FINAL November 1, 2022

BASELINE CONDITIONS REPORT

Baseline Conditions for the Trinity River Contract Water Management Plan

Trinity River (Photo from United States Bureau of Reclamation)

Prepared for:	Humboldt County
Prepared by:	Stantec Consulting Services Inc.
Project Number:	Trinity River Contract Water Management Plan Project no. 251008

Executive Summary

Humboldt County has a contractual right to annual water releases of not less than 50,000 acre-feet from the Trinity Reservoir for the beneficial use of Humboldt County and other downstream users (Contract Water). This contractual right was authorized by Congress in 1955 through the Trinity River Division Act and confirmed in a 1959 water contract signed by Humboldt County and the US Bureau of Reclamation. However, despite numerous attempts to call on Contract Water over the past several decades, Contract Water has never been released for the beneficial use of Humboldt County or other downstream users.

Humboldt County is developing a Water Management Plan that will describe a range of proposed annual Contract Water release scenarios with sufficient detail that the US Bureau of Reclamation can conduct an analysis and determine what additional actions may be required to make Humboldt County's water contract operational. The Water Management Plan will also include a framework for annual decision-making and will describe the legal and compliance steps necessary to implement the proposed releases.

The annual Contract Water release scenarios will be structured to benefit fisheries in the Trinity River and lower Klamath River, with the goal of expanding a harvestable surplus of Tribal, recreational, and commercial fisheries that exceeds the legal obligations associated with Proviso 1 of the Trinity River Division Act, Tribal Trust, and other laws. To assess whether this goal can be achieved, a suite of modeling and technical tools will be used to analyze annual conditions with and without Contract Water releases. Humboldt County will use an iterative and collaborative workshop process to develop preliminary release scenarios, analyze their efficacy, create a set of preferred release scenarios, and build all elements of the Water Management Plan necessary to define the preferred course of action.

This Baseline Conditions Report provides the necessary background, context, and supporting information to fully define how Contract Water release scenarios will be developed and evaluated. The focus of this report is on baseline conditions, or the current operational, regulatory, hydrologic, hydraulic, stream temperature, habitat, and fish production information for the Trinity River and Trinity Reservoir. The report concludes with further definition of potential Contract Water release scenarios and a description of how baseline conditions will be represented in the modeling and analytical tools that will be used to evaluate Contract Water release scenarios.

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Individuals
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Acronyms / Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
1-D	one-dimensional
2-D	two-dimensional
7DADA	7-day average of the daily average
AEAM	Adaptive Environmental Assessment and Management
Basin Plan	Water Quality Control Plan for the North Coast Region
BIA	U.S. Bureau of Indian Affairs
BO	Biological Opinion
BTU	British thermal unit
CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
cm	centimeter
CMIP3	Coupled Model Intercomparison Project Phase 3
COA	Coordinated Operating Agreement
Columnaris	*Flavobacter columnare*
Commission	California Fish and Game Commission
County	Humboldt County
CVP	Central Valley Project
CWRP	California Water Resilience Portfolio
DEM	digital elevation model
DO	dissolved oxygen
DOI	U.S. Department of the Interior
DSS	decision support system
DWR	California Department of Water Resources
EA	Environmental Assessment
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FAR	flow augmentation release
FERC	Federal Energy Regulatory Commission
FNF	full natural flow
GCM	global climate model
HDAT	Hoopa daily accumulated temperature model
HVT	Hoopa Valley Tribe
Ich	*Ichthyophthirius multifiliis*
ITP	incidental take permit
KMP	Klamath Mountains Province
KRFC	Klamath River fall-run Chinook Salmon
KRSC	Klamath River spring-run Chinook Salmon
kW	kilowatt
LTO	Coordinated Long-Term Operation of the Central Valley Project and State Water Project

LTP	Long-Term Plan for Protecting Late-Summer Adult Salmon in the Lower Klamath River
MAF	million acre-feet
mg/l	milligrams per liter
msl	mean sea level
MW	megawatt
NEPA	National Environmental Policy Act
NCRWQCB	North Coast Regional Water Quality Control Board
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OCAP	Operations Criteria and Plan
PL	Public Law
PL 84-386	Public Law 84-386
PFMC	Pacific Fishery Management Council
RBM10	River Basin Model 10
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
ReROC	Re-initiation of Consultation on the Long-Term Operation of the Central Valley Project and State Water Project
RM	river mile
ROC on LTO	Re-initiation of Consultation on the Coordinated Long-Term Modified Operations of the Central Valley Project and State Water Project
ROD	Record of Decision
RPA	Reasonable and Prudent Alternative
S3	Stream Salmonid Simulator
SALMOD	Salmonid Population Model
SONCC	Southern Oregon/Northern California Coast
SRH-2D	Sedimentation and River Hydraulics model
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TFH	Trinity Fish Hatchery
TMC	Trinity Management Council
TMDL	total maximum daily load
TRD	Trinity River Division
TRFES	Trinity River Flow Evaluation Study
TRRP	Trinity River Restoration Program
UKTR	Upper Klamath and Trinity Rivers
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VIC	Variable Infiltration Capacity
WCB	Wildlife Conservation Board
YTFP	Yurok Tribal Fisheries Program

1 INTRODUCTION

In 1949, the United States Department of Interior, Bureau of Reclamation (Reclamation) released preliminary plans to develop water infrastructure on the Trinity River in northern California as part of the Central Valley Project (CVP). The CVP is a large-scale water control and delivery system composed of dams, reservoirs, power plants, pumping plants, canals, aqueducts, and related facilities that distributes water to nearly 200 water service contractors throughout the Central Valley of California. The Trinity River Division (TRD) was envisioned as a project that could divert significant volumes of water from the Trinity River into the Sacramento River basin, making it available for delivery to Reclamation's CVP contractors.

In 1955, the US Congress authorized the TRD (1955 Act) as Public Law 84-386 (PL 84-386). Construction was complete in the early 1960's, and operation of the TRD commenced in 1963. The primary storage reservoir for the TRD is Trinity Lake (originally named Claire Engle Lake but renamed in 1997), formed by Trinity Dam, with a capacity of 2.4 million acre-feet (MAF). Trinity Dam discharges into Lewiston Lake (also known as Lewiston Reservoir), a regulating reservoir formed by Lewiston Dam approximately seven miles downstream. Lewiston Dam is the point of diversion from which water can be diverted to the Sacramento River Basin through a tunnel/penstock system into Whiskeytown Reservoir or released through the dam into Trinity River.

Congress authorized the TRD as an integrated component of the CVP to increase water supplies for irrigation and other beneficial uses in the Central Valley. Section 1 of the 1955 Act provided for the construction, operation, and maintenance of the TRD. Section 2 of the 1955 Act included two provisos that limit the integration of the TRD into the CVP. Proviso 1 directed the Secretary of the Interior to adopt appropriate measures to ensure the preservation and propagation of fish and wildlife, including certain minimum flows then deemed necessary in the Trinity River for the fishery. Proviso 2 specified that "not less than 50,000 acre-feet shall be released annually from the Trinity Reservoir and made available to Humboldt County and downstream water users". A contractual right for Proviso 2 was established in a water delivery contract executed between the United States Department of the Interior (DOI), Reclamation, and Humboldt County on June 19, 1959 (1959 Water Contract). Humboldt County's contractual right was also incorporated into Reclamation's eight 1959 water rights permits for storage and diversion of the Trinity River issued by the predecessor of the California State Water Resources Control Board.

Annual releases to the Trinity River from the TRD authorized by Proviso 2 of the 1955 Act and ratified under the 1959 Water Contract are referenced herein as Contract Water. There are currently no releases of Contract Water from Trinity Reservoir. Since early 2000, several unsuccessful attempts at making a water call for Contract Water have been made. In 2018, a draft Contract Water release scenario[1] was developed and shared with Reclamation. In subsequent conversations, Reclamation requested more detailed information regarding the purpose and proposed use of water in order to address questions regarding water rights and regulatory compliance.

In 2020, Humboldt County (County) applied for and received a Wildlife Conservation Board (WCB) Stream Flow Enhancement Program grant (WCB Grant No. WC-2157AB). The County proposed to use grant funding to solicit input from local interested parties, perform technical analysis and modeling, and develop a Water Management Plan that describes annual releases of

[1] When used in this report, release scenario refers to a specific release pattern that may vary by month or by year based on pre-determined decision criteria.

not less than 50,000 acre-feet of Contract Water from Trinity Reservoir into the Trinity River. The County has proposed initializing Contract Water releases for a non-consumptive use that benefits fish, habitat, and water quality while not precluding future consumptive uses. The primary goal of releases would be to expand a harvestable surplus for tribal, recreational, and commercial fisheries, exceeding Reclamation's obligations under Proviso 1. To maximize the instream benefit of Contract Water releases, the County will identify the optimal timing, duration, and volume of additional flows to further increase and enhance fish populations and structure annual Contract Water releases accordingly. The Water Management Plan will include decision criteria to guide annual decision-making around the type of release to be made and an environmental compliance strategy necessary for implementation. The Water Management Plan is intended to define a proposed action for Reclamation that will be used to support future environmental review and consultation, as applicable.

This baseline conditions report is the first in a series of technical documents that will form the basis of the Water Management Plan, to be finalized in 2023. This report is organized into four main sections that together document the baseline conditions of the TRD and the data, assumptions, and modeling efforts needed to evaluate and develop the Water Management Plan:

- **Chapter 2. Planning Background:** provides an overview of existing TRD facilities and operations, a summary of the water rights and regulatory compliance needs, a brief history of related plans and proposals, and the framework for advancing the Water Management Plan.

- **Chapter 3. Environmental Setting:** synthesizes existing data and studies that document the hydrologic, geomorphic, water quality, and biological conditions of the Trinity River below Trinity Lake.

- **Chapter 4. Contract Water Release Considerations:** outlines major considerations for how Contract Water could be released to achieve stated objectives.

- **Chapter 5. Baseline Conditions for Modeling Analysis:** summarizes the modeling approach for the project, and documents the baseline hydrologic, climate change, and regulatory conditions that will be assumed in the technical analysis.

2 PLANNING BACKGROUND

This section provides background information on facilities, operations, and regulatory topics that will inform the planning process for releases of Contract Water. The section ends with an overview of the framework proposed for developing a Water Management Plan for Contract Water.

2.1 Location and Facilities

The Trinity River originates in the northeast corner of the Trinity River watershed and flows in a south to southwesterly direction over 60 miles before entering Trinity Lake, and later Lewiston Reservoir (Figure 2-1). The total drainage area above Lewiston Dam is 717 square miles. The Trinity River flows approximately 112 miles downstream from Lewiston Dam (81 miles through Trinity County, then 31 miles through Humboldt County) until it reaches the confluence with the Klamath River at Weitchpec. The Trinity River is the largest tributary to the Klamath River, with a drainage area of nearly 3,000 square miles. The Klamath River flows through Humboldt County for approximately 60 river miles before discharging to the ocean in Del Norte County. The Hoopa Valley Tribe (HVT) has a reservation along the Trinity River, including the confluence with the Klamath River, situated within Humboldt County. The Yurok Tribe has a reservation along the lower Klamath River situated within Humboldt and Del Norte Counties.

Trinity Dam, Lake, and Powerplant, Lewiston Dam, Lake, and Powerplant, the Trinity River Hatchery, and a portion of the Clear Creek Tunnel are located on the Trinity River within Trinity County and the Trinity River watershed. The remaining TRD facilities – the downstream portion of Clear Creek Tunnel, Judge Francis Carr Powerhouse, Whiskeytown Dam and Lake, Clear Creek Powerhouse, and Spring Creek Tunnel, Dam, Reservoir, and Powerhouse – are in Shasta County and contribute flow to the Sacramento River.

Trinity Dam is a 538-foot high earthfill structure that forms Trinity Lake, a storage reservoir with total capacity of 2.4 MAF. The dam crest is at elevation 2,395 feet with a design maximum water surface elevation of 2,388.2 feet. The outlet works that release water downstream consist of three intakes within the reservoir (Wahl and Cohen 1999):

- A controlled outlet works intake at elevation 2,100 feet with a flow capacity of 7,000 cubic feet per second (cfs). The outlet works intake can deliver flows to the powerhouse, which contains two 70-megawatt (MW) hydropower turbines each with a rated discharge of 2,300 cfs, or to the river outlet works control house, which contains two hollow-jet valves that can discharge up to 7,000 cfs downstream.

- A controlled auxiliary outlet works intake at elevation 1,995.5 feet that can discharge up to 2,490 cfs into the spillway tunnel. Water released through the auxiliary outlet works has been used to access cold water for release into Trinity River when reservoir levels have been low.

- An uncontrolled glory hole spillway at elevation 2,370 feet with a design discharge of 22,400 cfs.

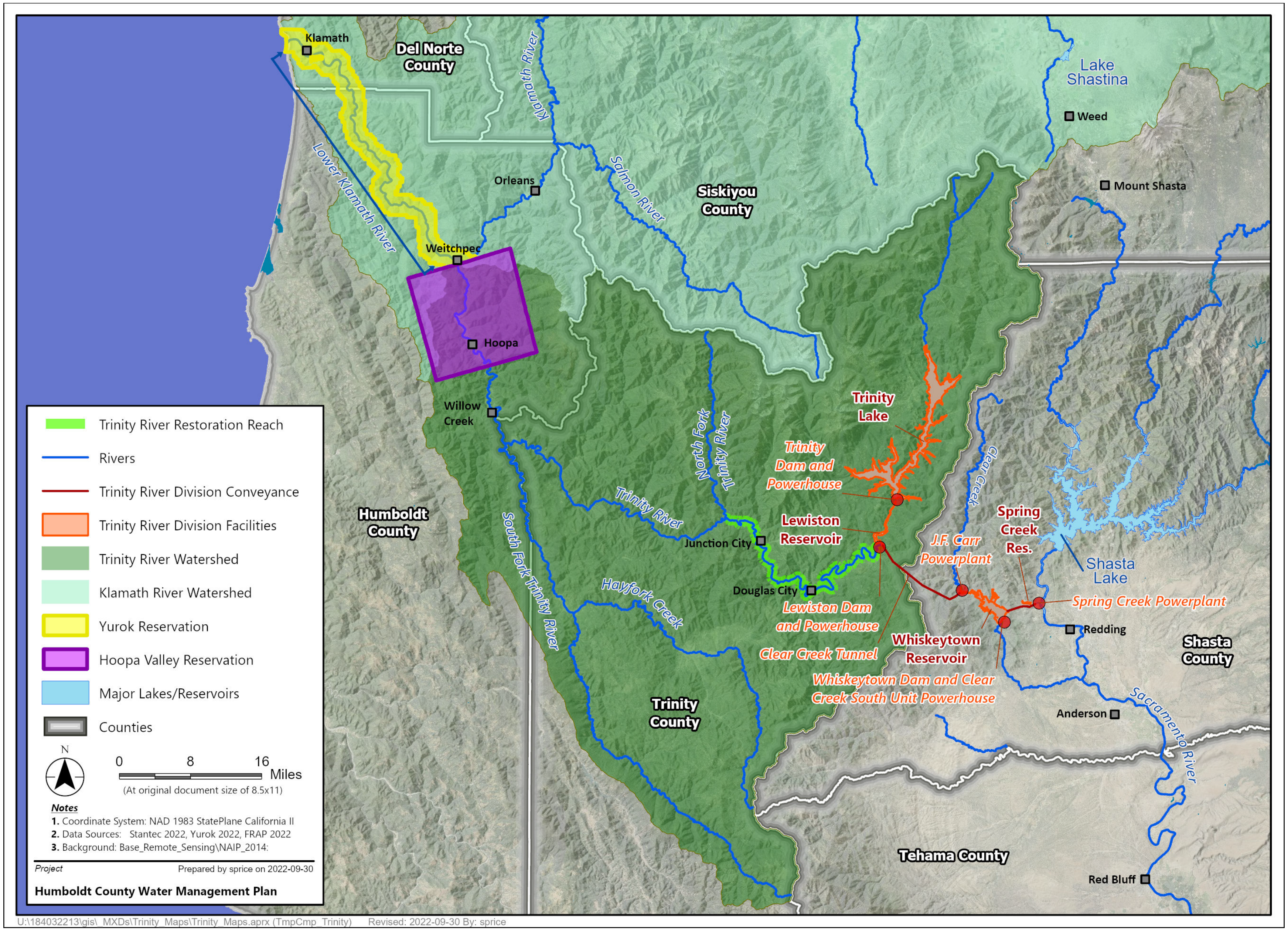


Figure 2-1. Major Facilities, Features, and Boundaries Associated with the Trinity River Division

Lewiston Dam is a 91-foot tall earthfill structure that forms Lewiston Lake, a regulating reservoir with total storage capacity of 14.7 thousand acre-feet (TAF). Lewiston Dam is located about 8 miles downstream from Trinity Dam, creating an afterbay to Trinity Powerplant that regulates releases from Trinity Dam into the Trinity River. Water is released from Lewiston Lake at four locations (Reclamation 2012):

- The controlled Clear Creek Tunnel intake at elevation 1,887 feet enables cross-basin transfers, diverting flows of up to 3,200 cfs through Clear Creek Tunnel to Whiskeytown Lake.

- The controlled fish hatchery intake at elevation 1,883 feet supplies up to 150 cfs to the Trinity River Hatchery, a facility operated by the California Department of Fish and Wildlife (CDFW), under agreement with Reclamation, to produce steelhead (Oncorhynchus mykiss), Coho Salmon (O. kisutch), and Chinook Salmon (O. tshawytscha).

- A controlled intake to Lewiston Powerplant at elevation 1,842 feet flow capacity of 325 cfs. The powerplant has a single turbine rated at 350 kilowatts (kW) for a rated flow discharge capacity of 325 cfs.

- A spillway at elevation 1,875 feet controlled by radial gates to release up to 30,000 cfs.

The Trinity River supports many different biological resources, as described further in Section 3.4. Water management for fisheries on the Trinity River system is primarily focused on anadromous salmonids, mainly steelhead, Coho Salmon, and Chinook Salmon. Currently, steelhead and Chinook Salmon comprise the commercial, tribal, and sport fisheries of the region. These fish species are anadromous, meaning adults migrate from the ocean upstream into freshwater habitat to spawn. Lewiston Dam is the first major impediment to upstream fish passage on the Trinity River, and releases from Trinity and Lewiston Dams are used to support the freshwater life phases of these species.

2.2 Operations

Water captured and stored in Trinity Lake is currently managed for flood control, hydropower generation, irrigation in the Central Valley, recreation, fisheries, environmental purposes, and tribal purposes. Water management is subject to constraints from dam and power generation infrastructure and Safety of Dams criteria (Buxton 2021a).

2.2.1 Flow Regime History

Since the beginning of the available period of record in 1911, four distinct flow regimes have been documented in the Trinity River near Lewiston (Figure 2-2):

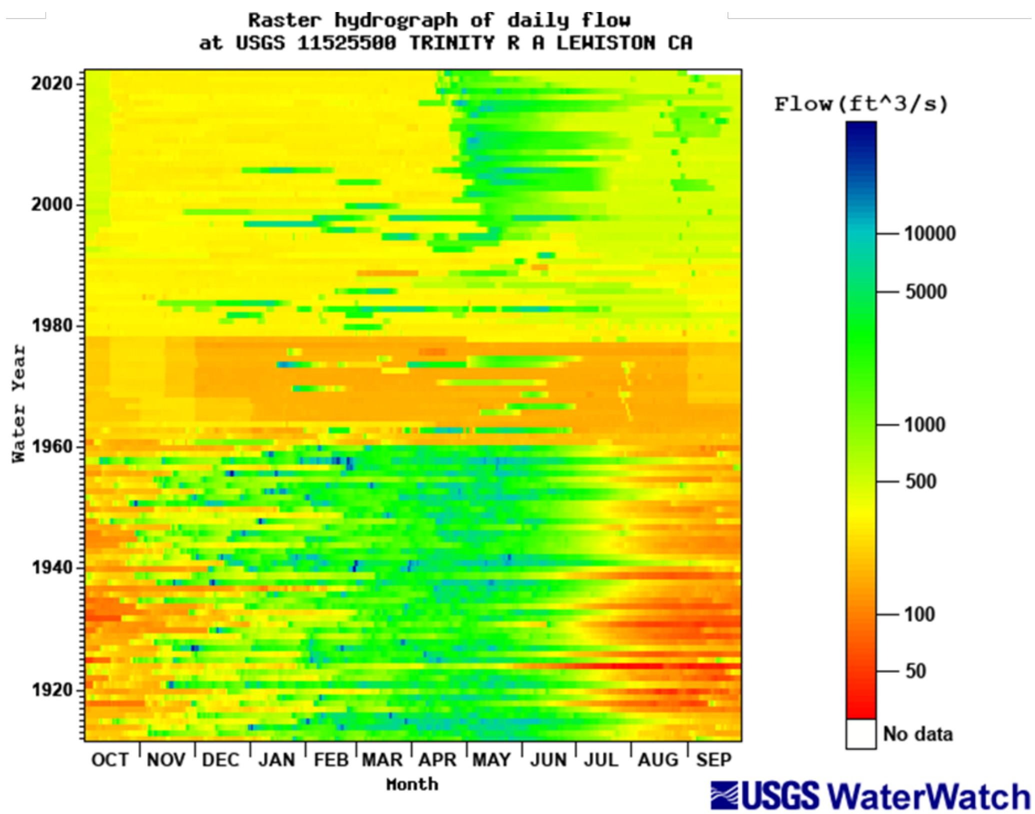
- From 1911 through 1960, Trinity River was a natural alluvial river with a highly variable flow regime, including low summer base flows, rising winter baseflows with intermittent high magnitude winter peak flows, and sustained high magnitude flows during spring snowmelt that rapidly receded back to low summer baseflows.

- From the early 1960s when the TRD became operational until the late 1970s, the TRD was operated primarily to export flow to the Sacramento River. For the first ten years of operation, the TRD diverted nearly 90 percent of Trinity River inflows to the Central

Valley. Until 1974, Reclamation operated the TRD to release a minimum of 150 cfs to 250 cfs into the Trinity River consistent with applicable water rights (USFWS and HVT 1999).

- A decision by the Secretary of Interior in 1981 increased annual instream flow releases based on water year type and directed the U.S. Fish and Wildlife Service (USFWS) to conduct the Trinity River Flow Evaluation. Relatively higher flow volumes were released until the Trinity River Restoration Program (TRRP) completed the infrastructure improvements (e.g., bridges, diversions) necessary to implement higher flows in 2006.

- After nearly 20 years of studies of the Trinity River and its fishery resources, USFWS and the HVT completed the final environmental impact statement (EIS) for the Trinity River Mainstem Flow Evaluation and issued a record of decision (ROD) in 2000 that established the framework for Reclamation's TRRP. Among other restoration actions, the ROD defined five water year types and established annual release volumes ranging from 368 TAF to 816 TAF (Table 2-1), with specific daily flow patterns based on water year type (Figure 2-3). These flows are referred to as ROD flows or restoration releases.



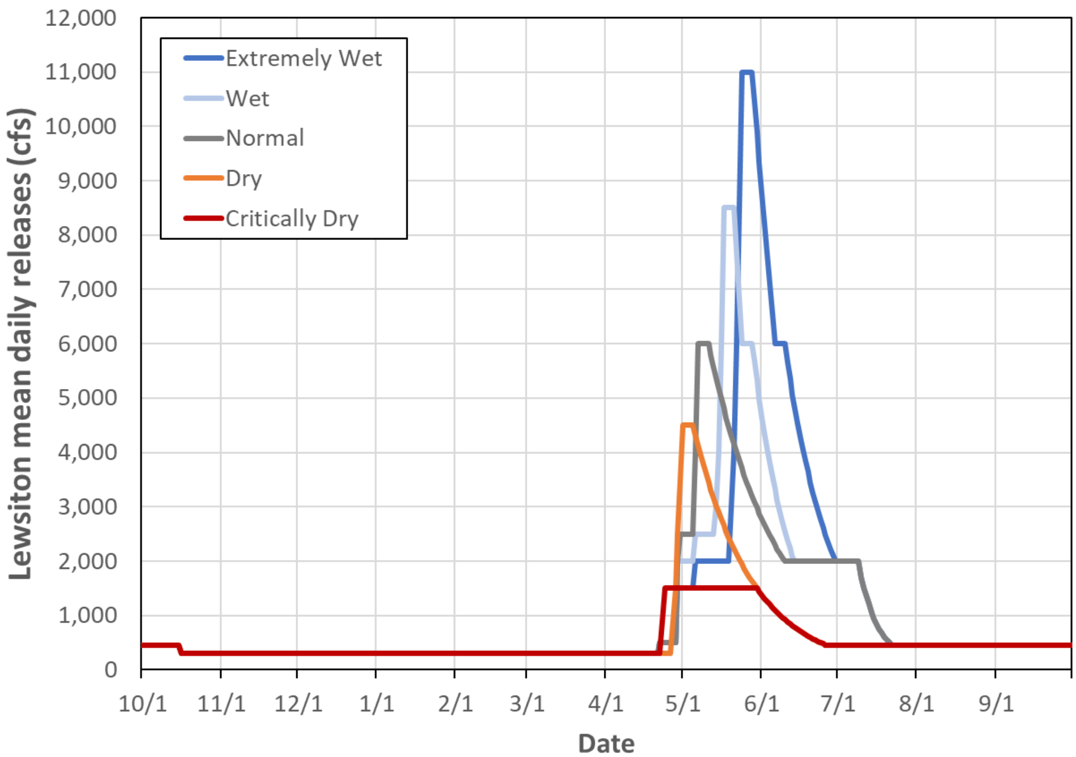
Key:
ft = feet
s = second
Trinity R A Lewiston CA = Trinity River at Lewiston California
USGS = United States Geologic Survey

Figure 2-2. Raster Hydrograph of Daily Flow from 1911 to 2022 at United States Geologic Survey Gate 11525500, Trinity River at Lewiston, California

Table 2-1. Recommended Annual Trinity River Release Volumes (USDOI 2000)

Water Year Type	Projected Full Natural Flow[1] at Lewiston Reservoir (thousand acre-feet)	Restoration Release (thousand acre-feet)
Extremely Wet	>2,000	815.2
Wet	1,350 – 2,000	701.0
Normal	1,025 – 1,350	646.9
Dry	650-1,025	452.6
Critically Dry	<650	368.6

[1] This projection is published annually by the California Department of Water Resources in its April 1st Bulletin 120 report. The full natural flow is the volume of water that would have passed Lewiston in a water year had Trinity and Lewiston Dams and the Clear Creek tunnel and other flow diversions not been in place.



Key: cfs = cubic feet per second

Figure 2-3. Mean Daily Restoration Releases from Lewiston by Water Year Type (USDOI 2000)

2.2.2 Releases, Exports, and Storage

Since the start of the TRRP and ROD flows, around half of the average annual Trinity River inflow is exported through Clear Creek Tunnel for irrigation in the Central Valley and to meet multiple objectives along the way. The amounts and timing of exports are determined by subtracting scheduled flows (described below) and targeted carryover storage from the forecasted Trinity River water supply. The remainder of inflows are stored or released for other purposes in the Trinity River and downstream. Five main categories comprise flow releases into the Trinity River:

- Scheduled releases to promote fishery resources and restore a healthy river ecosystem, as outlined in the TRRP ROD (USDOI 2000). These releases are referred to as restoration releases or ROD flows. Annual water volumes allocated for restoration releases vary by water year type with the forecasted full natural flow (FNF) volume at Lewiston (Table 2 1). Recommended daily releases by water year type are shown in Figure 2-3. As discussed in Section 4.3, daily releases are modified in some years to better meet TRRP objectives (annual release volumes remained unchanged).

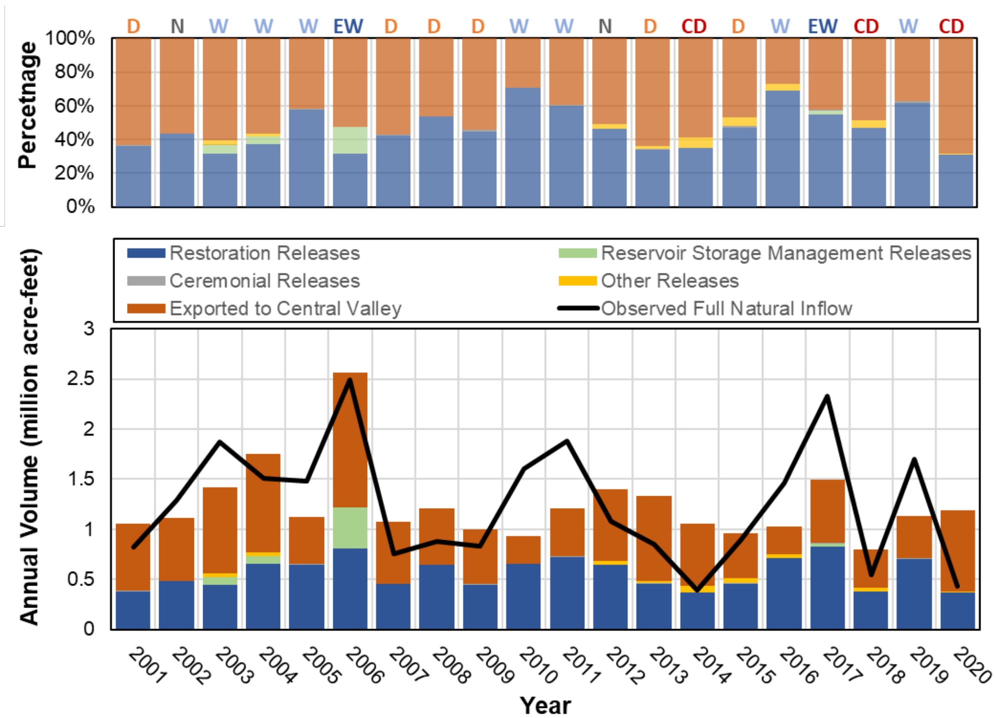
- Releases for reservoir storage management to protect the safety of Trinity and Lewiston Dams. These releases are typically implemented with short notice in winter or early spring and are designed to draw down a full or nearly full reservoir for public safety and to safeguard infrastructure from overtopping damage.

- Bi-annual releases in later August or early September of odd-numbered years to increase river depth and support the Yurok Tribe's ancient Boat Dance ceremonial event. Flows typically ramp up over one week to reach a peak of 2,000 to 3,000 cfs for a day or two, then ramp back down again to summer baseflows as prescribed in the ROD.

- Other releases in mid-August to late September to supplement flows in the lower Klamath River and prevent the large-scale die-off of adult salmon due to disease pathogens that generally develop during low flows, large run sizes, and warm water temperatures. These flows were assessed in the Long-Term Plan for Protecting Late-Summer Adult Salmon in the Lower Klamath River Environmental Impact Statement (Klamath LTP EIS) (Reclamation 2017) and codified in a 2017 ROD developed by Reclamation. Three flow augmentations may occur based on flow and biological conditions: a preventive baseflow release that helps meet a target flow of 2,800 cfs in the lower Klamath River, a preventive one-day pulse flow of 5,000 cfs, or an emergency five-day pulse flow of 5,000 cfs.

- Emergency flow releases may be used to meet Trinity River water temperature objectives and due to unforeseen operational issues associated with dam and other infrastructure.

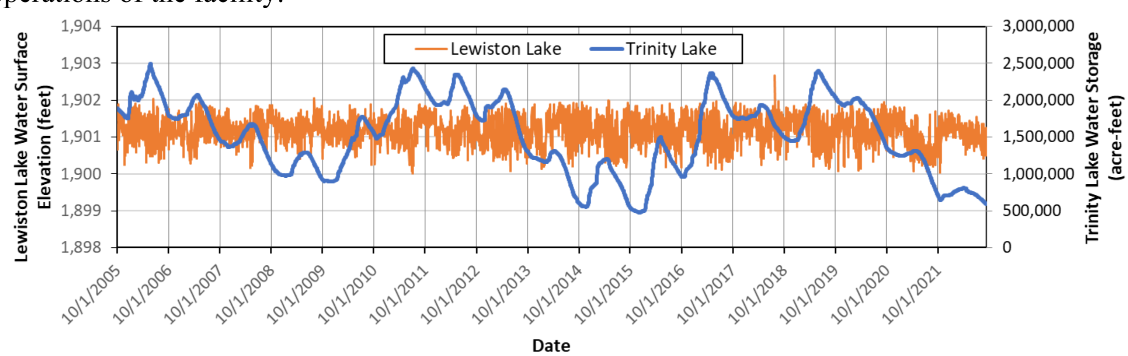
A timeseries of annual release types and exports from 2001 to 2020 shows that TRD operations are comprised primarily of restoration releases and exports to the Central Valley (Figure 2-4). The relative percentage of flow released to the Trinity River is generally greater in wetter years, while the relative percentage of flow diverted to the Central Valley is generally greater in drier years. Since 2012, other releases to the Trinity River have become more frequent.



Key: EW = Extremely Wet, W = Wet, N = Normal, D = Dry, CD = Critically Dry
Data source: Buxton 2021a

Figure 2-4. Annual Percentages (top) and Volumes (bottom) of Water Exported or Released from Lewiston from 2001 to 2020

The variability in inflows, water year type releases, exports, and carryover storage results in an annual and inter-annual variable storage level in Trinity Lake (Figure 2-5). The difference between minimum and maximum annual storage typically spans a range of 500,000 to 700,000 acre-feet, while total storage has ranged between 500,000 acre-feet and 2,500,000 acre-feet over the past twenty years. Despite the variability in Trinity Lake, Lewiston Lake water surface elevations (and storage) remain relatively constant, within a range of 2 feet, due to the regulating operations of the facility.



Data source: California Data Exchange Center (CDEC), Stations LEW (Lewiston Lake) and CLE (Trinity Lake).

Figure 2-5. Daily storage in Trinity Lake and Daily water surface elevation in Lewiston Lake.

Releases from Trinity Lake are also timed to meet daily average temperature objectives or targets in the Trinity River, which vary by reach and season (Table 2-2). Spring (April 15-July 15) temperature targets were established by the 2000 ROD (USDOI 2000), and these vary by water year type. Temperature targets from July through December were established by the North Coast Regional Water Quality Control Board Basin Plan (NCRWQCB 2011) and the State Water Resources Control Board (State Water Board) Order WR-90-52 (SWRCB 1990), independent of water year type. Water temperature targets specified at Douglas City and the confluence with North Fork Trinity River help provide suitable conditions for adult salmon upstream migration and holding in the mainstem channel (Buxton 2021a). Daily average temperature criteria specified for the Trinity River at Weitchpec aid juvenile salmonids in their downstream migration to the Klamath River (USFWS and HVT 1999). Exports from Lewiston also support compliance with daily water temperature objectives on Clear Creek and the Sacramento River.

Table 2-2. Trinity River Daily Average Temperature Objectives and Targets

<table>
<tr><th>Reach</th><th>Dates</th><th>Water Year Type</th><th>Target Temperature</th></tr>
<tr><td rowspan="2">Lewiston to Douglas City[1]</td><td>July 1 – September 14</td><td rowspan="2">All Types</td><td>≤ 60 °F (15.5 °C)</td></tr>
<tr><td>September 15 – October 1</td><td>≤ 56 °F (13.3 °C)</td></tr>
<tr><td>Lewiston to confluence of North Fork Trinity River[1]</td><td>October 1 – December 31</td><td>All Types</td><td>≤ 56 °F (13.3 °C)</td></tr>
<tr><td rowspan="6">Lewiston to Weitchpec[2]</td><td>April 15 – May 22</td><td rowspan="3">Normal, Wet, Extremely Wet</td><td>≤ 55 °F (12.8 °C)</td></tr>
<tr><td>May 23 – June 4</td><td>≤ 59 °F (15 °C)</td></tr>
<tr><td>June 5 – July 9</td><td>≤ 62.5 °F (17 °C)</td></tr>
<tr><td>April 15 – May 22</td><td rowspan="3">Dry, Critically Dry</td><td>≤ 59 °F (15 °C)</td></tr>
<tr><td>May 23 – June 4</td><td>≤ 62.5 °F (17 °C)</td></tr>
<tr><td>June 5 – July 15</td><td>≤ 68 °F (20 °C)</td></tr>
</table>

Key: °F = degrees Fahrenheit, °C = degrees Celsius

Notes: 1 North Coast Regional Water Quality Control Board Basin Plan (NCRWQCB 2011). 2 USDOI 2000

2.2.3 Operational Constraints

Planned releases at Trinity Dam are made through the powerplant, the river outlet works, the auxiliary outlet works, and the uncontrolled morning glory spillway, but not necessarily in combination with one another (Wahl and Cohen 1999). Each possible outlet serves specific operational purposes, e.g., power production, scheduled restoration releases, reservoir evacuation during an emergency, and protection of the dam during flood events. The outlet works were likely sized to meet emergency reservoir evacuation criteria and analyzed for separate operation because operability of the powerplant could not be assumed during an emergency. Similarly, the powerplant was designed for separate operation, since combined operation of the powerplant and the river outlet works would lead to reduced power output due to additional head loss in the penstocks.

A total controlled release of 10,900 cfs is possible from Trinity Dam using the auxiliary outlet works and the main outlet works while bypassing the powerhouse (Reclamation 2000). This is approximately the maximum restoration flow rate of 11,000 cfs, which at present can be safely implemented without detrimental downstream impacts, depending on accretion flows from Trinity River tributaries at the time of release. Lewiston Dam regulates the releases of Trinity Dam into Trinity River, with a design rate of fluctuation between 1898 feet and 1902 feet above mean sea level (msl). Lewiston Dam can release approximately 30,000 cfs at a reservoir elevation of 1902 feet above msl, greatly exceeding the maximum restoration flow of 11,000 cfs.

Reclamation established operating criteria for Trinity Dam in 1976 to reduce the probability of catastrophic dam failure during the flood risk season (Reclamation 2000). The elevation of

Trinity Lake is managed to meet the operation rule curve to minimize the chance of a large inflow resulting from a large storm event, or series of events, filling the reservoir and overtopping the dam. Release criteria generally provide for maximum storage in Trinity Lake of 2.1 MAF between November and March. Initial flood releases are discharged from Trinity Lake into Lewiston Reservoir, and then, through the powerplant and into Whiskeytown Lake in the Clear Creek watershed. To reduce the potential for flooding on the Trinity River, releases into the Trinity River generally are less than 11,000 cfs from Lewiston Dam (under Safety of Dams criteria) due to local high water concerns in the floodplain and local bridge flow capacities downstream.

2.2.4 Recent Release Studies

Two recent studies assessed potential modifications or augmentations to restoration releases but did not result in any release changes. These are summarized below and described elsewhere in the report:

- In 2018, as a predecessor to this project, Humboldt County submitted a request to USFWS and National Marine Fisheries Service (NMFS) for technical assistance in analyzing the benefits of a release of 50,000 acre-feet of Proviso 2 water (USFWS and NOAA 2018). The release would provide variable winter flows during the approximately six week Chinook Salmon juvenile rearing period. A technical memorandum was developed summarizing the release pattern development, methods, and results (see Section 4.4.1).

- In 2022, the TRRP office issued the Winter Flow Project Report (TRRP and Reclamation 2022), which provided the history, scientific rationale, and anticipated outcomes of a proposal to shift a portion of the ROD water volume used for restoration releases in the spring to the winter period to improve anadromous fish habitat conditions along the Restoration Reach (see Section 4.4.2)

2.3 Regulatory Environment and Compliance Requirements

This section summarizes the existing regulations, plans, acts, and programs that define the regulatory environment in which Contract Water release scenarios are being developed.

2.3.1 1959 Water Contract

In the years leading up to passage of the 1955 Act, the Humboldt County Board of Supervisors opposed diversion of the Trinity River unless provisions were made to address the County's water needs (e.g., Board Resolutions 430 and 827). Humboldt County's water interests were incorporated into Section 2, Proviso 2 of PL 84-386, which qualified the integration of the TRD into the CVP. Proviso 2 states:

> *"not less than 50,000 acre-feet shall be released annually from the Trinity Reservoir and made available to Humboldt County and downstream water users."*

Proviso 2 broadly requires flow releases for the benefit of Humboldt County and other downstream users without describing or placing any limitations on beneficial uses. Proviso 2 does not establish pre-conditions for release and does not prescribe discharge rates or other patterns of release. Proviso 2 allows, but does not require, additional flow releases above 50,000 acre-feet.

A contractual right for Proviso 2 was established in a water delivery contract executed between the DOI, Reclamation, and Humboldt County on June 19, 1959. The obligation under Proviso 2 to make water available to Humboldt County was formalized in Condition 8 of the 1959 Water Contract, which states:

> *"The United States agrees to release sufficient water from Trinity and/or Lewiston Reservoirs into the Trinity River so that not less than an annual quantity of 50,000 acre-feet will be available for the beneficial use of Humboldt County and other downstream users."*

The language from Condition 8 of the 1959 Water Contract was subsequently incorporated as a condition in each of Reclamation's eight water right permits for the TRD issued by the State Water Board in September 1959.

The 1959 Water Contract is not conditional on reservoir water storage or hydrological conditions and does not limit Humboldt County's right to a specific beneficial use, define "year", address flow scheduling, address whether unused volume in a given year may be rescheduled (carried over) for use in subsequent years, or contain an expiration date.

2.3.2 Reclamation's Water Rights

This section summarizes readily available information on the eight appropriative water right permits issued to Reclamation by the State Water Board for use of Trinity River water for the CVP (Table 2-3).

On July 30, 1927, Reclamation filed water rights application 5627 with the State of California – State Water Rights Board (agency that predated the State Water Board, Division of Water Rights) to appropriate water from the Trinity River in Trinity County, California. The application requested direct diversion of 1,100 cfs through a powerplant at Trinity Dam and then through a diversion at Lewiston Reservoir for use in the TRD, both of these diversions being for the beneficial use of power generation. The application also requested a diversion to storage in Trinity Reservoir of 1,540,000 acre-feet on an annual basis, to be used for power generation throughout the year.

Concurrently, Reclamation also filed application 5628 for a direct diversion of 2,500 cfs to appropriate water for the beneficial use of irrigation within the CVP place of use, along with domestic, saline and flood control, and navigation purposes. The application also requested a diversion to storage in Trinity Reservoir of 1,540,000 acre-feet on an annual basis.

In the early 1950s, Reclamation amended applications 5627 and 5628 to link them with several new water right applications. Application 15376 requested an additional 3,525 cfs of direct diversion for power generation at Trinity Dam, with 3,200 cfs being diverted at Lewiston Reservoir for use in the TRD. The application requested a diversion to storage in Trinity Reservoir of 1,800,000 acre-feet on an annual basis, so that collectively, applications 5627 and 15376 could be additive to 2,500,000 acre-feet of total storage, which was the proposed capacity of Trinity Reservoir. Permit conditions for these two applications specified that up to 325 cfs of water would be diverted from Trinity Dam and Lewiston Dam for power generation and subsequent release to the Trinity River downstream. Application 16768, filed in 1955, requested an additional 175 cfs of direct diversion for power generation and subsequent release to the Trinity River, and 700,000 acre-feet of diversion to storage. Together, applications 5627, 15376, and 16768 can cumulatively divert up to 3,700 cfs (3,200 cfs through the TRD and 500 cfs into the Trinity River) and up to 2,500,000 AF to storage annually for power generation.

Table 2-3. Reclamation's Water Right Permits on the Trinity River

Application	Permit	Status	Beneficial Use	Direct Diversion (cfs)	Diversion to Storage (acre-feet)	Face Value (acre-feet/year)	Place of Use
A005627	11966	Permitted	Power generation	1,100	1,540,000	2,336,375.3	Trinity and Lewiston Dams and powerplants located along main conduits. See Note 1.
A005628	11967	Permitted	Irrigation, domestic, saline and flood control and navigation	2,500	1,540,000	3,349,943.8	See Note 2.
A015374	11968	Permitted	Municipal and industrial	300	200,000	417,193.3	Within the service area of the Central Valley Project on file with the State Water Rights Board. See Note 2.
A015375	11969	Permitted	Irrigation, incidental domestic, fish and wildlife propagation, navigation, water quality control and incidental recreation	1,700	1,800,000	3,030,761.8	See Note 2.
A015376	11970	Permitted	Power generation	3,525	1,800,000	4,352,020.7	Trinity and Lewiston Dams and powerplants located along main conduits. See Note 1.
A016767	11971	Permitted	Irrigation and incidental domestic, and water quality control	See Note 3.	700,000	700,000	See Note 2.
A016768	11972	Permitted	Power generation	175	700,000	826,696.1	See Note 1.
A017374	11973	Permitted	Irrigation, navigation, domestic, stockwatering, fish and wildlife propagation, water quality control and recreational	1,500	0	1,085,966.3	See Note 2.

Key:
cfs = cubic feet per second
Notes:
1. Water appropriated will be utilized through powerplants at the following locations [Trinity, Clear Creek, Spring Creek, Keswick, Lewiston] for the production of electrical energy required for domestic, commercial and industrial use within the areas served by those systems interlocked with Central Valley Project in Northern California.
2. The water will be used within the service areas of districts, municipalities, water companies, corporations, and other legal entities within the gross area of the place of potential use delineated on Map 416-208-341, provided that the delivery of the water is conditioned upon execution of valid contracts for such deliveries. Water will be used by the United States of America, State or United States agencies, authorities, associations, public or private corporations, political subdivisions, and other agencies, whether as primary or supplemental supply, and under contracts with the United States of America or other authorization which may be made or given by authority and pursuant to law.
3. No direct diversion is applied for in this application. For diversion to be stored and later applied to beneficial use, 700,000 acre-feet are applied for for irrigation and incidental domestic use. This quantity of water (700,000 acre-feet), together with the 1,800,000 acre-feet applied for in Application 15375, are intended to be additive to a total of 2,500,000 acre-feet, which is the capacity of Trinity Reservoir.

Applications 15374 and 15375 requested 300 cfs and 1,700 cfs of direct diversions, respectively, for municipal, industrial, irrigation, fish and wildlife propagation, navigation, water quality control, and recreation beneficial uses within the CVP place of use. These two applications requested a diversion to storage in Trinity Reservoir of 200,000 acre-feet and 1,800,000 acre-feet, respectively. Application 16767 was filed in 1955 with no direct diversion but diversion to storage of 700,000 acre-feet per year to be used for irrigation and incidental domestic and water quality control. Application 17374 was filed in 1956 for direct diversion of 1,500 cfs with no diversion to storage. Together, applications 5628, 15374, 15375, 16767, and 17374 can cumulatively divert up to 3,200 cfs through the TRD and up to 2,500,000 AF to storage annually for specified beneficial uses.

The State Water Board held hearings on Reclamation's TRD permit applications from 1957 to 1959 and issued eight water rights permits in September 1959. As a result of the hearing process, the State Water Board adopted separate conditions for each proviso of the 1955 Act (USDOI 2014). Condition 8 (related to Proviso 1) and Condition 9 (related to Proviso 2) listed below apply to each of the eight water right permits:

> *Condition 8. Permitee shall at all times bypass or release over, around or through Lewiston Dam the following quantities of water down the natural channel of the Trinity River for the protection, preservation and enhancement of fish and wildlife from said dam to the mouth of said stream;*
>
> *October 1 through October 31 – 200 cfs*
>
> *November 1 through November 30 – 250 cfs*
>
> *December 1 through December 31 – 200 cfs*
>
> *January 1 through September 30 – 150 cfs*
>
> *Condition 9. Permitee shall release sufficient water from Trinity and/or Lewiston Reservoirs into the Trinity River so that not less than an annual quantity of 50,000 af will be available for the beneficial uses of Humboldt County and other downstream users.*

Several unresolved questions relating to the use of Proviso 2 water and the Reclamation CVP water right permits will be the subject of future efforts and discussions supporting development of a final Water Management Plan. In particular, the non-power generation water right permits list a designated place of use defined by Map 416-208-341, which does not include any lands or waters in the Trinity or Klamath watersheds (SWRCB 2004). The water right permits do not clearly specify whether there are any limitations or conditions for Proviso 2 releases related to place of use, either for consumptive or non-consumptive beneficial uses.

2.3.3 Chronology of Key Events Following 1959

A chronology of key events since Proviso 2 was codified in the 1959 Water Contract and TRD water right permits is summarized in Table 2-4.

Table 2-4. Chronology of Key Events

Year	Event	Relevance
1964	Completion of TRD	Beginning of TRD flow releases from Lewiston Dam.
1980	Reclamation EIS	Attributed depletion of fish populations to 3 causative factors: inadequately regulated harvest, excessive streambed sedimentation, and insufficient flows.
1980	Direction to perform 12-year Trinity River Flow Evaluation Study (TRFES)	TRFES initiated by Reclamation and the Hoopa Valley Tribe.
1980	EIS on the Management of River Flows to Mitigate the Loss of the Anadromous Fishery of the Trinity River, California	Prepared by USFWS in cooperation with the U.S. Bureau of Indian Affairs (BIA). Proposal to increase flows on the Trinity River to protect and restore Chinook Salmon and steelhead based on water year type and benefit commercial, sport and tribal harvest of fish, improve water quality and improve water-dependent recreational opportunities.
1980	Trinity River Stream Rectification Act	Initiated efforts to reduce fine sediment from Grass Valley Creek watershed and fine sediment reduction projects in 40-mile reach below Lewiston Dam.
1984	Trinity River Basin Fish and Wildlife Management Act	Directed Reclamation to restore fish and wildlife populations to levels approximate those that existed immediate before TRD construction began.
1992	Central Valley Project Improvement Act	Set the minimum flow volume in the Trinity River at not less than 340,000 AF and refined direction specific to the TRFES.
1993	DOI Solicitor Opinion	Confirmed fishing rights for Yurok and Hoopa Valley Tribes as a federal trust resource.
1999	Final EIS for TRFES completed	Prepared by Reclamation and HVT; defined the roles, responsibilities and objectives of the TRRP and its participants.
2000	Reclamation and Hoopa Valley Tribe sign Record of Decision for TRFES	Authorized TRRP, including flow management, channel restoration, sediment management and watershed restoration.
2004	Trinity River Fishery Restoration Supplemental EIS/Environmental Impact Report (EIR)	Prepared by Reclamation, USFWS, HVT, and Trinity County. Initially intended to supplement the 2000 ROD and satisfy the California Environmental Quality Act (CEQA) compliance, this effort was abandoned prior to issuance of a ROD or certified by Trinity County.

Year	Event	Relevance
2006	Completion of Trinity River Bridges Project	Provided initial implementation of full range of ROD flow release from Lewiston Dam.
2000 – 2014	Humboldt County calls on Contract Water	Several unsuccessful attempts were made by Humboldt County to make an annual call on Contract Water.
2014	DOI Solicitor issues opinion on Proviso 2 specific to Humboldt County[2]	In 2014, the Department of the Interior's Solicitor issued an opinion (USDOI 2014) affirming Reclamation's statutory obligation to release water for Humboldt County's beneficial use as provided for in Proviso 2 of PL 84-386 and Condition 8 of the 1959 Water Contract.
2017	DOI Solicitor issues letter on Proviso 2 specific to Yurok Tribe	Clarified that Yurok Tribe is one of the downstream water users for whose beneficial use of the water authorized for release per Proviso 2.
2017	Reclamation issues ROD for Long-term Plan to Protect Adult Salmon in the Lower Klamath River	Increase in Lower Klamath River flows to reduce likelihood and potentially reduce fish die offs in future years using flow augmentation measures available via Reclamation's TRD facilities.
2022	Winter Flow Project Report released by TRRP	Provided history, scientific rationale, and anticipated outcomes of a proposal for seasonal shift for a portion of ROD flow releases.

2.3.4 Tribal Trust Assets

The fishery and other resources of the Trinity River and the Klamath River Basins define the life and culture of area Tribes and have since time immemorial. Salmon, along with acorns, historically provided the primary dietary staples for the Native People of the area and are intrinsically connected to their cultural identities. Prior to colonization, reports indicate that local Tribes consumed over two million pounds of salmon annually (TRRP 2022a). Today fisheries still factor into the commercial and subsistence economies for area Tribes; however, in many years salmon returns are inadequate to meet Tribal needs today.

The federal trust responsibility requires that all federal agencies, including Reclamation and USFWS, take all actions reasonably necessary to protect Indian trust assets. The need for federal agencies to restore and maintain the natural production of anadromous fish in the Trinity River

[2] The 2014 Solicitor Opinion also provides guidance to Reclamation for responding to a request for release of water under Proviso 2. Specifically, "it is recommended that Reclamation conduct an appropriate level of analysis in response to a request for a release of water under Proviso 2 to determine the potential uses to which this water might be put, any other applicable legal requirements that must be addressed prior to releasing said water, whether existing operations or other authorities can fulfill the pending request, and then determine what additional actions may be appropriate under the circumstances."

mainstem originates partly from the United States' trust responsibility to protect the fishery resources of the region's tribes.

When the federal government established what are today the Hoopa Valley and Yurok Indian Reservations on the Trinity and lower Klamath Rivers, it reserved for the benefit of the Indian tribes of those reservations a right to the fisheries resources in the rivers running through them. The Yurok and the Hoopa Valley Tribes' federally reserved fishing rights entitle them to take fish for ceremonial, subsistence, and commercial purposes. More specifically, "the entitlement of the Yurok and Hoopa Valley Tribes is limited to a moderate living standard or 50 percent of the harvest of Klamath-Trinity basin salmon, whichever is less. Given the current depressed condition of the Klamath River basin fishery, and absent any agreement among the parties to the contrary, the Tribes are entitled to 50 percent of the harvest." (USDOI 1993). Thus, the federal government, as trustee, has an affirmative obligation to manage the Trinity River fishery to meet this standard.

The 1955 Act contains two provisos that limits Reclamation's ability to divert water from the Trinity River Basin for use by the CVP. Proviso 1 expressly directs Reclamation to provide adequate flows in the Trinity River for the propagation of fish and wildlife. Proviso 2 provides that annual releases of not less than 50,000 acre-feet be made available to Humboldt County and other downstream users. While Proviso 1 refers to the obligatory protection for fish and wildlife, thereby restricting the purpose of these releases, Proviso 2 releases rely on a water call by Humboldt County and other downstream users and has no such restrictions limiting the beneficial use of the released water (USDOI 2014). Thus, meeting the United States' Tribal Trust obligations to the Yurok and Hoopa Valley Tribes as it pertains to fisheries is vested in Proviso 1 of the 1955 Act. Consequently, the Water Management Plan is focused on flow benefits to fisheries that are distinct from that required by federal Tribal Trust obligations and Proviso 1.

2.3.5 National Environmental Protection Act

The National Environmental Policy Act (NEPA) was signed into law in 1970, 25 years after Congress authorized the construction and operation of the TRD. Since then, three EISs have been prepared under the auspices of the Department of Interior to address flow management of the TRD and the Trinity River. To varying degrees, each of these NEPA documents providing opportunities for tiering or incorporation by reference in future NEPA processes. As described in Table 2-4, the USFWS and BIA released an EIS that attributed depletion of the salmonid populations in the Trinity River following completion and operation of the TRD to three causative factors; inadequately regulated harvest, excessive streambed sedimentation (e.g., Grass Valley Creek watershed) and insufficient streamflow.

As a result, Reclamation initiated a number of efforts intended to address these factors, with cooperation from Tribes and other federal, state and local agencies. A key outcome of this EIS was the initiation of the Trinity River Flow Evaluation efforts that resulted in a number of projects and a wide array of scientific studies and investigations.

In 1999, the USFWS and Hoopa Valley Tribe completed the Trinity River Flow Evaluation Final Report; a report to the Secretary, U.S. Department of Interior. The collective scientific effort over many years led to three fundamental conclusions summarized below:

- A modified flow regime, a reconfigured channel and strategy for sediment management are necessary for a functional alluvial river that will provide the diverse habitat required to restore the fishery resources of the Trinity River.

- Described specific recommendations related to management of instream flows, channel rehabilitation and sediment (fine and coarse fractions).

- Utilize an Adaptive Environmental Assessment and Management (AEAM) approach to guide future management and ensure the restoration and maintenance of the fishery resources of the Trinity River.

Coincident with the scientific efforts associated with the TRFES, the USFWS and Trinity County began the public process for developing the Trinity River Mainstem Fishery Restoration EIS/EIR in 1994. Following extensive scoping efforts, a draft EIS/EIR was developed (USFWS et al. 1999) and following review and comments from Tribes, agencies and stakeholders, a Final EIS/EIR was published in 1999. A Record of Decision (ROD) issued by the Secretary of the Interior in 2000 (USDOI 2000); its noteworthy that Trinity County chose to not certify the Final EIR at that time. The ROD identified the preferred alternative to be the Flow Evaluation Alternative, in conjunction with watershed restoration components of the Mechanical Restoration alternative. The components of the preferred alternative described in the ROD included:

1. Infrastructure improvements to address impediments of bridges and houses/outbuildings to higher flows.

2. Variable annual water-year specific flow targets to meet physical and biological needs.

3. Mechanical channel rehabilitation to reshape the degraded channel condition.

4. Coarse sediment augmentation to support physical processes.

5. Watershed restoration to reduce fine sediment input to the mainstem Trinity River.

6. Implement the recommendations and recommend possible adjustments to the annual flow schedule through the AEAM Program.

From about 2003 through 2015, flow augmentation releases by PacifiCorp and Reclamation to the lower Klamath River frequently occurred to reduce the prevalence of fish disease. In anticipation that augmentation flows may be needed in future years, and recognizing competing environmental and water supply demands for TRD of the CVP water supplies, Reclamation started developing the Draft Long-Term Plan for Protecting Late-Summer Adult Salmon in the Lower Klamath River (Draft LTP) in 2013. A final EIS and ROD was released by Reclamation in January 2017.

The preferred alternative identified in the 2017 final EIS required supplemental flows from Lewiston Dam to prevent a disease outbreak in the lower Klamath River in years when the river’s flow at Klamath is projected to be less than 2,800 cubic feet per second (cfs). The water for these supplemental flows would come from water stored in Trinity Reservoir, to support “appropriate measures for the preservation and propagation of fish and wildlife” (Proviso 1) with releases of “not less than 50,000 acre-feet” for Humboldt County and downstream water users (Proviso 2), as provided in the 1955 Trinity River Division Act. On October 1, 2014, the U.S. District Court for the Eastern District of California ruled that Proviso 1 did not provide authority for releases made in 2012, 2013, and 2014. Reclamation identified both Proviso 1 and 2 as the primary authority for the flow releases in 2015, 2016, and in the Draft EIS. On February 21, 2017, the Ninth Circuit Court of Appeals reversed the District Court’s order regarding Proviso 1, holding that Proviso 1 provided authority for the flow releases. The final 2017 ROD thus identifies Proviso 1 as the source of supplemental flows. Supplemental flows would be provided as needed in a phased approach, based on environmental (e.g., flow) and biological conditions. These flows were characterized as preventative base flow augmentation, preventative pulse flows and emergency pulse flow augmentation; an annual implementation process was developed in conjunction with Tribes, federal and state agencies.

2.3.6 California Environmental Quality Act

As described previously, USFWS and Trinity County initiated a joint NEPA/CEQA process that resulted in the issuance of the Final Trinity River Mainstem Fishery Restoration EIS/EIR; the Flow Evaluation Alternative was identified as the preferred alternative, which also included elements of the Mechanical Channel Alternative. In 2000, the USFWS moved forward and issue a ROD that set forth prescribed Trinity River flows for five water year types in conjunction with mechanical channel restoration and sediment management projects, Trinity County made the decision that certification of the EIR would not occur pending the outcome of legal challenges unique to CEQA.

To-date, Reclamation has moved forward with ROD implementation for various projects related to mechanical channel rehabilitation, sediment management and infrastructure improvements with various CEQA lead and responsible agencies (e.g., Trinity County, California Department of Water Resources (DWR), NCRWQCB), but there have been no CEQA-dependent actions specific to flow management to-date. Therefore, there is no apparent CEQA document available to Humboldt County that could be used for tiering pursuant to CEQA. Some of the content of the 1999 FEIS/EIR and the 2017 LTP FEIS may provide some utility for incorporation by reference.

2.3.7 Water Quality Control Plan for the North Coast Region (2018)

The Water Quality Control Plan for the North Coast Region (Basin Plan) was developed by the North Coast Regional Water Quality Control Board to establish qualitative and quantitative objectives for the protection and enhancement of water quality within the boundaries of the North Coast Basin, which includes the Trinity and Klamath rivers. The plan designates beneficial uses of surface waters and groundwater, sets narrative and numeric objectives that must be attained or maintained to protect beneficial uses, defines implementation programs to achieve water quality objectives, and describes monitoring activities of the regional water board (NCRWQCB 2018). Contract Water releases must meet the narrative and numeric objectives associated with the beneficial uses of Trinity River.

The Basin Plan describes 14 existing beneficial uses on the Trinity River below Lewiston Dam: municipal and domestic supply, agricultural supply, groundwater recharge, freshwater replenishment, navigation, water contact recreation, non-contact water recreation, commercial and sport fishing, cold freshwater habitat, wildlife habitat, rare, threatened, or endangered species, migration of aquatic organisms, spawning, reproduction, and/or early development, and aquaculture.

The Basin Plan outlines specific water quality objectives for the Trinity River, including three waterbody-specific season-based temperature objectives at two locations downstream of Lewiston Dam (Table 2-2). Water temperature in Trinity River is influenced primarily by releases from Trinity Lake and Lewiston Reservoir, which are generally cooler than ambient water temperatures. The Basin Plan recognizes that the controllability of temperatures in the Trinity River downstream of Trinity Lake and Lewiston Reservoir is dependent on both climatic conditions and the operation of diversions to the Sacramento River. Water quality is also influenced by natural events such as fires and floods, as well as anthropogenic sources such as septic tanks, mines, and lumber mills. Mercury contamination has been observed in water upstream of Lewiston Dam and in sediments downstream as well, and the measured concentrations released by the sediment were below federal and state limits in all flow conditions.

Water quality standards for sediment in the Trinity River are exceeded due to excessive sediment. The reduction in quantity and variability of mainstem flows following TRD construction, coupled with an accelerated rate of sediment delivery due to intensive management practices throughout the Trinity River watershed, has resulted in an imbalance in the sediment budget and a reshaped channel (McBain and Trush 1997). As a result, the Trinity River is a 303(d) listed sediment-impaired water body with an established sediment total maximum daily load (TMDL) to protect river habitat for salmonids. Since the 1980s, sediment problems have been addressed via implementation of extensive watershed restoration projects (e.g., Grass Valley Creek watershed), various sediment-retention and soil stabilization projects on watersheds tributary to the Trinity River downstream of Lewiston Dam, and management of ROD flows. These combined efforts have led to reductions in the total amount of fine sediments in the river. Unlike sediment load, high turbidity is not a frequent problem observed in the Trinity River. The river is usually clear unless impacted by a specific event (e.g., fire, flood) or construction of TRRP in-channel restoration projects, at which point turbidity levels may rise beyond the 20 percent maximum increase specified by the plan's turbidity objective. However, it has been documented that such increases typically do not last more than 24 hours and do not impede upon beneficial use (NCRWQCB and Reclamation 2009).

2.3.8 Trinity River Restoration Program

The 2000 ROD for the Final Trinity River Mainstem Fishery Restoration EIS provided the framework for the TRRP and laid the foundation for the TRRP and provides a set of management actions and implementation guidance specific to the six discrete actions described previously. Since 2001, the TRRP has implemented a wide array of actions, including flow management, mechanical channel rehabilitation, infrastructure improvements or modifications, sediment management and watershed restoration within the Trinity River watershed, in some cases extending downstream to the lower Klamath River. The overriding principle of the TRRP has focused on a strategy of restoring the fishery resources of the Trinity River impacted by the construction and operation of the Trinity River Division of the Central Valley Project by managing flows to restore physical riverine processes and meet flow-dependent biological needs of anadromous salmonids. Due to infrastructure constraints, physical reshaping of floodplains and other alluvial features in conjunction with periodic augmentation of coarse sediment (e.g., spawning gravel) have also been actions implemented by the TRRP.

2.3.9 Klamath River Basin Fishing Regulations

Several concepts in anadromous fish population management are important to define prior to describing regulations relevant to fish species in the Trinity River. Run-size is the number of fish estimated annually to migrate from the ocean to spawn in fresh water river systems. Spawner escapement is the portion of the run-size (i.e., number of fish) that survive in-river tribal and recreational harvest to spawn. Spawning escapement goals refer to the number of fish that must escape harvest and spawn to promulgate a desired future run-size or meet a conservation objective. Annual fishing limits, also referred to as in-river harvest, are based on an allocation or quota system (PFMC 2019). This system uses the run-size to estimate a harvestable surplus, or the quantity of fish that can be harvested while still meeting spawning escapement goals. Quotas are designed to ensure natural and hatchery escapement needs for salmonid stocks are met while providing equitable harvest opportunities for ocean sport, ocean commercial, river sport, and tribal fisheries (both commercial and subsistence) (FGC 2014).

The California Code of Regulations Title 14 Section 7.40 describes the salmon sport fishing regulations in the Klamath River Basin, which consists of the Klamath River and Trinity River systems. In general, these regulations apply to Klamath River fall-run Chinook Salmon[3] (KRFC), which includes the combined fall-run Chinook Salmon in the Trinity and Klamath Rivers. Fishing for these species is managed through a cooperative system of state, federal, and tribal management agencies (FGC 2014):

- Each year, the Pacific Fishery Management Council (PFMC) is responsible for adopting recommendations for the management of sport and commercial ocean salmon fisheries in the Exclusive Economic Zone (three to 200 miles offshore) off the coasts of Washington, Oregon, and California. When approved by the Secretary of Commerce, these recommendations are implemented as ocean salmon fishing regulations by NMFS. The PFMC also establishes in-river harvest quotas for KRFC, based on run-size estimates established by CDFW that can range from no harvest up to two-thirds of the projected run-size to the basin (Kier et al 2021).

- The California Fish and Game Commission (Commission) adopts regulations for the ocean salmon sport fishery (inside three miles from the coast) and the Klamath River Basin sport fishery which are generally consistent with federal fishery management goals and harvest allocations established by the PMFC. Each year, CDFW evaluates the potential need to amend the existing harvest quotas to align with management goals. Any proposed changes to the salmon fishing regulations are presented to the Commission for consideration.

- The HVT and the Yurok Tribe maintain in-river fishing rights for ceremonial, subsistence, and commercial fisheries that are managed consistent with federal fishery management goals. Tribal fishing regulations are promulgated by the tribes.

KRFC harvest quotas are generally allocated each year for tribal purposes, in-river recreational fishing, and combined ocean troll and ocean recreational fisheries. In 1993, the U.S. Department of Interior Solicitor issued a legal opinion that concluded the Yurok Tribe and HVT of the Klamath Basin had a federally protected reserved right to 50 percent of the available KRFC harvest. Since 1994, half the annual harvest quota (50 percent) is allocated to the Yurok Tribe and HVT. Allocations for KRFC among non-tribal fisheries are based on annual negotiations and preseason PFMC recommendations. The pre-season KRFC allocations of the remaining 50 percent of the non-tribal catch are typically a minimum of 7.5 percent to the in-river recreational fishery and 42.5 percent or less to the combined ocean troll and ocean recreational fisheries (FGC 2021).

[3] KRFC is the only fishery resource that has a comprehensive fishery management plan that integrates all ocean and in-river fishery impacts with a minimum natural spawning escapement target into an annual harvest process. The Klamath River Basin also supports Klamath River spring-run (KRSC) Chinook Salmon, Coho Salmon, and steelhead. Presently, KRSC stocks are not managed or allocated by PFMC. This in-river sport fishery is managed by general basin seasons, daily bag limit, and possession limit regulations. When needed, KRSC regulations are amended in a separate rulemaking (FGC 2021). The Coho Salmon sport fishery has been closed for harvest since 1996 (CDFW 2022). Tribal and state governments manage fisheries that harvest or impact steelhead independently.

Recent data on run-size, escapement, and harvest is provided in Section 3.4.1. The Water Management Plan has a goal of supporting a harvestable surplus for tribal, recreational, and commercial fisheries. The technical analysis described in Section 5 will be used to determine how well Contract Water releases increase salmonid populations and contribute to this goal.

2.4 Other Relevant Plans

Several other plans and initiatives are currently under way that have a potential nexus to the releases of Contract Water. These plans are summarized below.

2.4.1 Reinitiation of Consultation on the Long-Term Operation of the CVP and SWP (2022)

In June 2004, Reclamation issued the Long-term CVP Operations Criteria and Plan (OCAP) to guide the coordinated operation of the CVP and State Water Project (SWP). Under Section 7 of the Endangered Species Act (ESA), federal agencies are required to consult with the USFWS and NMFS, depending on the species at issue, to ensure that their actions do not jeopardize the continued existence of species listed as threatened or endangered under the ESA or destroy or adversely modify their critical habitat. If the actions of a federal agency are found likely to jeopardize a listed species or adversely modify its critical habitat, USFWS or NMFS must propose reasonable and prudent alternatives that will mitigate the proposed action and avoid jeopardy and adverse habitat modification. To implement OCAP, Reclamation and DWR initiated ESA consultation under Section 7, which ultimately resulted in Biological Opinions (BOs) issued in 2008 by USFWS and 2009 by NMFS. These BOs contained reasonable and prudent alternatives that specified the terms under which the CVP (including the TRD) and SWP could be operated to be compliant with the ESA.

In 2016, Reclamation and DWR reinitiated consultation with USFWS and NMFS to propose an improved plan of operation for the CVP and SWP that better met biological objectives for threatened and endangered species. The Reinitiation of Consultation on the Coordinated Long-Term Modified Operations (ROC on LTO) of the CVP and SWP resulted in new BOs that were finalized in 2019. The BOs contained operational restrictions (i.e., reasonable and prudent alternatives to the proposed operations) intended to protect the following ESA-listed species, and their habitat, affected by CVP and SWP operations: Delta Smelt, North American green sturgeon, California Central Valley steelhead, Central Valley spring-run Chinook Salmon and Sacramento winter-run Chinook Salmon. In 2020, Reclamation signed the ROD to complete the ROC on LTO.

In 2021, in coordination with DWR and CDFW, Reclamation requested a second reinitiation of consultation on the Long-Term Operation of the CVP and SWP (ReROC) in anticipation of proposed modifications to CVP and SWP operations that may cause effects to ESA-listed species or designated critical habitat not covered under the 2019 BOs. The new resulting BOs could have the potential to impact operations of the CVP, including the TRD, in a manner that would affect flow in the Trinity and Klamath rivers. Conversely, the release of Contract Water may reduce diversion through the Clear Creek Tunnel, which could have an effect on flow and temperature, and subsequently ESA-listed species and their habitat, in the Sacramento River.

2.4.2 California Water Resilience Portfolio (2020)

In April 2019, the California Governor directed state agencies through Executive Order N-10-19 to develop a "water resilience portfolio," described as a set of actions to meet California's water needs through the 21st century. In response, state agencies developed an inventory and assessment of key aspects of California water, and an interagency working group considered this assessment and public input and developed a portfolio, which can be defined as the integrated use of a broad range of actions. The California Water Resilience Portfolio (CWRP) provides an overview of existing state water systems and challenges, followed by detailed solutions and execution strategies for preserving and expanding water resources in the state (CDWR 2020). Contract Water release scenarios should be consistent with the solutions and execution strategies outlined in the CWRP.

2.4.3 Humboldt County General Plan (2017)

The Humboldt County General Plan is a resource overview and management plan for anticipated county growth (Humboldt County 2017). The general plan establishes the kinds, locations, and intensities of land uses as well as applicable resource protection and development policies. Consistent with California law, the County's General Plan contains seven required elements: land use, open space, conservation, housing, circulation, noise, and safety. In the 2017 general plan, Humboldt County adopted a water resources element to address water planning issues including river and stream water quality, stormwater runoff, groundwater management, water needs of fish and wildlife, water consumption, conservation and re-use methods, and state and federal regulations. As an example, water resources policy 29 (WR-P29) states "the County shall advocate for reductions in water exports and improved flow release from existing reservoirs on the Trinity, Klamath and Eel rivers to restore and enhance fisheries, natural sediment transport, water quality, recreational opportunities, and other beneficial uses as identified in the Basin Plan". Contract Water release scenarios should be consistent with the goals and policies of the Water Resources element of the general plan.

2.4.4 First Steps toward a River Corridor Management Strategy (2016)

In 2016, a technical report was developed that attempted to address a need expressed by the Trinity Management Council (TMC) for a more holistic conceptual foundation to guide and integrate the various restoration actions implemented by the TRRP (Gaeuman et al. 2016). The purpose of this initial effort was to develop a comprehensive restoration strategy that included: (1) identifying and characterizing reaches of the Trinity River with different existing conditions, process controls, and future potentials, (2) defining metrics that can be used to differentiate reaches and quantify familiar but poorly defined concepts, such as channel complexity and floodplain connectivity, and (3) suggesting a general restoration strategy for the Trinity River as a whole, as well as local variations in that strategy for individual reaches of the river. The report suggested alterations to the three types of TRRP management actions – mechanical rehabilitation of the channel and its floodplains, flow management, and sediment management – to better achieve TRRP objectives, and outlined a process for evaluating management actions at specific locations. To date, these alterations and evaluations have not been initiated. To the extent possible, Contract Water release scenarios should be consistent with the flow management alterations suggested in the River Corridor Management Strategy.

2.4.5 Klamath Hydroelectric Settlement Agreement (2016)

Humboldt County is a signatory party to the Klamath Hydroelectric Settlement Agreement and Klamath Basin Restoration Agreement, a set of agreements signed in February 2010 that lay out the process for additional studies, environmental review, and a decision by the Secretary of the Interior whether removal of four PacifiCorp-owned dams on the Klamath River should be removed. The Klamath Hydroelectric Settlement Agreement established the process to transfer the ownership of the PacifiCorp's Klamath hydroelectric Project to a non-profit organization which would then pursue the decommissioning and removal of four dams on the upper Klamath

River (KHSA 2016). These hydroelectric facilities block fish passage, create detrimental water quality conditions for anadromous salmonids (increased water temperatures and toxic algae), and significantly contribute fish disease conditions affecting juvenile salmonids in the mainstem Klamath River below Iron Gate Dam. Removal of the dams will prevent poor water quality conditions created by the reservoirs and allow for fish passage into the upper Klamath Basin.

In August 2022, the Federal Energy Regulatory Commission (FERC) issued the final EIS for the surrender, decommissioning, and removal of projects works of the Lower Klamath Hydroelectric Project (i.e., the four PacifiCorp-owned dams) (FERC 2022). To the extent possible, Contract Water release scenarios should not adversely affect or cumulatively contribute to the negative effects of the removal on flow in the Lower Klamath River, including potential effects on aquatic biota, including Chinook Salmon, ESA-listed coho salmon and suckers, and other fish and wildlife species.

2.5 Water Management Plan Development Framework

Humboldt County intends to leverage the collective knowledge of the TRRP, tribes, federal and state agencies that participate in the TMC, as well as non-governmental organizations that are actively involved on fishery issues on the Trinity River to develop a Water Management Plan.. The Water Management Plan will explicitly describe a proposed annual release scenario, supported by a framework for annual decision-making and an environmental compliance strategy necessary to implement the proposed release scenario. This section outlines key assumptions and the framework proposed for developing the plan.

2.5.1 Key Assumptions

Subsequent sections will define the environmental setting, considerations for Contract Water releases, and technical analysis used to support development of the plan. Three key assumptions underly the discussion in these sections:

- **Location focus:** Commercial, Tribal, and sport fisheries depend on healthy populations of Chinook Salmon, Coho Salmon, and steelhead. These fish species are anadromous, meaning they are born in freshwater but spend most of their lives in saltwater before returning to freshwater to spawn. The Restoration Reach of the Trinity River, or the 40 river miles below Lewiston Dam that have been the focus of mechanical restoration projects since the 2001 ROD, provides spawning and rearing habitat for these species (USFWS and HVT 1999). The Restoration Reach is also the spatial domain where the most advanced biological modeling tools for the Trinity River have been developed. These tools are the best available to analyze whether Contract Water releases improve spawning and rearing habitat and create greater salmonid populations. Thus, the technical analysis will focus on the Trinity River in the Restoration Reach, which is in Trinity County. Contract Water releases that improve anadromous fish species habitat are anticipated to increase fish populations throughout the entire Trinity River, and the resulting fishable surplus would benefit the population of Humboldt County along with the populations of other counties.

- **Species focus**: an advanced set of modeling and analytical tools has been developed primarily for analyzing the effects of flow management on Chinook Salmon. The main assumption is that releases that benefit Chinook Salmon are generally beneficial to the other anadromous fish species in the Trinity River. The technical analysis will focus on assessing the effects of Contract Water releases on juvenile Chinook Salmon.

- **Additive use of Contract Water**: Contract Water releases are additive to the ROD flows currently released from Lewiston Dam. Release scenarios cannot contemplate shifting the timing of current ROD flows, and must assume Contract Water is used to supplement (i.e., is added to) ROD flows in any given month.

2.5.2 Framework

A framework has been developed that outlines the timeline, processes, and connections between planning and analysis efforts that will be used to develop the Water Management Plan (Figure 2-6). Major elements of the framework are summarized below:

- **Workshops**: a total of 6 workshops are proposed with those actively involved with management and/or scientific study of the ecology, hydrology, and fishery resources of the Trinity River and lower Klamath River. Workshops will be used to identify and access the best available scientific information, ensure coordination with related management efforts, and progressively build a collective understanding of objectives and outcomes. Initial workshops are focused on identifying limiting factors to fish production that should be targeted by Contract Water releases (see Section 4 for more details). The next workshops are focused on defining, modeling, analyzing, and iterating on a finite set of Contract Water release scenarios. The final workshops will focus on finalizing the key elements of the Water Management Plan based on the preferred Contract Water release scenario.

- **Technical Analysis**: A team of consultant and state and federal agency modeling experts will apply their experience in developing multi-model approaches to water management and habitat assessment scenarios to model the potential effects of different Contract Water release scenarios developed through the workshop process. The analysis will be iterative, allowing the modeling team to present initial results to the broader group, refine Contract Water scenarios, and then run the modeling tools again. Additional details on the technical analysis are found in Section 5.

- **Water Rights, Environmental Compliance, and Humboldt County/Tribal Coordination:** A parallel workstream to the technical analysis will be established to identify and coordinate on specific water rights, environmental compliance, and tribal coordination needs. These needs will be identified in workshops and other forums intended to inform development of an environmental compliance strategy that will be documented in the Water Management Plan.

- **Memorandums and Reports**: A set of technical memorandums and reports will be developed and finalized as the planning process moves forward. These documents, including this baseline conditions report and technical reports on the modeling and analysis of the effect of Contract Water releases on hydrology, water quality, geomorphology, and biological resources, will provide supporting rationale for the proposed action described in the Water Management Plan. Workshop participants will be provided the opportunity to review and comment on these technical documents.

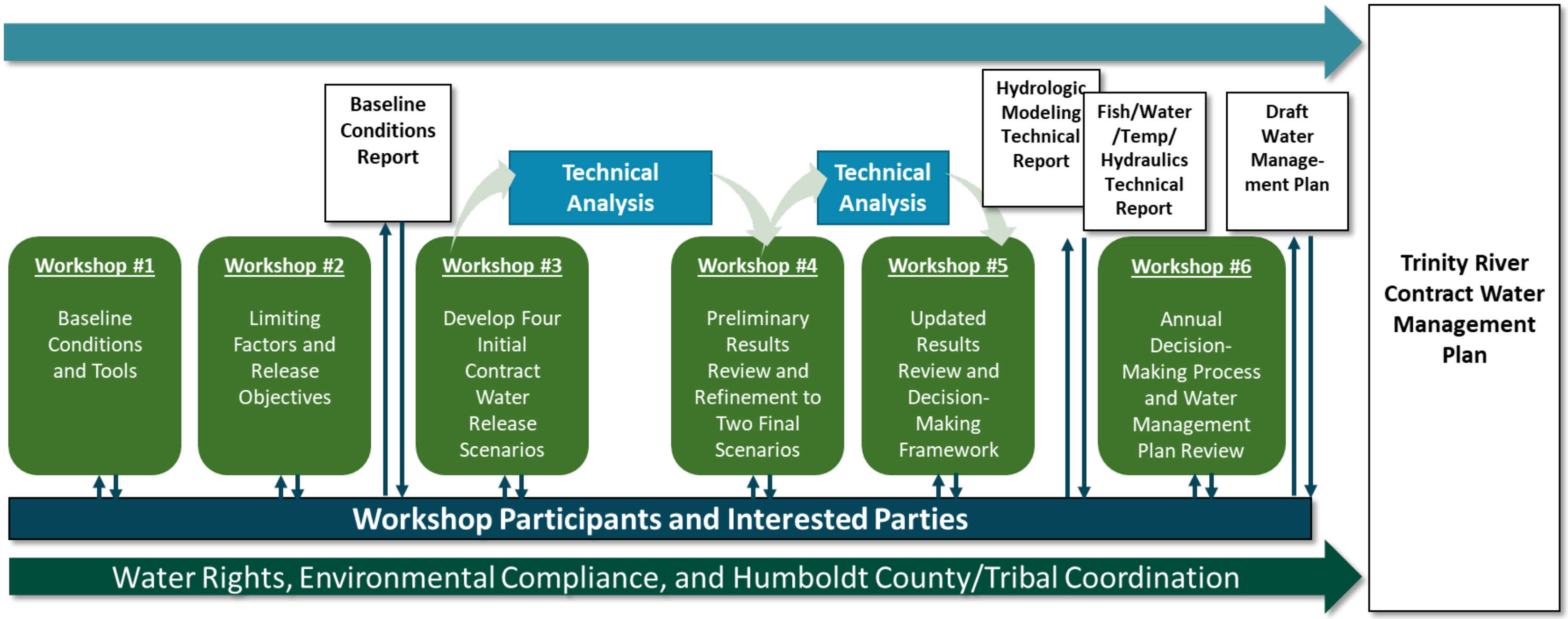


Figure 2-6. Water Management Plan Development Framework

3 ENVIRONMENTAL SETTING

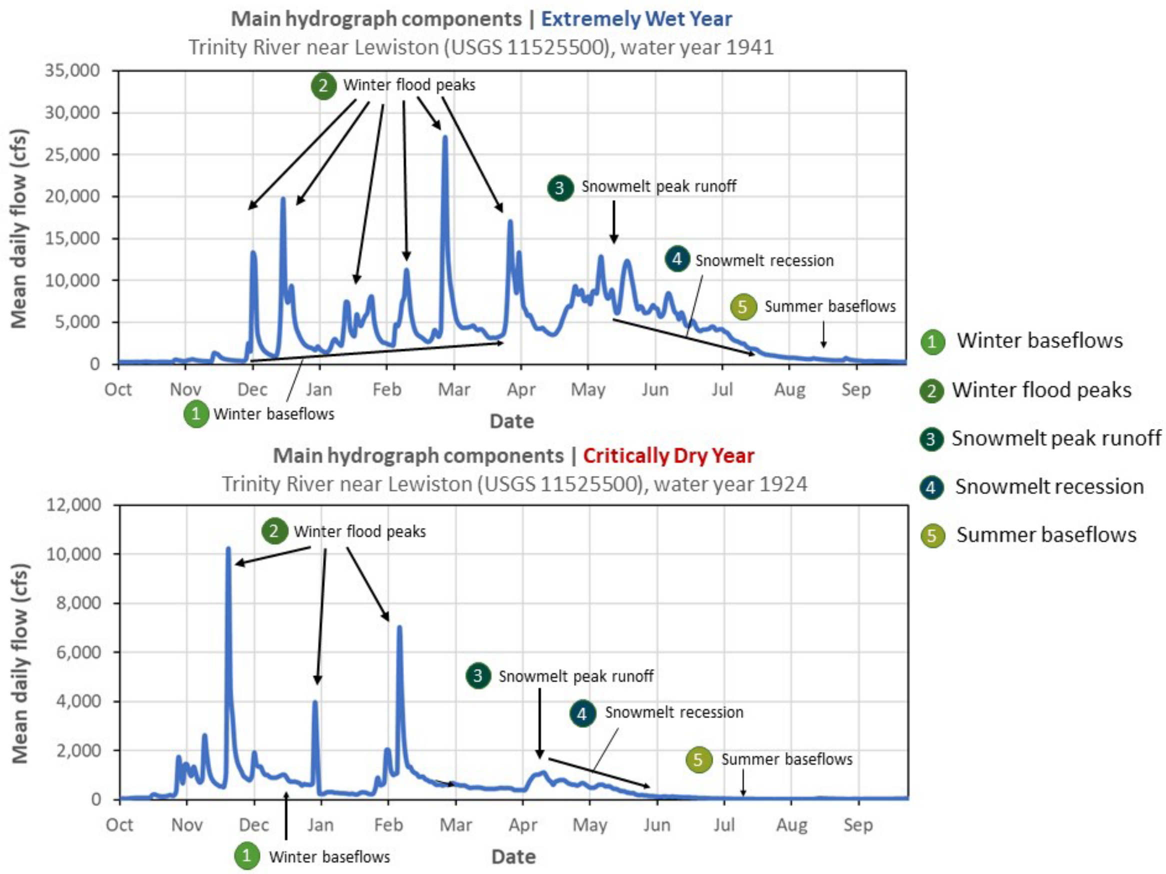
This section describes relevant history and current environmental conditions in the Trinity River, focusing on the 40 miles downstream of Lewiston Dam referred to as the Restoration Reach.

3.1 Hydrology

The Trinity River is the largest tributary to the Klamath River and drains over 2,000 square miles of the southern region of the Klamath River Basin (Reclamation 2017). The Trinity River includes the mainstem, North Fork Trinity River, South Fork Trinity River, New River, and numerous tributaries of various sizes. From its headwaters, the Trinity River flows approximately 170 miles south and west through Trinity County, then north through Humboldt County and the Hoopa Valley and Yurok Indian Reservations (Figure 2-1). The Trinity River meets the Klamath River at Weitchpec, approximately 44 miles upstream from the mouth of the Klamath River. The Trinity River subbasin ranges in elevation from over 9,000 feet above msl in the headwaters to less than 300 feet above msl at the confluence of the Trinity River with the Klamath River (NCRWQCB et al. 2011, USFWS et al. 2000).

The climate can be described as "Mediterranean" in terms of its rainfall distribution. Average precipitation in the Trinity River subbasin ranges from 30 to 70 inches per year, with a long-term average of approximately 62 inches per year (BLM 1995; Reclamation 2017). Over 90 percent of the precipitation occurs between October and April (Reclamation 2017). Precipitation ranges from mostly snow at higher elevations to mostly rain near the confluence with the Klamath River. This transient rain/snow zone geography typically creates a dampening influence on the relationship between precipitation and runoff depending on the temperature of the event and subsequent precipitation and temperature patterns—warm storms carrying large amounts of precipitation combined with snowmelt produce the highest runoff events (BLM 1995). The flood hydrology downstream of Lewiston is dominated by rainfall runoff events, whereas upstream of Lewiston is equally dominated by rainfall and snowmelt runoff events (Reclamation 2017).

The natural flow regime of the Trinity River varied considerably prior to TRD operations. During rain-on-snow storm events, instantaneous peak flows at Lewiston could range from 70,000 to 100,000 cfs, while flows in late summer dropped below 100 cfs (USFWS and HVT 1999). Total annual flow volume at Lewiston ranged from 0.27 to 2.7 MAF with a long-term average of 1.2 MAF (Reclamation 2017). The major pre-TRD hydrograph components for the Trinity River were identified by McBain and Trush (1997) using USGS and Reclamation Trinity Lake inflow data. The fall baseflows transitioned to several large magnitude, short duration winter flood events from mid-November to late January (Figure 3-1). Following the winter baseflows, the snowmelt peaks extended from late March to late June, producing flows peaking later in wet years than dry and comprised of low magnitude, long duration flood events. The snowmelt recession component usually began in late March in wet years and mid-May in dry years and receded into July. The summer baseflows establish mid- to late- July could range from 100 to 300 cfs in early summer but drop as low as 25 to 50 cfs in late summer (USFWS and HVT 1999).



Data source: USGS gage 11525500 Trinity River at Lewiston California

Figure 3-1. Trinity River at Lewiston Daily Average Streamflow Hydrograph Illustrating the Five Annual Hydrograph Components Described in the Trinity River Flow Evaluation Report (USFWS and HVT 1999) in Extremely Wet Year 1941 and Critically Dry Year 1924

The operation and flow regulation of the TRD facilities beginning in 1963 dramatically changed the hydrology of the Trinity River, greatly reducing flow and annual yields. The long-term average unregulated water yield at Lewiston (pre-TRD) and inflow into Trinity Lake (post-TRD) between 1912 and 1995 was 1,294 TAF; between 1963 and 1995, instream releases to the Trinity River downstream of Lewiston Dam, including flood control releases above the 120.5 TAF fishery flows, averaged 325 TAF, only 25 percent of the long-term average inflow (USFWS and HVT 1999). Following the 1981 Secretarial Decision, instream releases increased to an annual average of 35 percent of the unregulated yield above Trinity Lake, and again increased following the establishment of the TRRP and ROD flow schedules. Since the TRRP began implementing ROD flows in 2006, CVP exports out of Lewiston Reservoir to the Sacramento basin are on average 50 percent of inflow to Trinity Lake (Figure 2-4).

The reduction in flows and regulated release schedules have had longitudinally variable effects on the Trinity River from below Lewiston Dam to the confluence with the Klamath River. To varying degrees, the Restoration Reach has seen altering of flow duration curves, a large reduction in peak discharges, and a complete removal of components of the natural hydrograph, while farther downstream changes on the influence of tributary runoff were observed. The effects of regulation are greatest directly below Lewiston Dam, located at river mile (RM) 110.9, as flood magnitudes increase rapidly downstream due to the presence of unregulated tributaries and inflows from the North Fork Trinity River (RM 72.4) and South Fork Trinity River (Figure 2-1). TRD operations reduced flood magnitudes to 10 percent of their pre-TRD magnitudes at Lewiston, 50 percent at Burnt Ranch below the confluences of the North and South Fork (RM 48.6), but had no significant effect on flow magnitudes at Hoopa (RM 12.4) (McBain and Trush 1997). The frequency of large floods decreased resulting in a decrease in the flow duration curve at Lewiston by nearly an order of magnitude at the 10 and 30 percent exceedance probabilities (pre-TRD 4,000 - 1,900 cfs reduced to post-TRD 550 - 310 cfs) (McBain and Trush 1997). The 1.5-year flood is a significant hydrologic event throughout the Restoration Reach, largely responsible for channel formation, channel sizing, and mobilizing coarse bed material, and this event was reduced from 10,700 cfs to 1,070 cfs (USFWS and HVT 1999). The tributaries to the Trinity River are not large contributors from snowmelt runoff; therefore, until the implementation of ROD flows, the snowmelt peak and recession components were greatly reduced throughout the entire Trinity River, including the downstream reaches.

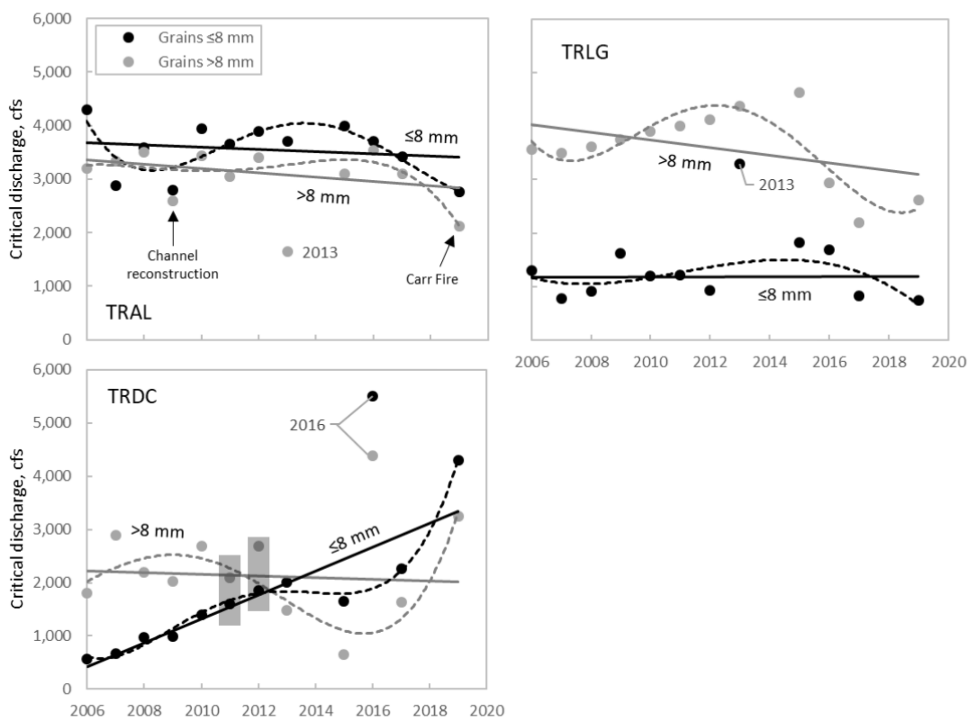
The hydrologic trends that have emerged and persisted in the Trinity River (across the full extent) since the start of TRD operations include: (1) a reduction in higher magnitude flows above a 50 percent exceedance and a removal of the winter flood peaks hydrologic component, (2) an increase in extremely low flows exceeded more than 85 percent of the time as a result of the artificially high summer baseflows, and (3) an overall reduction in the flow variability.

3.2 Geomorphology

The Trinity River mainstem is a mix of alluvial and bedrock-controlled channel morphologies (USFWS and HVT 1999). The historic natural hydrographic components and variability were important in shaping the historic alluvial channel and creating and maintaining quality aquatic and terrestrial habitats ideal for salmonid production. Winter peak floods mobilized and deposited sediment, created side channels, and maintained the integrity of alternate bar sequences. Alternate bars helped create hydraulic complexity (variable velocities and depths) allowing physical habitat to exist for several age classes of juvenile salmonids over a wide range of flows (USFWS and HVT 1999). Snowmelt peak runoff provided flow conditions ideal for mobilizing and depositing sediment suitable for spawning and rearing habitat for salmonids. Snowmelt recession and summer baseflows indirectly affected channel morphology by controlling seedling germination, establishment, and constraining the habitat extent of woody riparian vegetation.

Major alterations to the river channel began in the mid-19th century along with the California Gold Rush. Hydraulic mining and dredging of the river bed removed the coarse gravel necessary for salmonid spawning and rearing habitat; later the expansion of settlements along with logging and cattle ranching industries in the basin caused erosion and siltation (Perry et al. 2018). The Trinity and Lewiston Dams, completed in 1963, depleted sediment supply to the Trinity River. The reduced and regulated flows lacked the variability needed to maintain the historic channel diversity and the magnitudes needed to reach historic floodplains. The river no longer flooded, causing it to fill in with sand, while steady, low flows caused vegetation encroachment, could not initiate bedload transport, transport gravels and large woody debris, nor rework the steep banks and high terraces remaining from the mining era (TRRP 2022b). In general, the upper reaches directly downstream of Lewiston experienced these effects to a greater degree, as they lacked additional water and sediment supply that the unregulated tributaries can provide to the downstream reaches. To address these changes to the channel and deficit of flows required to initiate significant geomorphic changes, the 2000 ROD called for 47 mechanical channel rehabilitation projects in the 40 miles of river below Lewiston, which became known as the Restoration Reach (Figure 2-1). Since 2005, the TRRP has implemented restoration actions at more than 30 locations within the Restoration Reach, including mechanical channel rehabilitation projects to construct natural riverine features (floodplains, point bars, forced meanders, mid-channel islands, side channels, beaver analog structures and alcoves) and gravel augmentation projects to increase the amount of coarse bed material.

Watershed restoration activities implemented under the auspices of the 2000 ROD by the TRRP and its partners include road maintenance, road rehabilitation, and road decommissioning intended to reduce input of fine sediments. Tributaries deliver sediment to the river during winter floods, but currently the ROD flows do not initiate flows high enough to capture and transport them, which has resulted in an accumulation of fine sediments, especially at tributary junctions (TRRP and Reclamation 2021). This issue led to the implementation of an additional sediment monitoring program in 2004 to quantify annual bedload and suspended load sediment fluxes in the Trinity River. Empirical sediment rating curves developed by Gaeuman and Stewart (2017) and Pittman (2018) at four sites within Restoration Reach have been used to estimate the critical discharges for transportation of fine (≤8 mm) and coarse (>0.8 mm) sediment bed load (Figure 3-2). Hydraulic modeling by McBain Associates in the Restoration Reach estimated bed surface mobilization occurs at Shields values ≥ 0.02 and deeper bed scour of twice the D_{84} particle size occurs at a Shields values ≥ 0.03 (Buxton 2021a). In a synthesis of sediment monitoring data collected since 2004, Buxton (2021b) concluded that measures to reduce fine sediment in the channel have been ultimately successful upstream of Junction City to the point that a deficit of fine sediment now exists, especially between RM 110.2-107.9, and recommended an addition of fine sediments near Trinity River Hatchery to balance this deficit and promote better ecosystem functionality in the upper sections of the Restoration Reach.



Notes: Dotted lines are 4th order polynomials and solid lines are linear functions fit by least squares. Outliers not included in either curve are labeled by water year as are critical values for TRAL affected by channel reconstruction and the Carr Fire. Boxes at TRDC indicate years the station location was changed.
Figure source: Buxton 2021b

Figure 3-2. Critical Discharges for Fine and Coarse Bed Loads for Water Years 2006-2019 at 3 of the Sediment Monitoring Stations: Trinity River at Douglas City (TRDC), Trinity River at Limekiln Gulch (TRLG), and Trinity River at Lewiston (TRAL).

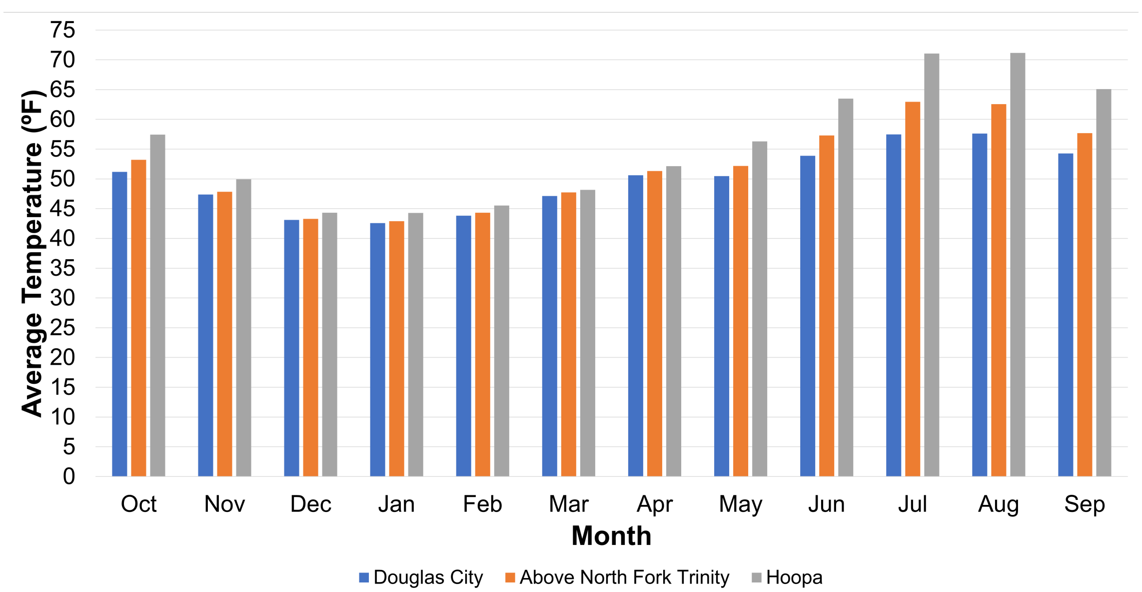
3.3 Water Quality

Water quality conditions in the Trinity River vary by regions within the basin and constituents of concern. In the Trinity River, key water quality concerns include water temperature, dissolved oxygen, nutrients and contaminants, and sediment and turbidity. Designated beneficial uses in the Trinity River include, but are not limited to groundwater recharge, freshwater replenishment, water contact recreation, commercial and sport fishing, cold freshwater habitat, rare, threatened, or endangered species, migration of aquatic organisms, spawning, reproduction, and early development (NCRWQCB 2011).

3.3.1 Water Temperature

Water temperature is a concern throughout California, including the Trinity River, as it supports sensitive cold water fish species. Water temperatures affect fish metabolism, feeding, growth and development, migration timing, spawning and rearing, and food availability. Trinity River water temperatures are primarily affected by TRD releases, flows, and solar radiation (Reclamation 2022). Reservoir releases have heavily altered the natural temperature regime by causing the downstream reaches to be warmer in the winter and cooler in the summer. This effect decreases to varying degrees based on the time of year and water year type (Reclamation 2022). The South Fork Trinity River is listed on the 303(d) list approved by the United States Environmental Protection Agency (USEPA) in 2010 for elevated water temperatures.

As shown in Figure 3-3, water temperature data for the Trinity River, between 2010 and 2022, show seasonal trends and the warming effect of ambient conditions at the downstream location. A study looking at the effects of flow and temperature on juvenile Chinook Salmon outmigration found that the best single variable for the timing of juvenile Chinook Salmon outmigration was the water temperature in the Trinity River above the confluence with the North Fork Trinity River (Gast & Associates 2021). Additionally, warmer water temperatures in the spring could encourage earlier outmigration.



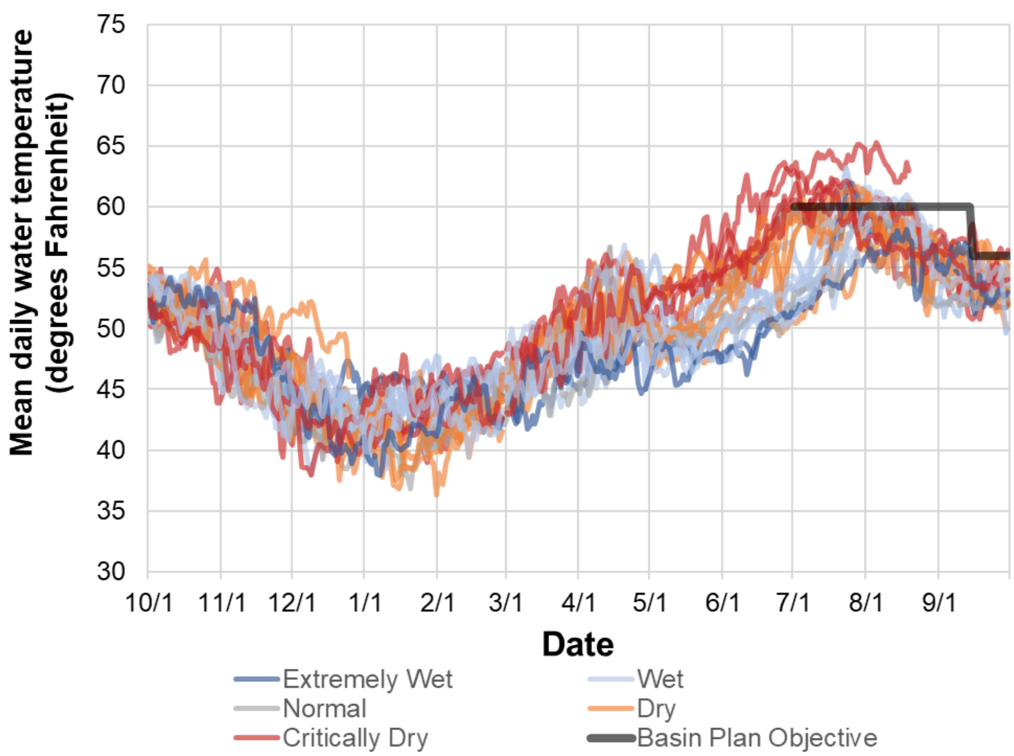
Data source: California Data Exchange Center (CDEC), Stations DGC (Trinity River at Douglas City), NFH (Trinity River above North Fork Trinity River near Helena), and HPA (Trinity River at Hoopa).

Figure 3-3. Mean Monthly Water Temperatures in the Trinity River from 2001 Through 2022

Trinity River summer and fall water temperature objectives or targets (summarized in Table 2-2) were set forth in the Basin Plan specifically applicable to the Trinity River, from Lewiston Dam to Douglas City and to the confluence with the North Fork Trinity River at Helena. Additionally, spring temperature targets were set by the 2000 ROD (Table 2-2). These criteria are reach dependent and vary seasonally.

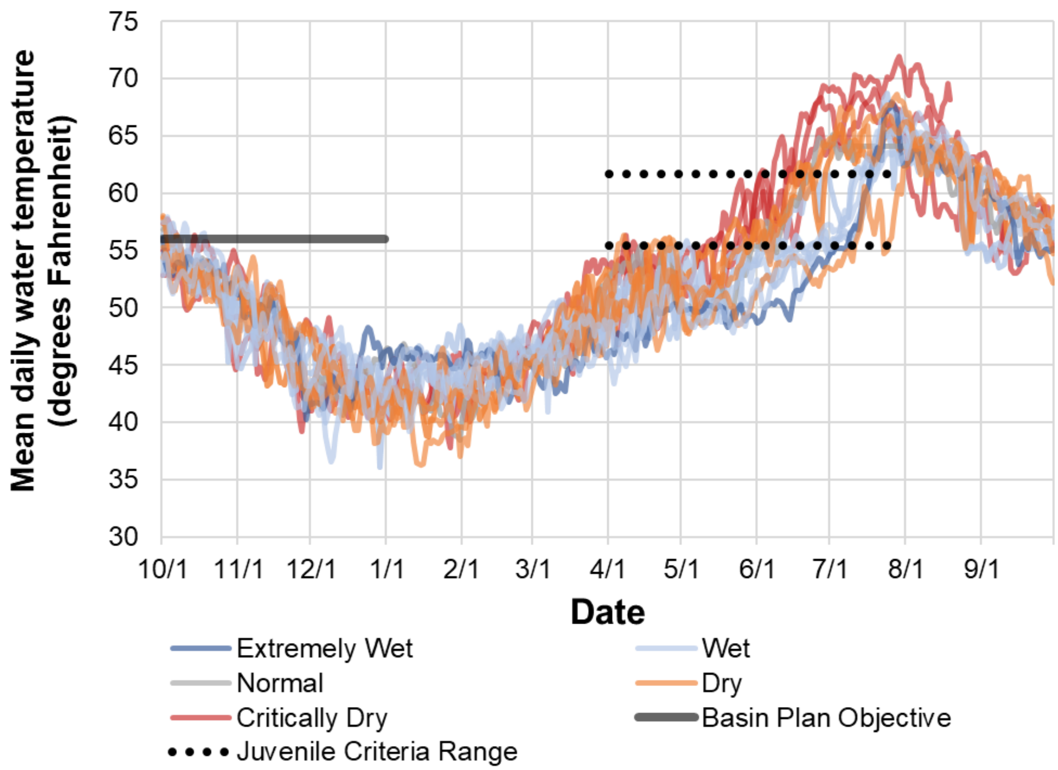
Recent evaluation of the objectives and targets established in the 2000 ROD resulted in recommendations from the TRRP's Fish Workgroup for additional temperature objectives specific to rearing juveniles in the mainstem Trinity River. This target range is currently under evaluation. The TRRP's Fish Workgroup recommended applying a target of 55.4 degrees Fahrenheit (°F) to 61.7 °F based on a 7-Day Average of the Daily Average (7DADA) to protect rearing juveniles in the Trinity River upstream from the North Fork Trinity River between April 1 and July 31 (Naman et al 2020).

Figures 3-4 and 3-5 show mean daily water temperatures in the Trinity River at two temperature compliance points (Douglas City and upstream from the North Fork Trinity River) for a 23-year period, covering all water year types. These temperatures show that fall and winter temperatures mostly fall below the objectives identified in the Basin Plan in both locations. Figure 3-5 shows water temperatures below the juvenile criteria range in April and early May.



Note: Adult water temperature targets are from the North Coast Regional Water Quality Control Board Basin Plan (NCRWQCB 2011)

Figure 3-4. Daily Water Temperatures in the Trinity River at Douglas City Between 2000 and 2022



Note: Adult water temperature targets are from the North Coast Regional Water Quality Control Board Basin Plan (NCRWQCB 2011). Juvenile Criteria Range is based on recommendations made by the TRRP Fish Workgroup (Naman et al 2020)

Figure 3-5. Daily Water Temperatures in the Trinity River Above North Fork Trinity River Between 2000 and 2021 at Douglas City

3.3.2 Dissolved Oxygen

Dissolved Oxygen (DO) is an important water quality component affecting the survival of aquatic organisms. Site specific objectives for DO were incorporated into the Basin Plan (NCRWQCB 2011). To protect beneficial uses of the lower Klamath River, including the cold freshwater habitat, water quality objectives were established in the Basin Plan and the Hoopa Valley Tribal Environmental Protection Agency (2008) for DO in the Klamath River and the Trinity River. For the lower Trinity River, DO shall not be reduced below 8 milligrams per liter (mg/l), with the 50 percent lower limit (i.e., the 50-percentile value of the monthly mean for a calendar year where 50 percent of more of the monthly means must be greater than or equal to the lower limit) is 10. Specific use water quality criteria for waters of the Hoopa Valley Indian Reservation includes 11 mg/l as a minimum water column DO concentration, and 8 mg/l as a minimum inter-gravel DO concentration.

3.3.3 Mercury

Elevated concentrations of mercury have been found in the water, sediment, and biota in the upper Trinity River upstream from Lewiston Dam. Studies conducted downstream from Lewiston Dam, however, have not found significantly elevated levels of mercury, and are below the criterion established by the EPA (Rytuba 2017).

3.3.4 Sediment and Turbidity

Construction of the TRD blocked the passage of gravel and fine sediment from being transported downstream. Gravel provides valuable habitat for salmonids, macroinvertebrates, and biofilm. Fine sediment provide habitat for other species such as lamprey and riparian plants. Additionally, historic disturbances associated with various land management practices, particularly in tributary watersheds upstream of Junction City in the Trinity River basin have resulted in high contributions of fine sediment into the Trinity River, primarily within the Restoration Reach.

In 1992, the EPA designated the Trinity River as impaired under Section 303(d) of the Clean Water Act due to excessive sediment. In 2001, the EPA established a TMDL for sediment and siltation in the Trinity River (SWRCB 2011a, b and c). Restoration activities in the Trinity River through the TRRP have worked towards reducing input of fine sediment and have introduced spawning gravel. Additionally, implementation of ROD flows has mobilized fine sediments in the upper Trinity River, which may now experience a deficit of fine sediment (TRRP and Reclamation 2021).

The Trinity River is typically clear, with turbidity levels during low flow conditions (300 to 450 cfs) around 0 to 1 nephelometric turbidity units (TRRP and Reclamation 2021). During winter and spring high flow events and restoration releases under the ROD, the Trinity River experiences temporary increases in suspended sediment and turbidity caused by riverbed scouring. This scour is a natural dynamic process and increases in turbidity are generally short in duration and extent. Recent fires, such as the 2018 Carr Fire, result in substantial increases in turbidity and sedimentation to the river following storms.

3.4 Biological Resources

3.4.1 Fisheries

The Trinity River is important to native anadromous salmonids – Chinook Salmon, Coho Salmon, and steelhead. The analysis for the Water Management Plan focuses on salmonid species, particularly Chinook Salmon, so the text below describes the status, distribution, and life histories for the Chinook Salmon, Coho Salmon and steelhead. Life history timing for the Chinook Salmon, Coho Salmon, and steelhead are shown in Table 3-1. Operations that benefit the salmonids will likely provide similar benefits to other native fishes in the Trinity River.

Table 3-1. Life History Timing for Chinook Salmon, Coho Salmon and Steelhead in the Trinity River

<table>
<tr><th>Species/Life Stage</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td colspan="13">Chinook Salmon</td></tr>
<tr><td rowspan="2">Adult Migration</td><td></td><td></td><td></td><td colspan="6" bgcolor="#8db3e2">Spring-run</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="5" bgcolor="#a9f59a">Fall-run</td></tr>
<tr><td rowspan="2">Spawning</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3" bgcolor="#8db3e2">Spring-run</td><td></td></tr>
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<tr><td rowspan="2">Incubation</td><td colspan="3" bgcolor="#8db3e2">Spring-run</td><td></td><td></td><td></td><td></td><td></td><td colspan="4" bgcolor="#8db3e2">Spring-run</td></tr>
<tr><td colspan="3" bgcolor="#a9f59a">Fall-run</td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3" bgcolor="#a9f59a">Fall-run</td></tr>
<tr><td>Emergence</td><td colspan="4" bgcolor="#8db3e2">Spring- and Fall-run</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Rearing</td><td colspan="12" bgcolor="#8db3e2">Spring-run</td></tr>
<tr><td colspan="10" bgcolor="#a9f59a">Fall-run</td><td></td><td></td></tr>
<tr><td>Outmigration</td><td></td><td></td><td colspan="8" bgcolor="#8db3e2">Spring- and Fall-run</td><td></td><td></td></tr>
<tr><td colspan="13">Coho Salmon</td></tr>
<tr><td>Adult Migration</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="4" bgcolor="#f59ac6"></td></tr>
<tr><td>Spawning</td><td bgcolor="#f59ac6"></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2" bgcolor="#f59ac6"></td></tr>
<tr><td>Incubation</td><td colspan="4" bgcolor="#f59ac6"></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2" bgcolor="#f59ac6"></td></tr>
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<tr><td>Rearing</td><td colspan="12" bgcolor="#f59ac6"></td></tr>
<tr><td>Outmigration</td><td></td><td colspan="5" bgcolor="#f59ac6"></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="13">Steelhead</td></tr>
<tr><td rowspan="3">Adult Migration</td><td></td><td></td><td></td><td></td><td colspan="4" bgcolor="#a9c2e8">Summer-run</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3" bgcolor="#a9f59a">Fall-run</td><td></td></tr>
<tr><td colspan="4" bgcolor="#f9f97a">Winter-run</td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2" bgcolor="#f9f97a">Winter-run</td></tr>
<tr><td>Spawning</td><td colspan="5" bgcolor="#a9c2e8">All runs</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Incubation</td><td></td><td colspan="5" bgcolor="#a9c2e8">All runs</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>Rearing</td><td colspan="12" bgcolor="#a9c2e8">All runs</td></tr>
<tr><td>Outmigration</td><td></td><td></td><td colspan="5" bgcolor="#a9c2e8">All runs</td><td></td><td></td><td colspan="2" bgcolor="#a9c2e8">All runs</td><td></td></tr>
</table>

3.4.1.1 Chinook Salmon

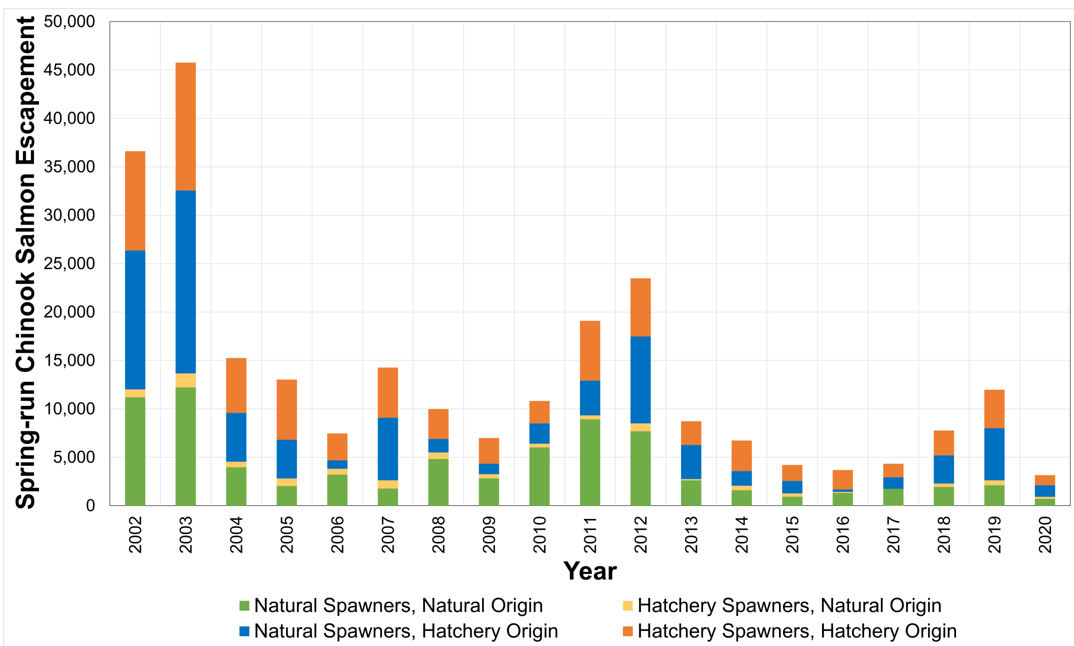
The Upper Klamath and Trinity Rivers (UKTR) Evolutionarily Significant Unit (ESU) includes fall- and spring-runs of Chinook Salmon that spawn in the Klamath and Trinity Rivers upstream of the Trinity River's confluence with the Klamath River. Although wild spring-run Chinook Salmon in the Klamath River system differ to a degree from fall-run Chinook Salmon genetically, and in life history and habitat requirements (NRC 2004), both are included within this ESU (Myers et al. 1998). A petition to list the Upper Klamath and Trinity Rivers ESU was submitted to NMFS in January 2011 (CBD et al. 2011); in April 2011, NMFS announced that listing was not warranted. However, in 2018, the Karuk Tribe and Salmon River Restoration Council petitioned NMFS to list the ESU as threatened or endangered or to create and list a new ESU as Klamath spring-run Chinook Salmon. NMFS released a 90-day finding stating the petition warranted further review (83 FR 8410). As of this date, no further action has occurred. Three hatchery stocks from the Iron Gate (fall-run) and Trinity River (spring- and fall-runs) Hatcheries are considered part of the ESU because they were founded using native, local stock in the watershed where fish are released (77 FR 19597). UKTR spring-run Chinook Salmon have been listed under the California Endangered Species Act as threatened.

Adult spring-run Chinook Salmon migrate upstream in the Trinity River from April through September, with most fish arriving at the mouth of the North Fork Trinity River by the end of

July. These fish remain in deep pools until the onset of the spawning season, which typically begins in September, peaks in October, and continues through November. The distribution of spawning extends upstream to Lewiston Dam and is concentrated in the Restoration Reach.

Emergence of spring-run Chinook Salmon fry in the Trinity River begins in January and continues into mid-April. Juvenile spring-run Chinook Salmon exhibit both ocean-type and stream-type rearing. That is, they may rear for a short period in the Trinity River and emigrate to sea in the spring or fall after hatching (ocean-type), or rear in the Trinity River for a year and emigrate to sea after a year of growth in the Trinity River. Outmigration from the lower Trinity River, as indicated by monitoring near Willow Creek, starts in March peaks in May and June and may continue through October (Gast & Associates 2021).

Population estimates for spring-run Chinook Salmon have been made by CDFW and the HVT at the Junction City Weir and at the Trinity River Hatchery since 1998, however early estimates were somewhat questionable. Between 2002 and 2020, the average annual run size (escapement plus angler harvest) in the Trinity River was 13,956, with an average annual population of natural origin spring-run Chinook Salmon of 4,162, and an average annual population of hatchery origin fish of 9,110. Figure 3-6 shows the yearly escapement estimates (fish that return to spawn, excluding those that are harvested) of spring-run Chinook Salmon since 2002. The TRRP established an in-river spawning population goal of 6,000 and a hatchery goal of 3,000 returning adult spring-run Chinook Salmon (USFWS et al. 1999).



Source: Kier et al. 2021

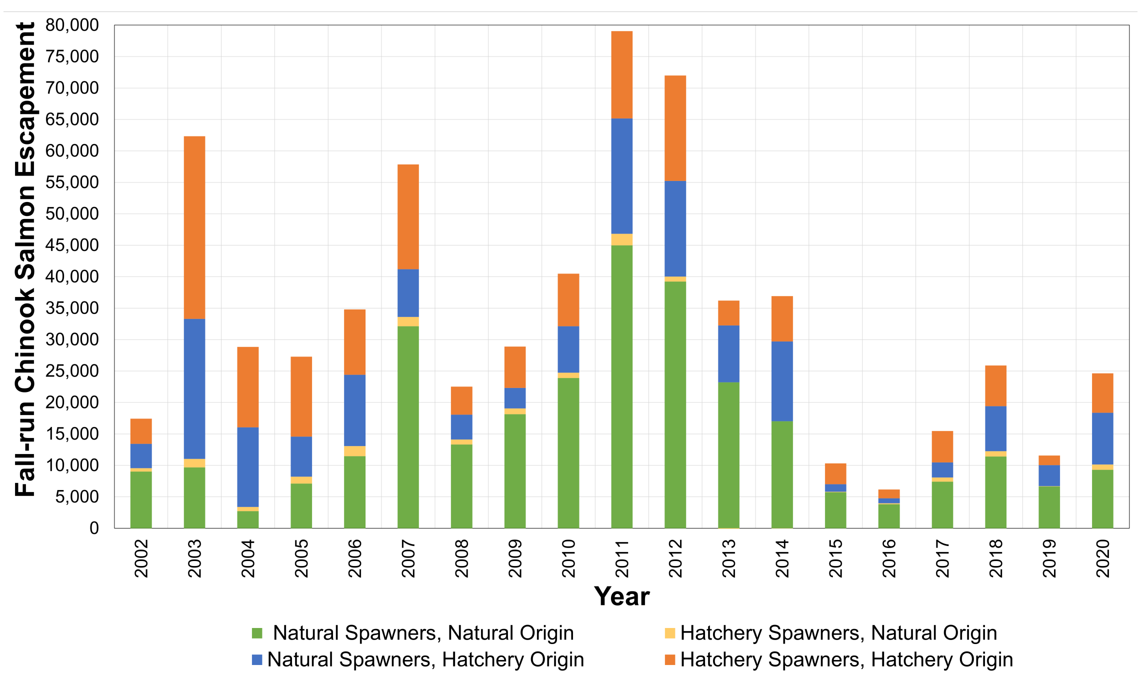
Figure 3-6. Annual Escapement for Spring-Run Chinook Salmon in the Trinity River at the Junction Creek Weir

Adult fall-run Chinook Salmon migration in the Trinity River begins in August and continues into December, with spawning beginning in early October. Spawning activity peaks in late October, and continues through December. Fall-run Chinook Salmon spawning occurs throughout the mainstem Trinity River from Lewiston Dam to the Hoopa Valley (Myers et al. 1998).

Trinity River fall-run Chinook Salmon fry begin emerging from the spawning beds in January and continue into mid-April. Juvenile fall-run Chinook Salmon typically emigrate after a few months of growth in the Trinity River. Outmigration from the upper river, as indicated by monitoring near Junction City, begins in March and peaks in early May, mostly ending by late May or early June but could continue into October. Outmigration of fall-run Chinook Salmon fry in the lower Trinity River occurs over approximately the same time period described above for the spring-run Chinook Salmon.

CDFW maintains an annual table that documents KRFC in-river run size, escapement, and harvest that differentiates in some categories between fall-run Chinook Salmon the Trinity and Klamath rivers (Table 3-2). Over the past 10 years, the annual in-river run size has varied from 27,369 to 316,754 but has generally been trending down. Spawning escapement of natural and hatchery fall-run Chinook Salmon is also trending down, ranging from 19,961 to 194,769, which is generally between 50 percent and 80 percent of the run size. In-river harvest generally varies from 20 percent to 40 percent of the run size, from 2,259 to 113,314. The adult in-river angler harvest quota has range from 0 to 67,000, but has not exceeded 8,000 since 2015.

The TRRP established an in-river spawning population goal of 62,000 and a hatchery goal of 9,000 returning adult fall-run Chinook Salmon on the Trinity River (USFWS et al. 1999). Spawning escapement estimates for fall-run Chinook Salmon on the Trinity River have been made by CDFW and the HVT at the Willow Creek Weir and at the Trinity River Hatchery since 1986, however early estimates were somewhat questionable. Between 2002 and 2020, the average annual run size (escapement plus harvest) in the Trinity River was 34,341, with an average annual population of natural origin fall-run Chinook Salmon of 16,641, and an average annual population of hatchery origin fish of 17,700. Approximately 25 percent of the juveniles released from the Trinity River Hatchery are coded wire tagged. Figure 3-7 shows the yearly escapement estimates of fall-run Chinook Salmon above the Willow Creek Weir since 2002.



Source: Kier et al. 2021

Figure 3-7. Annual Escapement for Fall-Run Chinook Salmon in the Trinity River at the Willow Creek Weir

Table 3-2. Klamath River Fall-Run Chinook Salmon: Annual In-River Run, Escapement, and Harvest Estimates

Category	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total In-river Run[1,3,4,a]	**107,500**	**186,872**	**316,754**	**179,381**	**182,717**	**83,915**	**27,369**	**53,320**	**101,932**	**47,035**	**54,486**	**64,591**
Total Spawner Escapement[1,3,a]	**69,584**	**142,373**	**194,769**	**88,072**	**144,878**	**43,113**	**19,961**	**50,880**	**79,188**	**31,700**	**42,692**	**50,340**
Total Spawner Escapement (% of run)	65%	76%	61%	49%	79%	51%	73%	95%	78%	67%	78%	78%
Trinity River Natural Escapement[2,3,a]	32,050	65,893	56,126	34,481	31,114	7,563	4,901	10,158	19,019	10,226	18,386	16,591
TRRP Goal[b]	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000
Trinity River Hatchery Escapement[2,3,a]	9,206	15,722	17,553	3,852	7,196	3,353	1,543	5,633	7,313	1,586	7,104	5,967
TRRP Goal[b]	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Total In-River Harvest[1,3,a]	**35,181**	**41,803**	**113,314**	**85,355**	**35,065**	**37,991**	**6,792**	**2,259**	**21,424**	**14,742**	**11,196**	**13,340**
Total In-River Harvest (% of run)	33%	22%	36%	48%	19%	45%	25%	4%	21%	31%	21%	21%
Total Tribal Harvest[1,3,a]	30,315	27,675	95,563	63,295	26,315	28,544	5,320	2,146	15,077	6,581	5,540	8,678
Trinity River Tribal Harvest[2,3,a]	3,953	5,289	4,200	3,035	2,504	2,067	771	1,854	2,505	2,564	1,066	3,077
Total Angler Harvest[1,3,a]	4,866	14,128	17,751	22,060	8,750	9,447	1,472	113	6,347	8,161	5,656	4,662
Adult Angler Harvest Quota[1,c]	12,000	7,900	67,000	40,006	4,128	14,133	1,110	0	3,490	7,637	1,296	N/A
Adult Angler Harvest[1,3,a]	3,035	4,147	13,876	19,800	5,386	7,842	1,310	71	4,110	5,376	5,123	2,265
Total Trinity River Angler Harvest[2,a]	686	2,371	2,106	1,220	1,096	87	85	13	1,304	574	399	561

Key:
TRRP = Trinity River Restoration Program
% = percent
N/A = not available
Notes:
1. Includes both the Klamath River and Trinity River
2. Includes Trinity River only
3. Adults and Grisle (salmon that has spent only one winter at sea before returning to the river to spawn)
4. Does not include angling mortality, net mortality, or Klamath Basin disease testing
Source:
a. CDFW 2022
b. USFWS and HVT 1999
c. Kier et al. 2021

3.4.1.2 Coho Salmon

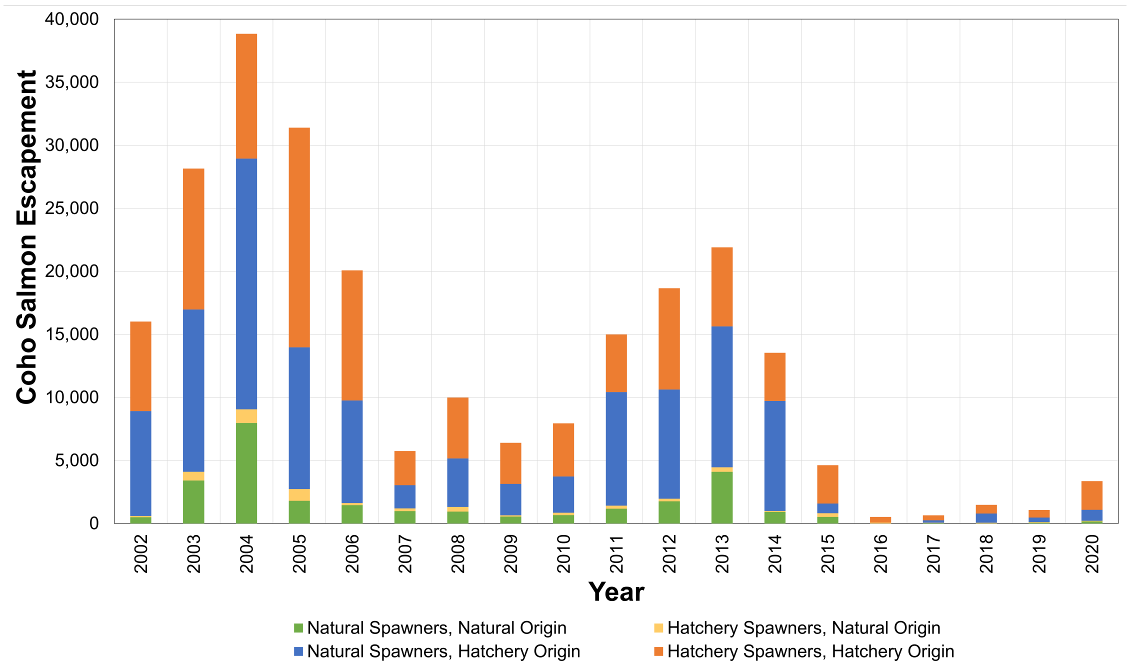
Coho Salmon in the Trinity River are in the Southern Oregon/Northern California Coast (SONCC) Coho Salmon ESU, and were listed as threatened under the ESA in 1997 (62 FR 24588, May 6, 1997) and threatened under the California Endangered Species Act in 2005. This ESU includes three artificially propagated stocks.

This ESU includes naturally spawning populations between Punta Gorda, California, and Cape Blanco, Oregon, which encompasses the Klamath River Basin (which includes the Trinity River) (62 FR 24588, May 6, 1997). In the Trinity River Region, all Trinity River reaches downstream from Lewiston Dam, the South Fork Trinity River, and the entire lower Klamath River are designated as critical habitat with the exception of tribal lands (64 FR 24049).

Coho Salmon in the Trinity River are thought to be primarily 3-year lifecycle fish, living a full year in the river as juveniles before migrating to the ocean. Most returning adult Coho Salmon enter the Trinity River between August and December (Table 3-1). Spawning in the Trinity River and tributaries occurs primarily in November through January. Most of the spawning by Coho Salmon in the mainstem Trinity River occurs from Lewiston Dam downstream to the North Fork Trinity River confluence (NMFS 2014). After emergence, fry move into areas out of the main current, and as they grow, they spread out from the areas where they were spawned. During summer, juveniles prefer pools and riffles with adequate cover such as large woody debris with smaller branches, undercut banks, and overhanging vegetation and roots.

Because juvenile Coho Salmon remain in their spawning stream year-round after emerging from the gravel, they are exposed to a broad range of freshwater conditions. The smolts typically emigrate between in the spring, with most leaving in April and May.

The Trinity River Hatchery tags 100 percent of the juvenile Coho Salmon released into the Trinity River. Population estimates for Coho Salmon have been made by CDFW and the HVT at the Willow Creek Weir and at the Trinity River Hatchery since 1997, however early estimates were somewhat questionable. Between 2002 and 2020, the average annual run size in the Trinity River is 12,962, with an average annual population of natural origin Coho Salmon of 1,738, and an average annual population of hatchery origin fish of 11,225. Figure 3-8 shows the yearly escapement estimates of Coho Salmon since 2002. The TRRP established an in-river spawning population goal of 1,400 and a hatchery goal of 2,100 returning adult Coho Salmon (USFWS et al. 1999).



Source: Kier et al. 2021

Figure 3-8. Annual Escapement for Coho Salmon in the Trinity River at the Willow Creek Weir

3.4.1.3 Steelhead

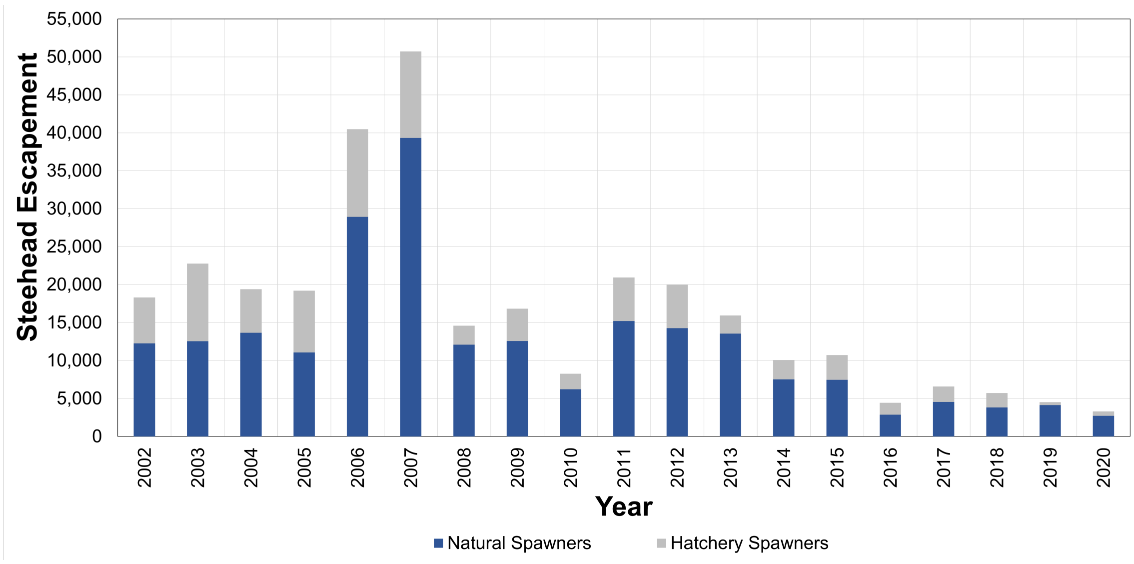
Klamath Mountains Province (KMP) steelhead have no federal special status under the federal Endangered Species Act, but are a California species of special concern. The KMP steelhead occupy the Klamath River basin and streams north to the Elk River, Oregon, including the Smith (California) and Rogue (Oregon) rivers. In the Klamath River, the upstream limit of steelhead migration is Iron Gate Dam. In the Trinity River, upstream migration is blocked by Lewiston Dam (Moffett and Smith 1950).

Trinity River steelhead exhibit two primary life history strategies: a summer-run that is stream maturing and a winter-run that is ocean maturing. There is also a fall-run, though many biologists lump those into either the summer-run or winter-run, based on when they migrate. Summer-run steelhead occur in the north and south forks of the Trinity River and in the New River and Canyon Creek tributaries (BLM 1995).

Adult summer-run steelhead enter the Trinity River from May through August and over-summer in deep pools in the mainstem and large tributaries. Some enter the smaller tributary streams of the Trinity River during the first November rains. Adult fall-run steelhead enter the Klamath River system in September through November, and adult winter-run steelhead begin their upstream migration in the Klamath River from November through April (Table 3-1).

Steelhead spawning in both the mainstem and tributaries occurs between January and May (Table 3-1). Juvenile steelhead may rear in fresh water for up to three years before outmigrating, and freshwater rearing histories of Trinity River steelhead are highly variable (Scheiff et al. 2001, Pinnix and Quinn 2009, Pinnix et al. 2013, Hodge et al. 2016). For juveniles that rear at least a year in fresh water, survival appears to be higher for those that outmigrate to the ocean at age 2+ (DFG 1998). Juvenile outmigration can occur from spring through fall, with three peak migration periods including March, May/June, and October/November (USFWS et al. 2004) (Table 3-1).

The Trinity River Hatchery tags 100 percent of the juvenile steelhead released into the Trinity River. Population estimates for adult steelhead have been made by CDFW and the HVT at the Willow Creek Weir and at the Trinity River Hatchery. Between 2002 and 2020, the average annual run size in the Trinity River is 17,071, with an average annual population of natural origin steelhead of 12.111, and an average annual population of hatchery origin fish of 4.960. Figure 3-9 shows the yearly escapement estimates of steelhead since 2002. The TRRP established an in-river spawning population goal of 40,000 and a hatchery goal of 10,000 returning adult steelhead (USFWS et al. 1999).



Source: Kier et al. 2021

Figure 3-9. Annual Escapement for Steelhead in the Trinity River at the Willow Creek Weir

3.4.2 Riparian and Terrestrial Communities

Terrestrial habitat along the Trinity River below Lewiston Dam has changed since construction of the TRD. The ongoing TRRP is restoring portions of the habitat below Lewiston Dam. The following description reflects recent habitat changes along the mainstem of the Trinity River between Lewiston Reservoir and the confluence of the Klamath River.

Riparian vegetation is most prevalent along the Trinity River from the Lewiston Dam downstream to the confluence with the North Fork Trinity River. This reach includes predominantly willow-alder mix, then early-successional, willow-dominated vegetation, and more mature, later-successional, alder-dominated vegetation (USFWS et al. 2000). Between the North Fork Trinity River and the South Fork Trinity River, the mainstem Trinity River channel is constrained by canyon walls and bedrock outcrops that limit riparian vegetation to a narrow band. In comparison to the mainstem Restoration Reach, peak flows in the mainstem Trinity River between the confluences of the North Fork and South Fork have been less affected by TRD operations. Between the South Fork Trinity River and the Klamath River, the Trinity River alternates between confined reaches with little riparian vegetation and alluvial reaches with vegetation similar to pre-dam conditions in the Restoration Reach.

Many wildlife species that inhabited river and riparian habitats prior to the TRD still occur along the Trinity River, although species that prefer early-successional stages or require greater riverine and/or riparian structural diversity likely occurred in greater abundance prior to the TRD. Species commonly present prior to the TRD likely included the rough-skinned newt (*Taricha granulosa*), western aquatic garter snake (*Thamnophis couchi*), foothill yellow-legged frog (*Rana boylii*), western pond turtle (*Actinemys marmorata*), and American dipper (*Cinclus mexicanus*). Wildlife species that foraged on the abundant runs of salmonids such as the black bear (*Ursus americanus*), bald eagle (*Haliaeetus leucocephalus*), and other scavengers, were also common along the pre-dam Trinity River (USFWS et al. 2000).

The post-dam flow regime established conditions that favored upland habitat at the expense of wetland and aquatic habitat. The shift in habitat types is a causative factor in the current depressed populations of aquatic, semi-aquatic, and riparian wildlife species compared to terrestrial species. Species such as the western pond turtle, an example of a semi-aquatic species, have declined since construction of the TRD in response to diminishing quality and abundance of riverine habitat. In contrast, species that favor mature, late-successional riparian habitats, such as the northern goshawk (*Accipiter gentiles*) and black salamander (*Aneides flavipunctatus*), prefer the current mature conditions (USFWS et al. 2000).

Despite the removal of certain riparian vegetation areas resulting from TRRP channel widening projects, the riparian corridor of the Trinity River throughout the Restoration Reach has remained nearly constant in size between 2003, when TRRP channel rehabilitation projects were initiated, and 2014, however, the corridor has increased in complexity (Alvarez et al. 2015). Between the North Fork and the South Fork, the Trinity River channel is restricted by steep canyon walls that limit riparian vegetation to a narrow band (NCRWQCB and Reclamation 2009; USFWS et al. 2000). Between the South Fork and the confluence with the Klamath River, there are confined reaches with little riparian vegetation, alternating with vegetation similar to the pre-dam conditions in the upper portions of the Restoration Reach.

The upland landscape throughout the Trinity River watershed is characterized by three major forest types (BLM 1995) —mixed evergreen conifer forest, Klamath montane mixed conifer forest in the higher elevations north of the Trinity mainstem, and Oregon white oak forest. Extensive south slope areas of the watershed are shrub-dominated.

3.5 Climate Change

A growing body of evidence indicates that Earth's atmosphere is warming. Records show that surface temperatures have risen about 0.7 degrees Celsius (°C) since the early twentieth century and that 0.5°C of this increase has occurred since 1978 (NAS 2006). Observed changes in oceans, snow and ice cover, and ecosystems are consistent with this warming trend (NAS 2006, IPCC 2007). In addition, global and regional sea levels have been increasing steadily over the past century and are expected to continue to increase throughout this century. Over the past several decades, sea level measured at tide gages along the California coast has risen at a rate of about 17 to 20 centimeters (cm) (6.7 to 7.9 inches) per century (Cayan et al. 2009).

California's Fourth Climate Change Assessment (Bedsworth et al. 2018) updated climate projections that provided state-of-the-art understanding of different possible climate futures for California. Major reported climate change trends are reported below for the North Coast region of California, encompassing Mendocino, Humboldt, Del Norte, Lake, Trinity, and Siskiyou Counties.

- Average annual maximum temperatures are likely to increase by 5 to 9 °F throughout the region through the end of the 21st century. Interior regions, like Trinity County, will experience the greatest degree of warming. The summer season temperatures in the North Coast region will increase 3 to 5 °F by mid-century (2040-2069) and 6 to 9 °F by end-century (2070-2099). Winter season temperatures are expected to increase by a greater magnitude: 5 to 7 °F by mid-century and 8 to 11 °F by end-century.

- Annual precipitation is not expected to change significantly but will likely be delivered in more intense storms and within a shorter wet season. As a result, the region is expected to experience prolonged dry seasons and reduced soil moisture content, even if annual precipitation stays the same or moderately increases. Less precipitation will fall as snow and total snowpack will be a small fraction of its historical average. Because of these changes, there is a higher likelihood of extreme wet years and extreme dry years (drought), and stream flow in the dry season is expected to decline while peak flows in the winter are likely to increase. In essence, an average rainfall year will become less common as precipitation and drought events become more extreme.

4 CONTRACT WATER RELEASE CONSIDERATIONS

Contract Water release scenarios are currently being considered for a non-consumptive use that benefits fish, habitat, and water quality while not precluding future consumptive uses, with a primary goal of supporting a harvestable surplus for tribal, recreational, and commercial fisheries. As part of the Water Management Plan framework, up to four preliminary Contract Water release scenarios are being developed and modeled to assess their relative potential of improving fish populations. To support further definition of Contract Water release scenarios, a literature review and data synthesis was conducted with the following objectives:

- Identify potential limiting factors to fish population that could be targeted for improvement with Contract Water releases

- Summarize the deviations in the current flow regime from an idealized natural flow regime and identify 'gaps' that could be targeted with Contract Water releases

- Gather and analyze modifications proposed by the TRRP Flow Workgroup to the annual ROD flow releases over the past 10 years to determine if any similar modifications should be considered by Contract Water release scenarios

- Review recent studies that proposed modifications or augmentations to ROD flow releases, or analyzed the effect of ROD flow releases on fisheries, to determine if any similar modifications should be considered by Contract Water release scenarios

- Convene a discussion with workshop participants to identify objectives for Contract Water releases.

This section summarizes these five topic areas and concludes with proposed recommendations for Contract Water release objectives provided by participants from Workshop 2.

4.1 Potential Limiting Factors

For this analysis, limiting factors are defined as environmental and biological factors that limit the freshwater production of anadromous salmonid populations. Bartholow and Henriksen (2006) summarized some useful generalizations on identifying and defining limiting factors for salmonid productivity: i) there may be several consecutive, independent habitat events that affect adult populations regardless of management actions; ii) limiting events occur over variable time scales; iii) habitat may be limited by both high and low flow events and the rate of change of these events, and the timing of habitat availability aligning with fish needs can determine the degree to which the habitat quantity is limiting; and iv) resources and habitat not directly used by the fish species (such as that used by macroinvertebrates which are a primary source of food supply for fish) may be important than the habitat used directly by the fish.

The 2000 ROD flows were established with the following assumptions about the limiting factors and deviations between the natural pre-TRD and post-TRD system, informed primarily by the Trinity River Flow Evaluation (USFWS and HVT 1999):

- Restoration of pre-dam attributes such as alternate bar sequences, effective sediment transport, and dynamic riparian communities would result in the restoration of anadromous fish production (USFWS et al. 2000).

- Reduced river flows, lack of side channel and floodplain habitat, increases in fine sediment input and reductions in coarse sediment recruitment were the primary limiting factors resulting in degradation of fish habitat (USDOI 2000).

- The reduction of peak winter and spring flows was the primary cause of habitat loss and a temperature regime that negatively impacts salmonids, so restoration flows should increase during this period.

- Watershed-wide restoration actions should be implemented to increase gravels, reduce fine sediments, and implement 47 mechanical channel rehabilitation projects because flows were too low to initiate necessary geomorphic changes in the river.

Using these background documents as a starting point, a generalized conceptual model of limiting factors was developed using Chinook Salmon as the primary species (Figure 4-1). The scope of the project is to focus on increasing habitat and productivity for salmonid species within the Restoration Reach, so factors that pertain to the upper watershed life stages and factors which can be controlled solely through flow management are emphasized. Factors influencing the ocean life cycle and outmigration passage below the confluence with the North Fork Trinity River are not described in detail, although they are relevant to the long-term sustainability of these populations. The conceptual model highlights four major limiting factors that have physical and biological impacts on the river system which affect fish productivity.

- Hydrology/Water Management refers to management actions that lead to changes in the hydrographic flow regime (i.e., altering the magnitude, frequency, duration, timing, and rate of change of flows) and is identified as the overarching limiting factor, because changing this factor will affect all other factors.

- Water Quality refers to the measurable chemical, physical, and biological characteristics, usually with respect to its suitability for a particular purpose and includes measures of water temperature, pH, DO, and other chemicals that may be considered contaminants to fish health.

- Habitat can refer to the quantity and quality of aquatic habitat for different life stages of salmonids (spawning, rearing, and outmigration), as well as considerations for habitat not directly used by the fish. This may constitute appropriate flows to provide suitable depths and velocities for the salmonid life stages, but lateral habitats such as side channels and floodplains that are variably accessible depending on flow, and habitat areas that are not directly utilized by fish, such as the habitat used by benthic organisms that become a food source for fish, or terrestrial riparian zones where vegetation provides cover and channel stability, are also highly important habitats.

- Geomorphology refers to the channel structure and morphology as well as sediment size and composition which affects the degree of sedimentation, turbidity, and availability of spawning gravels, which can all affect fish survival.

This conceptual model is used to organize limiting factors identified in subsequent sections.

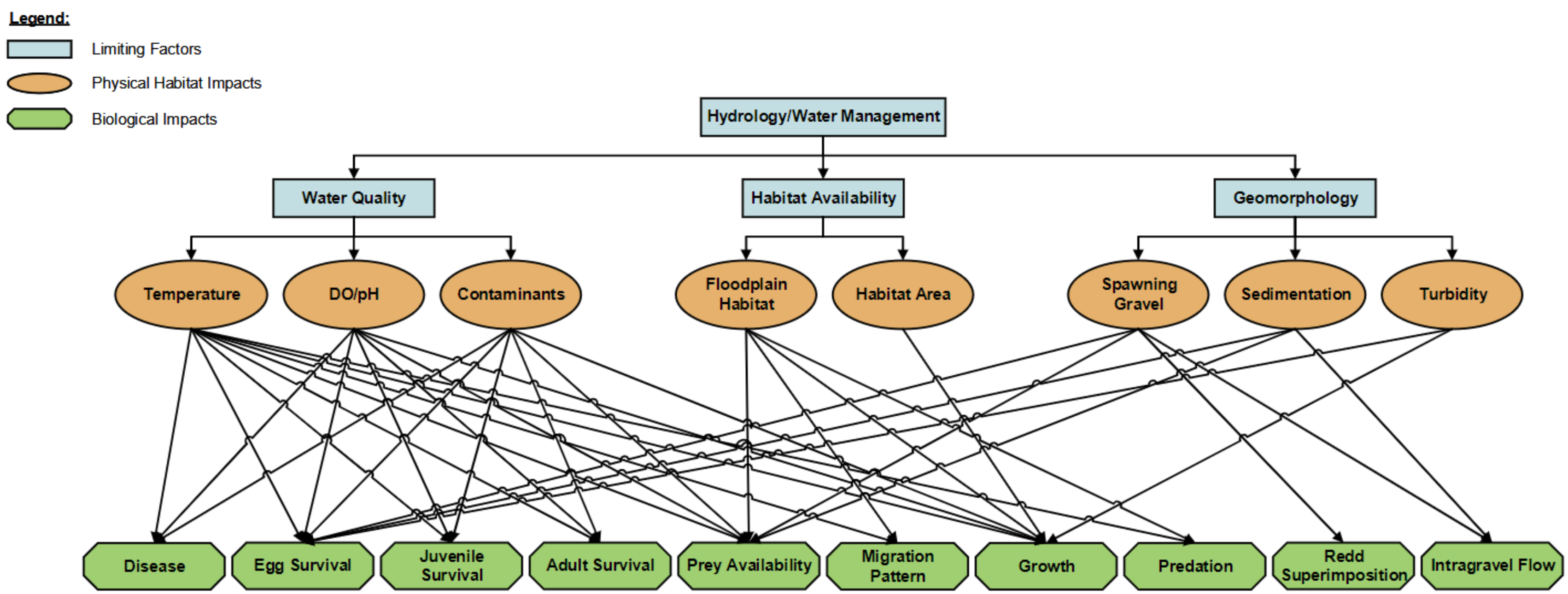
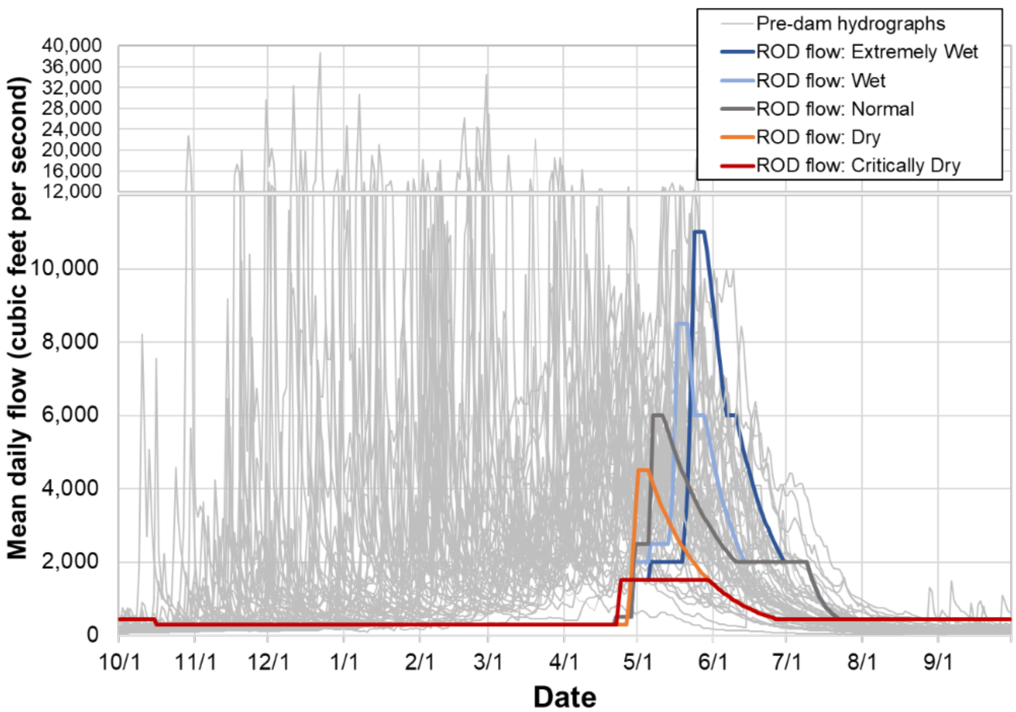


Figure 4-1. General Conceptual Model of Limiting Factors for Fish Productivity in the Trinity River, with Relationships to Physical and Biological Impacts

4.2 Differences from a Natural Flow and Temperature Regime

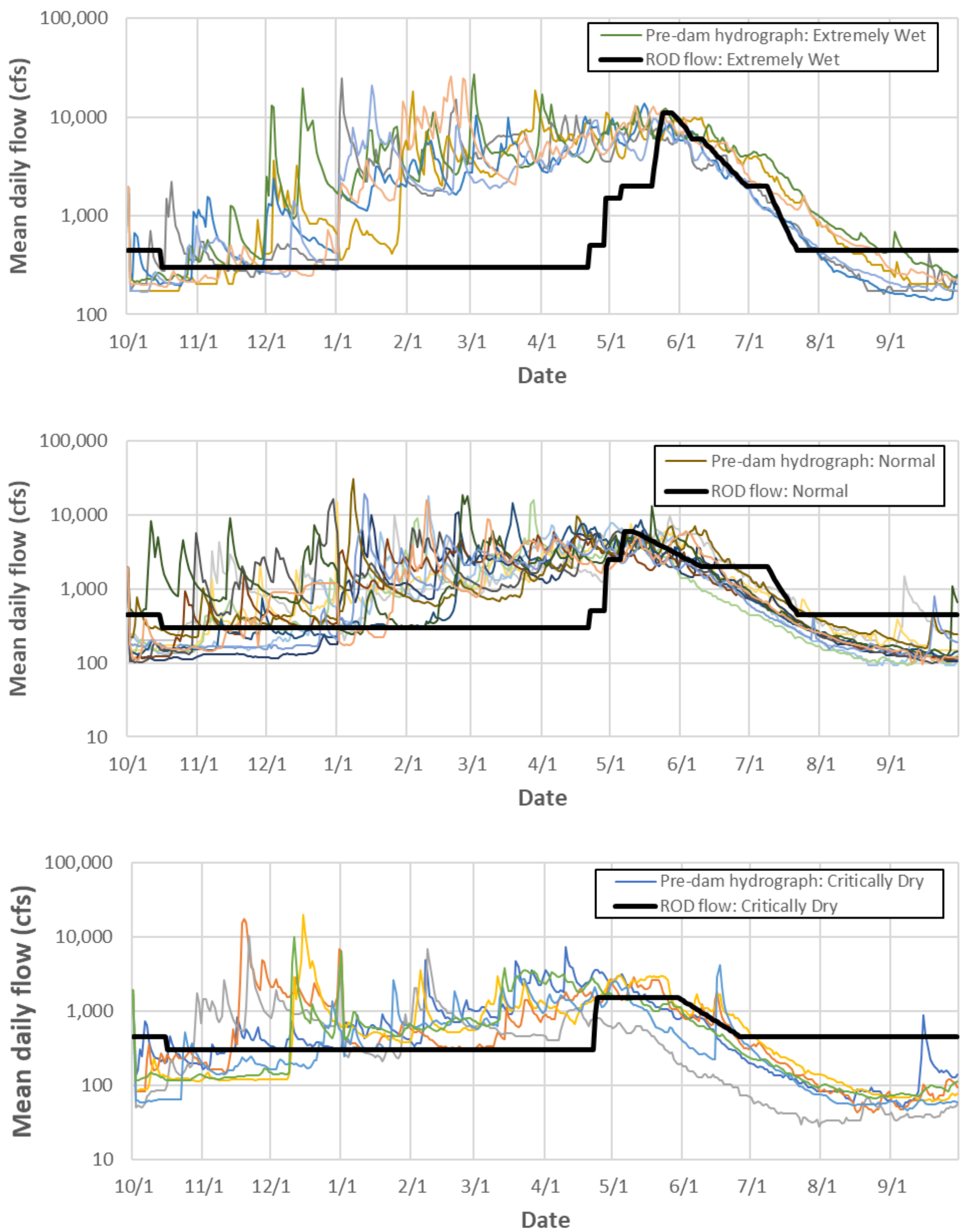
The natural flow regime of the Trinity River (as described in Section 3.1) consists of increasing and variable winter flows, a spring snowmelt peak, and a recession to low summer and fall baseflows. The annual ROD releases were developed to strike a compromise between a more natural regime, where flow volume varies based on water year type, and the need to consistently, reliably, and predictably release a reduced inflow volume (i.e., inflows minus exports) on an annual basis. For example, under the current ROD release structure, the majority of annual water volume is released after April 15 (Figure 4-3), once the Bulletin 120 water year type determination is made and there is certainty as to what volumes are available for release (Figure 4-2).



Data sources: Pre-dam hydrographs: USGS gage 11525500 Trinity River at Lewiston California, 1912 – 1960; post-dam ROD flows: USDOI 2000.

Figure 4-2. Mean Daily Flow Prior to Development of the Trinity River Division, and Mean Daily Flow by Water Year Type as Prescribed in the ROD

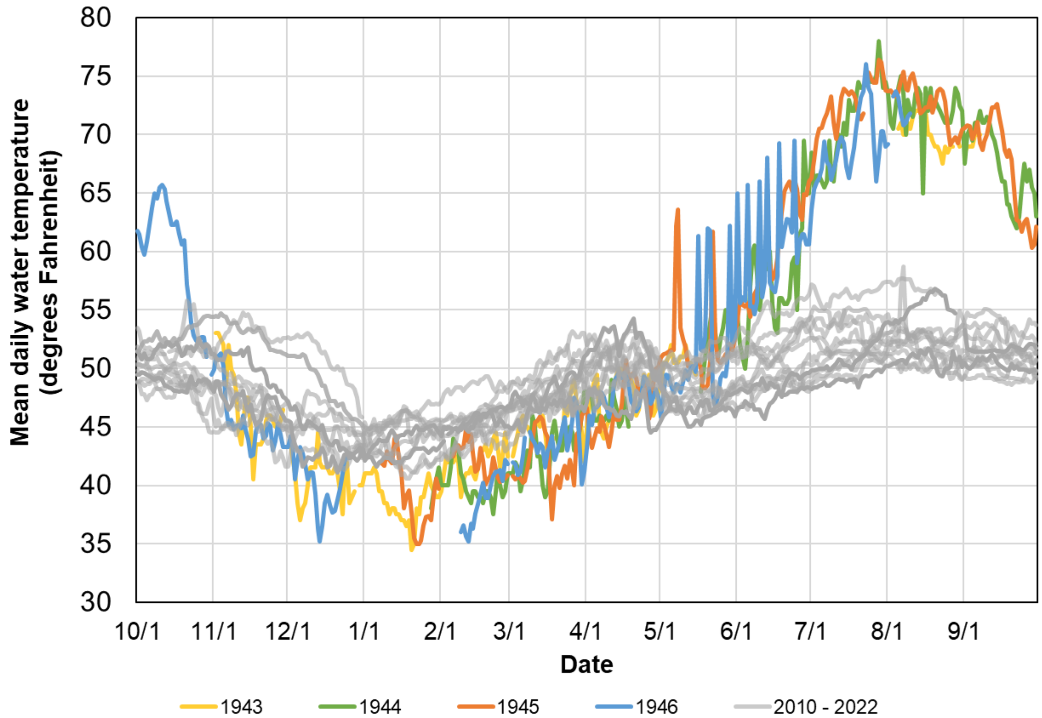
On a mean daily flow basis, there are at least three major natural hydrograph components that are not captured in the ROD releases in all or most water year types (see Figure 4-3). In winter, the river experienced large magnitude, short duration flood peaks and ascending baseflows from January until the snowmelt peak runoff, whereas the ROD flows prescribe a static 300 cfs baseflow release throughout this period. From October to April 15, the current ROD flow regime maintains a baseflow of only 300 cfs, releasing approximately 20 percent of the entire water year's total flow (TRRP and Reclamation 2021), compared to the pre-dam 50 percent average. In spring, the magnitude of the snowmelt peak runoff was typically lower than the peaks prescribed by the ROD regimes, and the timing was slightly earlier or later in the year. In late summer, ROD flows are slightly higher than natural summer baseflows in most water year types.



Data sources: Pre-dam hydrographs: USGS gage 11525500 Trinity River at Lewiston California, 1912 – 1960; post-dam ROD flows: USDOI 2000.

Figure 4-3. Mean Daily Flow by Water Year Type Prior to Development of the Trinity River Division (Pre-Dam Hydrograph), and Mean Daily Flow as Prescribed in the ROD. Top: Extremely Wet. Middle: Normal. Bottom: Critically Dry.

The water temperature regime in the Trinity River has also been modified since the operation of the TRD and implementation of the TRRP ROD flows. Prior to the TRD, water temperatures in Trinity River were cool and relatively stable during winter months, with a gentle rise into the snowmelt peak (Figure 4-4). Temperatures rose rapidly during the snowmelt recession, peaking in July and August near Lewiston (70 to 75 °F). At this point, salmonids were typically further upstream than Lewiston and were not subject to these water temperatures. After the summer peak, water temperatures declined during summer baseflow months. Currently, Trinity Lake provides colder deep-water (hypolimnetic) releases during the late spring/summer and warmer water temperatures during the winter due to the thermal stratification within the lake. Additionally, thermal impacts in late spring and early summer now extend farther downstream below Lewiston Dam due to high-magnitude flow releases (USFWS and HVT 1999). As a result, the annual regime of mean daily water temperatures follows roughly the same trend as the historical temperature regime, but now shows less variation in the range of temperatures throughout the year (40 to 60 °F near Lewiston), with a notable drop in water temperatures in April and May at the initiation of the ROD flows.



Data sources: 1943 – 1946: Moffett and Smith (1950); 2010 – 2022: CDEC Station LWS (Lewiston)

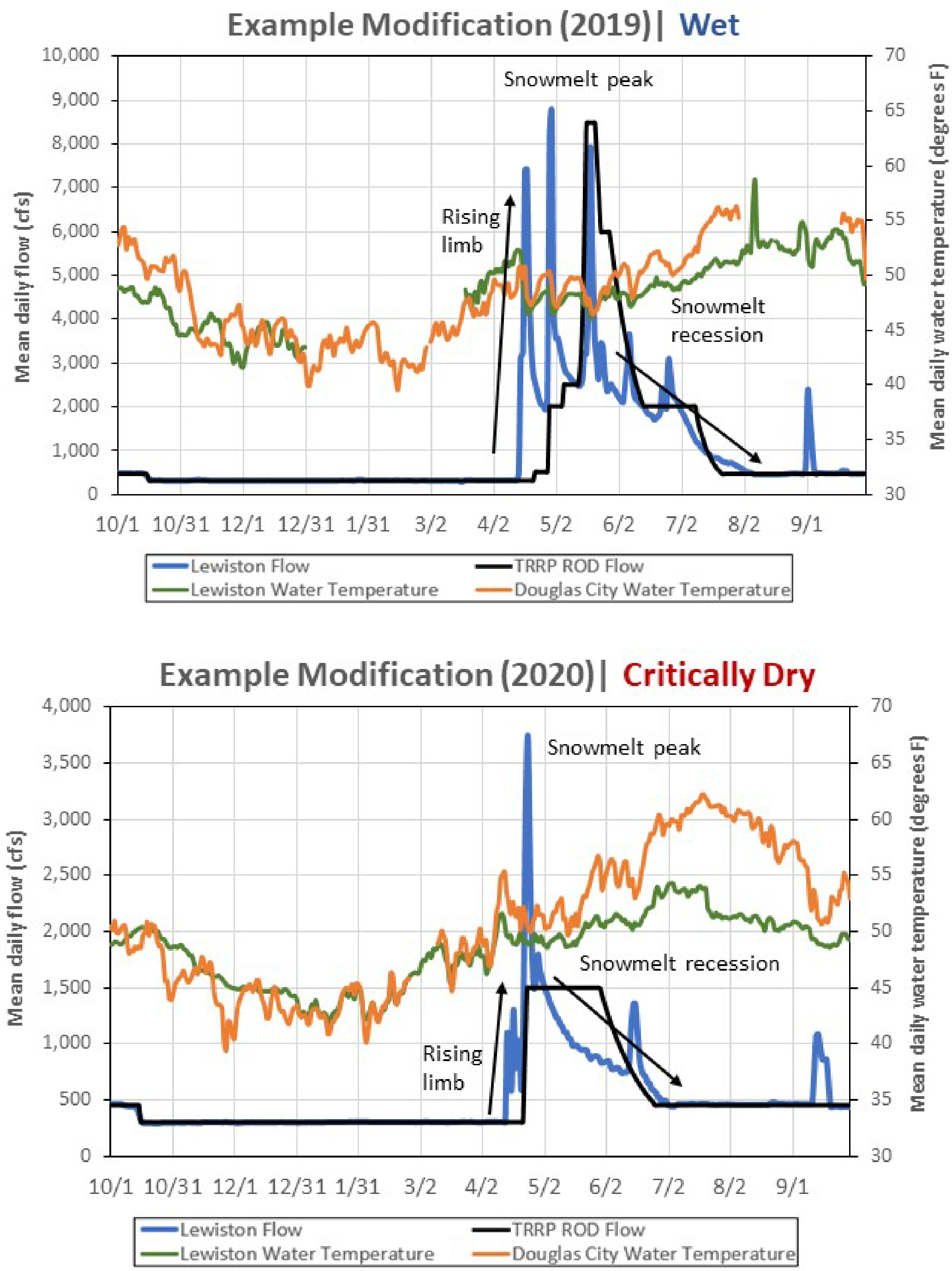
Figure 4-4. Mean Daily Water Temperature for the Trinity River near Lewiston

4.3 Recent Flow Modifications

The TRRP ROD established an adaptive management process through its AEAM Program to guide annual restoration water allocation, stipulating that "based on subsequent monitoring and studies guided by the TMC, the schedule for releasing water on a daily basis, according to that year's hydrology, may be adjusted but the annual flow volumes established…may not be changed" (USDOI 2000). The TRRP Flow Workgroup regularly meets to develop annual flow release scheduling modifications for restoration flow releases. These modifications may change the shape, but not the total release volume, of the annual ROD hydrograph to meet water year specific objectives (see example years in Figure 4-5). Non-restoration flows, typically during the summer, include the Klamath late summer emergency augmentation flows, releases for dam safety, and releases for Native American ceremonies and may not be modified under this agreement. By 2015, the Flow Workgroup developed a portfolio of at least 24 official hydrograph alternatives across the five water year types (TRRP 2015). Across the most recent 10-year period between 2011 and 2021, the ROD flow modifications focused on only two of the five natural hydrograph regime components, primarily due to management constraints: the snowmelt peak runoff and the snowmelt recession periods (Table 4-1).

More than half of the flow adaptations between 2011 and 2021 modified the snowmelt peak runoff period. In 6 out of 10 years, the modified hydrograph opted for an earlier spring ramp up compared to the ROD schedules, which was aimed at expanding the amount of habitat and food supply for juvenile salmonids earlier in the year, optimizing temperatures for rearing salmonids, and providing elevated flows to disperse steelhead hatchery smolt (TRRP 2013, Stewart 2016, TRRP 2018, Buxton 2021a, Buxton 2022). The magnitude of the snowmelt peak flow was increased in 6 out of 10 years to provide flows to initiate geomorphic changes including: scour the channel to clear pathway for gravels, provide flows for gravel augmentation, transport sediment, recruit leaf litter and nutrients into the channel, scour encroaching vegetation, and create side channel and pool habitat (Krause 2012, Stewart 2016, TRRP 2016, Buxton 2021a, TRRP 2021, Buxton 2022). In 7 out of 10 years, the length of the spring peak flow was shortened—this was primarily to accommodate an earlier, extended, gentle spring recession, but one report cited an objective of decreasing sediment hysteresis, which refers to the tendency for different sediment concentrations to occur at identical stream discharges of the rising versus the falling stages of a flood hydrograph (Wittler et al. 2013).

The snowmelt recession component was also modified in most years during this 10-year period. An earlier, slower, extended recession was recommended to gently increase temperatures for smolt outmigration and aid with regeneration and establishment of riparian vegetation and floodplains (Krause 2012, TRRP 2013, Wittler et al. 2013, Stewart 2016). Short duration benches, where flow is kept completely static for several consecutive days, were added in 2011 through 2017, but this was primarily to provide stable flows for habitat monitoring and did not have an objective specifically to benefit fish. In recent years (2016-2021), small, short duration peaks were added to the recession to provide flow variability that better mimics the natural stream system which was hypothesized to increase habitat diversity and ecological functions as well as variably inundating floodplains to recruit food and nutrients into the channel (Buxton 2019, Buxton 2020, Buxton 2021a). In some years, an elevated flow in June was added to disperse hatchery steelhead and Chinook Salmon, but these flows were not considered part of the restoration release objectives because they did not target natural origin fish in the Trinity River (Buxton 2020, Buxton 2021a).



Note: Summer peak releases in August and September were not restoration releases.
Data sources: Lewiston flow from USGS gage 11525500 Trinity River at Lewiston California, Lewiston water temperature from CDEC Station LWS, Douglas City water temperature from CDEC Station DGC.

Figure 4-5. Example Mean Daily ROD Flows (black line) and Flow Modifications (blue line) Implemented in a Wet (top) and Critically Dry (bottom) Year and Resulting Water Temperatures

Table 4-1. Recent ROD Flow Modifications and Proposed Modifications Summary

			Water Year Type	*W*	*N*	*D*	*CD*	*D*	*W*	*EW*	*CD*	*W*	*CD*	*CD*		
#	**Hydrograph Component**	**Sub-component**	**Modification**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Humboldt County Draft Proposal[1]**	**Winter Flow Project[2]**
1	**Winter baseflows**		Variably elevate baseflows												x	x
2	**Winter flood peaks**		Release a high magnitude pulse flow												x	x
3	**Snowmelt peak runoff**	**Rising limb**	Earlier ramp up			x				x	x	x	x	x	x	x
			Extend ramp up								x		x	x	x	
			Bench(es) on rising limb			x									x	
			Increase rate of ramp up	x					x	x		x				
			Decrease rate of ramp up								x		x	x	x	
			One or more peaks/variability						x		x	x	x	x	x	
		Peak flows	Earlier peak flow	x					x	x		x				
			Delay peak flows								x					
			Higher magnitude peak flow	x				x	x		x		x	x		
			Shorten the length of peak flow		x	x				x	x	x	x	x		
			Initiate multiple flood peaks						x		x	x				
			Ramp up to additional bench/peak							x		x	x	x		
			Diurnal variability in discharge								x	x				
4	**Snowmelt recession**		Earlier recession	x	x				x	x		x	x	x		x
			Slow rate of recession	x	x				x	x		x	x			
			Short-duration benches	x	x	x	x	x	x	x						
			One or more small peaks						x	x	x	x	x	x		
			Increase rate of recession													x
5	**Summer baseflows**		5-day pulse flow for Boat Dance ceremony[3]	x		x		x		x		x		x		
			Klamath River late summer flow augmentation or emergency flows[3]					x	x				x	x		

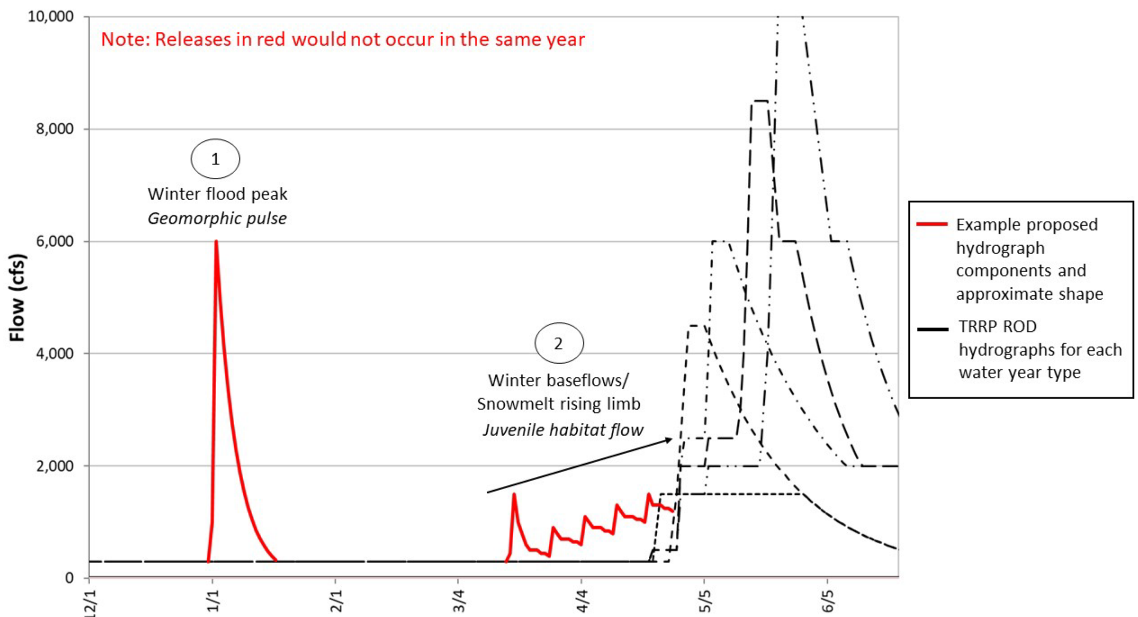
Source: [1]USFWS and NOAA 2018, Naman 2018, [2]TRRP and Reclamation 2022
Key: CD = Critically Dry; D = Dry; EW = Extremely Wet; N = Normal; W = Wet
Note: [3]Non-Restoration flow releases

4.4 Recent Studies

Several recent studies have analyzed, to varying degrees, the effects of flow modifications in the Trinity River on salmonids or the potential effects of flow modifications and augmentation on salmonids and their habitat. These studies are summarized below.

4.4.1 Draft Humboldt County Contract Water Study (2018)

Between 2016 and 2018, Humboldt County, USFWS, and NMFS coordinated in a planning and analysis effort for a proposed release of 50,000 acre-feet of Contract Water from Lewiston Reservoir. A release pattern was developed with two modified hydrograph components: increased winter baseflows to increase rearing habitat and a geomorphic pulse flow in winter (Figure 4-6).



Source: Modified from Naman 2018.

Figure 4-6. Preliminary 50,000 Acre-Feet Flow Release from the Humboldt County Contract Water Draft Study.

The winter baseflow component was defined as rising pulses and benches during winter baseflows, starting in March, to increase juvenile salmonid habitat. The purpose of the initial peak to 1,500 cfs was to entrain leaf litter, detritus, and terrestrial insects into the river, providing foraging opportunities for rearing salmonids as well as a variety of benefits to riverine ecological processes. The peaks and recessions that follow were meant to simulate increases and decreases in discharge following wintertime storm events which would have occurred naturally prior to dam flow regulation. The rationale for these releases was based on investigations into juvenile Chinook Salmon outmigration between 2003 and 2016 that found approximately 60 percent of Chinook Salmon had reared and outmigrated before the ROD snowmelt peak flow increase in April, indicating the majority of juvenile Chinook Salmon were not able to access valuable floodplain and side channel habitat while rearing (Petros et al 2017). USFWS and NMFS modeled and analyzed the potential benefit of this Contract Water release, relative to the baseline ROD hydrograph, in a Dry year for the Restoration Reach and showed a 10 percent increase in salmonid rearing habitat capacity over the 6-week augmentation period (USFWS and NOAA 2018).

The USFWS and NMFS team also proposed a hydrograph for the Trinity River that would release Contract Water as a geomorphic pulse flow synchronized with a natural high flow event. The goal of the geomorphic pulse flow was to scour and fill the channel, transport sediment, and prevent encroachment of riparian vegetation to create and maintain habitats for all salmonid life stages. A geomorphic pulse flow with a one-day magnitude of 6,000 to 8,000 cfs and an appropriately timed 16-day descending limb was determined possible using a volume of 50,000 acre-feet. The analysis assumed 6,000 cfs flow measured at the Junction City gage would trigger the 6,000 cfs geomorphic pulse release from Lewiston Dam, resulting in a roughly one day 12,000 cfs pulse magnitude at Junction City (Naman 2018). In years when the trigger was not met, a habitat release similar to that described above would be made. Using historic post-ROD flow data from 2003 to 2018, a geomorphic pulse flow would have been made 4 times, a habitat release would have been made 12 times, and there would have been an 8 year consecutive period (2007 to 2014) when no pulse flow was made. Additional pulse flow triggers were considered, including two consecutive years without a significant flow event, large sediment input from a tributary that poses a habitat degradation threat, or construction of a new channel rehabilitation site. The geomorphic pulse flow magnitude of 6,000 cfs at Lewiston is not likely to increase risk of redd scour. A study at the Sheridan Bar site[4] directly below Lewiston Dam, where spawning rates are typically high; determined that flows in the range of 6,000 cfs are unlikely to completely mobilize the armor layer and allow deep scour or the flushing of fine sediment from a substantial portion of the bed (May et al. 2007). The study also suggested redd site selection preferences based on depth, velocity, grain size, and proximity to the streambank corresponded to areas that were least likely to be mobilized or at risk of deep scour during high flow events.

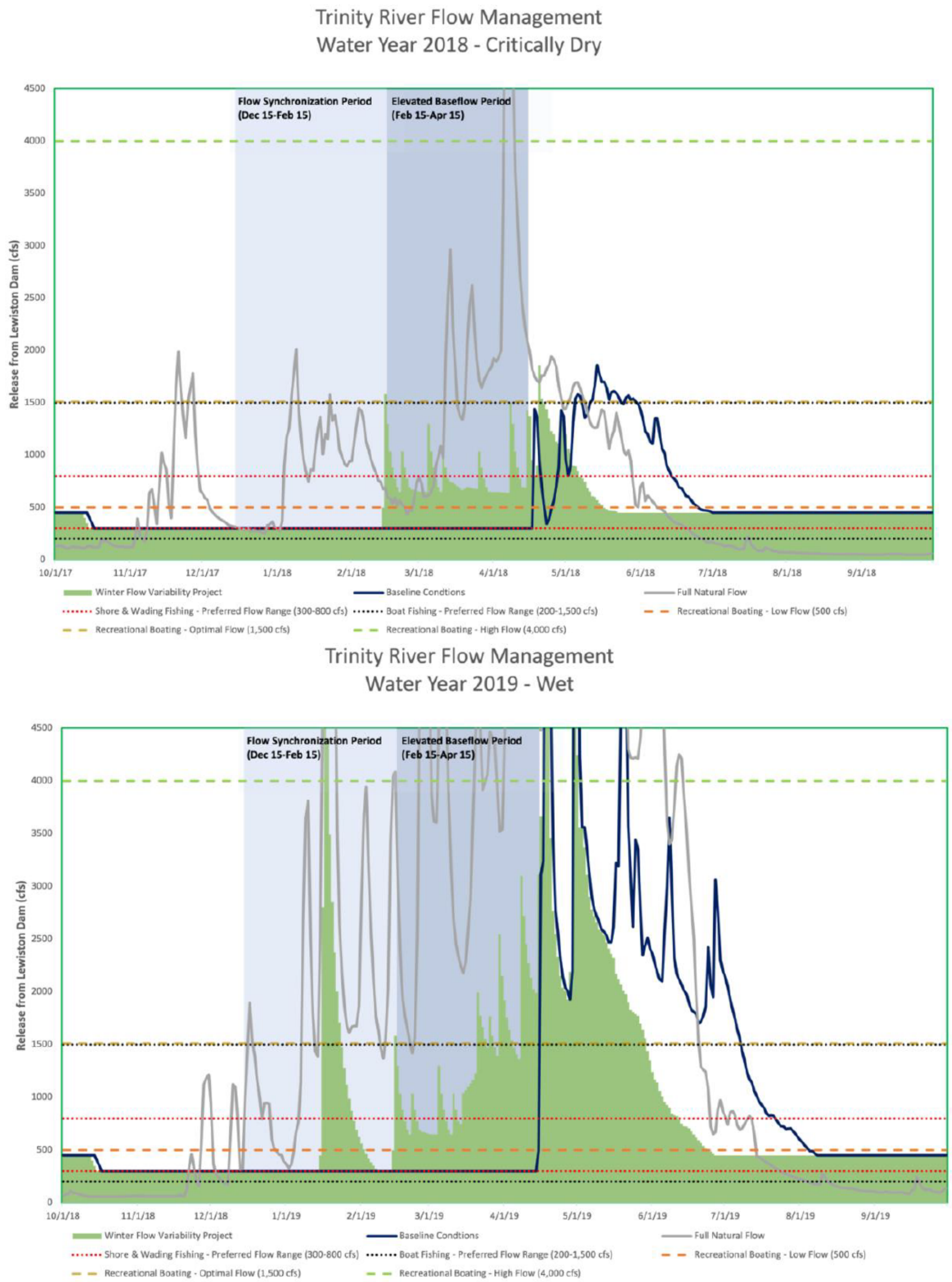
4.4.2 Winter Flow Project (2022)

The Trinity River Winter Flow Project (Winter Flow Project) studied modifications the timing of ROD flows intended to increase spawning and rearing habitat and to enhance river conditions for salmon and steelhead (TRRP and Reclamation 2022). The proposed action of this project would shift a portion of ROD flows to the winter period to better-mimic natural flow variability, inundate rearing habitats prior to fry emergence, reduce cold water suppression of juvenile salmonid growth in spring and early summer, create seasonally appropriate scour to promote primary production and drift foraging opportunities for juvenile fish, and encourage earlier outmigration (TRRP and Reclamation 2022). The Winter Flow Project identified timing of ROD flows as the main impediment to optimizing flow benefits for salmonids—therefore, volumes of water could be shifted to different times of the year to improve conditions without adding or subtracting from the annual volume. Releases did not target specific objectives or limiting factors, allowing for flexibility in management. Similar to the proposal developed in the Draft Humboldt County Contract Water Study, the Winter Flow Project identified the addition of a winter flood pulse and increased, variable winter baseflows as flow modifications that would provide additional benefits for fish.

A decision tree to guide timing and volume of flow releases that vary by water year type rather than prescribing a specific hydrograph shape (see example hydrographs in Figure 4-7). Typically, water would be removed from the spring period by truncating or shortening the duration of the receding limb of the spring recession period for use in the preceding winter period. Under the Winter Flow Project, Reclamation would distribute the spring water between two winter periods: the Flow Synchronization Period (December 15 – February 15) and the Elevated Baseflow Period (February 15 – April 15). During the Flow Synchronization Period, an average daily flow release of up to 6,500 cfs would be synchronized with a flow trigger event of 4,500 – 12,000 cfs as

[4] Constructed as part of TRRP Lewiston-Dark Gulch Project.

measured at the North Fork Trinity River gage to provide a geomorphic pulse flow. During the Elevated Baseflow Period, a volume of 0 – 120 TAF in years where the trigger occurred and 60 – 180 TAF in years where the trigger did not occur would be used to variably increase baseflows until March 15. After March 15, until April 15, an additional 20 – 60 TAF of water would be used to continue the elevated variable baseflows, depending on the water year type and whether the flow trigger had occurred.



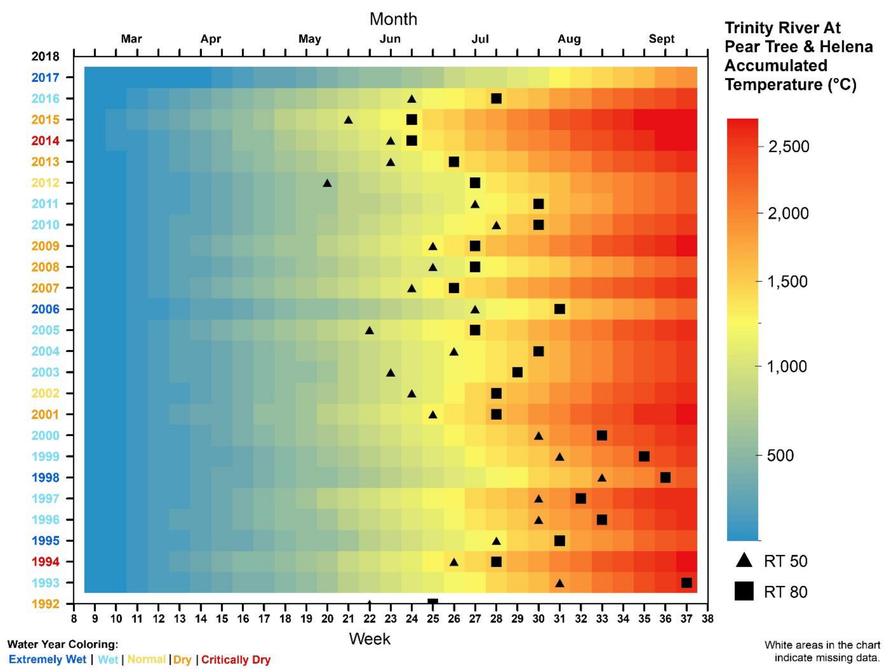
Note: The blue line represents the hydrograph that was implemented while the green represents the timing of hypothetical water releases that could occur under the Winter Flow Project
Source: TRRP and Reclamation 2022

Figure 4-7. Two Example Hydrograph Scenarios that Could Occur Under the Winter Flow Project in a Critically Dry (top) and Wet (bottom) Year

4.4.3 Willow Creek Outmigrant Trap Study (2021)

A recent study published by Gast & Associates (2021) used long-term data collected at the Willow Creek outmigrant trap on the Trinity River to assess the relationships between the timing of outmigration of Chinook Salmon juveniles and river temperature at Pear Tree. Despite the removal of certain riparian vegetation areas resulting from TRRP channel widening projects, the riparian corridor of the Trinity River throughout the Restoration Reach has remained nearly constant in size between 2003, when TRRP channel rehabilitation projects were initiated, and 2014, however, the corridor has increased in complexity (Alvarez et al 2015). (near North Fork Trinity River) and USGS gage 11530000 at Hoopa. Key data evaluated included emergence date, redd counts, discharge, fish length frequency, and fish condition. Bioenergetics analysis was used to compare Chinook Salmon juvenile growth between emergence and outmigration across years, and the Hoopa Daily Accumulated Temperature (HDAT) model (Hayden and Heacock 2014) was used to relate juvenile Chinook Salmon run timing to accumulated water temperature. The study found that accumulated temperature at Pear Tree (above the confluence with the North Fork Trinity River) was the best predictor of outmigration timing of Chinook Salmon (Figure 4-8). The bioenergetic analysis indicated that juvenile consumption rate and growth were highest in February through April due to higher discharges but decrease in May during colder ROD flow releases (Gast & Associates 2021).

These analyses suggest that warmer water temperatures during the spring would increase the potential for juvenile growth and suggest that the warmer water would encourage earlier outmigration. This is predicted to enhance fish survival by increasing smolt size and reducing their risk of parasitic infection, which increases as temperatures rise in the late summer months. Additionally, juvenile populations have been trending upwards since implementation of the TRRP and ROD flows, which focused primarily on increasing the volume of spring flows.



Note: RT50 = Date at which 50% of juvenile Chinook Salmon pass the Willow Creek trap; RT80 = Date at which 80% of juvenile Chinook Salmon pass the Willow Creek trap.
Key: °C = degrees Celsius. Source: Gast & Associates 2021

Figure 4-8. Accumulated Temperature Units at Pear Tree Starting Julien Week 9 with Mark Recapture RT50 and RT80 Dates

4.5 Preliminary Release Objectives

The preceding sections were the main subject of Workshop 2, which concluded in a discussion among workshop participants to define preliminary Contract Water release objectives. The following summarizes the main topics of discussion.

4.5.1 Timing of Use of Contract Water

There was general consensus that Contract Water should not be released to supplement the ROD flow increased snowmelt peak runoff releases in April through July. The main rationale provided was additive release of Contract Water to ROD flows during this time would likely decrease water temperatures, and low water temperatures have been shown to slow juvenile salmonid growth and potentially delay outmigration (Gast & Associates 2021). Contract Water released during the snowmelt peak would also counter the effects of the Winter Flow Project (TRRP and Reclamation 2022), which proposed shifting ROD flows from the summer period to earlier in the spring to improve temperature conditions for juvenile salmonids.

Contract Water releases were suggested to end around April 15, which is the typical start date for when the TRRP Flow Workgroup proposes elevating ROD flows. This date is approximately two weeks after DWR finalizes Bulletin 120, and at this time the water year type designation and subsequent ROD flow schedule for the remainder of the water year is set.

4.5.2 Limiting Factors to Target

Under the ROD hydrograph, baseflow is dropped from 450 cfs to 300 cfs in mid-October, when the natural flow regime generally shows an increase in baseflow at this time (see Figure 4-3). Studies have shown that ascending baseflows during this time could help distribute spawning adults and increase availability and spatial variation of spawning habitat (Goodman et al. 2018). It was noted that once baseflows are increased, they should not be decreased back to 300 cfs before fish have emerged from the gravel, to prevent dewatering redds.

Several types of geomorphic pulse flows were encouraged, and their benefits discussed:

- Recent work by the TRRP Fish and Flow Workgroups highlighted the importance of disturbing the riverbed so insects can colonize gravels at the correct time of year to provide a food resource for juvenile fish in the spring. January or February was proposed as the best time to provide bed disturbance to promote insect growth, and this was identified as an important portion of the hydrograph that is entirely missing right now but could provide benefits for juvenile salmonid rearing.

- There is a common misconception that in Dry and Critically Dry years there are no flows high enough to be considered a geomorphic flow. While these years may not have a high year-end volume, there are usually at least one or two flow events each year downstream of the Restoration Reach with a high enough peak flow to produce geomorphic scouring.

- Within the Winter Flow Project (TRRP and Reclamation 2022), releases of 3,500 cfs from Lewiston Dam were identified as the minimum threshold for when geomorphic work occurs downstream in the Trinity River in the Restoration Reach. However, this is a low threshold that would entrain mostly sand and silt and maybe small gravel.

- The magnitude of a flow increase varies with water year type and can change the mechanism through which fish obtain food. Juvenile salmonids get food through two primary mechanisms: 1) drift feeding of benthos, which is highly dependent on macroinvertebrate productivity in the channel, and 2) feeding from inundation of lateral habitat (i.e., floodplains and side channels). While the first mechanism is directly related to the bed disturbance regime produced by a geomorphic pulse flow, the second occurs mainly in wet years with elevated baseflow that may result in some degree of floodplain inundation. The second mechanism may be more important to productivity since it more broadly increases the lateral extent of wetted area and habitat. Therefore, there may not need to be a geomorphic flow in the channel every year. Geomorphic flows will always provide ecosystem benefits in the appropriate time of year, but it's more important to understand which components of the current hydrograph are missing and what ecological services they provided. Peak flows provide disturbance and geomorphic functions, but elevated winter baseflows can provide more lateral inundation which is highly important for fish productivity.

High water temperatures in late summer could potentially be reduced by holding Contract Water as carryover within the water year (i.e., not releasing it), and releasing it the next water year. The additional storage of 50,000 acre-feet may not produce significant temperature benefits, but should be assessed. The use of 100,000 acre-feet of Contract Water in the subsequent year (50,000 acre-feet of carryover plus 50,000 acre-feet for the next water year) could be used to target multiple limiting factors (e.g., habitat and geomorphology), and should be considered as a scenario.

4.5.3 Preliminary Release Recommendations

Based on the suggested timing of Contract Water releases and limiting factors to target, a set of preliminary release recommendations was developed in Workshop 2. These recommendations will form the starting point for Workshop 3, which is intended to develop up to four unique Contract Water release scenarios.

Table 4-2. Preliminary Contract Water Release Recommendations

Hydrograph Component	Modification	Limiting factor category	Ecological Services
Fall baseflows	When baseflow drops to 300 cfs October 15, add increasing levels of baseflow until December 1	Habitat	Increase spawning habitat area through increased wetted area for redd establishment and potential reduction in redd superimposition, increase rearing habitat
	Add flow peaks synchronized with storm events (release less than 3,000 cfs from Lewiston Dam)	Habitat	Distribute leaf litter for masticating insects, recruit organic matter for primary production, recruit terrestrial insects for food production, entrain benthic invertebrates into the water column for food. Inundate floodplains for juvenile habitat and juvenile growth.
Winter baseflows	Add increasing levels of baseflow from December 1 until April 15	Habitat	Increase spawning habitat area through increased wetted area for redd establishment and potential reduction in redd superimposition, increase rearing habitat
Winter flood peaks	Implement a high magnitude short duration geomorphic pulse flow below redd scouring flows (6,000 to 8,000 cfs). With or without synchronization with tributaries.	Geomorphology, Habitat	Promote sediment and large wood transport, clear out tributary deltas, help reset gravels for invertebrate production
Snowmelt peak runoff	Recommendation not to add Contract Water releases during this time	N/A	N/A
Snowmelt recession	Recommendation not to add Contract Water releases during this time	N/A	N/A
Summer baseflows	Recommendation not to add Contract Water releases during this time	N/A	N/A
Carryover	Carryover storage may not have appreciable water temperature benefits in a single year, but carryover of 50 TAF for use of 100 TAF in the following year should be considered for scenario analysis targeting the modifications above or others	Water Quality, Habitat, Geomorphology	Optimize water quality (temperature), habitat and geomorphic flows with use of carryover in a second year

Key: cfs = cubic feet per second, TAF = thousand acre-feet

5 MODELING AND TECHNICAL ANALYSIS FRAMEWORK

This section describes the set of existing numerical modeling tools being adapted to analyze how effective different Contract Water release scenarios may be at increasing salmonid production in the Trinity River. The tools will produce quantitative metrics that will help guide refinement and selection of a release scenario to include as the proposed action in the Water Management Plan. A more detailed description of the models, inputs, outputs, and assumptions will be provided in the Hydrologic Modeling Technical Report and the Fish Habitat, Fish Production, Water Temperature, and Hydraulic Analysis Technical Report, to be completed in 2023.

5.1 Modeling Overview

As a starting point, the modeling framework will adapt core elements of the Decision Support System (DSS) proposed by the TRRP Science Advisory Board (Buffington et al., 2014). The DSS is a series of linked physical and biological models that simulate the management of flow in the Trinity River and the subsequent effects on water temperature, sediment, habitat availability, and fish production. Some form of the DSS has been used to assess flow modifications proposals over the past five years, including annual TRRP hydrographs recommended to the TMC (See Section 4.3) and the Trinity River Winter Flow Variability Project (See Section 4.4.2).

An overview schematic of the modeling framework is shown in Figure 5-1, with component models, inputs, and outputs shown as boxes and linkages between the components shown as arrows. A brief description of each model and modeled process is provided in the following sections.

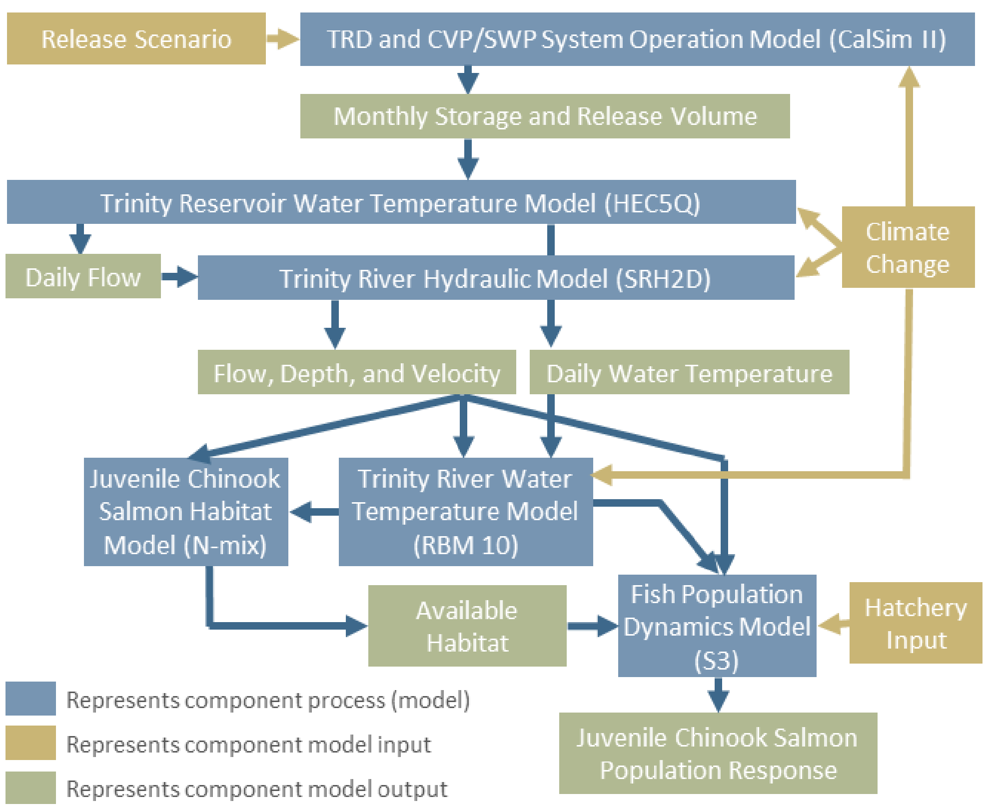


Figure 5-1. Modeling and Technical Analysis Framework for Analyzing Contract Water Release Scenarios

5.1.1 CalSim II

CalSim-II was jointly developed by Reclamation and DWR for performing planning studies related to CVP and SWP operations. The primary purpose of CalSim-II is to evaluate the water supply reliability of the CVP and SWP under existing and future conditions (e.g., 2022, 2030), which can vary in terms of assumed future facilities and modes of facility operations. Geographically, the model covers the drainage basin of the Delta, CVP (including imports from the Trinity River watershed), and SWP deliveries to the Tulare Basin, and SWP deliveries to the San Francisco Bay Area, Central Coast, and Southern California.

CalSim-II typically simulates system operations for an 82-year period using a monthly time step. The model assumes that facilities, land use, water supply contracts, and regulatory requirements are constant over this period, representing a fixed set of conditions (existing or future). The historical flow record of October 1921 to September 2003, adjusted for the influence of land-use change and upstream flow regulation, is used to represent a range of possible water supply conditions. Often, a future condition is represented by augmenting the adjusted historical flow record to incorporate the effects of climate change as predicted by specific global climate change models. Results from a single CalSim-II simulation may not necessarily correspond to actual system operations for a specific month or year, but they are representative of general water supply conditions. Model results are best interpreted using various statistical measures such as long-term or year-type averages.

A benchmark CalSim-II model is maintained and updated on a semi-regular basis by Reclamation and DWR. The benchmark model reflects the most recent operational and regulatory assumptions used by Reclamation in planning studies. A benchmark CalSim-II model obtained from Reclamation and dated 04/18/2022 will be used to support the technical analysis in the Water Management Plan.

5.1.2 HEC-5Q

The Trinity-Sacramento River HEC-5Q Water Quality model is a HEC-5Q-based (one-dimensional) reservoir and river water quality and temperature model of the Trinity Upper Sacramento River system including Trinity Dam and Reservoir, Trinity River to Lewiston Reservoir, Lewiston Dam and Reservoir, Clear Creek Tunnel, Whiskeytown Dam and Reservoir, Clear Creek below Whiskeytown Dam, Spring Creek Tunnel, Shasta Dam and Reservoir, Keswick Dam and Reservoir, Sacramento River from Keswick to Knights Landing, Red Bluff Diversion Dam, Black Butte Dam, and downstream Stony Creek. The Trinity-Sacramento River HEC-5Q model was developed using integrated HEC-5 and HEC-5Q models. The HEC-5 component of the model simulates reservoir and river flow operations (usually daily). The HEC-5Q component is a 1-dimensional (1-D) water quality model that simulates reservoir and river temperatures and other water quality parameters based on the flow inputs and meteorological parameters. The model operates on a 6-hour time step to capture diurnal temperature fluctuations.

A version of the Trinity-Sacramento River HEC-5Q model was obtained from Reclamation to conduct an analysis of alternatives for the Klamath LTP EIS (Reclamation 2017). This version of the model included recent updates, calibration and verification, and modified meteorological and equilibrium temperature data to incorporate a 2030 level of climate change, consistent with the climate change approach used in the LTO EIS (Reclamation 2015). The model is set up to simulate the full CalSim II model 82-year simulation period (water years 1922 through 2003) on a 6-hour time step using daily flow data, which includes a spreadsheet pre-processing tool to disaggregate the mean monthly CalSim II reservoir operations and stream flows to daily values for use in the simulation. The 6-hour time step allows for analysis of diurnal temperature fluctuations required for the fishery analysis. The HEC-5Q model used for the Klamath LTP EIS will be used to support the technical analysis in the Water Management Plan, and the pre-processing tool will be modified to calculate daily releases for Contract Water release scenarios.

5.1.3 SRH-2D

Reclamation's Sedimentation and River Hydraulics model (SRH-2D) is a two-dimensional (2D) flow hydraulic and mobile-bed sediment transport model for river systems. SRH-2D is used to evaluate river hydraulics including water surface elevations, flow velocity, shear stress, and sediment mobilization.

In 2015, a two-dimensional SRH-2D model was developed of the Trinity River from Lewiston Dam to the junction with the North Fork Trinity River at the request of the TRRP. The model predicts the spatial patterns of water depth, velocity, and shear stress, which have been used as input values to other models that estimate the location, quantity, and quality of salmonid habitat. The SRH-2D model has also been used to select sites on the river for habitat restoration work, to evaluate proposed restoration designs, and as the hydraulic input to a fish production model. The initial version of the model was based on topography and bathymetry surveyed in 2011 and 2012 (Bradley 2016). The Trinity River was re-surveyed in 2016, and the hydraulic model was updated to reflect changes in river morphology, both natural and constructed, between the two bathymetric surveys. The model has been recalibrated based on new observations of water surface elevation and run for approximately 20 different discharges (Bradley 2018). The updated 2018 SRH-2D model will be used to support the technical analysis in the Water Management Plan.

5.1.4 River Basin Model 10

River Basin Model 10 (RBM10) is a one-dimensional (1D) water temperature model that predicts daily water temperatures along the longitudinal profile of a river. The model uses a simple equilibrium flow model, assuming discharge in each river segment on each day is transmitted downstream instantaneously, and a heat-budget formulation that quantifies heat flux at the air-water interface using daily mean meteorological data. A version of the model was developed to simulate 112.2 river miles of the Trinity River. The modeling domain was divided into eight reaches ranging in length from 8.8 to 20.6 miles, which were calibrated and validated separately with observed water temperature data collected irregularly from 1980 to 2013 (Jones et al. 2016). The same model was modified to account for climate change conditions centered around the year 2030 and used to simulate future water temperatures in the Trinity River for the Klamath LTP EIS (Reclamation 2017). This RBM10 model will be used to support the technical analysis in the Water Management Plan.

5.1.5 Micro-Habitat Model

A juvenile Chinook Salmon microhabitat model developed by Som et al. (2018) uses continuous measures of depth, velocity, and cover distance to estimate habitat quality over a range of discharge levels. The model produces an instantaneous (daily) maximum capacity of fish to occupy individually delineated meso-habitat units. The micro-habitat model has been explicitly parameterized for the Trinity River (Perry et al. 2018), with a spatial domain that includes the Restoration Reach delineated into 356 contiguous meso-habitat units comprised of three distinct meso-habitat types: riffles, runs, and pools. The bathymetric template of the Restoration Reach used to parametrize the micro-habitat model is the same bathymetric template used to develop the SRH-2D model (Bradley 2018). The micro-habitat model parameterized to the Restoration Reach (Perry et al. 2018) will be used to support the technical analysis in the Water Management Plan.

5.1.6 Stream Salmonid Simulator

Stream Salmonid Simulator (S3) is a deterministic life-stage-structured population model that simulates growth, movement, and survival between spawning and outmigration or ocean entry. The S3 model is based in concept on SALMOD, a fish production model with a long history in the Klamath Basin. The model was developed based on the idea that flow affects temperature and habitat availability, which influences density-dependent processes. Model inputs include water temperature, discharge, hatchery and tributary abundances, and spawning distribution/abundance, which is then used to produce major outputs of juvenile fish abundance, size, and biomass.

An S3 model was constructed and parameterized for spring-run and fall-run Chinook Salmon of the Restoration Reach of the Trinity River (Perry et al. 2016). This model will be used to support the technical analysis in the Water Management Plan.

5.2 Baseline Assumptions

To implement the modeling framework and develop a consistent set of output metrics to analyze Contract Water release scenarios, several assumptions within and across models are made.

5.2.1 No Project and Proposed Project Conditions

For modeling purposes, the Water Management Plan will consider a No Project condition and a Proposed Project condition. The No Project condition will reflect TRD water management consistent with current regulatory and operational regimes, while the Proposed Project condition will integrate one preferred Contract Water release scenario into the operation of the TRD. This operation will assume Contract Water releases are made from Proviso 2 water, i.e., a separate annual volume above and beyond the Proviso 1 obligations currently modeled in CalSim-II. The preferred Contract Water release scenario will be identified through future workshops and will be selected from up to four initial Contract Water release scenarios. To the extent practicable, both the No Project and Proposed Project conditions will be based on a future condition centered around the year 2030, i.e., a future 20-year planning horizon (2021 – 2041).

A brief description of the main baseline assumptions is included in Table 5-1, and a more detailed table listing the baseline assumptions specific to CalSim-II will be included in the technical report.

Table 5-1. Baseline Assumptions for the No Project and Proposed Project

Regulation or Assumption	No Project	Proposed Project
HYDROLOGY AND CLIMATE CHANGE		
Planning horizon[a]	Year 2021	Same as No Project
Climate Change (See Section 5.2.2)	Hydrology and meteorological conditions based on projected changes over the 30-year climatological period centered on 2025 (i.e., 2011-2040)	Same as No Project
Sea Level Rise	15 cm	Same as No Project
Inflows/Supplies	Modified inflows based on historical hydrology projected 2020 modifications for operations upstream of the rim reservoirs	Same as No Project
Level of development	Projected 2030 level[b]	Same as No Project
TRINITY RIVER DIVISION OPERATIONS		
Minimum flow below Lewiston Dam	Trinity EIS Preferred Alternative (369-815 TAF/year)	Same as No Project
Trinity River Fall Augmentation Flows[c]	50 TAF total August 1 through September 30 in all but Extremely Wet years based on the Trinity River water year type I	Same as No Project
Trinity Reservoir end-of-September minimum storage	Trinity EIS Preferred Alternative (600 TAF as able)	Same as No Project
Proviso 2 releases to Trinity River	Not included	Based on Contract Water release scenarios
CENTRAL VALLY PROJECT/STATE WATER PROEJCT OPERATIONS		
Sharing of responsibility for in-basin-use	2018 Addendum to the 1986 Coordinated Operations Agreement	Same as No Project
Sharing of surplus flows	2018 Addendum to the 1986 Coordinated Operations Agreement	Same as No Project
Sharing of restricted export capacity for project-specific priority pumping	Sharing of export capacity under State Water Board D-1641, ROC on LTO, and ITP export restrictions as defined in the 2018 Addendum to the 1986 Coordinated Operations Agreement	Same as No Project
CENTRAL VALLY PROJECT/STATE WATER PROEJCT REGULATORY CONDITIONS		
NMFS and USFWS RPA Standards	2020 ROC on LTO of the CVP and SWP Biological Opinions	Same as No Project
SWP Restrictions	2020 Incidental Take Permit for the Long-Term Operation of the SWP	Same as No Project

Key:
cm = centimeter
CVP = Central Valley Project
EIS = Environmental Impact Statement
ITP = incidental take permit
LTO = Long-Term Operation
NMFS = National Marine Fisheries Service
ROC on LTO = Reinitiation of Consultation on the Long-Term Operation of the CVP and SWP
RPA = reasonable and prudent alternative
SWP = State Water Project
TAF = thousand acre-feet
USFS = United States Fish and Wildlife Service

Notes:
[a] These assumptions have been developed under the direction of the Bureau of Reclamation management team for the Re-initiation of Consultation on long-term operations of the CVP and SWP.
[b] The Sacramento Valley hydrology reflects 2020 land-use assumptions associated with Bulletin 160-98. The San Joaquin Valley hydrology reflects draft 2030 land-use assumptions developed by Reclamation.
[c] This assumed operation is not consistent with Klamath LTP EIS (Reclamation 2017). For implementation in the technical analysis, a daily pattern will be developed from these monthly volumes that mimics the Klamath LTP EIS to the extent possible.

5.2.2 Hydrology and Climate Change

Future climate change assumptions used in the technical analysis of the Water Management Plan will be consistent with those used to support the LTO EIS (Reclamation 2015). In that EIS, several climate change scenarios were developed from an ensemble of 112 bias corrected, spatially downscaled global climate model (GCM) simulations from 16 climate models of different emission scenarios. The GCMs were developed and refined in 2006 as part of the Coupled Model Intercomparison Project Phase 3 (CMIP3) and were used to simulate future projected hydrologic and meteorological changes over a 30-year climatological period centered on 2025 (i.e., 2011-2040).

To summarize these 112 scenarios, Reclamation developed five statistically representative climate change scenarios: (1) drier, less warming, (2) drier, more warming, (3) wetter, more warming, (4) wetter, less warming, and (5) a central tendency or central position of climate change. For the Water Management Plan, the central tendency scenario is selected to model the No Project and Proposed Project conditions in 2030, consistent with the LTO and with the future conditions assessed in the Klamath LTP EIS. To incorporate climate change into the hydrologic and meteorological conditions of CalSim-II and other models, historical streamflow and air temperature are perturbed by 2030 climate change conditions.

As applied in the LTO EIS and Klamath LTP EIS, climate change effects on hydrology were modeled by modifying historical runoff and streamflow. Changes to runoff and streamflow were estimated using a Variable Infiltration Capacity (VIC) model, then applied to runoff forecasts used for reservoir operations and allocation decisions, and to stream flow for all major streams in the Central Valley and Trinity River Basin. After determining the adjusted runoff and stream flows, water year types and other hydrologic indices that govern water operations or compliance were adjusted to be consistent with the new hydrologic regime. Changes in reservoir inflows, key valley floor accretions, and water year types and hydrologic indices were translated into modified input time series for the CalSim-II model. The resulting modeled monthly inflows to Trinity Reservoir in CalSim-II with and without the effects of 2030 climate change are shown in Figure 5-2.

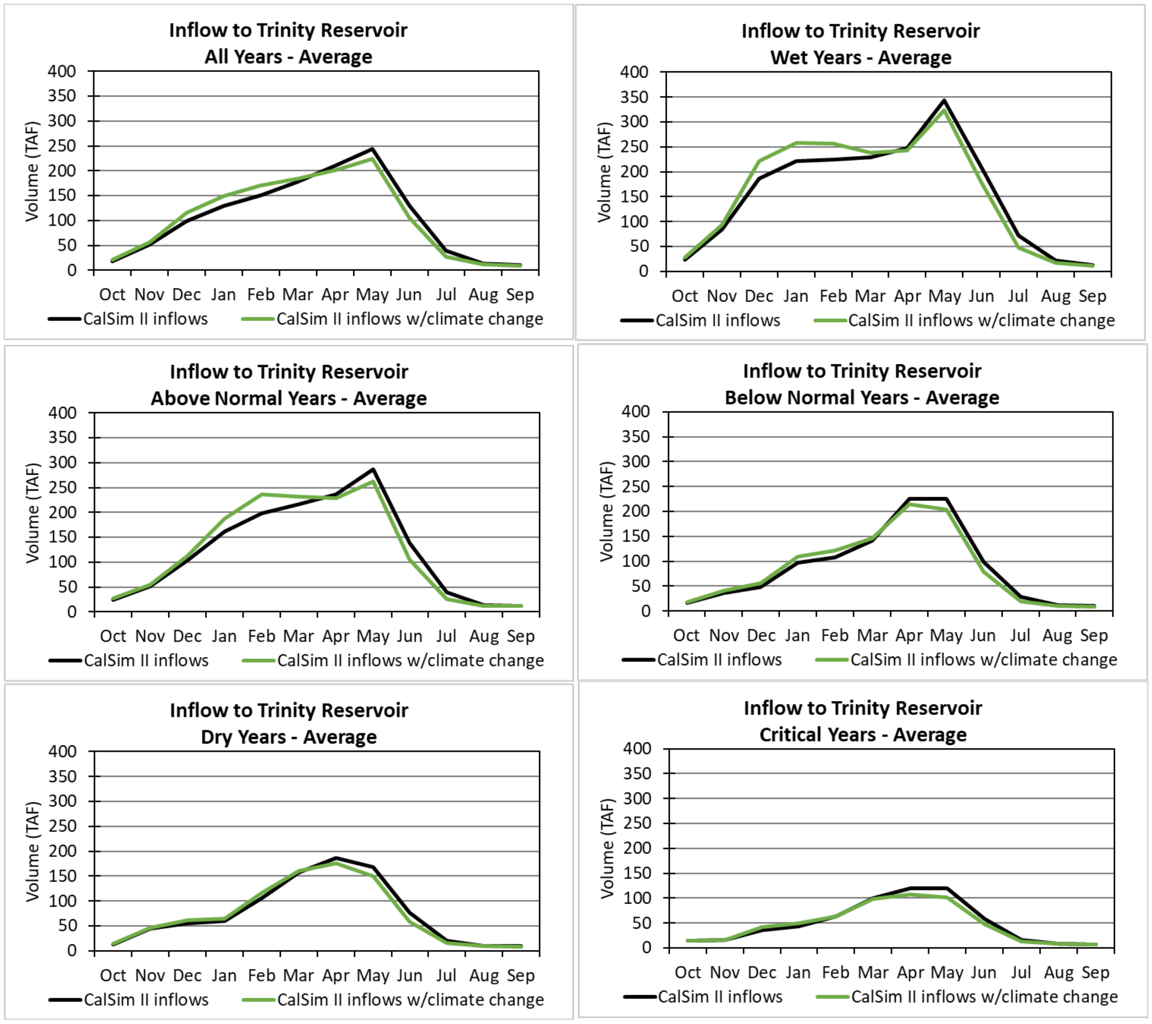


Figure 5-2. Comparison of Mean Monthly Trinity Reservoir Inflows in CalSim-II by Water Year Type with and Without the Effects of 2030 Climate Change

As applied in the LTO EIS and Klamath LTP EIS, historical 6-hour meteorological data derived from observed data from the Gerber and Nicolaus California Irrigation Management Information System (CIMIS) stations were adjusted to account for the effects of climate change. Historical equilibrium temperature (degrees Fahrenheit), coefficient of surface heat exchange (BTU/feet^2/day/°F), short wave solar radiation (BTU/feet^2/day), and wind speed (knots) were adjusted to the central tendency of 2030 climate change, then translated into an input time series for HEC-5Q. Mean monthly equilibrium temperature from HEC-5Q for Gerber station is shown in Figure 5-3 with and without the effects of 2030 climate change. In general, climate change effects include increased temperatures in all months, with greater increases in the warmer summer months. The average monthly temperature increased by 1.6 °F for Gerber station for all years under climate change conditions. Similar trends were observed for Nicolaus station, where average monthly temperatures increased by 1.9 °F for all years under climate change conditions.

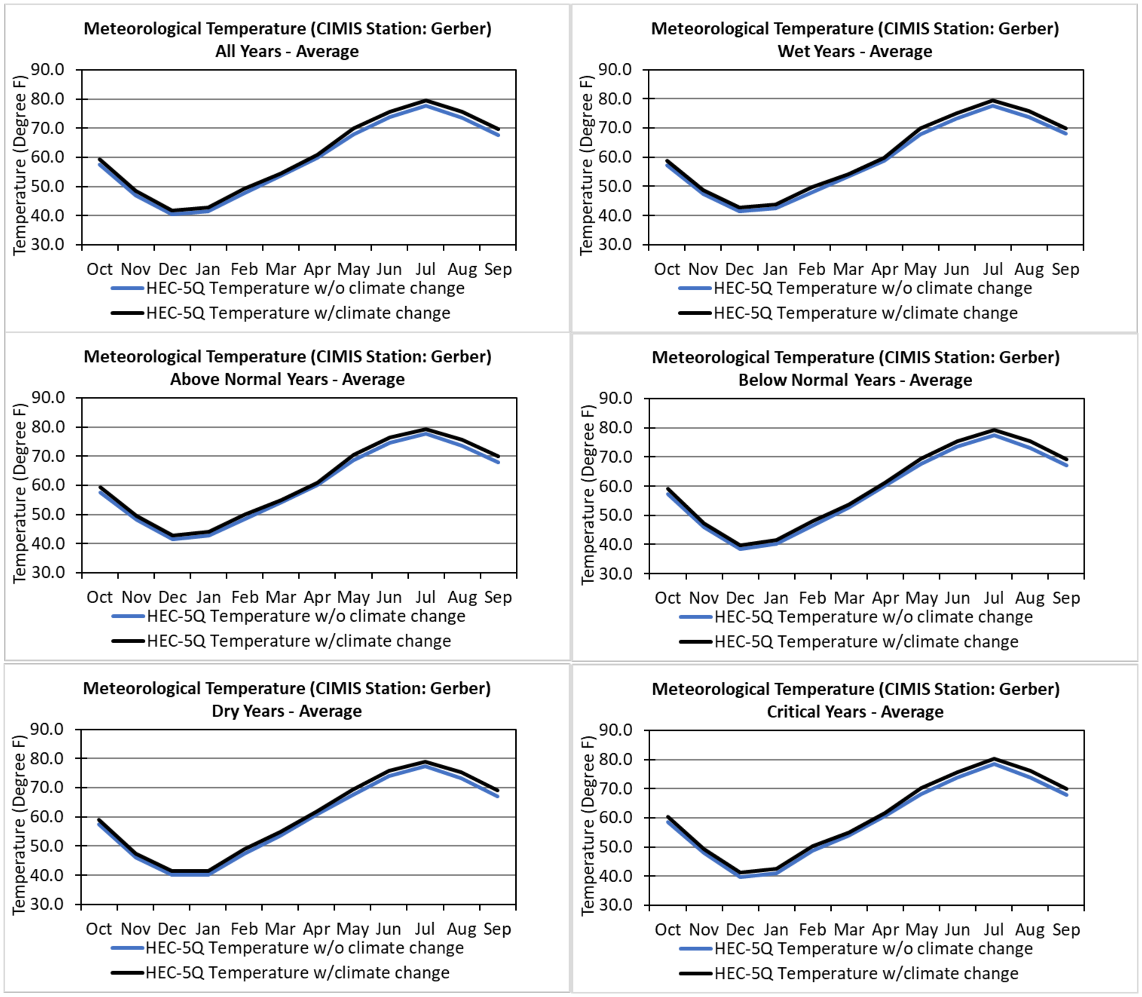


Figure 5-3. Comparison of Mean Monthly Air Temperature by Water Year Type at Gerber Station in HEC-5Q with and Without the Effects of Climate Change

5.2.3 Simulation Period and Model Output

Each model contains an established simulation period that will be used to model operations, physical processes, and biological responses (Table 5-2). For CalSim-II, model outputs are produced as a monthly timeseries. HEC-5Q converts monthly CalSim-II outputs into daily inputs based on a pre-processing tool, and then produces a daily timeseries of outputs. RBM10 routes daily flows and water temperatures from HEC-5Q down the Trinity River, producing a daily timeseries of outputs. The base simulation period for analysis of Contract Water release scenarios will be the overlapping period of record for these three models, 1980-2003. Both SRH-2D and the N-mix model rely on input values that reflect a specific daily value. These are not timeseries models – rather, for a given daily input value, they produce a daily output value. The S3 model uses daily input values to simulate growth, movement, and survival of juvenile salmonids. The model then simulates density-dependent population dynamics that are driven in part by pre-defined input spawner abundance values. Since there are limited spawner abundance estimates available prior to 2005, since the model does not explicitly reflect a historical condition prior to 2005, and since there is no water year correlation with spawner abundance, a high and low spawner abundance input scenario will be simulated for each year using flow conditions from 1980 – 2003. Results of high and low spawner abundance scenarios will be summarized by water year type.

Table 5-2. Simulation Period and Output Type for Each Model

Model	Simulation Period	Output Type
CalSim-II	1922 – 2003	Timeseries of monthly storage volume and release volume from Trinity Reservoir and Lewiston Reservoir
HEC-5Q	1922 – 2003	Timeseries of mean daily release rate and water temperatures from Lewiston Reservoir
RBM10	1980 – 2003*	Timeseries of mean daily water temperature along the Restoration Reach
SRH-2D	N/A	Instantaneous flow, depth, and velocity within specific channel segments based on an input flow value.**
Micro-habitat model	N/A	Daily habitat outputs within specific channel segments based on daily flow, depth, water temperature, and velocity inputs.**
S3	Annual	Annual population outputs, summarized by water year type, for both high and low spawner abundance input scenarios.***

Notes:
* The RBM10 modeling period will be limited to 2003 to be consistent with the operations, reservoir water temperature, and reservoir release temperature models which operate over a simulation period of 1922 – 2003. The current RBM10 model can simulate water temperatures up to 2015.
** Outputs are based on a static Trinity River bathymetric template that reflects channel conditions in 2018. Habitat restoration projects completed since 2018 represent proportionally a very small length of the total reach length. It was assumed the corresponding changes to hydraulics within the Restoration Reach from these projects are negligible, and model outputs thus reflect the current bathymetric template of the Trinity River.
*** The same two spawning abundance input scenarios will be run for each year of the simulation: high and low. Actual spawning abundance data from 2005 – 2018 will be used to populate each scenario.

A comparison of the water year types from 1980 – 2003 to the full historical period of record, 1912 – 2021, shows that wet and dry periods are represented relatively well in the abbreviated simulation period (Table 5-3).

Table 5-3. Water Year Type Distribution in the Simulation Period and the Historical Record

Time Period	1980 – 2003		1912 – 2021	
Water Year Type	**Number of Years**	**Percentage of Years**	**Number of Years**	**Percentage of Years**
Extremely Wet	4	17%	14	13%
Wet	9	38%	33	31%
Normal	2	8%	18	17%
Dry	7	29%	28	26%
Critically Dry	2	8%	13	12%

Key: % = percentage

5.3 Primary Analysis Variables

The modeling and technical analysis used to develop the Water Management Plan is structured to simulate and analyze long-term changes in local, regional, and statewide physical and biological systems due to a proposed operational change. The numerical models developed and applied in this technical analysis are generalized and simplified representations of complex water resources system and biological systems with uncertainty in inputs and boundary conditions. The models are not predictive models in how they are applied for this technical analysis, and therefore, results cannot be used to predict a future state of a system at a specific point in time. Even so, the models used are informative and helpful in understanding the performance and potential impacts (both positive and negative) of Contract Water release scenarios. Even though some of the models used in this planning analysis (e.g., RBM10) are calibrated and validated to represent physical processes, all the models used in the analysis should primarily be used to understand potential long-term average trends and reasonably foreseeable absolute impacts of a Contract Water release scenario. Modeling results will be presented as a relative comparison between Contract Water release scenarios and the No Project scenario by comparing long-term average annual values, long-term average monthly values, and long-term average annual and monthly values by water year type.

Output variables from all models will be assessed to determine the effects of Contract Water release scenarios (Table 5-4). Outputs from CalSim-II will be used primarily to assess monthly storage in and releases from Trinity Lake and Lewiston Reservoir, and the monthly volume of exports from Lewiston Reservoir to the Sacramento River. Outputs from HEC-5Q will be used to assess daily water temperature of both releases from Lewiston Reservoir into the Trinity River and diversions from Lewiston Reservoir into the Clear Creek tunnel.

RBM10, SRH-2D, the micro-habitat model, and S3 will be used to assess relative changes in model output variables, within the Restoration Reach, between the No Project scenario and Contract Water release scenarios. Outputs from RBM10 will be used to assess relative changes in mean daily and mean monthly water temperature. Outputs from SRH-2D will be used to assess sediment transport variables, including bedload transport, bed mobilization, and bed shear. Outputs from the micro-habitat model will be used to assess relative daily and annual habitat capacity changes. Outputs from S3 will be used to assess relative changes in annual population.

Table 5-4. Primary Model Output Variables Used to Assess Contract Water Release Scenarios

Model	Primary Outputs to be Analyzed
CalSim-II	Monthly storage in Trinity Lake Monthly storage in Lewiston Reservoir Monthly exports to Clear Creek Tunnel
HEC-5Q	Mean daily release rate from Lewiston Reservoir Mean daily water temperatures from Lewiston Reservoir Mean daily water temperatures of diversions through the Clear Creek Tunnel
RBM10	Mean daily water temperature of the Trinity River within the Restoration Reach
SRH-2D	Annual coarse bedload transport potential Annual area of partial stream bed mobilization Relative risk of redd scour
Micro-habitat model	Daily juvenile Chinook Salmon rearing capacity within each meso-habitat unit of the Restoration Reach
S3	Annual biomass and abundance of juvenile Chinook Salmon

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