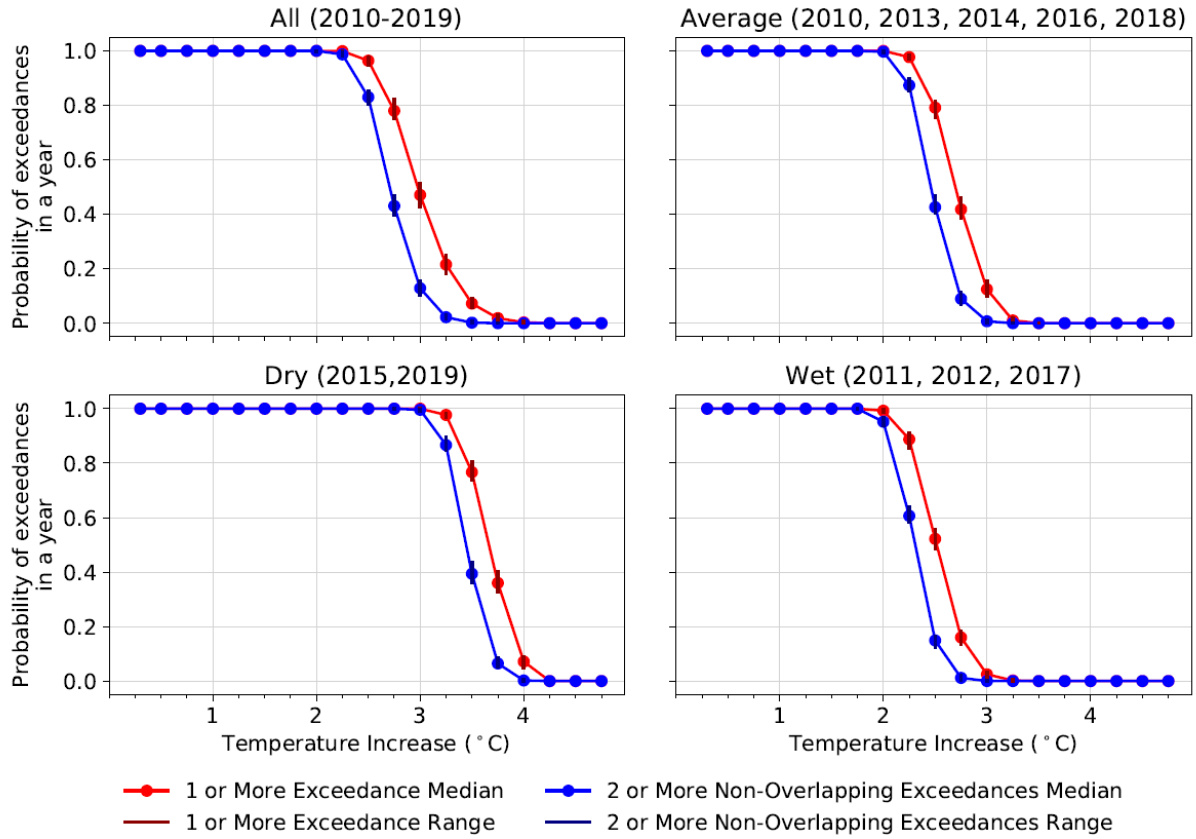


Figure 23 Comparison of simulated probabilities of two or more non-overlapping exceedances and one or more Exceedances for Reaches 1-3 (adapted from Mugunthan et al. 2019).

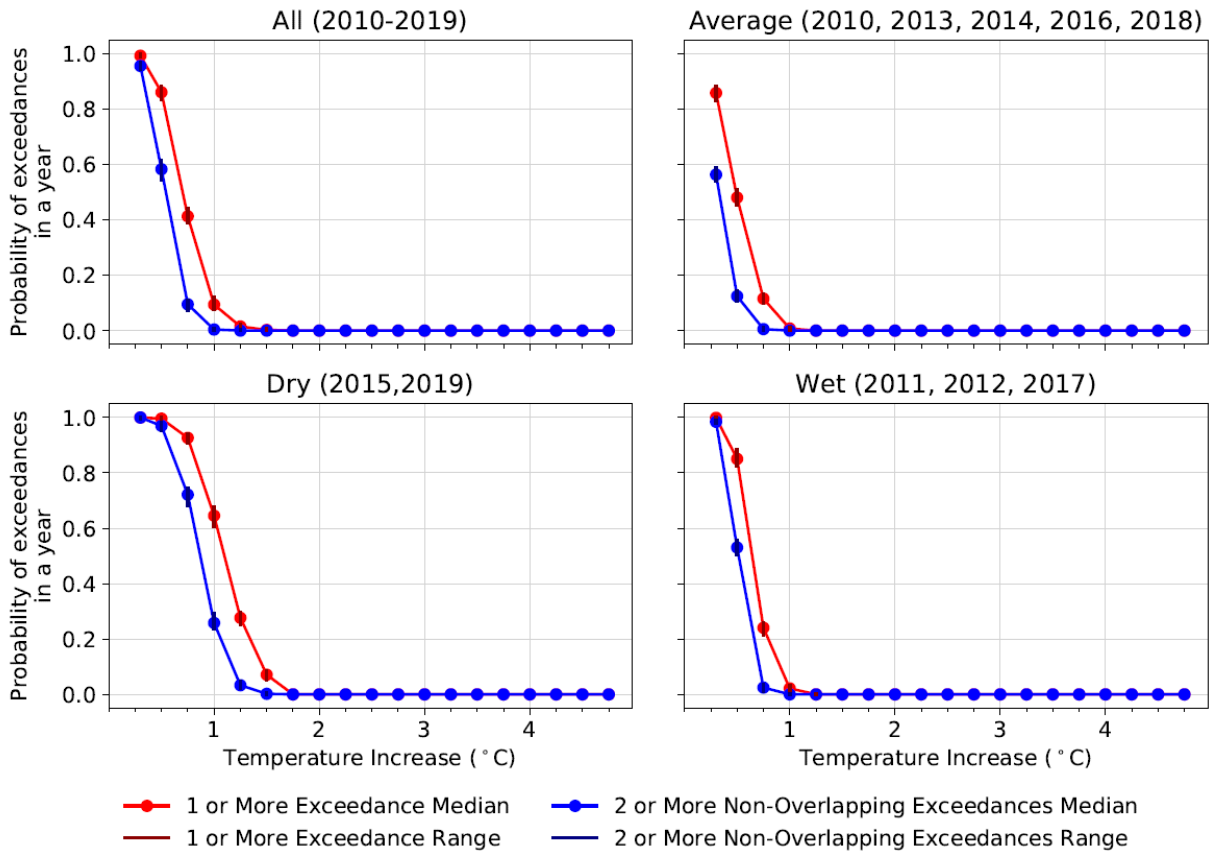


Figure 24 Comparison of simulated probabilities of two or more non-overlapping exceedances and one or more exceedance for the Reach 4 habitat channel (adapted from Mugunthan et al. 2019).

Water Temperature: Reach 1-3

The SSC for temperature developed by Chelan PUD is based on natural warming that occurs throughout Reaches 1-3. To develop site-specific water temperature criteria for the proposed use of migration for naturally limited waters for Reaches 1-3 on the Chelan River, background water temperatures must be established. Background conditions for the site-specific water temperature criteria are based on the water temperature at the LLO or dam outlet, otherwise known as the water directly feeding the headwaters of the Chelan River. Solar heating from Reach 1 to Reach 3 was accounted for by subtracting the water temperature from the end of Reach 3 from the water temperature at the LLO or the beginning of Reach 1. This water temperature differential was used to determine the maximum allowable heating in the Chelan River.

To develop SSC the magnitude, duration, and frequency of the criteria needs to be established. The standard duration for temperature criteria for Washington's water quality standards is a 7-day average of the daily maximum temperatures (7-DADMax) and the frequency is not more than one exceedance every 10 years. Chelan PUD has proposed an alternative duration based on two or more non-overlapping 7-DADMax increases in temperature. The 7-DADMAX increase rather than 7-DADMax is based on the temperature differential from the top of Reach 1 to the

end of Reach 3. Chelan PUD proposed a temperature increase from the LLO to the end of Reach 3 of 3.6°C. The Chelan PUD proposed 7-DADMax temperature increase of 3.6°C coupled with a duration of two or more non-overlapping 7-DADMax increased is predicted never to occur in the future based on statistical analyses.

We are suggesting revisions to Chelan PUD's proposal for site-specific temperature criteria in Reaches 1-3. Rather than using a modified definition of an exceedance (two or more non-overlapping 7-DADMax increases), we propose to use the standard definition of an exceedance, where one or more values greater than the 7-DADMax increase is considered out of compliance. The standard definition of an exceedance aligns with current methods for determining compliance for temperature in all state waters. The use of two or more non-overlapping exceedances, as proposed by Chelan PUD, provides significantly more leniency and is based upon our Policy 1-11 listing methodology for impaired waters. The implementation of the water quality standards differs from the methodology for determining an impaired water. We contend that it is not necessary to modify the definition of an exceedance as it may result in difficulties in interpretation and that modification to the magnitude of the criteria is the more appropriate pathway forward.

Chelan PUD has proposed a maximum allowable increase in the 7-DADMax of 3.6°C for Reaches 1-3. Chelan PUD's proposal of an allowable temperature increase of 3.6°C coupled with defining an exceedance as two or more non-overlapping 7-DADMax temperature increases is predicted to never result in a future exceedance based on statistical analyses. This proposal is not adequately stringent when considering the frequency component to temperature criteria, monitoring data, and statistical analyses. Washington's statewide temperature criteria has an allowable exceedance frequency of no more than once every 10 years on average, that in turn, provides flexibility and allows for an occasional exceedance during extreme climatic years. Using the standard definition of an exceedance, statistical analyses conducted by Chelan PUD suggests that an allowable 7-DADMax temperature increase of 3.75°C would be exceeded once every 50 years. While this may not align with the temperature criteria frequency of no more than one exceedance every 10 years, monitoring data from 2010-2018 has demonstrated warming up to 3.5°C on dry years (Figure 9). Considering nine years of data is not representative of climatic variation for all foreseeable years, and climate change will likely result in increased warming, we have proposed an allowable 7-DADMax temperature increase of 3.75°C, using the standard definition of an exceedance. While the 3.75°C 7-DADMax temperature increase represents a higher magnitude than the proposed value of 3.6°C by Chelan PUD, the overall proposed SSC is more stringent because of the decision to use the standard definition of an exceedance.

Water Temperature: Reach 4

The site-specific temperature criteria developed by Chelan PUD is based on natural warming that occurs throughout Reach 4. To develop site-specific water temperature criteria for Reach 4 on the Chelan River for the proposed aquatic life use of salmonid spawning, rearing, and migration for naturally limited waters, background water temperature was considered at the end of Reach 3. Solar heating was calculated by subtracting water temperature measured from

the end of Reach 3 to the end of the habitat channel in Reach 4. This water temperature differential was used to determine the maximum allowable heating in Reach 4.

To develop SSC the magnitude, duration, and frequency of the criteria needs to be established. The standard duration for temperature criteria for Washington's water quality standards is a 7-DADMax and the frequency is not more than one exceedance every 10 years. Chelan PUD has proposed an alternative duration based on two or more non-overlapping 7-DADMax increases in temperature. The 7-DADMAX increase is based on the temperature differential from the end of Reach 3 to the end of the Reach 4 habitat channel. Chelan PUD proposed a temperature increase from the end of Reach 3 to the end of the habitat channel in Reach 4 of 1.0°C. Chelan PUD proposal of a 7-DADMax temperature increase of 1.0°C, when coupled with a duration of two or more non-overlapping 7-DADMax increases, is predicted to occur every 500 years in the future based on statistical analyses.

We are proposing revisions to Chelan PUD's proposal for site-specific temperature criteria in Reach 4. Rather than using a modified definition of an exceedance (two or more non-overlapping 7-DADMax increases), we propose to use the standard method of an exceedance, where one or more values greater than the 7-DADMax increase is considered out of compliance. The standard definition of an exceedance aligns with current methods for determining compliance for temperature in all state waters. The use of two or more non-overlapping exceedances, as proposed by Chelan PUD, provides significantly more leniency and is based upon our Policy 1-11 listing methodology for impaired waters. The implementation of the water quality standards differs from the methodology for determining an impaired water. We contend that it is not necessary to modify the definition of an exceedance as it may result in difficulties in interpretation and that modification to the magnitude of the criteria is the more appropriate pathway forward.

Chelan PUD has proposed a maximum increase in the 7-DADMax of 1.0°C for Reach 4. We propose an allowable 7-DADMax temperature increase of 1.25°C. Chelan PUD's proposal of an allowable temperature increase of 1.0°C coupled with defining an exceedance as two or more non-overlapping 7-DADMax temperature increases is predicted to result in a water quality exceedance every 500 years based on statistical analyses. This proposal is not adequately stringent when considering the frequency component of temperature criteria, monitoring data, and statistical analyses. Washington's statewide temperature criteria has an allowable exceedance frequency of no more than once every 10 years on average that in turn, provides flexibility and allows for an occasional exceedance during extreme climatic years. Using the standard definition of an exceedance, statistical analyses conducted by Chelan PUD suggests that an allowable 7-DADMax temperature increase of 1.25°C would be exceeded approximately once every 56 years. While this may not align with the temperature criteria frequency of no more than one exceedance every 10 years, monitoring data from 2010-2018 has demonstrated warming up to 1.19°C on dry years (Figure 9). Considering nine years of data is not representative of climatic variation for all foreseeable years, and climate change will likely result in increased warming, we have proposed an allowable 7-DADMax temperature increase of 1.25°C, using the standard definition of an exceedance. While the 1.25°C 7-DADMax temperature increase represents a higher magnitude than the proposed value of 1.0°C by

Chelan PUD, the overall proposed SSC is more stringent because of the decision to use the standard definition of an exceedance.

Dissolved Oxygen: Reaches 1-4

Water temperatures in the Chelan River limit the capacity of oxygen to dissolve in water. When water temperature increases, DO concurrently decreases. The recorded water temperatures on the Chelan River that are naturally influenced by Lake Chelan preclude the attainment of the DO criteria. Therefore, it is necessary to develop SSC for DO to account for high water temperatures. The current DO criteria for Chelan River is 8.0 mg/L.

Chelan PUD has proposed a DO criterion of 8.0 mg/L or 90% oxygen saturation criteria. After reviewing and analyzing the DO data from 2015 at the headwaters of the Chelan River and the Reach 4 habitat channel of the Chelan River, we have decided that an 8.0 mg/L or 90% oxygen saturation criteria is appropriate for Reaches 1-3. Data suggests that as water enters the Chelan River from Lake Chelan, DO levels are depressed compared with DO further downstream (Table 3). Dissolved oxygen gradually increases as water moves downstream from the headwaters of Chelan River to end of the Reach 4 habitat channel (Table 3), suggesting limitations in the DO levels entering the Chelan River. One explanation for the lower DO in water that feeds Chelan River is that water is drawn from the lower part of the water column in the forebay of the dam. Dissolved oxygen generally decreases with water depth due to limited mixing with surface waters that acquire oxygen through diffusion of gaseous oxygen from the atmosphere and biological consumption of DO through respiration.

We found that oxygenation occurs as water moves downstream in the Chelan River, likely attributed to the surface area of the river exposed to gaseous oxygen in the atmosphere and mixing from the Reach 3 canyon and falls. Given this information and the presence of spawning salmonids in Reach 4, we have decided that an 8.0 mg/L or 95% oxygen saturation criteria is appropriate for Reach 4.

Table 3 Dissolved oxygen data from continuous monitoring recorded from 6/26/2015 to 8/20/2015 at the top of Reach 1, top of Reach 4, and end of Reach 4

Dissolved oxygen (mg/L)	Top of Reach 1	Top of Reach 4	End of Reach 4
Mean	8.15	8.41	8.56
10th percentile	7.92	8.22	8.13
90th percentile	8.42	8.97	8.76

Other Applicable Temperature Criteria

The site-specific temperature in Reaches 1-4 is applied when water temperatures at compliance points exceed 17.5°C. When the temperature at the compliance points are below 17.5°C, the site-specific temperature criteria described above will not be in effect, and the applicable temperature criteria will be 17.5°C. Thus, rather than applying the allowed 7-DADMax temperature increase year-round, the statewide applicable criteria of 17.5°C will apply when background temperatures are below 17.5°C. We determined that it is not appropriate to have a temperature allowance of 3.75°C from Reaches 1-3 and 1.25°C in Reach 4 from mid-fall to mid-spring, as would be the case if the SSC were applied year-round. Application of the SSC is not necessary year-round because background temperatures during this time of year are typically lower than 17.5°C. To ensure that Chelan River temperatures are limited to natural fluctuations between mid-fall to mid-spring, we have added a year-round provision to the SSC. The provision requires the Chelan River receive no anthropogenic heat source inputs year-round. This provision limits heat inputs in the Chelan River and only allows river warming to occur when it is due to natural sources of heat (i.e. solar heating).

Summary of the Revisions to Aquatic Life Uses and Site-Specific Criteria

A summary of the revisions that are being considered for aquatic life uses and SSC for the Chelan River can be found in Tables 4 and 5.

Table 4 Current and proposed aquatic life uses for the Chelan River.

Reach	Current Designated Aquatic Life Use1	Proposed Existing Aquatic Life Use2
1 to 3	Salmonid spawning, rearing, and migration	Migration for naturally limited waters
4	Salmonid spawning, rearing, and migration	Salmonid spawning, rearing, and migration for naturally limited waters

[1] Designated uses are those uses specified in water quality standards for each water body whether or not they are being attained
[2] Existing uses are those actually attained in the water body on or after November 28, 1975

Table 5 Proposed site-specific water temperature and dissolved oxygen criteria, duration, and frequency for the Chelan River.

Parameter	Reach	Proposed Water Quality Criteria	Duration	Frequency
Temperature	Reaches 1 to 3	• When temperature is >17.5°C at the end of Reach 3, the maximum allowable increase in temperature is 3.75°C from the dam outlet to end of the canyon in Reach 3	7-day average of the daily maximum increase	Same as statewide criteria
Temperature	Reach 4	• When temperature is >17.5°C at the end of Reach 4 habitat channel, the maximum allowable increase in temperature from the end of the canyon in Reach 3 to the end of the habitat channel in Reach 4 is 1.25°C	7-day average of the daily maximum increase	Same as statewide criteria
Temperature	All Reaches	• **No anthropogenic heat source inputs are allowed downstream of the Lake Chelan Dam outlet to the Chelan River confluence with the Columbia River**	-	-

Parameter	Reach	Proposed Water Quality Criteria	Duration	Frequency
Dissolved Oxygen	Reaches 1 to 3	8.0 mg/L or 90% saturation	1-day minimum	Same as statewide criteria
Dissolved Oxygen	Reach 4	8.0 mg/L or 95% saturation	1-day minimum	Same as statewide criteria

Conclusion

The completion of the actions outlined in the 401 WQC and the Chelan River Plan have led to efforts that have improved conditions for aquatic life and have assisted in the characterization of water quality, habitat, and aquatic life in the Chelan River. The work completed by Chelan PUD within their FERC license provides the foundation to assess the highest attainable aquatic life uses in the Chelan River and to characterize the water quality potential that is influenced by Lake Chelan. The data provided in the Chelan River UAA application is sufficient to demonstrate the highest attainable use in the Chelan River, and justifies SSC for two segments of the Chelan River. The monitoring and evaluation program that Chelan PUD implemented has demonstrated that it is appropriate to revise aquatic life uses that were designated by default to the Chelan River, where such uses were never existing uses based on naturally occurring limitations. The monitoring that Chelan PUD has conducted, and historical information, demonstrates that Lake Chelan strongly influences and limits the water quality potential in the Chelan River, thereby providing the basis for SSC.

We agree with the 40 CFR 131.10(g) factors presented in the Chelan UAA submittal to justify a UAA for two different segments of the Chelan River based on their unique geological and hydrological characteristics. We are proposing modifications to the SSC that was provided by Chelan PUD in their application. These modifications provide more clarity to the application of the SSC, while considering the unique hydrological regime of the Chelan River, and provide a seasonality aspect to water conditions.

References

BioAnalysts. 2000. *Historical occurrence of anadromous salmonids in Lake Chelan, Washington*. Prepared for Public Utility District No. 1 of Chelan County, Wenatchee, Washington. September 26, 2000.

Chelan PUD (Public Utility District No. 1 of Chelan County). 2000. Bypass reach (gorge) flow releases study report. Lake Chelan Hydroelectric Project, FERC Project No. 637, Final Report. Prepared by R2 Resource Consultants, Redmond, Washington and Ichthyological Associates, Inc., Lansing, New York for Public Utility District No. 1 of Chelan County, Wenatchee, Washington.

Chelan PUD (Public Utility District No. 1 of Chelan County). 2003. Lake Chelan Hydroelectric Project Comprehensive Settlement Agreement, Final, Lake Chelan Hydroelectric Project, FERC Project No. 637.

Chelan PUD (Public Utility District No. 1 of Chelan County). 2005. Outlet structure for bypassed reach flows: water temperature profile study results for pre-design information. Lake Chelan Hydroelectric Project FERC Project No. 637. June 6, 2005. Available at: http://www.chelanpud.org/departments/licensing Compliance/lc_implementation/ ResourceDocuments/8768_1.pdf.

Chelan PUD (Public Utility District No. 1 of Chelan County). 2011-2019. Lake Chelan Annual Flow and Temperature Reports 2010 – 2018, License Articles 405 & 408. Lake Chelan Hydroelectric Project. FERC Project No. 637.

Chelan PUD (Public Utility District No. 1 of Chelan County). 2017. Chelan River Biological Objectives 2017 Status Report. Lake Chelan Hydroelectric Project. FERC Project No. 637. April 25, 2017.

Chelan PUD (Public Utility District No. 1 of Chelan County). 2019. Final 2019 Biological Objectives Status Report. Lake Chelan Hydroelectric Project. FERC Project No. 637. April 30, 2019.

Ecology (Washington Department of Ecology). 1997. *Water Quality in the Wapato Basin of Lake Chelan, Summer 1996*. Washington Department of Ecology Report #97-323, August.

Ecology (Washington State Department of Ecology). 2018. Water Quality Program Policy 1-11, Chapter 1, Washington's Water Quality Assessment Listing Methodology to Meet Clean Water Act Requirements, Ecology Publication No. 18-10-25, Olympia, WA. October. Available at: https://fortress.wa.gov/ecy/publications/SummaryPages/1810035.html

Ecology (Washington State Department of Ecology). 2004. 401 Certification Order No. 1233, Lake Chelan Hydroelectric Project, FERC Project No. 637, Washington Department of Ecology, Yakima, Washington. June 1.

Herrera (Herrera Environmental Consultants, Inc.). 2015. *Chelan River Riparian Revegetation Feasibility Assessment (Chelan County, Washington).* Prepared for Chelan County Public Utility District, Wenatchee, Washington. June 18, 2015.

Jacobsen R, Nott J, Brown E, Weeber M, Lewis M, Hughes E. 2013. Assessment of western Oregon adult winter steelhead – 90ed surveys 2013. Monitoring Program Report Number OPSW-ODFW-2013-09. Oregon Department of Fish and Wildlife, Salem, Oregon.

Kendra W, Singleton L. 1987. *Morphometry of Lake Chelan*. Water Quality Investigations Section, Washington Department of Ecology Report No. 87-1, Olympia, Washington. January.

Mugunthan P, Miller J, Stachura M. 2019. Prepared for Public Utility District No. 1 of Chelan County. Prepared by Four Peaks Environmental Science & Data Solutions. Wenatchee, WA. December.

PCHB No. 03-075, Pollution Control Hearings Board. 2004. Confederated Tribes of the Umatilla Indian Reservation and The Columbia River Inter-Tribal Fish Commission v. Department of Ecology, Public Utility District No. 1 of Chelan County,

R2 and IA (R2 Resource Consultants, and Ichthyological Associates, Inc.). 2000. *Bypass reach (gorge) flow releases study report (final).* Lake Chelan Hydroelectric Project, FERC Project No. 637. Report prepared for Public Utility District No. 1 of Chelan County, Wenatchee, Washington.

Snow C, Frady C, Grundy D, Goodman B, Haukenes A. 2018. Monitoring and evaluation of the Wells Hatchery and Methow Hatchery programs: 2017 annual reports. Report to Douglas PUD, Grant PUD, Chelan PUD, and the Wells and Rocky Reach HCP Hatchery Committees, and the Priest Rapids Hatchery Subcommittees, East Wenatchee, Washington.

Stillwater Sciences, 2001. *Conceptual Alternative for Chelan River Restoration, Final Report*. Prepared for Lake Chelan Caucus and Chelan County Public Utility District No. 1. June 2001.

Van der Broek K, Pfleeger A, Pandit S, Bollman W. 2018. *Macroinvertebrate investigation, Chelan River (final report)*. Prepared by Terraqua, Inc. for Public Utility District #1 of Chelan County.

WEST Consultants. 2016. *Chelan River temperature model calibration and initial results, final.* Prepared by WEST Consultants, Inc, for the Public Utility District No. 1 of Chelan County, Washington. June 1, 2016.