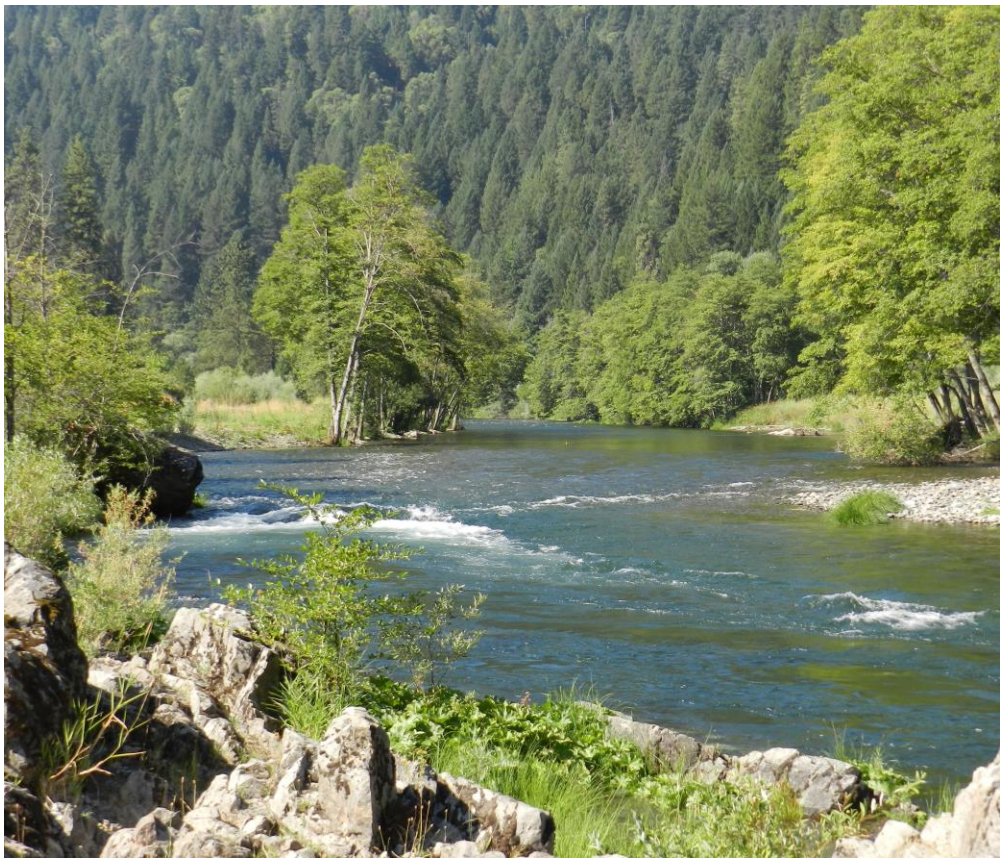
HUMBOLDT COUNTY WATER MANAGEMENT PLAN FOR TRINITY RIVER CONTRACT WATER: SUPPLEMENTAL FISHERIES RELEASES



Trinity River (Photo from Jeff Fortana, Bureau of Land Management)

Prepared for:	Humboldt County
Prepared by:	Stantec Consulting Services Inc.
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Executive Summary

In 1955, the United States Congress signed the Trinity River Division Act (1955 Act), which provided for the construction, operation, and maintenance of the Trinity River Division (TRD) of the Central Valley Project (CVP). Section 2 of the 1955 Act included two provisions, or Provisos, that limited 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." In 1959, the County of Humboldt and the United States Department of the Interior – Bureau of Reclamation entered into a contract for annual water releases of not less than 50,000 acre-feet from Trinity Reservoir into the Trinity River (Contract Water). This contractual right was also incorporated into Reclamation's eight water rights permits issued in 1959 for TRD storage and diversion.

Humboldt County has coordinated with Reclamation on potential calls for releases of Contract Water over the past several decades, but no releases of Contract Water have been made. In 2014, the Department of Interior Solicitor issued an opinion memo affirming the Bureau of Reclamation's obligation to fulfill its obligations under the contract with Humboldt County. The opinion memo also outlined actions required to implement releases of Humboldt County's Contract Water, which include a request to Reclamation from Humboldt County and other downstream water users for a release of water under Proviso 2, and an analysis by Reclamation to determine what operational, regulatory legal, or other actions may be necessary.

This Water Management Plan presents a proposal to release Contract Water as supplemental fisheries releases to enhance Trinity River fish populations and expand a harvestable surplus for tribal, recreational, and commercial fisheries that exceeds what is already required by applicable law and Proviso 1 of Section 2 of the 1955 Act. The main elements of the proposal include releases of supplemental baseflows from October through February in all years, release of supplemental fall pulse flows from October through December in most years, and release of supplemental baseflows from February through April in some years. The Water Management Plan is intended to guide decision-making over a 25-year planning period. As conditions within the Trinity River basin change over time, alternative proposed uses and release patterns of Contract Water may be considered, and implementation would be subject to the appropriate legal, regulatory, and contractual mechanisms.

The Water Management Plan was developed through a comprehensive process that included six workshops with interested parties to elicit feedback on Contract Water releases and implementation, completion of studies to identify needs and priorities for releasing additional water from Trinity Reservoir into the Trinity River to help restore natural processes and fisheries habitat and improve water quality, and completion of numerical modeling and technical analysis for a range of release scenarios. Contract Water release scenarios that had the greatest modeled increase in egg survival and juvenile Chinook Salmon abundance relative to baseline conditions were selected for inclusion in the Water Management Plan. Modeled beneficial effects on populations were primarily due to either (1) increases in habitat area during the spawning life stage in October through December, which decreased redd superimposition (e.g., the process of a later arriving spawner building a redd on top of an existing redd) and improved egg survival, or (2) increases in flow during the fry emergence and juvenile rearing life stage in March through April, which increased the fry and parr carrying capacity (e.g., the upper limit for the number of fry or parr that a habitat unit can support) of individual habitat units. Improvements to salmonid populations would have direct economic benefits to Humboldt County, Tribes, and surrounding areas, and other important social, cultural, recreational, and tribal benefits.

Acknowledgements

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Board of Supervisors
Department of Public Works

Agencies and Tribes

California Wildlife Conservation Board
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Non-Governmental Organizations

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Acronyms / Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
1-D	one-dimensional
2-D	two-dimensional
2021 LTO Consultation	2021 Reinitiation of Endangered Species Act Section 7 Consultation on the Long-Term Operations of the Central Valley Project and State Water Project
7DADA	7-day average of the daily average
AEAM	Adaptive Environmental Assessment and Management
AF	acre-feet
Basin Plan	Water Quality Control Plan for the North Coast Region
BO	Biological Opinion
CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
CESA	California Endangered Species Act
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CMIP3	Coupled Model Intercomparison Project Phase 3
CVO	Central Valley Operations
CVP	Central Valley Project
DOI	U.S. Department of the Interior
DSS	decision support system
DWR	California Department of Water Resources
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FNF	full natural flow
GCM	global climate model
HVT	Hoopa Valley Tribe
Ich	*Ichthyophthirius multifiliis*
KRFC	Klamath River fall-run Chinook Salmon
KRSC	Klamath River spring-run Chinook Salmon
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
MOA	Memorandum of Agreement
NEPA	National Environmental Policy Act
NCRWQCB	North Coast Regional Water Quality Control Board
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOD	North-of-Delta
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
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
S3	Stream Salmonid Simulator
SOD	South-of-Delta
SRH-2D	Sedimentation and River Hydraulics model
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TMC	Trinity Management Council
TRD	Trinity River Division
TRFES	Trinity River Flow Evaluation Study
TRH	Trinity River Hatchery
TRRP	Trinity River Restoration Program
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

1 INTRODUCTION

Humboldt County has a contractual right to annual water releases of not less than 50,000 acre-feet (AF) 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 Public Law 84-386 (PL 84-386), also known as the Trinity River Division Act (1955 Act) and consummated in a 1959 water contract signed by Humboldt County and the U.S. Department of the Interior, Bureau of Reclamation (Reclamation). The 1959 Contract is attached as Appendix A. Humboldt County has coordinated with Reclamation on potential calls for release of Contract Water over the past several decades. However, Reclamation has not released Contract Water, citing the need for additional information and regulatory compliance actions. The purpose of this document is to describe a Water Management Plan for release of Contract Water to benefit fisheries for Humboldt County residents and visitors over the next 25 years.

1.1 Trinity River Division

In 1949, 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 storage 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 and Bay Area 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 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).

In 1955, the U.S. Congress authorized the TRD through the 1955 Act. Construction of the TRD was complete in the early 1960's, and operation of the TRD commenced in 1963. The primary storage reservoir for the TRD is Trinity Reservoir (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 Reservoir (also known as Lewiston Lake), a regulating reservoir formed by Lewiston Dam approximately seven miles downstream. At Lewiston Dam, water can be diverted to the Sacramento River Basin through a tunnel/penstock system into Whiskeytown Reservoir or released downstream into the Trinity River.

1.2 Contract Water History

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:

> *"Provided* [Proviso 1], That the Secretary is authorized and directed to adopt appropriate measures to insure the preservation and propagation of fish and wildlife, including, but not limited to, the maintenance of the flow of the Trinity River below the diversion point at not less than one hundred and fifty cubic feet per second for the months July through November and the flow of Clear Creek below the diversion point at not less than fifteen cubic feet per second unless the Secretary and the California Fish and Game Commission determine and agree that lesser flows would be adequate for maintenance of fish life and propagation

> thereof; the Secretary shall also allocate to the preservation and propagation of fish and wildlife, as provided in the Act of August 14, 1946 (60 Stat. 1080), an appropriate share of the costs of constructing the Trinity River development and of operating and maintaining the same, such costs to be non-reimbursable:
>
> *Provided further* [Proviso 2], 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 Reclamation and Humboldt County on June 19, 1959 (1959 Contract) (Reclamation 1959). Humboldt County's contractual right was also incorporated into Reclamation's eight water rights permits issued by the State Water Rights Board in 1959 for storage and diversion of the Trinity River[1].

Historically, Contract Water has not been released from Trinity Reservoir. In 2014, the U.S. Department of the Interior's (DOI) 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 the 1955 Act and Condition 8 of the 1959 Contract. To implement Contract Water releases, the 2014 DOI Solicitor's opinion recommended Humboldt County and other downstream water users submit a request to Reclamation for release of water under Proviso 2, and then Reclamation conduct an analysis "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."

In 2021, the California Wildlife Conservation Board approved a funding allocation to Humboldt County through the Stream Flow Enhancement Program to develop a Water Management Plan for utilization of Humboldt County's Contract Water. The project was designed to engage interested parties, perform technical analysis and modeling, and develop a Water Management Plan to guide decision-making over a 25-year planning period. Throughout 2022 and 2023, Humboldt County developed the Water Management Plan (Figure 1-1), holding six workshops to elicit feedback on Contract Water releases and implementation, completing studies to identify needs and priorities for releasing additional water from Trinity Reservoir into the Trinity River to help restore natural processes and fisheries habitat and improve water quality, and performing technical analysis and modeling for a range of release scenarios. Detailed work products from this process are attached to the Water Management Plan as appendices, including the Baseline Conditions Report (Appendix B), Modeling Report (Appendix C), and Workshop Summary Notes (Appendix D). The process culminated in this document, which serves as the Water Management Plan for Humboldt County Contract Water, and a formal request to release water under Proviso 2 into the Trinity River.

1.3 Purpose of Contract Water Releases

Through this Water Management Plan, Humboldt County is proposing to release Contract Water as supplemental fisheries releases to enhance Trinity River fish populations and expand a harvestable surplus for tribal, recreational, and commercial fisheries that exceeds what is already required by applicable law and Proviso 1 of Section 2 of the 1955 Act. The purpose of Contract

[1] The State Water Rights Board was the predecessor to the State Water Resources Control Board, Water Rights Division, the entity currently responsible for issuing, administering, and adjudicating water rights in the State of California.

Water releases would be to create missing elements of the natural flow regime, enhance habitat quality for fish and wildlife, improve ecosystem health and resilience, and increase opportunities for ocean and river salmon fishing. The proposed use of Contract Water would be as a non-consumptive, instream use. This proposal for initial uses of Contract Water does not preclude future consumptive uses of Contract Water or alternative future non-consumptive uses that may differ from this proposal.

Reclamation CVP water rights for the TRD and the 1959 Contract (See Sections 2.2.2 and 2.2.3, respectively) state Proviso 2 releases shall be made for the beneficial use of Humboldt County and other downstream users. Water appropriated under a California water right "must be for some useful or beneficial purpose" (California Code, Water Code - WAT § 1240), and specific beneficial uses are defined in the California Code of Regulations (Cal. Code Regs. Tit. 23, § 659). The proposed use of Contract Water in this Water Management Plan is consistent with the fish and wildlife preservation and enhancement beneficial use (Cal. Code Regs. Tit. 23, § 666), which is defined as "using water to maintain or provide habitat or other benefit for fish and wildlife by taking water under control". The proposed use of Contract Water is also consistent with current beneficial uses designated by the North Coast Regional Water Quality Control Board for the Trinity River and Klamath River (see Section 2.2.7), including 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 Native American culture.

1.4 Tribal Consultation

Over the past several years, Humboldt County has engaged with the Hoopa Valley Tribe and the Yurok Tribe in conversations regarding development of a proposed three-party Memorandum of Agreement (MOA) for the use and co-management of Contract Water. Those conversations are ongoing. Humboldt County supports continued discussions to work toward completion of an MOA so the three parties will be in the best position to provide optimal benefits to the fisheries of the Trinity River and downstream water users.

1.5 Document Organization

This Water Management Plan describes a specific annual Contract Water release of no less than 50,000 acre-feet. It was developed to provide sufficient detail so that Reclamation can conduct an analysis and determine what actions may be required to implement Humboldt County's water contract. This Water Management Plan is organized into three main sections:

- **Section 2. Background:** provides an overview of existing TRD facilities and operations, a summary regulatory history, and frames the need for the Contract Water releases proposed in this Water Management Plan.

- **Section 3. Scenario Development and Evaluation:** describes the multi-year process used to identify and evaluate potential Contract Water release scenarios, including results from a robust modeling framework used to simulate potential Contract Water release scenarios and demonstrate fisheries benefits relative to a baseline condition.

- **Section 4. Plan Elements:** provides a description of proposed Contract Water flow releases, including release objectives, release timing and duration, decision criteria for differentiating between release types, an annual implementation process, and potential benefits. The section also includes a discussion on regulatory compliance and permitting that may be necessary to implement proposed Contract Water releases.

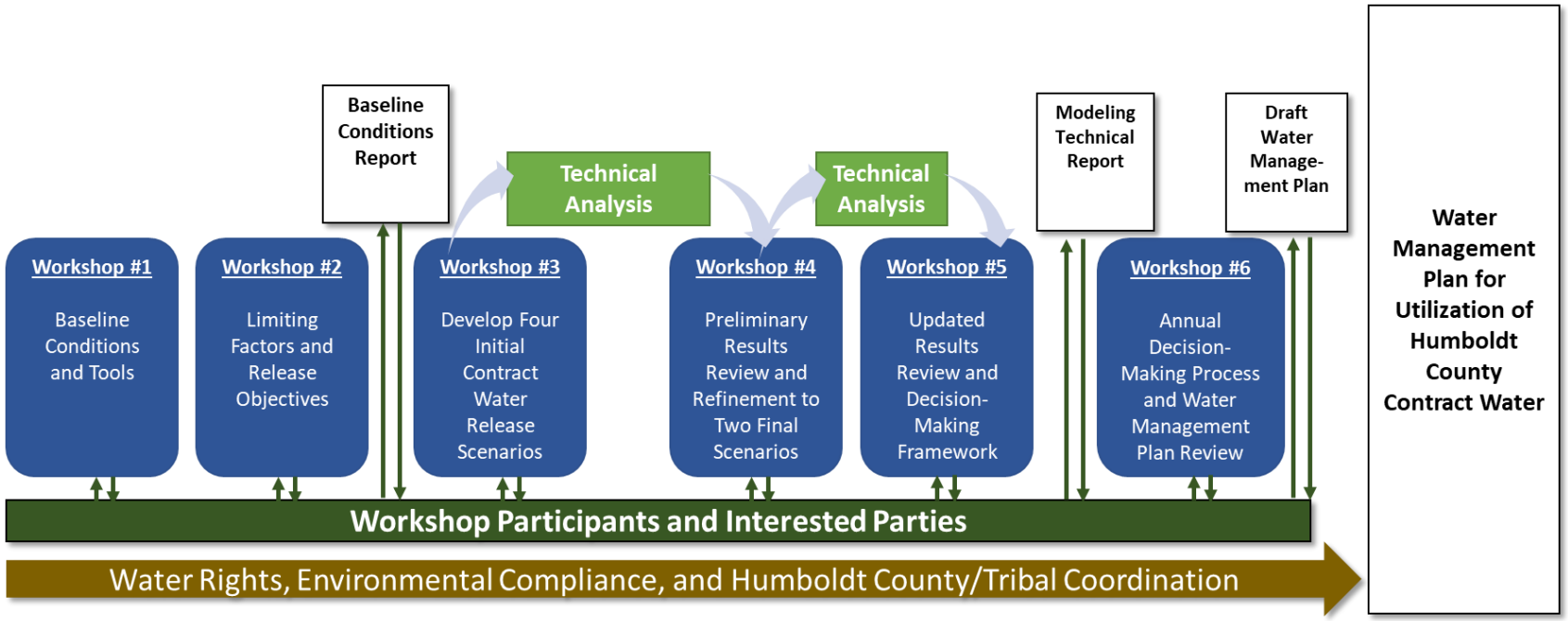


Figure 1-1. Process, Engagement, and Key Milestones Used to Develop the Water Management Plan

2 BACKGROUND

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 Reservoir, and later Lewiston Reservoir, both located in Trinity County (Figure 2-1). The Trinity River flows approximately 112 miles downstream from Lewiston Dam until it reaches the confluence with the Klamath River at Weitchpec. The Trinity River flows through Humboldt County for approximately 31 river miles and approximately 14% of the Trinity River watershed is situated within Humboldt County. 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.

Congress authorized the formation of the TRD as an integrated component of the CVP to increase water supplies for irrigation and other beneficial uses in the Central Valley. Between 1955 and 1964, TRD facilities were constructed along the Trinity River within Trinity and Shasta Counties. Trinity Dam, Lake, and Powerplant, Lewiston Dam, Reservoir, 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 Reservoir, a storage reservoir with total capacity of 2.4 MAF. 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. From Lewiston Dam, water may either be released downstream into the Trinity River or to the controlled Clear Creek Tunnel intake. Clear Creek Tunnel enables cross-basin transfers, diverting flows of up to 3,200 cubic feet per second (cfs) to Whiskeytown Lake where water may then be released into the Sacramento River Basin.

The Trinity River Hatchery (TRH) was constructed at the base of Lewiston Dam to provide mitigation for the loss of 109 miles of upstream anadromous salmonid riverine habitat caused by the construction of the Trinity and Lewiston Dams. Artificial propagation of Chinook Salmon, Coho Salmon, and steelhead from the TRH to the Trinity River has occurred since 1958. The hatchery, operated by the California Department of Fish and Wildlife (CDFW), releases approximately 1.4 million spring-run Chinook Salmon, 2.9 million fall-run Chinook Salmon, 500,000 Coho Salmon, and 800,000 steelhead annually into the Trinity River (fingerlings and yearlings combined) (NMFS 2009).

The Trinity River supports many different biological resources, as described further in Section 3.2. Water management for fisheries on the Trinity River system and lower Klamath River 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.

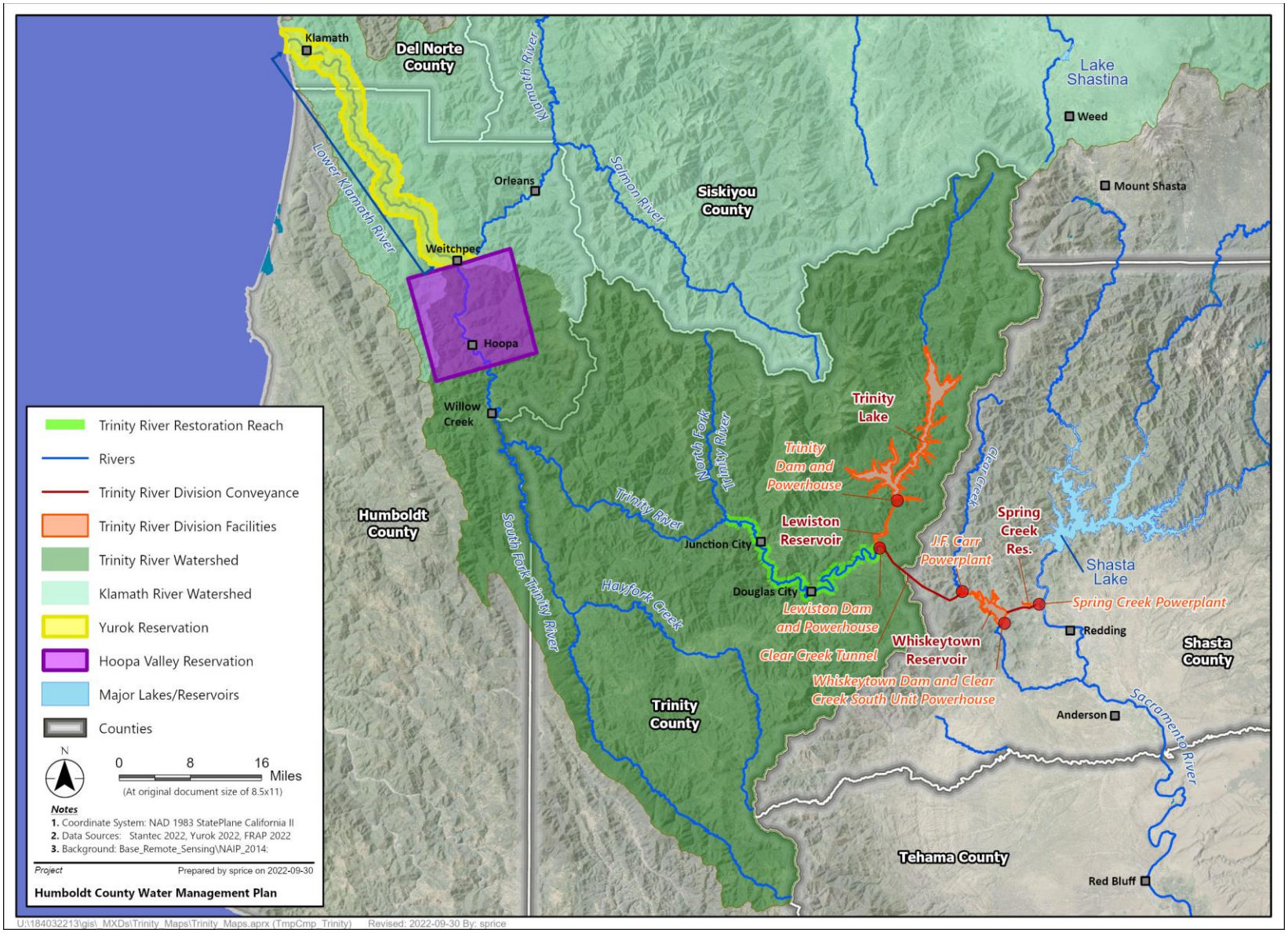


Figure 2-1. Major Facilities, Features, and Boundaries Associated with the Trinity River Division

2.2 Regulatory History

This section includes a summary of regulatory history relevant to the Water Management Plan. A more comprehensive history is provided in Appendix B, Sections 2.3 and 2.4.

2.2.1 1955 Act

In 1955, the U.S. Congress authorized the TRD in the 1955 Act. 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 stated "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".

2.2.2 Reclamation Water Rights

Between 1927 and 1956, Reclamation submitted eight water rights applications for the TRD (Table 2-1). Three water rights authorize the cumulative direct diversion of up to 3,700 cfs (3,200 cfs through the TRD and 500 cfs into the Trinity River) and diversion to storage of up to 2,500,000 acre-feet annually for power generation. The remaining five water rights authorize the cumulative direct diversion of 3,200 cfs through the TRD and diversion to storage of up to 2,500,000 acre-feet annually for municipal, industrial, irrigation, fish and wildlife propagation, navigation, water quality control, and recreation beneficial uses within the CVP place of use.

The State Water Rights Board held hearings on Reclamation's TRD permit applications from 1957 to 1959 and issued eight water rights permits for the TRD in September 1959. As a result of the hearing process, the State Water Rights 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. Permittee 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. Permittee 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 [acre-feet] af will be available for the beneficial uses of Humboldt County and other downstream users.*

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 River or Klamath River watersheds. The water right permits do not clearly specify whether there are any place of use limitations on Proviso 2 releases for consumptive or non-consumptive beneficial uses.

Table 2-1. 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 per 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, stock-watering, fish and wildlife propagation, water quality control and recreational	1,500	0	1,085,966.3	See Note 2.

Notes:

1. Water appropriated will be utilized through powerplants at 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 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.

Key: cfs = cubic feet per second

2.2.3 1959 Water Contract between Humboldt County and Reclamation

A contractual right for releases to Humboldt County under Proviso 2 was established in a water delivery contract executed between Reclamation and Humboldt County on June 19, 1959 (Reclamation 1959). The obligation under Proviso 2 to make water available to Humboldt County was formalized in Condition 8 of the 1959 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 1959 Contract is not conditioned on the volume of water stored in Trinity Reservoir nor on hydrological conditions. It does not address flow scheduling or whether unused volume in a given year may be rescheduled (carried over) for use in subsequent years. Additionally, the terms of the contract do not limit Humboldt County's right to a specific beneficial use, define a contract year, or contain an expiration date.

2.2.4 2000 Trinity River Mainstem Fishery Restoration Record of Decision

After the TRD became operational, salmonid fish populations in the Trinity River experienced a severe decline. In 1980, Reclamation prepared an Environmental Impact Statement (EIS) attributing depletion of fish populations in the Trinity River to multiple factors, including the effects of TRD operations leading to excessive streambed sedimentation and insufficient flows in the Trinity River. Over a 12-year period, the Trinity River Flow Evaluation Study (TRFES) was conducted by Reclamation and the Hoopa Valley Tribe, which concluded with a report released in 1999 documenting changes to the Trinity River since the implementation of the TRD (USFWS and HVT 1999). Coincident with the scientific efforts associated with the TRFES, the U.S. Fish and Wildlife Service (USFWS) and Trinity County began the public process to comply with the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA) by developing the Trinity River Mainstem Fishery Restoration EIS/Environmental Impact Report (EIR) in 1994. Following extensive scoping efforts, a draft EIS/EIR was developed in 1999, and following review and comments from Tribes, agencies, stakeholders, and the public, a Final EIS/EIR was published in 2000 (USFWS et al. 2000). A Record of Decision (ROD) was issued by the Secretary of the Interior and the Hoopa Valley Tribe in 2000 (USDOI and HVT 2000). 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 Adaptive Environmental Assessment and Management (AEAM) Program.

Most consequential of these actions to flow management of the TRD was an increase in flow volume released to the Trinity River. The ROD defined five water year types and established annual release volumes ranging from 368 TAF to 816 TAF, with specific daily flow patterns based on water year type (see Section 2.3). These flows are referred to as ROD flows or ROD releases within this document.

The 2000 ROD also established the framework for the Trinity River Restoration Program (TRRP). The TRRP is a multiple partner program with eight partners and numerous other collaborators; together these partners comprise the Trinity Management Council (TMC) which operates much like a Board of Directors for decision-making processes within the charter of the TRRP. Since 2001, the TRRP has implemented most components of the 2000 ROD preferred alternative, including flow management, mechanical channel rehabilitation, infrastructure improvements or modifications, sediment management, watershed restoration within the Trinity River watershed, and adjustments to ROD flows based on the principles of adaptive management.

2.2.5 2014 Department of the Interior Solicitor's Opinion on Section 2 of the 1955 Act

In 2014, the DOI Solicitor issued an opinion outlining their legal interpretation of Section 2 of the 1955 Act and the corresponding 1959 Contract (USDOI 2014). The opinion stated the two provisos of the 1955 Act "represent separate and independent limitations on the TRD's integration with, and thus diversion of water to, the CVP," and clarified that "water envisioned in Proviso 2 does not necessarily fall within the volumes released pursuant to Proviso 1." This opinion affirmed Reclamation's statutory obligation to release water for Humboldt County's beneficial use as provided for in Proviso 2 of the 1955 Act and Condition 8 of the 1959 Contract.

The 2014 DOI Solicitor's opinion also outlined actions required to implement releases of Humboldt County's Contract Water:

> *"Based upon this legal analysis, 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.*
>
> *For example, Humboldt County may anticipate future consumptive uses that would be incompatible with instream fishery purposes; releases for such beneficial uses likely should not be made under Proviso 1 but as additional releases under Proviso 2.*
>
> *Conversely, the County or other downstream users could request releases that would be consistent with or duplicative of releases already being made pursuant to Proviso 1; under those circumstances, releases as requested under Proviso 2 may not be required. To the extent Proviso 1 water is not available, the Proviso 2 water, which may be put to any beneficial use, should be available to satisfy the articulated use."*

In 2017, the DOI Solicitor issued a clarification to the 2014 DOI Solicitor's opinion, stating the Yurok Tribe is a downstream user for purposes of Proviso 2 of the 1955 Act (USDOI 2017).

2.2.6 Long-term Plan to Protect Adult Salmon in the Lower Klamath River

In September 2002, an unforeseen and unprecedented fish die-off due to an outbreak of *Ichthyophthirius multifiliis* (Ich) occurred during a two-week period in the lower Klamath River. From about 2003 through 2015, flow augmentation releases by Reclamation (and by PacifiCorp in one year) to the lower Klamath River were regularly implemented to reduce the prevalence of fish disease and prevent additional fish mortality. In anticipation that augmentation flows may be needed in future years and recognizing competing demands between environmental needs on the Trinity and Lower Klamath Rivers and water supply needs of the CVP, Reclamation started developing the Long-Term Plan to Protect Adult Salmon in the Lower Klamath River (Klamath LTP). The Klamath LTP Final EIS was released by Reclamation in January 2017 (Reclamation 2017a), and a ROD was signed in April 2017 (Reclamation 2017b).

The preferred alternative identified in the 2017 ROD required three flow augmentation components to be implemented as supplemental flows from Lewiston Dam as needed in a phased approach based on environmental and biological conditions: (1) a preventive baseflow release that targets increasing the baseflow of the lower Klamath River to 2,800 cfs between mid-August and late September; (2) a one-day preventive pulse flow (targeting 5,000 cfs in the lower Klamath River) to be used as a secondary measure to alleviate continued poor environmental conditions; and (3) a five-day emergency pulse flow (targeting 5,000 cfs in the lower Klamath River) to be used on an emergency basis when the first two flow augmentation components are not successful at meeting their intended objectives. An annual implementation process was established for implementing releases each year, if required, based on coordination with USFWS, CDFW, and the National Marine Fisheries Service (NMFS), and input from tribes, CVP water and power users, regulatory agencies, and other key stakeholders.

The 2017 EIS for the Klamath LTP identified Reclamation's statutory authority for flow augmentation releases based on Section 2 of the 1955 Act, including both Proviso 1 and Proviso 2. The 2017 ROD for the Klamath LTP confirmed the primary statutory authority for the proposed action is Section 2 of the 1955 Act, which provides for specific limitations on the integration of the TRD with the rest of the CVP and gives precedence to in-basin needs. Subsequent court rulings (San Luis & Delta-Mendota Water Auth. v. Haugrud 2017) held that Proviso 1 provided statutory authority for the Klamath LTP flow augmentation releases, not Proviso 2 (Reclamation 2017b).

2.2.7 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 lists designated existing and potential beneficial uses on the flow path from Trinity River below Lewiston Dam to the Pacific Ocean (Table 2-2). These beneficial uses reflect demands on the water resources of the North Coast Region as identified by the State Water Board. The purpose and proposed use of Contract Water releases, as described in Section 1.3, is consistent with existing designated beneficial uses on the Trinity and Klamath rivers, including

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 Native American culture.

Table 2-2. Beneficial Uses of Waters of the Trinity River and Klamath River Hydrologic Units within the North Coast Region

HU/HA/HSA	HU/HA/HSA Name	Beneficial Uses[1]																					
	Trinity River HU	MUN	AGR	IND	PRO	GWR	FRESH	NAV	POW	REC1	REC2	COMM	WARM	COLD	WILD	RARE	MIGR	SPWN	SHELL	AQUA	CUL	MAR	EST[2]
106.00	**Trinity River HU**																						
106.40	**Upper Trinity River HA**																						
	Trinity Lake	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	P	E		P			
	Lewiston Reservoir	E	E	P	P	E	E	E	E	E	E	E	P	E	E	E	P	E		E			
	Trinity River	E	E	P	P	E	E	E	P	E	E	E		E	E	E	E	E		E			
106.30	**Middle Trinity HA**																						
106.31	Douglas City HSA	E	E	E	P	E	E	E	P	E	E	E		E	E	E	E	E		P			
106.10	**Lower Trinity River HA**																						
106.15	Helena HSA	E	E	E	P	E	E	E	P	E	E	E		E	E	E	E	E	P	P			
106.13	Burnt Ranch HSA	E	E	E	P	E	E	E	P	E	E	E		E	E	E	E	E	P	E			
106.12	Willow Creek HSA[3]	E	E	E	P	E	E	E	E	E	E	E		E	E	E	E	E	P	P			
106.11	Hoopa HSA[3]	E	E	E	P	E	E	E	P	E	E	E		E	E	E	E	E	P	P	E		
105.00	**Klamath River HU**																						
105.10	**Lower Klamath River HA**																						
105.11	Klamath Glen HSA[3]	E	E	P	P	E	E	E	P	E	E	E	E	E	E	E	E	E	E	P	E	E	E

Source: (NCRWQCB 2018)

Key:

HU = Hydrologic Unit, HA = Hydrologic Area, HAS = Hydrologic Subarea, E = Existing, P = Potential, MUN = Municipal and Domestic Supply, AGR = Agricultural Supply, IND = Industrial Service Supply, PRO = Industrial Process Supply, GWR = Groundwater Recharge, FRSH = Freshwater Replenishment, NAV = Navigation, POW = Hydropower Generation, REC-1 = Water Contact Recreation, REC-2 = Non-Contact Water Recreation, COMM = Commercial and Sport Fishing, WARM = Warm Freshwater Habitat, COLD = Cold Freshwater Habitat, WILD = Wildlife Habitat, RARE = Rare, Threatened, or Endangered Species, MIGR = Migration of Aquatic Organisms, SPWN = Spawning, Reproduction, and/or Early Development, SHELL = Shellfish Harvesting, AQUA = Aquaculture, CUL = Native American Culture, MAR = Marine Habitat, EST = Estuarine Habitat

Notes:

[1] The following beneficial uses are identified by the State Water Board but are not recognized in the Water Quality Control Plan for the North Coast Region for these hydrology units: ASBS = Preservation of Areas of Special Biological Significance, SAL = Inland Saline Water Habitat, FLD = Flood Peak Attenuation/Flood Water Storage, WET = Wetland Habitat, WQE = Water Quality Enhancement, FISH = Subsistence Fishing

[2] EST use applies only to the estuarine portion of the waterbody as defined in Chapter 2 of the Basin Plan.

[3] Indicates a Hydrologic Subarea with a flow path that is within Humboldt County.

2.2.8 2021 Reinitiation of Endangered Species Act Section 7 Consultation on the Long-Term Operations of the Central Valley Project and State Water Project (2021 LTO Consultation)

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 the California Department of Water Resources (DWR) initiated ESA consultation under Section 7, which ultimately resulted in Biological Opinions (BO) 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., operations similar to the reasonable and prudent alternatives to the proposed operations identified in the 2008 and 2009 BOs) 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 again reinitiated consultation with USFWS and NMFS on the Long-Term Operation of the CVP and SWP (2021 LTO Consultation) 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. In June 2023, Reclamation released Draft Preliminary Alternatives for the TRD under the 2021 LTO Consultation that included modified operations of Trinity Reservoir (Reclamation 2023), including changes to the timing and magnitude of releases implemented since 2000 under the Trinity River Mainstem Fishery Restoration ROD. 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.

In June 2023, Humboldt County submitted a letter to Reclamation describing the proposed use of Contract Water detailed in this Water Management Plan and requesting that releases of Contract Water be included in the proposed action for the 2021 LTO Consultation. In October 2023, Reclamation staff completed a review of the June 2023 letter from Humboldt County and concluded that sufficient detail was provided to include release of Contract Water at a project level within the TRD Alternatives analyzed for the 2021 LTO Consultation.

2.3 Trinity River Division Operations

Water captured and stored in Trinity Reservoir is managed for flood control, hydropower generation, water supply in the Central Valley and Bay Area, recreation, fisheries, environmental,

and tribal purposes. Water operations are subject to constraints from dam and power generation infrastructure and safety-of-dams criteria (Buxton 2018). Additionally, Reclamation attempts to maintain the cold-water pool volume in Trinity Reservoir at or above 600 TAF as a recommended minimum from the Trinity River Mainstem Fishery Restoration EIS/EIR Preferred Alternative. Implementation of drawdowns below the 600 TAF minimum end-of-year carryover level in Trinity Reservoir are determined by Reclamation, USFWS, and NMFS on a case-by-case basis in dry and critically dry water years (USDOI and HVT 2000).

2.3.1 Trinity River Flow History

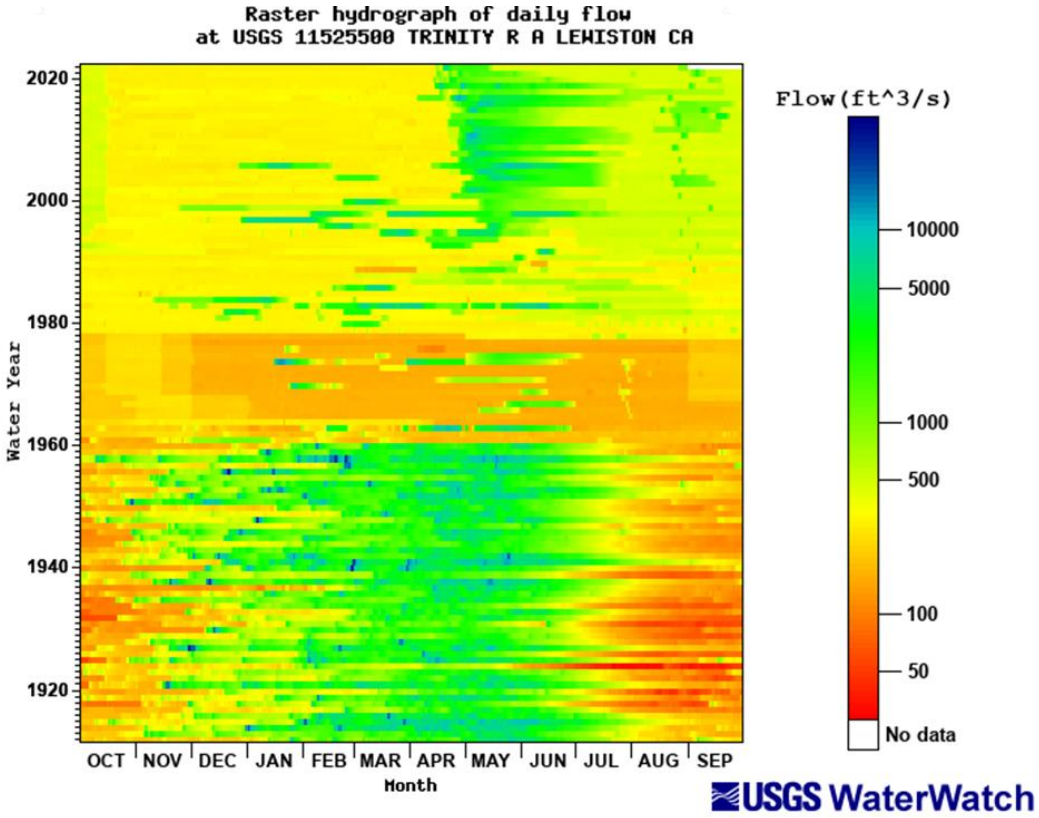
Since the beginning of the available period of record in 1911, four distinct flow regimes have been documented in the Trinity River near Lewiston (Figure 2-2):

- From 1911 through 1960, Trinity River was a natural semi-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).

- Through the 1960s and 1970s, riverine habitat conditions below Lewiston Dam degraded and salmon and steelhead populations declined noticeably in the Trinity River (USFWS and HVT 1999). This led to a decision by the Secretary of Interior in 1981 which directed the Trinity River Fishery Restoration Program to propose actions necessary for the restoration and maintenance of natural production of anadromous fish in the Trinity River (USDOI 1981). This decision increased annual instream flow releases based on water year type and directed USFWS to conduct the TRFES to determine limiting factors to anadromous fish in the Trinity River. Relatively higher flow volumes were released until the TRRP completed the infrastructure improvements (e.g., bridges, diversions) necessary to implement higher flows in 2005.

- After nearly 20 years of studies of the Trinity River and its fishery resources, USFWS and Hoopa Valley Tribe (HVT) completed the Trinity River Flow Evaluation Report as the final product of the TRFES (USFWS and HVT 1999) which informed the Trinity River Mainstem Fishery Restoration final EIS/EIR (USFWS et al. 2000); the ROD for the Trinity River Mainstem Fishery Restoration EIS/EIR (USDOI and HVT 2000) established the framework for TRRP. Among other restoration actions, the ROD defined five water year types and established annual release volumes ranging from 368 TAF to 816 TAF, with specific daily flow patterns based on a Trinity River water year type.



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

2.3.2 TRD Operations and Trinity River Flows Since 2005

After the 2000 ROD was signed, implementation was delayed by litigation. In addition, five years of infrastructure improvements in the Trinity River occurred to address impediments of bridges and houses/outbuildings to higher flow releases. Since 2005, flow releases into the Trinity River have been comprised of five main categories:

- Scheduled releases to promote fishery resources and restore a healthy river ecosystem, as outlined in the ROD (USDOI and HVT 2000). Annual water volumes allocated for ROD releases vary by water year type with the forecasted full natural flow (FNF) volume at Lewiston (Table 2-3). The five recommended daily release patterns by water year type are shown in Figure 2-3. These flows are part of Reclamation's obligations for flow releases to the Trinity River under Proviso 1.

- 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 late August or early September of odd-numbered years to increase river depth as needed for the Hoopa Valley Tribe's Boat Dance ceremony. 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. Reclamation made flow augmentation releases in 8 years from 2003 to 2016 to improve fishery conditions. These flows were assessed in the Klamath LTP EIS (Reclamation 2017a) and codified in a 2017 ROD (Reclamation 2017b). 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. The 2017 Klamath LTP ROD identified Proviso 1 as the source of flow augmentation releases.

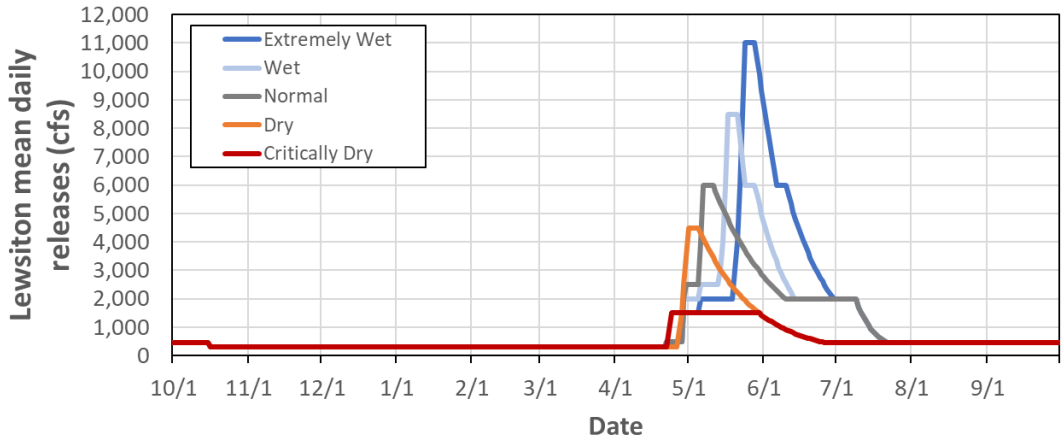
- Emergency flow releases may be used to meet Trinity River water temperature objectives and due to unforeseen operational issues associated with dam and other infrastructure.

Table 2-3. Recommended Annual Trinity River Release Volumes

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

Source: (USDOI and HVT 2000)

[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.



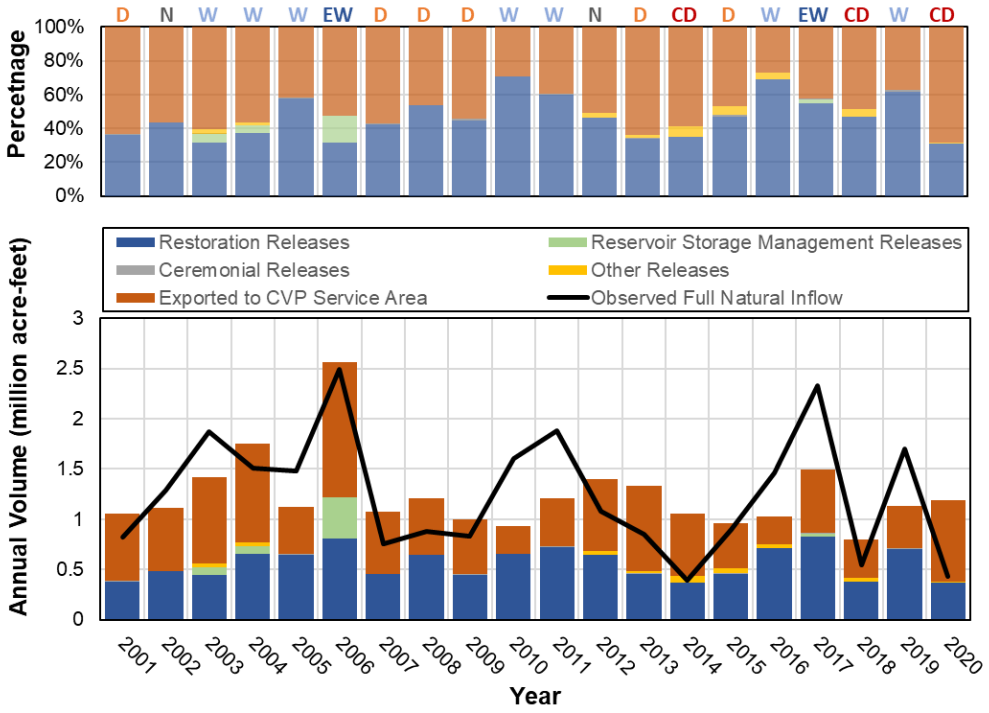
Source: Trinity River Mainstem Fishery Restoration Record of Decision, U.S. Department of Interior and Hoopa Valley Tribe (2000)

Key: cfs = cubic feet per second; ROD = Record of Decision

Figure 2-3. 2000 ROD Recommended Mean Daily Restoration Releases from Lewiston by Water Year Type

Since the establishment of the TRRP and initiation of ROD flows, around half of the average annual Trinity River inflow is exported through Clear Creek Tunnel for agricultural and municipal and industrial water supply within existing CVP service areas and to meet other purposes. On an annual basis, the volume 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. On a monthly basis, exports are determined based on water supply availability and demands throughout the CVP and the movement of water through Lewiston Reservoir needed to meet water temperature objectives and targets.

A timeseries of annual release types and exports from 2001 to 2020 shows that TRD operations are comprised primarily of ROD releases and exports to CVP service areas (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 CVP service areas is generally greater in drier years. Since 2012, other releases to the Trinity River have become more frequent.



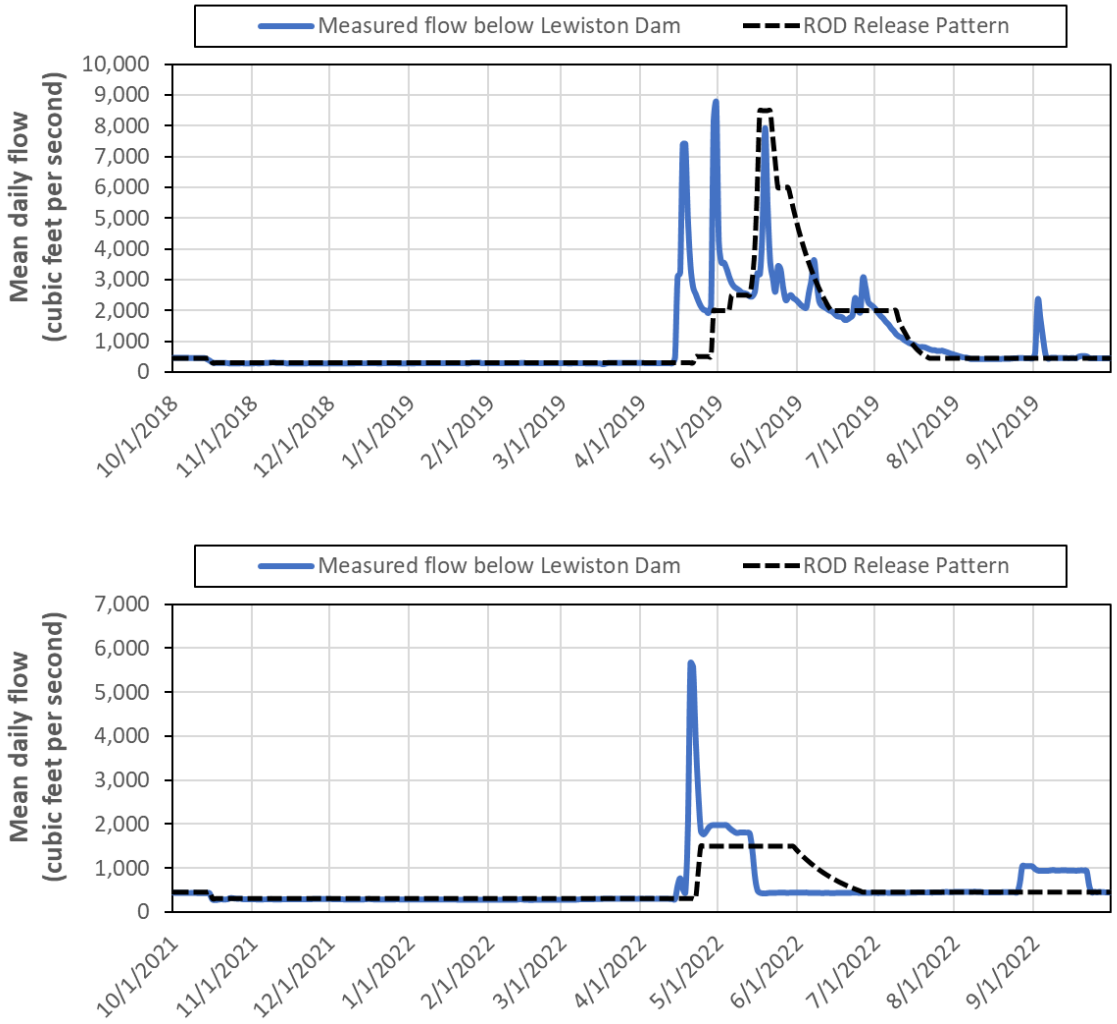
Key:
Trinity River Water Year Types: EW = Extremely Wet, W = Wet, N = Normal, D = Dry, CD = Critically Dry
Data source: Buxton 2021a

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

2.3.3 Recent Trinity River Flow Modifications

The 2000 ROD indicated 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 and HVT 2000). Until about 2015, ROD releases into the Trinity River largely followed the daily patterns identified in the 2000 ROD. Since 2015, the TRRP Flow Workgroup has met regularly to identify

potential modifications to ROD releases and has developed a portfolio of at least 24 hydrograph alternatives across the five water year types (TRRP 2015). Examples of implemented flow modifications compared to the ROD release patterns are shown in Figure 2-5, and additional detail is provided in Appendix B Section 4.3.

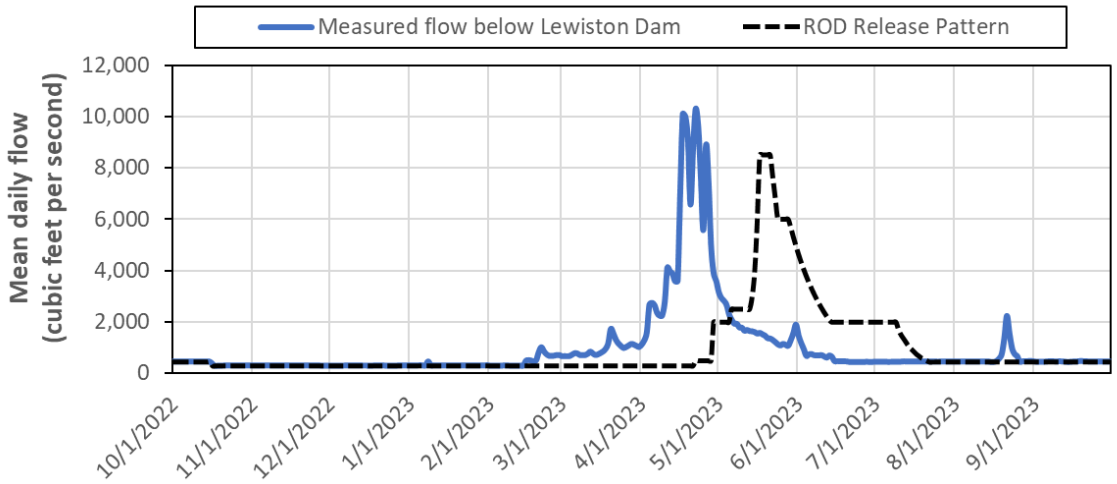


Data source: United States Geologic Survey Gage 11525500 Trinity R A Lewiston CA (USGS 2023)
Key: ROD = Record of Decision

Figure 2-5. Mean Daily Flow Measured Below Lewiston Dam and Daily 2000 ROD Release Patterns for a Wet Water Year in 2019 (top) and a Critically Dry Water Year in 2022 (bottom)

In 2022, the TRRP office issued the Trinity River 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 from the spring and summer period to the winter period to improve anadromous fish habitat conditions along the TRRP's Restoration Reach, which is the approximately 40-mile long length of the Trinity River downstream of Lewiston Dam to the confluence of the North Fork Trinity River. This proposal would add a winter flood pulse, implement elevated winter baseflows that would occur earlier and at a higher magnitude than ROD releases, and shift the release of peak restoration flows to earlier in the

season. By shifting a portion of the ROD volume earlier in the year, flow releases would more closely mimic the natural flow variability of the system. This would have an added benefit of scaling down water volumes later in the spring and early summer relative to ROD releases, which would allow river temperatures to elevate into a proposed range (see Section 2.3.4) that would provide better growth temperatures for Chinook Salmon relative to the current ROD releases, which maintain colder water temperatures than historic conditions. In water year 2023, the TMC approved the Winter Flow Project following a series of votes. Because the action was under active litigation, a winter flood pulse was not implemented in water year 2023, but elevated baseflows were initiated around February 15, and the restoration flow peak was shifted to occur about one month earlier than the ROD release pattern (Figure 2-6).



Data source: United States Geologic Survey Gage 11525500 Trinity R A Lewiston CA (USGS 2023)
Key: ROD = Record of Decision

Figure 2-6. Mean Daily Flow Measured Below Lewiston Dam and Daily 2000 ROD Release Patterns for 2023, the First Year of the Winter Flow Project

2.3.4 Water Temperature

Releases from Trinity Reservoir are also timed with consideration for meeting daily average temperature objectives or targets in the Trinity River, which vary by reach and season (Table 2-4). Spring (April 15-July 15) temperature targets vary by water year type and were adopted by the 2000 ROD (USDOI and HVT 2000). 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 (SWRCB) Order WR-90-5 (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 for the Trinity River at Weitchpec were developed to aid juvenile salmonids in their downstream migration to the Klamath River (USFWS and HVT 1999), but no longer are management objectives for the TRRP. Exports from Lewiston also support compliance with daily water temperature objectives on Clear Creek and the Sacramento River.

In 2022, the TRRP adopted two changes to the updated temperature targets based on a recommendation from the TRRP's Fish Workgroup. The rearing temperature target reach was changed to end at North Fork Trinity River instead of Weitchpec, to include a consistent optimal

temperature range for growth across water year types rather than a range that varied by water year type, and to reflect a 7-Day Average of the Daily Average (7DADA) temperature rather than an average temperature (TRRP 2022). The TRRP also formally dropped the Weitchpec temperature objective as it was counterproductive to fish growth higher in the river and discouraged appropriate migration timing (Mike Dixon 2023, personal communication).

Table 2-4. Trinity River Daily Average Temperature Objectives and Targets

Life Stage	Reach	Dates	Water Year Type	Target Temperature
Adult Holding[1]	Lewiston to Douglas City	July 1 – September 14	All Types	≤ 60 °F (15.5 °C)
		September 15 – October 1		≤ 56 °F (13.3 °C)
	Lewiston to confluence of North Fork Trinity River	October 1 – December 31	All Types	≤ 56 °F (13.3 °C)
Rearing[2]	Lewiston to Weitchpec	April 15 – May 22	Normal, Wet, Extremely Wet	≤ 55 °F (12.8 °C)
		May 23 – June 4		≤ 59 °F (15 °C)
		June 5 – July 9		≤ 62.5 °F (17 °C)
		April 15 – May 22	Dry, Critically Dry	≤ 59 °F (15 °C)
		May 23 – June 4		≤ 62.5 °F (17 °C)
		June 5 – July 15		≤ 68 °F (20 °C)
Rearing[3]	Lewiston to confluence of North Fork Trinity River	April 1 to July 31	All Types	55.4 °F to 61.7 °F (13 °C to 16.5 °C)

Notes:
1 North Coast Regional Water Quality Control Board Basin Plan (NCRWQCB 2011).
2 USDOI and HVT 2000, adopted prior to 2022.
3 TRRP 2022, adopted after 2022.
Key:
°C = degrees Celsius
°F = degrees Fahrenheit

2.4 Purpose of Water Management Plan

The Water Management Plan serves three distinct purposes in supporting the release of Contract Water under Proviso 2 of the 1955 Act.

First, Humboldt County has a shared interest with others in the Trinity and Klamath River watersheds to improve conditions for anadromous salmonids. As described in Section 3.1, population estimates for spring- and fall-run Chinook Salmon have decreased substantially over time, causing economic, social, and societal hardship for ocean, in-river, and tribal dependent fisheries. Historically, the local economy of Humboldt County was built on natural resources, including a robust fisheries industry, and Native people of the region have relied on an anadromous salmon population since time immemorial for subsistence, economic, and ceremonial purposes. Humboldt County has the opportunity to use Contract Water, consistent with the existing designated beneficial uses of the Trinity and Klamath rivers, to contribute towards recovery of anadromous salmonid populations. The Water Management Plan documents the process used to develop flow releases for a fisheries benefit, and describes how these releases would provide numerous direct and indirect benefits to fisheries and local communities.

Second, the Water Management Plan meets the implementation needs outlined by the 2014 DOI Solicitor's opinion and serves as the formal request from Humboldt County to Reclamation for

release of Contract Water. As described in Section 4.3, the main elements of the proposal include releases of supplemental baseflows and pulse flows based on a decision tree process. The Water Management Plan is being developed so Reclamation can conduct an analysis to determine the applicable legal, regulatory compliance, and water rights requirements and any additional actions that must be addressed prior to releasing water.

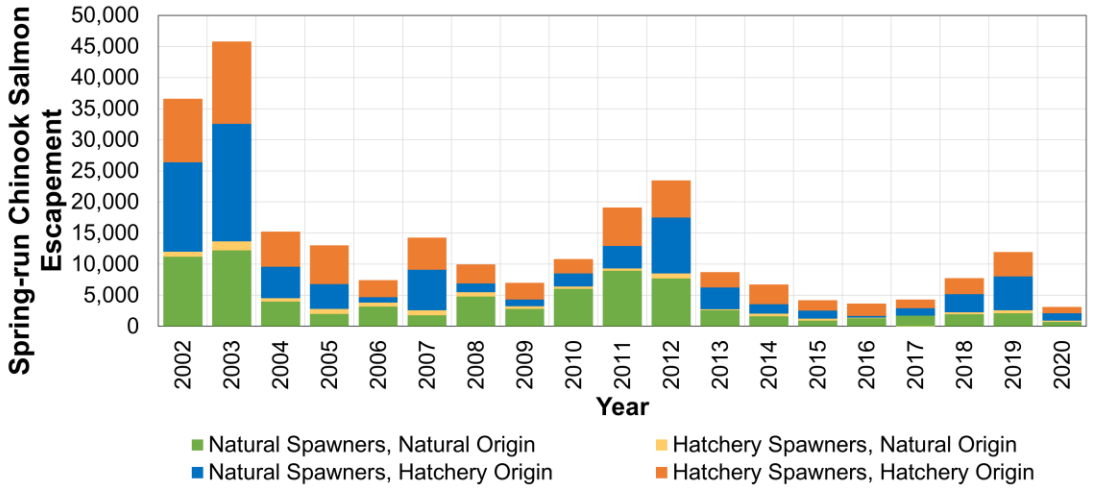
Finally, the Water Management Plan outlines the long-term coordination between Humboldt County and Reclamation that is necessary to operationalize the release of Contract Water. As this is the first Water Management Plan developed for Humboldt County Contract Water, it contains extensive background information and baseline information, in addition to a specific release proposal for a non-consumptive beneficial use and an annual implementation process that requires year-to-year coordination. Though the 1959 Contract does not have an expiration date, the Water Management Plan is intended to support decision-making over the next 25-years. Over time, additional proposed uses may be identified, or release proposal modifications may be suggested based on conditions within the Trinity River and lower Klamath River. Future Water Management Plans or amendments may tier off this initial Water Management Plan to provide necessary information on new proposed uses or release modifications.

3 SCENARIO DEVELOPMENT AND EVALUATION

In June 2022, Humboldt County initiated a collaborative Water Management Plan development process with interested parties, including Reclamation, the DOI Solicitor, NMFS, CDFW, USFWS, United States Geological Survey (USGS), the Yurok Tribe, and the Hoopa Valley Tribe. A series of five workshops were used to progressively develop, evaluate, and refine Contract Water release scenarios. This section provides a summary description of the scenario development process, including identification of the need for Contract Water releases, a review of baseline conditions and environmental setting, scenario development, and scenario evaluation. Additional details on baseline conditions, modeling and analysis, and workshop discussions are available in Appendix B, Appendix C, and Appendix D, respectively.

3.1 Need for Contract Water Releases

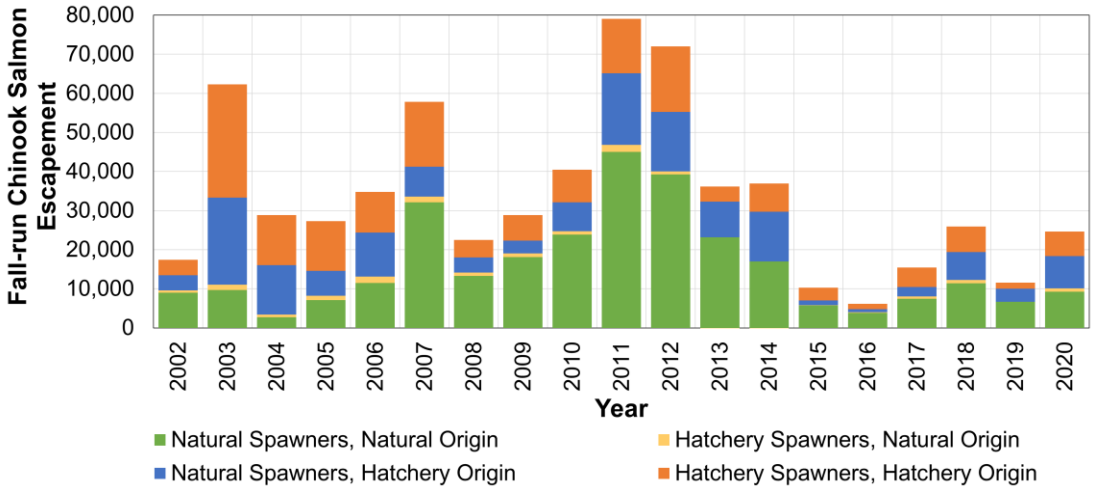
Contract Water releases could contribute towards increases in anadromous salmonid populations. Over the past 25 years, population estimates for spring- and fall-run Chinook Salmon have been made by CDFW and Hoopa Valley Tribe at the Junction City Weir and at the TRH. Between 2002 and 2020, the average spring-run Chinook Salmon spawning escapement[2] in the Trinity River was estimated at 13,956, comprised of 4,162 natural origin salmon[3] and 9,110 hatchery origin salmon[4] that spawned naturally[5] and in the TRH[6] (Figure 3-1). Since 2013, escapement numbers are approximately 50 percent less than their average from 2002 – 2020, with even greater declines in natural origin fish. Between 2002 and 2020, the average fall-run Chinook Salmon spawning escapement in the Trinity River was 34,341, comprised of 16,641 natural origin salmon and 17,700 hatchery origin salmon. Since 2013, escapement numbers are approximately 40 – 50 percent less than their average from 2002 – 2020 (Figure 3-2).



Source: Kier et al. 2021

Figure 3-1. Annual Escapement for Spring-Run Chinook Salmon in the Trinity River at the Junction Creek Weir.

[2] Salmon escapement is the amount of a salmon population that returns to their freshwater spawning area and does not get caught by commercial, recreational, or tribal fisheries.
[3] Natural origin salmon are salmon that were produced by parents spawning in natural environments.
[4] Hatchery origin salmon are salmon that were produced by parents spawned in a hatchery.
[5] Natural spawners are fish that spawned within the riverbed in natural areas.
[6] Hatchery spawners are fish that spawned within the Trinity River Hatchery.



Source: Kier et al. 2021

Figure 3-2. Annual Escapement for Fall-Run Chinook Salmon in the Trinity River at the Willow Creek Weir.

The Trinity River once supported large populations of naturally produced anadromous salmonids, including both spring- and fall-run[7] Chinook Salmon, Coho Salmon, and steelhead (USFWS and HVT 1999). Historically, spring-run Chinook Salmon were likely the predominant run type in the Klamath-Trinity River Basin (Myers et al., 1998). Most spawning and rearing habitat ideal for spring-run Chinook Salmon was blocked by the construction of dams in the late 1800s and early 1900s in the Klamath River and in the 1960s in the Trinity River Basin. As a result of these and other factors, spring-run Chinook Salmon populations are considered to be at less than 10 percent of their historical levels (Myers et al., 1998), and fall-run Chinook Salmon average returns are approximately twenty percent of pre-TRD estimates (TRRP 2022), with the fall-run populations now comprising the majority of Chinook Salmon in the Klamath-Trinity River Basin. Similar declines in population have been observed for Coho Salmon and steelhead. In 2021, California listed the Upper Klamath-Trinity River Chinook Salmon evolutionarily significant unit (ESU)[8] as threatened under the California Endangered Species Act (CESA). A similar petition to list under the federal ESA is pending.

A variety of factors have likely contributed to the decline in in-river escapement of salmonid populations in the Trinity River system, including harvest, ocean conditions, and in-river conditions in the Trinity River and Lower Klamath River. However, since construction of the TRD, the most prevalent changes in the system have included modifications to the flow and thermal regimes of the Trinity River and reductions in suitable habitat. Historically, the Trinity River had a naturally highly variable flow regime that provided flow-based cues for anadromous salmonid migration and spawning and contributed to the maintenance of spawning and rearing habitat. The natural flow regime and access to upstream reaches also offered thermal diversity, including the use of upstream reaches dominated by snowmelt runoff that remained cool throughout the year (USFWS and HVT 1999). Operation of the TRD has resulted in annual diversion of approximately half of the flow volume of the Trinity River to the Sacramento River, which, along with highly regulated flow releases, has substantially reduced natural flow

[7] "Run" refers to the timing when adult anadromous species migrate from the ocean back to freshwater to spawn.

[8] Under the Endangered Species Act, an evolutionarily significant unit, or ESU, is a population or group of populations that is substantially reproductively isolated from other conspecific populations.

variability. The near constant release of water from the lower elevations of Trinity Reservoir, where cold-water is predominant, has also reduced the thermal variability of the downstream river system.

Prior to the construction of the TRD, the spawning of spring- and fall-run Chinook Salmon was separated temporally and spatially due to the timing of adult upstream migration of each run, the hydrology of the river, and access to tributary spawning habitat (Gough et al. 2021). Following construction of Lewiston Dam, spring- and fall-run Chinook Salmon spawning in the mainstem Trinity River exhibited considerable spatial and temporal overlap, with high redd densities frequently observed directly below Lewiston Dam. Rogers (1972) documented that in 1970 more than 50 percent of Chinook Salmon spawned in the two miles immediately below Lewiston Dam. High redd densities likely limit reproductive success due to redd superimposition[9], which affects spawning success of both natural and hatchery origin fish. Severe redd superimposition has been observed directly below Lewiston Dam, where most in-river spawning of spring-run Chinook likely occurs (Sullivan and Hileman 2019). This stretch of the Trinity River is also the most affected and influenced by flow and temperature changes out of Lewiston Dam, as flow is released directly from Lewiston Dam without any flow or temperature effects from natural tributaries.

The primary factors currently thought to contribute to reduced anadromous salmonid populations in the Trinity River are anticipated to continue, including modified flow and thermal regimes and reductions in suitable spawning and rearing habitat. The purpose of Proviso 2 Contract Water releases is to create missing elements of the natural flow regime, enhance habitat quality for fish and wildlife, improve ecosystem health and resilience, and increase opportunities for ocean and river salmon fishing beyond those already required by Proviso 1 of the 1955 Act. The need for Contract Water releases is a decline in anadromous salmonid populations.

3.2 Consideration of Environmental Setting

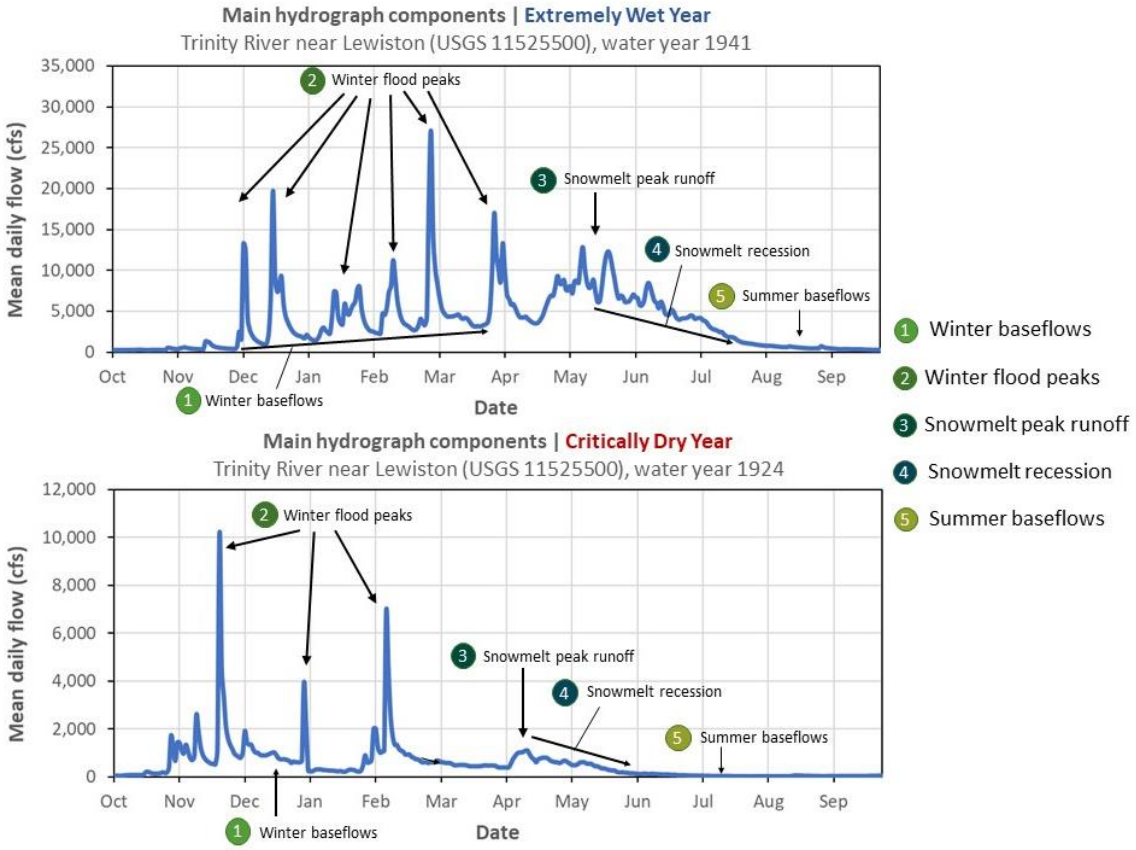
The following sections provide a summary of the relevant environmental conditions in the Trinity River, focusing on the 40-mile reach downstream of Lewiston Dam referred to as the Restoration Reach. Further detail is provided in Appendix B.

3.2.1 Hydrology

The natural flow regime of the Trinity River varied considerably prior to TRD operations (Figure 3-3). 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 2017a). The major pre-TRD hydrograph components for the Trinity River were identified by McBain and Trush (1997) using inflow data to Trinity Reservoir from both USGS and Reclamation gage data. The fall baseflows transitioned to several large magnitude, short duration winter flood events from mid-November to late January. Following winter baseflows, the snowmelt peak 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 usually began in late March in wet years and mid-May in dry years and

[9] Redd superimposition occurs when salmon build nests (redds) on top of other nests. This process is believed to be a major source of salmonid embryo mortality because eggs are easily scattered or crushed by the digging behavior of female (Quinn 2005).

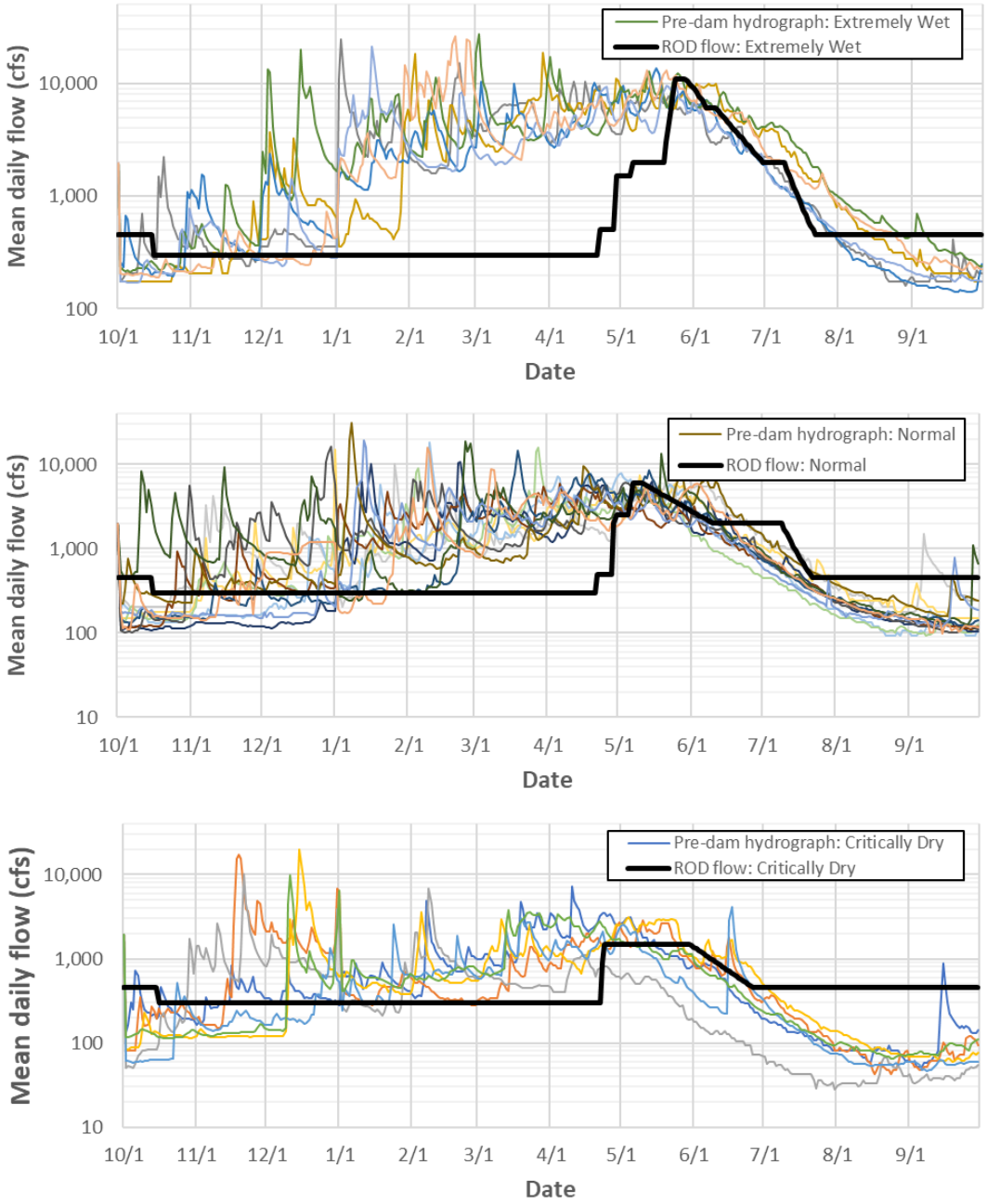
receded into July. The summer baseflows establish mid- to late- July could range from 100 to 300 cfs in early summer but drop as low as 25 to 50 cfs in late summer (USFWS and HVT 1999).



Data source: USGS gage 11525500 Trinity River at Lewiston California (USGS 2023)

Figure 3-3. 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 flow regime of the Trinity River was altered considerably following construction of the TRD, as described in Section 2.3.1. Under the current ROD release structure, the majority of annual water volume is released after April 15, once the DWR Bulletin 120 water year type determination is made and there is certainty as to what volumes are available for release. However, 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 (Figure 3-4). In winter, the Trinity River experienced large magnitude, short duration flood peaks and ascending baseflows starting in late fall, whereas the ROD flows prescribe a static 300 cfs baseflow release throughout this period. From October to April 15, the prescribed ROD flow regime maintains a baseflow of only 300 cfs, releasing approximately 20 percent of the entire water year's flow volume (TRRP and Reclamation 2022), compared to the pre-dam average of 50 percent of the water year flow volume. In spring, the magnitude of peak ROD releases are generally similar to (in wetter years) or slightly less than (in Critically Dry years) the magnitude of the historic snowmelt peak runoff, and the timing is generally 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: USGS 2023, USDOI and HVT 2000.
Note: Top: Extremely Wet. Middle: Normal. Bottom: Critically Dry.
Key: ROD = Record of Decision

Figure 3-4. 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

3.2.2 Geomorphology

The Trinity River mainstem is a mix of alluvial and bedrock-controlled channel morphologies (USFWS and HVT 1999). Major alterations to the river channel began prior to the TRD in the mid-19th century associated with the California gold rush. Hydraulic mining and dredging of the

riverbed 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. 2018a). The Trinity and Lewiston Dams, completed in 1963, depleted sediment supply to the Trinity River. In general, the portion of the Restoration Reach upstream of Rush Creek experienced these effects to a greater degree, as it lacked additional water and sediment supply that the unregulated tributaries can provide to the downstream segments. 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 throughout 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 available for transport and deposition.

Historically, components of the natural flood regime prior to establishment of the TRD, would have aided in initiating critical geomorphic processes. The high magnitude 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, scouring 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.

3.2.3 Water Quality

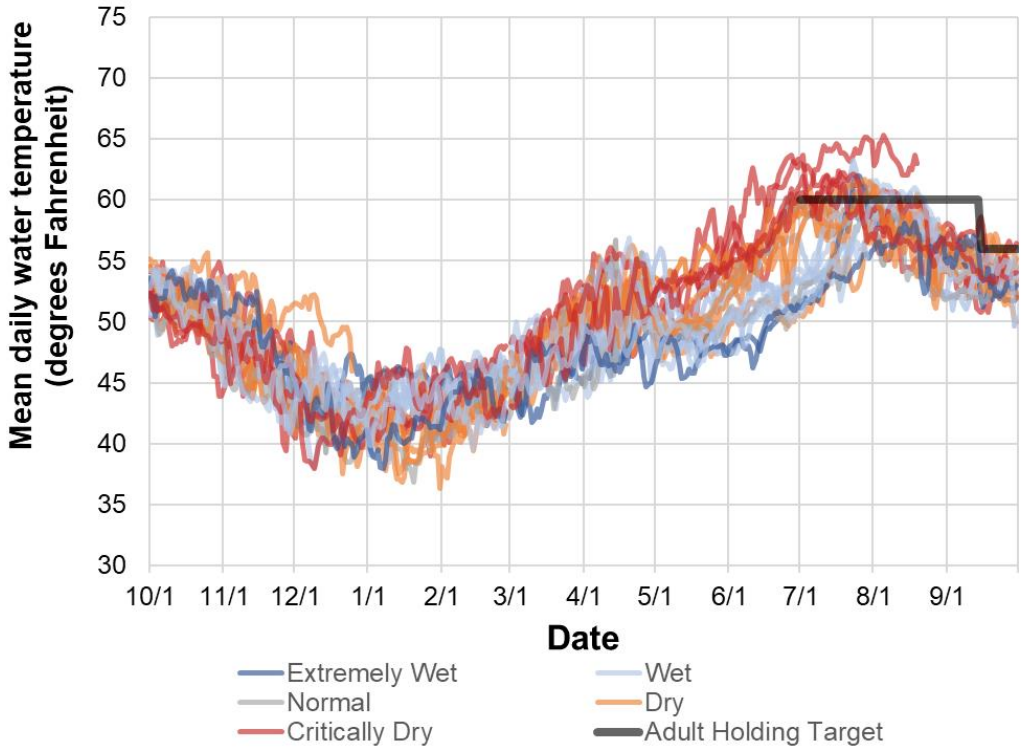
Water quality conditions and constituents of concern in the Trinity River vary by regions within the basin. In the Trinity River, key water quality concerns with significance to fish species include water temperature, dissolved oxygen, nutrients and contaminants, and sediment and turbidity. A more detailed review of these water quality constituents is contained in Appendix B; temperature issues are described in more detail within this section as reviews of previous studies indicate this water quality parameter to be the most significant limitation to Chinook Salmon production in the Trinity River.

Water temperature is a concern throughout the Trinity River, as it supports sensitive cold water fish species. Water temperatures affect fish metabolism, feeding, growth and development, migration timing, spawning, rearing, and food availability. Trinity River water temperatures are primarily affected by TRD release temperatures and flows, tributary flows, and solar radiation (TRRP and Reclamation 2022). Trinity 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 (TRRP and Reclamation 2022). The South Fork Trinity River is listed on the 303(d) list approved by the United States Environmental Protection Agency in 2010 for elevated water temperatures.

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. Trinity River summer and fall water temperature objectives or

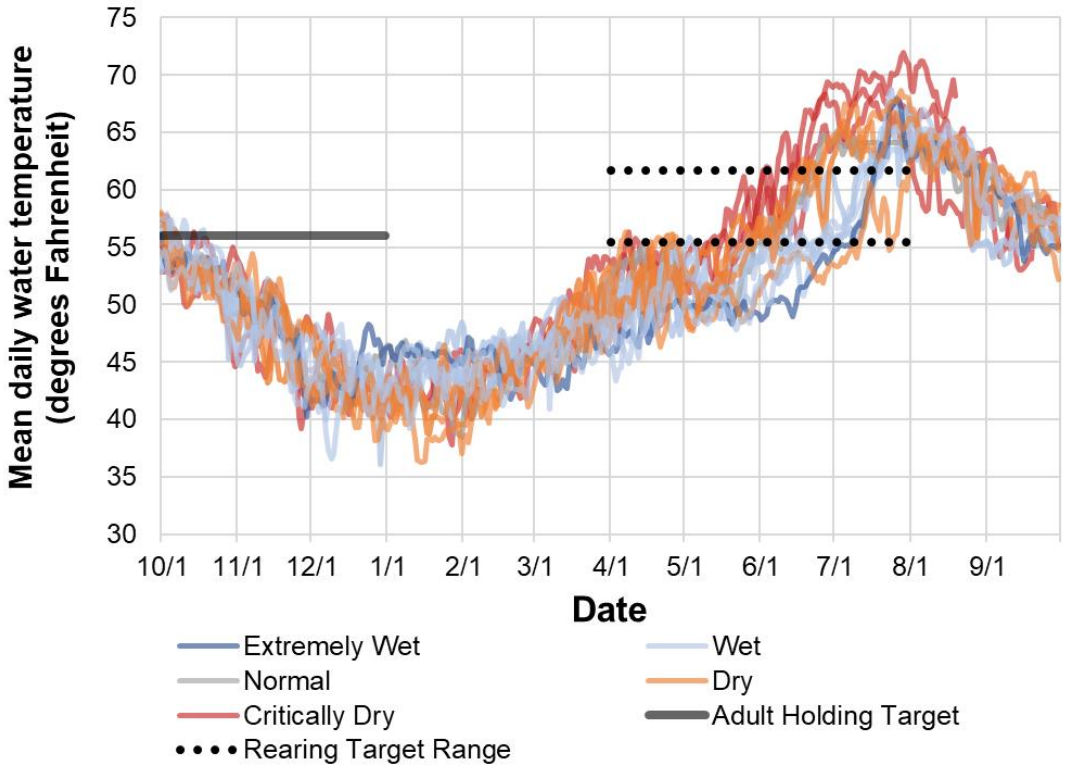
targets were set forth in the Water Quality Control Plan for the North Coast Region (Basin Plan) specifically applicable to the Trinity River, from Lewiston Dam to Douglas City and to the confluence with the North Fork Trinity River at Helena (NCRWQCB 2011). Additionally, spring temperature targets were set by the 2000 ROD. 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 modified temperature objectives specific to rearing juveniles in the mainstem Trinity River. The TRRP's Fish Workgroup recommended applying a target of 55.4 degrees Fahrenheit (°F) to 61.7 °F based on a 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).

Figure 3-5 and Figure 3-6 show mean daily water temperatures in the Trinity River at two temperature compliance points, Douglas City and upstream from the North Fork Trinity River, respectively, for a 23-year period, covering all water year types. These figures illustrate that fall and winter temperatures mostly fall below the objectives identified in the Basin Plan in both locations. Figure 3-6 shows water temperatures below the juvenile criteria range in April and early May.



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

Figure 3-5. Measured Daily Water Temperatures in the Trinity River at Douglas City Between 2000 and 2022



Note: Adult holding target water temperature is from the North Coast Regional Water Quality Control Board Basin Plan (NCRWQCB 2011). Rearing target range is based on recommendations made by the TRRP Fish Workgroup (Naman et al 2020). Note this target is a 7-Day Average of the Daily Average temperature target.

Figure 3-6. Measured Daily Water Temperatures in the Trinity River Above North Fork Trinity River Between 2000 and 2021

3.2.4 Biological Resources and Habitat

The analysis for the Water Management Plan focuses on salmonid species, particularly Chinook Salmon, so the section below describes the status and life histories for Chinook Salmon. A summary of the generalized life history timing for all anadromous species in the Trinity River, as reported by the TRRP, is included in Table 3-1, and additional detail is provided in Appendix B.

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 throughout the Restoration Reach 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).

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

Species/Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chinook Salmon												
Adult Migration				Spring-run								
								Fall-run				
Spawning									Spring-run			
										Fall-run		
Incubation	Spring-run								Spring-run			
	Fall-run									Fall-run		
Emergence	Spring- and Fall-run											
Rearing	Spring-run											
	Fall-run											
Outmigration			Spring- and Fall-run									
Coho Salmon												
Adult Migration												
Spawning												
Incubation												
Emergence												
Rearing												
Outmigration												
Steelhead												
Adult Migration					Summer-run							
									Fall-run			
	Winter-run										Winter-run	
Spawning		All runs										
Incubation			All runs									
Emergence				All runs								
Rearing	All runs											
Outmigration			All runs							All runs		

Source: adapted from TRRP 2023

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.

The TRFES identified the lack of available rearing habitat as a primary limiting factor for anadromous salmonid populations downstream of Lewiston Dam (USFWS and HVT 1999). Since the 2000 ROD, the TRRP has focused rehabilitation projects on increasing base flow juvenile rearing habitat availability for Coho and Chinook Salmon at site scales (TRRP 2014). Several short-term studies have shown that site-scale habitat availability has improved (TRRP 2014), while reach-scale habitat availability has remained relatively unchanged (Goodman et al. 2016), possibly due to the short sampling period relative to the long time scales needed to

instigate habitat-scale changes, and the lack of high-flow events since the 2000 ROD that could drive fluvial processes and improve habitats. The TRRP has suggested that as the river system evolves in response to post-ROD management actions, the hypothesis that juvenile rearing habitat is the primary limiting factor may be expected to change, and that fish population modeling could be used to examine alternative population limiting hypotheses (TRRP 2014).

Flow magnitude and timing may also be limiting anadromous salmonid populations. Investigations into juvenile Chinook Salmon outmigration between 2003 and 2016 found approximately 60 percent of Chinook Salmon 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). Consequently, more than half of the flow adaptations proposed by the TRRP Flow Workgroup between 2011 and 2021 included modifying the snowmelt peak runoff period to support rearing salmonids. 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 smolts (TRRP 2013, Stewart 2016, TRRP 2018, Buxton 2021a, Buxton 2022).

3.3 Objectives for Release of Proviso 2 Contract Water

Contract Water releases are proposed as non-consumptive instream flows to benefit fish, habitat, and water quality while not precluding future consumptive uses. The primary goal of Contract Water releases in this Water Management Plan is to support a harvestable fish surplus for tribal, recreational, and commercial fisheries. To support this goal, project workshops were used to develop Contract Water release objectives collectively with interested parties. Release objectives were developed by focusing on specific limitations to Chinook Salmon productivity that could be addressed by Contract Water releases. A set of Contract Water release objectives was developed over the course of several workshops (see Table 3-2 and Appendix C) and refined as modeling results and additional analyses were presented.

Table 3-2. Contract Water Release Objectives

#	Objectives	Method and Rationale	Reference
1	Increase spawning habitat area and quality for Chinook Salmon	Increase wetted area and flow variability during spawning period (September-December) for optimized redd establishment and potential reduction in redd superimposition.	Goodman, et al. (2018)
2	Improve Chinook Salmon egg survival	Moderate releases to maintain water temperatures at optimum range during egg incubation period (September-March). Relative to pre-TRD temperatures, Trinity Lake provides colder deep-water (hypolimnetic) releases during the late spring/summer and warmer water temperatures during the late fall and winter due to the thermal stratification within the lake. Colder water temperatures during incubation could lead to greater egg survival relative to the baseline.	USFWS and HVT 1999, Perry et al. 2018a
3	Reduce redd superimposition and distribute spawners	Provide increasing baseflows and pulse flows during spawning period (September-December) to distribute spawners and disperse hatchery Chinook Salmon releases.	Goodman, et al. (2018)
4	Increase spawning and rearing habitat for Coho Salmon, steelhead, and Lamprey	Increase baseflows from December-April to provide additional flow for Coho Salmon, steelhead, and Lamprey during Chinook Salmon hatching and rearing period (this may be studied using radio tag to determine whether this has positive or negative impacts on competition for resources and fish survival).	Appendix D (Workshops 3 and 4)
5	Increase rearing habitat area and quality for Chinook Salmon	Provide increasing baseflows in the spring period to inundate floodplains to allow access to juvenile habitat and promote juvenile growth.	USFWS and NOAA 2018, TRRP and Reclamation 2022
6	Recruit/entrain organic matter into Trinity River	Provide low magnitude pulse flows in the fall and spring periods to 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.	TRRP 2016, USFWS and NOAA 2018, Buxton 2021a, Buxton 2022
7	Redistribute juvenile salmonids and steelhead	Provide low magnitude pulse flows in spring period to redistribute juvenile salmonids, hatchery released steelhead smolts, and other fish	Stewart 2016, TRRP 2018, Buxton 2021a, Buxton 2022
8	Improve hatchery attraction	Provide low magnitude pulse flows in fall period timed with release of yearlings to improve adult attraction into the hatchery during adult migration (September-December)	Appendix D (Workshop 4)

3.4 Scenario Development

Based on a review of environmental setting and limiting factors in Workshop 1, a set of preliminary Contract Water release recommendations was developed in Workshop 2 that mapped Contract Water release objectives to specific components of the hydrograph (Table 3-3). All recommendations generally suggested releasing Contract Water between October and April, but varied in the specific pattern, timing, frequency, volume, and hydrograph shape.

Table 3-3. 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 and 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 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	Water Quality, Habitat, and Geomorphology	Optimize water quality (temperature), habitat and geomorphic flows with use of carryover in a second year

Key:
cfs = cubic feet per second
N/A=not applicable
TAF = thousand acre-feet

Through initial project workshops, the assumptions identified in Table 3-4 were identified to guide development of potential Contract Water release scenarios.

Table 3-4. Assumptions Guiding the Development of Contract Water Release Scenarios

Assumption	Rationale
Contract Water release scenarios are non-consumptive releases with a purpose to enhance Trinity River fish populations.	Non-consumptive releases meet the project objective and the terms of the grant agreement funding development of the Water Management Plan. However, this assumption does not preclude future releases that may have different purposes or consumptive uses.
Release no less than 50,000 AF of Contract Water annually.	Maintain consistency with Proviso 2 of the 1955 Act. Scenarios with higher release volumes are also considered for a relative comparison of effects.
Contract Water releases are additive to ROD releases.	The ROD flows represent the distinct purposes and use of Proviso 1 water supplies from Trinity Reservoir, and they form the baseline for modeling and analysis.
Scenarios are evaluated using an established scientific framework and existing modeling tools.	These existing modeling tools are readily available, and have been relied upon to support the TRRP Flow Workgroup annual ROD flow modification analysis, the Klamath LTP, and the Winter Flow Project.
Scenario analysis focuses on 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 2000 provides spawning and rearing habitat for salmonid species on the Trinity River (USFWS and HVT 1999).	The modeling and analytical tools available to evaluate release scenarios have been extensive calibrated to the Restoration Reach (see Appendix C), as this is the reach of Trinity River where the majority of spawning and juvenile rearing occurs (Perry et al. 2018a). Though the Restoration Reach 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.
The technical analysis focuses on assessing the effects of Contract Water releases on juvenile Chinook Salmon.	The existing set of modeling and analytical tools available to evaluate the effect of flow releases on fisheries of the Trinity River has been developed primarily for Chinook Salmon. The main assumption inherent to most modeling analyses is that releases that benefit Chinook Salmon are generally beneficial to the other anadromous fish species in the Trinity River.
The same release pattern or set of conditional rules is used every year of the simulation period for each scenario, regardless of the water year type.	Implementation of a water year type release in the Trinity River system is challenging as the water year type is not known with high certainty until April 1 when the DWR Bulletin 120 water year type forecast is made, six months or halfway into the water year. A release independent of water year type allows for comparison of the release effects in different water year types and for direct comparison across scenarios.
Releases are consistent with all release and operational constraints of the TRD, including maximum flow releases and ramping rates.	Ensure that releases can be implemented with current facilities and consistent with current Reclamation operational procedures.

Key:
TRRP = Trinity River Restoration Program
ROD = Record of Decision
Klamath LTP = Long-term Plan to Protect Adult Salmon in the Lower Klamath River

The understanding of limiting factors and these recommendations were used in subsequent workshops to develop four initial Contract Water release scenarios (Workshop 3) that were analyzed with a suite of modeling and analytical tools. A subsequent workshop (Workshop 4) was used to review results of these initial four Contract Water release scenarios and develop three additional Contract Water release scenarios.

A Baseline and seven Contract Water release scenarios were developed and modeled that included variations of elevated fall and winter base flows, fall and winter synchronized pulse flows, elevated spring baseflows, and a no-release scenario that assumed Contract Water was accumulated annually as storage in Trinity Reservoir. A summary of the scenario number and name, release description, timing, trigger criteria, and objective is provided in Table 3-5 for the initial four scenarios, and in Table 3-6 for three refined scenarios. Figure 3-7 provides an example annual hydrograph, with each of the seven scenarios overlaid together on ROD releases for a Normal water year type. Additional details on how each a timeseries of daily Contract Water releases was developed for each scenario, including constraints on timing, magnitude, and ramping rates, is provided in Appendix C.

Table 3-5. Initial Contract Water Release Scenarios

Scenario #	Scenario Name	Release	Annual Release Volume (acre-feet)	Timing	Trigger	Objectives
1	Building baseflow	Incrementally add baseflow each month to existing releases	53,084	Dec 15 – Apr 21/26/22*	Dec 15	• Increase rearing habitat area and quality for Chinook Salmon[M] • Increase available spawning and rearing habitat for Coho Salmon/steelhead[NM]
2	Fall pulse	Two 3,000 cfs pulses	49,755	Period 1: Oct 15 – Nov 15 Period 2: Nov 15 – Dec 15	1.5-year recurrence interval of Trinity River above North Fork for each period	• Recruitment/entrainment of organic matter (leaf litter, insects, benthic invertebrates)[NM] • Redistribute juvenile salmon and Lamprey[NM] • Reduce redd superimposition[M] • Provide distribution and velocities for spawners[M] • Inundate tributary delta deposits[NM] • If timed with release of yearlings, improve adult attraction into the hatchery[NM]
3	(A) One winter pulse **OR (if trigger not met)** (B) Two spring pulses	(A) One 6,000 cfs pulse **OR** (B) Two 3,000 cfs pulses	56,228	(A) Dec 15 – Feb 15 **OR** (B) Mar 15, Apr 15	(A) 4,500 cfs at Trinity River above North Fork **OR** (B) 15th of month	(A) • Sediment transport[M] • Reset the macroinvertebrate community[NM] • Scour channel[NM] (B) • Increase rearing habitat for Chinook Salmon[M] • Increase food availability for rearing Chinook Salmon[NM] • Disperse hatchery released Coho Salmon/steelhead[NM]
4	Baseflow + pulses	Combine Scenarios 1 – 3. For Scenario 3, always release spring pulses but only release winter pulse if triggered.	187,825	Combine Scenarios 1 - 3	Combine Scenarios 1 - 3	• Combine Scenarios 1 - 3

Key: cfs = cubic feet per second, M = modeled factor; NM = non-modeled factor
*End date depends on the TRRP water year type, with April 21/26/22 corresponding to the Extremely Wet, Wet, Normal / Dry / Critically Dry water year types, respectively.

Table 3-6. Refined Contract Water Release Scenarios

Scenario #	Scenario Name	Release	Annual Release Volume (acre-feet)	Timing	Trigger	Objectives
5	Two fall pulses with storage-based delay	Two 3,000 cfs pulses	49,755	Period 1: Oct 15 – Nov 15 Period 2: Nov 16 – Dec 15 Period 3: Dec 16 - Jan 15 Period 4: Jan 16 - Feb 15	1.5-year recurrence interval of Trinity River above North Fork for each period. If Trinity storage < 750 TAF in Period 1 or Period 2, delay pulse release until next period.	• Same as Scenario 2, with the added objective of avoiding releasing warm water into the Trinity River when Trinity Reservoir storage is low.
6	Modified fall baseflow	Increase fall baseflows	50,829	Oct 15 – Dec 31	Oct 15	• Increase spawning and rearing habitat area and quality for Chinook Salmon[M] while minimizing the risk for redd dewatering in January • Improve Chinook Salmon egg survival[M] • Increase spawning and rearing habitat for Coho Salmon[NM]
7	Carryover	No Contract Water release – accumulate 50 TAF each year and only release during spills	N/A	No annual Contract Water Release	When Trinity Reservoir safety-of-dams release occurs (earlier than would otherwise), assume Contract Water is spilled first	• Reduce water temperature of releases during Dry and Critically Dry years to reduce fish mortality in summer and fall and determine if high summer water temperatures are a limiting factor to fish production

Key: cfs = cubic feet per second, M = modeled factor; NM = non-modeled factor, TAF = thousand acre-feet

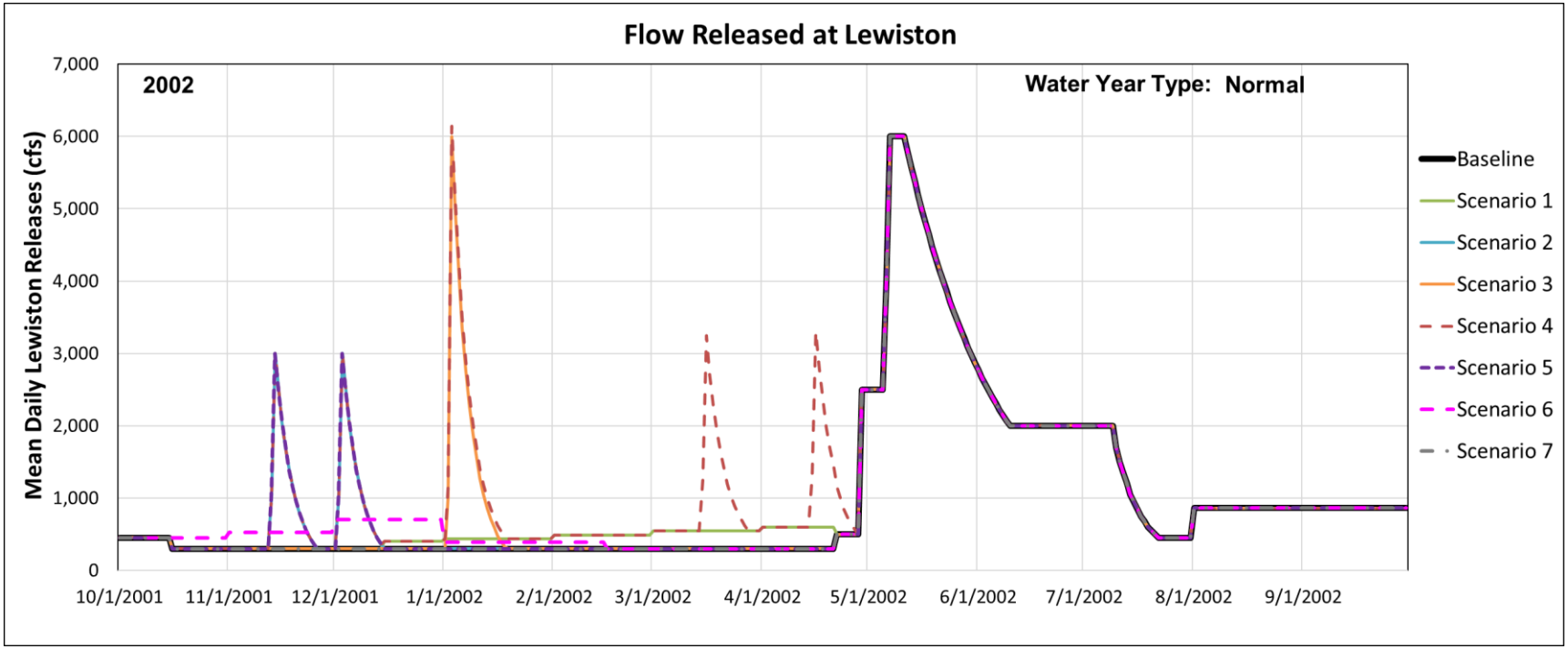


Figure 3-7. Example Contract Water Releases at Lewiston for Scenarios 1-7 Relative to Baseline Release in a Normal Water Year

3.5 Scenario Evaluation

The baseline and seven Contract Water release scenarios were assessed using a modeling framework that analyzed the effects of Contract Water releases on juvenile Chinook Salmon in the Trinity River and on the broader CVP water supply and delivery system. The framework is briefly summarized in this section, with additional detail provided in Appendix C. An overview schematic of the modeling framework is shown in Figure 3-8, with component models, inputs, and outputs shown as boxes and linkages between the components shown as arrows. The modeling framework adapts core elements of the Decision Support System (DSS) proposed by the TRRP's Science Advisory Board (Buffington et al., 2014).

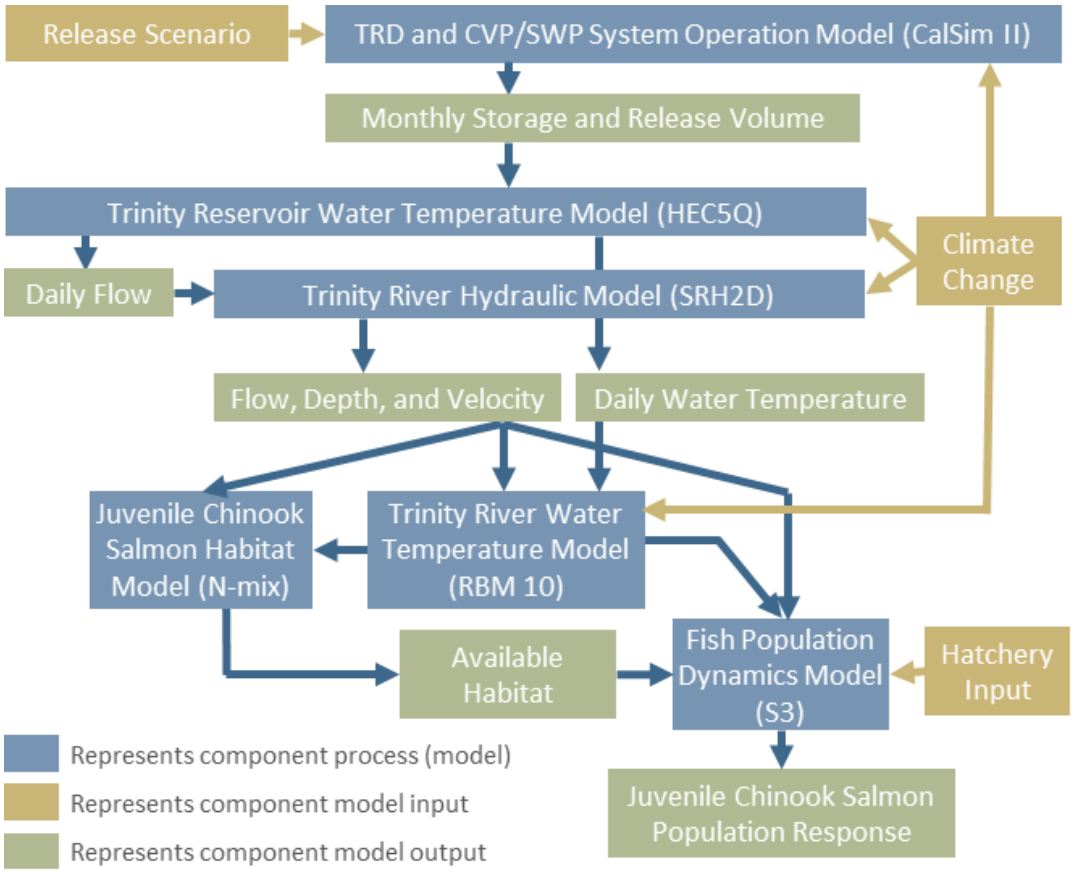


Figure 3-8. Modeling and Technical Analysis Framework for Analyzing Contract Water Release Scenarios

The seven main numerical models or model tools used to collectively assess effects of each scenario relative to the Baseline (e.g., ROD releases) include:

- **CalSim II**. This model was used to evaluate changes in TRD diversions to Whiskeytown Reservoir and associated impacts to water supply deliveries to the CVP and SWP, due to additional Contract Water released to the Trinity River.

- **HEC-5Q**. The Trinity-Sacramento River HEC-5Q Water Quality model is a one-dimensional reservoir and river water quality and temperature model of the Trinity and Upper Sacramento River system. It was used to evaluate changes to water temperature in

the Trinity, Lewiston, Whiskeytown and Shasta reservoirs and reservoir release temperatures under each scenario.

- **River Basin Model 10 (RBM10)**. This model, developed to simulate 112.2 river miles of the Trinity River is a one-dimensional (1-D) water temperature model that predicts daily water temperatures. It was used to evaluate changes to water temperature in the Trinity River under each scenario.

- **Sedimentation and River Hydraulics model (SRH-2D)**. Reclamation's SRH-2D model is a two-dimensional (2-D) flow hydraulic and mobile-bed sediment transport model for river systems. The model has been run for approximately 20 different discharges using the 2016 topography and bathymetry to determine water surface elevations, flow velocity, shear stress, and sediment mobilization (Bradley 2018).

- **Sediment models**. Sediment metrics were evaluated using a methodology similar to the Winter Flow Report (TRRP and Reclamation 2022) to quantify and evaluate the annual and total coarse bedload transport and annual partial stream bed mobilization created by each flow scenario. The coarse bedload transport was predicted using the most recent 2015 bedload rating curves from Gaeuman and Stewart (2017), while streambed mobilization was predicted using previously developed hydrodynamic outputs from SRH-2D (Bradley 2018).

- **Habitat models**. Two Chinook Salmon habitat models were used: a spawning habitat model (Goodman et al. 2018) and a juvenile microhabitat model (Som et al. 2018). Both models use outputs from SRH-2D hydrodynamic model of the Restoration Reach to predict spawning habitat and juvenile capacity (Bradley 2018).

- **Stream Salmonid Simulator (S3)**. This model is a deterministic life-stage-structured population model that simulates growth, movement, and survival of Chinook Salmon from spawning through outmigration to the ocean. S3 was constructed and parameterized for spring-run and fall-run Chinook Salmon of the Restoration Reach of the Trinity River (Perry et al. 2018b). Model inputs include water temperature, discharge, the number of juveniles from hatchery and tributary sources, as well as the spawning distribution and abundance within the mainstem Trinity River. Using these inputs, S3 simulates annual juvenile Chinook Salmon population to provide outputs for abundance, size, and biomass of the fish at a given location of the river.

For each modeling tool, a baseline model was developed to enable a relative comparison of Contract Water releases to baseline conditions. The baseline TRD and CVP regulatory and operational assumptions for scenario evaluation were based on a benchmark CalSim II model obtained from Reclamation reflecting operational assumptions as of January 1, 2021. Releases to the Trinity River in this model include ROD releases, safety-of-dams releases, and Klamath LTP releases. Flow releases from Trinity Reservoir as modeled in CalSim II served as inputs for flow-based effects in all other models.

CalSim II and HEC-5Q both were run using an 82-year simulation period, from 1922 – 2003, using historical hydrology perturbed by climate change, since model inputs have been developed for this period and applied in numerous CVP water resources planning studies. However, the River Basin 10 model was developed and calibrated for the time period 1980 – 2015. The focus of the analysis on habitat and fisheries populations was therefore only focused on the 23-year

time period of 1980 – 2003, when all models had overlapping periods of record. The S3 model relied on two primary forms of biological inputs to simulate population dynamics: (1) female spawners and (2) juvenile fish entering from tributaries and hatchery releases. The observed female spawner distribution and abundance for brood year 2007, a relatively high spawner abundance year, was used in all years of the baseline and all release scenarios to investigate density dependence in model simulations. The same spatial and temporal distribution of spawning fish was used to control for year-to year variability in population dynamics that results from variation in annual spawning abundance and distribution. Data on the numbers and sizes of juveniles that entered the Trinity River from tributary and hatchery source populations during migration year 2008 was selected to assess Contract Water release scenarios because this year follows the historical events that followed the 2007 brood year that was chosen for spawning.

All models included historical hydrology and air temperatures adjusted to reflect future climate change assumptions consistent with those used to support the Coordinated Long-Term Operation of the Central Valley Project and State Water Project (LTO) EIS (Reclamation 2015) and Klamath LTP EIS (Reclamation 2017a). In those studies, 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).

3.6 Summary of Results

The set of modeling tools was used to simulate a baseline condition and the seven different Contract Water release scenarios. For each scenario, primary model outputs included:

- Trinity Reservoir and CVP system operations
- Water temperature in Trinity, Lewiston, and Shasta reservoirs
- Lewiston Reservoir releases
- Flow and water temperature in the Trinity River and Sacramento River
- Sediment transport in the Trinity River
- Chinook Salmon habitat area and capacity
- Chinook Salmon abundance, survival, and growth in the Trinity River.

Summary results are provided in Table 3-7 and also narratively in the following subsections, based on effects of Contract Water releases relative to the baseline. Additional detailed results are available in Appendix C.

Table 3-7. Mean Annual Percent Changes Between the Scenario Metric and the Baseline Metric for the Seven Modeled Contract Water Release Scenarios in the Restoration Reach of the Trinity River

Scenario #	Modeling Tool	CalSim II		Sediment Transport		Habitat Model			Stream Salmonid Simulator (S3)				
	Primary Analysis Metric	Mean annual Lewiston releases	Mean annual CVP Contract deliveries	Total sediment mobilized	Stream bed mobil-ization	Redd habitat area	Fry capacity	Parr capacity	Egg survival	Juvenile survival	Abun-dance	Biomass	Fish mass[1]
	Scenario Description	Thousand acre-feet	Thousand acre-feet	Tons/year	% bed mobilized	Mean ha (Oct-Dec)	Mean n per m^2 (Mar-May)	Mean n per m^2 (Mar-May)	Mean annual %	Mean annual %	Mean annual n of fish	Mean annual metric tons	Mean annual grams/n
1	Building baseflow	**5%**	-0.2%	-0.3%	0.0%	0.5%	-1.6%	**2.3%**	-0.4%	0.5%	0.2%	**-4.0%**	**-4.1%**
2	Fall pulses	**5%**	-0.2%	-1.6%	-0.1%	0.4%	-0.8%	0.0%	1.3%	-0.9%	0.4%	0.9%	0.5%
3	Geomorphic pulse or spring pulses	**5%**	-0.2%	**7.5%**	**6.4%**	0.0%	0.0%	**2.3%**	-0.3%	-0.5%	-0.7%	**-2.4%**	-1.7%
4	Combine scenarios 1-3	**22%**	**-4.6%**	**15.0%**	**7.0%**	0.2%	**3.2%**	**10.5%**	0.9%	1.4%	**2.6%**	**-2.8%**	**-5.4%**
5	Fall pulses with storage-based delay	**5%**	-0.2%	-1.4%	-0.1%	0.2%	-0.7%	-1.0%	1.2%	-0.9%	0.3%	0.8%	0.6%
6	Fall baseflow	**5%**	-0.7%	-1.5%	0.0%	**5.1%**	-0.7%	-1.0%	**2.6%**	0.2%	**2.9%**	**2.8%**	-0.1%
7	Carryover	**5%**	-1.2%	**7.9%**	0.3%	0.0%	**4.6%**	**4.0%**	0%	-0.1%	-0.1%	0.3%	0.4%

Notes:
For a full description and discussion of modeling assumptions and limitations, and scenario specific assumptions, see Appendix C.
The first row lists the modeling tool used, the second row lists the primary evaluation metric, and the third row lists the units below each primary evaluation metric.
Metrics with greater than a positive 2% change relative to the baseline are presented in bold and highlighted gray.
Metrics with less than a negative 2% change relative to the baseline are presented in bold and highlighted orange.
1. Fish mass values for Scenarios 1 – 4 identified in Table ES-1 and Table 6-1 of Appendix C contained a calculation error that was corrected in this table.
Key:
% = percent
ha = hectares
m = meters
n = number of fish
TAF = thousand acre-feet

3.6.1 Effects on Trinity Reservoir

All Contract Water scenarios that released at least 50 TAF annually from Trinity Reservoir had similar effects on Trinity Reservoir storage (Figure 3-9). In general, these scenarios reduced mean annual Trinity Reservoir storage by 30 to 50 TAF, with smaller storage reductions of 0 to 10 TAF in wetter years and greater storage reductions of 50 to 100 TAF in drier years. The storage reduction was a result of increased annual releases to the Trinity River, and decreased exports to the CVP. In wetter years, the storage volume reduction, relative to the baseline, created by releasing Contract Water could be refilled with natural inflow that otherwise would have been discharged downstream through a safety-of-dams release. In consecutive drier years, natural inflow could not increase the storage volume reduction, and the effects of Contract Water began to accumulate, resulting in greater storage differences. When Contract Water was held as carryover and not released, the opposite effect was observed in drier years. An additional 50 TAF was allowed to accumulate, and storage increased by up to 350 TAF when a safety-of-dams release did not occur for multiple years.

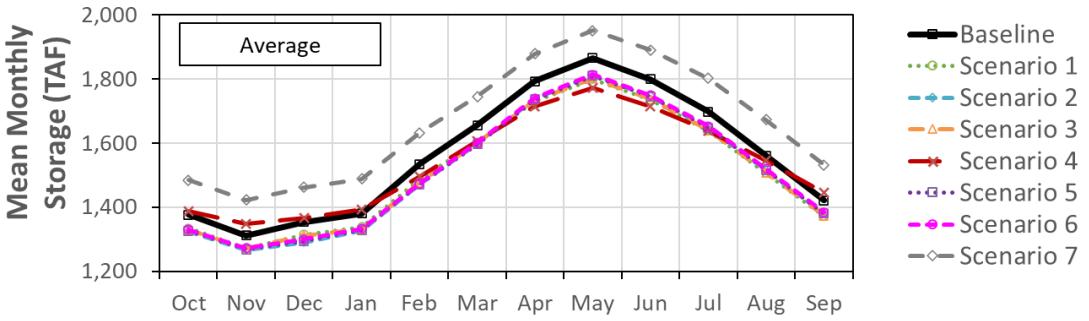


Figure 3-9. Trinity Reservoir Mean Monthly Storage in Thousand Acre-Feet (TAF) for All Scenarios.

Changes in Trinity Reservoir storage resulted in relatively small changes to Trinity Reservoir release temperature. Contract Water scenarios that released at least 50 TAF annually had similar effects – small increases in release temperature of up to 0.2°F from June through January. Scenario 4 released up to 170 TAF of Contract Water annually, which led to lower Trinity Reservoir summer storage levels and an increase in release temperature of up to 0.4°F in summer months. For Scenario 7 (carryover), release temperature decreased up to 0.4°F in summer months. These trends in release temperature changes were generally preserved through Lewiston Reservoir and into the Trinity River, but scenarios that released more water in March and April generally reduced water temperatures by up to 1.7°F, the result of higher magnitude cold water releases being routed through Lewiston Reservoir (Figure 3-10).

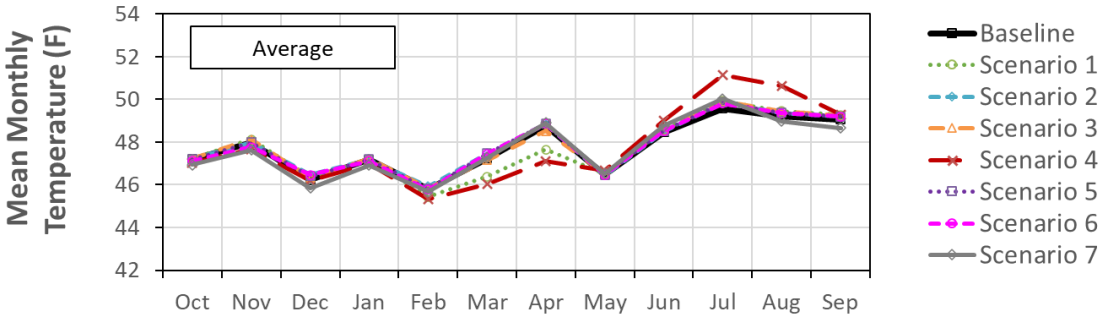


Figure 3-10. Lewiston Reservoir Mean Monthly Release Temperature in Degrees Fahrenheit (F) for All Scenarios.

3.6.2 Effects on Trinity River Physical Parameters

The effects of Contract Water releases on Trinity River flow and temperature were evaluated at the TRRP's Pear Tree restoration site. This site is typically where fish production and migration rates are measured and a location that receives inflow from tributaries between Lewiston Reservoir and North Fork Trinity River. For all scenarios, mean daily Trinity River water temperature differences relative to the baseline were generally less than 2°F, and less than 4°F for short duration periods (peak day of pulse or safety-of-dams release). Daily water temperatures were generally reduced most in the fall due to baseflow releases (Scenario 6) and in the spring due to baseflow and pulse flow releases (Scenarios 1, 3, and 4). The largest decreases in mean daily water temperature of -8°F in some years were in the spring. In most years, water temperatures in January through March were either similar to the baseline, or slightly higher due to lower Trinity Reservoir storage and lower magnitude cold water safety-of-dams releases. Trinity River water temperatures in April through June were generally similar to the baseline. July through September Trinity River water temperatures were generally increased by 0°F to 4°F for most scenarios except Scenario 7, which decreased water temperatures in some drier years.

Planned geomorphic pulses (Scenarios 3 and 4) or large relative magnitude safety-of-dams releases (Scenario 7) were required to initiate materially quantifiable bedload transport and streambed mobilization relative to the baseline (Figure 3-11). Scenarios 1, 2, 5, and 6 did not significantly affect bedload transport or partial bed mobilization (Table 3-7). Sediment transport exhibited a high degree of interannual variability, as only 42 percent of modeled years exhibited coarse bedload transport more than 10,000 tons above the baseline in scenarios 3, 4, and 7 and only 33 percent of modeled years increased the fraction of bed mobilized greater than 10 percent above the baseline in scenarios 3 and 4. The greatest effect on sediment transport relative to the baseline was observed when a safety-of-dams release was timed with a Contract Water pulse release (Scenarios 3 and 4), or when Contract Water carryover increased the safety-of-dams release magnitude (Scenario 7). Most of the transport and mobilization of sediment occurred in the downstream reaches of the Restoration Reach between Weaver Creek and North Fork Trinity River; however, because the majority of redds are established directly below Lewiston, relatively small increases in sediment mobilized in the upper reaches may create a larger impact on fish spawning habitat.

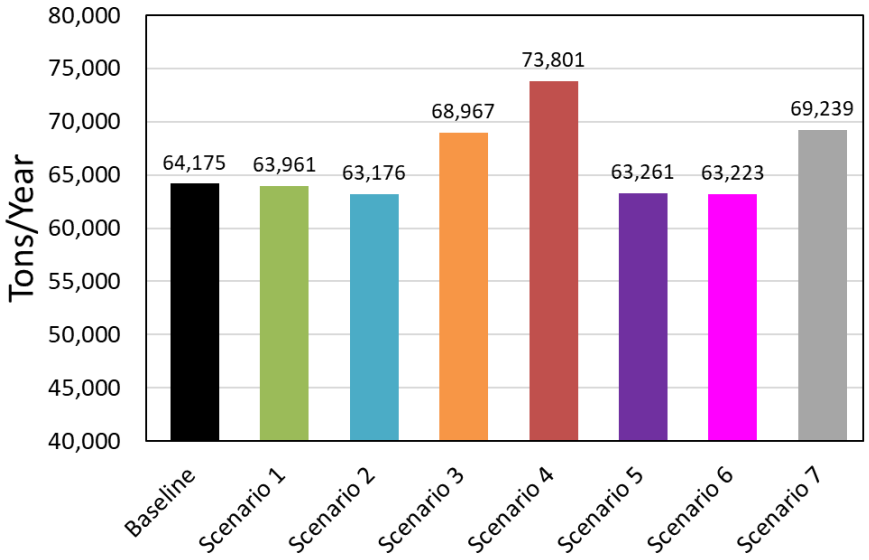


Figure 3-11. Annual Yield of Coarse Bedload in Tons/Year for All Scenarios.

3.6.3 Effects on Trinity River Juvenile Chinook Salmon

The effects of Contract Water releases on spawning and rearing habitat were primarily a function of the timing, duration, and magnitude of flow changes relative to the baseline. Fall flows released as pulses (Scenarios 2, 4, and 5) increased redd habitat area on the ascending and receding limbs of the pulse, and decreased habitat during the peak of the pulse. These scenarios produced higher egg survival relative to the baseline, indicating an overall net positive effect on spawning habitat suitability (Table 3-7). Fall flow released as a supplemental baseflow (Scenario 6) had a longer duration and more frequent positive effect on redd habitat area, which translated to the highest egg survival of all scenarios relative to the baseline (Table 3-7). Note the model did not account for the potential effects of redd dewatering following a reduction in baseflows on January 1. All other scenarios did not explicitly target the fall spawning period, and had minor effects on redd habitat area (Table 3-7). Spring releases generally increased fry and parr capacity regardless of whether those releases were modeled as a pulse or a baseflow. For scenarios that released water primarily in the fall, Trinity Reservoir storage was generally lower in the winter months, which allowed storage to stay below flood pool elevations for longer periods of time, resulting in lower average magnitude safety-of-dams releases relative to the baseline. This indirect effect of Contract Water releases resulted in reductions in spring habitat capacity in some years.

Contract Water release scenarios had different effects on juvenile Chinook Salmon egg survival, survival from emergence and outmigration towards the Pear Tree site, abundance, size, and biomass based on scenario specific combinations of flow and temperature (Table 3-7). Contract Water released in the fall had the greatest beneficial effects on egg survival, with flow released as a baseflow increasing survival more than flows released as a pulse flow (Figure 3-12). Juvenile fish survival increased for scenarios with higher magnitude releases in March and April (Scenarios 1 and 4), when juveniles are rearing, and also for Scenario 6, which had the highest egg survival rate (Figure 3-12). The largest increases in annual juvenile abundance were for Scenario 4, which released the largest volume of Contract Water, and Scenario 6, which had the highest egg survival rate. Scenario 6 released 50 TAF annually and produced higher abundance than Scenario 4, which released 170 TAF annually, highlighting the effect of Contract Water release timing as a key parameter influencing modeled population dynamics. Contract Water

scenarios that released higher magnitude, cooler (1 to 2°F) water in the spring – Scenarios 1, 3, and 4 – had the largest reductions in mean annual fish mass, while all other scenarios produced fish mass relatively similar to the baseline. Mean annual juvenile biomass changes reflect differences in both abundance and fish size. Consequently, Scenario 6 produced the largest biomass increase relative to the baseline. Scenarios that reduced fish size also had a reduction in annual biomass relative to the baseline.

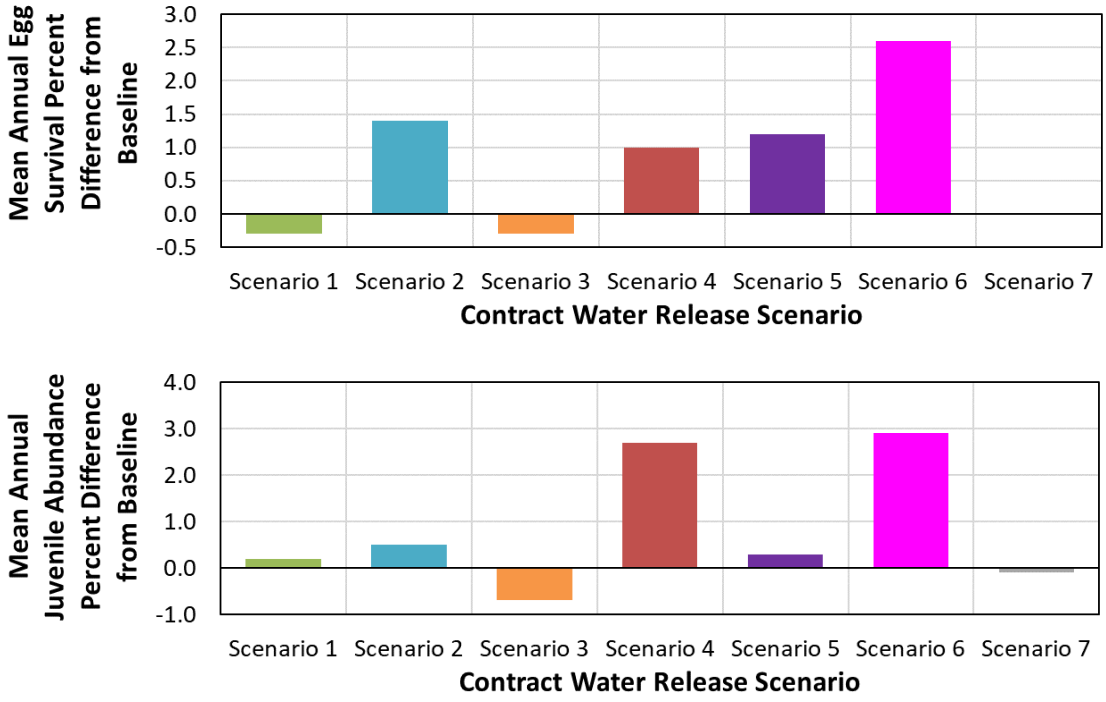


Figure 3-12. Mean Annual Modeled Percent Difference from Baseline for All Scenarios: Egg Survival (top) and Juvenile Abundance at Pear Tree (bottom).

3.6.4 Effects on CVP System

Two methods of CVP re-operation to balance TRD export reductions were modeled for each scenario that assumed 50 TAF of annual Contract Water use. The first method increased releases from Shasta Reservoir and maintained similar CVP contract deliveries North-of-Delta (NOD) and South-of-Delta (SOD) (Scenarios 1, 2, 3, and 5). Under this method, mean annual CVP deliveries NOD and SOD were reduced about 10 TAF (-0.2 percent), and mean annual Shasta Reservoir storage was reduced 20 TAF (-0.5 percent) relative to the baseline. The second method reduced CVP deliveries and maintained similar Shasta Reservoir storage and releases (Scenarios 4 and 6). Under this method, CVP delivery reductions ranged from 34 TAF (-0.7 percent) to 57 TAF (-1.2 percent) relative to the baseline, and Shasta Reservoir storage was reduced 6 TAF (-0.2 percent) relative to the baseline. Mean monthly CVP deliveries to NOD and SOD contractors are shown in Figure 3-13 for all scenarios. Sacramento River water temperatures below Clear Creek were generally similar to the baseline for each method, with increases of around 0.4°F in July and August (Figure 3-14), driven by changes in Shasta Reservoir release patterns and not due to any temperature changes in flow contributions from the TRD.

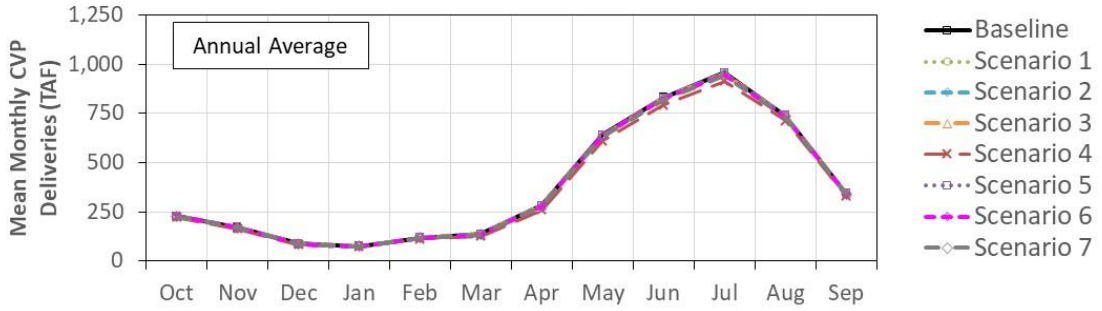


Figure 3-13. Mean Monthly CVP Deliveries to NOD and SOD Contractors in Thousand Acre-Feet (TAF) for All Scenarios.

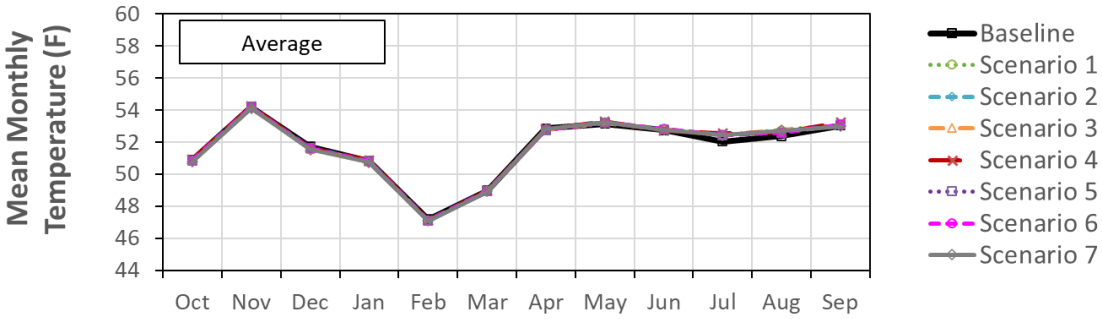


Figure 3-14. Sacramento River below Clear Creek Mean Monthly Water Temperature in Degrees Fahrenheit (F) for All Scenarios.

The effects of Contract Water releases on the broader CVP system were driven primarily by the volume of releases, and not the timing of releases, i.e., Contract Water scenarios that released around 50 TAF annually from Trinity Reservoir had similar effects. The magnitude of effects on Shasta Reservoir storage and CVP deliveries differed whether the first or second method described above was used to adjust CVP operations, but the magnitude of effects did not vary with the Contract Water release pattern from Trinity Reservoir. Whether releases were made as a fall baseflow, fall pulse flow, spring pulse flow, or spring baseflow, they all resulted in similar storage patterns in Trinity Reservoir – an annual reduction relative to the baseline that was relatively small in wetter years and larger in drier years. Lower Trinity storage created a similar reduction in TRD exports to the CVP. Because the timing of exports is similar each year, the reduction to exports occurred at the same time each year, independent of Contract Water release timing, resulting in similar storage, CVP delivery, and water temperature effects in the Sacramento River basin portion of the CVP. Water temperature effects on the Sacramento River were primarily attributed to changes in storage, release magnitude, and release temperature from Lake Shasta, and not due explicitly to inflows from the TRD. Scenario 4, which released around 187 TAF annually, had the greatest effect on the CVP system.

3.6.5 Scenarios Selected for Water Management Plan

Elevated fall and winter baseflows (Scenario 6) and fall pulse flows (Scenarios 2 and 5) had the largest modeled increases in juvenile Chinook Salmon abundance, size, and biomass relative to any other use of Contract Water, especially in average and drier water year types. These release patterns also had many hypothesized benefits that were not explicitly modeled (See Section 4.4.1.2). Because elevated fall and winter baseflows resulted in the greatest benefits to Chinook Salmon production regardless of water year type, these release patterns and timings were selected to provide the basis for the Contract Water releases under this Water Management Plan.

4 PLAN ELEMENTS

This section summarizes the main elements of the Water Management Plan, including a Contract Water release description, a qualitative description of Contract Water release benefits, and key considerations for implementation.

Humboldt County proposes that Contract Water be used to make supplemental fisheries releases to enhance Trinity River fish populations and expand a harvestable surplus for tribal, recreational, and commercial fisheries that exceeds what is already required by applicable law and Proviso 1 of Section 2 of the 1955 Act. Consistent with Proviso 2 of Section 2 of the 1955 Act, no less than 50,000 acre-feet annually would typically be released into the Trinity River as supplemental flow between March and February of the Reclamation contract year.

As conditions within the Trinity River basin change over time, other beneficial uses of Contract Water may be identified. This may lead to modified or additional proposed uses of Contract Water relative to what is described in this Water Management Plan. Once the Humboldt County water contract with Reclamation is implemented, revisions to beneficial uses and proposed uses will be reviewed as needed, and the appropriate legal, regulatory, and contractual mechanisms will be used to implement any modifications to the releases proposed in this Water Management Plan.

4.1 Contract Water Release Description

The main elements of the proposal include releases of supplemental baseflows from October through February in all years, release of supplemental fall pulse flows from October through December in most years, and release of supplemental baseflows from February through April in some years. Based on numerical modeling described in Section 2, these releases produced the greatest benefit to Chinook salmon populations in the Trinity River, and provided several additional apparent benefits that could not be quantified explicitly with modeling tools.

Humboldt County has described a general release proposal within this Water Management Plan and has not specified explicit timing or magnitudes with respect to baseflow or supplemental pulse flow release variations. The intent of the description is to provide operational flexibility in the future, allowing Humboldt County, with input from other parties, to develop fine-tuned annual release proposals that meet the needs of the fisheries of the system. As Contract Water releases become operational, existing data collection and monitoring efforts will be used to continue evaluating Chinook salmon populations in the Trinity River and lower Klamath River. As new data and analysis reflecting conditions with the addition of Contract Water releases becomes available, the specific timing and magnitude of Contract Water releases may be refined.

4.2 Consideration of 2021 LTO Consultation

Scenario development and modeling analysis to support the Water Management Plan was completed from mid-2022 through early 2023. In a separate but parallel process, Reclamation initiated the 2021 LTO Consultation around the same time, and began formulating TRD Draft Preliminary Alternatives. Humboldt County has been participating as an interested party in the 2021 LTO Consultation TRD workshops with Reclamation. Humboldt County has also provided feedback on presented materials and responded to Reclamation requests for information. The 2021 LTO Consultation TRD Preliminary Draft Alternatives were initially made available to Humboldt County and other TRD interested parties to review in mid-2023 after modeling to support the Water Management Plan was complete (Reclamation 2023). The TRD Preliminary

Draft Alternatives include new proposed operations for Trinity Reservoir, including modifications to the magnitude and timing of ROD releases that vary from the baseline operations assumed in the modeling to support the Water Management Plan. To resolve these two processes, Humboldt County has developed proposed flow releases in this Water Management Plan that:

- Preserve the primary flow patterns of scenarios identified in Section 2 that produced the greatest fisheries benefit, and
- Remain distinct but complementary to the flow releases in the anticipated 2021 LTO Consultation Proposed Action, TRD Preliminary Draft Alternative 2 – Multi-Agency Deliberation.

4.3 Flow Releases

Contract Water is proposed to be released during the contract year (March 1 through the end of February) as supplemental fall and winter baseflows and supplemental fall pulse flows based on a decision tree process.

4.3.1 Supplemental Fall and Winter Baseflows

Approximately 36,000 acre-feet of Contract Water would be released as supplemental baseflow in all years from around October 15 until around[10] February 15. Supplemental baseflows would be added to the 300 cfs minimum winter baseflows to increase redd habitat area for spawning spring-run and fall-run Chinook Salmon and to maintain elevated baseflows for Coho Salmon and steelhead spawning. A volume of 36,000 acre-feet released evenly over this period would increase continuous baseflows out of Trinity Reservoir and Lewiston Reservoir by about 150 cfs, raising the baseflow in the Trinity River from 300 cfs to 450 cfs relative to the baseline. Recent studies, however, have suggested a variable baseflow that mimics the natural hydrograph may be more suitable for fish (Goodman et al. 2018, USFWS and NOAA 2018, TRRP and Reclamation 2022), and an uneven distribution of supplemental baseflow that varied by month or day may also be released. The specific volume and timing of supplemental baseflow releases would be coordinated with Reclamation based on the timing of ROD releases and their future adaptive management process.

In years when elevated ROD baseflows were not proposed to begin around February 15, and are delayed until around April 15, up to 17,000 acre-feet of Contract Water would be released as supplemental baseflow from around[11] February 15 until around April 15. A volume of 17,000

[10] Recently, elevated ROD baseflows have been released starting February 15 (TRRP and Reclamation 2022). The 2021 LTO Consultation TRD Draft Preliminary Alternative 2 also release elevated ROD baseflows on February 15 (Reclamation 2023). Contract Water releases as supplemental fall and winter baseflows are proposed to end when elevated ROD baseflows begin, on or around February 15. The actual date when elevated ROD baseflows commence and Contract Water supplemental baseflows end would be determined each year upon coordination with the TRRP Flow Workgroup as described in Section 4.5.2.

[11] Humboldt County would coordinate with Reclamation and the TRRP to ensure Contract Water from the current contract year is released from around February 15 to the end of February, and Contract Water from the subsequent contract year is released from around March 1 through around April 15. If necessary, to enable release of subsequent contract year Contract Water on February 15, before the start of the contract year on March 1, Humboldt County would request from Reclamation permission to use during the current contract year a quantity of Contract Water from the subsequent year, referred to as "preuse". An example of a Reclamation TRD water contract provision for "preuse" of CVP water can be found in Section 3(g) of Appendix A at the following link: usbr.gov/mp/cvpia/3404c/env-docs/shasta-trinity-final-ea-02-2005.pdf [Accessed 5/11/2023].

acre-feet released evenly over this time period would allow for an increase in continuous baseflows released from Trinity and Lewiston Reservoirs of about 150 cfs, maintaining the baseflow in the Trinity River at 450 cfs[12] until ROD flows increased on or around April 15.

In any Reclamation contract year, which extends from March 1 to the end of February of the next year, Contract Water released as supplemental baseflow may total either approximately 36,000 acre-feet or approximately 53,000 acre-feet. In years when elevated ROD flows start around February 15, which is anticipated to occur in all but Critically Dry years, 36,000 acre-feet of Contract Water would be released as supplemental baseflow from around October 15 to around February 15. The remaining minimum annual Contract Water volume of 14,000 acre-feet would be released as supplemental fall pulse flows as described below (Section 4.3.2). In years when elevated ROD flows are not made starting around February 15, approximately 17,000 acre-feet of Contract Water would be released as supplemental baseflow from around February 15 to around April 15, and approximately 36,000 acre-feet of Contract Water would be released as supplemental baseflow from around October 15 to around February 15. In these years, all Contract Water would be released as supplemental baseflow.

4.3.2 Supplemental Fall Pulse Flows

In years when elevated ROD flows are made starting around February 15, approximately 14,000 acre-feet of Contract Water would be released as supplemental fall pulse flows between October and December. These fall pulse releases would support the outmigration of juvenile Chinook salmon released from the TRH, attract fish into the TRH, distribute spawners, distribute leaf litter for masticating insects, recruit organic matter for primary production, and recruit terrestrial insects for additional food production. Supplemental fall pulse flows would provide a short duration peak flow of up to 3,000 cfs followed by a multi-day recession flow and would be subject to ramping rate and other release restrictions consistent with current regulations (Buxton 2018). Potential examples of supplemental fall pulse flow daily magnitude are provided in Appendix C, Section 4.1.2. In general, releases from Lewiston Dam would not exceed 1,000 cfs[13] for more than 5 to 7 days. To avoid releasing warm water into the Trinity River, if storage in Trinity Reservoir was less than 750 TAF, the release would not occur until storage exceeded 750 TAF or after December 15, a date that generally indicates when turnover of the reservoir is likely to occur (i.e., when cooler surface water mixes with warmer, deeper water, creating a general cooling effect on the reservoir). The specific volume and timing of supplemental fall releases would be coordinated with Reclamation based on the timing of variable instream flow releases and their future adaptive management process.

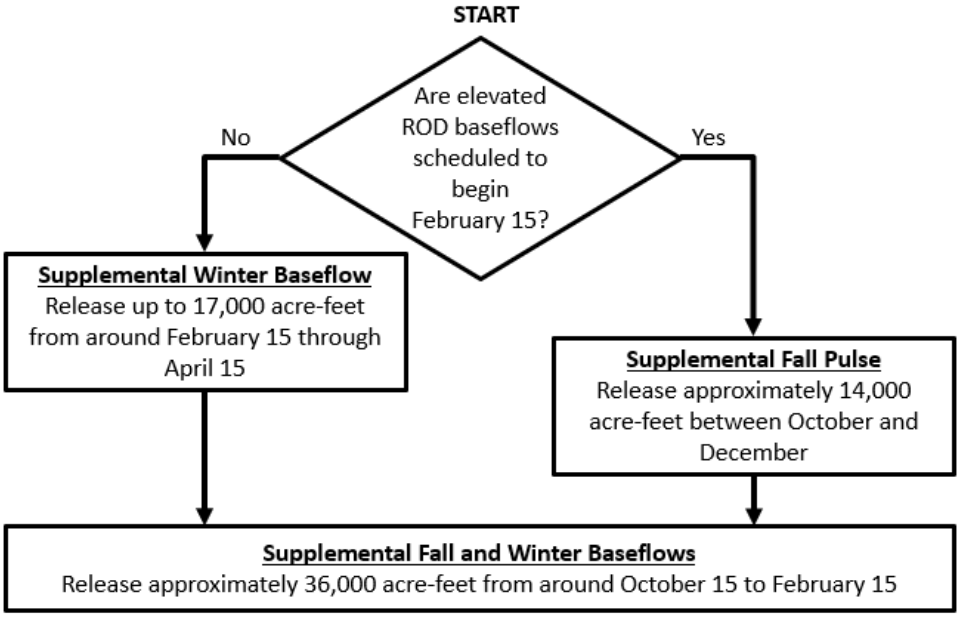
4.3.3 Decision Tree and Example Hydrographs

An example of potential Contract Water supplemental fisheries releases is provided below, with a sample annual decision tree shown in Figure 4-1. Water volumes for supplemental fisheries releases, consistent with Proviso Section 2 of the 1955 Act, would be made available on a Reclamation contract year from March 1 through the end of February. If elevated ROD baseflows are proposed starting around February 15, no supplemental fisheries releases with Contract Water

[12] A flow threshold of 1,750 cfs was the upper limit of baseflow released from Lewiston Dam between February 15 and April 28 in a proposal presented by Trinity County at a TMC meeting in December 2023, "Management of Trinity River Winter Flows to Meet Programmatic Goals and Objectives in WY2024". During the TMC meeting, a flow threshold of 1,200 cfs was presented as an upper limit of what can be safely managed for fishing on the Trinity River. Proposed supplemental winter baseflows would remain below this threshold.

[13] See footnote 12.

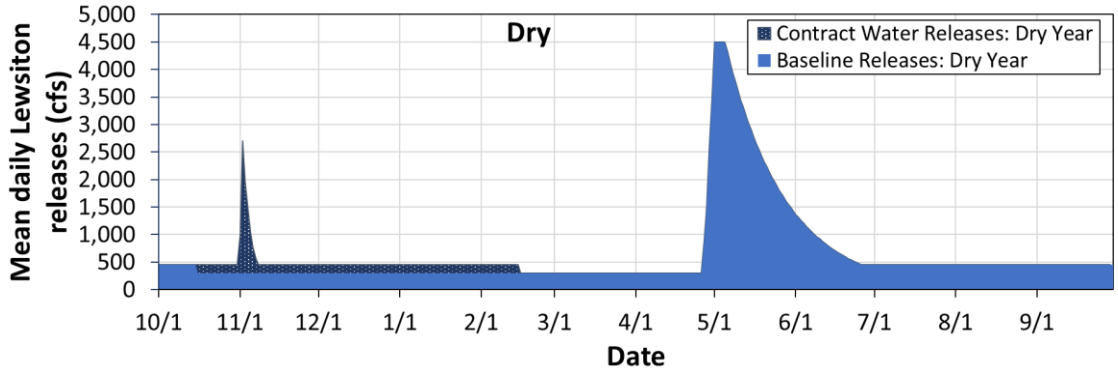
would be made, and approximately 50,000 acre-feet would be released as a combination of supplemental fall pulses and supplemental winter baseflow between approximately October 15 and February 15. If elevated ROD baseflows are not scheduled to be released around February 15, then supplemental winter baseflows of up to 17,000 acre-feet of Contract Water would be made between approximately February 15 and April 15, and approximately 36,000 acre-feet would be released as supplemental winter baseflow between roughly October 15 and February 15.



Key:
ROD = record of decision

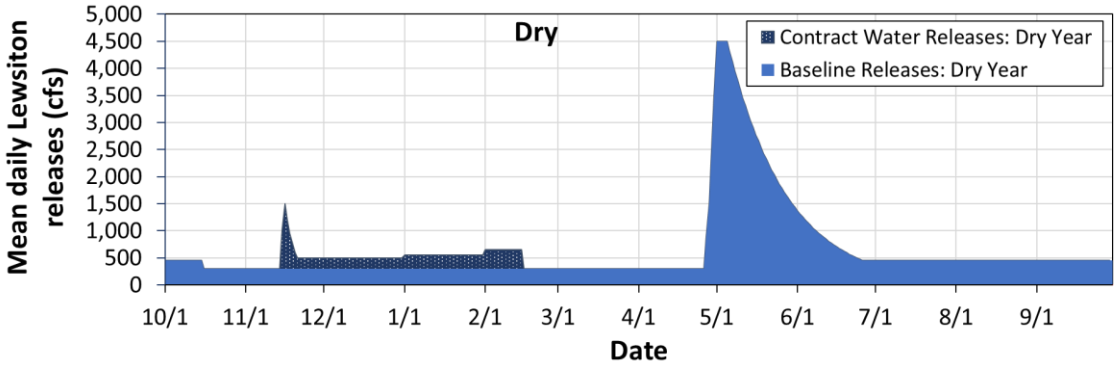
Figure 4-1. Sample Decision Tree to Calculate Contract Water Volume Allocated to Supplemental Fisheries Releases

Three example hydrographs are provided to demonstrate how the decision tree may be implemented in certain water-year types. An example of a supplemental fall pulse flow and supplemental winter baseflow (the right side of the decision tree) in a Dry year is provided in Figure 4-2. The releases total approximately 50 TAF, with continuous supplemental baseflow of 150 cfs released from October 15 to February 15, and a supplemental fall pulse with a magnitude of 2,700 cfs released on November 1. Another example of a supplemental fall pulse flow and supplemental winter baseflow (the right side of the decision tree) in a Dry year is provided in Figure 4-3. Under this example, a pulse flow with a 1,500 cfs magnitude is released on November 15, followed by an increasingly elevated baseflow, from 500 cfs after the pulse to 550 cfs on January 1 to 650 cfs on February 1.



Note: In this example, the preceding water year was not a Critically Dry year, and about 50,000 acre-feet was released from October through February. Contract Water releases are stopped on February 15, assuming releases of elevated ROD baseflows (not shown on graph) begin on February 15 at the same magnitude as Contract Water releases.

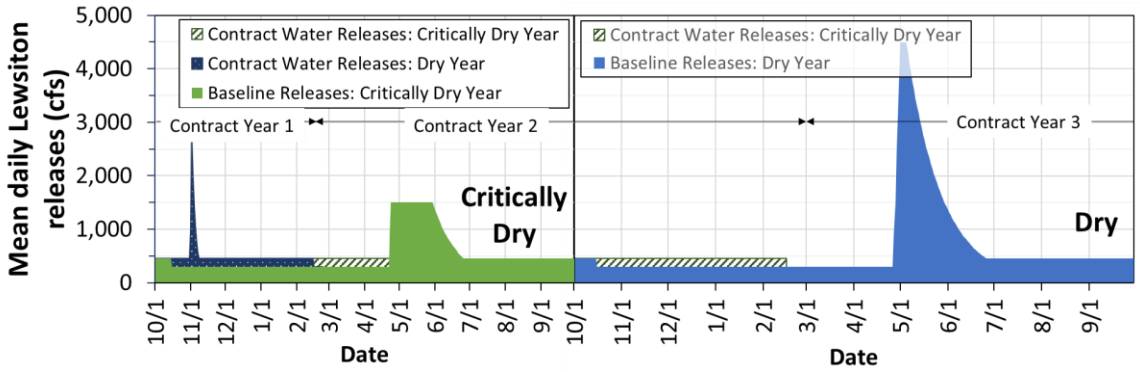
Figure 4-2. Example Hydrograph of Supplemental Baseflow and Fall Flow Contract Water Releases in a Dry Water Year



Note: In this example, the preceding water year was not a Critically Dry year, and about 50,000 acre-feet was released from October through February. Contract Water releases are stopped on February 15, assuming releases of elevated ROD baseflows (not shown on graph) begin on February 15 at the same magnitude as Contract Water releases.

Figure 4-3. Example Hydrograph of Supplemental Baseflow and Fall Flow Contract Water Releases in a Dry Water Year

In water years when elevated ROD baseflows are not proposed starting on February 15, primarily Critically Dry water years, supplemental winter baseflows would be released in February (the left side of the decision tree). An example of this release pattern is shown during a sequence of Dry, Critically Dry, and Dry water years in Figure 4-4. In the first contract year, Contract Water is released from October through February. In this example, it is assumed a Dry water year ends in September and a Critically Dry water year starts in October. Due to the difference in timing between the contract year and the water year, releases from October through February of the Critically Dry water year are from water allocated in February of the first Dry year. Starting February of the Critically Dry water year, about 17,000 acre-feet of Contract Water is used to continue supplemental baseflows through March and April until baseline ROD restoration flows are released. The remaining Contract Water is released as supplemental baseflow from October 15 through about February 15. Again, because of the mismatch in timing between contract years and water years, the flow released from October 15 through February 15 is from the Critically Dry water year, even though the transition to the next water year, a Dry year, occurred on October 1.



Note: In this example, the water year sequence is Dry (not shown on graph), Critically Dry, then Dry, and the approximate timing of contract years is shown as horizontal lines. About 50,000 acre-feet of Contract Water is released from October through February as supplemental fall flows and supplemental baseflows in contract year 1. About 17,000 acre-feet of Contract Water is released for contract year 2 starting on February 15, assuming no releases of elevated ROD baseflows from February 15 to about April 15. During the next Dry water year (but still within contract year 2), the remaining Contract Water is released as supplemental baseflow from October 15 to February 15, assuming elevated ROD baseflows (not shown on graph) begin on February 15 at the same magnitude as Contract Water releases. Contract year 3 releases would begin again on approximately October 15 (not shown).

Figure 4-4. Example Hydrograph of Supplemental Baseflow and Fall Flow Contract Water Releases in a Dry Year Followed by Supplemental Baseflow Contract Water Releases in a Critically Dry Water Year

4.3.4 Carryover Storage in Trinity Reservoir

Reclamation water contracts for delivery of TRD water to CVP contractors contain a provision that allows the contractor to request permission to reschedule for use during subsequent years some or all of their contract water from the current year[14]. This provision, known commonly as "carryover", allows the water contractor to store water supplies in TRD storage facilities and delay delivery of water supplies to a future contract year. Use of the carryover provision requires Reclamation's written approval and use of carryover must be in accordance with applicable statutes, regulations, guidelines, and policies. Despite requests to reschedule contract water, CVP contractors have indicated the use of TRD storage carryover has historically not been permitted (BVWD 2020).

Humboldt County has engaged in discussions with the DOI Solicitor's office regarding the opportunity to reschedule Contract Water in the future, should the need arise. The DOI Solicitor's office has indicated that, based on their interpretation of the 1959 Contract and subsequent documents, Contract Water could not be rescheduled into a subsequent contract year or held as carryover in TRD storage facilities. The current Contract Water release proposal does not include a carryover component, but Humboldt County reserves the right to request permission from Reclamation to reschedule Contract Water for use during subsequent years.

[14] An example of a Reclamation TRD water contract provision for rescheduling CVP water can be found in Section 3(g) of Appendix A at the following link: usbr.gov/mp/cvpia/3404c/env-docs/shasta-trinity-final-ea-02-2005.pdf [Accessed 5/11/2023]

4.4 Benefits

Contract Water releases are anticipated to result increase salmonid populations and biomass in the Trinity River and lower Klamath River realized through increased suitable salmonid habitat. Improvements to salmonid populations would have both direct economic benefits and other benefits to Humboldt County, Tribes, and surrounding areas.

4.4.1 Fisheries Physical and Biological Benefits

During development and evaluation of Contract Water release scenarios, modeling results from scenarios 2, 5 and 6 showed the most beneficial effects to fisheries relative to baseline releases. The largest modeled increase to fisheries abundance, egg survival, and biomass were observed when Contract Water was released in the fall, either as supplemental baseflow or as pulse flows (See Scenario 6 and Scenario 5, respectively, in Section 3.4, with additional detail provided in Appendix C). As a result, supplemental baseflow and fall pulse flow scenarios were selected for inclusion in the Water Management Plan. Subsequent to completing numerical modeling, these scenarios underwent some modifications to be consistent with the ongoing 2021 LTO Consultation TRD Preliminary Draft Alternatives. Generally, the supplemental baseflows were decreased in magnitude and extended in duration to ensure continuity in baseflows and no drop that could dewater redds, and fall pulse flows were decreased in frequency. The modeled fisheries benefits described below, however, still likely reflect general trends applicable to the Water Management Plan proposed releases.

4.4.1.1 Modeled Benefits

A significant benefit of Contract Water releases would be increased habitat area during the fall spawning season. Model results indicated when habitat area increased during spawning season, egg mortality decreased relative to the baseline, primarily due to reduced redd superimposition. Regardless of whether Contract Water was released in the fall as a pulse flow or as a continuous supplemental baseflow, model results showed that egg survival was increased 2 – 4 percent relative to the baseline depending on water year type (Figure 4-5). Water released as supplemental baseflow later in the winter (Scenario 1) had little direct effect on egg survival, as release magnitudes were not substantial enough to reduce redd superimposition, substantially increase juvenile (fry and parr) rearing habitat, and most eggs had emerged as fry before Contract Water releases were completed.

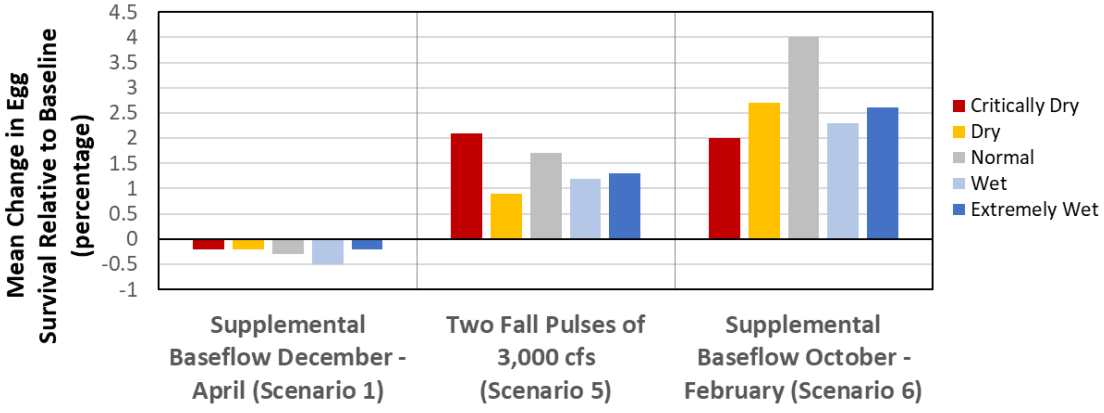


Figure 4-5. Changes in Modeled Chinook Salmon Egg Survival by Trinity River Water Year Type Across Modeled Scenarios

Modeled increases in egg survival due to Contract Water releases generally produced higher modeled abundance of outmigrating juvenile Chinook Salmon across water year types (Figure 4-6). The highest modeled increase in juvenile abundance of 2 to 5 percent relative to the baseline occurred when Contract Water was released as supplemental winter baseflow (Scenario 6), producing nearly 60,000 more juvenile Chinook Salmon per year than the baseline scenario. On average, modeled mean annual juvenile Chinook Salmon abundance increased 0.3 and 0.2 percent relative to the baseline when Contract Water was released as supplemental fall pulse flows (Scenario 5) and as late winter supplemental baseflow (Scenario 1), respectively, though some water year types showed decreases in abundance relative to the baseline.

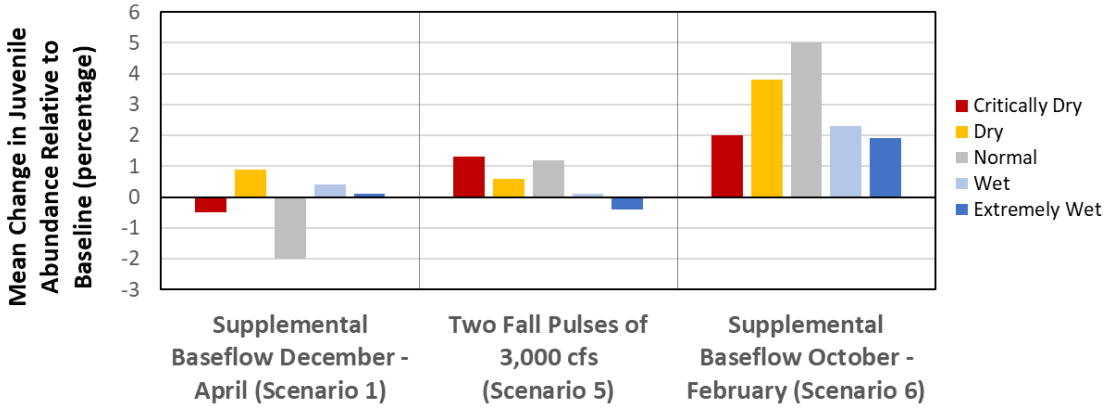


Figure 4-6. Changes in Modeled Juvenile Chinook Salmon Abundance by Trinity River Water Year Type Across Modeled Scenarios

The Water Management Plan was developed to include those release types that showed the greatest potential for increasing Chinook Salmon populations in the Trinity River and lower Klamath River. Based on the modeling framework developed and applied to evaluate Contract Water releases, supplemental baseflow (Scenario 6) and supplemental fall pulse flows (Scenario 5) showed the greatest modeled benefit to egg survival and juvenile Chinook Salmon abundance. Model results from Scenario 1 showed that, despite increased habitat capacity during the rearing period, benefits of Contract Water releases did not accrue in the form of increased egg survival or juvenile Chinook Salmon abundance when baseflow was increased only in the spring. This scenario was included in the Water Management Plan only as a strategy to maintain continuity in elevated baseflows in Critically Dry water year types – it is not included in any other water year type. The possibility of omitting Scenario 1 from the Water Management Plan and dropping baseflows from an elevated value back to 300 cfs starting February 15 was discussed within project workshops (see Appendix D), and it was deemed important to not lower water levels during the period of time when steelhead, Coho Salmon, and Chinook Salmon are spawning, incubating, and emerging. Lowering water levels could potentially dewater redds and may lead to other concerns including lowered head pressure, changes in dissolved oxygen reaching the eggs, and reduced evacuation of waste products.

4.4.1.2 Non-Modeled Benefits

The modeling framework developed to analyze Contract Water releases was not capable of quantifying all potential effects or benefits of different release types. Throughout the course of the scenario development process, numerous additional non-modeled benefits were hypothesized by interested parties for certain scenarios (see Appendix D). These potential non-modeled benefits are described in Table 4-1.

Table 4-1. Potential Non-Modeled Benefits from Contract Water Release Scenarios

Contract Water Release Component	Potential Non-Modeled Benefit	Rationale
Supplemental Baseflow (October – February)	Increase available spawning habitat for Coho Salmon	The modeling framework applied to Chinook Salmon, but the same general relationships between increased habitat area, decreased redd superimposition, and increased egg survival is believed to be applicable to Coho Salmon.
	Increase available rearing habitat for Coho Salmon	As juvenile salmonids grow, they require more habitat. Increasing flow generally produces more suitable area, which increases the number of fish a segment of the river can support. The modeling framework applied to Chinook Salmon, but the same general relationship between increased habitat area and rearing success is believed to be applicable to Coho Salmon.
	Increase the amount of food drift flux for juveniles	Juvenile salmonids forage on drifting invertebrates, and the drift flux available to them is the product of drift concentration and water velocity. Increasing baseflows would increase flow velocity, which would increase drift flux which may lead to greater food resource and larger fish. Higher velocities may also increase swimming costs and decrease prey capture success (Fausch 1984), and this relationship is not well understood in the Trinity River.
Supplemental Fall Pulse Flows (October – December)	Recruit/entrain organic matter into the stream	Increase primary production in the stream for increased nutrients and food production and availability for salmonid as they emerge from eggs.
	Redistribution of juvenile salmonids and Lamprey	Improve rearing outcomes for salmonids by encouraging juvenile salmonids and Lamprey to redistribute and expand their locations with the stream, reducing competition for space and resources within the stream.
	Inundate tributary delta deposits and lateral stream channels	Inundation of delta deposits helps to improve water quality and spawning habitat by clearing excess fine sediment (Buxton 2021b), maintain side channels, and support riparian vegetation production along stream edges.
	Improve adult attraction into the Trinity River Hatchery	Pulse flows and flow variation are a missing part of the natural flow regime under current releases, and typically provide cues for salmonids to migrate upstream in the fall period.
	Support distribution and outmigration if timed with yearling release from Trinity River Hatchery	Improve egg survival and rearing outcomes for salmonids by encouraging outmigration of juveniles, reducing competition for resources.
	Increase oxygen saturation for redds	Increasing flow velocity and depth provides more oxygen supply to eggs within redds. Salmon eggs need a consistent supply of oxygen and nutrients to flow over them during incubation for the eggs to grow properly.
Supplemental Baseflow (February – April)	Increase available spawning and rearing habitat for Coho Salmon and steelhead	As juvenile salmonids continue to grow, they require more habitat for rearing. Increasing flow generally produces more suitable habitat area, which increases the number of fish a given segment of the river can support (e.g., USFWS and NOAA 2018)

4.4.2 Economic Benefits

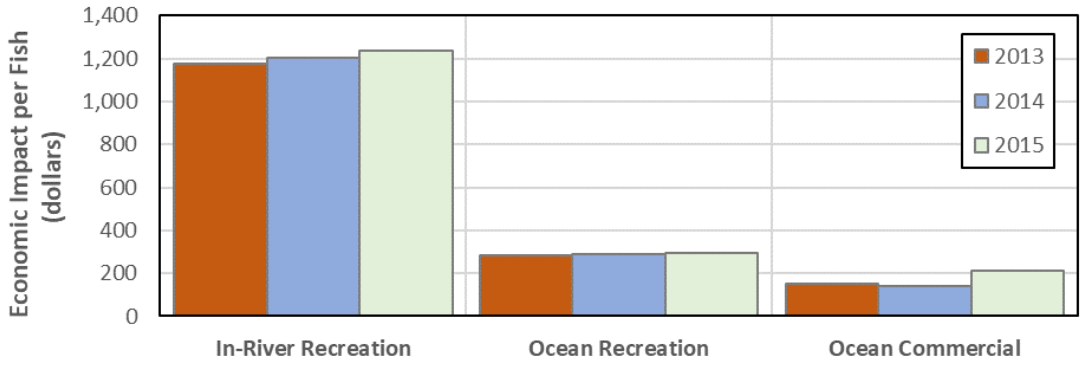
The Trinity River and lower Klamath River support several fisheries with distinct purposes, including ocean (recreational and commercial purposes), in-river (recreational purposes), and Tribal (ceremonial, subsistence, and commercial purposes) fisheries. Improving fisheries populations with Contract Water releases would produce economic benefits for these fisheries in different ways.

Klamath River fall-run Chinook Salmon (KRFC), which includes Trinity River origin fish, 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 (PFMC 2016). Ocean commercial and recreational fisheries operating in this area are managed to maximize natural production consistent with meeting the U.S. obligation to Indian tribes with federally recognized fishing rights, and recreational needs in inland areas (PFMC 2022). Presentation of information is limited to KRFC for the in-river fisheries and total landings (no-river of origin) for ocean fisheries since these are the fisheries that are intensively managed and monitored[15]. Harvest levels generally follow the abundance of the KRFC population.

4.4.2.1 In-River and Ocean Fisheries

The economic benefits of in-river and ocean fisheries to California have been assessed in several studies and informal analyses. Economic information for ocean commercial and recreational fisheries is published annually in detail by the Pacific Fishery Management Council (PFMC) (PFMC 2022), but limited information is available on the economic impacts of in-river recreational fishing. An estimate of the economic impact of salmon caught by in-river and ocean recreational fisheries and ocean commercial fisheries in California (using published data from PFMC, among other sources) showed that in-river recreational fishing economics benefits were substantially higher on a per fish basis than either ocean recreation or ocean commercial fishing (FISHBIO 2014, 2016, 2017). These estimates reflect the total economic impact of each fish caught, including the economic effects to businesses that provide goods and services that support these fisheries. In 2015 dollars, each Chinook Salmon harvested by in-river recreational fisheries had a value of $1,236 to the California economy, compared to a value of $295 per ocean recreational salmon and $214 per ocean commercial salmon (Figure 4-7). The higher value of an in-river recreationally caught salmon is mainly a reflection of the higher number of fishing days required to catch a salmon – each fishing day results in local economic effects through additional spending by anglers. The relatively lower fishing effort per fish for ocean fishing reflects both the lower number of fishing days to catch an ocean salmon recreationally, and the higher efficiency of commercial fishing (i.e., one day of commercial fishing yields many more fish than one day of recreational fishing).

[15] Tribal and State governments manage fisheries that harvest or impact spring-run Chinook Salmon, Coho Salmon, Steelhead, Green Sturgeon, and Pacific Lamprey independently. Trinity River origin Coho Salmon are managed under the Endangered Species Act as part of the Southern Oregon-Northern California Coast ESU administered by the National Marine Fisheries Service in consultation with the various Federal, Tribal and State fishery managers.



Source: Data from FISHBIO 214, 2016, 2017

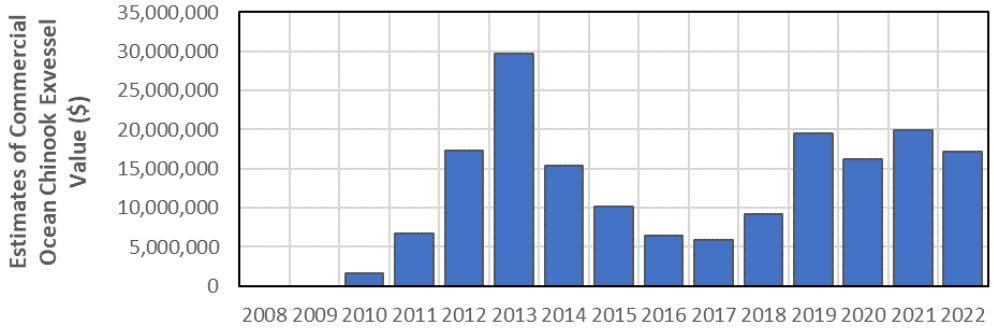
Figure 4-7. Estimated Economic Impact in California per Salmon Caught

The goal of releasing Contract Water is to expand a harvestable surplus for tribal, recreational, and commercial fisheries. The total Trinity River in-river recreational angler harvest of KRFC has ranged from a low of 13 fish in 2013 to a high of 2,371 in 2011. Based on the 2015 estimated in-river recreational economic benefit per salmon caught in California, the annual economic effects of Trinity River Chinook salmon fishing have ranged from $16,000 to nearly $3 million per year over the past ten years. This range is notable for both the large contribution to the local economy in years with a relatively high angler harvest, and the significant loss of economic impact in years when the harvest is low. Humboldt County contains many businesses that serve anglers, including bait and tackle shops, guide services, restaurants, and hotels, along with other industries that support fishing and aquaculture, many of which have deteriorated over the past decades due to low fish populations and downturns in the fishing industry (Humboldt County 2017). The modeled benefits of Contract Water releases include increased Chinook salmon abundance, which would likely translate to higher future run sizes, and greater future opportunities for in-river recreational fishing on the Trinity River, and greater economic benefits to Humboldt County.

The PFMC publishes detailed economic analyses of salmon fishing in California, including ocean commercial and recreational fishing. The ex-vessel (i.e., pertaining to when a commercial fishing boat lands or unloads a catch) value of the landings of commercial ocean Chinook Salmon fishery in California has ranged from zero in 2008 and 2009 when the fishery was shut down to an annual average of $13.5 million for the 2010 – 2022 period (PFMC 2022) (Figure 4-8). When accounting for community and personal income benefits of the ocean commercial fishery, the total value in California over the past 12 years has ranged from about $10 million in 2016 to $47 million in 2013, with most of the benefit in the San Francisco, Monterey, and Fort Bragg areas. The direct benefit to Humboldt County is likely correlated to benefits assessed in the Eureka area, which ranged from $26,000 in 2020 to $2 million in 2013 (Figure 4-9). This benefit ranged from around 5 percent of the total state benefit in 2013 to less than 1 percent of the total state benefit in 2022. The value of the ocean recreational salmon fishery in California, accounting for community and personal income benefits, ranged from $11 million in 2020 to $27 million in 2013, with most of the benefit in the San Francisco, Monterey, and Fort Bragg areas. The direct benefit to Humboldt County is likely correlated to benefits assessed in the Eureka area, which ranged from zero in 2017 when the recreational ocean fishery was closed to just over $2 million in 2013 (Figure 4-10). This benefit ranged from around 8 – 9 percent of the total state benefit in 2013 to 2 percent of the total state benefit in 2022.

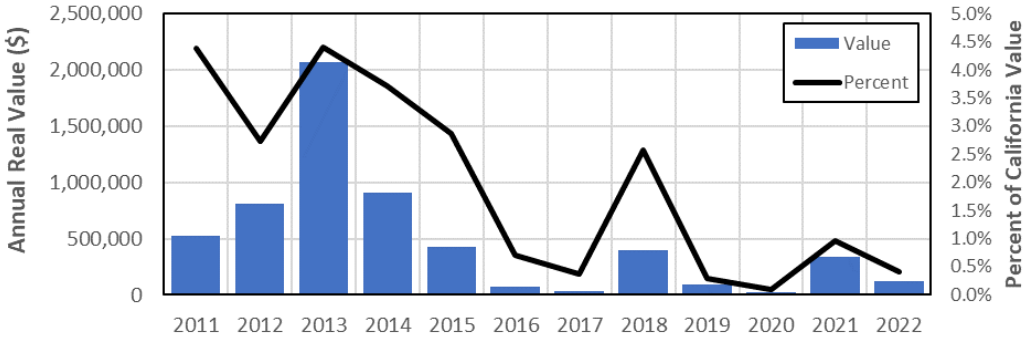
Over the past 10 years, the estimated annual economic impact of in-river recreational, ocean recreational, and ocean commercial fishing for the Humboldt County area ranged from relatively

no impact in years with low run sizes and fishing restrictions to around $6 million in years with the greatest harvest opportunities. The fisheries in the Humboldt County area likely contribute between 5 – 10 percent of the total economic impact of California salmon fisheries, but have trended downward over the past decade. The modeled benefit of Contract Water releases includes increases to Chinook Salmon populations in the Trinity River, which would translate to increased economic benefits to both the Humboldt County area and the broader California economy.



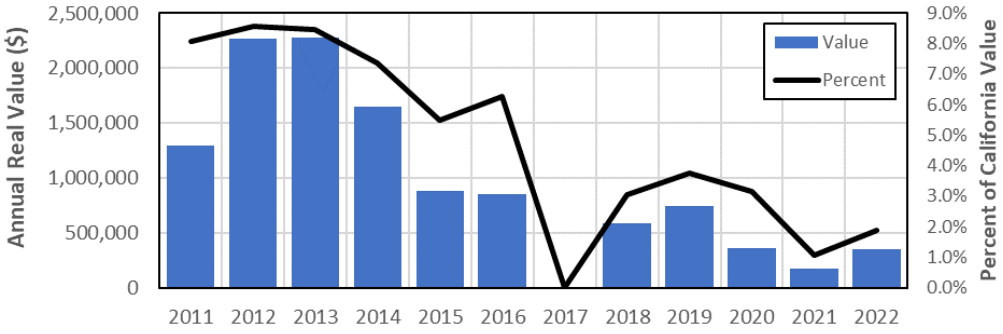
Source: Data from PFMC 2022

Figure 4-8. Estimated Annual Ex-Vessel Value of the Commercial Ocean Chinook Salmon Fishery in California



Source: Data from PFMC 2022

Figure 4-9. Estimated Annual Coastal Community and Personal Income Impact in Real Dollars of the Ocean Commercial Salmon Fishery in the Eureka Area



Source: Data from PFMC 2022

Figure 4-10. Estimated Annual Coastal Community and Personal Income Impact in Real Dollars of the Ocean Recreational Salmon Fishery in the Eureka Area

4.4.2.2 Tribal Fisheries

The Hoopa Valley Tribe and the Yurok Tribe maintain in-river fishing rights for ceremonial, subsistence, and commercial fisheries that are managed consistent with federal fishery management goals. Each year, KRFC in-river harvest quotas are developed by the PFMC, with input from CDFW. In 1993, the U.S. DOI Solicitor issued a legal opinion which concluded that the Yurok Tribe and Hoopa Valley Tribe 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 Hoopa Valley Tribe.

Commercial sales from the Yurok and Hoopa Valley Tribe tribal spring and fall gillnet fisheries on the Klamath River and Trinity River occur periodically (PFMC 2022). However, the 2022 salmon season was the seventh consecutive year in a row that the Yurok Tribe has received no or extremely low economic opportunity from their commercial fishery due to low KRFC populations (Yurok Tribe 2023). Similarly, the Hoopa Valley Tribe has chosen not to pursue a commercial fishery for KRFC in many recent years on account of a prioritized need to meet ceremonial and subsistence needs with the relatively low quota numbers (HVT 2017). Only two commercial harvest opportunities occurred in the past seven years: 1,900 KRFC were harvested commercially in 2019 and 17,100 KRFC were harvested commercially in 2015. The average annual commercial catch of KRFC during years that the fishery was open (sales from the KRFC fishery occurred in 1987-1989, 1996, 1999-2004, 2007-2015, and 2019) was 21,200 fish. Records are not available for the value of harvests for most years. The 1989 total harvest of 25,500 KRFC reportedly sold for $852,000 ($1.4 million in inflation-adjusted 2018 dollars, or $55 per fish). In 1996, 40,100 KRFC were harvested and sold combined with the Klamath River spring-run Chinook Salmon (KRSC) for $525,000 ($0.7 million in inflation-adjusted 2018 dollars, or $16 per fish).

The economic impacts to the Hoopa Valley Tribe and Yurok Tribe of reduced or no commercial fishery opportunities have been severe, as tribal members rely on income from the commercial season to provide for their families, and tribal businesses supporting the fishery have also lost annual income. The loss of economic opportunity has exacerbated existing poor economic climate of the community, a significant portion of which already live below the poverty line. As a result, both the Yurok Tribe and Hoopa Valley Tribe have requested and been recognized as an affected commercial fishery in federal fishery disaster recognition in recent years. A total of 8 federal disaster declarations have been made regarding California salmon fisheries in the past 15 years (i.e., greater than one in every two years), a frequency that has accelerated since 2005 (NMFS 2023).

The modeled benefit of Contract Water releases includes increases to Chinook Salmon populations in the Trinity River, which would contribute towards increasing KRFC run size and subsequent in-river harvest quotas. Higher quotas would contribute towards recovery of the KRFC tribal commercial fisheries, which would translate to increased economic benefits to the Hoopa Valley Tribe and Yurok Tribe.

4.4.3 Other Benefits

The Native People of the Klamath River basin have depended on the salmon of the Trinity and Klamath Rivers since time immemorial for subsistence, economic, and ceremonial purposes. The cyclical nature of the salmon's yearly migrations over the centuries have influenced almost every aspect of their lives (PFMC 2000). Many members of the Yurok Tribe believe that losing salmon means losing their culture, and ultimately themselves, that being in the river, catching fish with their families, learning from elders, or passing on those traditions gives them purpose (USFWS

2023). Adult salmon runs are currently below what is needed to meet Yurok Tribe subsistence and ceremonial needs (Yurok Tribe 2023), and the Hoopa Valley Tribe has experienced severe hardship due to loss of fish populations (HVT 2017), resulting in declining opportunities to enhance human health and well-being, knowledge transfer and capacity building in tribal communities. The release of Contract Water to increase salmon populations in the Trinity River would contribute to restoring subsistence and ceremonial opportunities.

More broadly, various pathways of societal benefits from increases in salmon populations have been recognized (Weber 2015). For example, an angler may contribute only minimally to a local economy through the act of fishing—yet the opportunity to engage in this pastime may be of extraordinarily high value to that individual, including recreational enjoyment of a fishing experience and knowledge that their children and future generations will be able to enjoy the same amenities that they enjoy today. Human appreciation for natural resources such as salmon has a quantifiable value, based on the notion that people derive satisfaction in simply knowing that a natural resource exists in some natural state, and are willing to pay to protect of increase environmental amenities even if that person were never to visit the amenity. The release of Contract Water would contribute to a societal benefit from enjoyment of enhanced Chinook Salmon populations on the Trinity River.

4.5 Management and Implementation

4.5.1 Management Structure

Humboldt County would coordinate with the TRRP Flow Workgroup and solicit input from the Hoopa Valley Tribe, Yurok Tribe, USFWS, NMFS, CDFW, and the Humboldt County Fish and Game Advisory Commission to develop an annual release proposal, but Humboldt County would have sole discretion over the timing and magnitude of annual Contract Water releases proposed to Reclamation.

Humboldt County recognizes the management structure of Contract Water releases may evolve over time as the 1959 Contract is implemented. Humboldt County is seeking to develop a formal co-management agreement with the Hoopa Valley Tribe and the Yurok Tribe that would allow each party to work in good faith to reach consensus on decisions regarding the annual use of the Contract Water while preserving the rights and interests of all parties. The management structure proposed in this section may be modified at a future date if a formal MOA is developed between Humboldt County and one or both of the tribes.

4.5.2 Annual Implementation Process

The anticipated annual implementation process for developing a Contract Water release proposal is shown in Table 4-2. The process would entail two phases during a Reclamation contract year: an initial phase to prescribe Contract Water releases, if any, from February 15 – April 15, and a final phase to prescribe Contract Water releases from October 15 – February 15.

Starting in December, Humboldt County would begin soliciting input on the timing and magnitude of Contract Water releases for the upcoming contract year. Humboldt County would coordinate with the TRRP Flow Workgroup in December to determine planned Proviso 1 flow releases through April 15. Historically, the TRRP Flow Workgroup has developed initial

hydrographs for release of Proviso 1 water starting in early December[16]. These hydrographs are refined over the following months as more information about the water year becomes available (Buxton 2021a). The hydrographs are presented to the TRRP Interdisciplinary Team for review and potential modification before presentation to the TMC for approval in early April, once the official water year type is specified in the April 1st Bulletin 120 Report. The TMC approved hydrograph is submitted to the regional directors of Reclamation and USFWS for approval. The approved flow release schedule is then provided to Reclamation Central Valley Operations (CVO) for review and implementation. This process typically modifies the ROD releases for the year and should be considered during the Initial Contract Water Release Proposal phase.

Humboldt County would also solicit input from the TRRP Flow Workgroup, USFWS, NMFS, CDFW, Hoopa Valley Tribe, Yurok Tribe, Trinity County, and the Humboldt County Fish and Game Advisory Commission on the best available data and science related to fisheries on the Trinity River and lower Klamath River to determine the specific timing and magnitude of Contract Water releases. By mid-January, Humboldt County staff would develop a Contract Water release proposal based on the best available information on proposed Proviso 1 releases from the TRRP Flow Workgroup. If Proviso 1 elevated baseflows are not proposed by the TRRP Flow Workgroup to start[17] on February 15, the Contract Water release proposal would request supplemental winter baseflows be released from February 15 to April 15, and again from October 15 through February 15 of the next year. If Proviso 1 elevated baseflows are proposed by the TRRP Flow Workgroup to start on February 15, the Contract Water release proposal would request supplemental fall flows and winter baseflows be released from October 15 through February 15.

An initial Contract Water release proposal would be submitted to the Humboldt County Board of Supervisors for approval by mid-January. The Board of Supervisors would review and approve an initial Contract Water release request to be submitted by February 1 to Reclamation for the use of Proviso 2 water within the upcoming Reclamation contract year.

In early August, Humboldt County would coordinate with the TRRP Flow Workgroup to review Trinity Storage levels and proposed Proviso 1 releases through the remainder of the year, and with the Trinity River Hatchery to determine proposed timing of hatchery fish releases. Humboldt County would again solicit input from the TRRP Flow Workgroup, USFWS, NMFS, CDFW, Hoopa Valley Tribe, Yurok Tribe, Trinity County, and the Humboldt County Fish and Game Advisory Commission on the best available data and science that should be used to refine timing and magnitude of Contract Water releases from October 15 through February 15. If necessary, refinements to the magnitude and timing of proposed Contract Water releases during the October 15 to February 15 period would be developed.

A refined Contract Water release proposal would be submitted to the Humboldt County Board of Supervisors for approval by mid-September. The Board of Supervisors would review and approve a refined Contract Water release request to be submitted by October 1 to Reclamation for the use

[16] This process may be modified based on 2021 LTO Consultation TRD Preliminary Draft Alternatives, which include earlier releases of Proviso 1 water in the fall and winter as synchronized flow and elevated baseflow, respectively.

[17] Based on the 2021 LTO Consultation TRD Draft Preliminary Alternative 2, if the 90th percentile forecast of full natural flow in the February 1 and March 1 DWR Bulletin 120 report corresponds to a Critically Dry water year type, elevated baseflows using Proviso 1 water would not be released from February 15 – April 15. For the purposes of Contract Water implementation, it is assumed the February 1 Bulletin 120 forecast is used to determine initial Contract Water releases from February 15 – April 15.

of Proviso 2 water within the remainder of the Reclamation contract year, from October 15 to February 15.

Table 4-2. Annual Implementation Process for Contract Water Releases

Phase	Timeframe	Actions
Initial Contract Water Release Proposal	December	• Humboldt County staff coordinate with TRRP Flow Workgroup. • Humboldt County staff solicit input from TRRP Flow Workgroup, USFWS, NMFS, CDFW, Hoopa Valley Tribe, Yurok Tribe, and the Humboldt County Fish and Game Advisory Commission.
	Mid-January	• Draft initial Contract Water release proposal submitted to Humboldt County Board of Supervisors for approval.
	February 1	• Humboldt County Board of Supervisors submits initial Contract Water release request to Reclamation outlining the volume of water to be released in the February 15 – April 15 timeframe. • If the 90th percentile forecast of full natural flow in the February 1 Bulletin 120 report corresponds to a Critically Dry water year, Humboldt County would request approximately 14,000 AF of Contract Water be released from February 15 – April 15. Otherwise, Humboldt County would request approximately 50,000 AF of Contract Water be released from October 15 – February 15 using a delivery pattern submitted to Reclamation by October 1.
	February 15 – April 15	• In Critically Dry water years, Reclamation would release 14,000 AF of Contract Water. In all other water years, no releases of Contract Water would be made.
Refined Contract Water Release Proposal	August	• Humboldt County staff coordinate with TRRP Flow Workgroup, TRH, and CDFW. • Humboldt County staff solicit input from TRRP Flow Workgroup, USFWS, NMFS, CDFW, Hoopa Valley Tribe, Yurok Tribe, and the Humboldt County Fish and Game Advisory Commission.
	Mid-September	• Draft refined Contract Water release proposal submitted to Humboldt County Board of Supervisors for approval.
	October 1	• Humboldt County Board of Supervisors submits refined Contract Water release request to Reclamation

Key:
AF = acre-feet
CDFW = California Department of Fish and Wildlife
NMFS = National Marine Fisheries Service
TRRP = Trinity River Restoration Program
USFWS = United States Fish and Wildlife Service

4.5.3 Data Collection and Monitoring

This Water Management Plan does not propose the development of new data collection or monitoring programs. However, existing and proposed monitoring and existing data collection efforts within the Klamath and Trinity River systems were reviewed and discussed within Workshop 5 as part of the development of the decision-making process framework. The working

group identified existing data and monitoring programs that could provide data relevant to support the annual decision-making process under this Water Management Plan and potential future adaptations to Contract Water releases. Table 4-3 and Table 4-4 provide a summary of existing data and existing and proposed monitoring programs, respectively, in the Klamath and Trinity Rivers, as well as how each data point could be leveraged to support the annual decision-making process for Contract Water releases.

In the future, identification and designation of a technical committee (e.g., similar to the TMC of the TRRP) may be appropriate. Such a group would provide oversight to identify studies which would develop new data to improve understanding of Contract Water release effects and guide adaptations of the release schedule. However, such a group is not proposed as part of this Water Management Plan.

The TRRP releases annual reports each year documenting restoration actions, monitoring programs, and findings from recent scientific studies within the Trinity River system. The reports are not released on the same month every year (reports are typically published June-December of the year following the report year), which would make review of the reports difficult to integrate into the Annual Implementation Process. However, these reports could provide relevant data and a source of compiled information to aid in the decision-making process for Contract Water releases. The TRRP Annual Reports can be found online at: https://www.trrp.net/annual-reports/.

Table 4-3. Existing Relevant Data Sources Within the Klamath and Trinity Rivers

Data	Data Source	Timing	Example of how data could support Contract Water releases
Trinity River Water Year Type	DWR Bulletin 120	April 1	Inform a release decision (e.g., release supplemental baseflows if Critically Dry).
Trinity Reservoir storage	CDEC[1]	Hourly, daily, monthly	Delay supplemental fall pulse flow if storage is below 750 TAF.
Pre-season run-size forecast (spring-run Chinook Salmon only)	Pacific States Marine Fisheries Commission	Annually, end of April	Lower run-size may lead to lower redd superimposition and more habitat per spawner available, which may inform specific timing and magnitude of supplemental baseflow releases.
Brood year abundance of prior three years	CDFW, HVT	Annual reports[2]	Indicative of parent stock of expected returns in coming year, which may inform specific timing and magnitude of supplemental baseflow releases.
Klamath River conditions for initiation of LTP flow releases	Multiple[3]	Continuous data, assessed March – September	Poor water quality in the lower Klamath River may inform specific timing and magnitude of supplemental baseflow releases or supplemental pulse flows.
Forecasted Trinity Storage for the end of December	Reclamation[4]	Projections released monthly	Delay supplemental fall pulse flow if storage is below 750 TAF or request additional Contract Water releases if high risk of spill.
Trinity River temperature	USGS gages[5]	Continuous	Provide feedback on downstream riverine temperature response to supplemental baseflows or supplemental pulse flows in relation to temperature targets, which could be used to adjust timing and magnitude of future releases.
Trinity River flows	USGS gages[5]	Continuous	Provide feedback on downstream discharge to inform assessment of effect of releases on habitat-discharge relationships, which could be used to adjust timing and magnitude of future releases.

Notes:

1. California Data Exchange Center (CDEC) reports hourly, daily, and monthly storage at Trinity Reservoir (TRINITY LAKE (CLE)). Available at: https://cdec.water.ca.gov/dynamicapp/staMeta?station_id=CLE (CDEC 2023).
2. Klamath/Trinity Program Biological Information Documents (containing CDFW annual run-size estimates and escapement reports) available at: https://nrm.dfg.ca.gov/documents/contextdocs.aspx?cat=klamathtrinity
3. Refers to multiple data sources and indicators (temperature, flow, presence of Ich, and fish population densities) used to determine whether to release preventive baseflows, a preventive one-day pulse flow, or an emergency five-day pulse flow, as described in the Klamath LTP EIS (Reclamation 2017a).
4. Reclamation produces federal end of month storage estimates for all major CVP reservoirs, projected out one year. These estimates are posted publicly within monthly meeting materials. For Trinity Reservoir, see Water Year Meeting Materials repository for the Sacramento River Temperature Task Group: https://www.usbr.gov/mp/bdo/sacramento-river-temperature-task-group.html
5. USGS gages in Restoration Reach measuring flow and temperature: Trinity R a Lewiston CA (11525500), TRINITY R BL LIMEKILN GULCH NR DOUGLAS CITY CA (11525655), TRINITY R A DOUGLAS CITY CA (11525854), TRINITY R A JUNCTION CITY CA (11526250), TRINITY R AB NF TRINITY R NR HELENA CA (11526400).

Key:

CDEC = California Data Exchange Center; CDFW = California Department of Fish and Wildlife; DWR = Department of Water Resources; HVT = Hoopa Valley Tribe; LTP = Long-Term Plan to Protect Adult Salmon in the Lower Klamath River; RBM10 = River Basin Model 10; TAF = thousand acre-feet; USGS = U.S. Geological Survey

Table 4-4. On-Going and Proposed Monitoring Programs and Studies Within the Klamath and Trinity Rivers

Monitoring Data	Agencies	Timing	Description	How data could support the decision to release Contract Water
Macroinvertebrate sampling	Yurok Tribe	Previous (June 2023-October 2023	Assess colonization after disturbance by sampling prior to and after scour event and locations inundated for specific periods of time.	Identify whether supplemental fall releases are effective at stimulating macroinvertebrate production, which could provide feedback into future release type and timing decisions.
Redds	Yurok Tribe, HVT, USFWS	On-going	Spawner surveys identifying redd locations to: • Assess redd superimposition • Cross-reference georeferenced redds with 2-D model to look at effects on changes in depth at redd locations	Identify whether supplemental fall releases are effective at providing increased redd habitat. Determine whether post-spawning releases are suitable to provide sufficient depths for salmon eggs during the incubation stages (provides sufficient oxygenation, nutrients, etc. to maintain or increase egg survival rates).
Outmigrant monitoring	Yurok Tribe, HVT, USFWS	On-going	Use data from the Pear Tree and Willow Creek sites combined with the USFWS stewards data to assess changes in fish growth and abundance	Identify whether releases are resulting in anticipated increases in fish abundance, size, and biomass.
Salmon egg mortality study	Yurok Tribe	Proposed for fall of 2023	In this pilot study, Chinook salmon egg mortality rates would be studied using artificial redds (techniques similar to San Joaquin River Restoration Program study[1]).	This would add a missing component in the S3 model and can be used for model validation between modeled and observed egg survival rates.
Telemetry studies	Yurok tribe, HVT, USGS, and USFWS (HVT-led in Trinity)	Ongoing (2022-2026)	Pilot year completed in 2022 studying migration patterns of juvenile salmon	Monitor the behavior, movement, habitat use, and survival of juvenile salmonids, and use to adjust timing and magnitude of supplemental baseflows and pulse flows.

Notes:
1. DWR 2010
Key:
2-D = two-dimensional;
HVT = Hoopa Valley Tribe;
S3 = Stream Salmonid Simulator;
USFWS = U.S. Fish and Wildlife Service;
USGS = U.S. Geological Survey

4.6 Regulatory Compliance and Permitting

Efforts to confirm the applicability of NEPA and CEQA for implementation of the Water Management Plan are ongoing and are currently linked to environmental analyses being conducted as part of the 2021 LTO Consultation (See Sections 2.2.8 and 4.2). In the future, when these analyses are substantially advanced, two documents will be completed to support regulatory compliance and permitting. An Environmental Compliance Strategy Memo will assess the applicability of NEPA, CEQA, and other laws and regulations, perform a preliminary scoping of potential environmental impacts, identify listed species and critical habitat that could be affected, and develop a strategy for complying with applicable laws and regulations. A Water Rights Memo will clarify any legal or regulatory questions regarding pertinent water rights and identify the roles, procedures, and work products needed to implement changes to those rights, as necessary, to facilitate the release of Contract Water.

4.6.1 National Environmental Policy Act (NEPA)

The proposed use of Proviso 2 of the 1955 Act as clarified in the 2014 DOI Solicitor's opinion establishes the framework for Humboldt County's Water Management Plan. Implementation of the Water Management Plan would be considered a discretionary action under NEPA through its association as an action alternative currently under consideration as part the 2021 LTO Consultation. It will be important to address the relationship between Humboldt County's Water Management Plan and tribal trust assets of the Yurok and Hoopa Valley Tribes through the ongoing NEPA processes related to the 2021 LTO Consultation.

In the event that Reclamation determines that the Water Management Plan is subject to additional NEPA review, as the lead federal agency, Reclamation would be required to comply with applicable federal laws, regulations and policies. While it is likely that ESA consultation would be required, the nature of the action considered under NEPA would not likely require authorization under the Clean Water Act or consultation under the National Historic Preservation Act.

4.6.2 California Environmental Quality Act (CEQA)

Compliance with CEQA is required for an activity undertaken by a state or local government agency that qualifies as a project, requires discretionary authority, and is not otherwise exempt from CEQA by statute in an act of the Legislature. CEQA Guidelines section 15378 states that an activity is a project if it has the potential for resulting in either a direct physical change in the environment, or a reasonably foreseeable indirect physical change in the environment. Humboldt County is evaluating potential activities that may be subject to CEQA for implementation of the Water Management Plan.

None of the Reclamation non-power generation water right permits listed in Table 2-1 include a designated place of use of lands or waters in the Trinity or Klamath watersheds located within Humboldt County. Implementation of the Water Management Plan may require the SWRCB to revise one or more of the water rights listed in Table 2-1 to establish Humboldt County as a place of use for water appropriated by Reclamation for the CVP. This would constitute a discretionary action under CEQA and require the SWRCB to document compliance with CEQA. If there is a discretionary action that requires compliance with CEQA, a number of state statutes, regulations, and policies (e.g., California ESA, Porter-Cologne Act, etc.) would be applicable prior to authorization by a CEQA agency.

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6 APPENDICES

The following documents are included as appendices to the Water Management Plan:

Appendix A: Contract Between the United States and Humboldt County.

Appendix B: Baseline Conditions Report. Baseline Conditions for the Trinity River Contract Water Management Plan.

Appendix C: Modeling Report. Hydrologic, Water Operations, Reservoir Temperature, River Temperature, Sediment Transport, Habitat, and Fish Population Modeling for the Trinity River Water Management Plan.

Appendix D: Trinity River Water Management Plan Workshops. Summary Notes from Workshops 1 – 6.

Appendix A

Contract Between the United States and Humboldt County

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Central Valley Project, California

CONTRACT BETWEEN THE UNITED STATES AND
HUMBOLDT COUNTY

1. THIS CONTRACT, made this 19th day of June 1959, in pursuance generally of the act of Congress approved June 17, 1902 (32 Stat. 388), and all acts of Congress amendatory thereof or supplementary thereto, including the act of Congress approved August 12, 1955 (69 Stat. 719), all of which are commonly known and referred to as the Federal reclamation laws, between THE UNITED STATES OF AMERICA, hereinafter referred to as the "United States," represented by the officer executing this contract, and HUMBOLDT COUNTY, a political subdivision of the State of California, duly organized and existing pursuant to the laws thereof, with its principal place of business in the town of Eureka, State of California, hereinafter referred to as the "County";

WITNESSETH, THAT:

EXPLANATORY RECITALS

2. WHEREAS, the Bureau of Reclamation, of the United States Department of the Interior, has been duly authorized to construct and operate the Trinity River Division of the Central

Valley Project, which Division will include Trinity and Lewiston Dams and appurtenant works, for the purpose of the conservation of water resources, which dams are to be located respectively in the County of Trinity, State of California, on the Trinity River, at or about N. 34° 42' E., 2,308 feet from the Southwest corner of Section 15, T. 33 N., R. 8 W., M.D.B.&M., and at or about N. 73° 56' E., 3,777 feet from the Southwest corner of Section 8, T. 33 N., R. 8 W., M.D.B.&M., and which dams will affect flows of the Trinity River; and

3. WHEREAS, the County has appeared as an interested party at the hearing on the 29th day of December 1958, before the State Water Rights Board of the State of California with reference to the issuance of permits on Applications No. 5627, 5628, 15374, 15375, 15376, 16767, 16768, and 17374 for the appropriation of unappropriated water of the Trinity River, which have been filed by the United States; and

4. WHEREAS, Section 8 of the said Reclamation Act of June 17, 1902, provides as follows:

> "That nothing in this act shall be construed as affecting or intended to affect or to in any way interfere with the laws of any State or Territory relating to the control, appropriation, use, or distribution of water used in irrigation, or any vested right acquired thereunder and the Secretary of the Interior, in carrying out the provisions of this act, shall proceed in conformity with such laws, and nothing herein shall in any way affect any right of any State or of the Federal Government or of

any landowner, appropriator, or user of water in, to, or from any interstate stream or the waters thereof: Provided, That the right to the use of water acquired under the provisions of this act shall be appurtenant to the land irrigated and beneficial use shall be the basis, the measure, and the limit of the right."

and

5. WHEREAS, the said act of August 12, 1955, provides in Section 2 thereof in part as follows:

". . . 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."

and

6. WHEREAS, it is desired to establish by terms of this contract operating criteria the observance of which will not impair rights to the reasonable and beneficial use of water originating above Trinity Dam;

NOW, THEREFORE, in consideration of the provisions hereinabove set out and in compliance with the hereinabove quoted provisions of the said acts, it is hereby agreed by and between the parties hereto as follows:

7. The United States shall have the right to divert and store the waters of the Trinity River and its tributaries, and the right to use the water so stored for beneficial use for irrigation and other purposes and for the generation of electric energy in connection with the Central Valley Project.

8. 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.

9. Authorized representatives of the County shall have access at all reasonable times during office hours to records and computations pertaining to releases from said reservoirs and, upon reasonable request, shall be furnished copies of such records and computations.

EFFECT OF WAIVER OF BREACH

10. The waiver of a breach of any of the provisions of this contract shall not be deemed to be a waiver of any other provisions hereof or of a subsequent breach of such provisions.

RESPONSIBILITY FOR INTERRUPTION

11. In the event the performance, in whole or in part, of the obligations of the respective parties under this contract is hindered, interrupted, or prevented by war, strikes, lockouts, fires, acts of God, or by other similar or different acts of civil or military authorities, or by any cause beyond the control of the respective parties hereto, whether similar to the causes herein specified or not, such obligations of the respective parties under this contract shall be suspended to the extent and for the time that performance thereof is prevented or affected by such hindrance,

interruption, or prevention, but due diligence shall be observed by the respective parties hereto, so far as lies in their power, in performing their respective obligations under this contract.

OFFICIALS NOT TO BENEFIT

12. No Member of or Delegate to Congress or Resident Commissioner shall be admitted to any share or part of this contract or to any benefit that may arise herefrom, but this restriction shall not be construed to extend to this contract if made with a corporation or company for its general benefit.

SUCCESSORS AND ASSIGNS BOUND

13. This contract shall be binding upon and inure to the benefit of the successors and assigns of the respective parties hereto.

IN WITNESS WHEREOF, the parties hereto, by their respective officers thereunto duly authorized, have duly executed these presents on the day and year first hereinabove written.

THE UNITED STATE OF AMERICA

By _____
Regional Director, Region 2
Bureau of Reclamation

ATTEST:

_____
County Clerk of the County of Humboldt

HUMBOLDT COUNTY

By _____
Chairman of the Board of Supervisors

Appendix B

Baseline Conditions Report

Baseline Conditions for the Trinity River Contract Water Management Plan

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.

Acknowledgements

Humboldt County

Board of Supervisors
Department of Public Works

Agencies and Tribes

California Wildlife Conservation Board
California Department of Fish & Wildlife
United States Geological Survey
United States Fish and Wildlife Service
National Oceanic and Atmospheric Administration
Hoopa Valley Tribe
Yurok Tribe
United States Bureau of Reclamation

Non-Governmental Organizations

CalTrout
Pacific Coast Federation of Fishermen's Associations

Consultant Team

Suits and Signs Consulting
Stantec Consulting Services Inc.
Thomas Gast & Associates

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Tom Stokely and Joe Polos

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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.

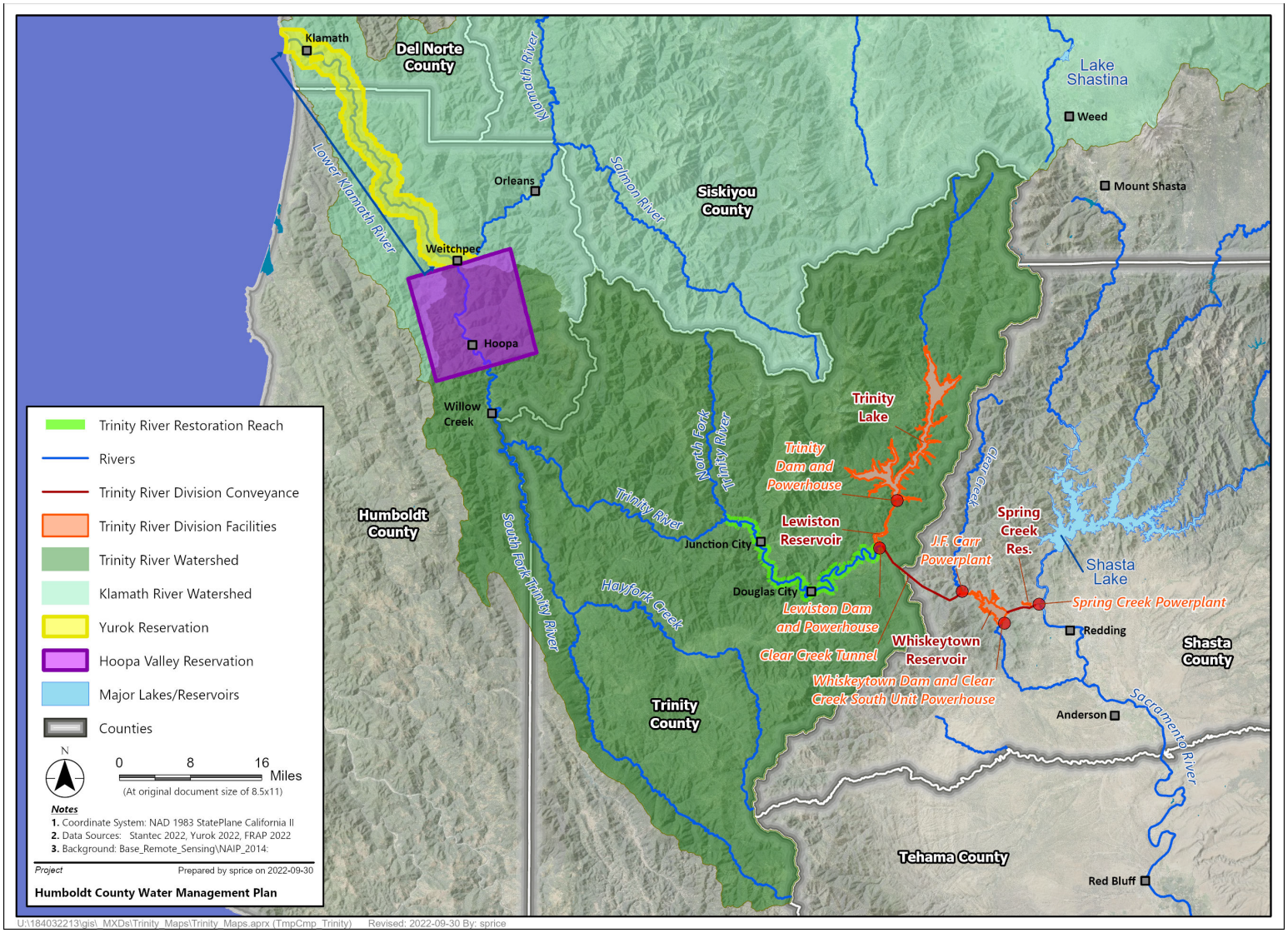


Figure 2-1. Major Facilities, Features, and Boundaries Associated with the Trinity River Division

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):

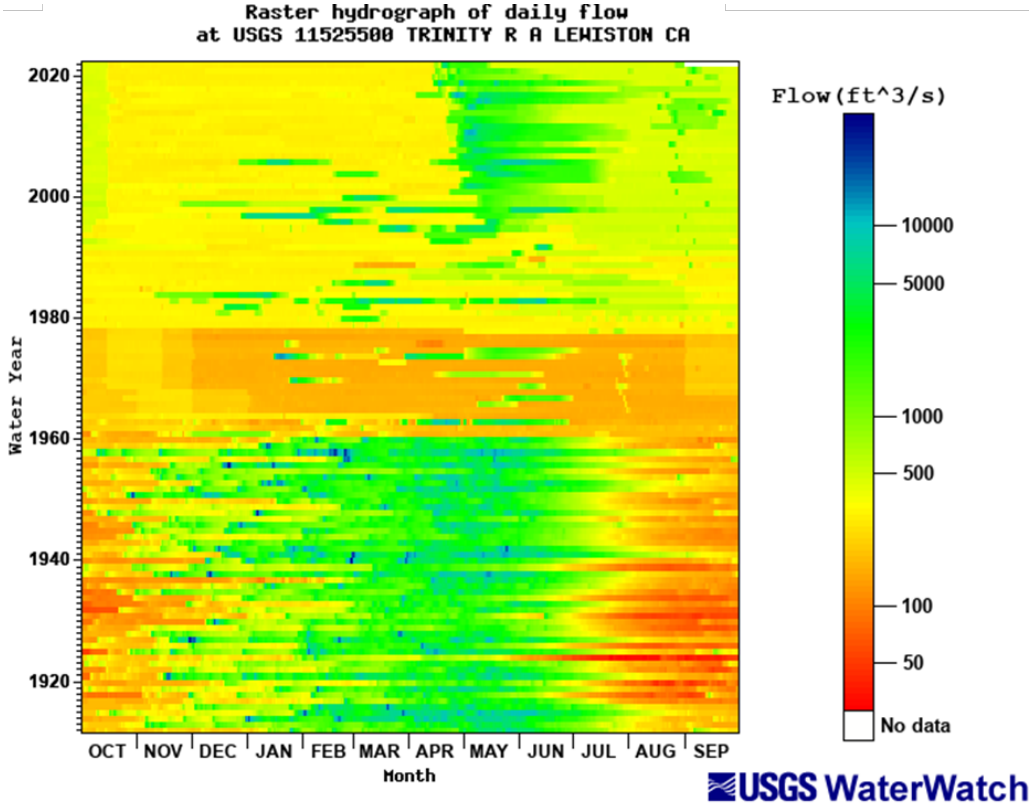
- From 1911 through 1960, Trinity River was a natural alluvial river with a highly variable flow regime, including low summer base flows, rising winter baseflows with intermittent high magnitude winter peak flows, and sustained high magnitude flows during spring snowmelt that rapidly receded back to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



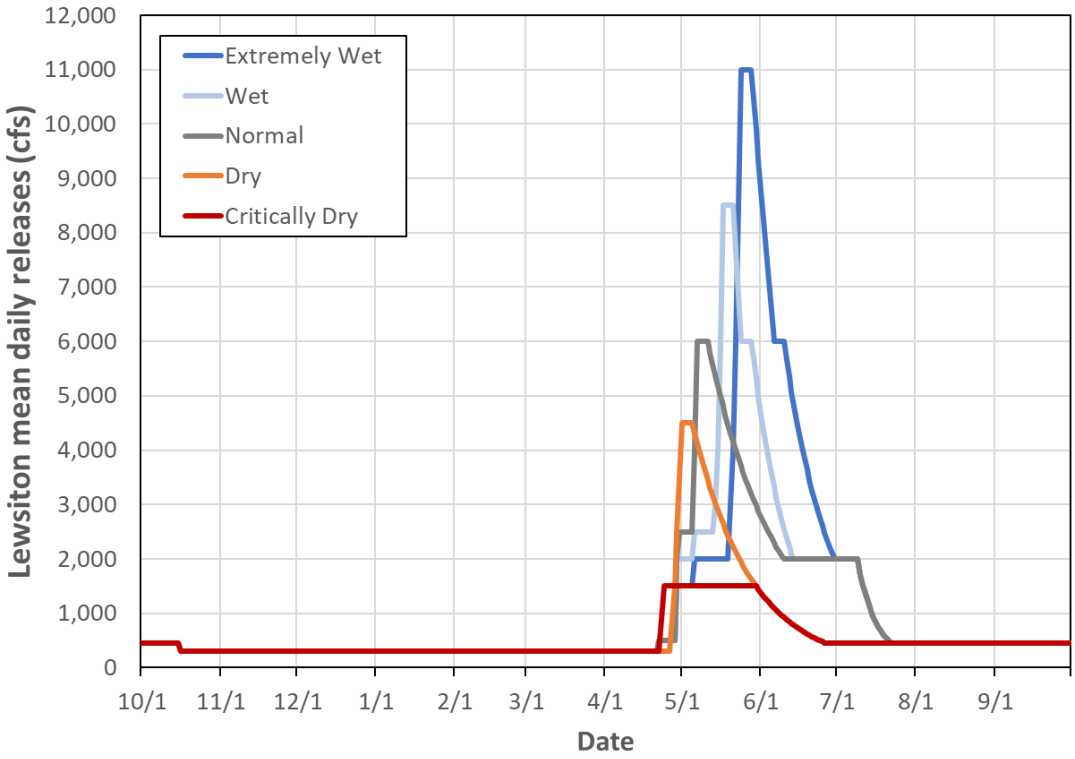
Key:
ft = feet
s = second
Trinity R A Lewiston CA = Trinity River at Lewiston California
USGS = United States Geologic Survey

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).

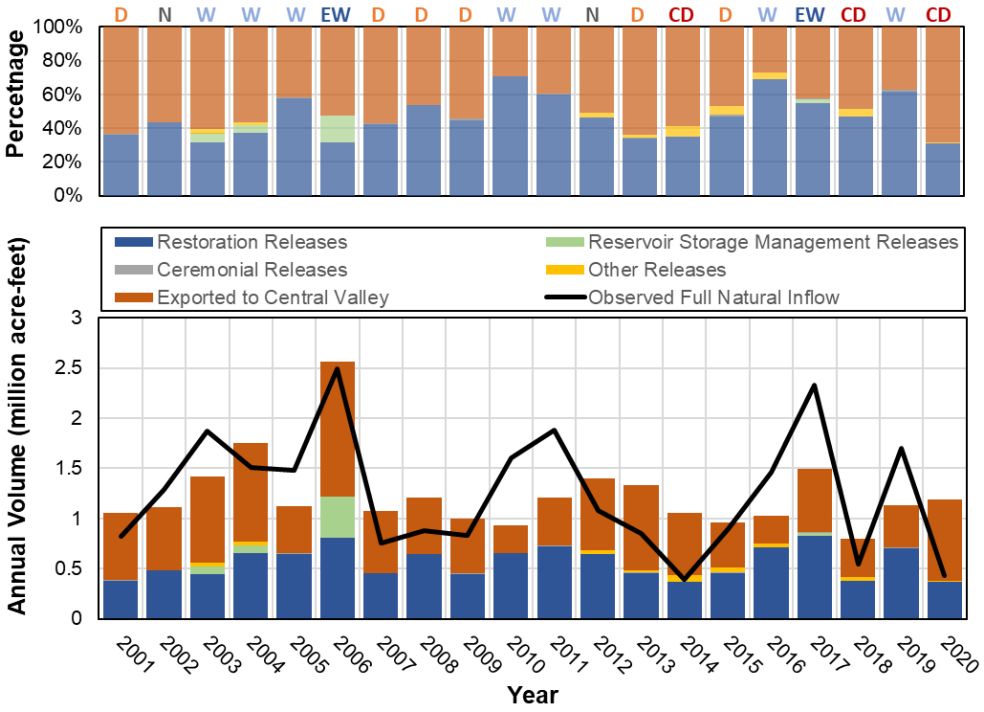
- Releases for reservoir storage management to protect the safety of Trinity and Lewiston Dams. These releases are typically implemented with short notice in winter or early spring and are designed to draw down a full or nearly full reservoir for public safety and to safeguard infrastructure from overtopping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

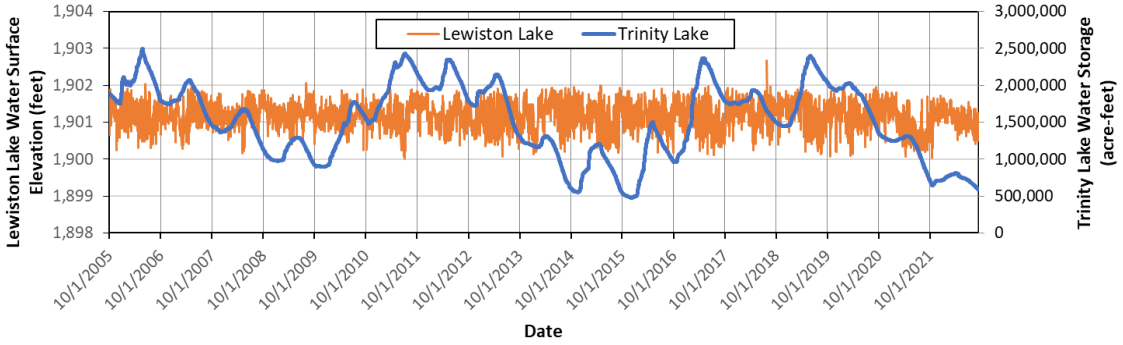
A timeseries of annual release types and exports from 2001 to 2020 shows that TRD operations are comprised primarily of restoration releases and exports to the Central Valley (Figure 2-4). The relative percentage of flow released to the Trinity River is generally greater in wetter years, while the relative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

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

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.

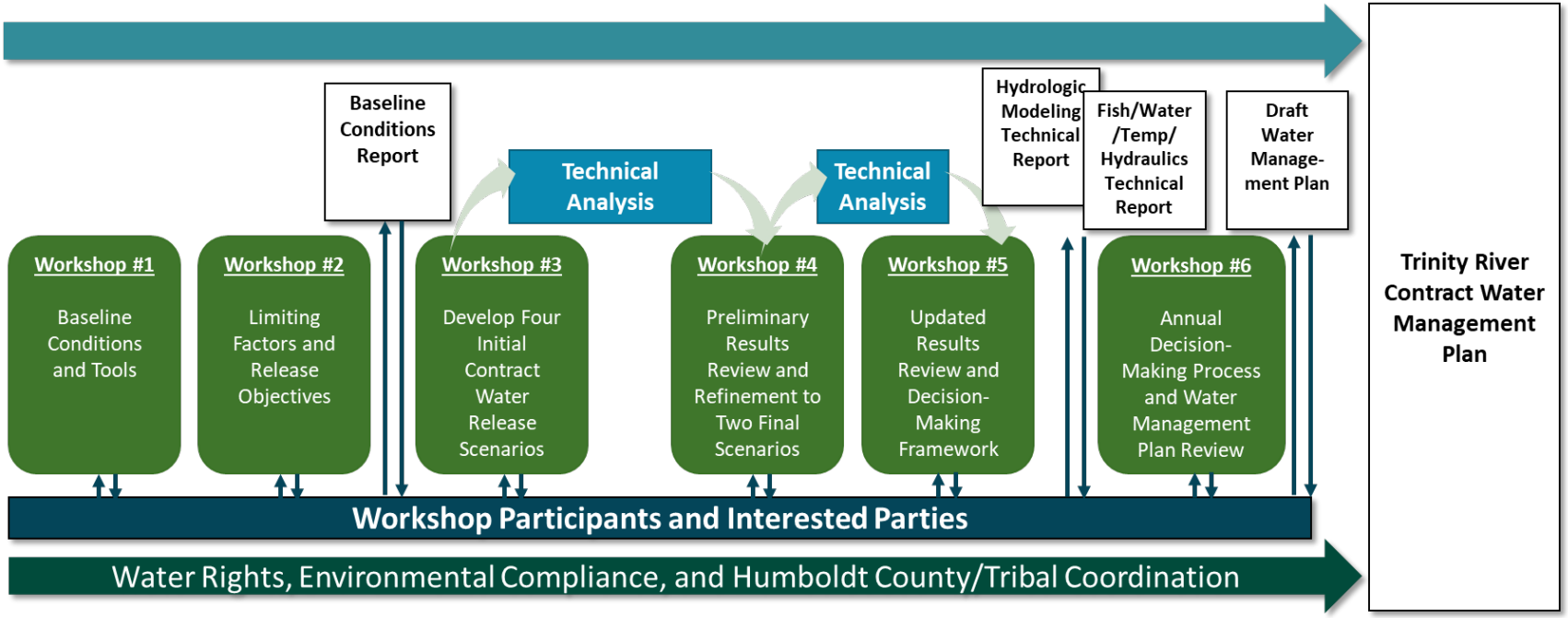


Figure 2-6. Water Management Plan Development Framework

3 ENVIRONMENTAL SETTING

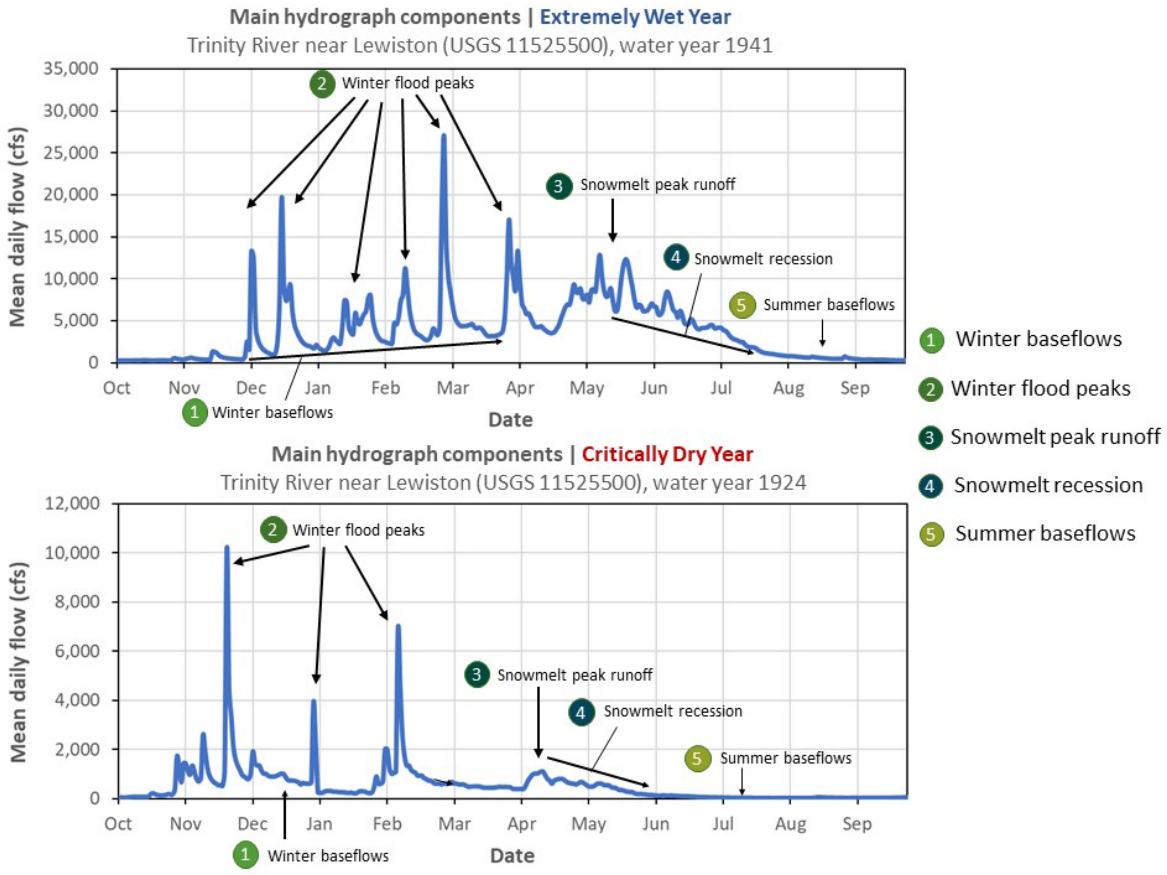
This section describes relevant history and current environmental conditions in the Trinity River, focusing on the 40 miles downstream of Lewiston Dam referred to as the Restoration Reach.

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.

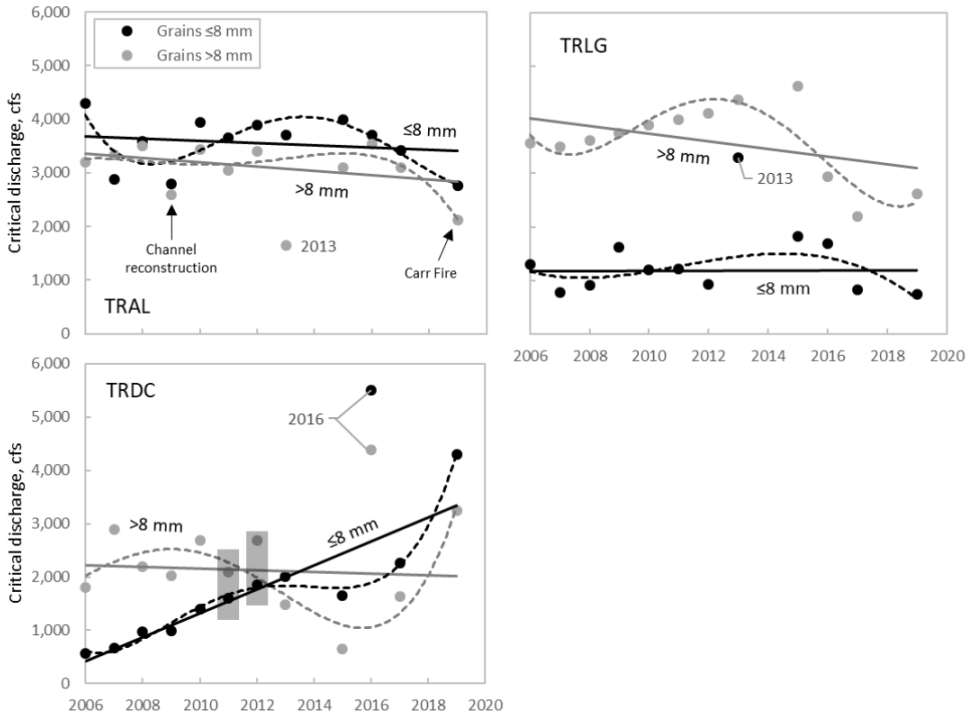
3.2 Geomorphology

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).

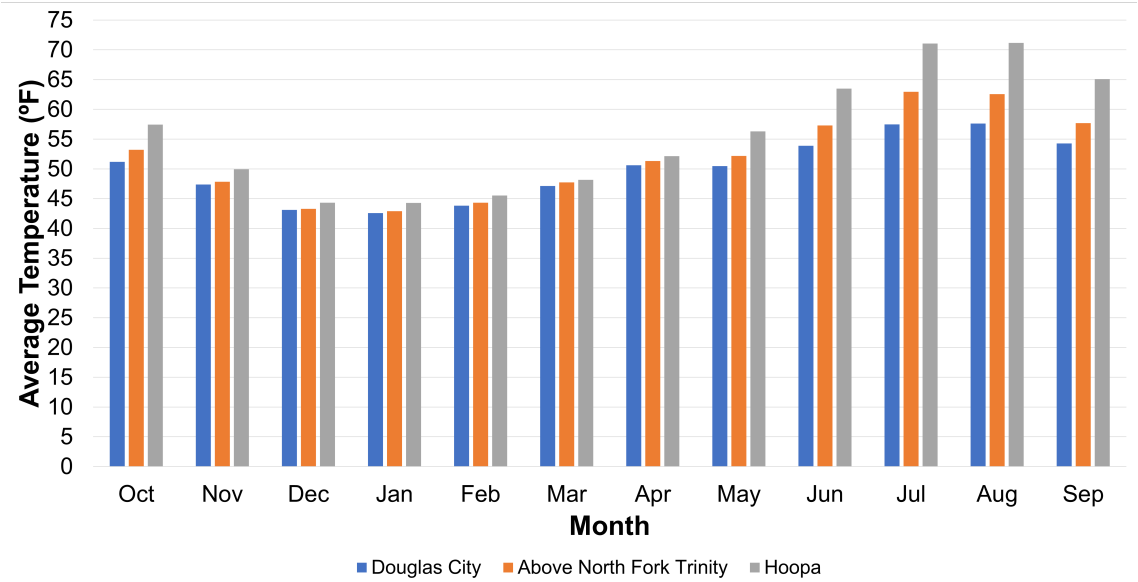
3.3 Water Quality

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.



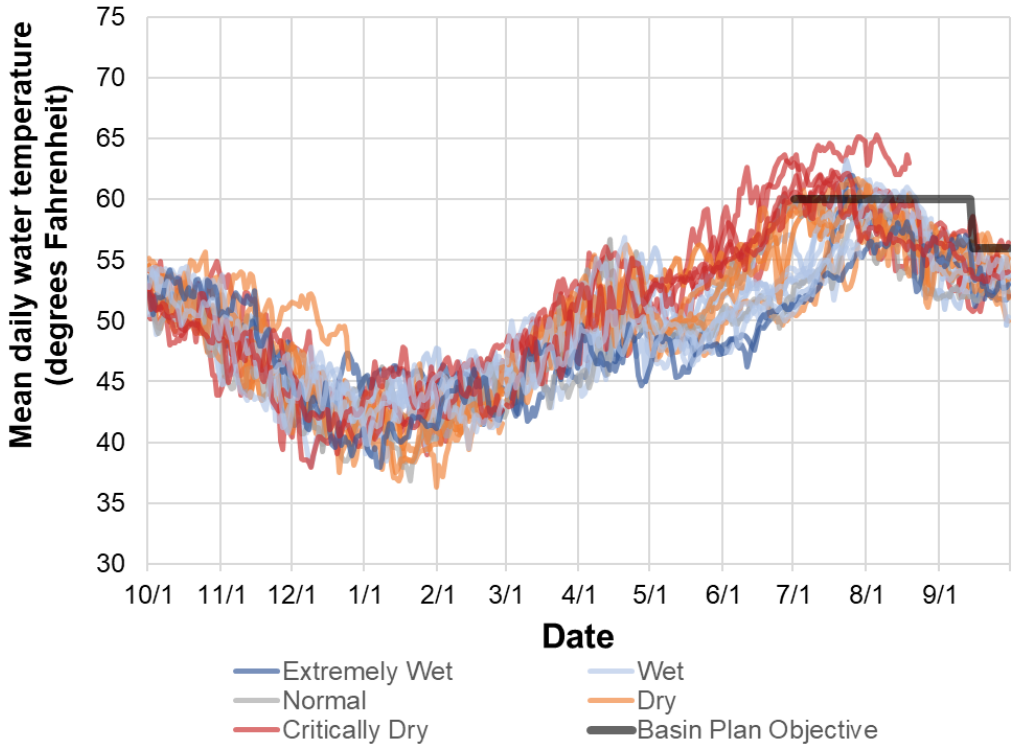
Data source: California Data Exchange Center (CDEC), Stations DGC (Trinity River at Douglas City), NFH (Trinity River above North Fork Trinity River near Helena), and HPA (Trinity River at Hoopa).

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.

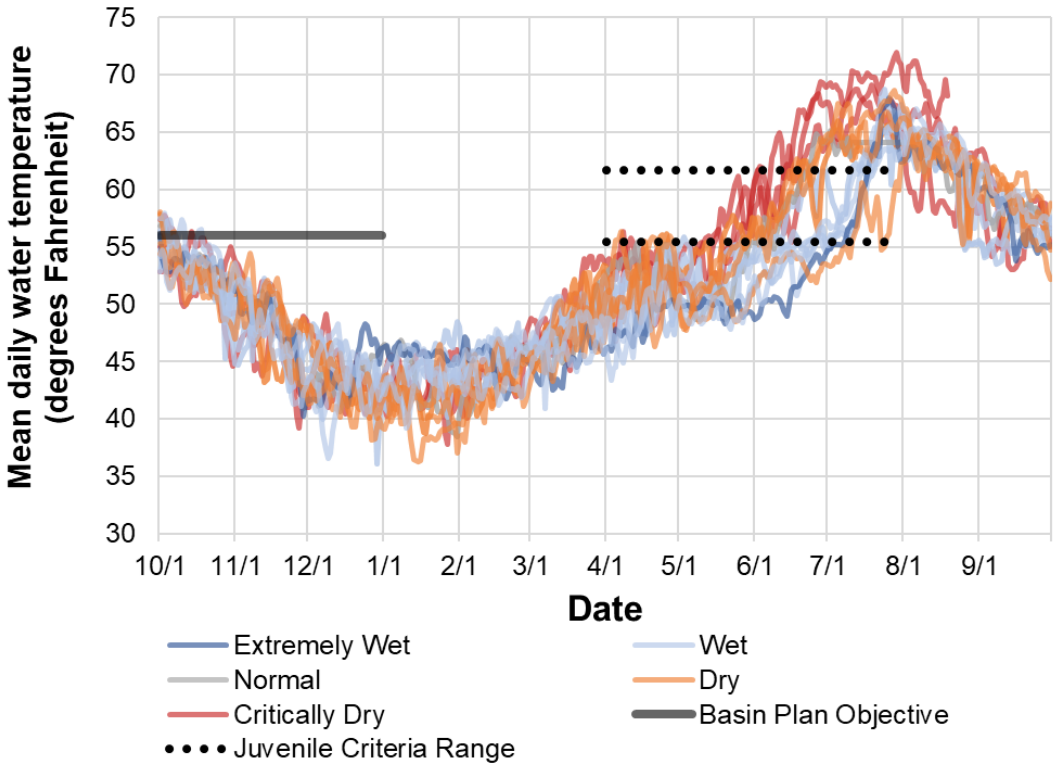
Recent evaluation of the objectives and targets established in the 2000 ROD resulted in recommendations from the TRRP's Fish Workgroup for additional temperature objectives specific to rearing juveniles in the mainstem Trinity River. This target range is currently under evaluation. The TRRP's Fish Workgroup 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

Species/Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chinook Salmon												
Adult Migration				Spring-run								
								Fall-run				
Spawning									Spring-run			
										Fall-run		
Incubation	Spring-run								Spring-run			
	Fall-run									Fall-run		
Emergence	Spring- and Fall-run											
Rearing	Spring-run											
	Fall-run											
Outmigration			Spring- and Fall-run									
Coho Salmon												
Adult Migration												
Spawning												
Incubation												
Emergence												
Rearing												
Outmigration												
Steelhead												
Adult Migration					Summer-run							
									Fall-run			
	Winter-run										Winter-run	
Spawning		All runs										
Incubation			All runs									
Emergence				All runs								
Rearing	All runs											
Outmigration				All runs						All runs		

3.4.1.1 Chinook Salmon

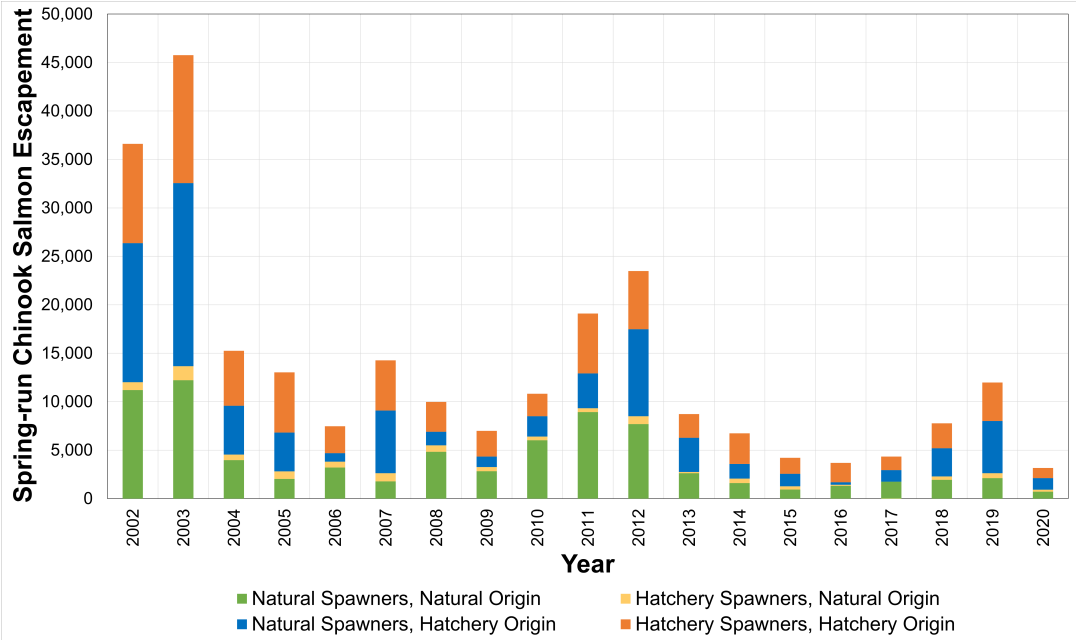
The Upper Klamath and Trinity Rivers (UKTR) Evolutionarily Significant Unit (ESU) includes fall- and spring-runs of Chinook Salmon that spawn in the Klamath and Trinity Rivers upstream of the Trinity River's confluence with the Klamath River. Although wild spring-run Chinook Salmon in the Klamath River 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

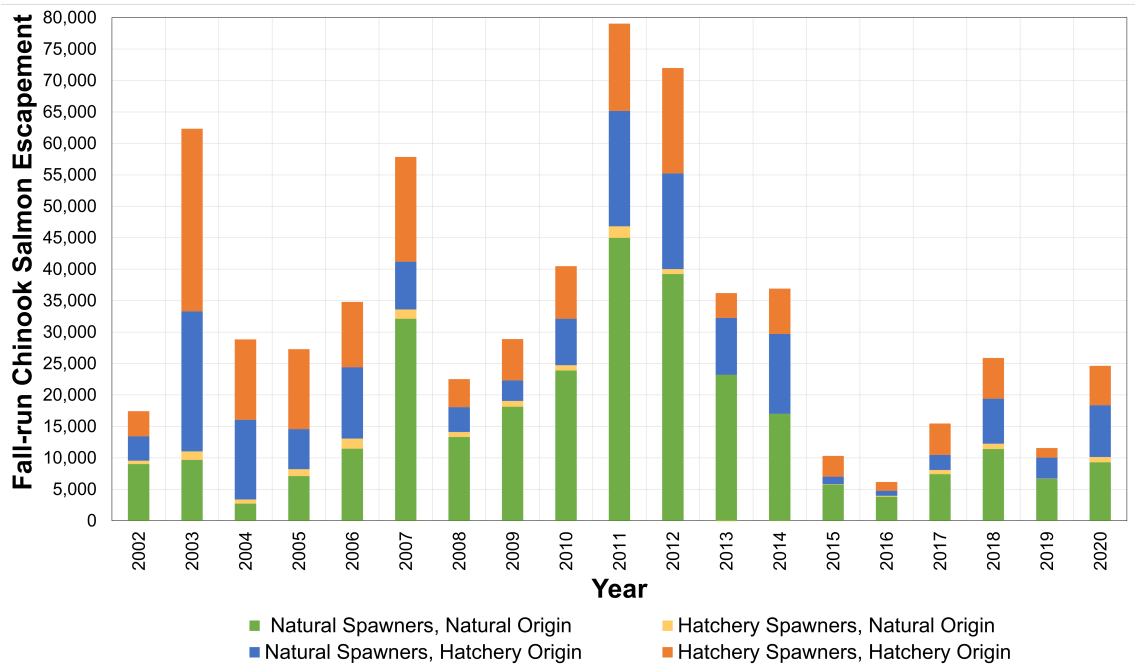
Figure 3-6. Annual Escapement for Spring-Run Chinook Salmon in the Trinity River at the Junction Creek Weir

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

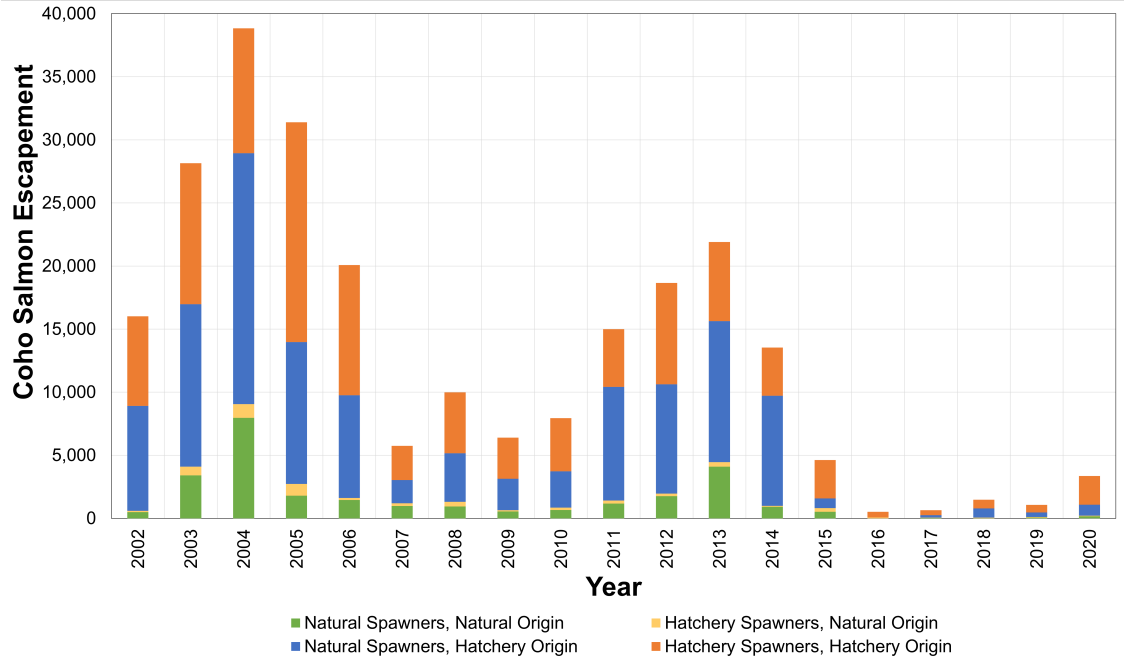
Coho Salmon in the Trinity River are in the Southern Oregon/Northern California Coast (SONCC) Coho Salmon ESU, and were listed as threatened under the ESA in 1997 (62 FR 24588, May 6, 1997) and threatened under the California Endangered Species Act in 2005. This ESU includes three artificially propagated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

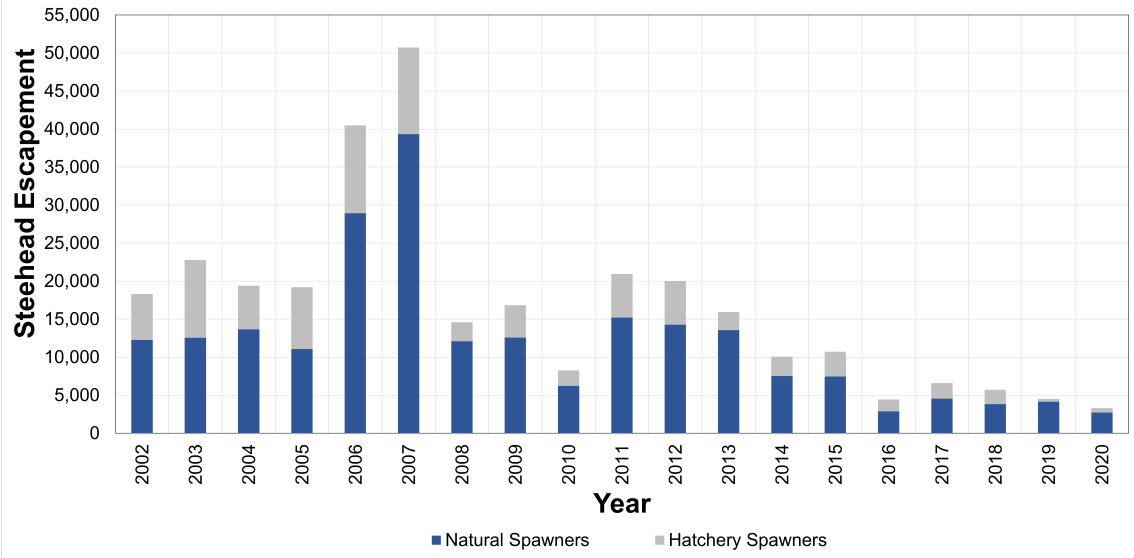
Klamath Mountains Province (KMP) steelhead have no federal special status under the federal Endangered Species Act, but are a California species of special concern. The KMP steelhead occupy the Klamath River basin and streams north to the Elk River, Oregon, including the Smith (California) and Rogue (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.

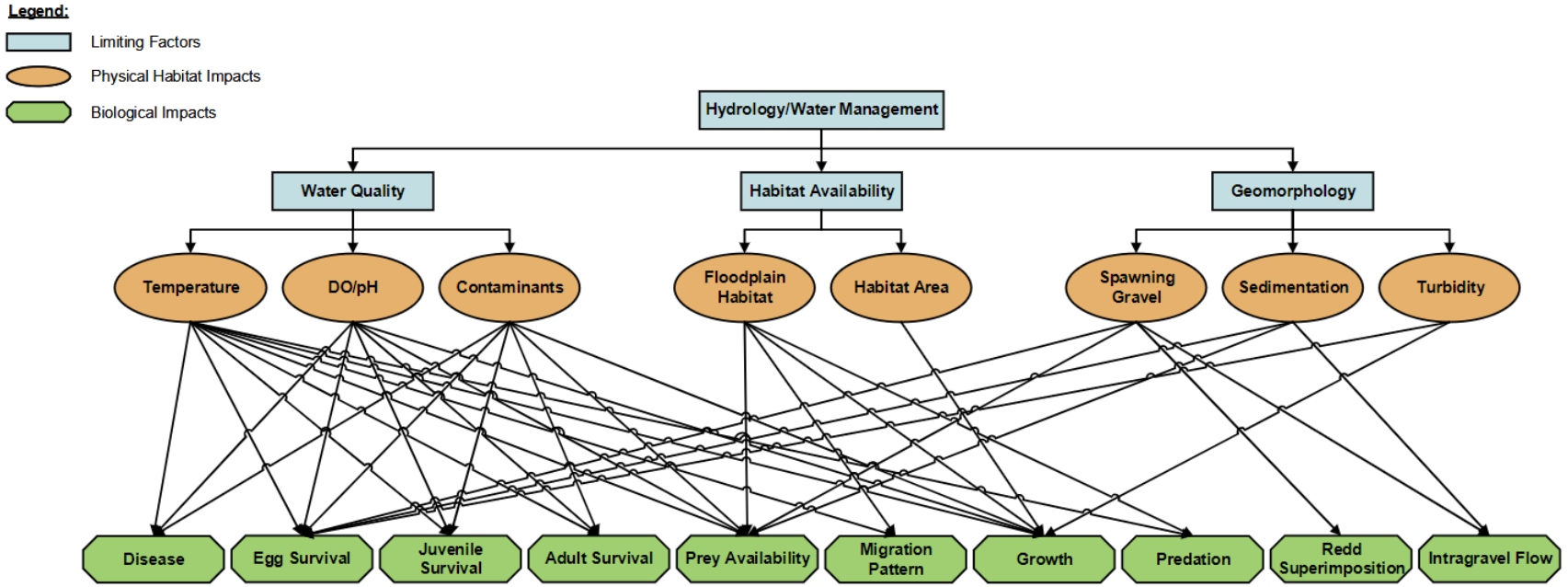
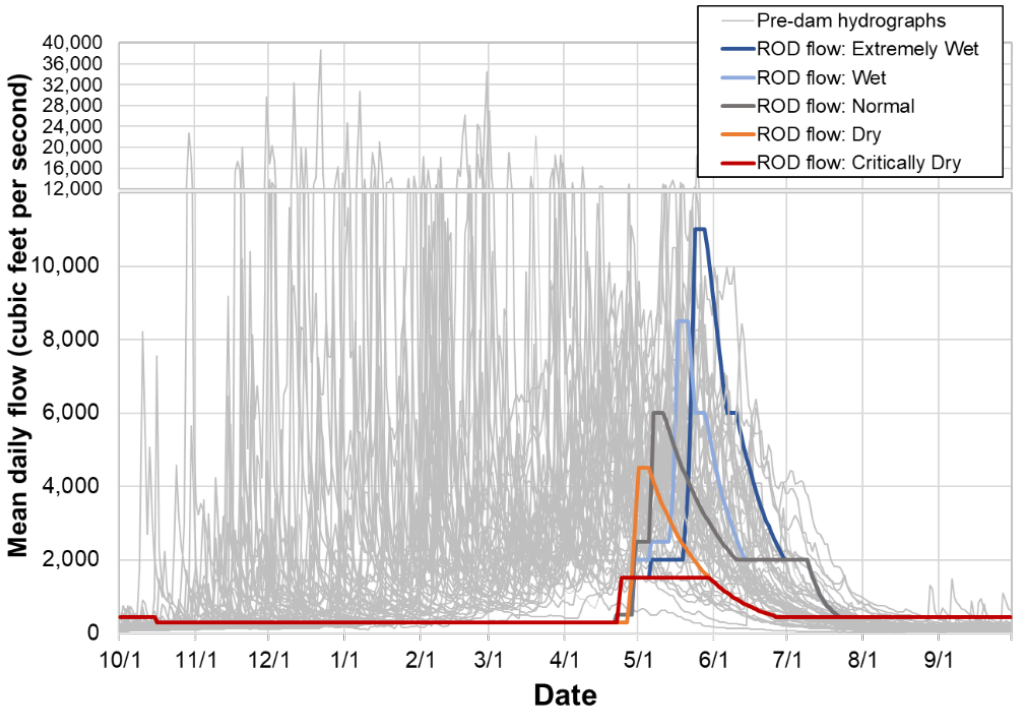


Figure 4-1. General Conceptual Model of Limiting Factors for Fish Productivity in the Trinity River, with Relationships to Physical and Biological Impacts

4.2 Differences from a Natural Flow and Temperature Regime

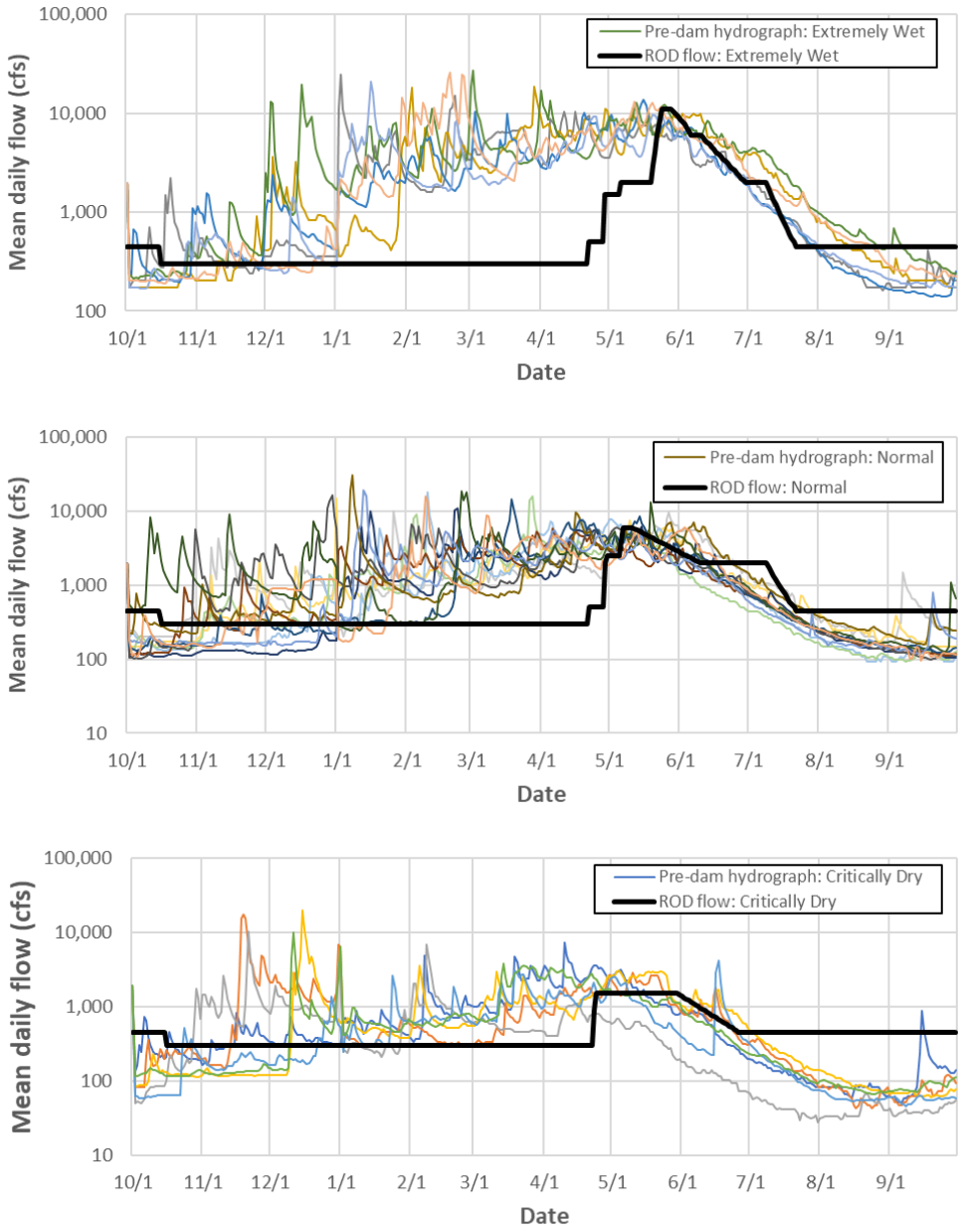
The natural flow regime of the Trinity River (as described in Section 3.1) consists of increasing and variable winter flows, a spring snowmelt peak, and a recession to low summer and fall baseflows. The annual ROD releases were developed to strike a compromise between a more natural regime, where flow 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.

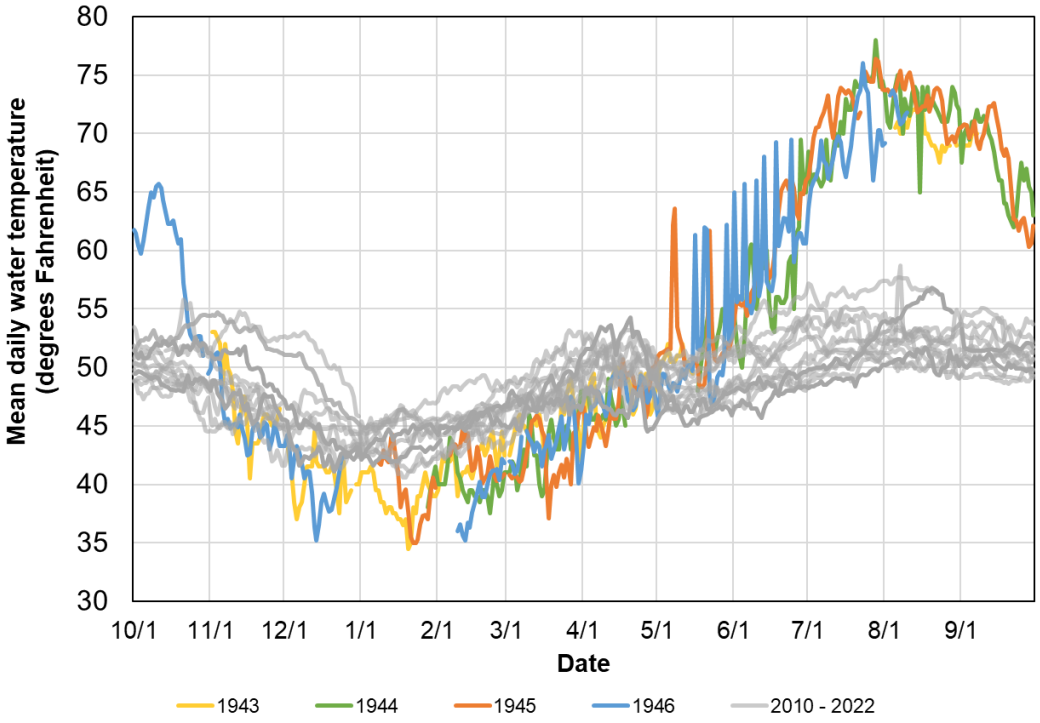


Data sources: Pre-dam hydrographs: USGS gage 11525500 Trinity River at Lewiston California, 1912 – 1960; post-dam ROD flows: USDOI 2000.

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)

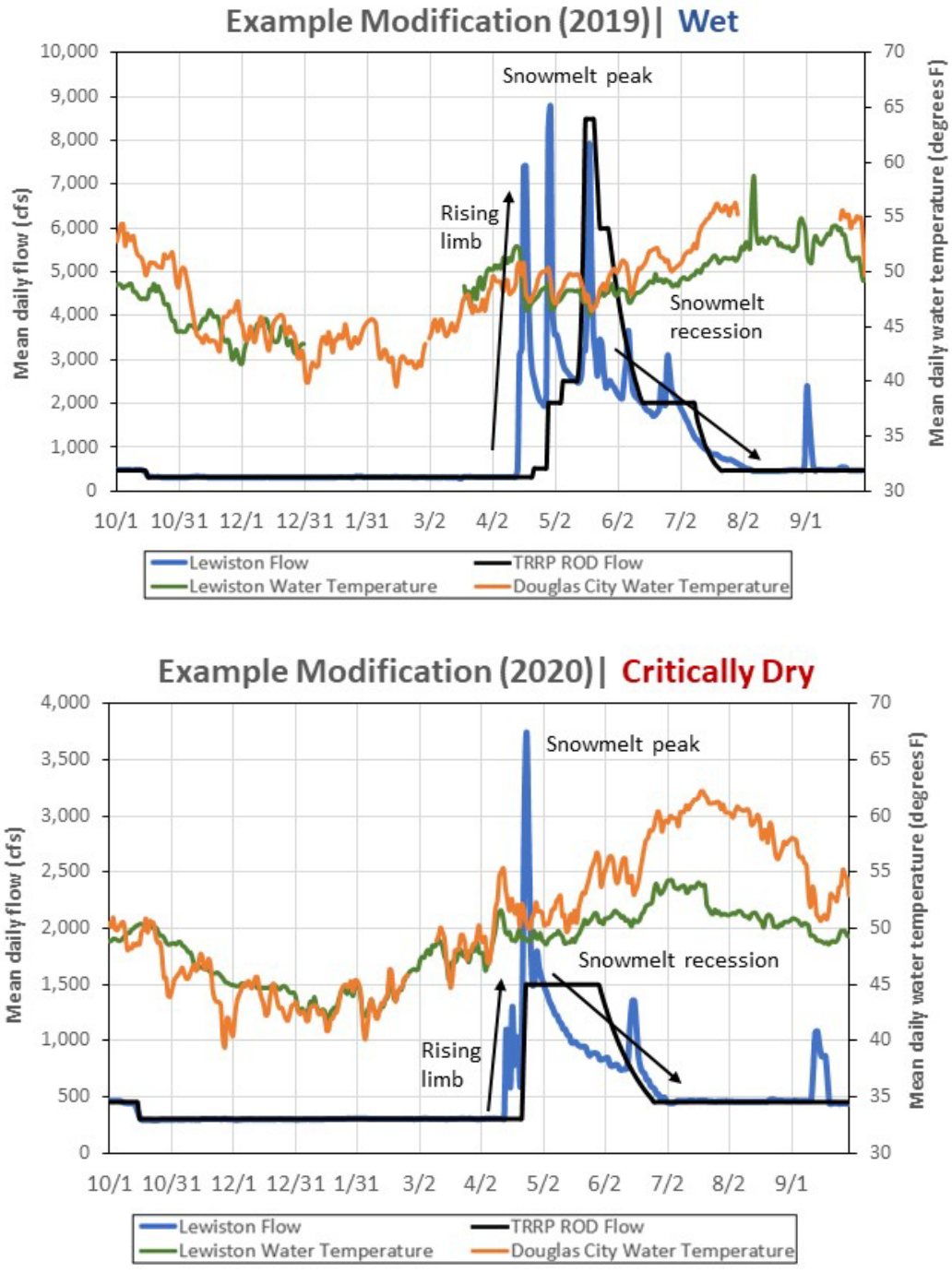
Figure 4-4. Mean Daily Water Temperature for the Trinity River near Lewiston

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**		

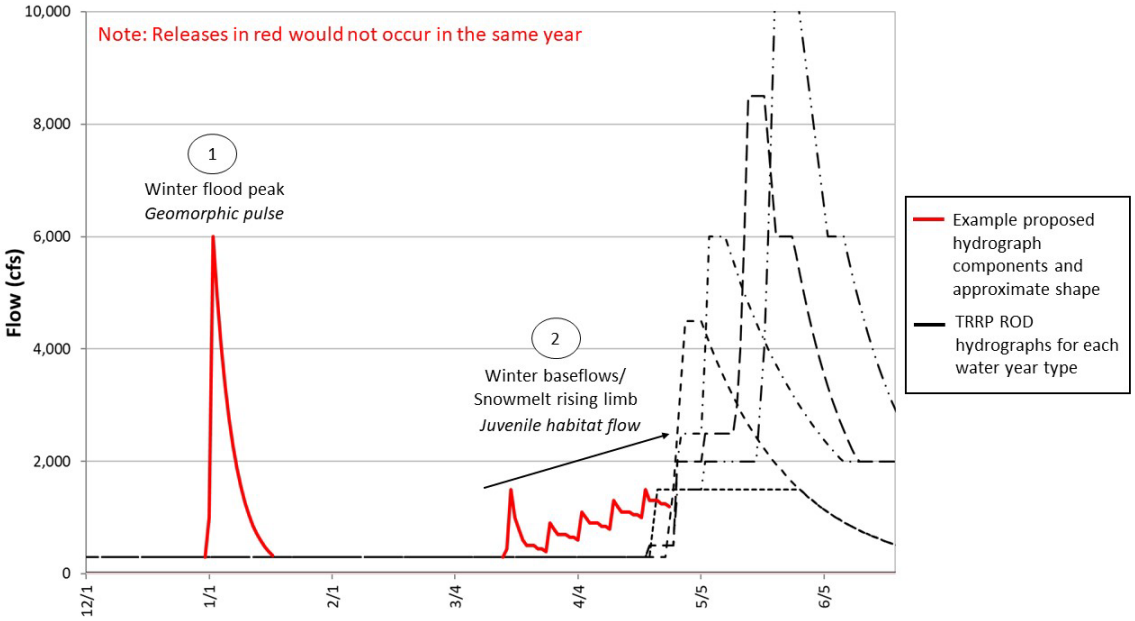
Source: [1]USFWS and NOAA 2018, Naman 2018, [2]TRRP and Reclamation 2022
Key: CD = Critically Dry; D = Dry; EW = Extremely Wet; N = Normal; W = Wet
Note: [3]Non-Restoration flow releases

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.

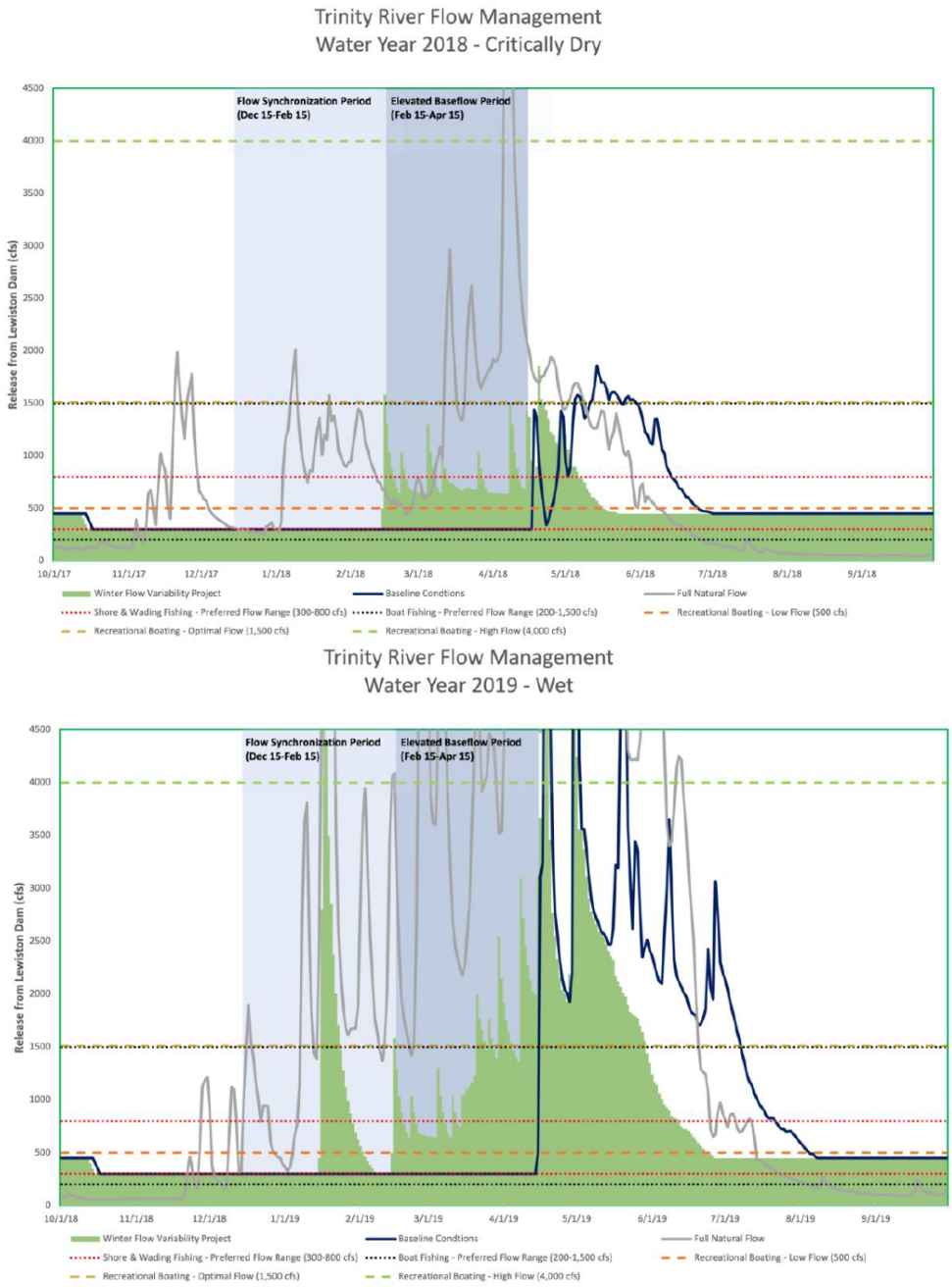
4.4.2 Winter Flow Project (2022)

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.



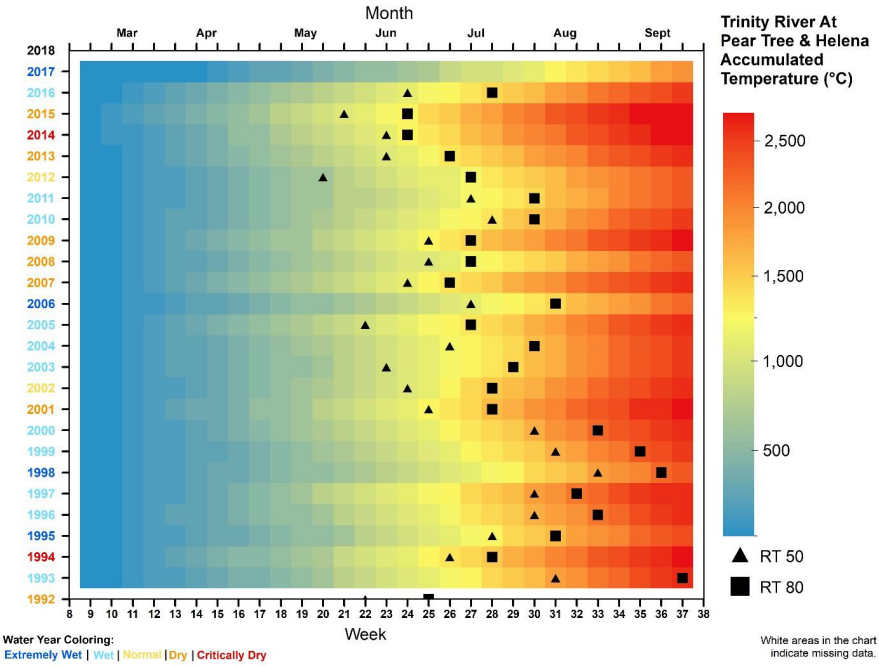
Note: The blue line represents the hydrograph that was implemented while the green represents the timing of hypothetical water releases that could occur under the Winter Flow Project
Source: TRRP and Reclamation 2022

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.

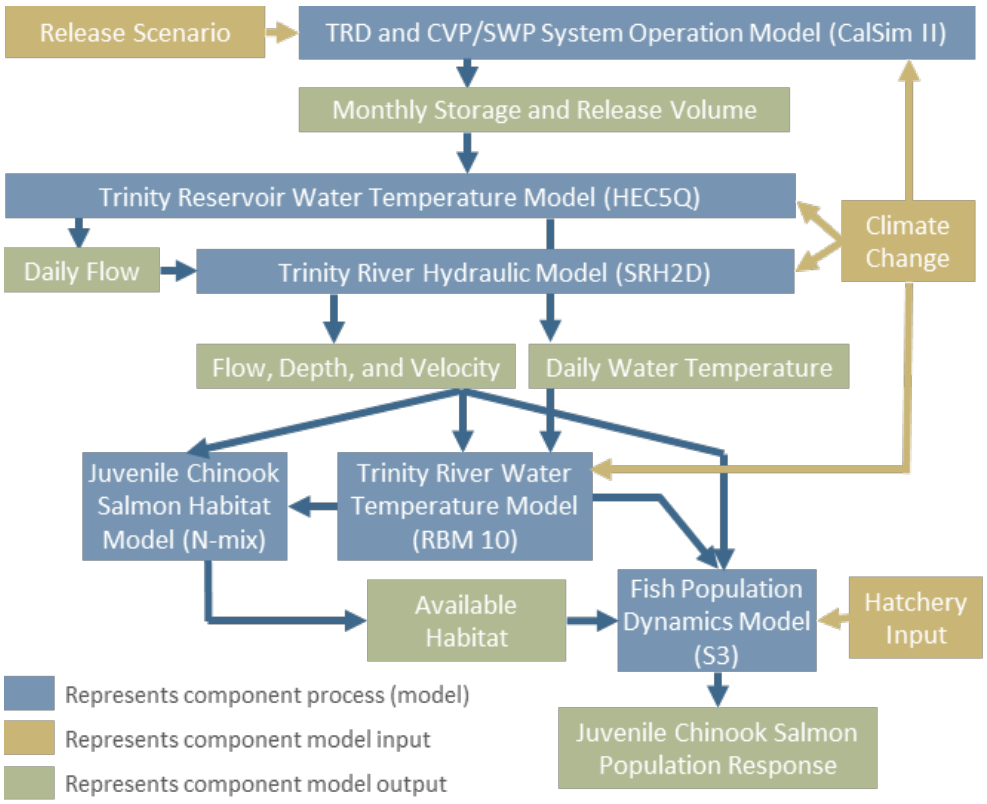


Figure 5-1. Modeling and Technical Analysis Framework for Analyzing Contract Water Release Scenarios

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.

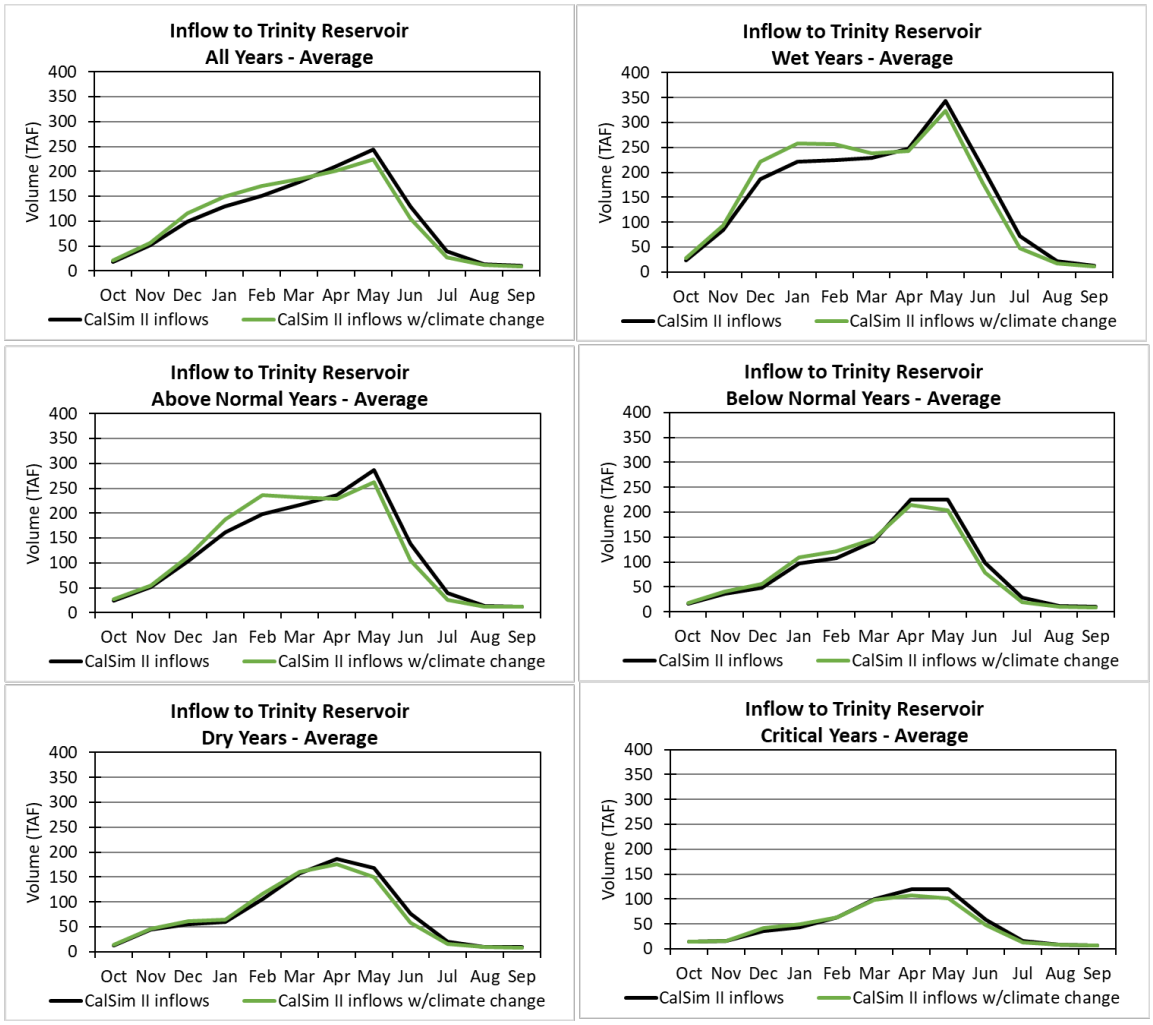


Figure 5-2. Comparison of Mean Monthly Trinity Reservoir Inflows in CalSim-II by Water Year Type with and Without the Effects of 2030 Climate Change

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.

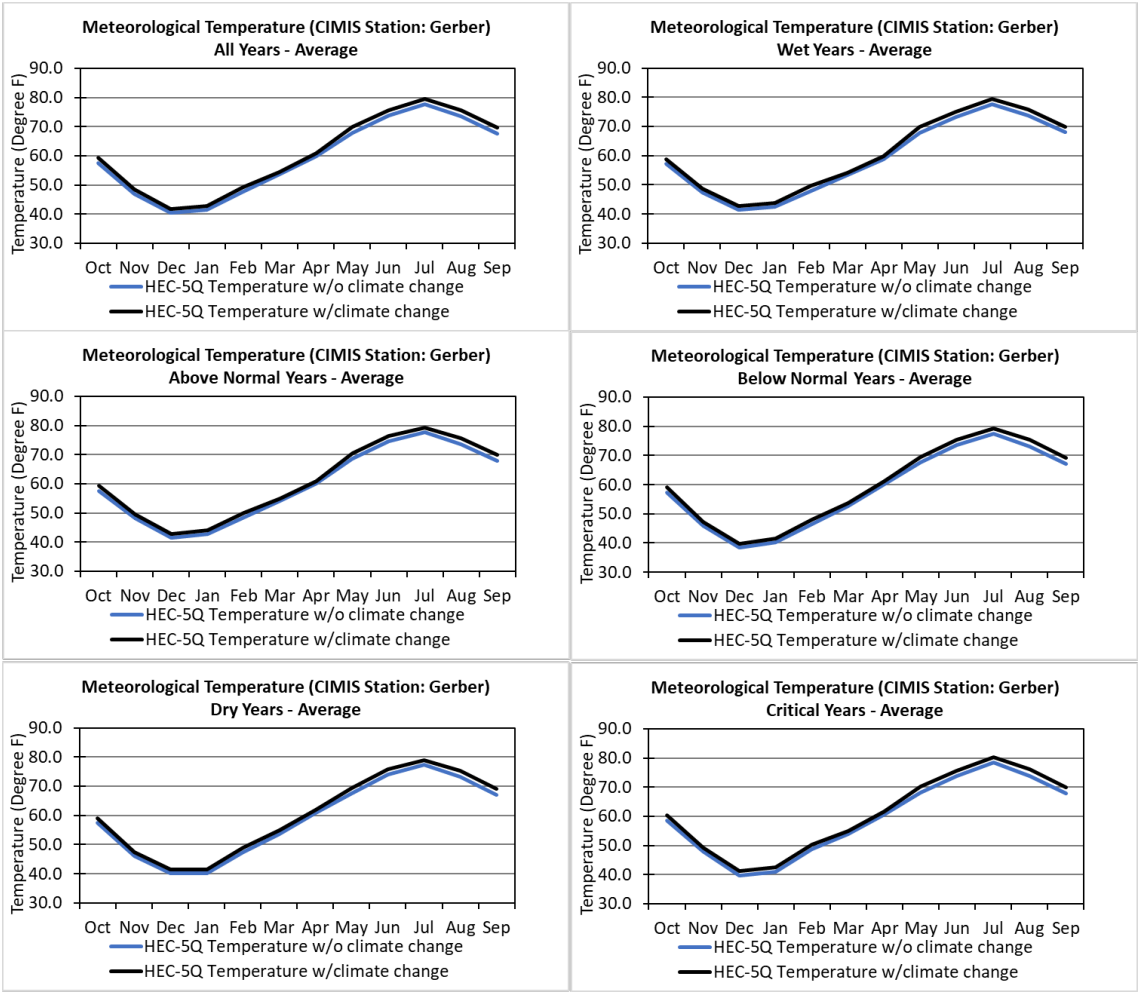


Figure 5-3. Comparison of Mean Monthly Air Temperature by Water Year Type at Gerber Station in HEC-5Q with and Without the Effects of Climate Change

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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Appendix C

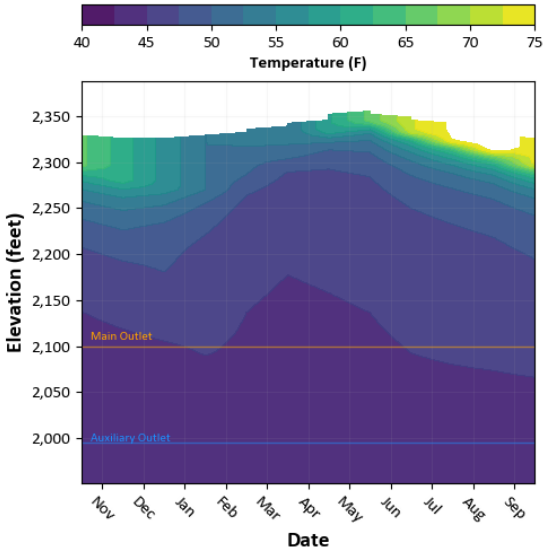
Modeling Report

Hydrologic, Water Operations, Reservoir Temperature, River Temperature, Sediment Transport, Habitat, and Fish Population Modeling for the Trinity River Water Management Plan

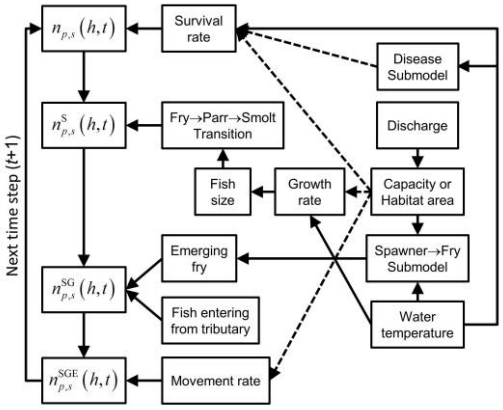
MODELING REPORT

Hydrologic, Water Operations, Reservoir Temperature, River Temperature, Sediment Transport, Habitat, and Fish Population Modeling for the Trinity River Water Management Plan









Top Left: Trinity Lake (Photo from United States Bureau of Reclamation https://commons.wikimedia.org/wiki/File:TrinityDam2.jpg)
Top Right: HEC-5Q Model output of Trinity Lake Water Temperatures
Bottom Left: Chinook Salmon (Photo from California Department of Fish and Wildlife https://wildlife.ca.gov/Fishing/Hatcheries/Trinity-River/Species-Raised)
Bottom Right: Model Structure of the Stream Salmonid Simulator (Image from Open-File Report 2018-1056. https://pubs.er.usgs.gov/publication/ofr20181056)

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

Executive Summary

Humboldt County is developing a Water Management Plan that will describe a range of proposed annual releases from Trinity Reservoir consistent with the 1959 water delivery contract between Humboldt County and the U.S. Bureau of Reclamation (Reclamation). The 1959 contract states that Reclamation shall release not less than an annual quantity of 50,000 acre-feet into the Trinity River for the beneficial use of Humboldt County and other downstream users (Contract Water).

The Water Management Plan will outline how Contract Water should be released for the benefit of fisheries in the Trinity River and lower Klamath River, with the primary goal of expanding a harvestable surplus of Tribal, recreational, and commercial fisheries. A set of annual Contract Water release scenarios were developed during five workshops conducted in 2022 and 2023 with interested parties including Humboldt County, state and federal resource agencies, tribal representatives, Reclamation, and the U.S. Department of the Interior Solicitor's office. A suite of modeling and technical tools was used to analyze annual conditions with and without Contract Water releases.

This Modeling Report describes the modeling tools used to assess Contract Water release scenarios, including CalSim II, HEC-5Q, RBM10, sediment transport models, Chinook Salmon habitat models, and the Stream Salmonid Simulator. Results from all models are summarized to provide a comparative overview of modeled release scenarios to modeled baseline conditions.

Mean annual Contract Water release scenarios ranged from 50,000 acre-feet to 170,000 acre-feet, and varied in timing, magnitude, and duration, though all releases were made between October and April. As shown in Table ES-1, a key finding of this modeling report is Contract Water releases that had the greatest modeled increase in Chinook Salmon abundance relative to baseline conditions included those that released 50,000 acre-feet in the fall period from October through December as pulse flows or baseflows, and those that released 170,000 acre-feet from October through April as a combination of pulse flows and baseflows. Modeled beneficial effects on populations were primarily due to either (1) increases in habitat area during the spawning life stage in October through December, which decreased redd superimposition (e.g., the process of a later arriving spawner building a redd on top of an existing redd) and improved egg survival, or (2) increases in flow during the fry emergence and juvenile rearing life stage in March through April, which increased the fry and parr carrying capacity (e.g., the upper limit for the number of fry or parr that a habitat unit can support) of individual habitat units.

Another key finding of this report is all Contract Water scenarios that released at least 50,000 acre-feet annually from Trinity Reservoir had similar effects on Trinity Reservoir storage, Central Valley Project (CVP) storage, CVP contract water deliveries, and Sacramento River water temperatures. Whether these scenarios were released annually as a fall baseflow, fall pulse flow, spring pulse flow, or spring baseflow, they all resulted in similar storage patterns in Trinity Reservoir – an annual reduction in storage relative to the baseline that was relatively small in wetter years and larger in drier years. As a result of lower Trinity Storage levels, Trinity River Division (TRD) exports to the CVP were reduced. Because the timing of exports is similar each year, reaching a peak in July through September, the reduction to exports occurred at the same time each year, independent of Contract Water release timing, resulting in similar storage, CVP delivery, and water temperature effects in the Sacramento River basin portion of the CVP. The water temperature effects on the Sacramento River were limited to the months of July and August, relatively minor, and were primarily attributed to changes in storage, release magnitude, and release temperature from Lake Shasta, and not due explicitly to inflows from the TRD.

Table ES-1. Mean Annual Percent Changes Between the Scenario Metric and the Baseline Metric for the Seven Modeled Contract Water Release Scenarios in the Restoration Reach of the Trinity River.

	Modeling Tool	CalSim II		Sediment Transport		Habitat Model			Stream Salmonid Simulator (S3)				
	Primary Analysis Metric	Mean annual Lewiston releases	Mean annual CVP Contract deliveries	Total sediment mobilized	Stream bed mobil-ization	Redd habitat area	Fry capacity	Parr capacity	Egg survival	Juvenile survival	Abun-dance	Biomass	Fish mass
Scenario #	Scenario Description	Thousand acre-feet	Thousand acre-feet	Tons/year	% bed mobilized	Mean ha (Oct-Dec)	Mean n per m^2 (Mar-May)	Mean n per m^2 (Mar-May)	Mean annual %	Mean annual %	Mean annual n of fish	Mean annual metric tons	Mean annual grams/n
1	Building baseflow (50 TAF)	**5%**	-0.2%	-0.3%	0.0%	0.5%	-1.6%	**2.3%**	-0.4%	0.5%	0.2%	**-4.0%**	-1.6%
2	Fall pulses (50 TAF)	**5%**	-0.2%	-1.6%	-0.1%	0.4%	-0.8%	0.0%	1.3%	-0.9%	0.4%	0.9%	**3.1%**
3	Geomorphic pulse or spring pulses (50 TAF)	**5%**	-0.2%	**7.5%**	**6.4%**	0.0%	0.0%	**2.3%**	-0.3%	-0.5%	-0.7%	**-2.4%**	**2.3%**
4	Combine scenarios 1-3 (170 TAF)	**22%**	**-4.6%**	**15.0%**	**7.0%**	0.2%	**3.2%**	**10.5%**	0.9%	1.4%	**2.6%**	**-2.8%**	-1.6%
5	Fall pulses with storage-based delay (50 TAF)	**5%**	-0.2%	-1.4%	-0.1%	0.2%	-0.7%	-1.0%	1.2%	-0.9%	0.3%	0.8%	0.6%
6	Fall baseflow (50 TAF)	**5%**	-0.7%	-1.5%	0.0%	**5.1%**	-0.7%	-1.0%	**2.6%**	0.2%	**2.9%**	**2.8%**	-0.1%
7	Carryover (50 TAF)	**5%**	-1.2%	**7.9%**	0.3%	0.0%	**4.6%**	**4.0%**	0%	-0.1%	-0.1%	0.3%	0.4%

Notes:
The first row lists the modeling tool used, the second row lists the primary evaluation metric, and the third row lists the units below each primary evaluation metric.
Metrics with greater than a positive 2% change relative to the baseline are presented in bold and highlighted gray.
Metrics with less than a negative 2% change relative to the baseline are presented in bold and highlighted orange.
Key: TAF = thousand acre-feet, ha = hectares, % = percent, m = meters, n = number of fish

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The data that support the findings of this study are available from Hank Seemann, Deputy Director - Environmental Services, Humboldt County Public Works Department, upon reasonable request.

Non-endorsement disclaimer
Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government

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Acronyms / Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
1-D	one-dimensional
2-D	two-dimensional
Ag	agricultural
AN	above normal
BN	below normal
BO	biological opinion
CCWD	Contra Costa Water District
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
cm	centimeter
CMIP3	Coupled Model Intercomparison Project Phase 3
COA	Coordinated Operating Agreement
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
DFG	California Department of Fish and Game
DOI	U.S. Department of the Interior
DSS	decision support system
DWR	California Department of Water Resources
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
FC&WCD	Flood Control and Water Conservation District
FERC	Federal Energy Regulatory Commission
FRSA	Feather River Service Area
g	grams
GCM	global climate model
GVC	Grass Valley Creek
ID	irrigation district
ITP	incidental take permit
JPOD	joint point of diversion
KCWA	Kern County Water Agency
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
LYRA	Lower Yuba River Accord
m	meters
M&I	municipal and industrial
MAF	million acre-feet
MHU	meso-habitat unit
MWD	Metropolitan Water District
n	number of fish
NBA	North Bay Aqueduct
NCRWQCB	North Coast Regional Water Quality Control Board
NDOI	net Delta outflow index
NMFS	National Marine Fisheries Service

NOD	North-of-Delta
NPS	National Park Service
OMR	Old and Middle River
PCWA	Placer County Water Agency
PP	pumping plant
RBM10	River Basin Model 10
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
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
SBA	South Bay Aqueduct
SMSCG	Suisun March Salinity Control Gates
SOD	South-of-Delta
SJRRP	San Joaquin River Restoration Program
SRH-2D	Sedimentation and River Hydraulics model
SRP	Stepped Release Plan
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TRAL	Trinity River at Lewiston
TRD	Trinity River Division
TRDC	Trinity River at Douglas City
TRFES	Trinity River Flow Evaluation Study
TRGVC	Trinity River at Grass Valley Creek
TRLG	Trinity River at Limekiln Gulch
TRRP	Trinity River Restoration Program
U.S.	United States
USBR	U.S. Bureau of Reclamation
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WR	water right
yr	year

1 INTRODUCTION

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 U.S. Bureau of Reclamation (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.

Congress authorized the Trinity River Division (TRD) as an integrated component of the Central Valley Project (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.

Current flow releases into the Trinity River are based on the framework established in the 2000 record of decision (ROD) implementing the final environmental impact statement (EIS) for the Trinity River Mainstem Flow Evaluation Report (USFWS and the HVT 1999, USDOI 2000). Among other restoration actions, the ROD defined five water year types and established annual release volumes ranging from 368 thousand acre-feet (TAF) to 816 TAF, with specific daily flow patterns based on water year type. These flows are referred to as ROD flows or restoration releases, and generally describe Reclamation's obligations for releases under Proviso 1.

Since 2018, Humboldt County has been developing a Water Management Plan that describes a range of proposed annual Contract Water release scenarios capable of benefiting fisheries in the Trinity River and lower Klamath River. Contract Water would be released annually in addition to ROD water. The primary goal of annual Contract Water releases is to expand 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. The Water Management Plan must contain sufficient detail that Reclamation can conduct an analysis and determine what additional actions may be required to make Humboldt County's water contract operational.

Since July of 2022, Humboldt County has held workshops with interested parties to review data and modeling tools, develop release scenario objectives, define release scenario volumes, timing, and triggers, and elicit feedback on development of the Water Management Plan. Workshops completed to date include:

- Workshop 1: Introduction, project background, and review of baseline conditions and modeling framework.

- Workshop 2: Evaluate limiting factors to juvenile Chinook Salmon productivity in the Trinity River and develop Contract Water release objectives.
- Workshop 3: Develop four initial Contract Water release scenarios.
- Workshop 4: Review model results of four initial Contract Water release scenarios and develop refined scenarios.
- Workshop 5: Review model results of refined Contract Water release scenarios and discuss a decision-making framework for annual use of Contract Water.

This Modeling Report summarizes the overall analytical framework and modeling methodology used to assess four initial and three refined Contract Water release scenarios. It is the second[1] in a series of technical documents that will form the basis of the Water Management Plan. This report is organized into six main sections:

- **Chapter 1. Introduction:** provides background for the project and summarizes work to date leading up to application of the modeling tools.
- **Chapter 2. Modeling and Technical Analysis Framework:** summarizes the modeling approach for the project, including the baseline hydrologic, climate change, and regulatory conditions that will be assumed in the technical analysis.
- **Chapter 3. Model Assumptions and Modifications:** summarizes the modeling tools, main assumptions, and modifications needed within each tool to simulate Contract Water release scenarios.
- **Chapter 4. Release Scenario Timeseries Development:** summarizes the objectives of seven unique annual releases scenarios of Contract Water, and describes the methods used to develop input time series of each scenario for the modeling tools.
- **Chapter 5. Model Results:** summarizes modeling results using figures, tables, and narrative description.
- **Chapter 6. Summary:** presents summary findings from the analysis.
- **Chapter 7. References:** includes a list of references cited in this report.

[1] The first technical document is the Baseline Conditions Report (Humboldt County, 2022)

2 MODELING AND TECHNICAL ANALYSIS FRAMEWORK

A framework of integrated analyses including hydrologic operations, hydrodynamics, water quality, and fisheries analyses is required to provide information to comparatively assess the effects of Contract Water releases on several resources, including water supply, surface water, water temperature, and aquatic resources. Releases of Contract Water require operational changes to the TRD of the CVP to increase the amount of water that is annually released into the Trinity River. These operational changes and other external factors, such as climate and sea-level changes, influence the future conditions of physical parameters, including reservoir storage, reservoir water temperature, river flow, Delta flows, Delta exports of CVP supplies, river temperature, and water quality. These physical parameters, primarily flow regimes and water temperature, influence the future conditions of salmonid habitat and populations. Evaluation of physical conditions and fisheries response is the primary focus of this modeling analyses.

2.1 Overview

A set of existing numerical modeling tools was adapted to analyze Contract Water release scenarios. An overview schematic of the modeling framework is shown in Figure 2-1, with component models, inputs, and outputs shown as boxes and linkages between the components shown as arrows. The modeling framework adapts core elements of the Decision Support System (DSS) proposed by the Trinity River Restoration Program (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 Trinity Management Council (Buxton 2021, 2022) and the Trinity River Winter Flow Project (TRRP and Reclamation 2022).

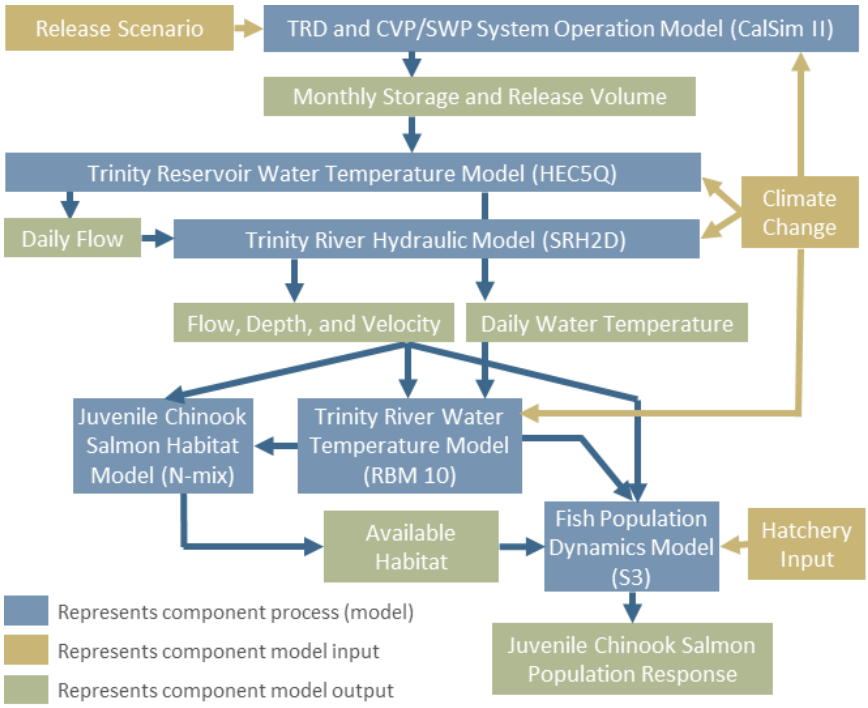


Figure 2-1. Modeling and Technical Analysis Framework for Analyzing Contract Water Release Scenarios

The main elements of the modeling framework are as follows:

- Historical hydrology is perturbed to reflect future climate change and is routed through the CalSim II model. The model simulates operation of the major CVP and State Water Project (SWP) facilities, including different assumed operations for each Contract Water release scenario, and generates estimates of river flows, reservoir storage, water deliveries, and other parameters. CalSim II simulates system operations for an 82-year period, from 1922 – 2003, using a monthly time step. The model uses historical hydrology perturbed by future climate change, but 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).
- A HEC-5Q water temperature model for the primary integrated reservoir and river systems (i.e., Trinity Reservoir and Trinity River, lower Sacramento River, Clear Creek, Shasta Dam and Sacramento River) uses the CalSim II reservoir storage, reservoir releases, river flows, and meteorological conditions to estimate daily reservoir release and river temperatures for each release scenario. The HEC-5Q model estimates water temperatures for the Trinity River at Lewiston, and for the Sacramento River at various points from Shasta Dam through the Sacramento San-Joaquin Delta.
- Lewiston Dam release water temperatures are used as inputs to River Basin Model 10 (RBM10), a one-dimensional (1D) water temperature model that predicts daily water temperatures along the length of the Trinity River. The version of RBM10 applied for this modeling effort uses daily tributary inflow and water temperature inputs from the Long-Term Plan for Protecting Late-Summer Adult Salmon in the Lower Klamath River Environmental Impact Statement (Klamath LTP EIS) (Reclamation 2017).
- Outputs from an existing two-dimensional (2D) flow hydraulic and mobile-bed sediment transport model, Sedimentation and River Hydraulics model (SRH-2D), are used to evaluate river hydraulics including water surface elevations, flow velocity, shear stress, and sediment mobilization. The SRH-2D model was initially developed in 2016 using topography and bathymetry surveyed in 2011 and 2012 (Bradley 2016), then updated in 2018 using topography and bathymetry surveyed in 2016 (Bradley 2018). Additional empirical relationships are used to evaluate coarse bedload transport in the Restoration Reach (Gaeuman and Stewart, 2017).
- A Chinook Salmon spawning habitat model (Goodman et al. 2018) and a juvenile Chinook Salmon microhabitat model (Som et al. 2018) both use depth, velocity, and other hydrodynamic outputs from the SRH-2D model of the Restoration Reach to predict spawning habitat and juvenile capacity.
- 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. Model inputs include water temperature and discharge from RBM10, hatchery and tributary abundances, spawning distribution/abundance, and micro-habitat quality. Model outputs include juvenile fish abundance, size, and biomass. The S3 model used for this analysis was constructed and parameterized for spring-run and fall-run Chinook Salmon of the Trinity River (Perry et al. 2018a).

2.2 Key Modeling Framework Assumptions

The following set of assumptions are common to the modeling framework. Model specific assumptions (e.g., regulatory assumptions regarding CVP and SWP operations in CalSim II) are described in detail in each model description in the appendix.

2.2.1 Contract Water Release Assumptions

For modeling purposes, a baseline condition (i.e., No Project) and several Contract Water release scenarios (i.e., Alternatives) are considered. The baseline condition reflects TRD water management consistent with current regulatory and operational regimes, while the release scenario conditions integrate a single Contract Water release scenario into the operation of the TRD. This operation assumes 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. Contract Water releases are assumed to be additive to the ROD flows currently released from Lewiston Dam, i.e., they are used to supplement ROD flows in any given month. Release scenarios do not contemplate shifting the timing of current ROD flows.

2.2.2 Location Focus

Commercial, Tribal, and sport fisheries depend on healthy populations of Chinook Salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*O. kisutch),* and steelhead (*O. mykiss*). 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 2000 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. The TRD location within the Trinity River watershed is shown in Figure 2-2. Major tributaries and other features of Restoration Reach of the Trinity River included in the modeling are shown in a more detailed map in Figure 2-3.

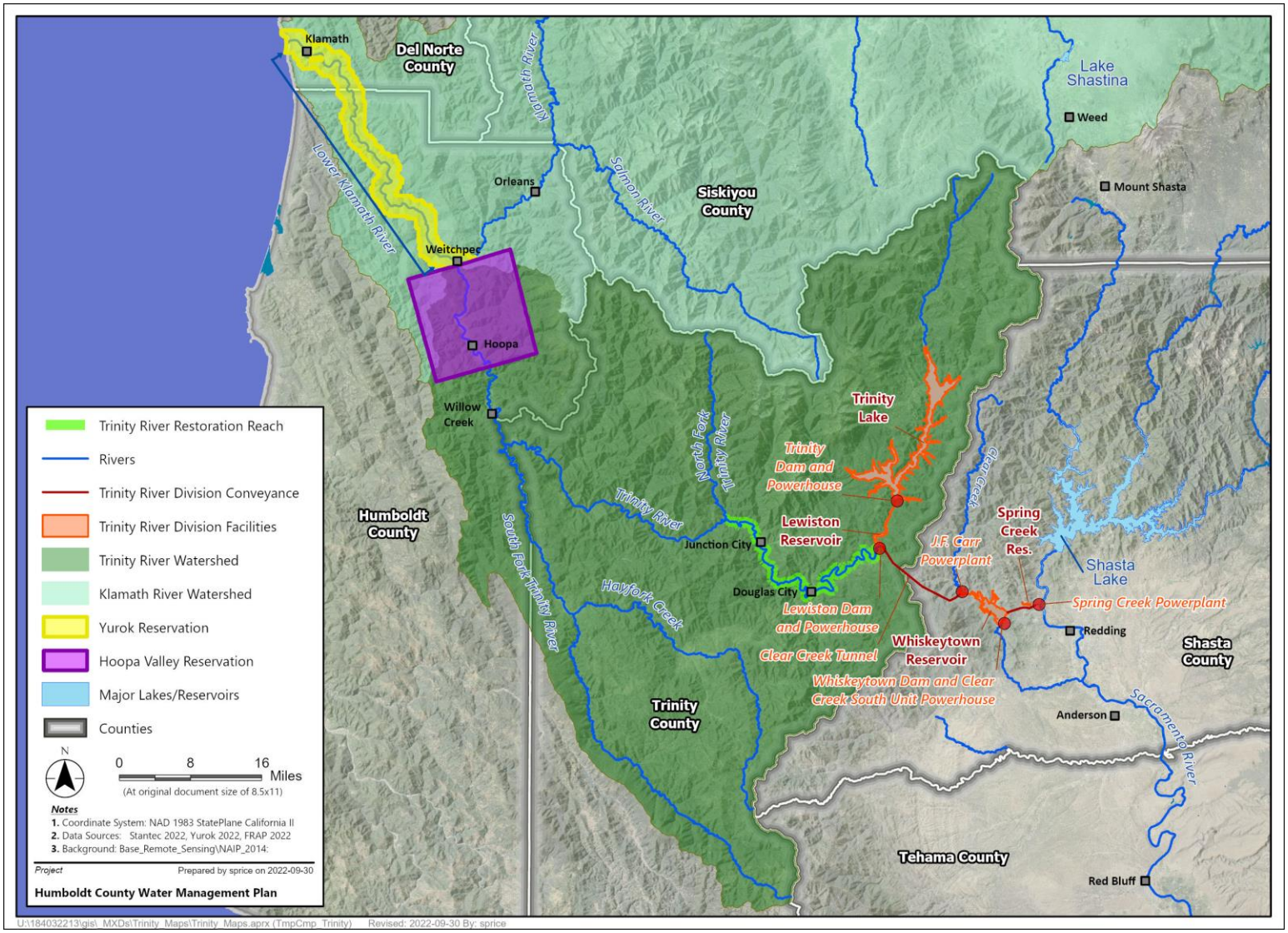


Figure 2-2. Major Facilities, Features, and Boundaries Associated with the Trinity River Division.

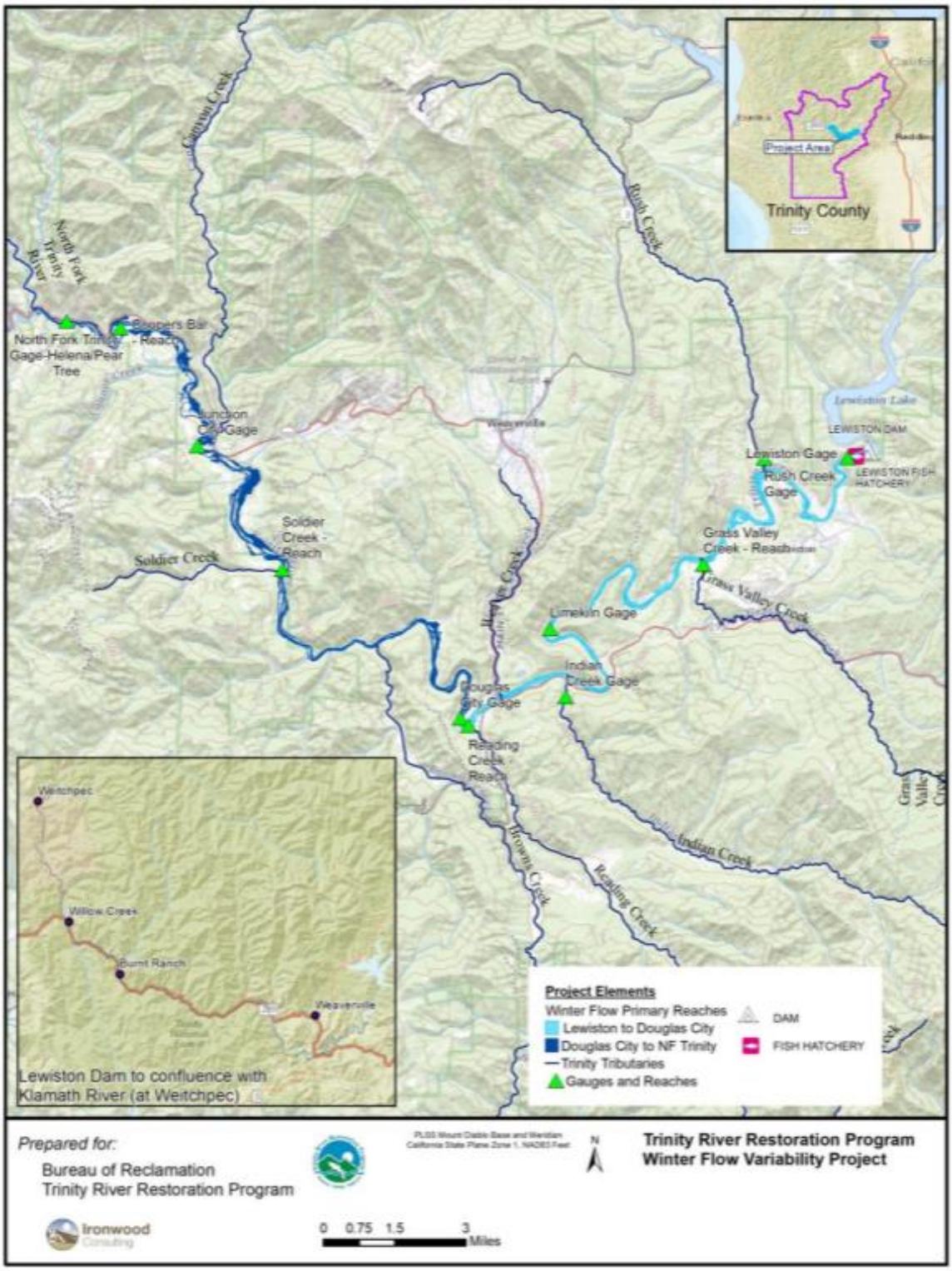


Figure 2-3. The Restoration Reach of the Trinity River (TRRP and Reclamation 2022).

2.2.3 Simulation Period and Model Output

Each model contains an established simulation period used to model operations, physical processes, and biological responses (Table 2-1). 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 was the overlapping period of record for these three models, 1980-2003. Both SRH-2D and the habitat models 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. Because there are limited spawner abundance estimates available prior to 2005, since the model does not explicitly reflect a historical condition prior to 2005, and no water year correlation with spawner abundance, a single spawner abundance input scenario was selected for each year using flow conditions from 1980 – 2003.

Table 2-1. 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 and Sediment models	N/A	Instantaneous flow, depth, and velocity within specific channel segments based on an input flow value**, coarse bedload transport, partial bed mobilization**
Habitat models	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 at relatively high spawner abundance when the effects of increasing habitat would be most apparent

Notes:
* The RBM10 modeling period ends in 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 static Trinity River topography and bathymetry that reflect channel conditions either in 2011 and 2012 (as applied in the habitat models) based on Bradley 2016, or channel conditions in 2016 (as applied in the partial bed mobilization analysis) based on Bradley 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 water year types and modeled annual Trinity Reservoir inflow for the 1980 – 2003 simulation period are shown in Figure 2-4 (annual modeled inflows reflect future climate change conditions as described in Section 2.2.5). The simulation period captures several extremely wet years in the early 1980s and mid- to late-1990s, as well as a significant drought period that occurred from water years 1987 through 1982. 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 2-2).

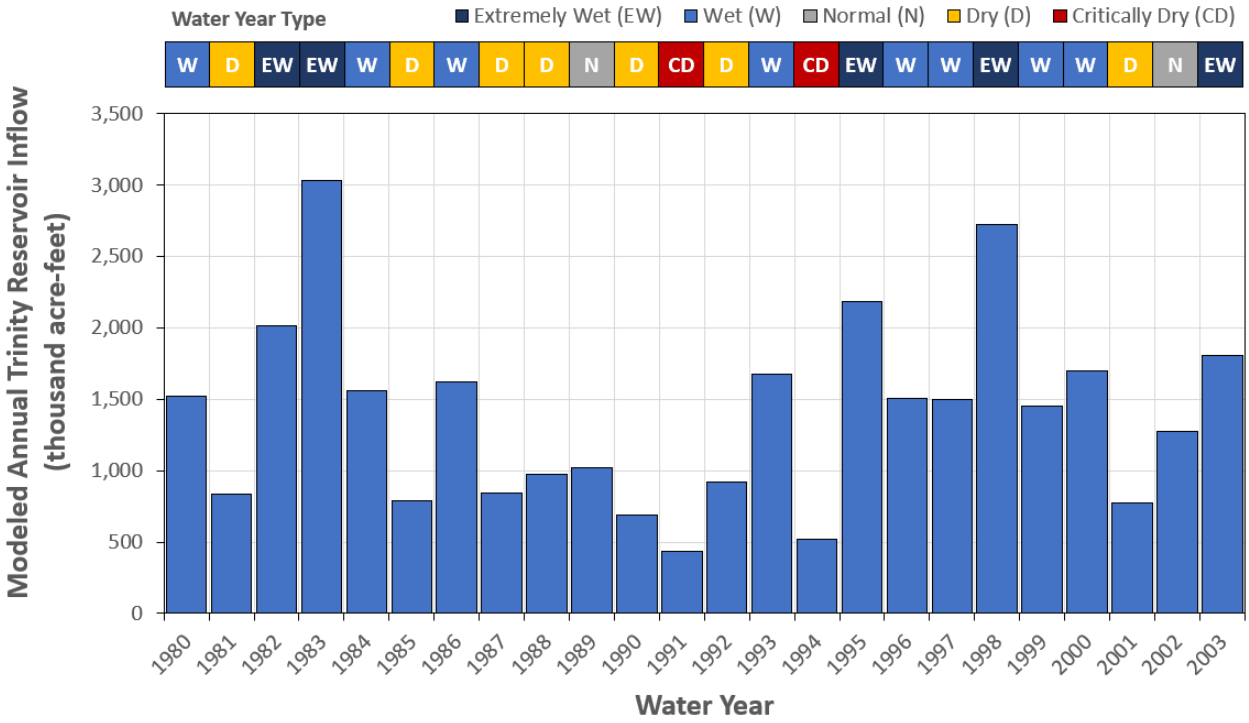


Figure 2-4. Modeled Annual Trinity Reservoir Inflow and Water Year Type in the Simulation Period.

Table 2-2. 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	5	21%	14	13%
Wet	8	33%	33	31%
Normal	2	8%	18	17%
Dry	7	29%	28	26%
Critically Dry	2	8%	13	12%

Key: % = percentage

2.2.4 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 focuses on assessing the effects of Contract Water releases on juvenile Chinook Salmon. Other fish species which are highly prevalent in the Trinity River include Coho Salmon, steelhead, and lamprey. A summary of the generalized life history timing for the anadromous species, as reported by the TRRP (TRRP 2023), is included in Table 2-3.

Table 2-3. Generalized Life History Timing for Chinook Salmon, Coho Salmon, and Steelhead in the Trinity River (adapted from TRRP 2023).

Species/Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chinook Salmon												
Adult Migration				Spring-run								
								Fall-run				
Spawning									Spring-run			
										Fall-run		
Incubation	Spring-run								Spring-run			
	Fall-run									Fall-run		
Emergence	Spring- and Fall-run											
Rearing	Spring-run											
	Fall-run											
Outmigration			Spring- and Fall-run									
Coho Salmon												
Adult Migration												
Spawning												
Incubation												
Emergence												
Rearing												
Outmigration												
Steelhead												
Adult Migration					Summer-run							
									Fall-run			
	Winter-run										Winter-run	
Spawning		All runs										
Incubation			All runs									
Emergence				All runs								
Rearing	All runs											
Outmigration			All runs							All runs		

2.2.5 Climate Change Considerations

Future climate change assumptions are consistent with those used in modeling to support the Coordinated Long-Term Operation of the Central Valley Project and State Water Project EIS (LTO EIS) (Reclamation 2015) and the Klamath LTP EIS (Reclamation 2017). In those modeling efforts, 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 baseline and Contract Water release scenario 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 perturbing historical monthly runoff and streamflow using a change factor developed from statistical analysis of hydrologic models that used climate change perturbed precipitation and air temperature as inputs. 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.

As applied in the Klamath LTP EIS, climate change effects on water temperature were primarily implemented by using climate change perturbed air temperatures as water temperature model inputs. To implement this process, historical air temperature time series were perturbed by a change factor developed from statistical analysis of climate change perturbed air temperature.

2.3 Appropriate Use of Model Results

Modeling used in this report is for a planning analysis conducted to understand long-term changes in local, regional, and statewide water systems and biological populations due to a proposed change. The numerical models developed and applied in this analysis are generalized and simplified representations of complex water resources systems with uncertainty in inputs and boundary conditions. The models are not predictive models in how they are applied for this 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 the operation of a project, its interaction with the water resources system under consideration, and its positive and negative potential effects relative to Alternative operations. Even though some of the models used in this planning analysis (e.g., S3) 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 effects of an alternative.

An appropriate interpretation of model results, and the method employed in this analysis, is development and presentation of seasonal patterns from long-term averages and water year-type averages. Statistics are computed and presented based on long-term, monthly, and water year-type averages, and results are presented as computed differences between long-term, monthly, or water year-type averages of model results from two or more scenarios. Comparative analysis which uses the differences between these long-term averages (e.g., comparisons of long-term average water deliveries or reservoir storage levels) is used to assess effects of the alternatives. Model results are not used to compute absolute differences or evaluate impacts at a point in time between an alternative and an existing condition (e.g., computing differences between alternatives for a particular month and year within the period of record of simulation). Likewise computing absolute differences between model results from a baseline or alternative condition at a specific point in time and a specific threshold value or standard is an inappropriate use of model results.

3 MODEL ASSUMPTIONS AND MODIFICATIONS

This section provides more detail on each individual model and describes the assumptions and modifications made to simulate baseline and Contract Water scenarios.

3.1 CalSim II

CalSim II was jointly developed by Reclamation and the California Department of Water Resources (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, and SWP deliveries to the San Francisco Bay Area, Central Coast, Southern California, and the Tulare Basin.

3.1.1 Baseline Assumptions

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 dated 04/18/2022 was obtained from Reclamation for use in this project. A brief description of the main assumptions for the baseline and Contract Water release scenarios is included in Table 3-1.

Table 3-1. Cal-Sim II Assumptions for the Baseline and Contract Water Release Scenarios

Regulation or Assumption	Baseline	Scenarios
GENERAL		
Planning horizon[a]	Year 2021	Same as Baseline
Period of simulation	82 years (1922-2003)	Same as Baseline
HYDROLOGY		
Climate Change (See Section 2.2.5)	Hydrology and meteorological conditions based on projected changes over the 30-year climatological period centered on 2025 (i.e., 2011-2040)	Same as Baseline
Sea Level Rise	15 cm	Same as Baseline
Inflows/Supplies	Modified inflows based on historical hydrology projected 2020 modifications for operations upstream of the rim reservoirs	Same as Baseline
Level of development	Projected 2030 level[b]	Same as Baseline
DEMANDS, WATER RIGHTS, CVP/SWP CONTRACTS		
Sacramento River Region (excluding American River)		
CVP[c]	Land-use based, full build-out of contract amounts, except for Settlement Contractors represented with historical diversions.	Same as Baseline

Regulation or Assumption	**Baseline**	**Scenarios**
SWP (FRSA)[d]	Land-use based, limited by contract amounts	Same as Baseline
Non-project	Land use based, limited by water rights and SWRCB Decisions for Existing Facilities	Same as Baseline
Antioch Water Works	Pre-1914 water right	Same as Baseline
Federal refuges	Firm Level 2 water supply needs	Same as Baseline
Sacramento River Region - American River[e]		
Water rights	Year 2025, full water rights	Same as Baseline
CVP	Year 2025, full contracts except for Settlement Contractors at historical diversions, including Freeport Regional Water Project	Same as Baseline
San Joaquin River Region[f]		Same as Baseline
Friant Unit	Limited by contract amounts, based on current allocation policy	Same as Baseline
Lower Basin	Land-use based, based on district level operations and constraints	Same as Baseline
Stanislaus River	Land-use based, Stepped Release Plan (SRP)	Same as Baseline
San Francisco Bay, Central Coast, Tulare Lake and South Coast Regions (CVP/SWP project facilities)		
CVP[c]	Demand based on contract amounts	Same as Baseline
CCWD[g]	195 TAF/yr CVP contract supply, water rights and in-Delta transfers	Same as Baseline
SWP[d,h]	Demand based on Table A amounts	Same as Baseline
Article 56	Based on 2001-08 contractor requests	Same as Baseline
Article 21	MWD demand up to 200 TAF/month from December to March subject to conveyance capacity, KCWA demand up to 180 TAF/month and other contractor demands up to 34 TAF/month in all months, subject to conveyance capacity	Same as Baseline
North Bay Aqueduct (NBA)	77 TAF/yr demand under SWP contracts, up to 43.7 cfs of excess flow under Fairfield, Vacaville and Benecia Settlement Agreement	Same as Baseline
Federal refuges	Firm Level 2 water needs	Same as Baseline
FACILITIES		
Systemwide		
Systemwide	Existing facilities	Same as Baseline
North Coast Region		
Trinity Lake	Existing, 2,448 TAF capacity	Same as Baseline
Sacramento River Region		
Shasta Lake	Existing, 4,552 TAF capacity	Same as Baseline
Red Bluff Diversion Dam	Diversion dam gates out all year. Pumping Plant operated to deliver CVP water with capacity of 2,000 cfs.	Same as Baseline
Hamilton City Pump Station	Pumping plant with capacity of 3,000 cfs.	Same as Baseline
Fremont Weir	Notched Fremont Weir as represented in Yolo Bypass Salmonid Habitat Restoration and Fish Passage EIS/EIR Alternative 1 (preferred alternative)	Same as Baseline
Colusa Basin	Existing conveyance and storage facilities	Same as Baseline
Lake Oroville	Existing, 3,538 TAF capacity	Same as Baseline

Regulation or Assumption	Baseline	Scenarios
Upper American River[e,i]	PCWA American River Pump Station	Same as Baseline
Folsom Lake	Existing, 976 TAF capacity	Same as Baseline
American River	Existing Folsom Dam including auxiliary spillway	Same as Baseline
Lower Sacramento River	Freeport Regional Water Project[j]	Same as Baseline
San Joaquin River Region		Same as Baseline
Millerton Lake (Friant Dam)	Existing, 520 TAF capacity	Same as Baseline
Lower San Joaquin River	City of Stockton Delta Water Supply Project, 30-mgd capacity. SJRRP Recapture simulated at West Stanislaus ID, Patterson ID, and Banta Carbona ID	Same as Baseline
SWP Banks Pumping Plant (South Delta)[k]	Physical capacity is 10,300 cfs but 6,680 cfs permitted capacity in all months. Pumping can be up to 10,300 cfs during Dec 15 – Mar 15 depending on Vernalis flow conditions; additional capacity of 500 cfs (up to 7,180 cfs) allowed Jul – Sep for reducing impact of Spring Outflow Action on SWP	Same as Baseline
CVP C.W. Bill Jones Pumping Plant (Tracy PP)	Permit capacity is 4,600 cfs in all months (allowed for by the Delta-Mendota Canal–California Aqueduct Intertie)	Same as Baseline
Upper Delta-Mendota Canal Capacity	Existing plus 400 cfs Delta-Mendota Canal–California Aqueduct Intertie	Same as Baseline
CCWD Intakes	Los Vaqueros Reservoir with existing storage capacity (160 TAF), and existing intakes except for Mallard Slough Intake. Updated to be consistent with latest Los Vaqueros modeling	Same as Baseline
Suisun March Salinity Control Gates (SMSCG)	Delta salinity conditions are adjusted for months in which the salinity control gate is operated (see operations)	Same as Baseline
San Luis Reservoir	Existing, 2,041 TAF capacity	Same as Baseline
San Francisco Bay Region		
South Bay Aqueduct (SBA)	SBA rehabilitation, 430 cfs capacity from junction with California Aqueduct to Alameda County FC&WCD Zone 7 diversion point	Same as Baseline
South Coast Region		
California Aqueduct East Branch	Existing capacity	Same as Baseline
REGULATORY STANDARDS		
North Coast Region		
Trinity River		
Minimum flow below Lewiston Dam	Trinity EIS Preferred Alternative (369-815 TAF/yr)	Same as Baseline
Trinity River Fall Augmentation Flows[o]	420 cfs August 1 through September 30 in all but wet years	Same as Baseline
Trinity Reservoir end-of-September minimum storage	Trinity EIS Preferred Alternative (600 TAF as able)	Same as Baseline
Proviso 2 releases to Trinity River	Not included	Based on Contract Water release scenarios defined in Section 4
Sacramento River Region		

Regulation or Assumption	Baseline	Scenarios
Clear Creek		
Minimum flow below Whiskeytown Dam	Downstream water rights, 1963 USBR Proposal to USFWS and NPS; and 200 cfs October through May or 150 cfs in Critical years and 150 cfs June through September with 10 TAF for channel maintenance in February of BN, AN and Wet years and 10 TAF for Spring pulse flows in June of non-Critical years; in June of Critical years, pulse of 900 cfs.	Same as Baseline
Upper Sacramento River		
Shasta Lake end-of-September minimum storage	1900 TAF in non-critically dry years (not explicitly modeled - achieved through project allocation profiles when hydrologically feasible)	Same as Baseline
Minimum flow below Keswick Dam	SWRCB WR 90-5; and stabilize fall flows to reduce redd dewatering and rebuild cold water pool; and spring pulse flow up to 150 TAF if projected May 1 storage > 4.1 MAF	Same as Baseline
Feather River		
Minimum flow below Thermalito Diversion Dam	2006 Settlement Agreement (700 / 800 cfs)	Same as Baseline
Minimum flow below Thermalito Afterbay outlet (maintained down to mouth of Feather)	1983 DWR, DFG Agreement (750-1,700 cfs)	Same as Baseline
Yuba River		
Minimum flow below Daguerre Point Dam	D-1644 Operations (Lower Yuba River Accord)[m]	Same as Baseline
American River		
Minimum flow below Nimbus Dam	American River Flow Management Standard, per 2017 Water Forum Agreement with a planning minimum end of December storage target of 275 TAF	Same as Baseline
Minimum Flow at H Street Bridge	SWRCB D-893	Same as Baseline
Lower Sacramento River		
Minimum flow near Rio Vista	SWRCB D-1641	Same as Baseline
San Joaquin River Region		
Mokelumne River		
Minimum flow below Camanche Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (100-325 cfs)	Same as Baseline
Minimum flow below Woodbridge Diversion Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (25-300 cfs)	Same as Baseline
Stanislaus River		Same as Baseline
Minimum flow below Goodwin Dam	Flows per New Melones SRP	Same as Baseline
Minimum dissolved oxygen	SWRCB D-1422	Same as Baseline
Merced River		
Minimum flow below Crocker-Huffman Diversion Dam	Cowell Agreement	Same as Baseline
Minimum flow at Shaffer Bridge	FERC 2179 (25-100 cfs) with 12.5 TAF in October based on 2002 Merced ID and CDFW Memorandum of Understanding	Same as Baseline

Regulation or Assumption	Baseline	Scenarios
Tuolumne River		
Minimum flow at Lagrange Bridge	FERC 2299-024, 1995 (Settlement Agreement) (94-301 TAF/yr)	Same as Baseline
San Joaquin River		
San Joaquin River below Friant Dam/ Mendota Pool	San Joaquin River Restoration-full flows, not constrained by current river capacity, model implementation includes recapture in the San Joaquin River and in the Delta	Same as Baseline
Maximum salinity near Vernalis	Stanislaus contribution per New Melones SRP	Same as Baseline
Minimum flow near Vernalis	Stanislaus contribution per New Melones SRP	Same as Baseline
Sacramento River–San Joaquin Delta Region		
Delta Outflow Index (Flow, NDOI)	SWRCB D-1641 and for Summer/Fall Delta Smelt habitat operate to meet X2 of 80 km for September and October of AN, and Wet years with transitional flows in last half of August. SWP to allow up to 150 TAF of Delta outflow in April and May. Spring outflow action shall not exceed 150 TAF and is subject to a 44,500 cfs Delt Outflow off-ramp. SWP to release 100 TAF block of water in Jun through Sep of Wet and Above Normal years.	Same as Baseline
Delta Cross Channel gate operation	Gate operations per Multi Year Study Program; model representation as SRWCB D-1641 with additional days closed from Oct 1 – Jan 31 based on NMFS BO (Jun 2009) Action IV.1.2 (closed during flushing flows from Oct 1 – Dec 14 unless adverse water quality conditions would result)	Same as Baseline
South Delta export limits (Jones PP and Banks PP)	SWRCB D-1641 Vernalis flow-based export limits Apr 1 – May 31, (additional 500 cfs allowed for Jul – Sep for reducing impact on SWP)	Same as Baseline
Combined Flow in Old and Middle River (OMR)	OMR target of -5,000 cfs January through June except for 5 days of -2,000 cfs when turbidity bridge occurs (turbidity bridge consideration only January through March) and 7 days of -6,000 cfs when increased pumping due to storm is possible, followed by "first flush" action if it occurs in December or January (14 days of -2,000 cfs), and OMR target of -3,500 cfs in March, April, and May of non-Critical years. Health and Safety off-ramp when exports are low.	Same as Baseline
OPERATIONS CRITERIA: RIVER-SPECIFIC		
Sacramento River Region		
Upper Sacramento River: Flow objective for navigation (Wilkins Slough)	Flow objective for Wilkins Slough based on month, CVP allocation, and Shasta storage condition to reflect CVP operations for local delivery	Same as Baseline
American River: Folsom Dam flood control	Fixed 400 TAF flood control diagram	Same as Baseline
San Joaquin River Region		

Regulation or Assumption	Baseline	Scenarios
Stanislaus River: Flow below Goodwin Dam	Flows per New Melones SRP	Same as Baseline
San Joaquin River: Salinity at Vernalis	Grasslands Bypass Project (full implementation)	Same as Baseline
Sacramento – San Joaquin River Delta Region		
Suisun Marsh Salinity Control Gates	Operate to meet SWRCB D-1641 water quality standards in Montezuma Slough during salinity control season October through May; and for Summer/Fall Delta Smelt habitat operate for up to 60 days June through October of Below Normal, Above Normal, and Wet years. SWP facilitates operations for up to 60 days in June through October of Dry years.	Same as Baseline
OPERATIONS CRITERIA: SYSTEMWIDE		
CVP water allocation		
Settlement / Exchange	100% (75% in Shasta critical years)	Same as Baseline
Refuges	100% (75% in Shasta critical years)	Same as Baseline
Agriculture Service	100%-0% based on supply, South-of-Delta allocations are additionally limited due to D-1641 and OMR action	Same as Baseline
Municipal & Industrial Service	100%-50% based on supply, South-of-Delta allocations are additionally limited due to D-1641and OMR action	Same as Baseline
SWP water allocation		
North of Delta (FRSA)	Contract specific	Same as Baseline
South of Delta (including North Bay Aqueduct)	Based on supply; equal prioritization between Ag and M&I based on Monterey Agreement; allocations are additionally limited due to D-1641 and OMR action and Spring Outflow Action.	Same as Baseline
CVP-SWP coordinated operations		
Sharing of responsibility for in-basin-use	Revised Coordinated Operations Agreement	Same as Baseline
Sharing of surplus flows	Revised Coordinated Operations Agreement	Same as Baseline
Sharing of restricted export capacity for project- specific priority pumping	Revised Coordinated Operations Agreement	Same as Baseline
Water transfers	Acquisitions by SWP contractors are wheeled at priority in Banks Pumping Plant over non-SWP users; LYRA included for SWP contractors	Same as Baseline
Sharing of export capacity for lesser priority and wheeling-related pumping	Cross Valley Canal wheeling (max of 128 TAF/yr), CALFED ROD defined Joint Point of Diversion (JPOD)	Same as Baseline
San Luis Reservoir	San Luis Reservoir is allowed to operate to a minimum storage of 100 TAF	Same as Baseline
CVPIA 3406(b)(2)[l,n]		
Policy Decision	N/A	Same as Baseline
Allocation	No B2 Allocation modeled	Same as Baseline
Actions	Pre-determined upstream fish flow objectives below Whiskeytown Dam	Same as Baseline
Accounting[m]	No B2 Accounting modeled	Same as Baseline
WATER MANAGEMENT ACTIONS		

Regulation or Assumption	Baseline	Scenarios
Water Transfer Supplies (long term programs)		
Lower Yuba River Accord[m]	Yuba River acquisitions for reducing impact of D-1641 and OMR Action export restrictions on SWP	Same as Baseline
Phase 8	None	Same as Baseline

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 (Reclamation) management team for the Re-initiation of Consultation on long-term operations of the Central Valley Project (CVP) and State Water Project (SWP).

[b] The Sacramento Valley hydrology used in the Future Conditions CALSIM II model reflects 2020 land-use assumptions associated with Bulletin 160-98. The San Joaquin Valley hydrology reflects draft 2030 land-use assumptions developed by Reclamation. Development of Future-level projected land-use are being coordinated with the California Water Plan Update for future models.

[c] Refer to Attachment 5 CalSim II Model Delivery Specifications for contract specific details

[d] Refer to Attachment 5 CalSim II Model Delivery Specifications for contract specific details

[e] Assumptions regarding American River water rights and CVP contracts with the Sacramento River Water Reliability Project are documented in the Delivery Specifications attachments. The Sacramento Area Water Forum agreement, its dry year diversion reductions, Middle Fork Project operations and water is not included. Refer to Attachment 5 CalSim II Model Delivery Specifications for contract specific details

[f] The CALSIM II representation of the San Joaquin River reflects the difficulties on-going groundwater overdraft problems. The 2030 level of development representation of the San Joaquin River Basin does not make any attempt to offer solutions to groundwater overdraft problems. In addition a dynamic groundwater simulation is not yet developed for the San Joaquin River Valley. Groundwater extraction/ recharge and stream-groundwater interaction are static assumptions and may not accurately reflect a response to simulated actions. These limitations should be considered in the analysis of results.

[g] The actual amount diverted is operated is conjunction with supplies from the Los Vaqueros project. The existing Los Vaqueros storage capacity is 160 TAF. Associated water rights to fill Los Vaqueros with Delta excess flows are included, but CCWD's water right permit and water right license on Mallard Slough are not included.

[h] It is assumed that SWP Contractors can take delivery of all Table A allocations and Article 21 supplies. Article 56 provisions are assumed and allow for SWP Contractors to manage storage and delivery conditions such that full Table A allocations can be delivered. Detailed analysis of the South Coast and Tulare regions support these assumptions. NBA Article 21 deliveries are dependent on excess conditions only, all other Article 21 deliveries also require that San Luis Reservoir be at capacity and that Banks PP and the California Aqueduct has available capacity to divert from the Delta for direct delivery.

[i] PCWA American River pumping facility upstream of Folsom Lake is included.

[j] Mokelumne River flows are modified to reflect modified operations associated with EBMUD supplies from the Freeport Regional Water Project.

[k] Current ACOE permit for Banks PP allows for an average diversion rate of 6,680 cfs in all months. Diversion rate can increase up to 1/3 of the rate of San Joaquin River flow at Vernalis during Dec 15th – Mar 15th up to a maximum diversion of 10,300 cfs, if Vernalis flow exceeds 1,000 cfs.

[l] Delta actions, under USFWS discretionary use of CVPIA 3406(b)(2) allocations, are no longer dynamically operated and accounted for in the CALSIM II model. The Combined Old and Middle River Flow and Delta Export restrictions under the FWS BO (Dec 15th 2008) and the NMFS BO (June 4th 2009) severely limit any discretion that would have been otherwise assumed in selecting Delta actions under the CVPIA 3406(b)(2) accounting criteria. Therefore, it is anticipated that CVPIA 3406(b)(2) account availability for upstream river flows below Whiskeytown, Keswick and Nimbus Dams would be very limited. The future of these operations is uncertain. For these baseline simulations, upstream flows on the Clear Creek and Sacramento River are pre-determined based on CVPIA 3406(b)(2) based operations from the Aug 2008 BA Study 7.0 and Study 8.0 for Existing and Future Conditions respectively. The procedures for dynamic operation and accounting of CVPIA 3406(b)(2) are not included in the CALSIM II model.

[m] D-1644 and the Lower Yuba River Accord is assumed to be implemented. The Yuba River is not dynamically modeled in CALSIM II. Yuba River hydrology and availability of water acquisitions under the Lower Yuba River Accord are based on modeling performed and the Lower Yuba River Accord EIS/EIR study team.

[n] In cooperation with Reclamation, National Marine Fisheries Service, Fish and Wildlife Service, and Ca Department of Fish and Game, the Ca Department of Water Resources has developed assumptions for implementation of the FWS BO (Dec 15th 2008) and NMFS BO (June 4th 2009) in CALSIM II. The FWS BO and NMFS BO assumptions are documented in the Appendix 5A of the LTO EIS (Reclamation 2015b).

[o] This assumed operation is not consistent with Klamath LTP EIS (Reclamation 2017). For implementation in the technical analysis, no attempt was made to repattern the 450 cfs monthly release to match the Klamath LTP EIS.

3.1.2 Modifications for Release of Contract Water

The benchmark CalSim II model was modified to enable release of Contract Water for different scenarios. Three general categories of modifications were made to assess potential methods of accounting for reductions in TRD exports due to the release of Contract Water, described further below. Detailed descriptions of the release scenarios are described in Section 4.

- Minimize effects on CVP contractor delivery by allowing releases from Lake Shasta to increase (Scenarios 1-3, 5)
    - Exports of water from the TRD to the CVP were reduced due to lower Trinity Reservoir and Lake Shasta storage levels.
    - Lake Shasta releases were allowed to increase to offset TRD export reductions and maintain similar flows as the baseline in the Sacramento River. This resulted in slightly lower Lake Shasta storage levels.

- Minimize effects on Lake Shasta storage by modifying CVP contractor deliveries (Scenarios 4 and 6)
    - For Scenario 4, CVP South of Delta (SOD) and North of Delta (NOD) Ag allocations were reduced by similar amounts to minimize the number of dead pool months below 5 for Shasta, Trinity, and Folsom. Exports of water from the TRD to the CVP were reduced due to lower Trinity Reservoir and Lake Shasta storage levels.
    - For Scenario 6, CVP NOD Ag allocations were reduced to offset reduced exports from the TRD and maintain similar flows in the Sacramento River as the baseline.
    - Lake Shasta releases were maintained relatively similar to the baseline, resulting in smaller relative differences in Lake Shasta storage levels.
- Explicitly remove Contract Water from CVP storage calculations (Scenario 7)
    - To account for 50 TAF of Contract Water being held cumulatively each year as carryover, a separate storage account for Contract Water was created and held separate from storage used to contribute to the Sacramento Basin CVP operations. Water going into this account came from reductions in TRD exports to the CVP.
    - When Trinity Reservoir physically spilled or made a safety-of-dams release, the minimum of the volume of spill above the monthly ROD release volume or the volume of water in Contract Water carryover storage account was added to the Lewiston Reservoir instream flow requirement. In sum, the Carryover Storage account was the first water to spill out of Trinity Reservoir.
    - CVP NOD and SOD Ag allocations were reduced to offset reduced exports from the TRD and maintain similar flows in the Sacramento River as the baseline.

3.2 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 and 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. Figure 3-1 shows a schematic of the Trinity-Sacramento River HEC-5Q model and shows all of the reservoir and river control points where temperatures are simulated. 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). The model version was from November 2019 and 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). One of the major updates includes improved temperature continuity around Lewiston Reservoir and diversion temperatures to Clear Creek Tunnel. 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 model can also provide the temperature profiles for Trinity, Lewiston, and other selected reservoirs in the model.

Trinity Dam has no specific temperature control device but includes an auxiliary outlet that allows access to the reservoir pool that cannot be accessed by the power outlets. This auxiliary outlet is only used in actual operations under emergency situations to control temperatures in the Trinity River when they exceed specific targets in the summer/fall months. The HEC-5Q model uses a tailwater temperature target of 49 degrees Fahrenheit (°F) between August 15th and October 31st when temperature management is most important. If release temperatures from the power outlets exceed this temperature target during this period, the auxiliary outlet is operated to blend with the releases from the power outlets to achieve the temperature target. A temperature target of 60°F is used for the remaining period. More detail is provided in the Appendix 6B, Section C of the 2015 LTO EIS (Reclamation 2015).

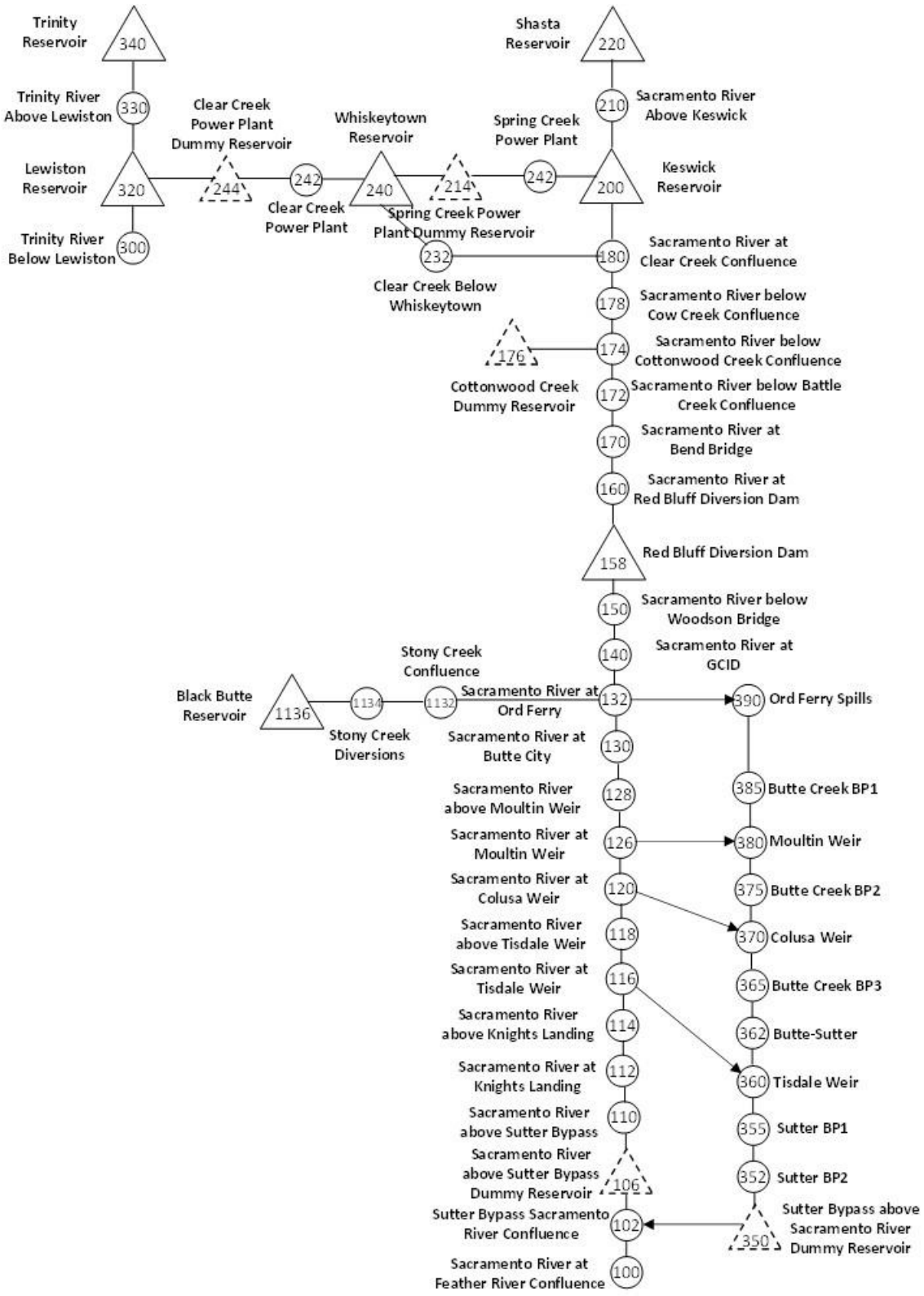


Figure 3-1. Schematic of Trinity-Sacramento River HEC-5Q Model.

Reclamation uses temperature control curtains at Lewiston Reservoir to modify reservoir release temperatures. Water from the Trinity River Basin is diverted into the Sacramento River Basin through two tunnels and three reservoirs. Trinity River water is diverted from Lewiston Reservoir through Clear Creek Tunnel to the Judge Francis Carr powerplant and discharged into Whiskeytown Reservoir. From there, water flows through the reservoir, into Spring Creek Tunnel and through Spring Creek Powerplant. Spring Creek Powerplant discharges into Keswick Reservoir where it combines with Sacramento River water released from Shasta Dam. Water released from Keswick Dam enters the upper Sacramento River. Over the course of this diversion and prior to curtain installation, Trinity River water temperatures were commonly increased 10 to 13°F (Vermeyen 2000). To provide cold water releases, Reclamation uses two flexible temperature curtains in Lewiston Reservoir to control mixing and provide for withdrawal at a specified elevation.

Two flexible curtains made of 60 mil Hypalon material were installed in Lewiston Reservoir in 1992. One curtain was designed to hold back warmer surface water while accessing colder water near the bottom for release to Clear Creek Tunnel and ultimately the lower Sacramento River Basin. The second curtain was designed to provide warmer surface withdrawals (when operating in overdraw mode) for Lewiston fish hatchery. Figure 3-2 shows the schematic of the Lewiston Reservoir flexible curtain and its components (USDOI 2020). Figure 3-3 shows the relative elevations of the features proximate to Lewiston Dam, along with the operating range of the reservoir and the downstream elevation of Trinity River (Reclamation 2012).

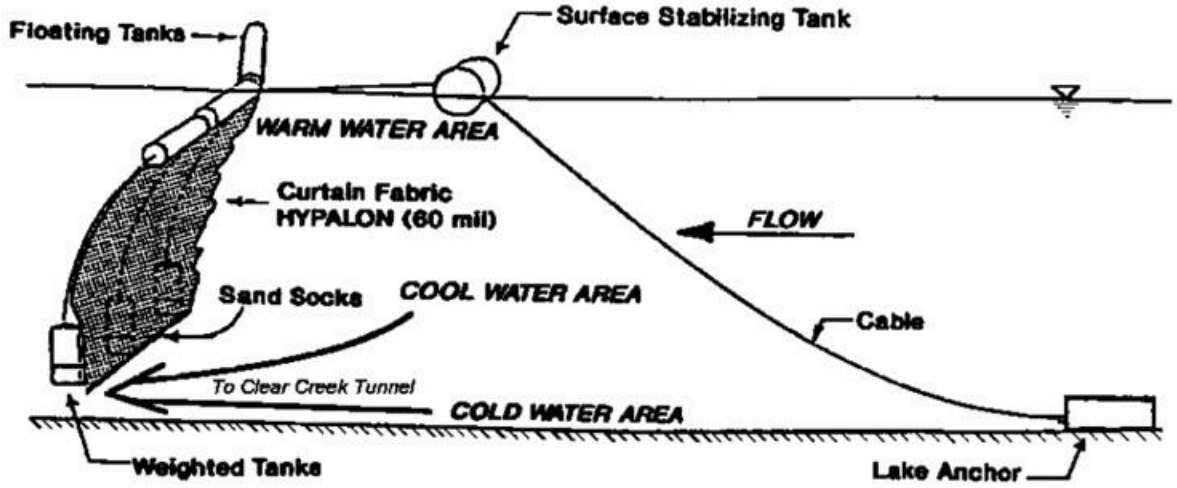


Figure 3-2. Schematic of the Lewiston Reservoir Flexible Temperature Curtain and its Components.

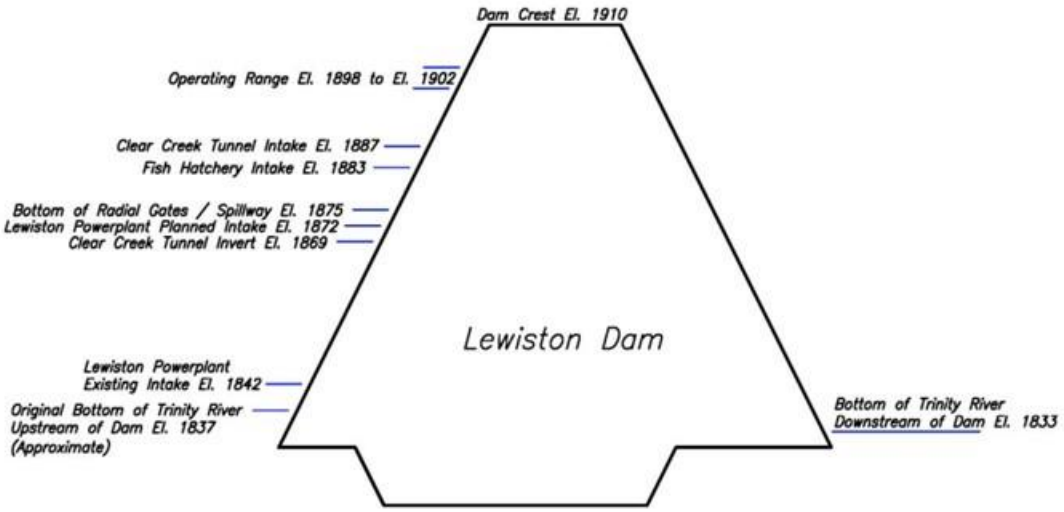


Figure 3-3. Lewiston Dam Elevation Diagram.

There are several limitations to the HEC-5Q models and the simulated water temperatures, both in their capability to simulate observed water temperatures and as applied in this modeling analysis. Calibration of the HEC-5Q model was focused on simulating daily average observed temperatures, primarily in the warmer periods, and the model adequately represents the thermal responses to the hydrologic and meteorological changes. Even though the HEC-5Q models simulate water temperatures on a sub-monthly timescale, given that they are driven by the monthly CalSim II results as inputs, the use of modeled temperatures should generally be limited to monthly average values, even though short-term fluctuations may be real and important to biological resources. If sub-monthly results are to be used, it is important to understand that the HEC-5Q models adheres to the CalSim II monthly volumes of reservoir storages, releases, and diversions. HEC-5Q models do not alter operations (other than temperature control device gate settings) to meet a temperature objective downstream in the river, and there is no feedback to CalSim II to alter the storage or release volumes.

3.3 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 was used to support the technical analysis and to provide flow and water temperature inputs to S3. For this analysis, RBM10 input files constructed for the Klamath LTP EIS (Reclamation 2017) were modified. Specifically, inputs to RBM10 included Lewiston Dam releases and water temperatures as simulated by CalSim II and HEC-5Q for the baseline and 7 Contract Water release scenarios. All other model inputs including meteorological data (e.g.,

daily air temperature and solar radiation) and tributary boundary conditions (daily tributary inflow and water temperature) were identical to the RBM10 analysis performed for the Klamath LTP EIS (Reclamation 2017). RBM10 was run to output water temperature and discharge at 17 locations (approximately 5 km intervals) between Lewiston Dam and the confluence with the North Fork Trinity River. These outputs served as flow and temperature inputs for S3.

3.4 Sediment Models

Sediment metrics were evaluated using a methodology similar to the Winter Flow Report (TRRP and Reclamation 2022) to quantify and evaluate the annual and total coarse bedload transport and annual partial stream bed mobilization created by each flow scenario. Daily flow releases at Lewiston under each scenario were combined with the daily flow for the seven major tributaries between Lewiston Dam and North Fork Trinity in the Trinity watershed (see tributaries in Figure 2-3) which were modeled in RBM10 for the Klamath LTP EIS (Reclamation 2017). The Winter Flow Report analysis used the hydrologic record from years 2004-2019, and the analysis only included years where a geomorphic pulse flow synchronization occurred (6 of 17 years); this analysis used the entire daily hydrograph for all years modeled, 1980-2003, to compare each scenario to the baseline.

3.4.1 Coarse Bedload Transport

Sediment supply and transport has been closely monitored in the Restoration Reach by the TRRP since 2004. There are four sediment monitoring stations: Trinity River at Lewiston (TRAL), Trinity River at Grass Valley Creek (TRGVC), Trinity River at Limekiln Gulch (TRLG), and Trinity River at Douglas City (TRDC) (Figure 3-4). Between 2004 and 2015, seven annual and one long-term historical rating curves were developed at each of the four stations which can be used to estimate sediment transport at different discharges. The most recent sediment rating curves developed for the four sediment monitoring stations for the 2015 water year were used in this analysis. The sediment rating curves and equations from Gaeuman and Stewart (2017) used in this analysis relating the coarse bedload (gravel-sized sediment with diameter >8mm) transported to the discharge are summarized in Figure 3-5.

The spatial extent of the Restoration Reach was subdivided into six reaches to analyze sediment mobilization. The daily flow at each reach was a sum of the flow for all modeled inputs above that reach and sediment monitoring station rating curves were assigned to each reach based on proximity, as summarized in Table 3-2. The amount of coarse bedload transport estimates the total amount of sediment greater than 8mm in diameter that would be transported and is an indicator of the amount of geomorphic work that would potentially be performed by each scenario relative to the baseline.

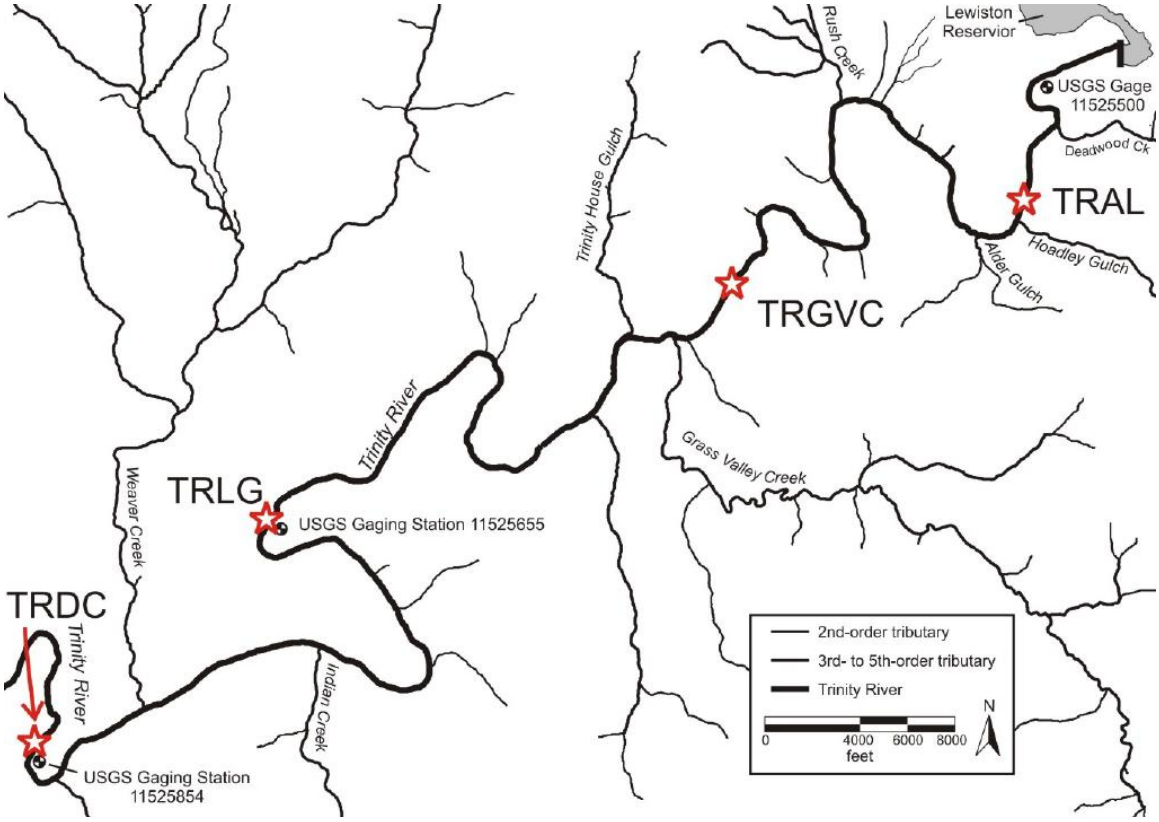


Figure 3-4. Location of the Four Sediment Monitoring Stations within Restoration Reach of the Trinity River, CA.

Note: TRAL = Trinity River at Lewiston; TRGVC = Trinity River at Grass Valley Creek; TRLG = Trinity River at Limekiln Gulch; TRDC = Trinity River at Douglas City (Gaeuman and Stewart 2017).

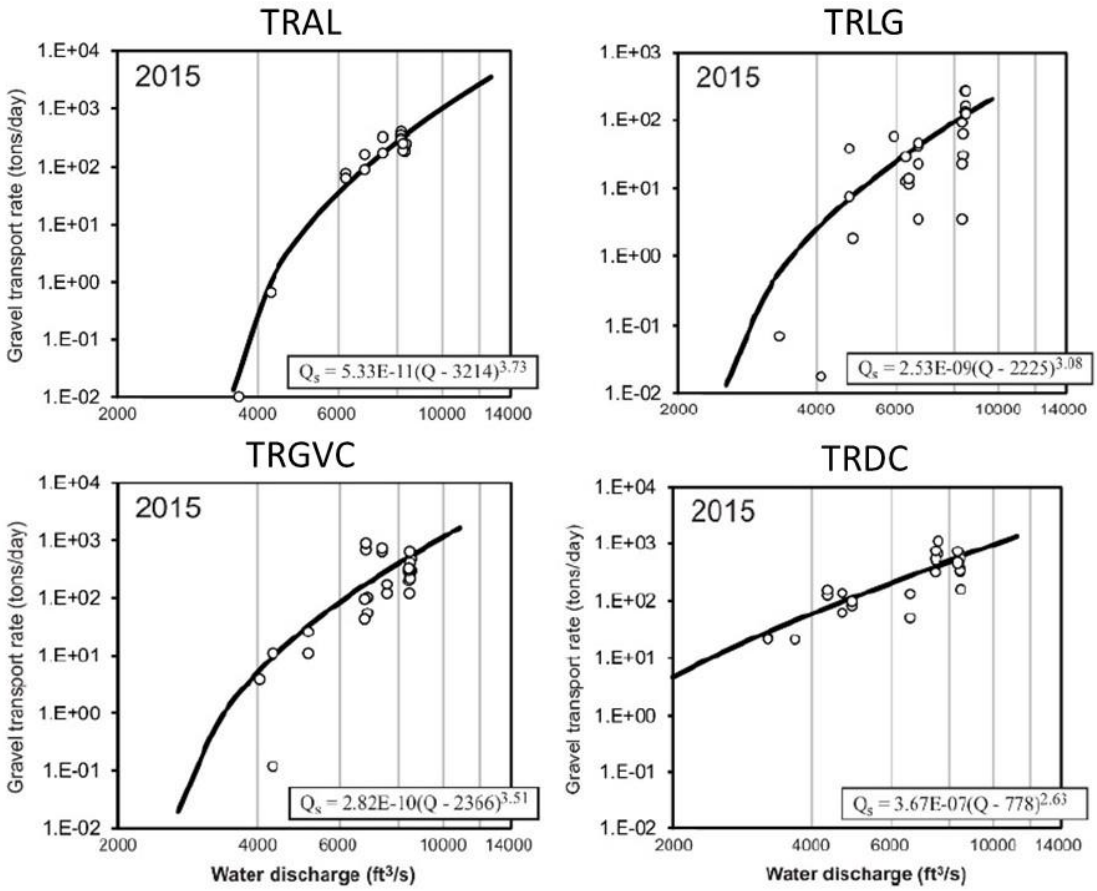


Figure 3-5. Rate of Coarse Bedload (gravel-sized sediment >8mm diameter) Transport in Tons/Day with Discharge (Q) in Cubic Feet per Second.

Note: Observations at each sediment station from the 2015 water year represented as points, with the rating curve equation displayed on each graph. TRAL = Trinity River at Lewiston; TRGVC = Trinity River at Grass Valley Creek; TRLG = Trinity River at Limekiln Gulch; TRDC = Trinity River at Douglas City (Gaeuman and Stewart 2017).

Table 3-2. Reaches, Sediment Monitoring Stations, and Flow Inputs Used to Calculate the Bedload Transport Metric.

Reach	Sediment Monitoring Station	Average Daily Flow
Lewiston Dam to Rush Creek	TRAL	Lewiston
Rush to Grass Valley Creek	TRGVC	Lewiston + Rush
Grass Valley to Indian Creek	TRLG	Lewiston + Rush + GVC
Reading to Browns Creek	TRDC	Lewiston + Rush + GVC + Indian + Weaver + Reading
Soldier to Canyon Creek	TRDC	Lewiston + Rush + GVC + Indian + Weaver + Reading + Browns
Cooper's Creek to North Fork Trinity River	TRDC	Lewiston + Rush + GVC + Indian + Weaver + Reading + Browns + Canyon

Key: GVC = Grass Valley Creek

3.4.2 Partial Bed Mobilization

The fractional area of streambed that experiences partial mobilization quantifies the maximum annual amount of streambed that would experience Shields stress values high enough to reset the macroinvertebrate community and increase food availability for juveniles. To quantify partial bed mobilization, this analysis used the same method as the Winter Flow Report, which relied on outputs from SRH-2D coupled with grain size maps generated by Alvarez et. al (2015) to create rating curves of discharge and percent of bed mobilized.

SRH-2D is a two-dimensional 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 SRH-2D hydraulics outputs for shear stress from the Bradley (2018) model were combined with a grain size map generated by Alvarez et. al (2015) to create maps of the spatially explicit Shields values at varying discharges. These Shields stress maps were generated for seven reaches, delineated by the extent at the Maximum Fisheries Flow, at eight different discharges (summarized in Table 3-3). From these data, curves analyzing the relationship between discharge and percent area of the bed mobilized assuming a necessary Shields stress value of $\tau^*>0.03$ and $\tau^*>0.045$ to mobilize the bed were generated by Gaeuman et al. (2023). Shields stress values of 0.03 - 0.045 are assumed to be sufficient to affect the macroinvertebrate community (Wilcock and McArdell 1993), and the more conservative value of 0.045 was used for this assessment. The curves shown in Figure 3-6 were used with the daily hydrographs—linear interpolation between the points was used to estimate the fractional area based on the discharge. Below 4,000 cfs the fraction of bed mobilized is assumed to be 0—4,000 cfs is near the threshold discharge needed to initiate gravel transport in the Trinity River (Gaeuman et al. 2017), and there were no discharges lower than 4,000 cfs modeled in SRH-2D. Since the partial bed mobilization metric applies only to the maximum annual flow to determine the fraction of streambed mobilized for the year, this assumption was deemed sufficient to capture the metric appropriately, given that the maximum annual flow at all reaches was typically greater than 4,000 cfs, except in Critically Dry water years 1991 and 1994.

The results are described on an annual basis by taking the maximum bed disturbed fraction for the year at each reach which becomes the fraction of bed mobilized for that year. This result was then averaged across the reaches, averaged across all years for each reach, and described in terms of percent change between the Baseline and each Scenario using Equation (1) below.

$$\%\ change = \frac{Scenario - Baseline}{Baseline} * 100 \qquad \textit{(Eq. 1)}$$

Table 3-3. Reaches Delineated at the Maximum Fisheries Flow indicated and Flow Inputs Used to Calculate the Partial Streambed Mobilization Metric.

Segment	Reach	Maximum Fisheries Flow (cfs)	Average Daily Flow
1	Lewiston Dam to Rush Creek	11,000	Lewiston
2	Rush to Grass Valley Creek	12,096	Lewiston + Rush
3	Grass Valley to Indian Creek	13,692	Lewiston + Rush + GVC
4	Indian to Weaver Creek	15,771	Lewiston + Rush + GVC + Indian
5	Weaver to Browns Creek	17,544	Lewiston + Rush + GVC + Indian + Weaver + Reading
6	Browns to Canyon Creek	21,336	Lewiston + Rush + GVC + Indian + Weaver + Reading + Browns
7	Canyon Creek to North Fork Trinity	23,207	Lewiston + Rush + GVC + Indian + Weaver + Reading + Browns + Canyon

Key: GVC = Grass Valley Creek

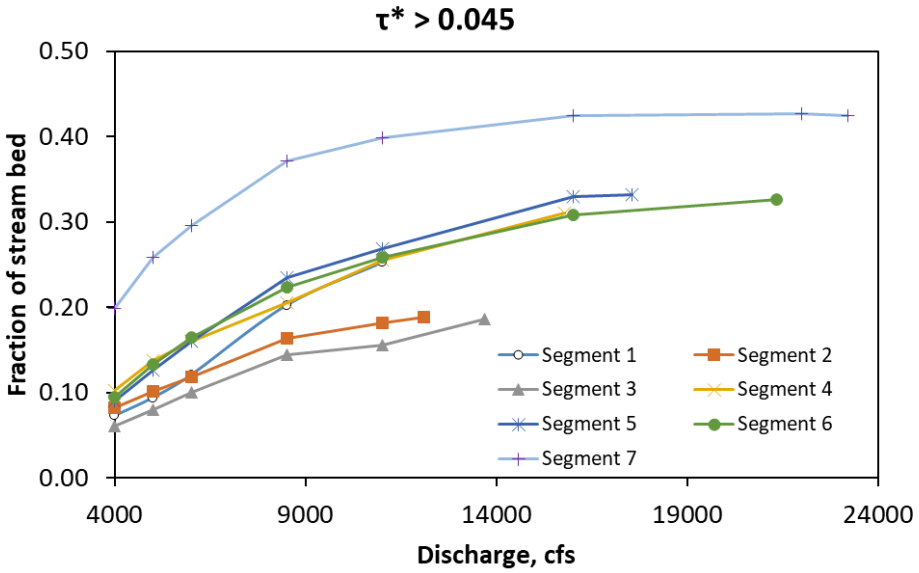


Figure 3-6. Fraction of Stream Bed Mobilized for Each Segment with Discharge, Assuming Shields Stresses (τ*) of Greater Than 0.045 Mobilize Bed (Gaeuman et al. 2023).

3.5 Habitat Models

Two Chinook Salmon habitat models were used to support the technical analysis in the Water Management Plan: a spawning habitat model (Goodman et al. 2018) and a juvenile microhabitat model (Som et al. 2018). Both models use depth, velocity, and other hydrodynamic metric output from the SRH-2D hydrodynamic model of the Restoration Reach to predict spawning habitat and juvenile capacity (Bradley 2016). The spawning habitat model estimates the probability that a cell in the 2D model is spawning habitat, while the juvenile Chinook Salmon microhabitat model estimates the expected mean abundance in a 2D cell.

Both habitat models are used in S3 to drive density-dependent population dynamics. Results from applying the habitat models to the 2D hydrodynamic model are summarized for each of the 356 meso-habitat units forming the S3 spatial domain. Spawning habitat is summarized into a daily time series of available spawning habitat (in square meters) in each habitat unit. The amount of available spawning habitat affects redd superimposition probability, which in turn drives egg survival. For juveniles, carrying capacity of fry and parr is estimated by predicting the 95th

percentile as an upper bound for abundance. This process produces a daily time series of fry and parr capacity for each habitat unit. In turn, carrying capacity drives density dependent fish movement, with the probability of moving increasing as the ratio of abundance to capacity increases. Further details on the how these habitat models are implemented can be found in Perry et al. (2018a).

3.6 Stream Salmonid Simulator

Stream Salmonid Simulator (S3) is a deterministic life-stage-structured population model that simulates growth, movement, and survival of Chinook Salmon from spawning through outmigration to the ocean. S3 was constructed and parameterized for spring-run and fall-run Chinook Salmon of the Restoration Reach of the Trinity River (Perry et al. 2018a) and was used to support this technical analysis. The S3 model is predicated on the idea that flow affects temperature and habitat availability for fish (as determined by the micro-habitat model), which in turn, influences density-dependent processes such as fish movement. Model inputs include water temperature, discharge, the number of juveniles from hatchery and tributary sources, as well as the spawning distribution and abundance within the mainstem Trinity River. Using these inputs, S3 simulates the demographics and vital rates of an annual juvenile Chinook Salmon population to provide outputs for abundance, size, and biomass of the fish at a given location of the river. The following sections briefly describe the S3 model, and the inputs used to assess the effect of the Contract Water release scenarios on annual juvenile Chinook Salmon production within the Restoration Reach of the Trinity River.

3.6.1 Habitat Template and Physical Inputs for S3

The spatial domain of the S3 model is defined by a one-dimensional representation of discrete meso-habitat units (MHUs). MHUs are spatially referenced by their upstream and downstream boundaries measured as the distance in river kilometers from the Klamath River confluence. The length of an MHU is simply the difference between its upstream and downstream boundaries. The Restoration Reach was partitioned into 356 contiguous MHUs classified by meso-habitat types of runs, riffles, and pools (Perry et al. 2018a). To define the quality and quantity of fish habitat within each MHU, output from the SRH-2D hydraulic model (Bradley 2016) and habitat models (Goodman et al. 2018, Som et al. 2018) were used. Each MHU was represented as a polygon (Perry et al. 2018a), which allowed for assignment of cells from the finer-scale hydraulic model to each MHU. Output from the habitat models were then applied to the cells of the 2D hydraulic model and summarized over each MHU to construct the one-dimensional habitat inputs required by the S3 model (Perry et al. 2018a, b).

3.6.2 Biological Inputs for S3

The S3 model relies on the two primary forms of biological inputs to simulate population dynamics: (1) female spawners and (2) juvenile fish entering from tributaries and hatchery releases. This section defined model assumptions for the spatial and temporal distribution of spawners and the release of hatchery fish and juvenile fish from tributaries into the Trinity River S3 model.

3.6.2.1 Spawner Abundance and Distribution

To develop inputs for the number of female spawners, spawner survey data (Chamberlain et al., 2012) was summarized as a weekly time-series of redd counts by survey reach. Of the 14-spawning survey reaches between Lewiston Dam and the Klamath River confluence, 7 reaches fall within the Restoration Reach used for this analysis (Perry et al. 2018b). Model simulations tracked two subpopulations of early (spring) and late (fall) spawning female Chinook Salmon in

the same manner as Perry et al. (2018b). To construct model inputs, the reach-level redd survey data was mapped to each MHU and the weekly redd counts were converted to daily redd counts by dividing weekly counts by seven. Within each survey reach, daily redds were then distributed to MHUs proportional to the distribution of daily suitable habitat area for redds in each survey reach.

The baseline and seven Contract Water release scenarios were simulated using the observed spawner distribution and abundance for brood year 2007. Spawner abundance in 2007 was 4,794 spring and fall run Chinook Salmon, representing the 93rd percentile over the 14 years of data (2005 – 2018) currently available for S3 simulation (Figure 3-7). Brood year 2007 was the second highest spawner abundance over these data. This relatively high spawner abundance was selected to investigate density dependence in model simulations. At low spawner abundance and in turn, low juvenile Chinook Salmon abundance, the effect of water releases on fish habitat would be moot.

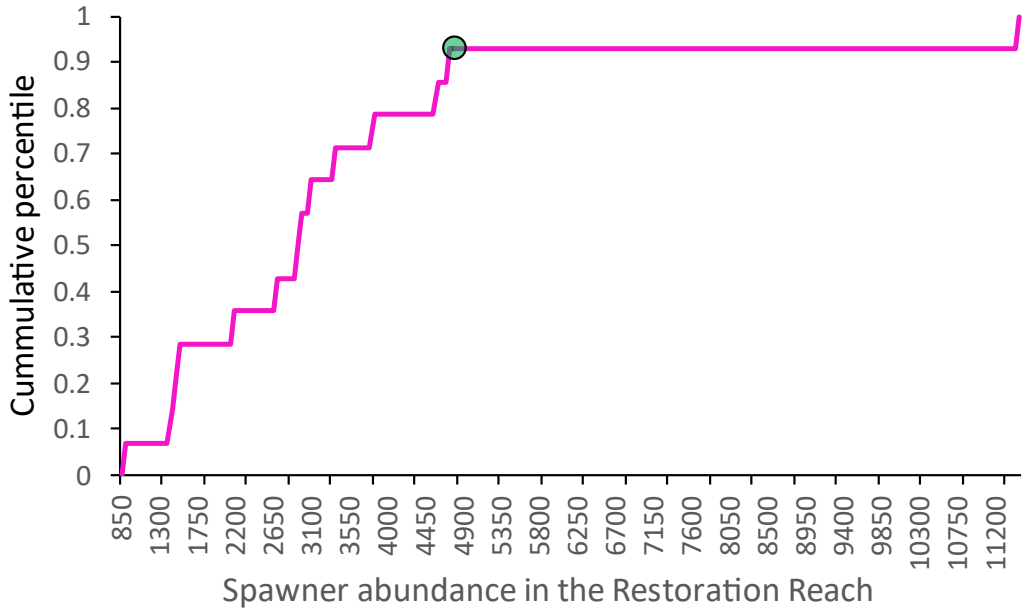


Figure 3-7. Cumulative Percentile of Female Spawner Abundance for Spring and Fall Run Chinook Salmon in the Restoration Reach of the Trinity River, CA.
Note: The circled location represents the 93rd percentile in spawner abundance (4,794 fish) used to simulate Water Contract release scenarios.

The spatial and temporal distributions of spawning females dictate the initial biological conditions for annual S3 simulations. Using the same spatial and temporal distribution of spawning fish in our simulations controls for year-to year variability in population dynamics that results from variation in annual spawning abundance and distribution. The 2007 brood year used in S3 simulated Contract Water release scenarios was typical of the spatial and temporal distribution of Chinook Salmon spawning for the Trinity River (Figure 3-8). Fish spawned at the highest densities just below Lewiston dam (river kilometer 180.6) with spring and fall-run Chinook Salmon having a very similar spatial spawning distribution. Because spring- and fall-run Chinook Salmon are defined by a cutoff date of November 1st (Borok et al., 2014), the temporal distribution of spawning determines the abundance of spring- versus fall-run Chinook Salmon.

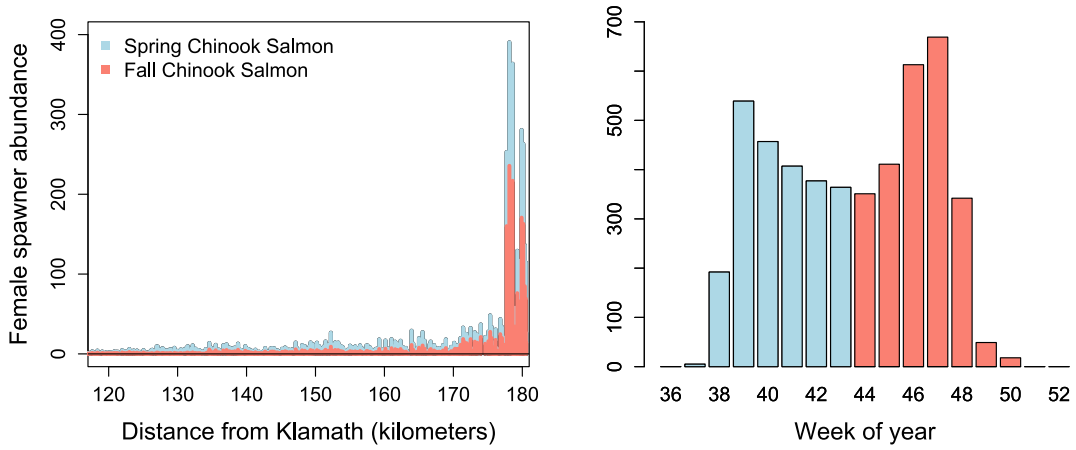


Figure 3-8. The Spatial (left) and Temporal (right) Distributions for Female Spring and Fall Chinook Salmon Spawner Abundance within the Restoration Reach of the Trinity River, CA, during the 2007 Brood Year Used to Simulate and Assess Contract Water Release Scenarios.

3.6.2.2 Juveniles from Tributary and Hatchery Sources

Data on the numbers and sizes of juveniles that entered the Trinity River from tributary and hatchery source populations during migration year 2008 was selected to assess Contract Water release scenarios because this year follows the historical events that followed the 2007 brood year that was chosen for spawning.

One of the four major tributaries to the Trinity River, Canyon Creek, is thought to contribute to the abundance of juvenile Chinook Salmon above the Pear Tree fish trap (Figure 2-3). The estimated juvenile Chinook Salmon abundance and size at emigration from Canyon Creek reported by Plumb et al. (2023) was used in S3 simulations of Contract Water releases. However, these fish are not included in the summary of S3 model output because of the proximity of Canyon Creek to Pear Tree and the little effect that flow scenarios would have over the short distance (9.3 km) to Pear Tree.

Hatchery releases of age 0 (fingerling) juvenile Chinook Spring and Fall Chinook Salmon were included as separate sub-populations in S3. Data on hatchery releases of Chinook Salmon were obtained from the Regional Mark Information System database (http://www.rmpc.org/; Perry et al. 2018b). Daily hatchery release numbers and weighted-mean fish weights were computed separately for spring- and fall-run Chinook Salmon input data. Simulated hatchery inputs entered the river just below the dam, and the two sub-populations were tracked separately in S3.

3.6.3 S3 Model Structure and Parameter Settings

3.6.3.1 Spawning, Egg Development and Egg Survival

The number of eggs that survive to emerge as fry is affected by several S3 parameters and submodels. The fecundity of female spawners was set to 3,135 eggs per redd to approximate the mean number of eggs observed for Chinook Salmon returning to the Trinity and Klamath River Hatcheries. The mean time from spawning to fry emergence was modeled as a function of daily water temperature and the accumulated degree days (Perry et al., 2018a, b). Variation in emergence timing was assumed to follow a normal distribution about the mean emergence date

and was controlled by the standard deviation in degree days required to hatch, which was set to 26.6-degree days.

During the incubation period, S3 includes three mechanisms that affect egg-to-fry survival: (1) baseline "natural" mortality, (2) temperature-related mortality, and (3) redd superimposition (Perry et al., 2018a). The natural mortality rate was set at 0.25 percent per day, which equates to a baseline survival rate of about 92.8 percent per month. Thermal tolerance parameters were set so that water temperatures less than or equal to 62.6°F (17°C) had no effect on egg survival, but temperatures greater than 62.6°F (17°C) imposed a daily mortality rate of 25 percent (Geist et al., 2006).

Redd superimposition is the process whereby a later arriving spawner builds a redd on top of an existing redd and dislodges or entombs the eggs laid by the earlier spawner. Superimposition is modeled in S3 as a function of habitat capacity and spawner abundance. Habitat capacity is the quotient of suitable habitat area for redds divided by the size of a redd, which was set to 4.5 m^2. The probability of redd superimposition is defined by redd density (redd abundance/redd capacity), which is calculated and applied daily for each habitat unit. The amount of redd mortality attributed to superimposition on day *t* is simply the number of redds to be recruited that day multiplied by the existing pre-recruitment redd density. However, given the propensity of Chinook Salmon to guard their redds until death, the guarding period was set to 10 days, assuming semelparous Chinook Salmon live to guard their nests for 10 days after spawning. Redds are not vulnerable to superimposition during the guarding period. Although redd scour owing to freshets is known to influence survival of eggs, mortality due to scour has not yet been implemented in the S3 model. The S3 model does not account for the desiccation and mortality of eggs due to dewatering of redds as river flows decrease.

3.6.3.2 Juvenile Survival, Movement, and Growth

When simulating fish populations with S3, some population dynamics are dictated via user defined options and parameter inputs. Juvenile fish populations in the S3 model are affected by three dynamic processes: (1) survival, (2) movement, and (3) growth. The parameter set calibrated for the S3 model reported by Perry et al. (2018b) was used, where survival processes were expressed as density-independent, yet fry and parr movement was density-dependent. Parameters for survival and movement were provided separately for hatchery and natural fish. Hatchery survival and movement parameters were equal across life stages, yet for natural fish survival and movement, parameters were provided for fry and parr life stages. In the same manner as Perry et al. (2018b), the assumed constant proportion of maximum consumption was set at C = 0.66 when simulating fish growth. For more detail about the S3 model see Perry et al. (2018a, b).

Table 3-4. Survival, Movement, and Consumption Parameters for the S3 Model Used to Simulate the Baseline and Contract Water Release Scenarios.

Parameter	Definition	Hatchery (fry, parr, smolt)	Natural (fry)	Natural (parr and smolt)
Survival	Density-independent daily rate	0.848	0.987	0.889
Movement	Density-dependent intercept of Beverton-Holt model for daily rate of remaining in habitat	0.279	0.476	0.010
Consumption	Density-independent daily rate	0.66	0.66	0.66

4 RELEASE SCENARIO TIMESERIES DEVELOPMENT

Based on a discussion of limiting factors and release objectives, a set of Contract Water release recommendations was developed in Workshop 2. There was consensus that Contract Water releases should end around April 15 (the typical date when the TRRP Flow Workgroup proposes elevating ROD flows) and should not be released to supplement the ROD flow snowmelt peak runoff releases in April through July. These recommendations were used in subsequent workshops to develop four initial release scenarios (Workshop 3) and three refined release scenarios (Workshop 4). The following subsections describe the main elements and objectives of each release scenario and the data used to develop input time series for the modeling tools.

4.1 Initial Release Scenario Development

Four initial scenarios developed in Workshop 3 are summarized in Table 4-1 and described in more detail in the following subsections.

Table 4-1. Four Initial Scenario Recommendations.

Scenario #	Scenario Name	Release	Timing	Trigger	Objectives
1	Building baseflow	Incrementally add baseflow each month to existing releases	Dec 15 – Apr 21/26/22*	Dec 15	• Increase rearing habitat area and quality for Chinook Salmon[M] • Increase available spawning and rearing habitat for Coho Salmon/steelhead[NM]
2	Fall pulse	Two 3,000 cfs pulses	Period 1: Oct 15 – Nov 15 Period 2: Nov 15 – Dec 15	1.5-year recurrence interval of Trinity River above North Fork for each period	• Recruitment/entrainment of organic matter (leaf litter, insects, benthic invertebrates)[NM] • Redistribute juveniles and lamprey[NM] • Reduce redd superimposition[M] • Provide distribution and velocities for spawners[M] • Inundate tributary delta deposits[NM] • If timed with release of yearlings, improve adult attraction into the hatchery[NM]
3	(A) One winter pulse **OR (if trigger not met)** (B) Two spring pulses	(A) One 6,000 cfs pulse **OR** (B) Two 3,000 cfs pulses	(A) Dec 15 – Feb 15 **OR** (B) Mar 15, Apr 15	(A) 4,500 cfs at Trinity River above North Fork **OR** (B) 15th of month	(A) • Sediment transport[M] • Reset the macroinvertebrate community[NM] • Scour channel[NM] (B) • Increase rearing habitat for Chinook Salmon[M] • Increase food availability for rearing Chinook Salmon[NM] • Disperse hatchery released Coho Salmon/steelhead[NM]
4	Baseflow + pulse	All of the above	All of the above	All of the above	All of the above

*End date depends on the TRRP water year type, with April 21/26/22 corresponding to the Extremely Wet, Wet, Normal / Dry / Critically Dry water year types, respectively.
M = modeled factor; NM = non-modeled factor

Release prior to April 15 were desirable; however, this is prior to the TRRP water year type designation released in the DWR Bulletin 118. Therefore, releases were designed independent of

water year type, so that timing and magnitude of releases did not vary over the simulation period (as in Scenario 1) or were dependent on flow triggers internal to the system, such as the flow at the Trinity River at North Fork for Scenarios 2 and 3.

4.1.1 Scenario 1

Scenario 1, Building Baseflow, was designed to release Contract Water in an incrementally increasing stair-step pattern, between December 15 and the start of ROD flows in mid-April. An incrementally increasing pattern was favored over a static baseflow as it more closely mimics the natural hydrograph component of ascending winter baseflows and is similar to previous Chinook Salmon rearing habitat flows designed for the Winter Flow Project (TRRP and Reclamation 2022) and Draft Humboldt County Contract Water Study (Naman 2018; USFWS and NOAA 2018).

The monthly release pattern is the same in all simulated years, with some small differences. Because the ROD flow is initiated at different start dates in April, depending on the water year type (April 21 in Extremely Wet, Wet, and Normal year types, April 26 in Dry years, and April 22 in Critically Dry years), the ending date of Contract Water release varies with year type, varying the number of flow days and release volume of Contract Water. The Scenario 1 release pattern would require 50,114 acre-feet of Contract Water distributed across 127 flow days in Extremely Wet, Wet, and Normal years, 53,084 acre-feet over 132 flow days in Dry years, and 50,708 acre-feet over 128 flow days in Critically Dry years. The average monthly release pattern is summarized for a Critically Dry water year in Figure 4-1 and for all years in Table 4-2.

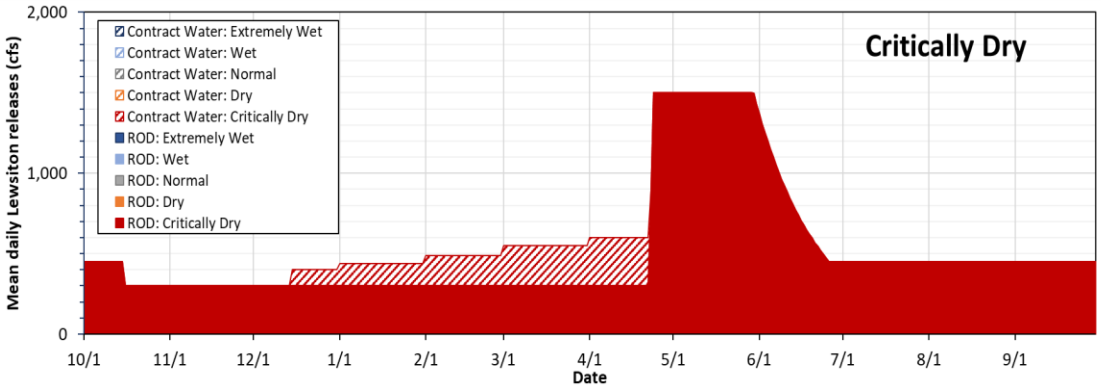


Figure 4-1. Example Combined ROD and Contract Water Releases at Lewiston in a Critically Dry Year for Scenario 1.

Table 4-2. Average Monthly ROD and Contract Water Releases at Lewiston for Scenario 1, Years 1980-2003.

Month	Average Monthly ROD Release (cfs)	Average Monthly Contract Water Release (cfs)	Average Monthly Combined Release (cfs)
October[1]	373	0	373
November	300	0	300
December[2]	300	55	355
January	300	140	440
February	300	190	490
March	300	250	550
April[3]	501	222	723
May	3,578	0	3,578
June	2,168	0	2,168
July	841	0	841
August	450	0	450
September	450	0	450

Notes:
1. The October monthly average ROD release reflects a release of 450 cfs from October 1 through October 15 and a release of 300 cfs from October 16 through October 31.
2. The December monthly average Contract Water release reflects a release of 0 cfs from December 1 through December 14 and a release of 100 cfs from December 15 through December 31.
3. The April monthly average reflects a release of 300 cfs of Contract Water and 300 cfs of ROD release April 1 until the elevated Spring ROD flow is initiated (April 21 in Extremely Wet, Wet, and Normal year types, April 26 in Dry years, and April 22 in Critically Dry years).

4.1.2 Scenario 2

Scenario 2, fall pulse flow, was designed to create two 3,000 cfs peak, 13-day duration "biologic pulses" that could recruit leaf litter and food to the stream and redistribute juveniles and fall hatchery released fish to reduce redd superimposition. These pulses were believed to be too low magnitude to create geomorphic changes or significant habitat increases. One pulse would be released between October 15 and November 15 (Period 1). The trigger for the release would be the 1.5-year recurrence interval flow at the Trinity River above North Fork for that period (e.g., the 1.5-year recurrence interval of annual peak flows during the October 15 to November 15 period) being met or exceeded. If the trigger was not met, the pulse would be released the last day of the period, November 15. The second pulse would follow the same rule, with the trigger being adjusted to the 1.5-year recurrence interval flow between November 16 and December 15. If the 13-day duration of Pulse 1 extended into Period 2 (e.g., started on November 15), the Period 2 pulse was delayed until the next time the trigger occurred or December 15, whichever came first.

To develop pulse triggers, first the daily flow record at Trinity River above North Fork was estimated using the 1980-2003 RBM10 daily flow pattern produced for the major tributaries in the Trinity watershed for the Klamath LTP EIS (Reclamation 2017). The flow was a sum of the daily modeled flow at each time step for the ROD release at Lewiston, Rush Creek, Grass Valley Creek, Indian Creek, Weaver Creek, Reading Creek, Browns Creek, and Canyon Creek. The daily flow was separated into the two fall periods, and the maximum mean daily flow for each year and period was selected and used to create an annual exceedance ranking. The 1.5-year recurrence interval flow at Trinity River above North Fork was 532 cfs for Period 1 and 1,147 cfs for Period 2.

This biologic pulse release was designed as a 13-day pattern, which assumed the baseflow release at Lewiston is 300 cfs during the fall periods. It was created by modifying the geomorphic pulse

pattern release designed for the Draft Humboldt County Contract Water Study (Naman 2018; USFWS and NOAA 2018). On day 1, the total flow at Lewiston was increased to 1,000 cfs, then to a peak of 3,000 cfs on day 2. The ramp down rate was defined by

$$Q_i = Q_o e^{kt} \quad \textit{(Eq. 2)}$$

where Q_i is equal to the release rate at Lewiston on day i, Q_o is the initial peak flow, k = -0.192, and t is the number of days from Q_o. The ramp up rate (1,350 cfs/day; k = 1.151), peak, and ramp down rate are all within acceptable criteria for ramping rates and safety of dams as defined in the Trinity River Mainstem Fishery Restoration Final EIS/EIR (USDOI 2000) and the TRRP Flow Workgroup recommendations (Buxton 2018). The total Contract Water volume required for this pattern is 49,755 acre-feet.

The daily release pattern is shown in Table 4-2 for a Dry water year and the 13-day daily flows are listed in Table 4-3. The focus of the analysis on habitat and fisheries populations is focused on the time period of 1980 – 2003. However, CalSim II and HEC-5Q require inputs from 1922 – 2003. No flows were modeled for the Trinity River at North Fork prior to 1980, so to extend the release series to the 1922-1979 period for modeling in HEC-5Q and CalSim II, an assumption was made that pulse releases always occurred at the ends of each period on November 15 and December 15.

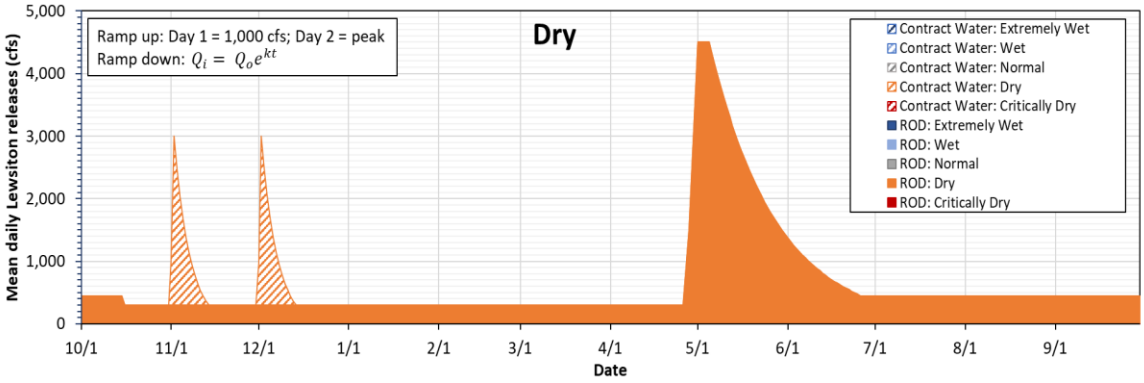


Figure 4-2. Example Combined ROD and Contract Water Releases at Lewiston in a Dry Year for Scenario 2.

Table 4-3. Fall Pulse 13-Day Release Pattern at Lewiston.

Day of Pulse	Mean Daily ROD Release (cfs)	Mean Daily Contract Water Release (cfs)	Mean Daily Combined Release at Lewiston (cfs)
1	300	700	1,000
2	300	2,700	3,000
3	300	2,176	2,476
4	300	1,744	2,044
5	300	1,387	1,687
6	300	1,092	1,392
7	300	849	1,149
8	300	649	949
9	300	483	783
10	300	346	646
11	300	233	533
12	300	140	440
13	300	63	363

4.1.3 Scenario 3

Scenario 3, winter pulse or spring pulses, was designed to add a geomorphically significant pulse of 6,000 cfs, synchronized with a flow trigger of 4,500 cfs at the Trinity River above North Fork, which is the same trigger used to initiate the pulse flow during the Flow Synchronization Period in the Winter Flow Project (TRRP and Reclamation 2022). If the trigger for the geomorphic pulse does not occur, then two biologic pulses with the same pattern as designed in Scenario 2 are released later in the spring—one on March 15 and one on April 15.

The daily flow record at Trinity River above North Fork was developed using the method described in Scenario 2. Constraints and checks were added to the geomorphic pulse release so that the flow would not exceed 18,000 cfs at North Fork, following Reclamation guidelines and the release constraint for the Winter Flow Project (TRRP and Reclamation 2022). The gage at North Fork has a flow forecast window of 5 days, so the pulse release would not occur if the flow at Trinity River exceeded 12,000 cfs in the subsequent 5 days. An additional check was added to reduce the geomorphic pulse flow release if it would cause Trinity River flow at North Fork to exceed 18,000 cfs—this occurred only once during the simulated period, resulting in a loss of 27 cfs on the last release day.

This geomorphic pulse release was designed with a 17-day duration, which assumed the baseflow release at Lewiston was 300 cfs during the fall periods. It is identical to the geomorphic pulse pattern release designed for the Draft Humboldt County Contract Water Study (Naman 2018; USFWS and NOAA 2018). On day 1, the total flow at Lewiston is increased to 1,000 cfs, then peaks at 6,000 cfs on day 2. The ramp down rate is defined by Equation 1, where k = -0.194. The ramp up rate (2,850 cfs/day; k = 1.498), peak, and ramp down rate are all within acceptable criteria for ramping rates and safety of dams as defined in the Trinity River Mainstem Fishery Restoration Final EIS/EIR (USDOI 2000) and the TRRP Flow Workgroup recommendations (Buxton 2018). The total Contract Water volume required for the geomorphic release pattern is 56,228 acre-feet. The daily release pattern is shown in Figure 4-3 for a Dry water year and the 17-day daily flows are listed in Table 4-4.

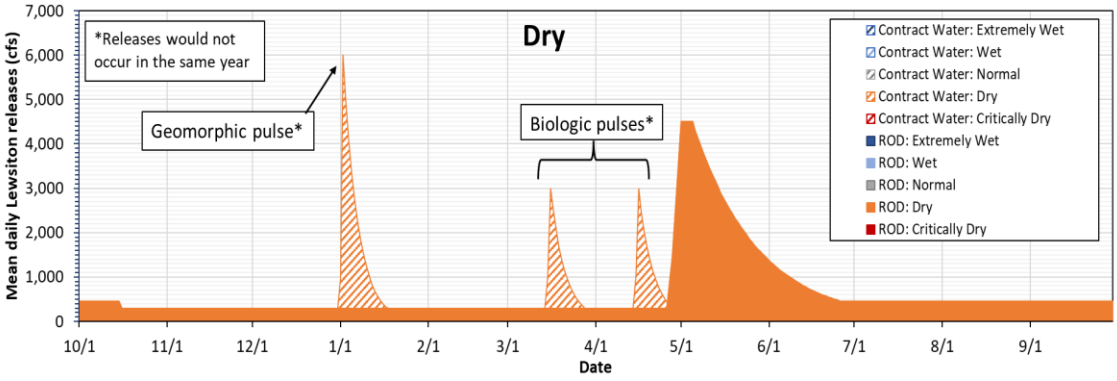


Figure 4-3. Example Combined ROD and Contract Water Releases at Lewiston in a Dry Year for Scenario 3.

Table 4-4. Geomorphic Pulse 17-Day Release Pattern at Lewiston.

Day of Pulse	Mean Daily ROD Release (cfs)	Mean Daily Contract Water Release (cfs)	Mean Daily Combined Release at Lewiston (cfs)
1	300	700	1,000
2	300	5,700	6,000
3	300	4,642	4,942
4	300	3,770	4,070
5	300	3,053	3,353
6	300	2,461	2,761
7	300	1,974	2,274
8	300	1,573	1,873
9	300	1,243	1,543
10	300	971	1,271
11	300	747	1,047
12	300	562	862
13	300	410	710
14	300	285	585
15	300	182	482
16	300	97	397
17	300	27	327

Flows at Trinity River at North Fork were not modeled prior to 1980, so to extend the release series for the geomorphic pulse releases to 1922-1979 for modeling in HEC-5Q and CalSim-II, the probability of the daily flow exceeding 4,500 cfs at Trinity River above North Fork was analyzed by month and water year type for the modeled 1980-2003 period. In an Extremely Wet year, the trigger was met 38.7% of the time between February 1 – 15, which was a greater probability than the trigger being met in December or January, so in the extended series, the geomorphic pulse was released on February 1 in Extremely Wet years. Similarly, in Wet years, December had the greatest probability of having the trigger criteria met, 32.1% of the time, so in Wet years, the pulse was released December 15. In Normal years, the trigger was only met in January, so the pulse was released January 1. In Dry years the probability of the trigger being met was highest in January, but only occurred 1% of the time and did not occur in any Critically Dry years, so for both of those year types, the geomorphic pulse flow was not released, and the two spring biologic pulses were released on March 15 and April 15.

4.1.4 Scenario 4

Scenario 4 was designed to combine Scenarios 1 – 3, while only releasing the geomorphic pulse if the flow at Trinity River above North Fork reached at least 4,500 cfs. It was designed as an upper bookend of potential benefits if an annual Contract Water request was made of between 150 TAF to 200 TAF, consistent with Proviso 2 of the 1955 Act that specifies releases of not less than 50 TAF should be made annually to Humboldt County. An example daily release pattern is shown in Figure 4-4.

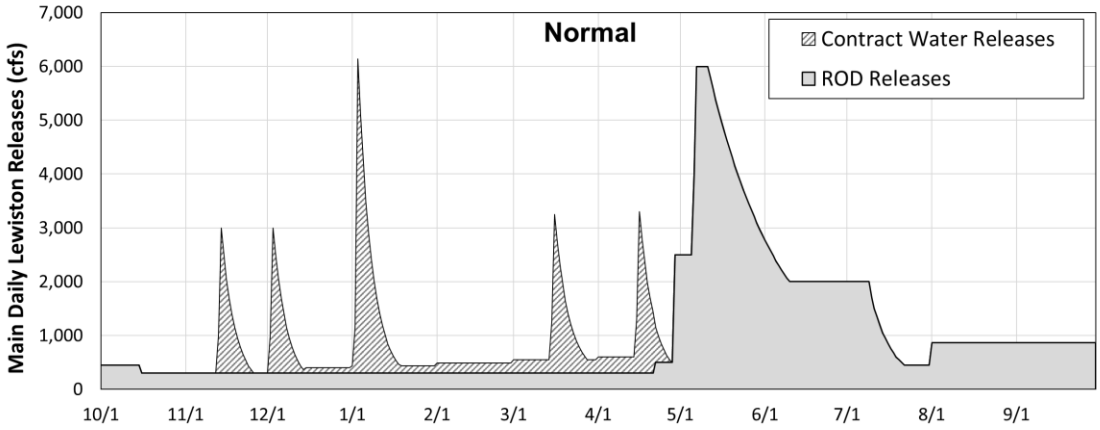


Figure 4-4. Example Combined ROD and Contract Water Releases at Lewiston in a Normal Year for Scenario 4.

4.2 Refined Release Scenario Development

Scenarios 1 – 4 were implemented in the modeling tools, and a summary of results was provided to interested parties during Workshop 4 (see Section 5 for results). Based on a review of results, revised release recommendations included the following:

- Due to the approval and impending implementation of the Winter Flow Project for the 2023 water year, with elevated baseflow being released on February 15, there was strong consensus to focus only on flow releases for the fall period, and to not duplicate Winter Flow Project releases.
- Scenario 1, or any similar building baseflows scenario in the spring, should be revised to concentrate flows in March and April, across a shorter duration once fry have emerged. This would allow the 50 TAF to be released at a higher magnitude, which would increase habitat area and likely result in modeled increases in fish population benefits.
- Scenario 2 should include a constraint where the fall pulse is not released if storage in Trinity Reservoir is less than 750 TAF, as warmer release temperatures below this storage level are known to be inhospitable for Coho Salmon.

Based on these considerations, Scenario 5 was defined fully in the workshop as a modification to Scenario 2 using end of month storage in Trinity Reservoir as a new trigger. As shown in Section 5, Scenario 2 also produced favorable fisheries model outputs, which led the group to prefer minor revisions to this scenario. Based on feedback from participants, the modeling team developed two additional refined scenarios. Scenario 6 was developed to simulate the maximum potential benefit of Contract Water on spawning habitat. Under this scenario, baseflows would be increased in the fall to increase redd habitat area and improve egg survival. Scenario 7 was developed to simulate the potential effects if Contract Water were held as carryover in Trinity Reservoir and not released into Trinity River. Under this scenario, the beneficial use of Contract Water would be to increase the volume of the cold-water pool in Trinity Reservoir, leading to cooler releases during summer and fall months. This scenario would demonstrate whether or not summer water temperatures are a limiting factor to fish production. These three refined scenarios are summarized in Table 4-5 and described in more detail in the following subsections.

Table 4-5. Refined Scenario Recommendations

Scenario #	Scenario Name	Release	Timing	Trigger	Objectives
5	Two fall pulses with storage-based delay	Two 3,000 cfs pulses	Period 1: Oct 15 – Nov 15 Period 2: Nov 16 – Dec 15 Period 3: Dec 16 - Jan 15 Period 4: Jan 16 - Feb 15	1.5-year recurrence interval of Trinity River above North Fork for each period. If Trinity storage < 750 TAF in Period 1 or Period 2, delay pulse release until next period.	Same as Scenario 2 and 3B.
6	Modified fall baseflow	Increase fall baseflows	Oct 15 – Dec 31	Oct 15	• Increase spawning and rearing habitat area and quality for Chinook Salmon[M] • Improve Chinook Salmon egg survival[M] • Increase spawning and rearing habitat for Coho Salmon[NM]
7	Carryover	No Contract Water release – accumulate 50 TAF each year and only release during spills	No annual Contract Water Release	When Trinity Reservoir safety-of-dams release occurs (earlier than would otherwise), assume Contract Water is spilled first	• Reduce water temperature of releases during Dry and Critically Dry years to reduce fish mortality in summer and fall[M]

Notes: M = modeled factor; NM = non-modeled factor

4.2.1 Scenario 5

Scenario 5 was the same as the Scenario 2 pattern – two 3,000 cfs pulses over a 13-day duration – with the added constraint that if storage in Trinity Reservoir was less than 750 TAF, the release would not occur until storage exceeded 750 TAF or after December 15. December 15 was selected based on water temperature modeling of Trinity Reservoir (see Section 5.1) as a date when turnover of the reservoir is likely to occur, i.e., cooler surface water mixes with warmer, deeper water, creating a general cooling effect on the reservoir. If the biologic pulses were not made through Periods 1 and 2, then the pulses would occur during the winter period, triggered by the 1.5-year recurrence flow during the period of December 16 – January 15 (Period 3) and January 16 – February 15 (Period 4). If the flow trigger was not met during either period, the pulse was released on the last day of the period.

The flow at Trinity River above North Fork and exceedance intervals were developed using the method described in Scenario 2. The 1.5-year recurrence interval flow at Trinity River above North Fork was 1,907 cfs for Period 3 and 2,401 cfs for Period 4. Only two of the modeled years 1980-2003 changed as a result of this constraint—in Dry water year 1992 the releases were delayed to the end of Periods 3 and 4 and in the following Wet water year 1993 the releases were at the end of Period 3 and with a flow trigger on February 9 in Period 4.

For the extended 1922-1979 period, the daily simulated storage in Trinity Reservoir which was produced through the original modeling of Scenario 2 in CalSim II and HEC-5Q was used to set a constraint on the releases. In 10 of the 58 water years in this period (1925, 1930-1937, and 1979), the releases were delayed until the end of Period 3 and 4 due to low storage in Trinity Reservoir.

4.2.2 Scenario 6

Scenario 6, fall baseflow, was designed to release Contract Water in an incrementally increasing stair-step pattern, between October 16 and December 31 to target spawning, with an extended release of 90 cfs from January 1 to February 15 to avoid redd dewatering as described below. The ascending baseflow pattern and timing was designed to mimic a lower magnitude release analogous to the hydrograph designed by Goodman, et al. (2018) to optimize increased spawning habitat. The Scenario 6 release pattern would require 50,569 acre-feet of Contract Water distributed across 122 flow days. The daily release pattern is shown in Figure 4-5 for a Critically Dry water year and mean monthly releases are listed in Table 4-6.

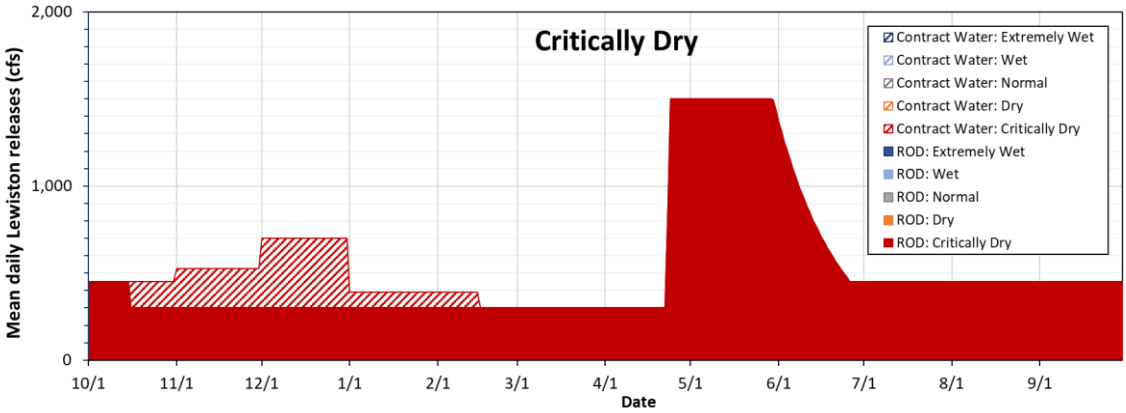


Figure 4-5. Example Combined ROD and Contract Water Releases at Lewiston in a Critically Dry Year for Scenario 6.

Table 4-6. Average Monthly ROD and Contract Water Releases at Lewiston for Scenario 6, Years 1980-2003.

Month	Monthly Average ROD Release (cfs)	Monthly Average Contract Water Release (cfs)	Monthly Average Combined Release (cfs)
October[1]	373	77	450
November	300	225	525
December	300	400	700
January	300	90	390
February[2]	300	48	348
March	300	0	300
April	501	0	501
May	3,578	0	3,578
June	2,168	0	2,168
July	841	0	841
August	450	0	450
September	450	0	450

Notes:
1. The October monthly average ROD release reflects a release of 450 cfs from October 1 through October 15 and a release of 300 cfs from October 16 through October 31. The October monthly average Contract Water release reflects a release of 0 cfs from October 1 through October 15 and a release of 150 cfs from October 16 through October 31.
1. The February monthly average Contract Water release reflects a release of 90 cfs from February 1 through February 15 and a release of 0 cfs from February 16 through February 28. The February monthly average combined release reflects a release of 390 cfs from February 1 through February 15 and a release of 300 cfs from February 16 through February 28.

Scenario 6 was developed to minimize the risk of redd dewatering. Chinook Salmon incubation and fry emergence life stages occur within the gravel interstitial spaces of redds. A reduction in

flow during these life stages, which can extend from January through mid-March, could result in reduction of redd submergence, and potentially mortality if the redd is fully dewatered. To minimize the potential for redd dewatering, the reduction in flows on January 1 was limited to 310 cfs, or a drop from 700 cfs to 390 cfs, based on the following logic:

- Redd surveys from 2007, 2012, 2014 indicated the majority of redds in the Restoration Reach are formed in the upper reach directly below Lewiston and above Rush Creek (Figure 3-8; Gaeuman et al. 2023). Lewiston releases are the primary flow contribution that maintains water depth at this location (i.e., additional tributary inflows are not present), and all flow changes at Lewiston reflect flow changes in this reach.
- An analysis of the stage-discharge relationship at U.S. Geological Survey (USGS) gage 11525500 Trinity River at Lewiston indicated a drop in flow from 700 cfs to 390 cfs corresponds to a drop in water surface elevation of 0.5 feet (6 inches) (USGS 2022).
- Spring-run and fall-run Chinook Salmon spawning depth suitability is 0 at depths less than 0.8 feet and 0.5 feet, respectively, and preferred spawning habitat is at depths of 1 to 3 feet (USFWS 2007, CalTrout 2017). Chinook Salmon spawning observations for the Trinity Flow Evaluation Study on the Trinity River confirmed the majority of Chinook Salmon redds were located at depths between 0.8 and 2.5 feet (USFWS and HVT 1999). Steelhead spawning depth suitability is 0 at depths of less than 0.4 feet and the majority of Coho salmon observed spawning in the Trinity Flow Evaluation Study constructed redds at depths between 0.5 and 2.2 feet (USFWS and HVT 1999, USFWS 2007).
- California Department of Fish and Wildlife (CDFW) developed criteria for identifying flow depths that support physical movement of salmonids through critical riffle sites (CDFW 2017). A minimum depth of 0.9 ft is required for adult Chinook Salmon and 0.7 ft for adult steelhead and Coho Salmon. At flows less than the minimum depth, critical life history tactics of salmon are impeded, including passage to and from spawning areas.
- It is unlikely redds would be established at depths of less than 0.5 ft since these depths do not provide unimpeded passage and are not suitable for spawning. For scenario 6, when the water surface elevation drops 0.5 ft following a flow reduction of 700 cfs to 390 cfs in January, it is unlikely that any redds would be completely dewatered.

4.2.3 Scenario 7

Scenario 7 was designed to use carryover storage in Trinity Reservoir as a beneficial use of Contract Water and as a bookend to determine if water temperature during summer and fall months was a limiting factor in fish production. Increasing storage is expected to increase thermal buffering capacity of the reservoir and increase the cold-water pool volume. By increasing carryover storage cumulatively each year by 50 TAF, particularly during drought years, Contract Water would have the effect of reducing water temperature of releases to Trinity River, particularly during the months of July through October when the North Coast Regional Water Quality Control Board Basin Plan (NCRWQCB 2011) temperature targets are specified and generally exceeded under existing condition (Humboldt County 2022).

Development of this release scenario occurred within the CalSim II model and was described in Section 3.1.2. In general, 50 TAF of Contract Water was accumulated in a separate storage account in Trinity Reservoir every year. When a safety-of-dams release was made, Contract Water in the carryover storage account was spilled first.

5 MODEL RESULTS

This section summarizes results from all models. Results in Sections 5.1 through 5.5 are summarized by the five water year types of the Trinity River system as established in the ROD: Extremely Wet, Wet, Normal, Dry, and Critically Dry. Results in Section 5.6 are summarized by the five water year types of the Sacramento Valley Index: Wet, Above Normal, Below Normal, Dry, and Critical.

5.1 Trinity Reservoir and Lewiston Reservoir

Following development of a daily time series of ROD water and Contract Water releases, CalSim II was modified to release a monthly volume of Contract Water consistent with the daily release pattern of each scenario. Monthly release volumes from Trinity Reservoir and Lewiston Reservoir were input to the HEC-5Q model, which repatterned releases into a daily flow based on ROD water obligations, Contract Water release assumptions, and required safety-of-dams releases that CalSim II forces out of Trinity Reservoir to maintain water surface elevations below flood pool elevation requirements. This section summarizes results from all scenarios for the simulation period of 1922 – 2003.

5.1.1 Trinity Reservoir Storage

Trinity Reservoir storage was modeled in CalSim II based on a water balance of inflows and outflows. Outflows from Trinity Reservoir were higher under all scenarios due to the release of at least 50 TAF of Contract Water every year. TRD exports were also reduced under all scenarios, but not enough to offset the full release of Contract Water. As shown in Figure 5-1 and Table 5-1, mean annual Trinity Reservoir storage was 30 – 50 TAF less than the baseline under Scenarios 1 – 6, and 100 TAF greater than the baseline for Scenario 7 due to the consistent accumulation of carryover water. The annual timeseries of Trinity Reservoir storage for all scenarios (Figure 5-2) shows that most scenarios maintain similar storage to the baseline in wetter periods, while storage drops relative to the baseline in drier years, and more so in extended dry periods (e.g., 1988 – 1994). Mean monthly Trinity Reservoir storage by water year type is shown in Figure 5-3. Scenarios 1 – 6 show similar storage to the baseline in Extremely Wet years, while dropping to 100 TAF less relative to the baseline in Critically Dry years, with consistent difference across months in all water year types. Scenario 7 shows similar storage to the baseline, increasing to 150 TAF greater storage in Critically Dry years, which generally occur after periods of prolonged drought when there were no safety-of-dams releases.

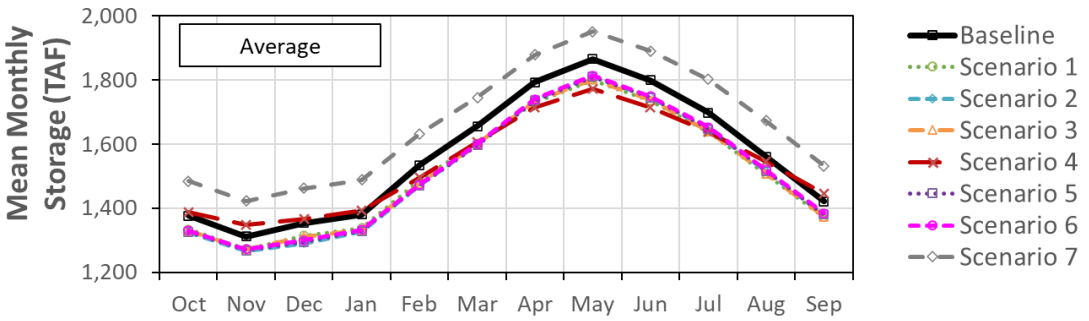


Figure 5-1. Trinity Reservoir Mean Monthly Storage in Thousand Acre-Feet (TAF) for All Scenarios.

Table 5-1. Trinity Reservoir Mean Monthly Storage in Thousand Acre-Feet (TAF) for All Scenarios.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean
Baseline	1,377	1,311	1,353	1,380	1,534	1,656	1,793	1,866	1,800	1,699	1,561	1,421	1,563
Scenario 1	1,334	1,272	1,314	1,337	1,487	1,603	1,731	1,800	1,736	1,639	1,507	1,372	1,511
Diff (TAF)	-42	-40	-40	-43	-47	-53	-63	-65	-64	-60	-54	-48	-52
Diff (%)	-3	-3	-3	-3	-3	-3	-3	-4	-4	-4	-3	-3	-3
Scenario 2	1,325	1,267	1,290	1,328	1,471	1,598	1,738	1,812	1,747	1,650	1,517	1,381	1,510
Diff (TAF)	-52	-44	-63	-53	-63	-58	-55	-54	-53	-49	-44	-40	-52
Diff (%)	-4	-3	-5	-4	-4	-4	-3	-3	-3	-3	-3	-3	-3
Scenario 3	1,329	1,272	1,312	1,332	1,477	1,600	1,734	1,802	1,738	1,640	1,509	1,374	1,510
Diff (TAF)	-48	-39	-41	-48	-57	-56	-60	-63	-62	-58	-52	-47	-53
Diff (%)	-3	-3	-3	-3	-4	-3	-3	-3	-3	-3	-3	-3	-3
Scenario 4	1,388	1,347	1,367	1,393	1,496	1,606	1,715	1,773	1,715	1,639	1,545	1,446	1,536
Diff (TAF)	11	35	13	12	-38	-50	-79	-93	-85	-60	-15	26	-27
Diff (%)	1	3	1	1	-2	-3	-4	-5	-5	-4	-1	2	-2
Scenario 5	1,326	1,268	1,294	1,329	1,472	1,596	1,737	1,810	1,746	1,648	1,515	1,380	1,510
Diff (TAF)	-50	-44	-59	-51	-62	-60	-56	-55	-54	-50	-45	-41	-52
Diff (%)	-4	-3	-4	-4	-4	-4	-3	-3	-3	-3	-3	-3	-3
Scenario 6	1,330	1,272	1,300	1,333	1,474	1,600	1,740	1,814	1,750	1,653	1,520	1,384	1,514
Diff (TAF)	-47	-39	-53	-47	-60	-56	-53	-51	-50	-46	-41	-37	-48
Diff (%)	-3	-3	-4	-3	-4	-3	-3	-3	-3	-3	-3	-3	-3
Scenario 7	1,485	1,423	1,462	1,488	1,633	1,746	1,880	1,952	1,891	1,803	1,673	1,532	1,664
Diff (TAF)	108	111	109	108	99	90	86	86	91	104	112	111	101
Diff (%)	8	9	8	8	6	5	5	5	5	6	7	8	6

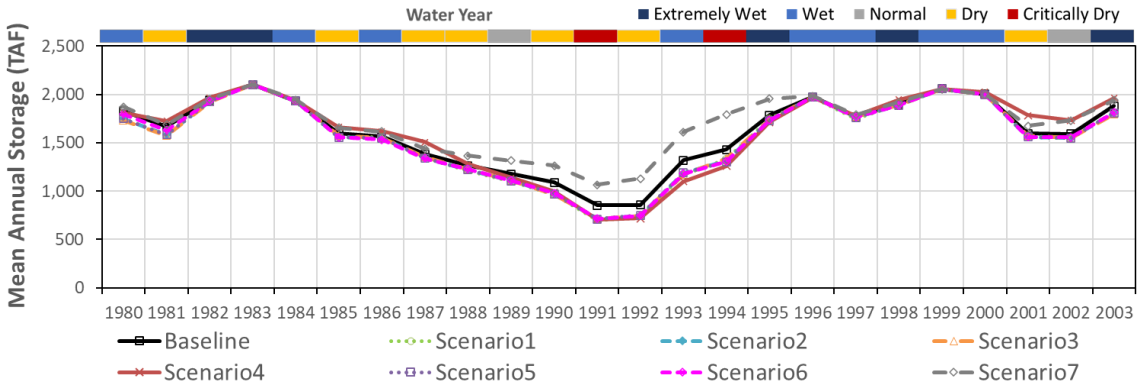


Figure 5-2. Trinity Reservoir Mean Annual Storage in Thousand Acre-Feet (TAF) for All Scenarios.

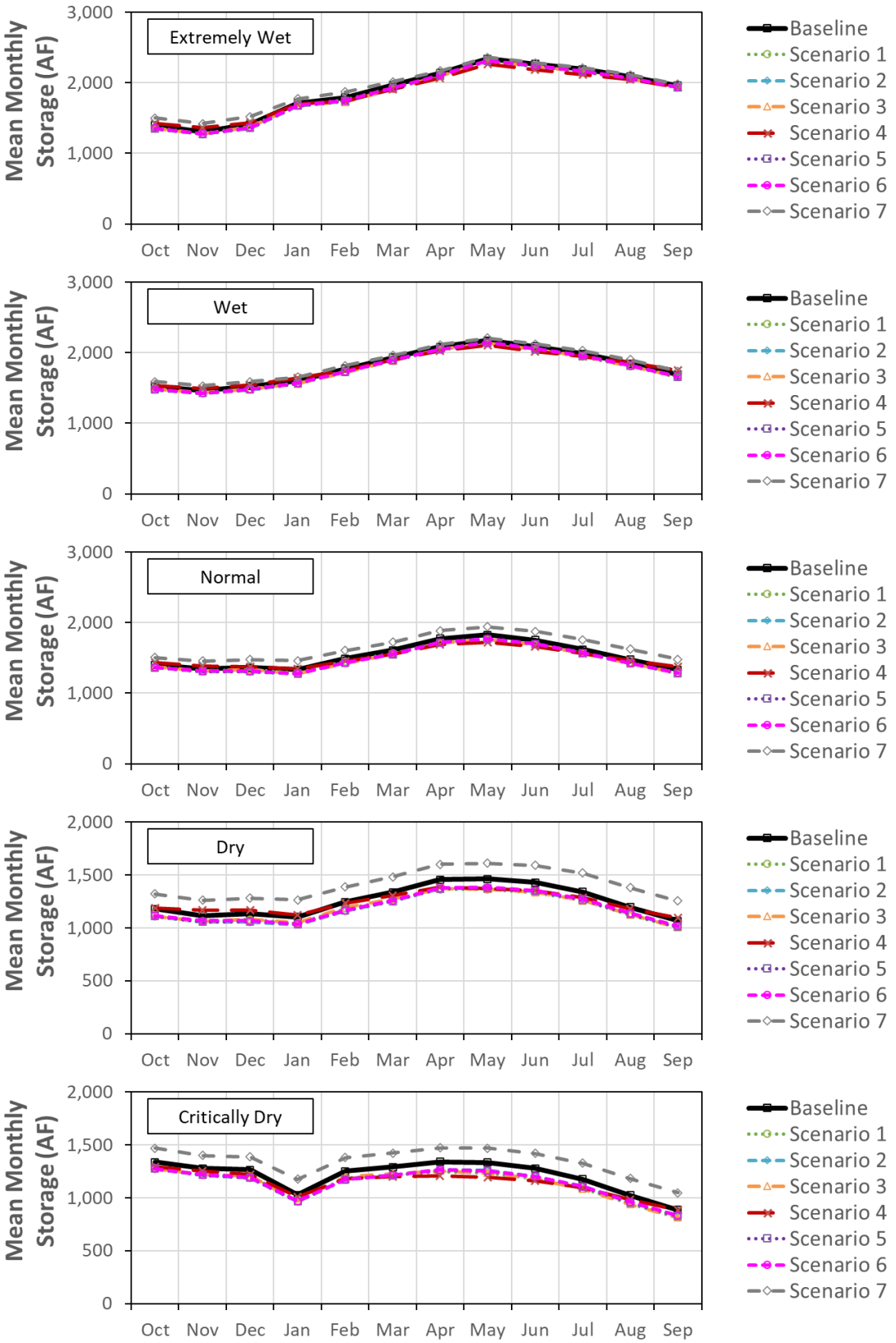


Figure 5-3. Trinity Reservoir Mean Monthly Storage in Thousand Acre-Feet (TAF) for All Scenarios by Water Year Type.

5.1.2 Trinity Reservoir Releases

Trinity Reservoir releases were modeled in HEC-5Q based on monthly releases modeled in CalSim II. Monthly releases were repatterned to a daily timeseries in HEC-5Q to reflect ROD flows, safety-of-dams releases, late-summer and fall releases consistent with the LTP, TRD exports, and Contract Water releases.

Mean monthly Trinity Reservoir releases are shown in Figure 5-4 and Table 5-2. In general, all but Scenario 4 showed releases relatively consistent to the baseline from May through September. Scenario 4 released 150 to 200 TAF annually down the Trinity River, which required additional TRD export cuts. Since TRD exports are highest in July through August (see section 5.6.2), a reduction in exports resulted in a reduction in releases from Trinity Reservoir. All scenarios required higher release magnitudes from October through April depending on the timing of the specific scenario. Mean monthly Trinity Reservoir releases by water year type are shown in Figure 5-5. The trends across water year types generally follow the same trends as the mean annual releases, with Scenario 4 showing larger magnitude reductions relative to the baseline for longer durations in drier years.

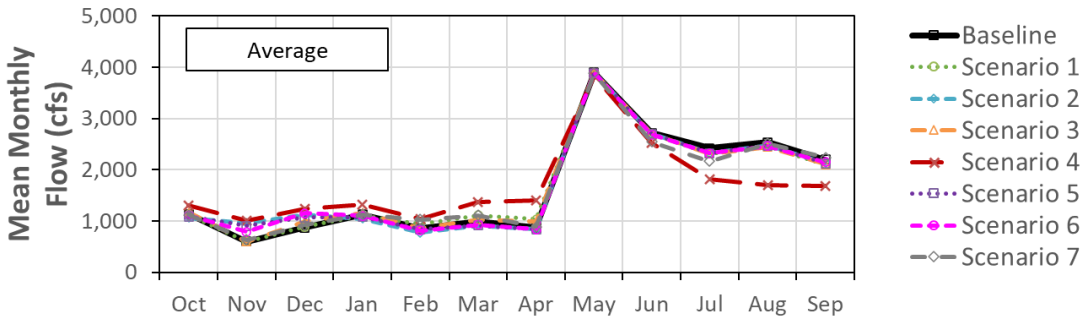


Figure 5-4. Trinity Reservoir Mean Monthly Releases in Cubic Feet per Second (cfs) for All Scenarios.

Table 5-2. Trinity Reservoir Mean Monthly Releases in Cubic Feet Per Second for All Scenarios.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean
Baseline	1,132	602	866	1,122	852	995	874	3,896	2,721	2,419	2,532	2,194	1,684
Scenario 1	1,122	594	890	1,113	934	1,110	1,038	3,889	2,697	2,311	2,453	2,100	1,688
Diff (cfs)	-10	-8	24	-9	82	116	164	-7	-24	-108	-79	-95	4
Diff (%)	0	-1%	3%	-1%	10%	12%	19%	0%	-1%	-4%	-3%	-4%	0%
Scenario 2	1,057	960	1,127	1,047	769	914	841	3,890	2,703	2,326	2,473	2,129	1,686
Diff (cfs)	-76	359	261	-75	-83	-81	-32	-6	-19	-93	-59	-66	2
Diff (%)	-7%	60%	30%	-7%	-10%	-8%	-4%	0%	-1%	-4%	-2%	-3%	0%
Scenario 3	1,170	600	986	1,159	861	1,023	982	3,888	2,703	2,314	2,449	2,110	1,687
Diff (cfs)	38	-2	120	37	9	29	109	-8	-18	-104	-83	-84	3
Diff (%)	3%	0%	14%	3%	1%	3%	12%	0%	-1%	-4%	-3%	-4%	0%
Scenario 4	1,304	1,004	1,234	1,316	1,032	1,370	1,401	3,835	2,530	1,821	1,697	1,674	1,685
Diff (cfs)	171	402	368	194	180	375	527	-61	-191	-598	-835	-520	1
Diff (%)	15%	67%	42%	17%	21%	38%	60%	-2%	-7%	-25%	-33%	-24%	0%
Scenario 5	1,087	903	1,069	1,077	834	914	841	3,890	2,702	2,325	2,470	2,126	1,687
Diff (cfs)	-45	301	202	-44	-18	-81	-32	-6	-19	-94	-62	-69	3
Diff (%)	-4%	50%	23%	-4%	-2%	-8%	-4%	0%	-1%	-4%	-2%	-3%	0%
Scenario 6	1,111	785	1,152	1,102	810	926	836	3,889	2,687	2,326	2,461	2,145	1,686
Diff (cfs)	-21	184	286	-20	-42	-68	-38	-7	-35	-93	-72	-49	2
Diff (%)	-2%	31%	33%	-2%	-5%	-7%	-4%	0%	-1%	-4%	-3%	-2%	0%
Scenario 7	1,120	630	924	1,130	1,024	1,111	887	3,882	2,547	2,165	2,509	2,241	1,681
Diff (cfs)	-13	29	57	8	172	117	14	-14	-174	-253	-24	46	-3
Diff (%)	-1%	5%	7%	1%	20%	12%	2%	0%	-6%	-10%	-1%	2%	0%

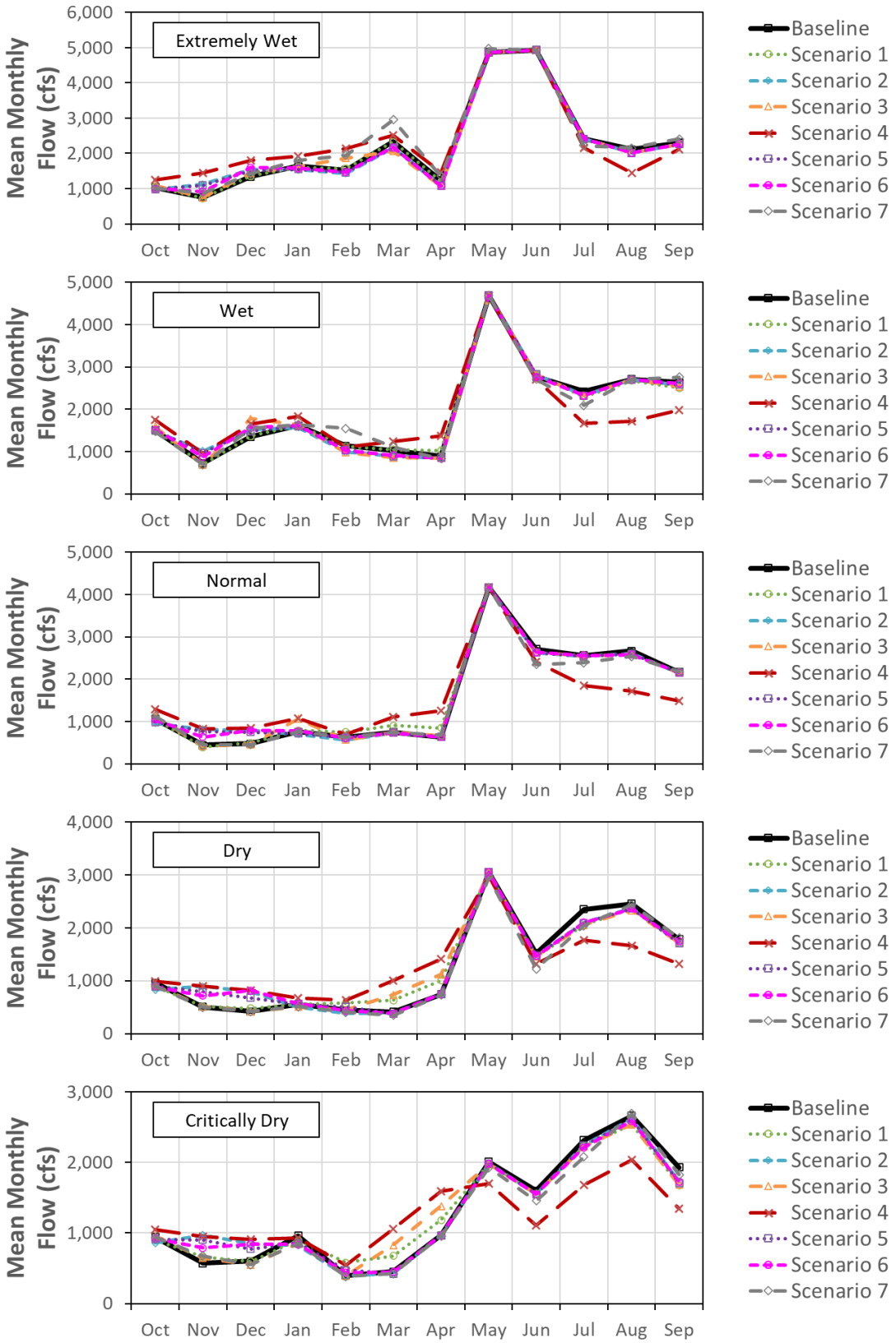


Figure 5-5. Trinity Reservoir Mean Monthly Releases in Cubic Feet per Second (cfs) for All Scenarios. by Water Year Type.

5.1.3 Trinity Reservoir Release Temperature

Trinity Reservoir release temperatures were modeled in HEC-5Q based on modeled water temperature profiles in Trinity Reservoir and model logic that selects release elevation.

Mean monthly Trinity Reservoir release temperatures are shown in Figure 5-6 and Table 5-3. Results across scenarios were generally similar, with notable changes for Scenario 4 and Scenario 7. From June through August, Scenario 4 produced slightly lower Trinity Reservoir storage levels relative to the baseline, but reduced releases relative to the baseline the most of any scenarios due to the higher volume Contract Water releases. The result of lower storage and a release reduction was a slight increase in release water temperature. From July through January, Trinity Reservoir storage in the baseline is relatively low for the year (see Section 5.1.1), but Scenario 7 increases storage due to carryover. The result of increased storage during this period is a slight reduction in release temperatures (0.3 – 0.5 degrees F) relative to the baseline. Mean monthly Trinity Reservoir release temperatures by water year type are shown in Figure 5-7. The trends across water year types generally follow the same trends as the mean annual releases, with all Scenarios 1 – 6 showing greater differences from the baseline predominantly in Normal, Dry, and Critically Dry years.

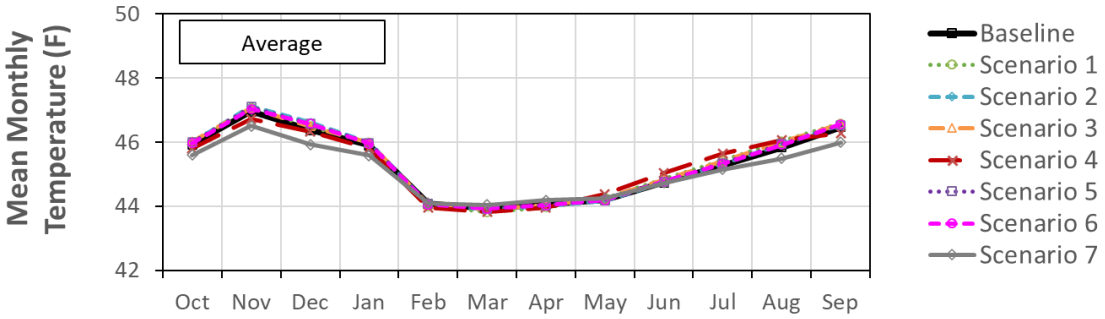


Figure 5-6. Mean Monthly Release Temperature in Degrees Fahrenheit (F) from Trinity Reservoir for All Scenarios.

Table 5-3. Mean Monthly Trinity Reservoir Release Temperature in Degrees Fahrenheit for All Scenarios.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean
Baseline	46	47	46	46	44	44	44	44	45	45	46	46	45
Scenario 1	46	47	46	46	44	44	44	44	45	45	46	47	45
Diff (°F)	0.1	0.1	0.1	0.1	-0.1	-0.1	-0.1	0.0	0.1	0.1	0.2	0.1	0.1
Diff (%)	0	0	0	0	0	0	0	0	0	0	0	0	0
Scenario 2	46	47	47	46	44	44	44	44	45	45	46	47	45
Diff (°F)	0.1	0.2	0.2	0.1	0.0	0.0	-0.1	0.0	0.0	0.0	0.1	0.1	0.1
Diff (%)	0	0	1	0	0	0	0	0	0	0	0	0	0
Scenario 3	46	47	46	46	44	44	44	44	45	45	46	47	45
Diff (°F)	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.1
Diff (%)	0	0	0	0	0	0	0	0	0	0	0	0	0
Scenario 4	46	47	46	46	44	44	44	44	45	46	46	46	45
Diff (°F)	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	0.2	0.3	0.4	0.2	-0.2	0.0
Diff (%)	0	0	0	0	0	0	0	0	1	1	0	0	0
Scenario 5	46	47	47	46	44	44	44	44	45	45	46	47	45
Diff (°F)	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Diff (%)	0	0	0	0	0	0	0	0	0	0	0	0	0
Scenario 6	46	47	47	46	44	44	44	44	45	45	46	47	45
Diff (°F)	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0
Diff (%)	0	0	0	0	0	0	0	0	0	0	0	0	0
Scenario 7	46	47	46	46	44	44	44	44	45	45	45	46	45
Diff (°F)	-0.3	-0.5	-0.5	-0.3	0.0	0.1	0.1	0.0	0.0	-0.1	-0.3	-0.5	-0.2
Diff (%)	-1	-1	-1	-1	0	0	0	0	0	0	-1	-1	0

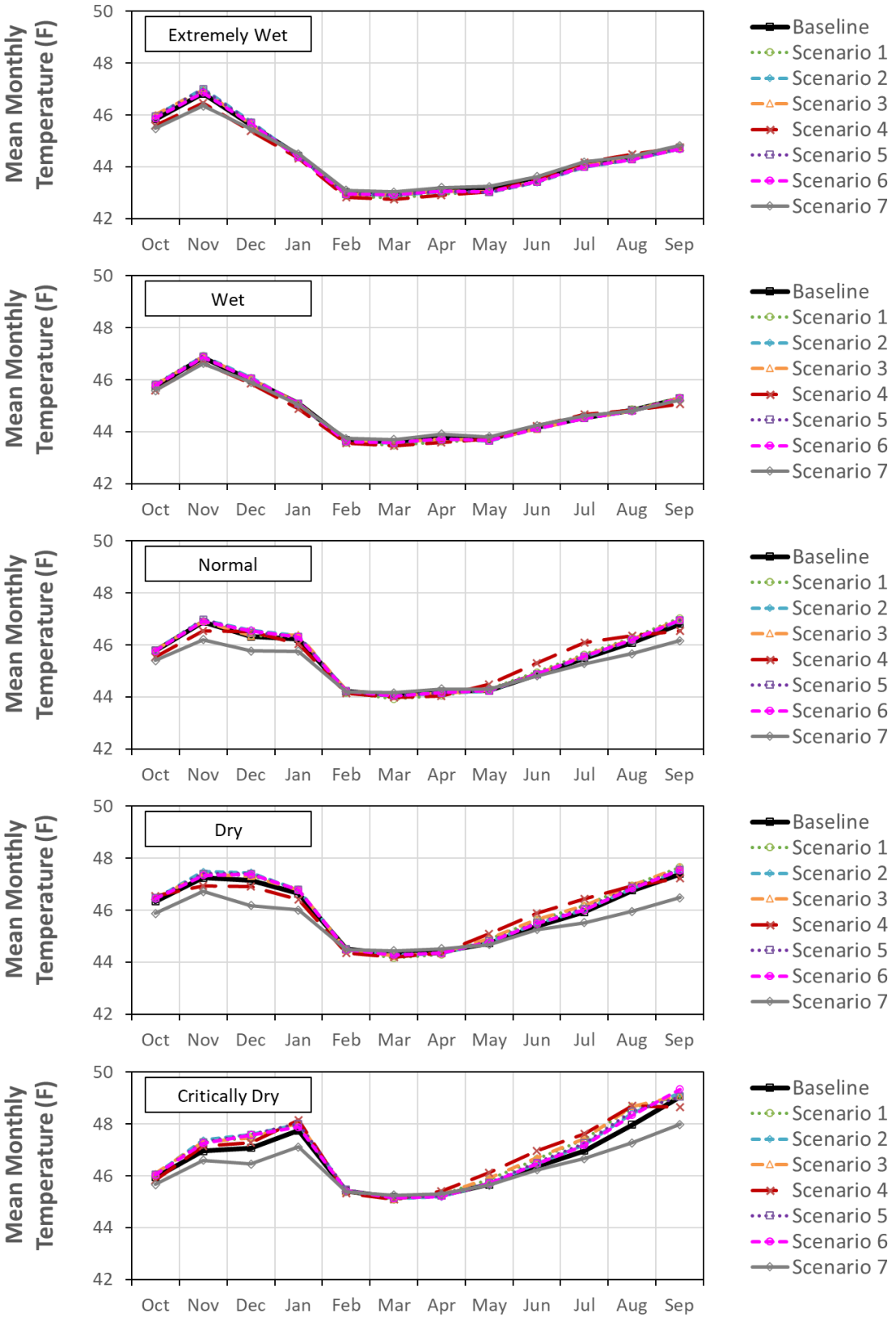


Figure 5-7. Mean Monthly Release Temperature in Degrees Fahrenheit (F) from Trinity Reservoir for All Scenarios by Water Year Type.

5.1.4 Lewiston Reservoir Releases

Lewiston Reservoir releases were modeled in HEC-5Q based on monthly releases modeled in CalSim II. Monthly releases were repatterned to a daily timeseries in HEC-5Q to reflect ROD flows, safety-of-dams releases, late-summer and fall releases consistent with the LTP, TRD exports, and Contract Water releases.

Mean monthly releases throughout the entire simulation period are shown in Figure 5-8 and Table 5-4, and mean monthly releases by water year type throughout the entire simulation period are shown in Figure 5-9. Key takeaways include the following:

- Releases are generally increased from the baseline only from October through April based on the timing of the individual scenario.
- There are no relative increases from May through September on average or in any water year type for any scenario.
- The magnitude of relative release increases over the baseline is greater in Dry and Critically Dry years. This is because there are few safety-of-dams releases in these water year types.

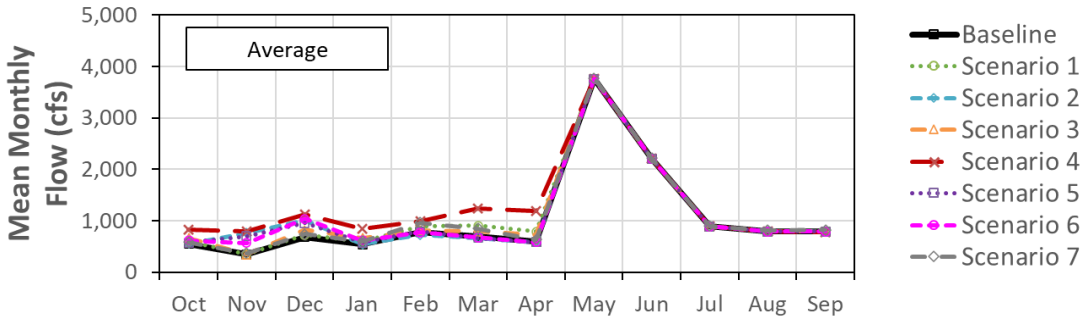


Figure 5-8. Lewiston Reservoir Mean Monthly Releases in Cubic Feet per Second (cfs) for All Scenarios.

Table 5-4. Lewiston Reservoir Mean Monthly Releases in Cubic Feet per Second (cfs) for All Scenarios.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean
Baseline	546	346	680	543	781	697	587	3,753	2,210	890	788	788	1,051
Scenario 1	602	342	723	600	889	902	792	3,753	2,210	890	788	788	1,107
Diff (cfs)	56	-3	43	57	107	205	205	0	0	0	0	0	56
Diff (%)	0	-1	6	10	14	29	35	0	0	0	0	0	5
Scenario 2	545	763	1,011	542	724	668	580	3,753	2,210	890	788	788	1,105
Diff (cfs)	-2	417	331	-2	-57	-29	-7	0	0	0	0	0	54
Diff (%)	0	121	49	0	-7	-4	-1	0	0	0	0	0	5
Scenario 3	666	344	825	662	817	785	723	3,753	2,210	890	788	788	1,104
Diff (cfs)	120	-2	145	118	35	88	136	0	0	0	0	0	53
Diff (%)	22	-1	21	22	4	13	23	0	0	0	0	0	5
Scenario 4	819	788	1,124	837	993	1,236	1,190	3,753	2,210	890	788	777	1,284
Diff (cfs)	273	442	443	294	211	539	603	0	0	0	0	-11	233
Diff (%)	50	128	65	54	27	77	103	0	0	0	0	-1	22
Scenario 5	575	701	951	571	789	668	580	3,753	2,210	890	788	788	1,105
Diff (cfs)	28	355	271	28	8	-29	-7	0	0	0	0	0	54
Diff (%)	5	103	40	5	1	-4	-1	0	0	0	0	0	5
Scenario 6	614	566	1,032	612	768	668	580	3,753	2,210	890	788	788	1,106
Diff (cfs)	68	220	352	68	-13	-29	-7	0	0	0	0	0	55
Diff (%)	12	64	52	13	-2	-4	-1	0	0	0	0	0	5
Scenario 7	578	370	740	595	963	849	627	3,774	2,211	897	810	823	1,103
Diff (cfs)	32	24	60	51	182	152	40	20	1	7	22	36	52
Diff (%)	6	7	9	9	23	22	7	1	0	1	3	5	5

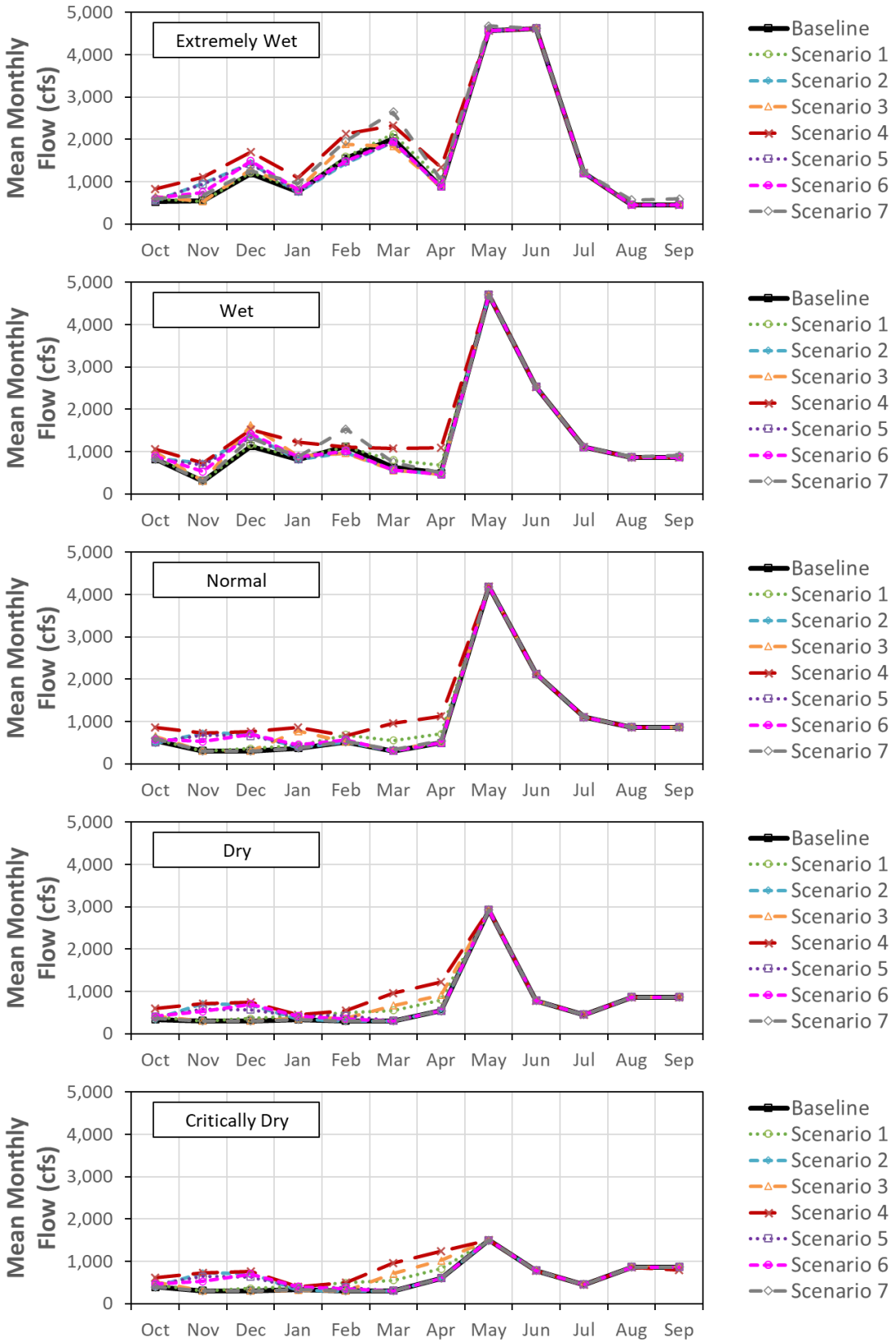


Figure 5-9. Lewiston Reservoir Mean Monthly Flow in Cubic Feet per Second (cfs) for All Scenarios by Water Year Type.

5.1.5 Lewiston Reservoir Release Temperature

Lewiston Reservoir release temperatures were modeled in HEC-5Q based on modeled water temperature profiles in Lewiston Reservoir and model logic that selects release elevation.

Mean monthly Lewiston Reservoir release temperatures are shown in Figure 5-10 and Table 5-5, and by water year type in Figure 5-11. Key takeaways include the following:

- Scenarios that put more water down in the spring months of March and April (Scenarios 1, 3, and 4) on average showed reduced release temperatures of 1 – 1.5 F relative to the baseline, particularly in drier water year types. In these months, the higher volume of cold-water releases resulted in lower travel times of releases through Lewiston and less warming of flows.
- Scenarios that put more water down in the fall months of October through December (Scenarios 2, 5, 6) on average or across water year type did not show a notable release temperature change during those months relative to the baseline.
- Scenario 4 resulted in warmer monthly release temperatures July through September, especially in drier years, due to the combination of lower Trinity Reservoir storage and reduced Trinity Reservoir releases (i.e., fewer TRD exports). For all other scenarios except Scenario 7, release temperatures in the summer are consistent with the baseline, except in Critically Dry years, when release temperatures are consistently elevated between 0.5 F and 1 F above the baseline.
- Scenario 7 resulted in slightly lower (0.5 – 1 F) release temperatures relative to the baseline from August through January of drier water year types, a result of higher Trinity Reservoir storage producing cooler Trinity Reservoir releases (see Section 5.1.3).

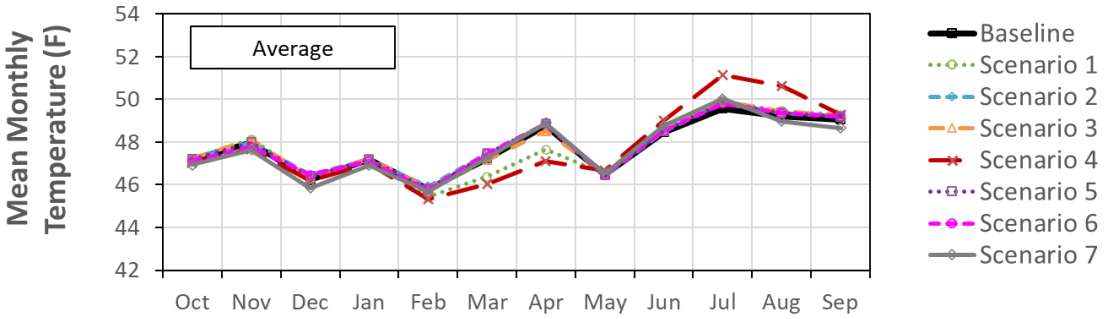


Figure 5-10. Lewiston Reservoir Mean Monthly Release Temperature in Degrees Fahrenheit (F) for All Scenarios.

Table 5-5. Lewiston Reservoir Mean Monthly Release Temperature in Degrees Fahrenheit (F) for All Scenarios.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean
Baseline	47	48	46	47	46	47	49	46	48	50	49	49	48
Scenario 1	47	48	46	47	45	46	48	47	49	50	49	49	48
Diff (°F)	0.0	0.2	0.1	0.0	-0.4	-0.8	-1.1	0.0	0.1	0.4	0.3	0.2	-0.1
Diff (%)	0	0	0	0	-1	-2	-2	0	0	1	1	0	0
Scenario 2	47	48	46	47	46	47	49	46	49	50	49	49	48
Diff (°F)	0.0	0.0	0.2	0.0	0.1	0.2	0.1	0.0	0.0	0.3	0.2	0.1	0.1
Diff (%)	0	0	0	0	0	1	0	0	0	1	0	0	0
Scenario 3	47	48	46	47	46	47	49	47	49	50	49	49	48
Diff (°F)	0.0	0.1	0.1	0.0	0.0	-0.1	-0.2	0.0	0.1	0.3	0.3	0.2	0.1
Diff (%)	0	0	0	0	0	0	0	0	0	1	1	0	0
Scenario 4	47	48	46	47	45	46	47	47	49	51	51	49	48
Diff (°F)	-0.2	-0.3	0.0	-0.2	-0.5	-1.2	-1.7	0.2	0.6	1.6	1.4	0.2	0.0
Diff (%)	0	-1	0	0	-1	-3	-3	0	1	3	3	0	0
Scenario 5	47	48	46	47	46	47	49	46	49	50	49	49	48
Diff (°F)	0.0	0.0	0.2	0.0	0.0	0.2	0.1	0.0	0.1	0.3	0.2	0.1	0.1
Diff (%)	0	0	0	0	0	1	0	0	0	1	0	0	0
Scenario 6	47	48	46	47	46	47	49	46	49	50	49	49	48
Diff (°F)	-0.1	-0.2	0.2	-0.1	0.0	0.2	0.1	0.0	0.1	0.3	0.2	0.1	0.1
Diff (%)	0	0	1	0	0	0	0	0	0	1	0	0	0
Scenario 7	47	48	46	47	46	47	49	47	49	50	49	49	48
Diff (°F)	-0.2	-0.3	-0.4	-0.3	-0.1	0.1	0.2	0.1	0.3	0.5	-0.2	-0.4	-0.1
Diff (%)	-1	-1	-1	-1	0	0	0	0	1	1	0	-1	0

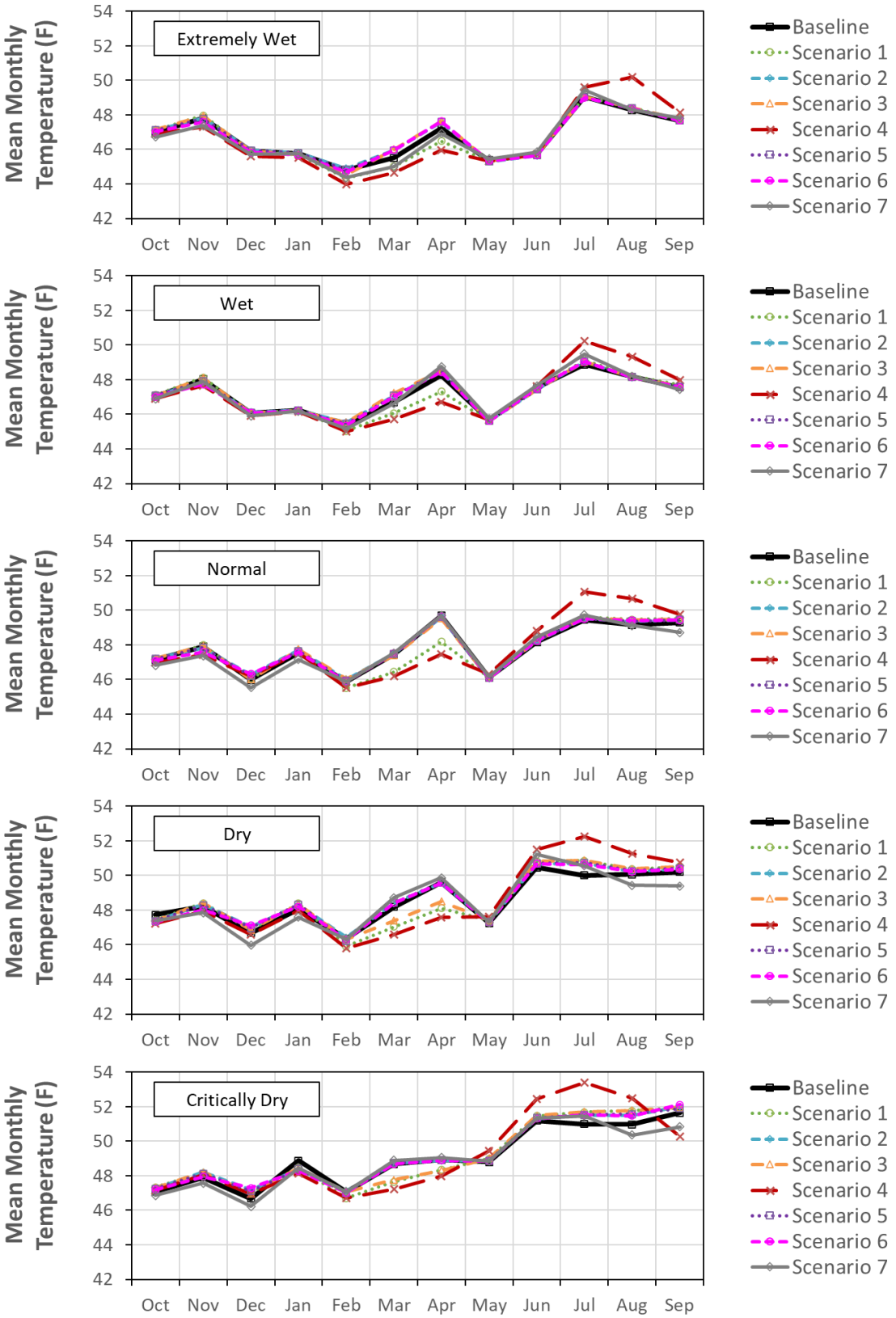


Figure 5-11. Lewiston Reservoir Mean Monthly Release Temperature in Degrees Fahrenheit (F) for All Scenarios by Water Year Type.

5.2 Trinity River Discharge and Water Temperature

A daily discharge time series at Pear Tree Creek, located just upstream of the North Fork Trinity River confluence (Figure 2-3), is shown in Figure 5-12 for the 23-year simulation period. River flows at Pear Tree reflect inputs from tributaries downstream of Lewiston Dam. Because tributary inputs are held constant between scenarios, differences in flow at Pear Tree are due to differences in Lewiston Dam releases among scenarios.

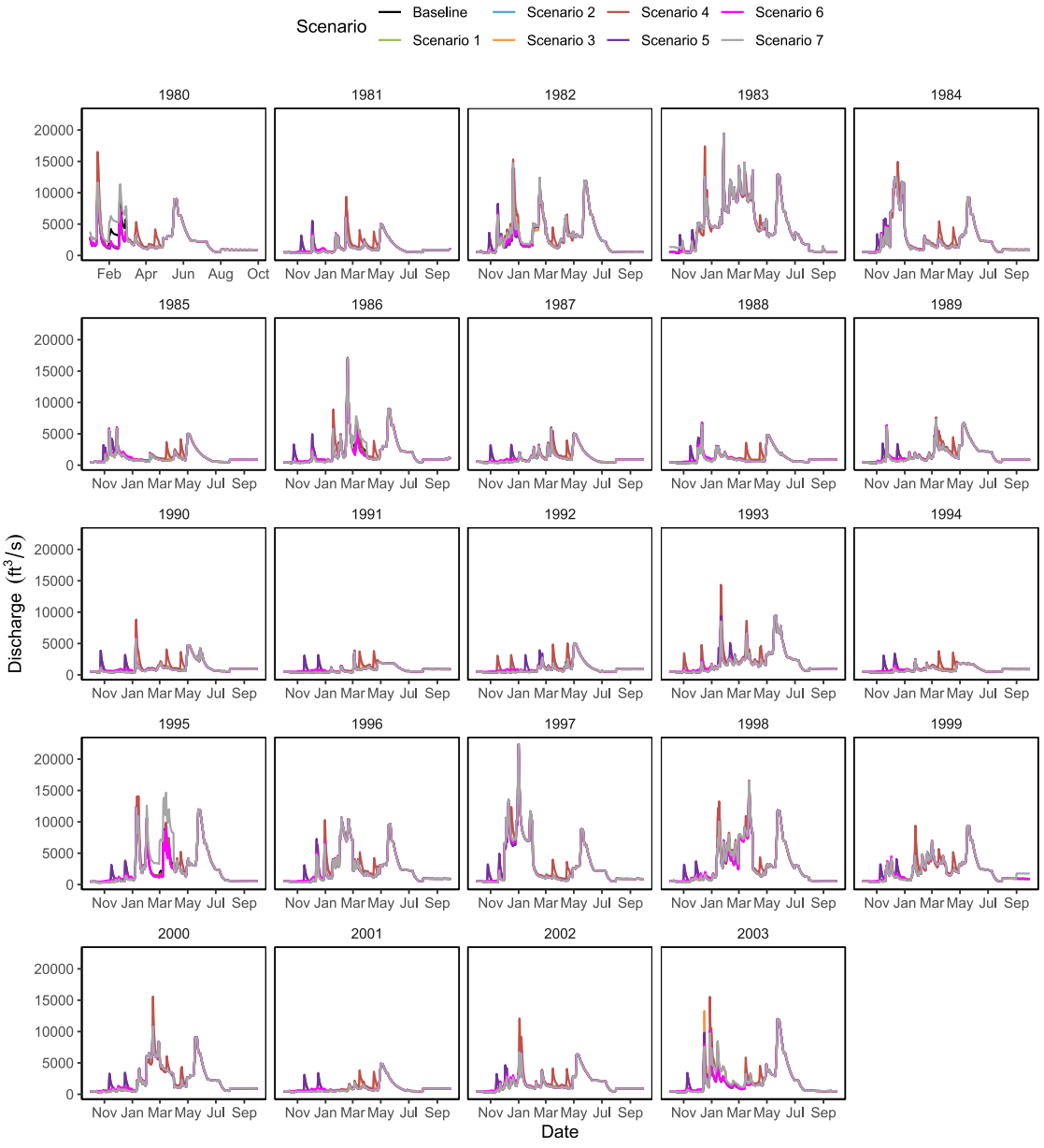


Figure 5-12. Daily Discharge of the Trinity River at Pear Tree Creek (River Kilometer 119) as Simulated by RBM10 for All Scenarios.

A daily water temperature time series at Pear Tree Creek is shown in Figure 5-13 for the 23-year simulation period. Although tributary discharge and water temperatures were the same among scenarios, water temperature at Pear Tree reflects both differences in temperature of water released from Lewiston Dam and changes in water temperature owing to heat exchange at the air-water interface. Daily water temperature differences relative to the baseline tended to be less than 4°F (2°C), with some larger differences for shorter durations in some years (Figure 5-14). As shown in Section 5.1.5, mean monthly Lewiston release temperature changes relative to the baseline were on average less than 1°F, but daily fluctuations due to pulse releases, safety-of-dams releases, and the relationship between Trinity Reservoir releases and TRD exports from Lewiston resulted in greater range of daily temperature differences.

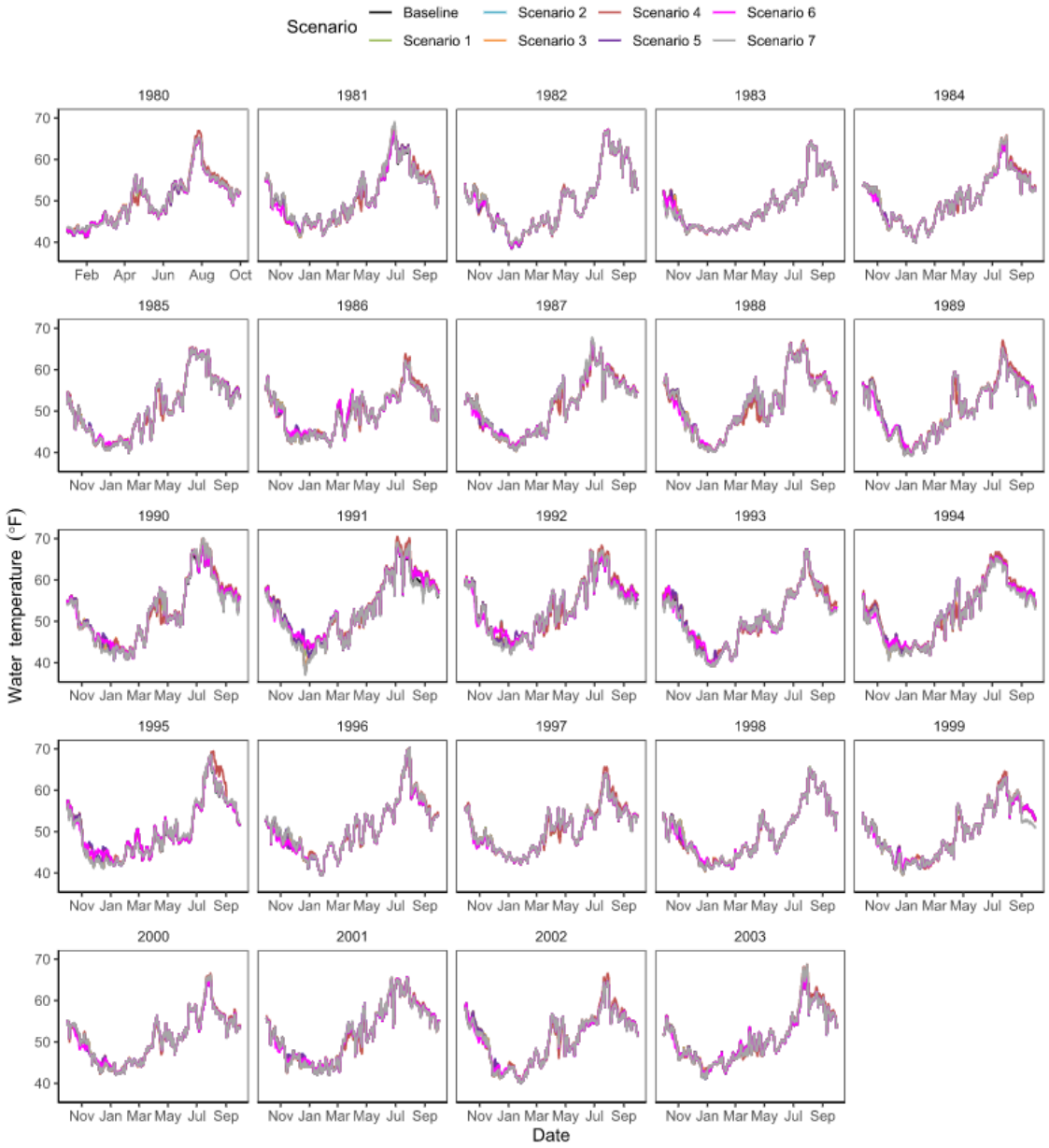


Figure 5-13. Daily Water Temperature of the Trinity River at Pear Tree Creek (River Kilometer 119) as Simulated by RBM10 for All Scenarios.

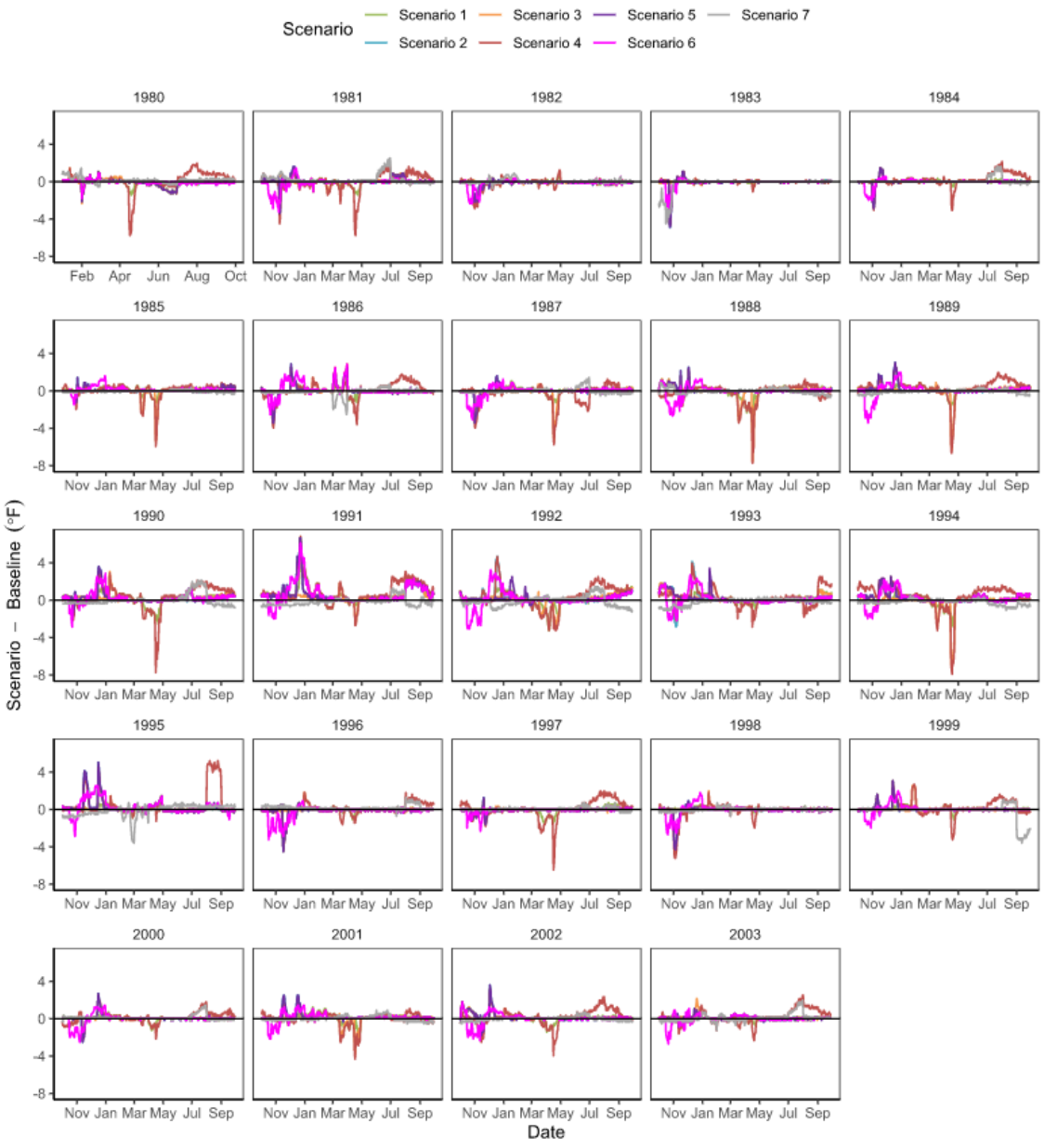


Figure 5-14. Difference Between the Baseline and each Contract Water Release Scenario in Mean Daily Water Temperature of the Trinity River at Pear Tree Creek (River Kilometer 119) as Simulated by RBM10.

5.3 Habitat

The Chinook Salmon habitat models revealed that the scenarios differed in the amount of habitat for different life stages. For spawning habitat, Scenario 6 led to an increase in spawning habitat that was maintained for the duration of spawning season relative to the baseline (October – January; Figure 5-15 and Figure 5-16). In contrast, scenarios with fall pulse flows tended to either decrease (during the peak) or increase (during ascending and descending limbs) spawning habitat for relatively brief periods (i.e., days). For juvenile capacity, there was a large difference in capacity among water years, with wetter years (e.g., 1983) increasing capacity for a longer period of time relative to drier years (e.g., 1994, Figure 5-17 and Figure 5-19). Relative to the baseline, fry and parr capacity increased in response to both fall and spring flow increases, but such increases tended to be of short duration (Figure 5-18 and Figure 5-20). Scenarios with a fall release produced lower winter Trinity Reservoir storage, which resulted in lower magnitude safety-of-dams releases in the spring, reducing spring fry and parr capacity in some years.

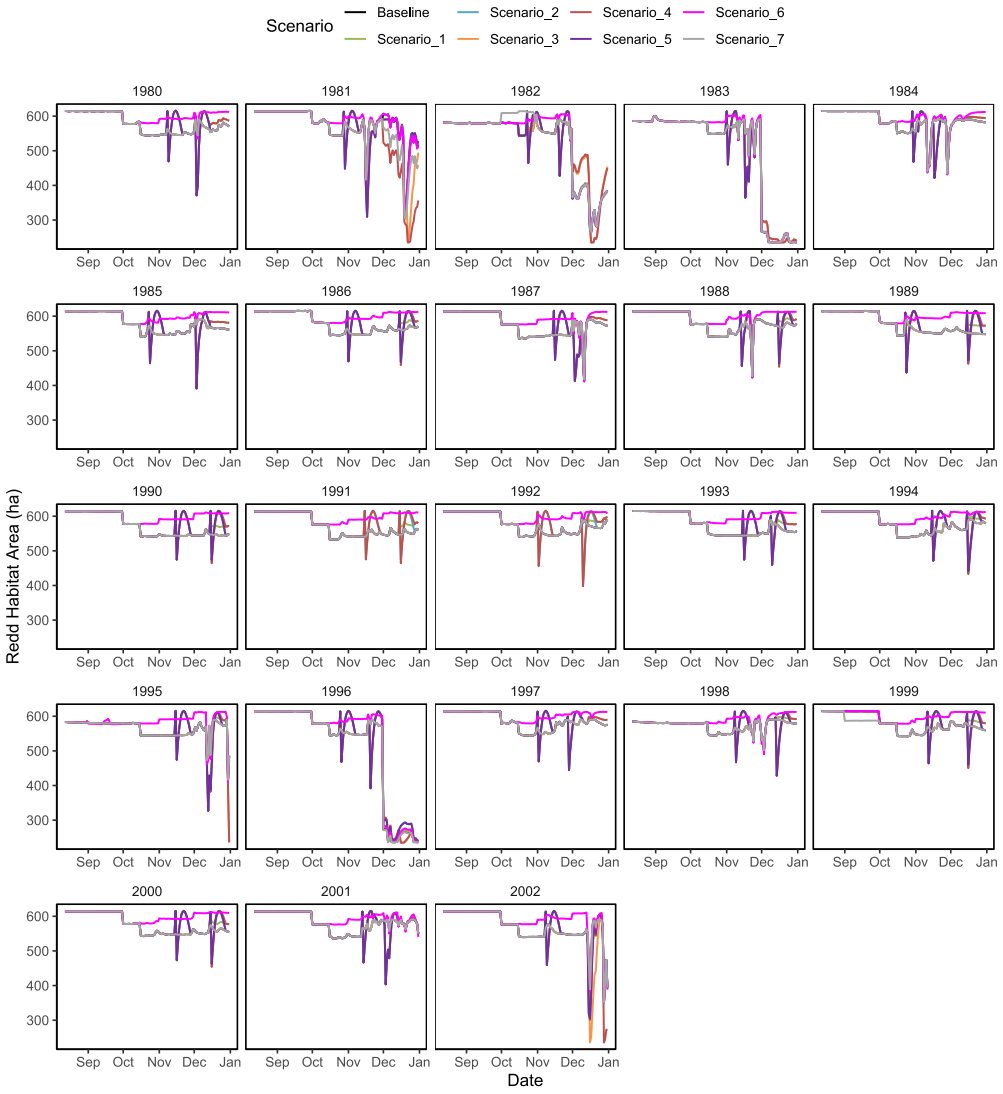


Figure 5-15. Daily Time Series of Total Spawning Habitat Area in the Restoration Reach for All Scenarios.

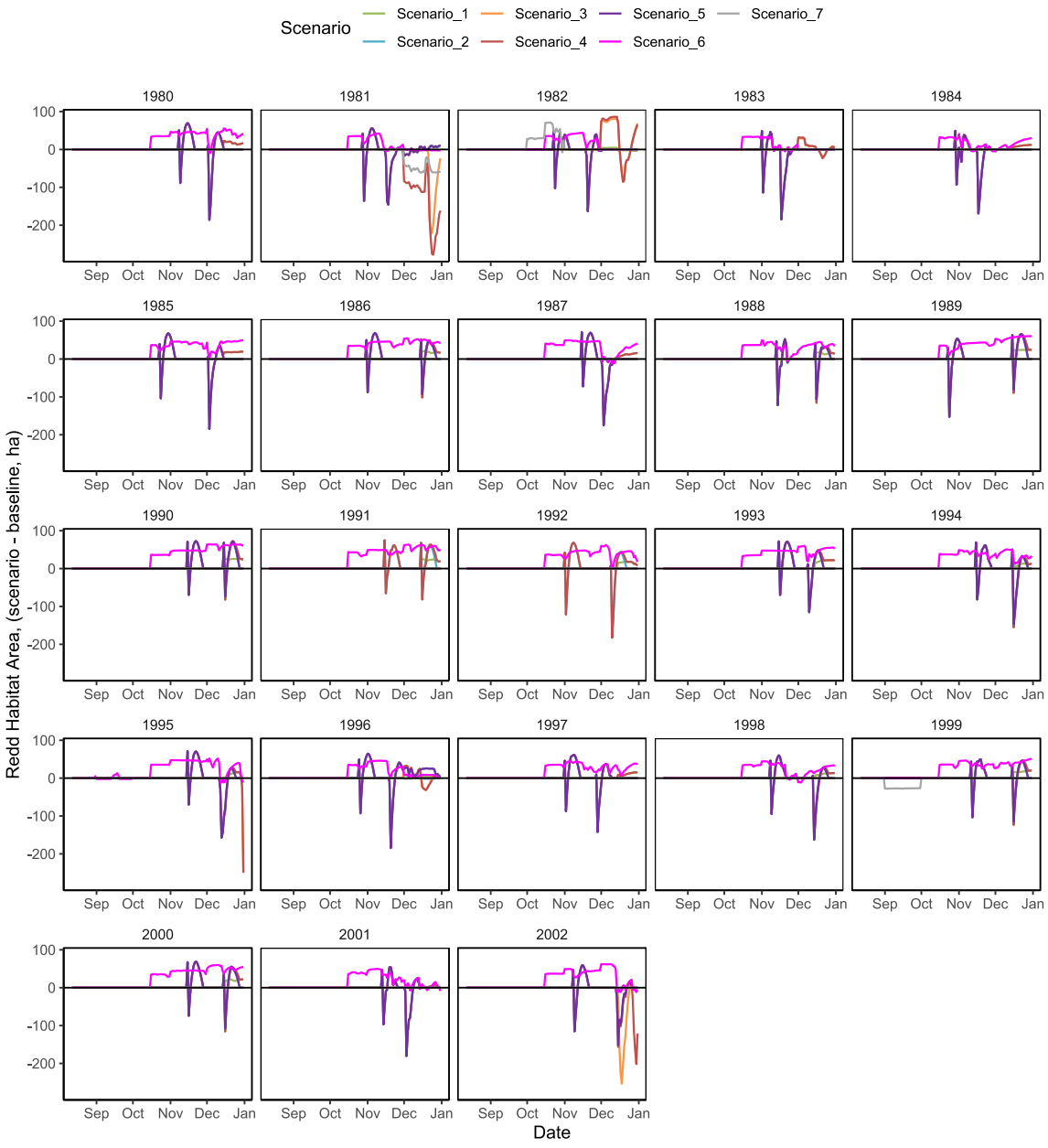


Figure 5-16. Daily Time Series of the Difference in Total Spawning Habitat Area in the Restoration Reach Relative to the Baseline for All Scenarios.

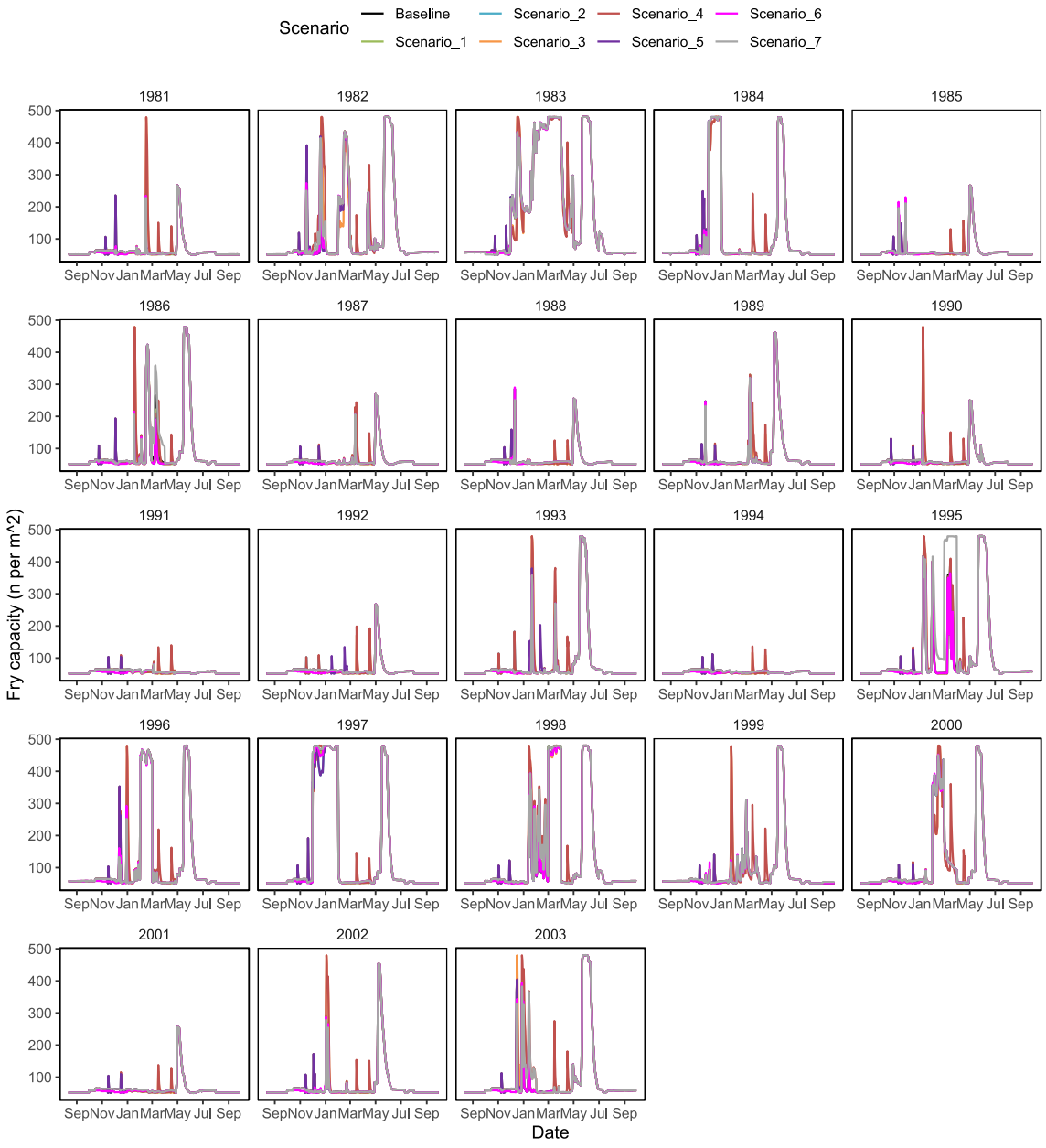


Figure 5-17. Daily Time Series of Mean Fry Capacity in the Restoration Reach for All Scenarios.

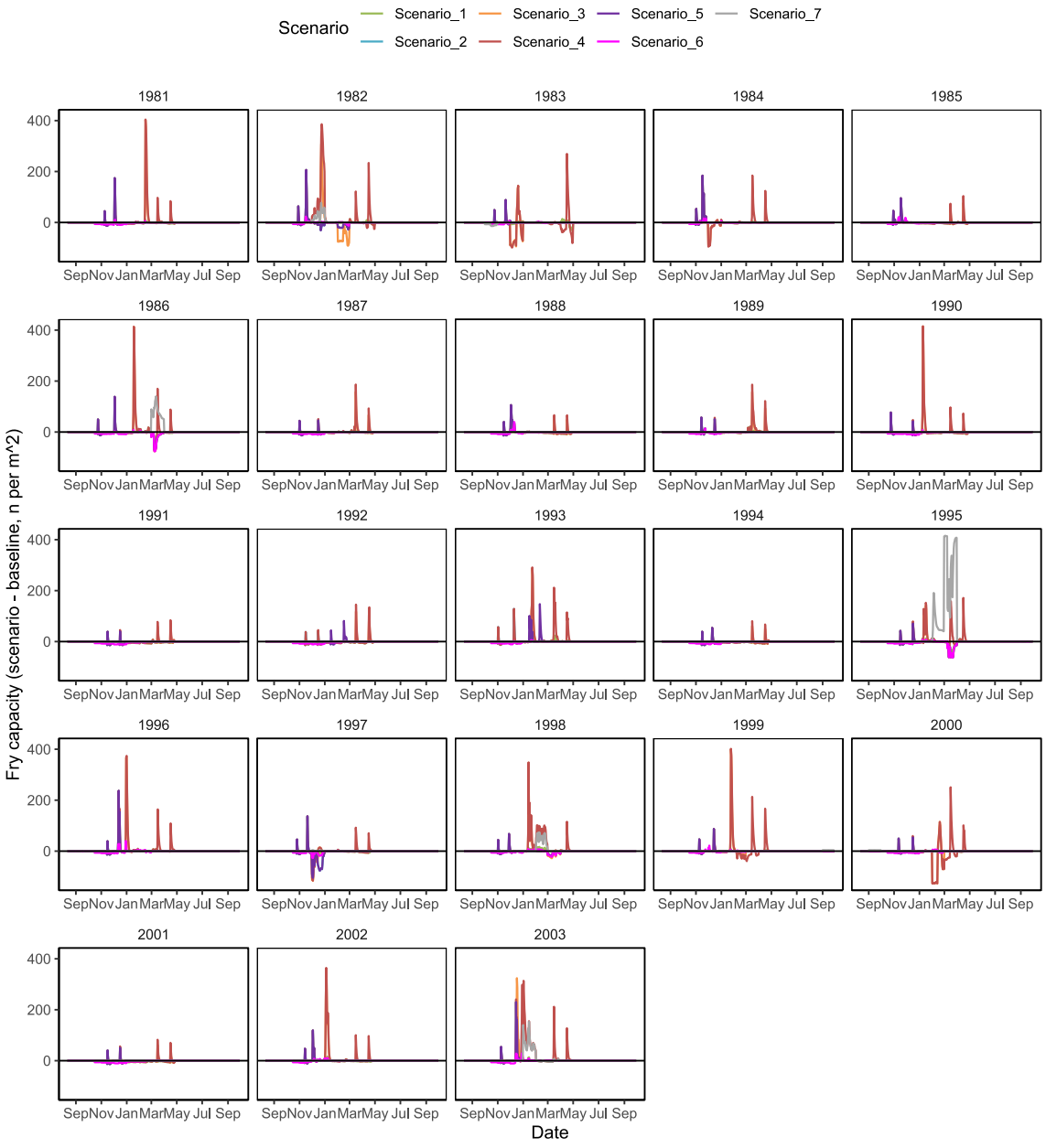


Figure 5-18. Daily Time Series of the Difference in Mean Fry Capacity in the Restoration Reach Relative to the Baseline for All Scenarios.

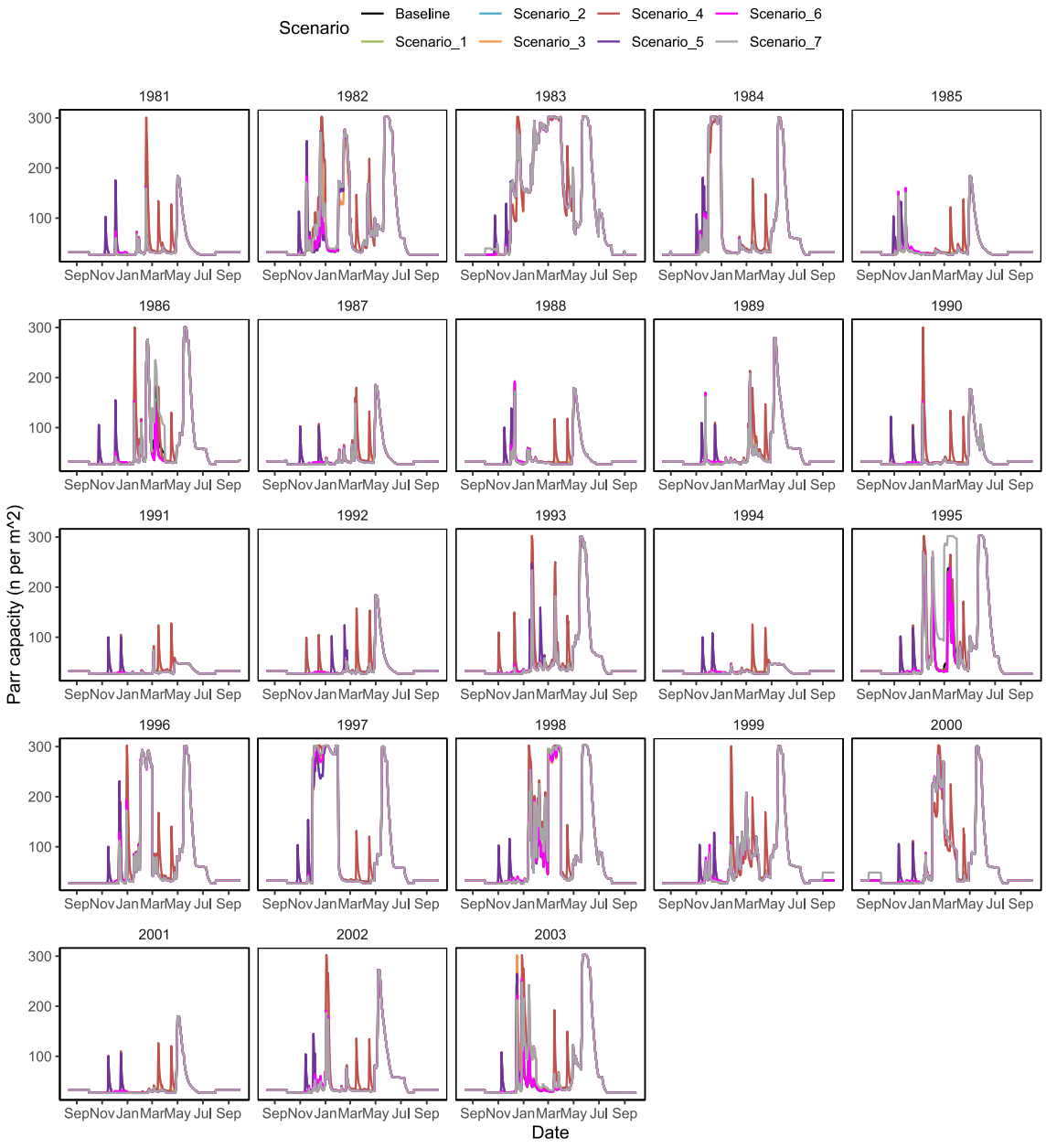


Figure 5-19. Daily Time Series of Mean Parr Capacity in the Restoration Reach for All Scenarios.

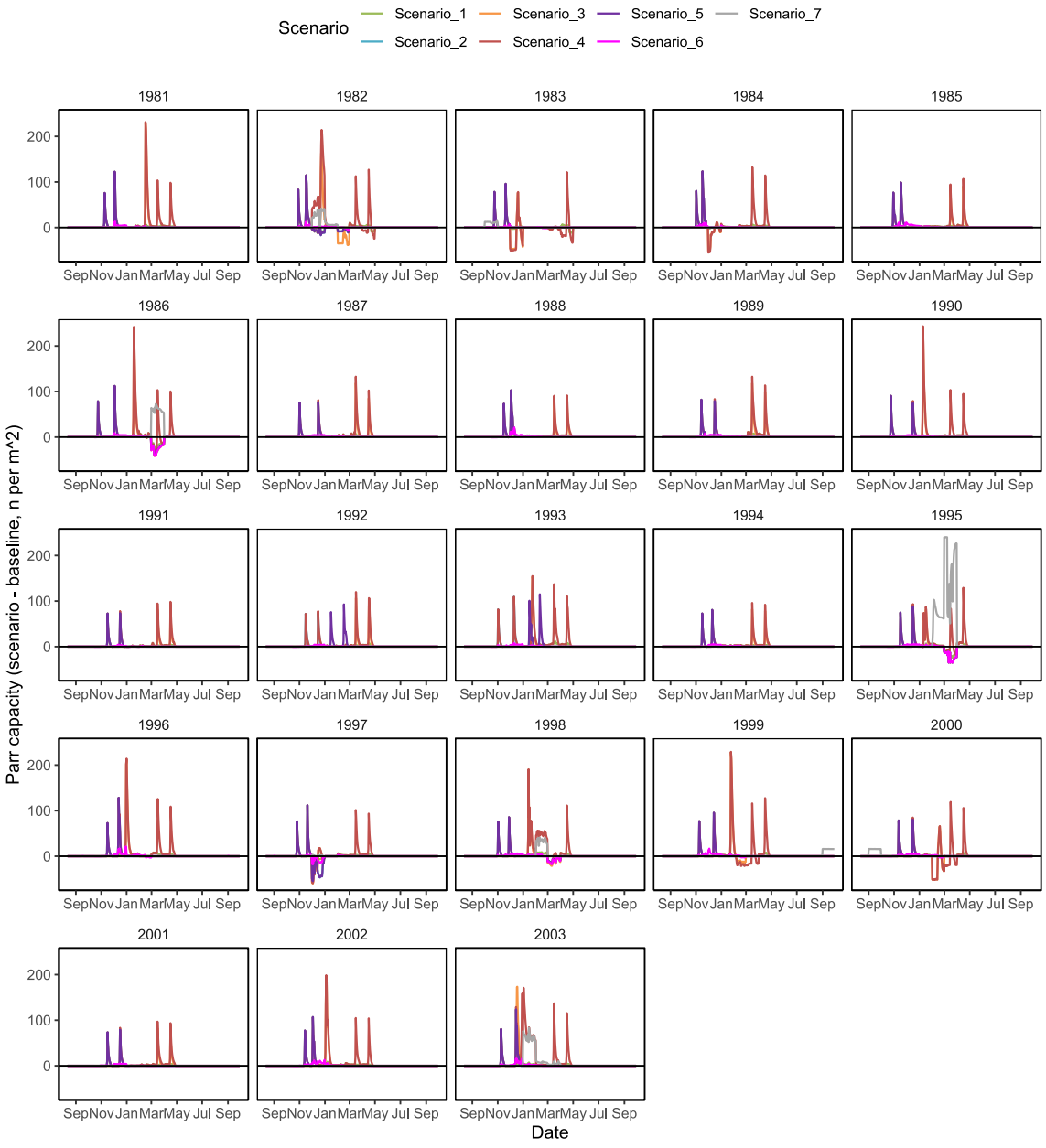


Figure 5-20. Daily Time Series of the Difference in Mean Parr Capacity in the Restoration Reach Relative to the Baseline for All Scenarios.

5.4 Fisheries

Output from an annual S3 model simulation can be summarized on a daily, weekly, monthly, or annual time scale. Because the seven Contract Water release scenarios were run over 23 water years, the S3 model output was summarized on an annual basis with emphasis on evaluating the effect of Contract Water release scenarios relative to baseline conditions.

5.4.1 Mean Annual and Water Year Metrics

The annual S3 output is summarized by calculating (1) egg survival (percentage) from spawning to emergence, (2) juvenile fish survival (percentage) from emergence to the Pear Tree fish trap, (3) the annual abundance of fish (number of fish) that passed Pear Tree, (4) the mean annual mass (grams) of individual fish that passed Pear Tree, and (5) the mean annual biomass (metric tons) of fish that passed Pear Tree (i.e., mean annual mass times annual abundance). For each of these metrics, the annual difference is calculated relative to the corresponding metric in the baseline as $(Scenario - Baseline)/Baseline$. The annual time series of the metrics across scenarios and water year types is tabulated. Summary tables of all five metrics across scenarios are shown in Table 5-6 for mean annual metrics, in Table 5-7 for mean annual metrics averaged by water year type, in Table 5-8 for the magnitude difference between each scenario and the baseline for mean annual metrics averaged by water year type, and Table 5-9 for the percentage difference between each scenario and the baseline for mean annual metrics averaged by water year type. Details about simulated egg survival and emergence, and simulated juvenile survival, abundance, and biomass are described in the following two sections. Key observations from the mean annual summary statistics relative to the baseline include the following:

- Egg survival increased for Scenarios 2, 4, 5, and 6 that release water in the fall, and decreased (less than 0.5% reduction and within the range of normal annual variation) for the Scenarios 1, 3, and 7. Increases ranged from 1% to 2.6%, with the largest increase due to fall baseflow releases (Scenario 6).
- Juvenile fish survival increased for scenarios that have higher magnitude releases in March and April (Scenarios 1 and 4) and for Scenario 6, but decreased for Scenarios 2, 3, 5, and 7 (less than 0.2% reduction and within the range of normal annual variation). The largest increase of 1.6% was for Scenario 4, which released a spring baseflow and fall and spring pulses in all years.
- Annual juvenile abundance increased for most scenarios and decreased by less than 1% for Scenarios 3 and 7, within the range of normal annual variation. The largest increases in abundance were 2.9% for Scenario 4, which released the largest volume of Contract Water, and 2.7% for Scenario 6, which had the highest egg survival increase.
- Mean annual fish mass increased for Scenarios 2, 5, and 7, and decreased for all other scenarios from 0% to 5%. The largest decreases in fish mass occurred for scenarios releasing water in the spring that was generally 1°F to 2°F cooler than the baseline (Scenarios 1 and 4).
- Mean annual juvenile biomass changes reflect differences in both abundance and fish size. Juvenile biomass increased for Scenarios 2, 5, 6, and 7, and decreased for Scenarios 1, 3, and 4. The increase in juvenile biomass for Scenario 6 was three times greater than for any other scenario, primarily due to an increase in abundance.

Table 5-6. Mean Annual Metrics of Stream Salmonid Stimulator (S3) Output for Juvenile Life Stages of Chinook Salmon in the Restoration Reach of the Trinity River.

Scenario	Egg survival (percent)	Juvenile survival (percent)	Juvenile abundance (number of fish)	Juvenile size (grams)	Juvenile biomass (metric tons)
Baseline	67.3	21.2	2,138,140	1.335	2.845
Scenario 1	67.0	21.3	2,142,655	1.277	2.731
Scenario 2	68.2	21.0	2,147,696	1.34	2.872
Scenario 3	67.1	21.1	2,123,236	1.309	2.774
Scenario 4	67.9	21.5	2,194,435	1.257	2.755
Scenario 5	68.1	21.0	2,144,826	1.34	2.868
Scenario 6	69.0	21.2	2,197,813	1.333	2.923
Scenario 7	67.2	21.1	2,136,551	1.34	2.845
Percent difference from the baseline					
Scenario 1	-0.3	0.6	0.2	-4.1	-3.9
Scenario 2	1.4	-0.9	0.5	0.5	0.9
Scenario 3	-0.3	-0.4	-0.7	-1.7	-2.4
Scenario 4	1	1.6	2.7	-5.4	-2.8
Scenario 5	1.2	-0.9	0.3	0.6	0.8
Scenario 6	2.6	0.2	2.9	-0.1	2.8
Scenario 7	0	-0.1	-0.1	0.4	0.3
Difference from the baseline					
Scenario 1	-0.3	0.1	4,515	-0.06	-0.11
Scenario 2	0.9	-0.2	9,556	0.01	0.03
Scenario 3	-0.2	-0.1	-14,904	-0.03	-0.07
Scenario 4	0.6	0.3	56,295	-0.08	-0.09
Scenario 5	0.8	-0.2	6,686	0.01	0.02
Scenario 6	1.7	0.0	59,673	0	0.08
Scenario 7	-0.1	-0.1	-1,589	0.01	0.01
Percent of water years with annual metric values exceeding the baseline					
Scenario 1	18.2	68.2	59.1	4.5	13.6
Scenario 2	95.5	22.7	72.7	54.5	77.3
Scenario 3	18.2	36.4	31.8	13.6	31.8
Scenario 4	90.9	59.1	72.7	13.6	36.4
Scenario 5	90.9	22.7	68.2	54.5	77.3
Scenario 6	95.5	54.5	86.4	18.2	77.3
Scenario 7	27.3	22.7	45.5	50	54.5

Note: Metrics were calculated annually and averaged over the 23 simulated water years for the baseline and each Contract Water release scenario. The percent difference from the baseline was calculated as the mean of all individual year differences, not as the difference of the mean of the simulation period.

Table 5-7. Means of Annual Population Statistics by Water Year Type for Juvenile Chinook Salmon Life Stages as Simulated by the Stream Salmonid Simulator (S3) Model Applied to Contract Water Release Scenarios in the Restoration Reach of the Trinity River.

		Mean of annual values				
Scenario	**Water year type**	**Egg survival (percent)**	**Juvenile survival to Pear Tree (percent)**	**Abundance at Pear Tree (number of fish)**	**Mean fish size at Pear Tree (grams)**	**Biomass at Pear Tree (metric tons)**
Baseline	Critically Dry	69.0	21.0	2,177,751	1.405	3.053
Baseline	Dry	67.2	20.4	2,060,907	1.446	2.98
Baseline	Normal	66.4	20.7	2,063,537	1.491	3.078
Baseline	Wet	67.6	21.0	2,128,796	1.287	2.739
Baseline	Extremely Wet	66.5	22.7	2,273,343	1.156	2.629
1	Critically Dry	68.9	20.9	2,166,033	1.342	2.905
1	Dry	67.0	20.6	2,079,631	1.352	2.812
1	Normal	66.2	20.3	2,020,749	1.356	2.741
1	Wet	67.2	21.2	2,138,427	1.247	2.669
1	Extremely Wet	66.4	22.8	2,276,217	1.155	2.63
2	Critically Dry	70.5	20.8	2,204,614	1.4	3.083
2	Dry	67.9	20.4	2,077,843	1.442	2.997
2	Normal	67.5	20.6	2,088,052	1.486	3.103
2	Wet	68.5	20.7	2,135,410	1.299	2.774
2	Extremely Wet	67.4	22.4	2,263,783	1.173	2.656
3	Critically Dry	68.8	20.7	2,143,681	1.332	2.855
3	Dry	67.0	20.6	2,077,268	1.389	2.885
3	Normal	66.2	20.2	2,013,023	1.401	2.82
3	Wet	67.3	20.8	2,108,359	1.296	2.733
3	Extremely Wet	66.5	22.5	2,244,327	1.169	2.624
4	Critically Dry	69.7	21.2	2,222,044	1.311	2.914
4	Dry	67.6	21.0	2,135,371	1.326	2.832
4	Normal	67.1	20.1	2,031,312	1.311	2.662
4	Wet	68.6	21.6	2,222,954	1.226	2.728
4	Extremely Wet	67.0	22.8	2,291,406	1.161	2.659
5	Critically Dry	70.5	20.8	2,205,458	1.399	3.082
5	Dry	67.8	20.4	2,073,876	1.442	2.991
5	Normal	67.5	20.6	2,087,852	1.486	3.103
5	Wet	68.4	20.7	2,130,372	1.299	2.768
5	Extremely Wet	67.4	22.3	2,262,927	1.173	2.655
6	Critically Dry	70.4	21.0	2,221,660	1.395	3.092
6	Dry	69.0	20.6	2,138,966	1.434	3.067
6	Normal	69.0	20.9	2,168,180	1.482	3.214
6	Wet	69.1	21.0	2,175,494	1.294	2.812
6	Extremely Wet	68.2	22.6	2,313,760	1.163	2.691
7	Critically Dry	68.9	21.0	2,177,239	1.415	3.072
7	Dry	67.0	20.3	2,042,985	1.458	2.978
7	Normal	66.2	20.6	2,046,315	1.506	3.082
7	Wet	67.8	21.1	2,153,758	1.286	2.768
7	Extremely Wet	66.5	22.6	2,263,272	1.155	2.613

Table 5-8. Mean Percent Changes from the Baseline for Population Statistics on Juvenile Chinook Salmon Life Stages as Simulated by the Stream Salmonid Simulator (S3) Model Applied to Contract Water Release Scenarios in the Restoration Reach of the Trinity River.

		Mean percent difference in annual values from Baseline				
Scenario	**Water year type**	**Egg survival**	**Juvenile survival to Pear Tree**	**Abundance at Pear Tree**	**Mean fish size at Pear Tree**	**Biomass at Pear Tree**
1	Critically Dry	-0.2	-0.2	-0.5	**-4.3**	**-4.7**
1	Dry	-0.2	1.2	0.9	**-6.6**	**-5.6**
1	Normal	-0.3	-1.7	**-2**	**-9.1**	**-10.9**
1	Wet	-0.5	1	0.4	**-3**	**-2.6**
1	Extremely Wet	-0.2	0.4	0.1	-0.1	0
2	Critically Dry	**2.1**	-0.9	1.2	-0.2	1
2	Dry	1.1	-0.4	0.8	-0.2	0.5
2	Normal	1.7	-0.5	1.2	-0.4	0.9
2	Wet	1.4	-1.1	0.3	1	1.2
2	Extremely Wet	1.3	-1.8	-0.4	1.5	1.1
3	Critically Dry	-0.4	-1.4	-1.6	**-5**	**-6.3**
3	Dry	-0.2	1	0.8	**-4**	**-3.2**
3	Normal	-0.3	**-2.2**	**-2.4**	**-5.9**	**-8.1**
3	Wet	-0.4	-0.5	-0.9	0.7	-0.3
3	Extremely Wet	-0.1	-1.1	-1.2	1	-0.2
4	Critically Dry	1	1	**2.1**	**-6.2**	**-4.3**
4	Dry	0.7	**2.8**	**3.6**	**-8.2**	**-4.7**
4	Normal	1	**-2.7**	-1.5	**-12.3**	**-13.4**
4	Wet	1.5	**3**	**4.5**	**-4.5**	-0.3
4	Extremely Wet	0.7	0.1	0.8	0.4	1.3
5	Critically Dry	**2.1**	-0.9	1.3	-0.2	1
5	Dry	0.9	-0.3	0.6	-0.2	0.4
5	Normal	1.7	-0.5	1.2	-0.4	0.8
5	Wet	1.2	-1.1	0.1	1.1	1
5	Extremely Wet	1.3	-1.8	-0.4	1.7	1.1
6	Critically Dry	**2**	0	**2**	-0.7	1.4
6	Dry	**2.7**	1	**3.8**	-0.9	**2.9**
6	Normal	**4**	1.2	**5**	-0.7	**4.4**
6	Wet	**2.3**	0	**2.3**	0.6	**2.7**
6	Extremely Wet	**2.6**	-0.7	1.9	0.5	**2.5**
7	Critically Dry	-0.1	0	0	0.8	0.7
7	Dry	-0.3	-0.6	-0.9	0.8	-0.1
7	Normal	-0.2	-0.5	-0.8	1	0.1
7	Wet	0.4	0.8	1.1	0	1.1
7	Extremely Wet	0	-0.4	-0.4	0.2	-0.5

Note: The mean percent differences were calculated by averaging the differences from each individual year and are not representative of the difference in mean values presented in Table 5-7. Results representing equal to or greater than a positive or negative 2% Change (+ or -) from the baseline are presented in bold and highlighted gray and orange, respectively.

Table 5-9. Mean Annual Differences in Summary Statistics Relative to the Baseline for Juvenile Chinook Salmon Life Stages as Simulated by the Stream Salmonid Simulator (S3) Model Applied to Contract Water Release Scenarios in the Restoration Reach of the Trinity River.

		Mean annual difference in values from Baseline				
Scenario	**Water year type**	**Egg survival**	**Juvenile survival to Pear Tree**	**Abundance at Pear Tree (number of fish)**	**Mean fish size at Pear Tree (grams)**	**Biomass at Pear Tree (metric tons)**
1	Critically Dry	-0.2	0.0	-11,718	-0.065	-0.148
1	Dry	-0.2	0.2	18,724	-0.096	-0.169
1	Normal	-0.2	-0.4	-42,789	-0.135	-0.336
1	Wet	-0.4	0.2	9,631	-0.04	-0.07
1	Extremely Wet	-0.1	0.1	2,874	-0.002	0.001
2	Critically Dry	1.4	-0.2	26,864	-0.005	0.03
2	Dry	0.7	-0.1	16,936	-0.003	0.017
2	Normal	1.1	-0.1	24,514	-0.005	0.026
2	Wet	1.0	-0.2	6,614	0.013	0.035
2	Extremely Wet	0.9	-0.4	-9,560	0.018	0.028
3	Critically Dry	-0.2	-0.3	-34,070	-0.075	-0.198
3	Dry	-0.2	0.2	16,361	-0.059	-0.095
3	Normal	-0.2	-0.5	-50,514	-0.09	-0.258
3	Wet	-0.3	-0.1	-20,437	0.009	-0.007
3	Extremely Wet	-0.1	-0.2	-29,016	-0.005	-0.001
4	Critically Dry	0.7	0.2	44,293	-0.14	0.007
4	Dry	0.4	0.6	74,464	-0.12	-0.149
4	Normal	0.7	-0.5	-32,226	-0.185	-0.416
4	Wet	1.0	0.6	94,158	-0.06	-0.012
4	Extremely Wet	0.4	0.0	18,063	0.004	0.03
5	Critically Dry	1.5	-0.2	27,708	-0.005	0.029
5	Dry	0.6	-0.1	12,969	-0.003	0.011
5	Normal	1.1	-0.1	24,314	-0.005	0.026
5	Wet	0.8	-0.2	1,576	0.014	0.029
5	Extremely Wet	0.9	-0.4	-10,416	0.02	0.027
6	Critically Dry	1.4	0.0	43,908	-0.01	0.039
6	Dry	1.8	0.2	78,060	-0.013	0.086
6	Normal	2.6	0.2	104,642	-0.01	0.136
6	Wet	1.5	0.0	46,699	0.007	0.073
6	Extremely Wet	1.7	-0.2	40,417	0.006	0.062
7	Critically Dry	-0.1	0.0	-512	0.01	0.02
7	Dry	-0.2	-0.1	-17,922	0.011	-0.002
7	Normal	-0.2	-0.1	-17,222	0.015	0.005
7	Wet	0.2	0.2	24,962	0	0.029
7	Extremely Wet	0.0	-0.1	-10,071	0.002	-0.016

Note: The mean annual differences in values were calculated by averaging the differences from each individual year and are not representative of the difference in mean values presented in Table 5-7.

5.4.2 Simulated Egg Survival and Emergence Timing

Annual egg survival estimates include the period from spawning to fry emergence. Simulated egg mortality can result from redd superimposition during spawning or naturally during incubation. Given a time-dependent egg mortality rate of 0.25 percent per day during incubation, cumulative egg survival would be 86% after 60 days and 79% after 90 days of simulated incubation time. Given the difference in time between spawning and emergence distributions (Figure 3-8), incubation time contributed to a large fraction of the egg mortality. Given an incubation time of 90 days, cumulative egg survival would be 79%, and any additional mortality in S3 would be due to superimposition mortality and changes in spawning habitat availability. Mean egg survival under the baseline was 67%, while mean egg survival by scenario ranged from 67% to 69% (Table 5-6; Figure 5-21, Figure 5-22). The largest average increase in egg survival was measured for Contract Water release Scenario 6, which resulted in a mean annual egg survival rate 2.6% higher than the baseline. Given this difference in egg survival rate, the total number of spawners (4,794 females), and the assumed fecundity (3,135 eggs per female), then Scenario 6 created about 81 more redds than the baseline. Note, as mentioned in Section 4.2.2, Scenario 6 results do not account for the potential effects of redd dewatering, as this is not explicitly incorporated into S3. Contract Water release scenarios 2, 4, 5, and 6 all produced a high frequency (> 90%) of simulated years with higher egg survival than the baseline (Table 5-6).

Emergence timing in S3 simulations is a function of water temperature during egg incubation. Within optimal temperatures for egg incubation, decreases in water temperature decrease egg maturation rates, which in turn, result in later fish emergence and lower egg survival. For example, later and more protracted emergence times and lower egg survival rates were apparent during extremely wet (and cooler) water year types (Figure 5-23; Table 5-7, Table 5-8, Table 5-9). There were no marked differences in emergence time across the Contract Water release scenarios. For example, Scenario 6 had the earliest median day of emergence across the water years at day 81 (March 22nd), whereas Scenarios 1, 3, 4, and the Baseline had the latest median day of emergence at day 83 (March 24th), a difference of only 2 days.

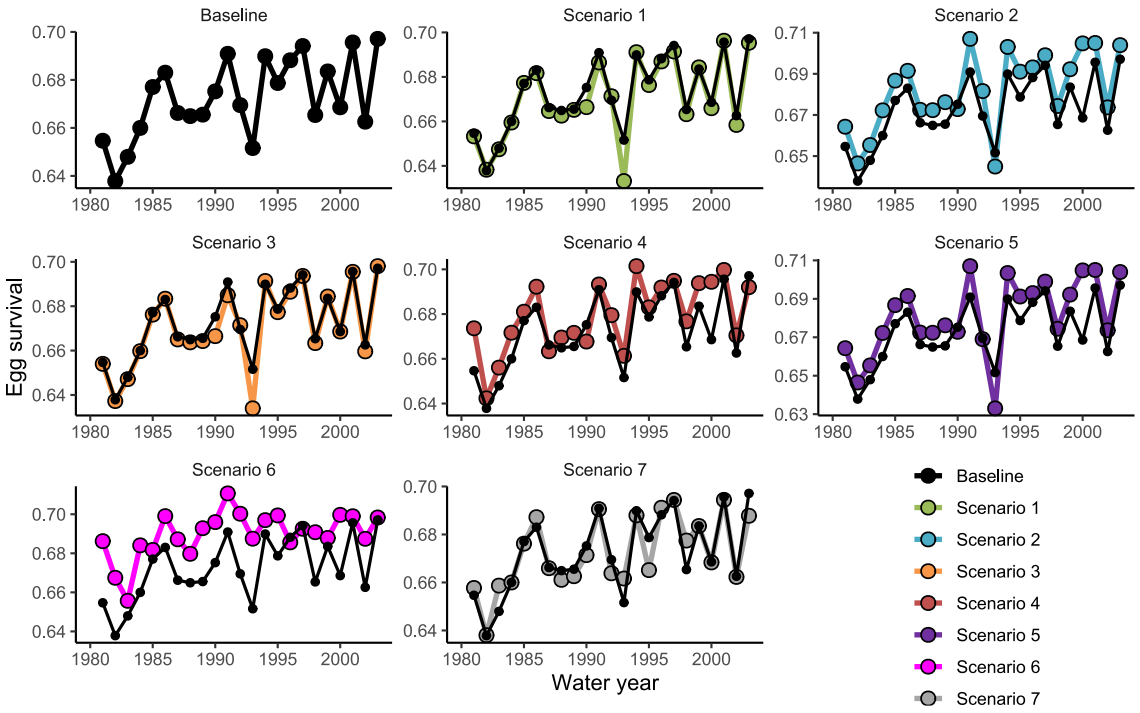


Figure 5-21. Time Series of Annual Egg Survival from Spawning to Emergence Within the Restoration Reach of the Trinity River, CA for All Scenarios.

Note: Annual egg survival is shown for each simulated Contract Water release scenario relative to the baseline.

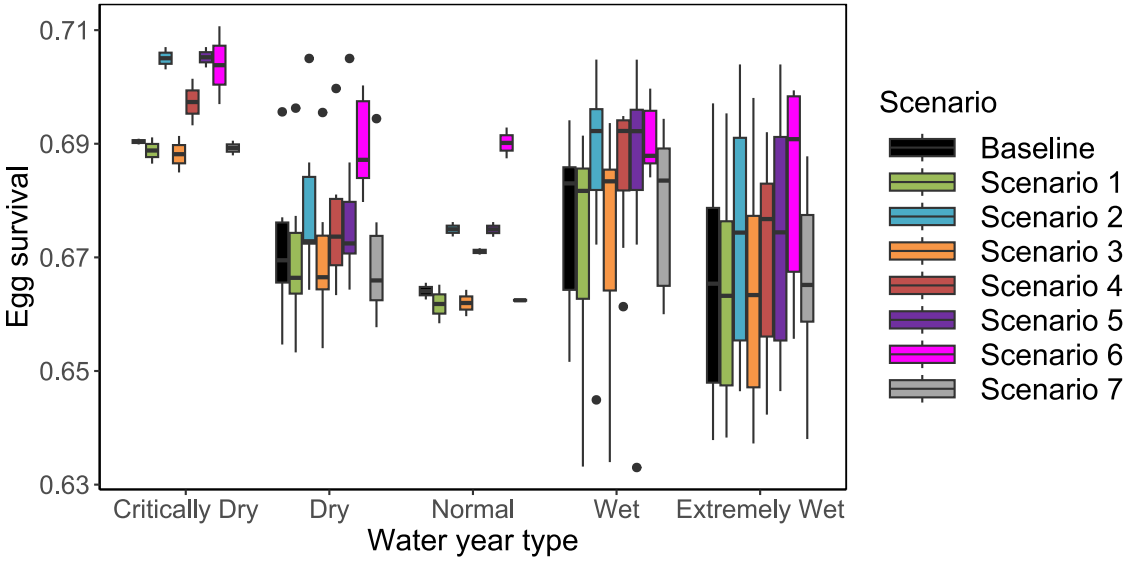


Figure 5-22. Boxplots of Mean Annual Egg Survival from Spawning to Emergence Within the Restoration Reach of the Trinity River, CA for All Scenarios.

Note: Annual egg survival is colored by the simulated Contract Water release scenario and grouped by water year type.

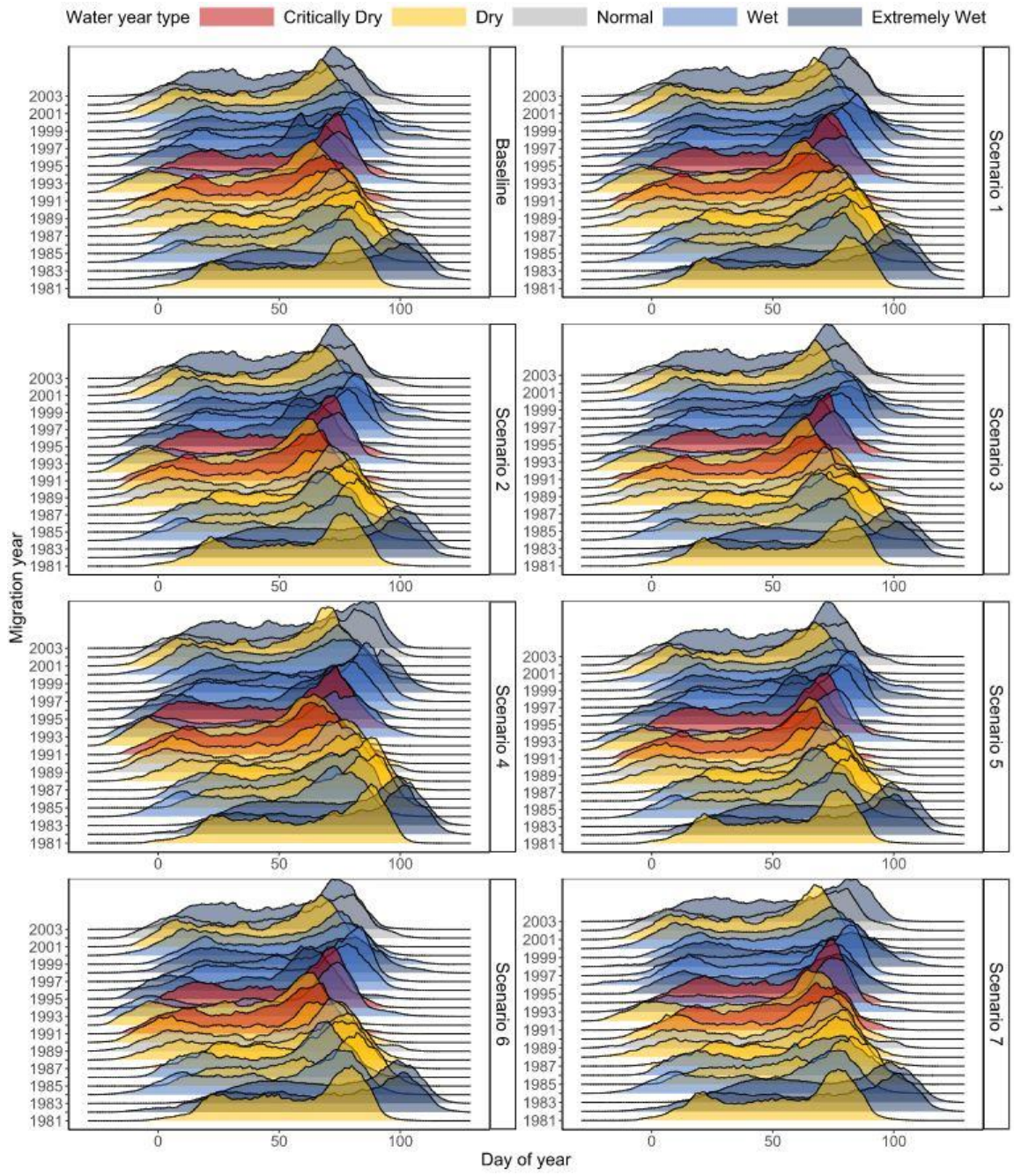


Figure 5-23. Emergence Timing Distributions of Juvenile Chinook Salmon as Simulated by the Stream Salmonid Simulator model (S3) in the Restoration Reach of the Trinity River, CA for All Scenarios.

Note: Plots are ordered by water year and colored by water year type. The origin for day of year is January 1.

5.4.3 Simulated Juvenile Survival, Abundance, and Size

Estimates of juvenile Chinook Salmon survival through the Restoration Reach of the Trinity River encompasses the time from emergence to passage of the Pear Tree reference site. Mean juvenile Chinook Salmon survival was similar across the Contract Water release scenarios ranging from 21.0% to 21.5% (Table 5-7, Figure 5-24). Scenario 4 had the highest water volume released and also had the largest positive effect on juvenile Chinook Salmon survival. Under Scenario 4, juvenile Chinook Salmon survival was, on average, 1.6% higher than juvenile survival under the baseline (Table 5-6). Over the simulated water years, Scenario 1 had the highest frequency (68%) of years with survival greater than the baseline. Scenario 4 had the second highest frequency (59%) of years with juvenile Chinook Salmon survival greater than the baseline.

Comparison of juvenile Chinook Salmon survival across water year types supported the conclusion that higher annual water volumes released from October through April under the proposed release patterns would modestly increase fish survival from emergence to Pear Tree (Table 5-7, Table 5-8, Table 5-9). All simulated scenarios showed slightly higher average survival in Extremely Wet years (range 22.3% to 22.8%) compared to survival in Critically Dry years (range 20.7% to 21.2%; Figure 5-25). The largest percent increase in survival relative to the baseline was in Scenario 4 (2.8%) during Dry water years (Table 5-8). Thus, even though Extremely Wet years were simulated to have higher juvenile Chinook Salmon survival, the increase in survival was relatively small (<2.8%) across the Contract Water release scenarios in comparison to the baseline. Many scenarios and water year types were also associated with modest decreases in survival relative to the baseline. For example, Scenario 2 resulted in lower survival to Pear Tree relative to the baseline in all water year types.

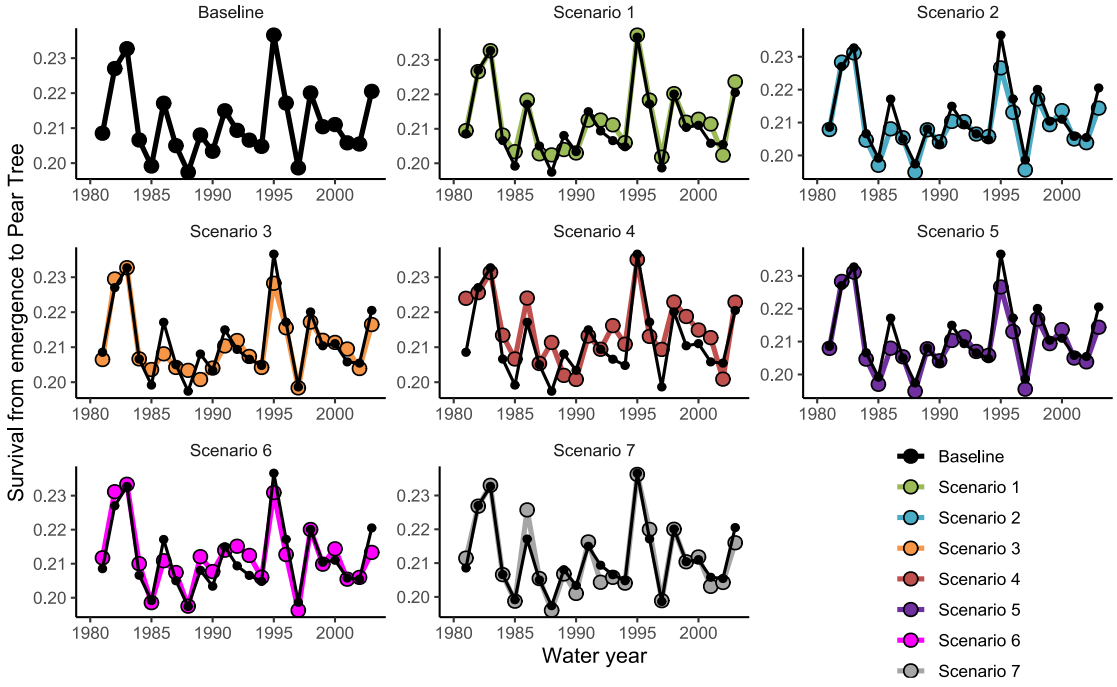


Figure 5-24. Time Series of Annual Juvenile Chinook Salmon Survival from Emergence to Passing Pear Tree at the End of the Restoration Reach of the Trinity River, CA for All Scenarios.

Note: Annual survival is shown by simulated Contract Water release scenario in contrast to the baseline.

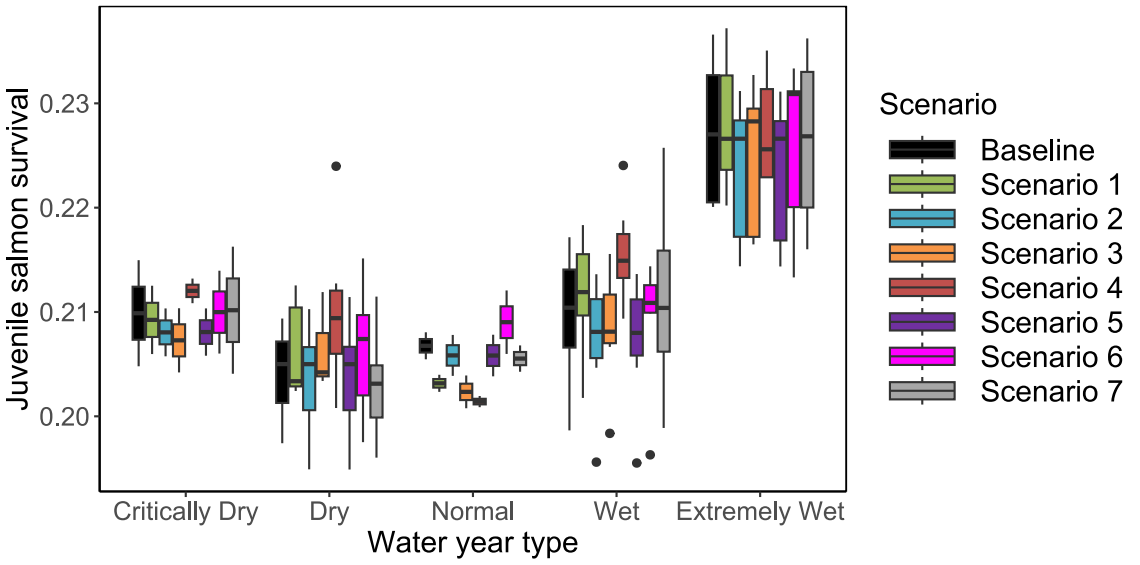


Figure 5-25. Boxplots of Mean Annual Juvenile Chinook Salmon Survival from Emergence to Pear Tree within the Restoration Reach of the Trinity River, CA for All Scenarios.
Note: Annual Survival is colored by the simulated Contract Water release scenario and grouped by water year type.

Variation in the annual abundance of simulated juvenile Chinook Salmon passing the Pear Tree reference site was the result of differences in survival between egg and juvenile life stages. For example, Scenario 6 had the greatest average increase (2.9%) in annual abundance relative to the baseline, which was in association with this scenario's high average egg and juvenile survival (Table 5-6; Figure 5-26, Figure 5-27). On average, Scenario 6 resulted in 59,673 more juvenile Chinook Salmon and Scenario 4 resulted in 56,295 more juvenile Chinook Salmon at Pear Tree than the baseline. Scenario 3 resulted in 14,904 fewer juvenile Chinook Salmon at Pear Tree than the baseline. Higher abundance was simulated during Critically Dry years compared to Dry, Normal, and Wet years due to the higher simulated egg and juvenile Chinook Salmon survival during Critically Dry conditions (Table 5-7, Table 5-8, Table 5-9). Interestingly, Scenario 6 released about one third of the water volume as Scenario 4, yet Scenario 6 was associated with higher estimates of abundance across the water year types, indicating that the timing of water releases with respect to early life stages may be just as influential to fish population dynamics as the total amount of water released.

The abundance of fish arriving at Pear Tree over time reflected fish emergence times, with later emerging fish arriving at Pear Tree later in the year (Figure 5-28). There were no marked differences in arrival at Pear Tree across the Contract Water release scenarios. However, in a similar fashion as emergence timing, Extremely Wet years were associated with a later and more protracted emigration of fish passing Pear Tree. Likewise, there was a tendency for fish to emigrate earlier in Critically Dry and Dry water year types.

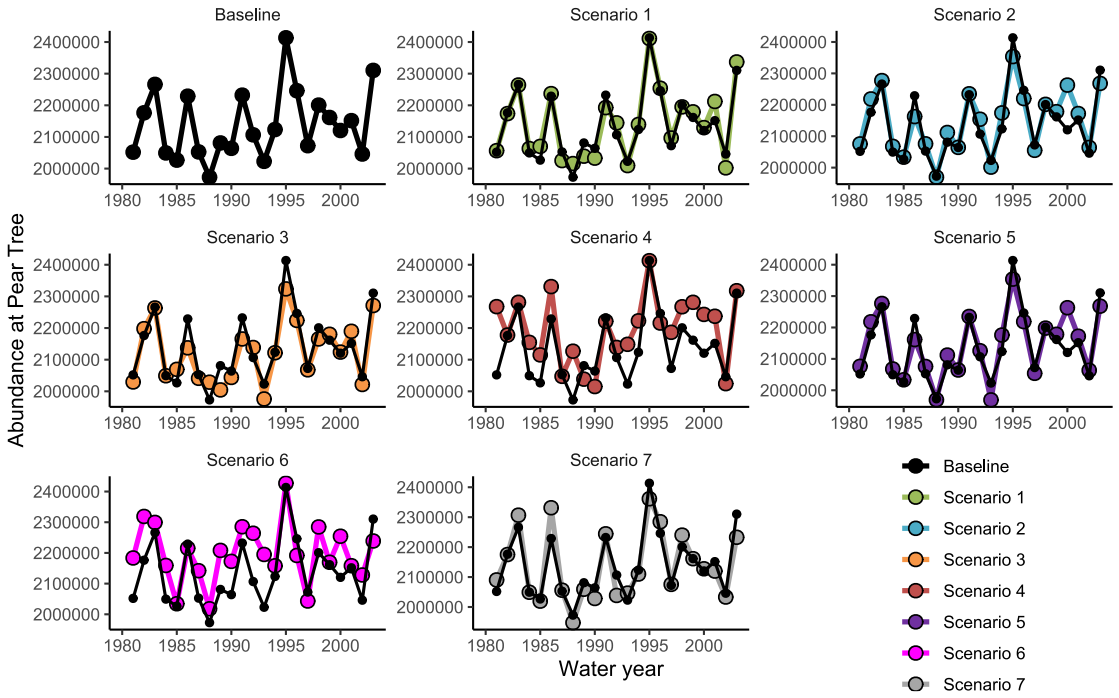


Figure 5-26. Time Series of Annual Juvenile Chinook Salmon Abundance Passing Pear Tree at the End of the Restoration Reach of the Trinity River, CA for All Scenarios.
Note: Annual abundances are shown by simulated Contract Water release scenario in contrast to the baseline.

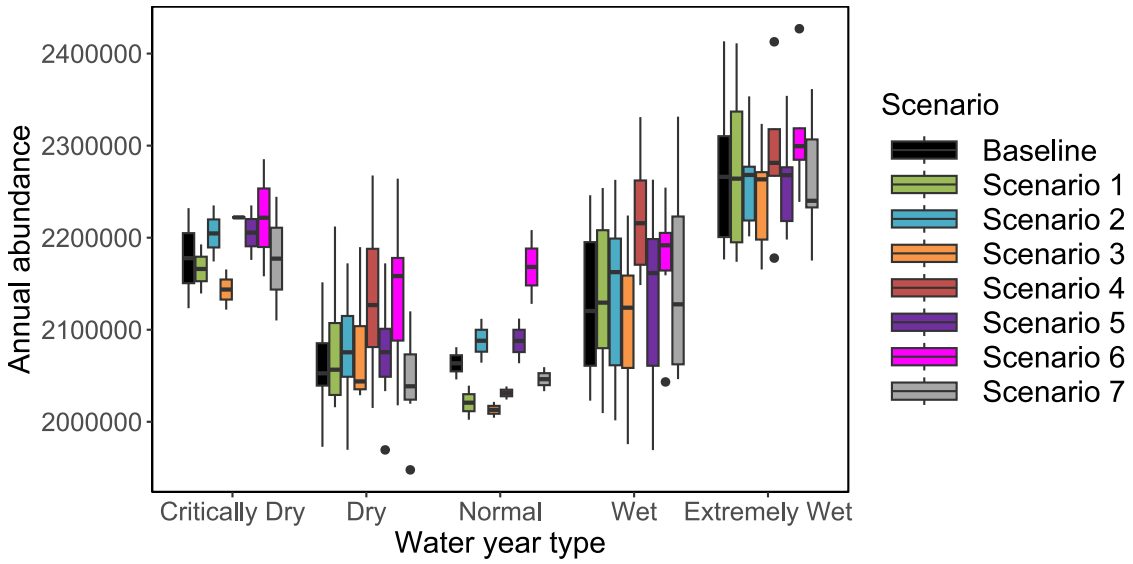


Figure 5-27. Boxplots of Mean Annual Juvenile Chinook Salmon Abundance Passing Pear Tree at the End of the Restoration Reach of the Trinity River, CA for All Scenarios.
Note: Annual Abundance is colored by the simulated Contract Water release scenario and grouped by water year type.

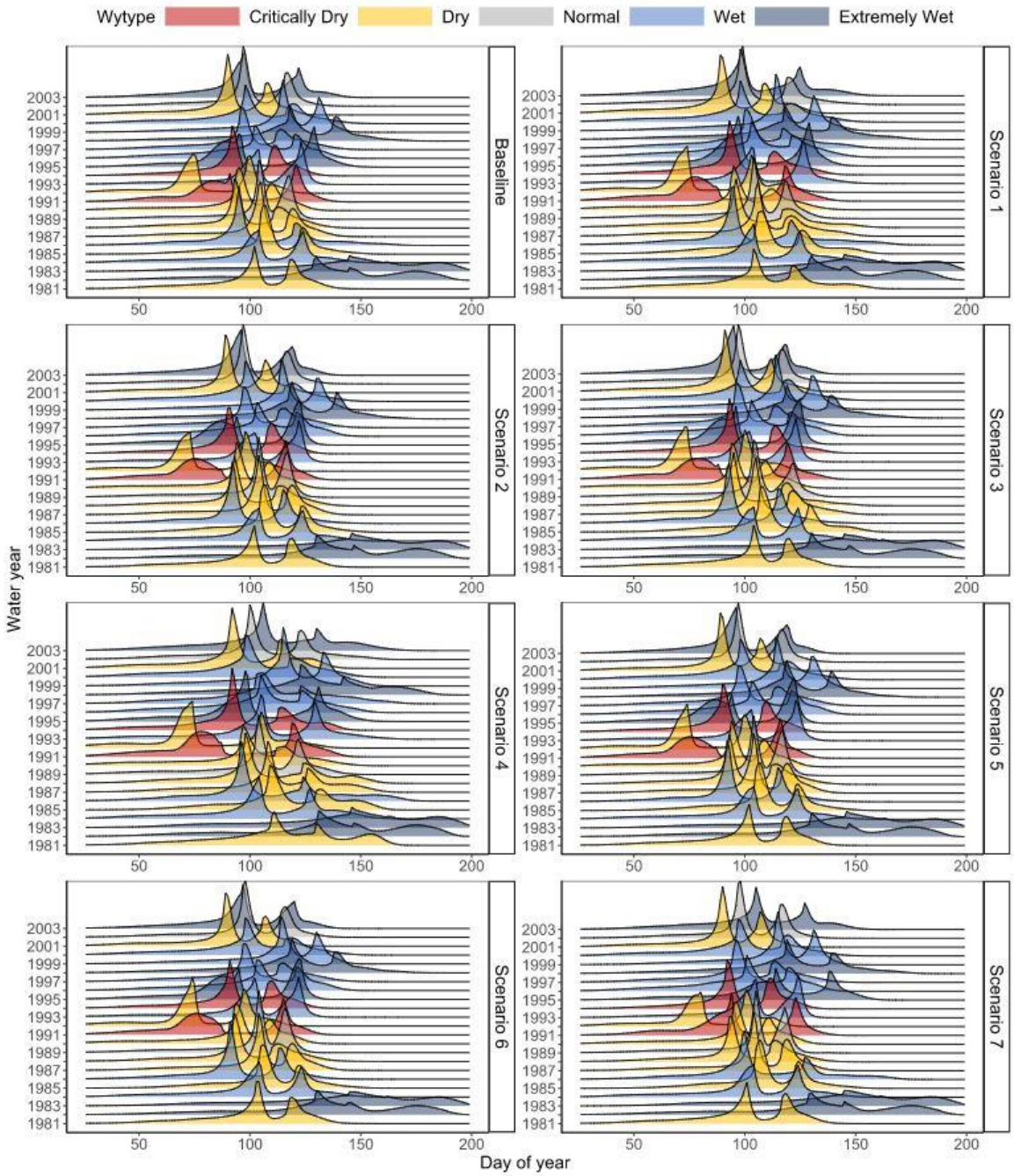


Figure 5-28. Emigration Timing Distributions of Juvenile Chinook Salmon passing Pear Tree as Simulated by the Stream Salmonid Simulator model (S3) in the Restoration Reach of the Trinity River, CA for All Scenarios.

Note: Plots are ordered by water year and colored by water year type. The origin for day of year is January 1.

The size of simulated fish passing the Pear Tree reference site is a consequence of fish travel time and the intervening water temperatures during emigration. Scenario 4 with the largest (and cooler during spring months) volume of Contract Water released was associated with the greatest reduction in fish size at Pear Tree (Figure 5-29, Figure 5-30). On average, Scenario 4 reduced the size of fish passing Pear Tree by about 5.4% relative to the baseline, with just 13% of simulated water years resulting in greater fish size than the baseline (Table 5-6). Scenario 1 also released a large volume of cooler Contract Water in the spring, which resulted in reduced fish size similar to Scenario 4. Scenario 5 had the largest positive effect on fish size, increasing fish size by 0.6% relative to the baseline. Scenario 5 resulted in 54% of water years with greater average fish size than the baseline. Simulations also indicated a clear reduction in average fish sizes in wetter and cooler water year types (Table 5-7, Table 5-8, Table 5-9).

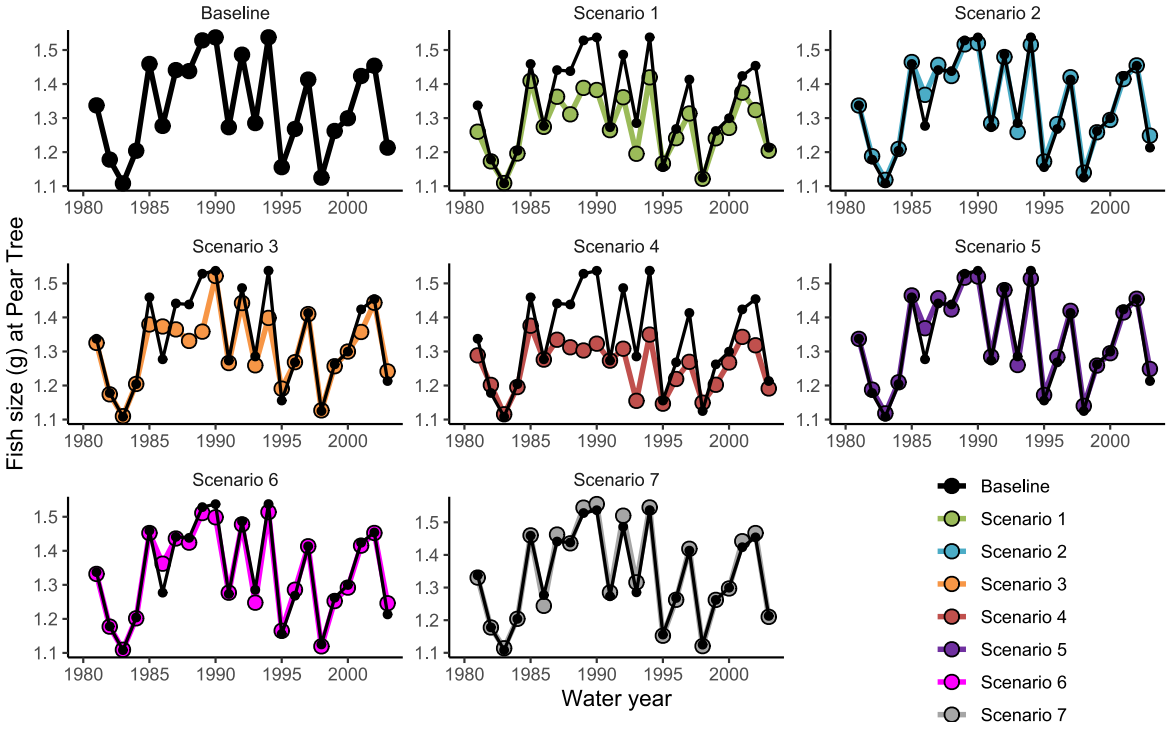


Figure 5-29. Time Series of Annual Size (grams) of Juvenile Chinook Salmon Passing Pear Tree at the End of the Restoration Reach of the Trinity River, CA for All Scenarios.
Note: Annual size is shown by simulated Contract Water release scenario in contrast to the baseline.

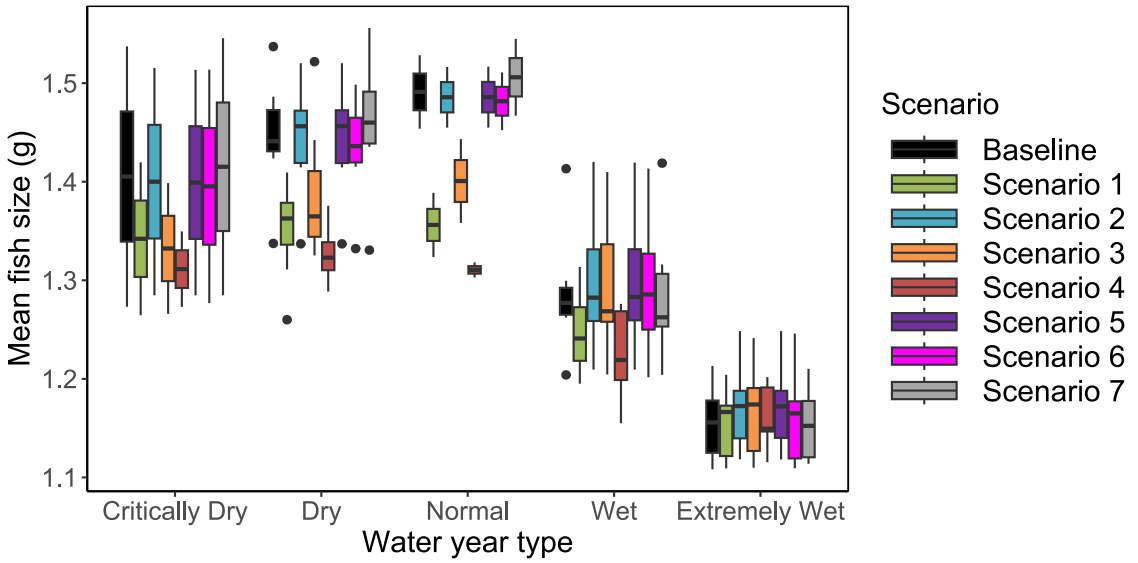


Figure 5-30. Boxplots of Mean Annual Juvenile Chinook Salmon Size at Pear Tree Within the Restoration Reach of the Trinity River, CA for All Scenarios.
Note: Annual size is colored by the simulated Contract Water release scenario and grouped by water year type.

The annual biomass of juvenile Chinook Salmon at Pear Tree is the product of the mean annual fish size and mean annual abundance. As a consequence of the higher abundance, simulations of Scenario 6 resulted in higher average biomass (2.8%) compared to the baseline (Table 5-6; Figure 5-31, Figure 5-32). In accordance with their smaller average fish sizes, Scenarios 1 and 4 resulted in the largest reductions (-2.8% and -3.9%, respectively) in fish biomass at Pear Tree relative to the baseline. The effect of water year type on biomass was apparent across the Contract Water release scenarios (Table 5-7, Table 5-8, Table 5-9). For example, even though Scenario 6 often resulted in higher average biomass, a marked decrease in biomass at Pear Tree was evident during Wet and Extremely Wet water year types. Although S3 simulated generally higher abundances during wetter conditions and years, this reduction in biomass was a consequence of reduced fish size (Figure 5-27).

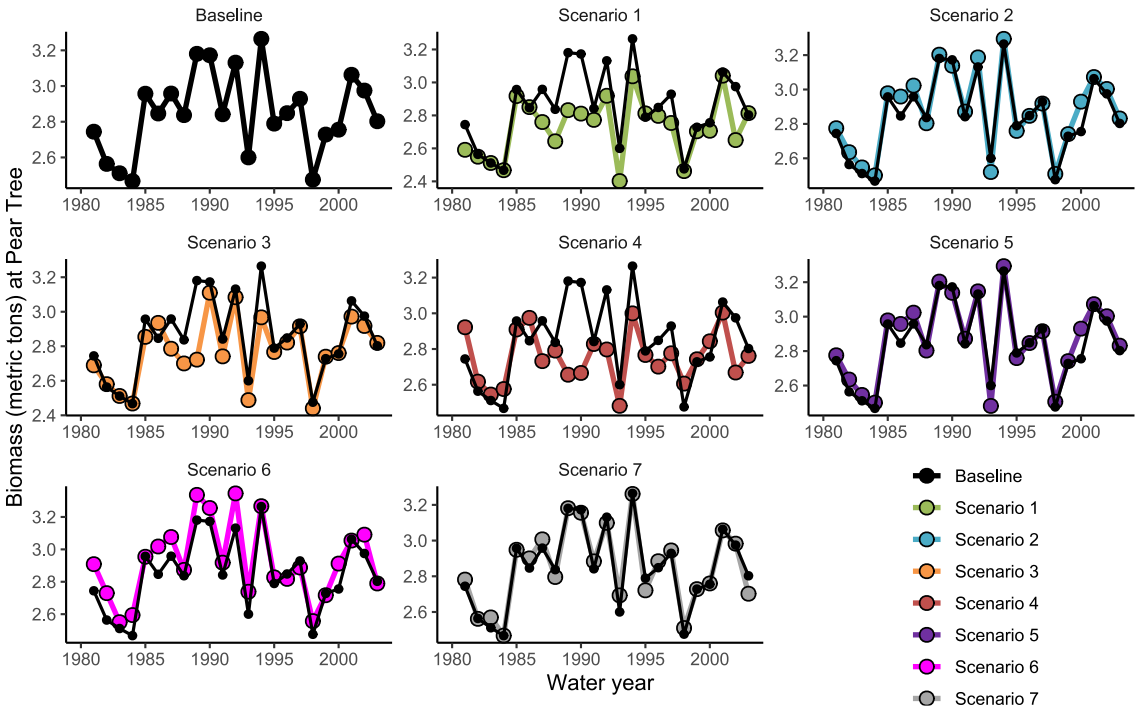


Figure 5-31. Time Series of Annual Biomass (metric tons) of Juvenile Chinook Salmon Passing Pear Tree at the End of the Restoration Reach of the Trinity River, CA for All Scenarios.

Note: Annual biomass is shown by simulated Contract Water release scenario in contrast to the baseline.

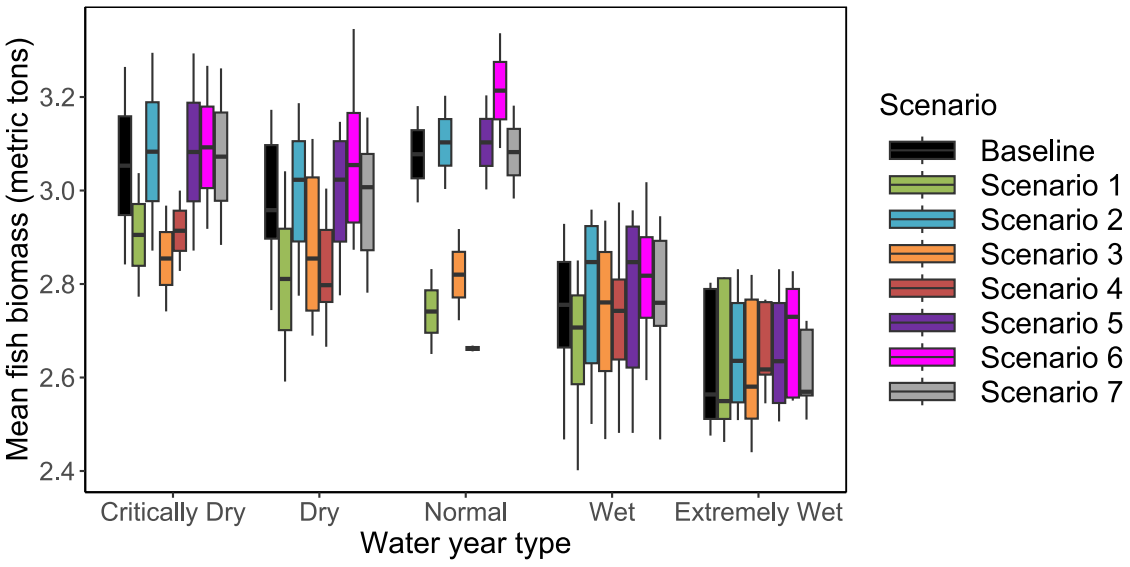


Figure 5-32. Boxplots of Mean Annual Juvenile Chinook Salmon Biomass (metric tons) at Pear Tree within the Restoration Reach of the Trinity River, CA for All Scenarios.

Note: Annual biomass is colored by the simulated Contract Water release scenario and grouped by water year type.

5.5 Sediment

5.5.1 Coarse Bedload Transport

The annual yield of coarse bedload for each scenario was analyzed by summing the daily transport for all six reaches in tons/day to total volume in tons across the total period, divided by 23.75 years. Annual coarse bedload transported throughout Restoration Reach is shown in Figure 5-33. Scenario 4 was the only scenario to explicitly include sediment transport as an objective and produced the largest increase from the baseline of 14% annually. Scenarios 3 and 7 were the only other scenarios to increase the magnitude of high flow events in the spring through pulses and larger magnitude safety-of-dams releases, respectively. Scenario 3 transported about 5,000 tons per year more than the baseline, around a 7% increase, and Scenario 7 transported 8% more bedload than the baseline. Scenario 1 transported the same amount of bedload as the Baseline. Scenarios 2, 5, and 6 all transported slightly less bedload, as the early fall pulses and baseflow releases reduced storage in Trinity Reservoir prior to the winter season, which typically reduced the magnitude of the required safety-of-dams releases during the winter and spring.

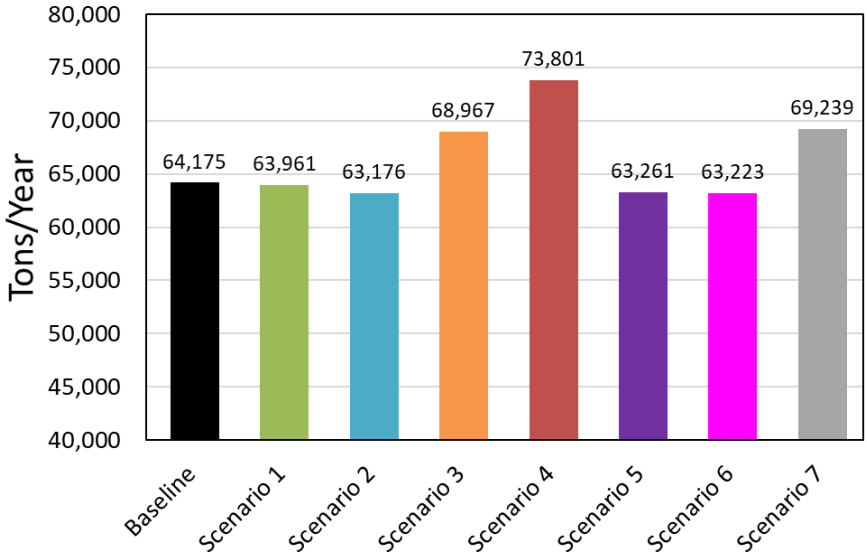


Figure 5-33. Annual Yield of Coarse Bedload in Tons/Year for All Scenarios.

The annual sediment transport for each reach was analyzed by summing the daily transport in tons/day to total volume in tons across the total period, divided by 23.75 years. Figure 5-34 shows the difference in annual average bedload yield in tons per year in each reach for each scenario relative to the Baseline. Sediment transport varies from upstream to downstream, with the three most downstream reaches transporting most of the additional bedload for Scenarios 3, 4, and 7, which emphasizes the influence of additional downstream tributary inflows on sediment transport. Although additional annual sediment yield in scenarios 3 and 4 in the upper three reaches was minimal (+100 to 600 tons/year) relative to the downstream reaches, the majority of redds are established in the reach directly below Lewiston (based on 2007, 2012, and 2014 surveys; Figure 3-8, Gaeuman et al. 2023), so this increase in sediment yield could still have a large impact on spawning habitat. The sediment rating curve for TRDC is more sensitive than at the upstream sites, with the equation suggesting potential transport at flows as low as 1,000 cfs. Presumably this is based on the sediment supplied from tributaries that create a finer, more mobile substrate. Scenario 3 experienced a 7% increase in annual yield relative to the baseline while Scenario 4 experienced a 14% increase in annual yield—double the increase of Scenario 3.

This is because Scenario 4 added on fall and winter biologic pulses every year in addition to the geomorphic pulses, which, even though they are only designed to peak at 3,000 cfs, would be enough to transport sediment in the downstream reaches based on the rating curve.

The annual amount of sediment transported in relation to the year, water year type, and whether a geomorphic pulse occurred (for Scenario 3 and 4) is shown in Figure 5-35. The 14 wetter years, mostly Wet and Extremely Wet (~60% of the modeled years) were responsible for most of the sediment transport which occurred. Notably, this graph shows that 1995 was the year responsible for most of the bedload transport in Scenario 7. This is because a large volume of Contract Water carryover that accumulated during several preceding dry years was evacuated during a safety-of-dams release during the Extremely Wet 1995 water year, which led to a modeled 6,000 cfs release for a month in that year.

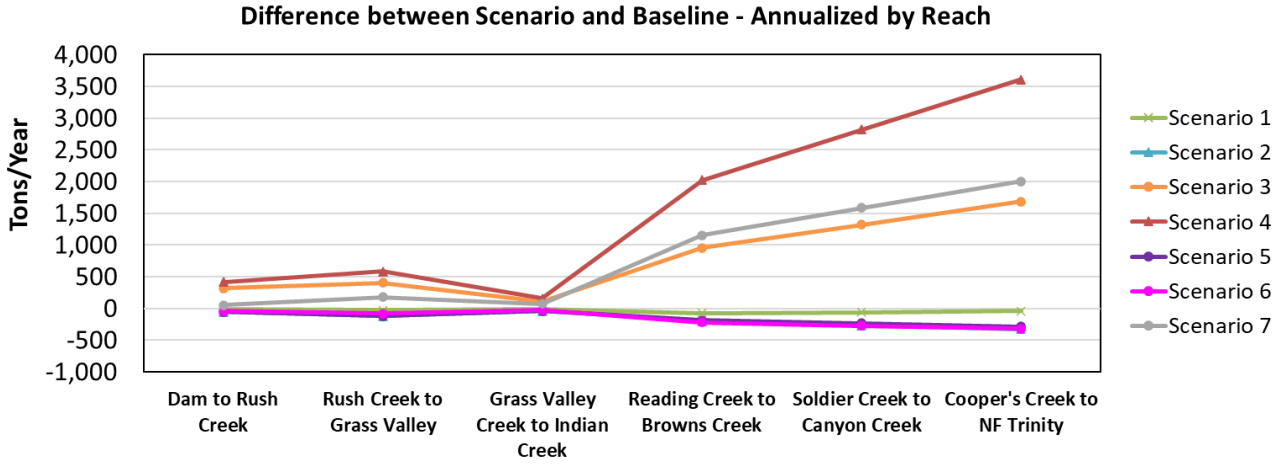


Figure 5-34. Difference Between Scenario and Baseline in the Annual Yield of Coarse Bedload by Reach.

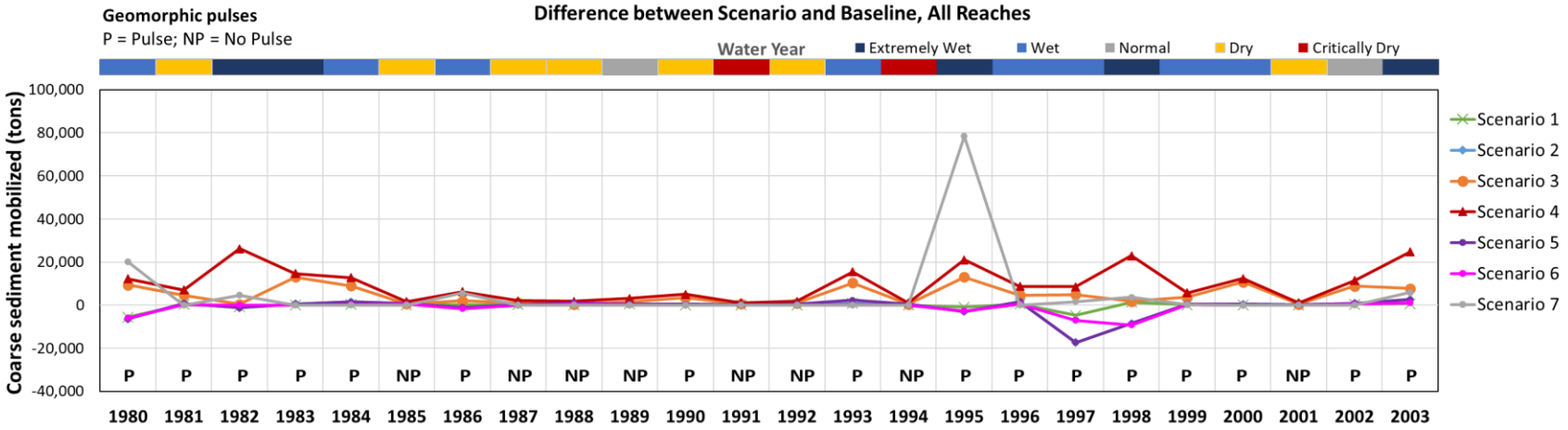


Figure 5-35. Difference Between Scenario and Baseline of the Annual Bedload Yield in Tons Summed Across All Reaches.

Note: Water year type and geomorphic pulse for Scenario 3 and 4 indicated for each year.

5.5.2 Partial Bed Mobilization

Figure 5-36 shows the average percent change in fraction of streambed mobilized in each reach relative to the Baseline across all years. Scenarios 1, 2, 5, 6, and 7 showed almost no difference relative to the Baseline. Scenario 3 and 4 both showed a similar pattern, with increases of 4-10% of the fraction of bed mobilized on average in each reach, but generally greatest in the two downstream reaches between Weaver Creek and Canyon Creek.

The interannual variability is shown in Figure 5-37 as the percent change in the fraction of bed mobilized in each year, averaged across the six reaches, in relation to the year, water year type, and whether a geomorphic pulse occurred for scenario 3 and 4. As expected, a geomorphic pulse (initiated in scenarios 3 and 4) was required to see any increase in percent of bed mobilized, due to the minimum flow of 4,000 cfs required to initiate streambed mobilization. There was less of a trend relative to bedload transport of partial bed mobilization being positively correlated with wet years and years with a geomorphic pulse. Additionally, for Scenario 7, when a large safety-of-dams release was made in 1995 causing a large amount of coarse bedload mobilization (as described in section 5.4.1. above), there was not a proportionally large increase in the fraction of bed mobilized. These trends seen in Scenarios 3, 4, and 7 are due to the fact that, unlike coarse bedload yield which is a function of volume and magnitude of daily flows across the entire hydrograph, the maximum annual fraction of bed mobilized is a function of the maximum flow for the water year, hence why partial bed mobilization does not correlate as strongly with the water year type. There were only five years with a notably significant increase in fraction of bed mobilized (>10%).

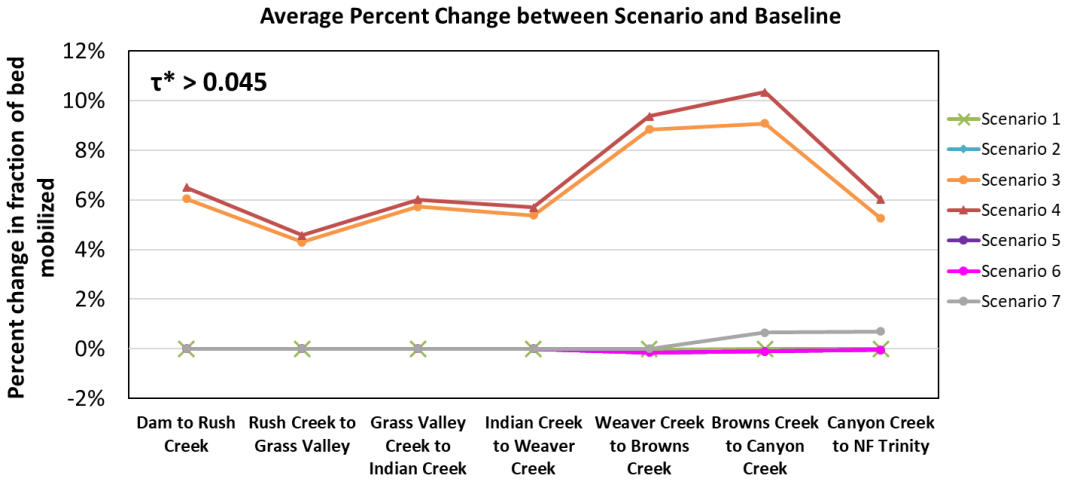


Figure 5-36. Mean Percent Change in Fraction of Bed Mobilized Across All Years Relative to Baseline. τ* = Shields Stress.

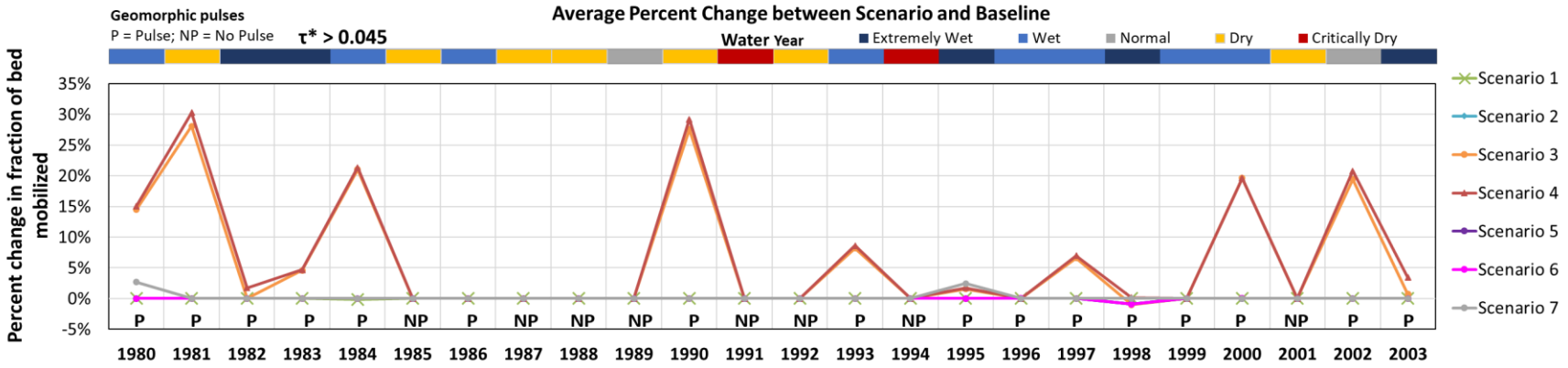


Figure 5-37. Percent Change in Fraction of Bed Mobilized for Each Year Across All Reaches Relative to Baseline.

Note: Water year type and geomorphic pulse for Scenario 3 and 4 indicated for each year. τ* = shields stress.

5.6 CVP Effects

CalSim II and HEC-5Q were used in combination to model and assess the effects of each scenario on TRD exports to the CVP, total CVP deliveries to NOD and SOD contractors, Shasta Reservoir storage, and water temperatures on the Sacramento River. This section summarizes results from all scenarios for the simulation period of 1922 – 2003.

5.6.1 General Observations

The release of 50 TAF or more of Contract Water down the Trinity River resulted in lower Trinity Reservoir storage levels, which reduced TRD exports to the Sacramento Valley. This resulted in reductions in water supply deliveries to CVP contractors relative to the baseline, as discussed in Section 3.1.2. The operation also resulted in changes to Shasta storage and releases – when TRD exports were reduced, there was less streamflow in the Sacramento River, and Shasta was operated to make up that streamflow to the extent possible to minimize effects on aquatic species. The key takeaways of the effect of Contract Water releases on the CVP system include:

- Most scenarios that release 50 TAF had similar effects on the CVP contract deliveries and Sacramento River water temperatures regardless of the timing of Contract Water releases. That is, fall releases resulted in the same effects as spring releases.
- The reduction of TRD exports did not have a notable effect on Clear Creek water temperatures. Changes to Sacramento River water temperatures were primarily a result of Lake Shasta operations that were modified to offset the effect of reduced TRD exports.

5.6.2 Trinity River Division Exports

Trinity River Division exports to the CVP were modeled in CalSim II on a mean monthly basis. As described in Section 3.1.2, TRD exports were reduced by various amounts to balance the release of Contract Water down the Trinity River.

Mean monthly TRD exports are shown in Figure 5-38 and Table 5-10, and mean monthly releases by water year type throughout the entire simulation period are shown in Figure 5-39. Key takeaways include the following:

- Mean annual reductions in TRD exports are around 40 TAF for scenarios 1 – 3 and 5 – 7. In wetter years, Trinity Reservoir is able to fill with additional water once Contract Water is released, resulting in less than 50 TAF (-8%) reduction in TRD exports relative to the baseline. For Scenario 4, mean annual reductions in TRD exports were 170 TAF (-36%) relative to the baseline to offset the release of Contract Water.
- TRD exports are highest in July through October, and these months have the greatest reductions in exports relative to the baseline. The result in export cuts is a reduction in Trinity Reservoir releases (see Section 5.1.2) and in some cases an increase in Trinity Reservoir release temperature (see Section 5.1.3).

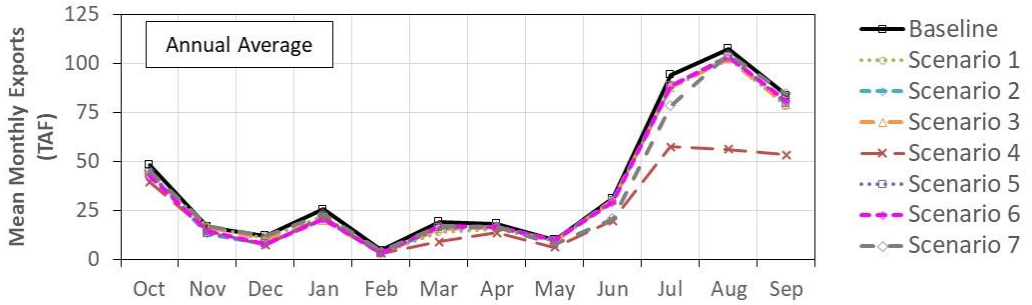


Figure 5-38. Mean Monthly Trinity River Division Exports in Thousand Acre-Feet (TAF) for All Scenarios.

Table 5-10. Mean Monthly Trinity River Division Exports in Thousand Acre-Feet (TAF) for All Scenarios.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Baseline	48	17	12	25	5	19	18	10	31	94	107	84	471
Scenario 1	44	16	11	22	3	14	16	10	30	88	102	78	433
Diff (TAF)	-5	0	-1	-3	-1	-6	-2	0	-1	-7	-5	-6	-38
Diff (%)	-10	-2	-10	-12	-30	-29	-13	-5	-5	-7	-5	-7	-8
Scenario 2	44	13	8	21	3	16	17	10	30	89	104	80	434
Diff (TAF)	-4	-3	-4	-5	-1	-3	-2	0	-1	-6	-4	-4	-38
Diff (%)	-8	-21	-35	-19	-31	-16	-8	-4	-4	-6	-3	-5	-8
Scenario 3	44	17	11	20	3	16	17	10	30	88	102	79	435
Diff (TAF)	-4	0	-2	-6	-1	-4	-2	0	-1	-6	-5	-5	-36
Diff (%)	-9	0	-13	-22	-31	-19	-9	-5	-3	-7	-5	-6	-8
Scenario 4	40	15	7	22	3	9	14	6	20	57	56	53	302
Diff (TAF)	-9	-2	-5	-4	-2	-10	-5	-4	-11	-37	-51	-30	-169
Diff (%)	-18	-13	-39	-15	-36	-53	-25	-37	-37	-39	-48	-36	-36
Scenario 5	44	13	8	21	3	16	17	10	30	88	104	80	434
Diff (TAF)	-4	-3	-4	-5	-1	-3	-2	0	-1	-6	-4	-4	-38
Diff (%)	-8	-19	-34	-19	-31	-16	-8	-4	-4	-6	-4	-5	-8
Scenario 6	42	14	8	21	3	17	16	10	29	89	103	81	433
Diff (TAF)	-6	-2	-4	-5	-2	-2	-2	0	-2	-6	-4	-3	-38
Diff (%)	-13	-13	-33	-19	-34	-13	-10	-4	-7	-6	-4	-3	-8
Scenario 7	45	17	12	23	4	17	17	8	21	78	105	84	431
Diff (TAF)	-3	0	0	-2	-1	-2	-2	-2	-10	-16	-3	1	-40
Diff (%)	-6	2	-1	-9	-13	-11	-9	-21	-34	-17	-3	1	-9

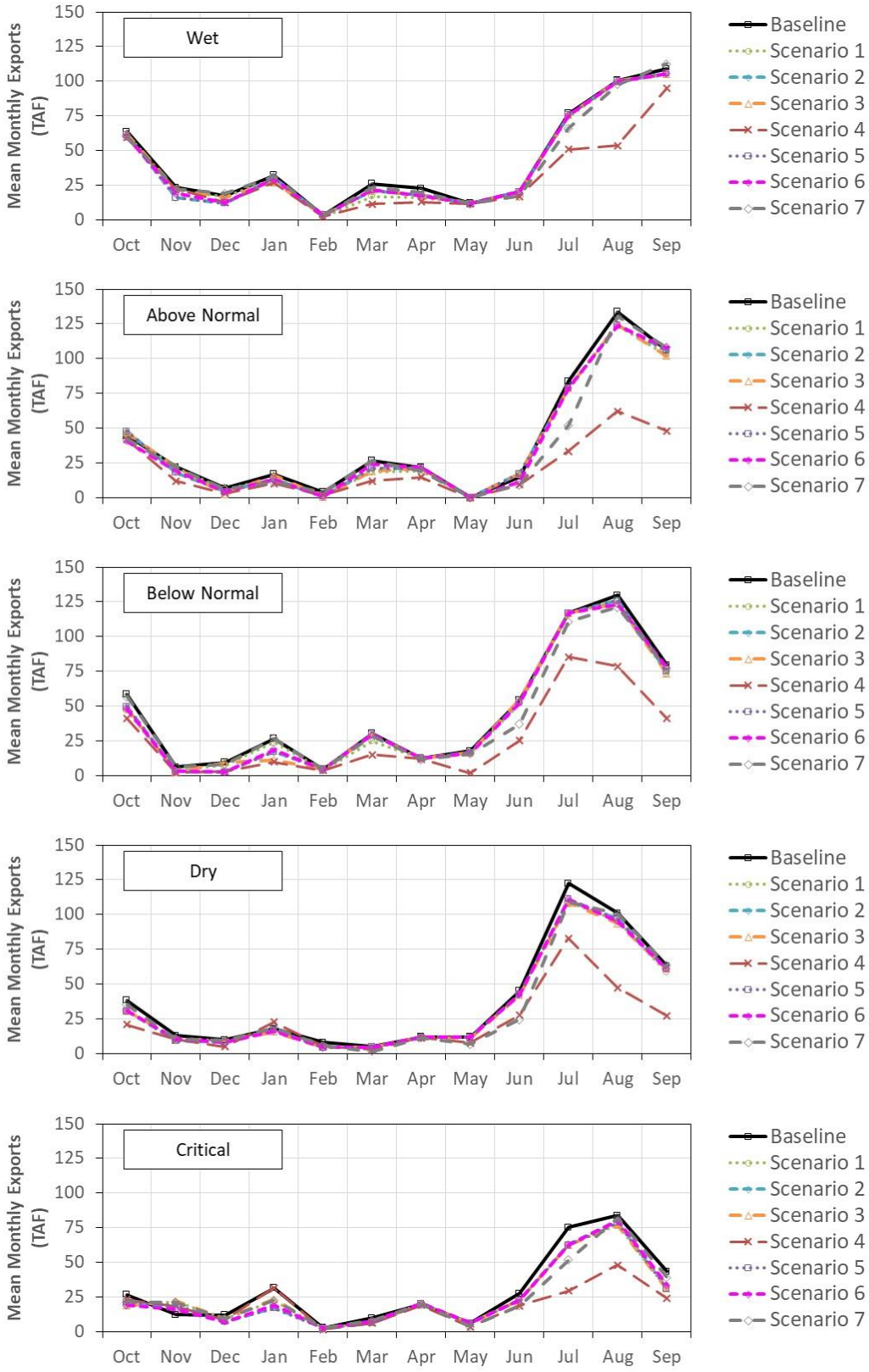


Figure 5-39. Mean Monthly Trinity River Division Exports in Thousand Acre-Feet (TAF) for All Scenarios by Sacramento Valley Water Year Type.

5.6.3 Total CVP Deliveries to NOD and SOD Contractors

Total CVP deliveries to NOD and SOD contractors were modeled in CalSim II on a mean monthly basis. As described in Section 3.1.2, CVP delivery reductions were balanced by Lake Shasta releases in different ways depending on the scenario to balance the release of Contract Water down the Trinity River.

Mean monthly CVP deliveries to NOD and SOD contractors are shown in Figure 5-40 and Table 5-11, and mean monthly CVP deliveries by water year type are shown in Figure 5-41. Key takeaways include the following:

- Mean annual reductions in CVP deliveries are primarily a result of reductions in TRD exports. For scenarios 1 – 3 and 5, Lake Shasta was allowed to release more water and drop storage slightly lower relative to the baseline to make up the difference in CVP delivery cuts. This resulted in mean annual reductions in CVP deliveries of about 10 TAF (-0.2%) relative to the baseline for these scenarios.
- For Scenario 4, to offset the larger reduction in TRD exports due to larger Contract Water release volumes, CVP deliveries were cut and Lake Shasta was allowed to release more water relative to the baseline. This resulted in mean annual reductions in CVP deliveries of 210 TAF (-4.6%) relative to the baseline.
- Scenarios 6 and 7 were operated similar to Scenario 4 – CVP deliveries were cut, but Lake Shasta was operated to maintain storage similar to the baseline. This required greater cuts to CVP deliveries than Scenarios 1 – 3 and 5, resulting in annual CVP delivery reductions of 34 TAF (-0.7%) and 57 TAF (-1.2%) relative to the baseline for Scenario 6 and 7, respectively.
- CVP delivery reduction magnitudes were similar across all years for Scenarios 1 – 3 and 5 – 7. For Scenario 4, CVP delivery reductions were greater in wetter years and less in drier years.

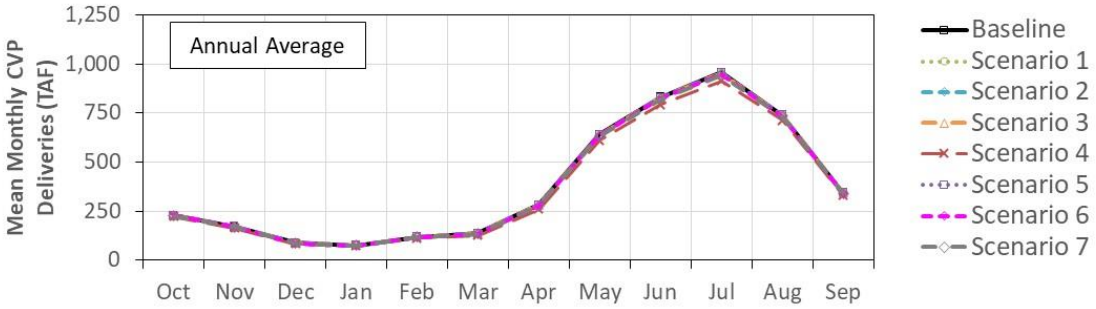


Figure 5-40. Mean Monthly CVP Deliveries to NOD and SOD Contractors in Thousand Acre-Feet (TAF) for All Scenarios.

Table 5-11. Mean Monthly CVP Deliveries to NOD and SOD Contractors in Thousand Acre-Feet (TAF) from the Trinity River Division for All Scenarios.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Baseline	229	170	88	77	120	137	283	640	831	956	740	343	4,614
Scenario 1	228	170	88	77	120	136	282	639	829	954	739	342	4,604
Diff (TAF)	-2	1	0	0	0	0	-1	-2	-2	-2	-1	-1	-11
Diff (%)	-0.7	0.5	-0.3	-0.1	-0.1	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.3	-0.2
Scenario 2	228	171	88	77	120	136	282	639	829	954	739	343	4,605
Diff (TAF)	-2	1	0	0	0	-1	-1	-2	-2	-2	-1	-1	-10
Diff (%)	-0.7	0.8	-0.3	-0.1	-0.1	-0.4	-0.4	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2
Scenario 3	228	171	88	77	120	136	282	639	829	954	739	342	4,604
Diff (TAF)	-2	1	0	0	0	-1	-1	-2	-2	-2	-1	-1	-10
Diff (%)	-0.7	0.6	-0.3	-0.1	-0.1	-0.4	-0.3	-0.3	-0.2	-0.2	-0.2	-0.3	-0.2
Scenario 4	222	163	83	72	114	125	262	611	793	915	713	331	4,404
Diff (TAF)	-7	-7	-5	-5	-6	-11	-21	-29	-38	-41	-27	-13	-210
Diff (%)	-3.2	-3.9	-5.4	-6.7	-5.1	-8.2	-7.5	-4.6	-4.6	-4.2	-3.7	-3.7	-4.6
Scenario 5	228	171	88	77	120	136	282	639	829	954	739	342	4,604
Diff (TAF)	-2	1	0	0	0	-1	-1	-2	-2	-2	-1	-1	-10
Diff (%)	-0.7	0.8	-0.4	-0.1	-0.1	-0.4	-0.4	-0.3	-0.2	-0.2	-0.2	-0.3	-0.2
Scenario 6	228	170	88	76	119	135	279	635	825	950	735	341	4,580
Diff (TAF)	-2	0	-1	0	0	-2	-4	-6	-6	-6	-5	-2	-34
Diff (%)	-0.7	0.0	-0.7	-0.6	-0.4	-1.6	-1.4	-0.9	-0.7	-0.6	-0.7	-0.6	-0.7
Scenario 7	226	168	87	75	118	134	277	633	820	944	735	340	4,558
Diff (TAF)	-3	-1	-1	-2	-2	-3	-6	-7	-11	-12	-5	-3	-57
Diff (%)	-1.4	-0.7	-1.4	-2.2	-1.7	-2.2	-2.0	-1.2	-1.3	-1.3	-0.7	-0.9	-1.2

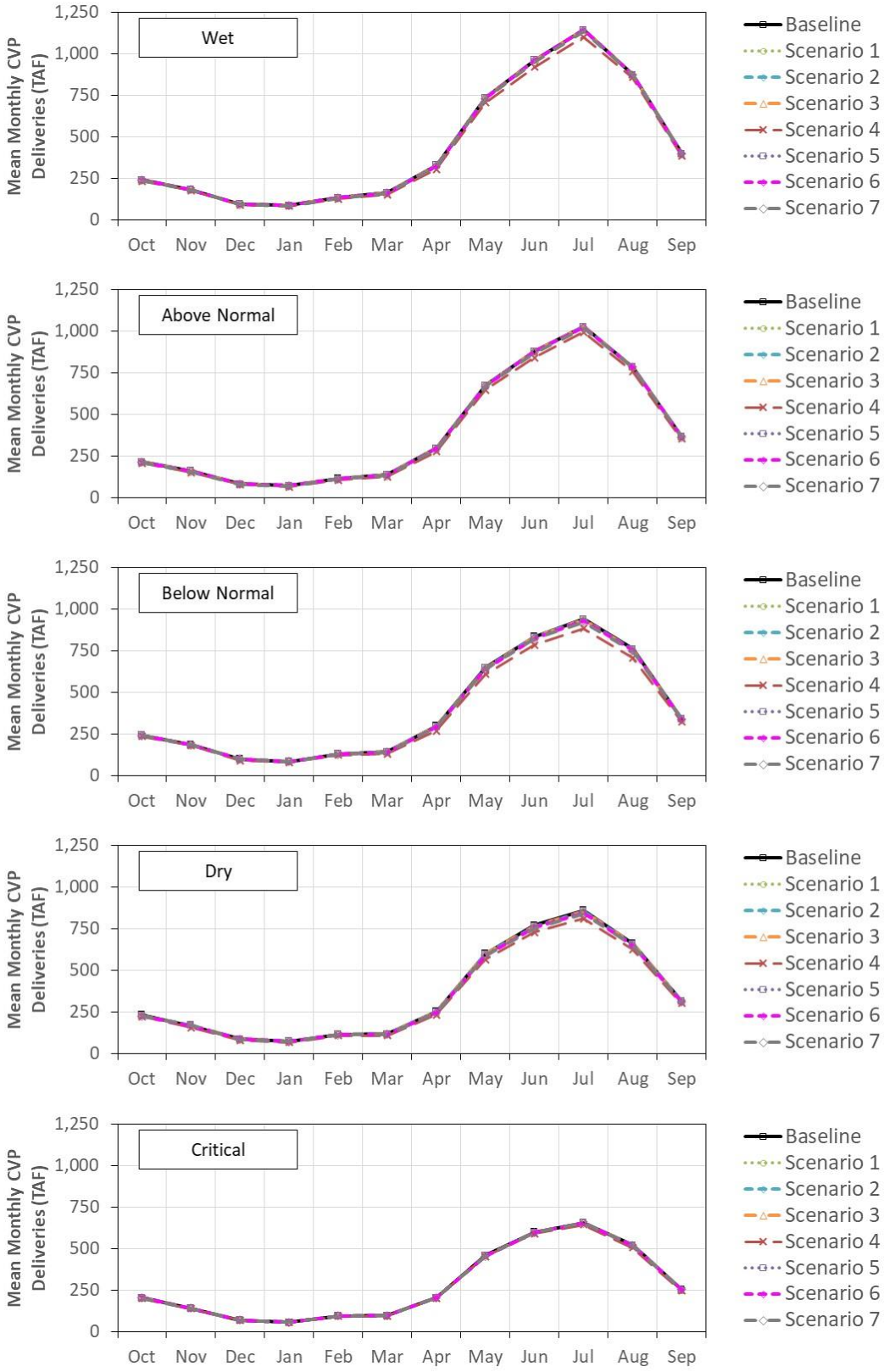


Figure 5-41. Mean Monthly CVP Deliveries to NOD and SOD Contractors in Thousand Acre-Feet (TAF) for All Scenarios by Sacramento Valley Water Year Type.

5.6.4 Lake Shasta Storage

Total Lake Shasta storage was modeled in CalSim II on a mean monthly basis. As described in Section 3.1.2, CVP delivery reductions were balanced by Lake Shasta releases in different ways depending on the scenario to balance the release of Contract Water down the Trinity River.

Mean monthly Lake Shasta storage is shown in Figure 5-42 and Table 5-11, and mean monthly CVP deliveries by water year type are shown in Figure 5-43. Key takeaways include the following:

- Mean annual reductions in Lake Shasta storage are primarily a result of increased releases that offset the reduction in TRD exports. For scenarios 1 – 3 and 5, Lake Shasta was allowed to release more water and drop storage slightly lower relative to the baseline to make up the difference in CVP delivery cuts. This resulted in mean annual Lake Shasta storage reductions of around 20 TAF (-0.5%) relative to the baseline for these scenarios.
- For Scenario 4, to offset the larger reduction in TRD exports due to larger Contract Water release volumes, CVP deliveries were cut, and Lake Shasta was allowed to release only slightly more water relative to the baseline. This resulted in mean annual Lake Shasta storage reductions of around 6 TAF (-0.2%) relative to the baseline.
- Scenarios 6 and 7 were operated similar to Scenario 4 – CVP deliveries were cut, but Lake Shasta was operated to maintain storage similar to the baseline. This required greater cuts to CVP deliveries than Scenarios 1 – 3 and 5, but mean annual Lake Shasta storage reductions were only 6 TAF (-0.2%) less than the baseline.
- CVP delivery reduction magnitudes were similar across all years for Scenarios 1 – 3 and 5 – 7. For Scenario 4, CVP delivery reductions were greater in wetter years and less in drier years.

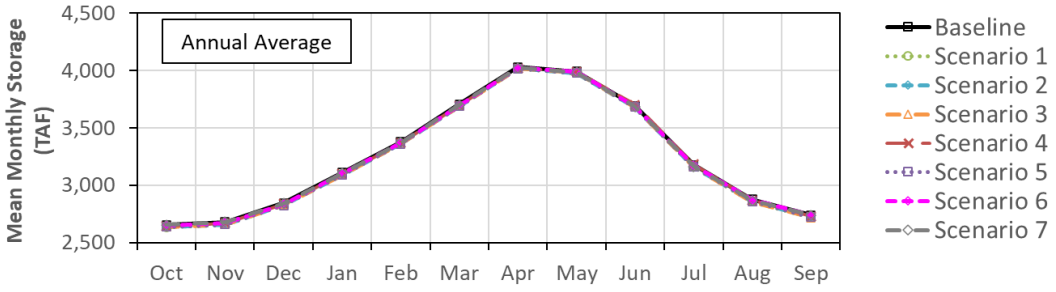


Figure 5-42. Lake Shasta Mean Monthly Storage in Thousand Acre-Feet (TAF) for All Scenarios.

Table 5-12. Lake Shasta Mean Monthly Storage in Thousand Acre-Feet (TAF) for All Scenarios.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean
Baseline	2,655	2,678	2,843	3,108	3,378	3,705	4,032	3,992	3,693	3,175	2,876	2,740	3,239
Scenario 1	2,634	2,657	2,825	3,090	3,361	3,689	4,016	3,979	3,680	3,158	2,855	2,717	3,222
Diff (TAF)	-21	-21	-18	-18	-16	-16	-16	-14	-13	-18	-21	-22	-18
Diff (%)	-0.8	-0.8	-0.6	-0.6	-0.5	-0.4	-0.4	-0.3	-0.4	-0.6	-0.7	-0.8	-0.5
Scenario 2	2,637	2,658	2,825	3,088	3,360	3,688	4,016	3,978	3,680	3,159	2,857	2,721	3,222
Diff (TAF)	-17	-19	-18	-20	-18	-17	-16	-14	-13	-16	-19	-19	-17
Diff (%)	-0.7	-0.7	-0.6	-0.6	-0.5	-0.5	-0.4	-0.4	-0.4	-0.5	-0.6	-0.7	-0.5
Scenario 3	2,635	2,658	2,826	3,089	3,361	3,689	4,017	3,980	3,681	3,159	2,856	2,719	3,222
Diff (TAF)	-20	-20	-17	-19	-16	-16	-15	-13	-12	-17	-20	-21	-17
Diff (%)	-0.7	-0.7	-0.6	-0.6	-0.5	-0.4	-0.4	-0.3	-0.3	-0.5	-0.7	-0.8	-0.5
Scenario 4	2,645	2,669	2,838	3,099	3,367	3,695	4,021	3,990	3,701	3,184	2,868	2,729	3,234
Diff (TAF)	-10	-8	-5	-9	-10	-10	-10	-2	8	9	-8	-10	-6
Diff (%)	-0.4	-0.3	-0.2	-0.3	-0.3	-0.3	-0.3	-0.1	0.2	0.3	-0.3	-0.4	-0.2
Scenario 5	2,637	2,658	2,825	3,088	3,360	3,688	4,016	3,978	3,680	3,159	2,857	2,720	3,222
Diff (TAF)	-17	-19	-18	-20	-18	-17	-16	-14	-13	-17	-19	-19	-17
Diff (%)	-0.7	-0.7	-0.6	-0.6	-0.5	-0.5	-0.4	-0.3	-0.4	-0.5	-0.7	-0.7	-0.5
Scenario 6	2,650	2,671	2,835	3,098	3,368	3,696	4,024	3,987	3,690	3,173	2,873	2,738	3,233
Diff (TAF)	-5	-7	-8	-10	-10	-9	-8	-6	-3	-3	-3	-2	-6
Diff (%)	-0.2	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2
Scenario 7	2,654	2,677	2,841	3,102	3,372	3,699	4,025	3,986	3,683	3,162	2,867	2,737	3,234
Diff (TAF)	0	0	-3	-6	-6	-6	-7	-6	-10	-14	-9	-2	-6
Diff (%)	0.0	0.0	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.4	-0.3	-0.1	-0.2

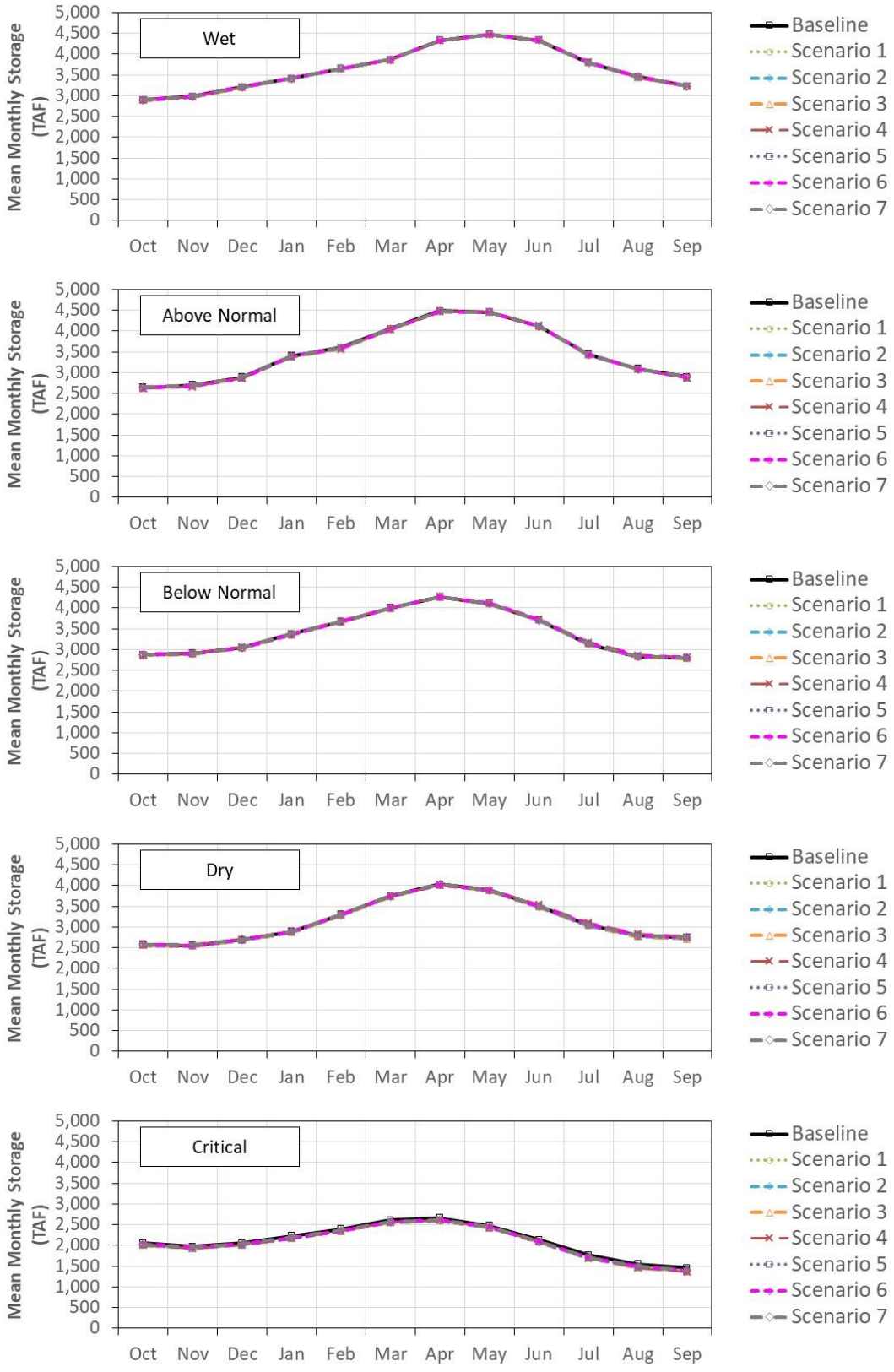


Figure 5-43. Lake Shasta Mean Monthly Storage in Thousand Acre-Feet (TAF) for All Scenarios by Sacramento Valley Water Year Type.

5.6.5 Clear Creek Above Sacramento River Water Temperature

Daily water temperatures in Clear Creek above the Sacramento River were modeled in HEC-5Q. Mean monthly water temperatures are shown in Figure 5-44 and Table 5-13, and mean monthly water temperatures by water year type are shown in Figure 5-45. Key takeaways include the following:

- All scenarios showed a similar mean annual result, with minimal water temperature changes relative to the baseline (between 0 and -0.2 F, or 0 to -0.2% change annually).
- In wetter years, Scenario 4 showed slightly increased water temperatures of 0.5 – 1 F in August and September relative to the baseline, a result of the larger relative decrease in volume of cold-water TRD exports.
- In drier years, Scenario 7 showed slightly decreased water temperatures of 0.5 – 1 F in August through January relative to the baseline, a result of the increase in storage in Trinity Reservoir that decreased the water temperature of Trinity Reservoir releases and TRD exports.

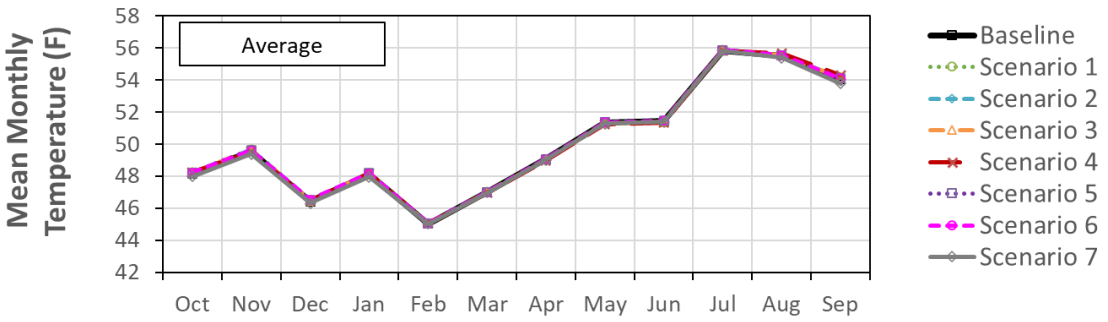


Figure 5-44. Clear Creek Above Sacramento River Mean Monthly Water Temperature in Degrees Fahrenheit (F) for All Scenarios.

Table 5-13. Clear Creek Above Sacramento River Mean Monthly Water Temperature in Degrees Fahrenheit (F) for All Scenarios.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean
Baseline	48	50	46	48	45	47	49	51	51	56	56	54	50
Scenario 1	48	50	46	48	45	47	49	51	51	56	56	54	50
Diff (°F)	0.1	0.1	0.0	0.1	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.1	0.0
Diff (%)	0.2	0.2	0.1	0.2	0.0	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.2	0.0
Scenario 2	48	50	47	48	45	47	49	51	51	56	56	54	50
Diff (°F)	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diff (%)	0.1	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Scenario 3	48	50	46	48	45	47	49	51	51	56	56	54	50
Diff (°F)	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Diff (%)	0.2	0.2	0.1	0.2	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.2	0.0
Scenario 4	48	50	46	48	45	47	49	51	51	56	56	54	50
Diff (°F)	0.1	0.0	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.1	0.2	0.0
Diff (%)	0.2	-0.1	0.1	0.2	0.1	-0.1	-0.2	-0.2	-0.2	0.0	0.2	0.4	0.0
Scenario 5	48	50	47	48	45	47	49	51	51	56	56	54	50
Diff (°F)	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diff (%)	0.1	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Scenario 6	48	50	47	48	45	47	49	51	51	56	56	54	50
Diff (°F)	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diff (%)	0.1	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1
Scenario 7	48	49	46	48	45	47	49	51	51	56	55	54	50
Diff (°F)	-0.2	-0.2	-0.1	-0.2	0.0	0.0	0.0	-0.1	-0.1	0.0	-0.2	-0.3	-0.1
Diff (%)	-0.4	-0.3	-0.2	-0.4	0.0	-0.1	-0.1	-0.2	-0.1	0.0	-0.3	-0.5	-0.2

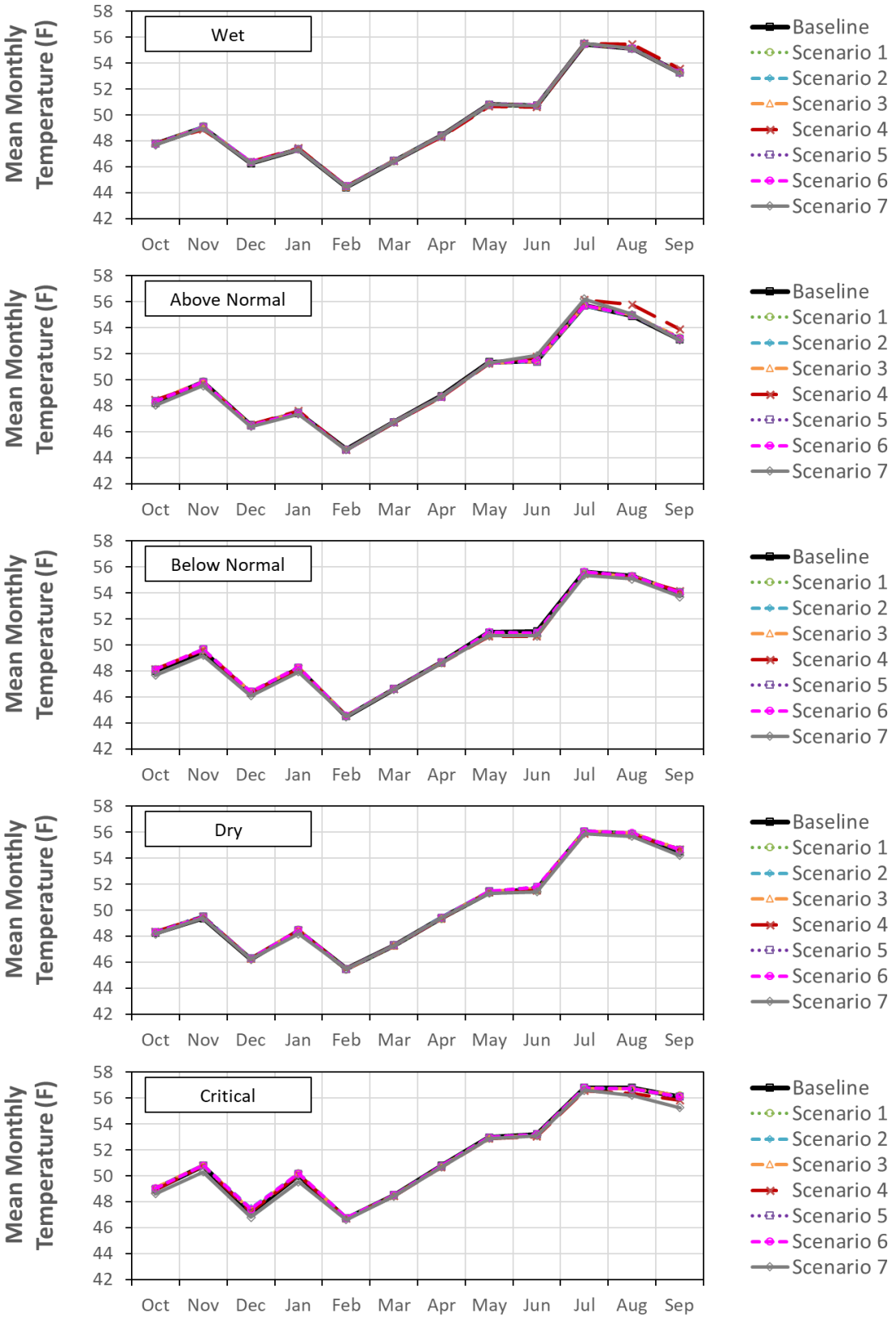


Figure 5-45. Clear Creek Above Sacramento River Mean Monthly Water Temperature in Degrees Fahrenheit for All Scenarios by Sacramento Valley Water Year Type.

5.6.6 Sacramento River Below Clear Creek Water Temperature

Water temperatures in Sacramento River below Clear Creek were modeled in HEC-5Q. Daily water temperatures in the Sacramento River below Clear Creek reflects the weighted flow and temperature contributions of the flow in Clear Creek and the flow in the Sacramento River that was released from Lake Shasta. By separately comparing the water temperatures in Clear Creek above the Sacramento River and the Sacramento River below Clear Creek, the relative influences of TRD export reductions and Lake Shasta release reductions can be evaluated.

Mean monthly Sacramento River water temperatures are shown in Figure 5-46, Figure 5-44 and Table 5-14, and mean monthly Sacramento River water temperatures by water year type are shown in Figure 5-47. Key takeaways include the following:

- All scenarios showed a similar mean annual result, with minimal water temperature changes relative to the baseline in most months, and a slight increase in water temperatures (between 0 and 0.5 F, or 0 to 0.8% change annually) in July and August. Because water temperatures in Clear Creek did not generally show an increase relative to baseline for the scenarios, the slight increase in Sacramento River water temperatures is attributed to changes in Lake Shasta storage and releases.
- July water temperature increases were consistent across water year types, while August and September water temperature increases were greater in drier years relative to the baseline.
- Contract Water releases targeting the fall or spring had the same effect on Sacramento River water temperature, indicating the effects of each scenario on Sacramento River water temperature were independent of release timing.
- Despite the relatively larger cut to TRD exports, Scenario 4 did not have significantly greater effects on Sacramento River water temperatures than any other scenario.

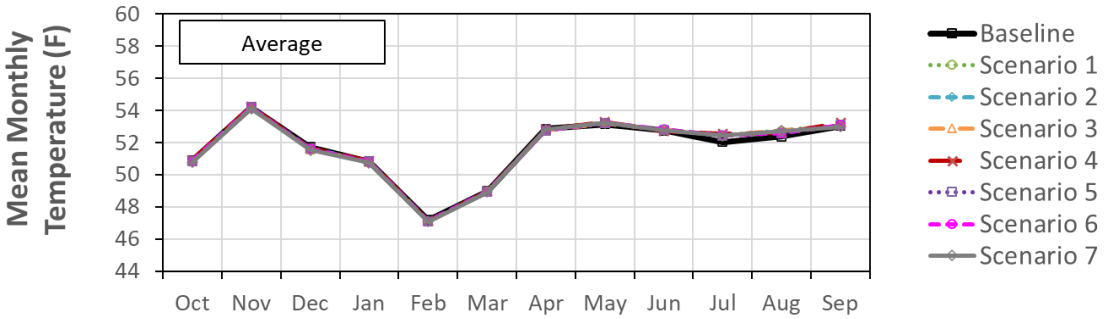


Figure 5-46. Sacramento River below Clear Creek Mean Monthly Water Temperature in Degrees Fahrenheit (F) for All Scenarios.

Table 5-14. Sacramento River below Clear Creek Mean Monthly Water Temperature in Degrees Fahrenheit (F) for All Scenarios.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean
Baseline	51	54	52	51	47	49	53	53	53	52	52	53	52
Scenario 1	51	54	52	51	47	49	53	53	53	52	53	53	52
Diff (°F)	0.0	0.0	-0.1	0.0	-0.1	0.0	-0.1	0.1	0.0	0.4	0.4	0.0	0.0
Diff (%)	0.0	-0.1	-0.3	0.0	-0.2	-0.1	-0.2	0.1	0.1	0.8	0.7	0.1	0.1
Scenario 2	51	54	52	51	47	49	53	53	53	52	53	53	52
Diff (°F)	0.0	0.0	-0.1	0.0	-0.1	0.0	-0.1	0.1	0.1	0.4	0.2	0.0	0.0
Diff (%)	0.0	0.0	-0.1	0.0	-0.1	-0.1	-0.2	0.1	0.1	0.8	0.4	0.1	0.1
Scenario 3	51	54	52	51	47	49	53	53	53	52	53	53	52
Diff (°F)	0.0	0.0	-0.1	0.0	-0.1	0.0	-0.1	0.1	0.0	0.4	0.4	0.0	0.0
Diff (%)	0.0	-0.1	-0.2	0.0	-0.2	-0.1	-0.2	0.1	0.1	0.8	0.8	0.1	0.1
Scenario 4	51	54	52	51	47	49	53	53	53	53	53	53	52
Diff (°F)	0.0	0.0	-0.1	0.0	-0.1	0.0	0.0	0.1	0.0	0.5	0.3	0.2	0.1
Diff (%)	0.1	0.1	-0.1	0.1	-0.1	0.0	-0.1	0.2	-0.1	1.0	0.5	0.3	0.2
Scenario 5	51	54	52	51	47	49	53	53	53	52	53	53	52
Diff (°F)	0.0	0.0	-0.1	0.0	-0.1	0.0	-0.1	0.1	0.1	0.4	0.2	0.1	0.0
Diff (%)	0.0	0.0	-0.1	0.0	-0.1	-0.1	-0.2	0.1	0.1	0.8	0.4	0.1	0.1
Scenario 6	51	54	52	51	47	49	53	53	53	52	53	53	52
Diff (°F)	0.0	0.0	-0.1	0.0	-0.1	0.0	-0.1	0.1	0.1	0.4	0.2	0.0	0.0
Diff (%)	0.0	-0.1	-0.2	0.0	-0.1	-0.1	-0.2	0.2	0.1	0.8	0.4	0.1	0.1
Scenario 7	51	54	52	51	47	49	53	53	53	52	53	53	52
Diff (°F)	-0.1	-0.1	-0.2	-0.1	-0.1	0.0	-0.1	0.1	0.0	0.4	0.4	-0.1	0.0
Diff (%)	-0.2	-0.1	-0.3	-0.2	-0.2	-0.1	-0.1	0.1	0.1	0.8	0.7	-0.1	0.0

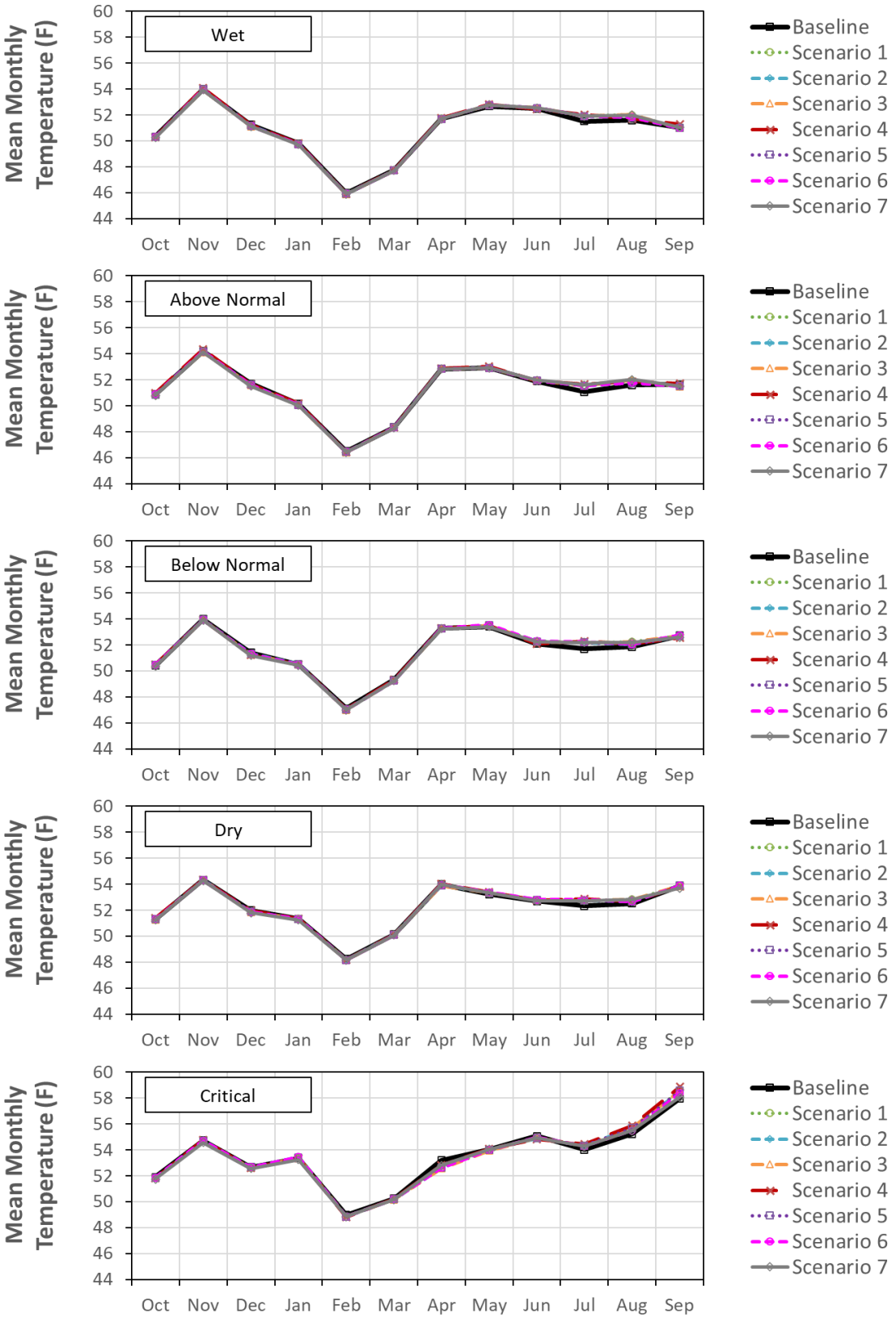


Figure 5-47. Sacramento River below Clear Creek Mean Monthly Water Temperature in Degrees Fahrenheit for All Scenarios by Sacramento Valley Water Year Type.

5.7 Non-Modeled Factors

The seven modeled scenarios each cite one or more objectives that were expected to positively benefit Chinook Salmon and other aquatic species in the Trinity River. Table 4-1 and Table 4-5 highlight beneficial factors which were expected under each release scenario and indicate which were captured quantitatively by the suite of models used in this project, and which were not modeled. The non-modeled factors and the expected benefits or potential impacts of each are described below.

- **All Scenarios: Increased spawning and rearing habitat and distribution of Coho, steelhead, and lamprey.** The effects of increased habitat in the Micro-Habitat Model and S3 are only quantified for natural Chinook Salmon and not for other species that spawn and rear in the Trinity River and lower Klamath River, including Coho Salmon, steelhead, and lamprey. The effects of Contract Water releases on these species were not assessed, though workshop participants hypothesized releases that benefitted Chinook Salmon would also benefit these species. In addition, the interactions between Chinook Salmon and these other species are not represented. Biologic pulse flows (Scenarios 2, 3(B), 4, 5) are expected to redistribute or disperse these other species, which should provide a benefit to rearing Chinook Salmon by decreasing local competition for resources. However, increased spawning and rearing habitat for Coho Salmon and steelhead provided by Scenarios 1 and 6 could negatively affect Chinook Salmon by increasing their competition with these other species.
- **Scenarios 2, 4, 5: Recruitment/entrainment of organic matter (leaf litter, insects, benthic invertebrates).** Biologic pulses are expected to distribute leaf litter for masticating insects, recruit organic matter into the river to support invertebrates and primary producers that utilize detritus as a food resource, entrain terrestrial insects into the river as a food source, and suspend benthic macroinvertebrates into the water column for food. All of these factors would be expected to increase food supply and nutrients for rearing fish, enhancing juvenile survival and increasing fish size.
- **Scenarios 3 and 4: Resetting the macroinvertebrate community.** Geomorphic pulses reach magnitudes (≥ 6,000 cfs) known to be sufficient to transport gravel and disturb biofilm. This process would create clean surfaces for microorganisms to colonize, which could recruit macroinvertebrate species at higher densities, increasing benthic productivity and food availability for rearing salmonids. All of these factors would be expected to increase food supply and nutrients for rearing fish, enhancing juvenile survival and increasing fish size.
- **Scenarios 3 and 4: Scouring and geomorphic changes**. SRH-2D and the Micro-Habitat Model assume a static topography using the 2018 survey data. Geomorphic pulses reach magnitudes (≥ 6,000 cfs) known to be sufficient to provide significant scour, geomorphic changes to the morphological structure including transporting large woody debris, sediment load, and sediment composition in Trinity River. Maintaining dynamic processes are closer to the natural river environment created by the pre-dam hydrograph and would be expected to provide habitat and ecological services conducive to all life stages of salmonids.
- **Scenarios 2, 3, 4, 5: Biologic pulses in fall (Scenarios 2, 4, 5) or spring (Scenario 3) timed with hatchery operations.** In the fall (October), yearling hatchery Chinook Salmon are released. In spring (March-April), hatchery Coho Salmon, hatchery steelhead smolt, and additional hatchery Chinook Salmon are released. Fall and spring pulses could aid with disbursement of juveniles released from the hatchery, alleviating competition

between natural and hatchery fish. This would be expected to enhance juvenile survival. Fall pulses could improve attraction flows for adult salmonids to the hatchery, increasing the amount of salmonids and steelhead trapped for spawning and increase the intermixing of natural and hatchery fish, which improves genetic diversity.

- **Scenario 6: Risk of redd dewatering when baseflow releases are reduced in January.** A drop in flows during the spawning, egg incubation, or fry emergence life stage could result in a drop in water surface elevation, which could dewater redds, eggs, and larvae, or have other detrimental effects such as changes in pressure, interstitial flow, and dissolved oxygen concentrations. This would be expected to negatively impact the benefits to Chinook Salmon by reducing egg survival.

6 SUMMARY

A set of modeling tools including CalSim II, HEC-5Q, RBM10, sediment models, Chinook Salmon habitat models, and S3, were applied to evaluate the effects of releasing at least 50 TAF of additional flow annually down the Trinity River. The tools simulated a baseline condition and seven different release scenarios. For each scenario, primary model outputs included Trinity Reservoir and CVP system operations, water temperature in Trinity Reservoir, Lewiston Reservoir, and Lake Shasta, Lewiston Reservoir releases, flow and water temperature in the Trinity River and Sacramento River, and the resulting effects on sediment transport, Chinook Salmon habitat, and Chinook Salmon abundance, survival, and growth in the Trinity River.

Modeling results are summarized below, quantitatively in Table 6-1 and also narratively in the following subsections, based on effects of Contract Water releases, relative to the baseline, on Trinity Reservoir, Trinity River juvenile Chinook Salmon, and the CVP system.

Effects on Trinity Reservoir
All Contract Water scenarios that released at least 50 TAF annually from Trinity Reservoir had similar effects on Trinity Reservoir storage. In general, these scenarios reduced mean annual Trinity Reservoir storage by 30 to 50 TAF, with smaller storage reductions of 0 to 10 TAF in wetter years and greater storage reductions of 50 to 100 TAF in drier years. The storage reduction was a result of increased annual releases to the Trinity River, and decreased exports to the CVP. In wetter years, the storage volume reduction, relative to the baseline, created by releasing Contract Water could be refilled with natural inflow that otherwise would have been passed downstream through a safety-of-dams release. In consecutive drier years, natural inflow could not increase the storage volume reduction, and the effects of Contract Water began to accumulate, resulting in greater storage differences. When Contract Water was held as carryover and not released, the opposite effect was observed in drier years. An additional 50 TAF was allowed to accumulate, and storage increased by up to 350 TAF when a safety-of-dams release did not occur for multiple years.

Changes in Trinity Reservoir storage resulted in relatively small changes to Trinity Reservoir release temperature. Contract Water scenarios that released at least 50 TAF annually had similar effects – small increases in release temperature of up to 0.2°F from June through January. Scenario 4 released up to 170 TAF of Contract Water annually, which led to lower Trinity Reservoir summer storage levels and an increase in release temperature of up to 0.4°F in summer months. For Scenario 7 (carryover), release temperature decreased up to 0.4°F in summer months. These trends in release temperature changes were generally preserved through Lewiston Reservoir and into the Trinity River, but scenarios that released more water in March and April generally reduced water temperatures by up to 1.7°F, the result of higher magnitude cold water releases being routed through Lewiston Reservoir.

Table 6-1. Mean Annual Percent Changes Between the Scenario Metric and the Baseline Metric for the Seven Modeled Contract Water Release Scenarios in the Restoration Reach of the Trinity River.

	Modeling Tool	CalSim II		Sediment Transport		Habitat Model			Stream Salmonid Simulator (S3)				
	Primary Analysis Metric	Mean annual Lewiston releases	Mean annual CVP Contract deliveries	Total sediment mobilized	Stream bed mobil-ization	Redd habitat area	Fry capacity	Parr capacity	Egg survival	Juvenile survival	Abun-dance	Biomass	Fish mass
Scenario #	Scenario Description	Thousand acre-feet	Thousand acre-feet	Tons/year	% bed mobilized	Mean ha (Oct-Dec)	Mean n per m^2 (Mar-May)	Mean n per m^2 (Mar-May)	Mean annual %	Mean annual %	Mean annual n of fish	Mean annual metric tons	Mean annual grams/n
1	Building baseflow	**5%**	-0.2%	-0.3%	0.0%	0.5%	-1.6%	**2.3%**	-0.4%	0.5%	0.2%	**-4.0%**	-1.6%
2	Fall pulses	**5%**	-0.2%	-1.6%	-0.1%	0.4%	-0.8%	0.0%	1.3%	-0.9%	0.4%	0.9%	**3.1%**
3	Geomorphic pulse or spring pulses	**5%**	-0.2%	**7.5%**	**6.4%**	0.0%	0.0%	**2.3%**	-0.3%	-0.5%	-0.7%	**-2.4%**	**2.3%**
4	Combine scenarios 1-3	**22%**	**-4.6%**	**15.0%**	**7.0%**	0.2%	**3.2%**	**10.5%**	0.9%	1.4%	**2.6%**	**-2.8%**	-1.6%
5	Fall pulses with storage-based delay	**5%**	-0.2%	-1.4%	-0.1%	0.2%	-0.7%	-1.0%	1.2%	-0.9%	0.3%	0.8%	0.6%
6	Fall baseflow	**5%**	-0.7%	-1.5%	0.0%	**5.1%**	-0.7%	-1.0%	**2.6%**	0.2%	**2.9%**	**2.8%**	-0.1%
7	Carryover	**5%**	-1.2%	**7.9%**	0.3%	0.0%	**4.6%**	**4.0%**	0%	-0.1%	-0.1%	0.3%	0.4%

Notes:
The first row lists the modeling tool used, the second row lists the primary evaluation metric, and the third row lists the units below each primary evaluation metric.
Metrics with greater than a positive 2% change relative to the baseline are presented in bold and highlighted gray.
Metrics with less than a negative 2% change relative to the baseline are presented in bold and highlighted orange.
Key: TAF = thousand acre-feet, ha = hectares, % = percent, m = meters, n = number of fish

Effects on Trinity River Physical Parameters

The effects of Contract Water releases on Trinity River flow and temperature were evaluated at Pear Tree, which is typically where fish production and migration rates are measured and a location that receives inflow from additional tributaries between Lewiston Reservoir and North Fork Trinity River. For all scenarios, mean daily Trinity River water temperature differences relative to the baseline were generally less than 2°F, and less than 4°F for short duration periods (peak day of pulse or safety-of-dams release). Daily water temperatures were generally reduced the most in the fall due to baseflow releases (Scenario 6) and in the spring due to baseflow and pulse flow releases (Scenarios 1, 3, and 4). The largest decreases in mean daily water temperature of -8°F in some years were in the spring. In most years, water temperatures in January through March were either equivalent to the baseline, or slightly higher due to lower Trinity Reservoir storage and lower magnitude cold water safety-of-dams releases. Trinity River water temperatures in April through June were generally similar to the baseline. July through September Trinity River water temperatures were generally increased by 0°F to 4°F for most scenarios except Scenario 7, which decreased water temperatures in some drier years.

Planned geomorphic pulses (Scenarios 3 and 4) or large relative magnitude safety-of-dams releases (Scenario 7) were required to initiate materially quantifiable bedload transport and streambed mobilization relative to the baseline. Scenarios 1, 2, 5, and 6 did not significantly affect bedload transport or partial bed mobilization. Sediment transport exhibited a high degree of interannual variability, as only 42% of modeled years exhibited coarse bedload transport >10,000 tons above the baseline in scenarios 3,4, and 7 and only 33% of modeled years increased the fraction of bed mobilized >10% above the baseline in scenarios 3 and 4. The greatest effect on sediment and geomorphic work relative to the baseline was observed when a safety-of-dams release was timed with a Contract Water pulse release (Scenarios 3 and 4), or when Contract Water carryover increased the safety-of-dams release magnitude (Scenario 7). Most of the transport and mobilization of sediment occurred in the downstream reaches of the Restoration Reach between Weaver Creek and North Fork Trinity River; however, because the majority of redds are established directly below Lewiston, relatively small increases in sediment mobilized in the upper reaches may create a larger impact on fish spawning habitat.

Effects on Trinity River Juvenile Chinook Salmon

The effects of Contract Water releases on spawning and rearing habitat were primarily a function of the timing, duration, and magnitude of flow changes relative to the baseline. Fall flows released as pulses (Scenarios 2, 4, and 5) increased redd habitat area on the ascending and receding limbs of the pulse, and decreased habitat during the peak of the pulse. These scenarios produced higher egg survival relative to the baseline, indicating an overall net positive effect on spawning habitat suitability. Fall flow released as a baseflow had a longer duration and more frequent positive effect on redd habitat area, which translated to the highest egg survival of all scenarios relative to the baseline. Note the model did not account for the potential effects of redd dewatering following a reduction in baseflows on January 1. All other scenarios did not explicitly target fall releases, and had minor effects on redd habitat area. Spring releases generally increased fry and parr capacity regardless of whether those releases were a pulse or a baseflow. For scenarios that released water primarily in the fall, Trinity Reservoir storage was generally lower in the winter months, which allowed storage to stay below flood pool elevations for longer, resulting in lower average magnitude safety-of-dams releases relative to the baseline. This indirect effect of Contract Water releases resulted in reductions in spring habitat capacity in some years.

Contract Water release scenarios had different effects on juvenile Chinook Salmon egg survival, survival from emergence to Pear Tree, abundance, size, and biomass based on scenario specific combinations of flow and temperature. Contract Water released in the fall had the greatest beneficial effects on egg survival, with flow released as a baseflow increasing survival more than flows released as a pulse flow. Juvenile fish survival increased for scenarios with higher magnitude releases in March and April (Scenarios 1 and 4), when juveniles are rearing, and also for Scenario 6, which had the highest egg survival rate. The largest increases in annual juvenile abundance were for Scenario 4, which released the largest volume of Contract Water, and Scenario 6, which had the highest egg survival rate. Scenario 6 released 50 TAF annually and produced higher abundance than Scenario 4, which released 170 TAF annually, highlighting the effect of Contract Water release timing, rather than magnitude, as a key parameter influencing modeled population dynamics. Contract Water scenarios that released higher magnitude, cooler (1 to 2°F) water in the spring – Scenarios 1, 3, and 4 – had the largest reductions in mean annual fish mass, while all other scenarios produced fish mass relatively similar to the baseline. Mean annual juvenile biomass changes reflect differences in both abundance and fish size. Consequently, Scenario 6 produced the largest biomass increase relative to the baseline. Scenarios that reduced fish size also had a reduction in annual biomass relative to the baseline.

Effects on CVP System

Two methods of CVP re-operation to balance TRD export reductions were modeled for each scenario that assumed 50 TAF of annual Contract Water use. The first increased releases from Lake Shasta and maintained similar CVP contract delivery amounts NOD and SOD. Under this method, mean annual CVP deliveries NOD and SOD were reduced about 10 TAF (-0.2%), and mean annual Lake Shasta storage was reduced 20 TAF (-0.5%) relative to the baseline. The second method reduced CVP deliveries and maintained similar Lake Shasta storage and releases. Under this method, CVP delivery reductions ranged from 34 TAF (-0.7%) to 57 TAF (-1.2%) relative to the baseline, and Lake Shasta storage was reduced 6 TAF (-0.2%) relative to the baseline. Sacramento River water temperatures below Clear Creek were generally similar to the baseline for each method, with increases of around 0.4°F in July and August.

It is concluded that Contract Water scenarios that release at least 50 TAF annually from Trinity Reservoir have similar effects on the CVP system. The magnitude of effects on Lake Shasta storage and CVP deliveries would differ whether the first or second method described above was used to adjust CVP operations, but the magnitude of effects would not vary across the type of Contract Water release made from Trinity Reservoir. Whether releases were made annually as a fall baseflow, fall pulse flow, spring pulse flow, or spring baseflow, they all resulted in similar storage patterns in Trinity Reservoir – an annual reduction in storage relative to the baseline that was relatively small in wetter years and larger in drier years. This lower storage pattern created a similar reduction in TRD exports to the CVP. Because the timing of exports is similar each year, the reduction to exports occurred at the same time each year, independent of Contract Water release timing, resulting in similar storage, CVP delivery, and water temperature effects in the Sacramento River basin portion of the CVP. The water temperature effects on the Sacramento River were primarily attributed to changes in storage, release magnitude, and release temperature from Lake Shasta, and not due explicitly to inflows from the TRD.

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Appendix D

Trinity River Water Management Plan

Workshops

Summary Notes from Workshops 1 – 6

Meeting Summary

Date/Time: July 13, 2022 / 8:30 AM PT

Subject: Water Management Plan for Utilization of Humboldt County Contract Water, Workshop #1

Place: Zoom

Attendees:

Attendee	Affiliation	Attendee	Affiliation
Hank Seemann	Humboldt County	Ken Lindke	CDFW
Steve Madrone	Humboldt County	Allison Mitchell	DOI
Craig Tucker	Suits and Signs Consulting	Elizabeth Hadley	Reclamation
Kyle De Julio	Yurok Tribe	Mike Dixon	Reclamation
Barry McCovey	Yurok Tribe	Adam Witt	Stantec
Amy Cordalis	Yurok Tribe	Mary Paasch	Stantec
Mike Orcutt	Hoopa Valley Tribe	Blair Greimann	Stantec
Jason Reed	Hoopa Valley Tribe	Paul Uncapher	Stantec
Darren Mierau	CalTrout	Stephanie Theis	Stantec
Nick Som	USFWS	Arielle Gervasi	Stantec
Bill Pinnix	USFWS	Derek Morimoto	Stantec
Seth Naman	NMFS	Thomas Gast	Thomas Gast & Assoc.

Agenda:

Item	Responsible Party
1. Introduction	Craig Tucker
2. California Wildlife Conservation Board Grant No. WC-2157AB	Hank Seemann
3. Project Background	Adam Witt
4. Water Management Plan	Adam Witt
5. Baseline Conditions	Adam Witt
6. Initial Discussion on Limiting Factors	Adam Witt
7. Next Steps and Action Items	Adam Witt

Purpose and Objectives:

The purpose of this workshop was to provide an overview of the project, present models and tools to assess baseline conditions and project alternatives once developed, and brainstorm potential limiting factors constraining fish productivity in the Trinity River.

The objectives of this workshop were to:

- Provide background, context, and overview for development of the Water Management Plan for use of Humboldt County Contract Water.
- Outline a plan for five future workshops.

- Identify the known body of data and best available science to inform the development of the Water Management Plan and to request information from attendees for any additional information.
- Share perspectives from workshop participants on limiting factors constraining fish productivity on the Trinity River.

Note: This Meeting Summary documents the discussions that followed the presentation. The content presented during the workshop can be viewed at: https://stantec.sharepoint.com/:b:/r/teams/TrinityContractWaterManagementPlan/Shared%20Documents/99_Secure_Data_Share/workshop_data_share/Workshop_1/20220713_FINAL_Humboldt_Workshop_1.pdf?csf=1&web=1&e=g6peDj

Workshop Summary:

Introduction

Craig Tucker presented the workshop agenda and objectives. Hank Seemann outlined the roles of each agency.

California Wildlife Conservation Board Grant No. WC-2157AB

Hank Seemann provided background information on Humboldt County Contract Water, specifically the contract signed between Humboldt County and Reclamation in 1959. The contract gives Humboldt County a contract right to annual releases from Trinity Reservoir (authorized under Proviso 2 of the 1955 Trinity River Division Act). Condition 8 of the contract states that not less than 50,000 acre-feet of water shall be released annually into the Trinity River for the beneficial use of Humboldt County and other downstream users. Hank Seemann explained why Humboldt County (herein referred to as "County") applied for California Wildlife Conservation Board Grant No. WC-2157AB funding to support a planning level analysis for development of a Water Management Plan for use of the County's Contract Water. The primary goal of the Plan is to guide the instream use of the Contract Water to benefit Tribal, recreational, and commercial fisheries and support a harvestable surplus. The Plan will include a proposed set of release scenarios and will define a proposed action over a 25-year planning period for a subsequent phase of environmental review and consultation.

Project Background

Adam Witt presented background information on the Trinity River near Lewiston Dam and key events relevant to the Water Management Plan since construction of the Trinity River Division in 1955.

Discussion that followed the presentation:

- Yurok and Hoopa Valley Tribes as downstream users expressed the need for equity between other downstream users and Humboldt County
    - Amy Cordalis noted that the Reclamation Solicitor formally identified the Yurok Tribe as a beneficiary and downstream user under Proviso 2, which should be added to the timeline. The Yurok's interests are the same as the County – to get water in the river as soon as possible because it is important for fish preservation and cultural survival. Efforts can get obstructed by legal issues. There should be equitability between all users and not provide benefits solely to the County. If we are going to go through process, it is worth doing correctly.
    - Mike Orcutt commented on Proviso 1 that an additional example of Reclamation using discretion was in August 2021. Under fall augmentation releases (FARs), Reclamation releases water pursuant to Proviso 1. In August 2021, Reclamation completed a separate EA to release water outside the window of the typical FARs, also pursuant to Proviso 1. He suggested additional context for the legislative history, specifically noting that the original intention of Proviso 2 specified economic benefits for the County and downstream water

users. He concurred with Amy Cordalis that Yurok was a 3rd party beneficiary of Proviso 2 and stated that the County is on record recognizing Hoopa as a downstream water user. These roles should be fully acknowledged so the Hoopa Valley and Yurok Tribes are appropriately included in the process.
    - Craig Tucker expressed the County's intent for continued discussions with the Yurok and Hoopa Valley Tribes regarding the proposed Memorandum of Understanding on the use and management of the Contract Water, separate and parallel to the technical discussions.
  - Mike Orcutt inquired about the definition of beneficial uses in the Contract, how it was originally defined and interpreted, and how it has changed over time.
    - Craig Tucker responded that it is complicated but encouraged the group to continue the Workshop focusing on the fisheries aspect while understanding that there will be another workstream focusing on policy and legal issues.

Water Management Plan

Adam Witt provided an overview of the Water Management Plan's objectives, process and schedule, and engagement and coordination.

Discussion that followed the presentation:

- Mike Orcutt asked who would be the senior person identified from the agencies for participation.
  - Nick Som stated that USFWS received a formal request from the County to participate in the project.
  - Hank Seemann added that the County set up an informal collaborative process for this project to cultivate the best-informed plan, with formal participation from USFWS and USGS via a letter requesting technical assistance.
- Seth Naman inquired what the Water Management Plan is, if Reclamation would be required to conduct NEPA, and, in terms of analysis, if they were only looking at 50 TAF or also what Reclamation is releasing to the river.
  - Craig Tucker stated that the County will work to define the legal requirements of NEPA and CEQA for implementing the water plan but that analysis will be in a different but parallel workstream.. Whatever the group proposes for the flow schedule will need to be consistent with the Trinity Division facilities and their operational limitations.
  - Ken Lindke inquired if the Water Management Plan will factor Reclamation's TRRP and Klamath River activities into the technical analyses. If the Winter Flow Variability project is implemented, that may modify the technical analysis.
  - Craig Tucker stated the challenge is that between the Klamath and Trinity, there are a lot of moving pieces.
- Mike Orcutt expressed concern about the quick completion timeframe, since it falls in line with the 2021 Reinitiation of Consultation for the Long-Term Operations of the CVP and SWP (2021 Consultation on LTO of CVP and SWP) and there is concern whether there will be time to implement the new 2021 Consultation on LTO of CVP and SWP without an acknowledgement of the Proviso 2 water. Communication with Reclamation is very important.
  - Seth Naman agreed that the 2021 Consultation on LTO of CVP and SWP needs to be considered. How/if this process fits in the 2021 Consultation on LTO of CVP and SWP should be noted in the project timeline, and stated efficiencies between the two processes may be leveraged.
  - Craig Tucker said this would be a good discussion between Reclamation and the County.
  - Supervisor Madrone was encouraged by the group coming together to decide the water use for the benefit of fish, Yurok and Hoopa Valley Tribes, and Klamath/Trinity; this project is long overdue.
- Other Data and Best Available Science to Inform Development of the Water Management Plan
  - Seth Naman suggested discussing this topic on another call with the TRRP technical staff to get their list of studies and reports.

- Ken Lindke clarified that CDFW maintains adult weir and hatchery data while USFWS and Yurok and Hoopa Valley Tribes maintain carcass, redd survey, and juvenile outmigration data.
- Mike Dixon noted that the NEPA document for the Winter Flow Variability Draft EA was changed into a Technical Report and is currently undergoing internal review. It would be better to reference the Technical Report rather than the draft EA.
- Kyle De Julio stated that hatchery production should be included in the data list. Most studies focused on natural production; there are no restrictions on natural versus hatchery fish for Proviso 2. He suggested the group may want to look for more information on the benefits of flow management on migrating hatchery versus natural production.

- Model overview
  - Adam Witt discussed that from 2001-2009, 648 TAF was released annually from the reservoir to the Trinity River and 614 TAF to Whiskeytown and the Sacramento River, so a little more than 50% goes to the Trinity River. CalSim II will be used to model these operations. Reservoir temperatures and cold-water pool are modeled with HEC5Q. SRH2D will be based on 2016 bathymetry and topography of the Trinity River near Lewiston Dam to the confluence with the North Fork.
  - Nick Som stated their model feeds river temperatures from RBM10 into habitat and production models, and they have to decide spawning rates and natural versus hatchery fish populations as model inputs.
- CalSim II vs. CalSim III
  - Seth Naman asked why CalSim III is not being used because it has a longer period of record. The background data goes to 2003, which limits the applicability of the results to water planning. In 2003, the year CalSim II went up to, there was a big shift in water availability for the Trinity River. There has also been a decline in water yield for the basin since 2003 and using this information to plan for the future comes with that caveat. Furthermore, the current drought is more severe than that in the 1930s, and the dust bowl area does not represent the most severe drought conditions.
  - Mary Paasch responded that there are tradeoffs in model selection for this and any project. Based on time and budget, CalSim II was the most appropriate tool since it has inputs, including climate change data, already established for the system. Although CalSim III goes up to 2015, it has not yet been fully vetted and used in a final environmental document. Integrating climate change models for the lower Klamath River into the analysis would be challenging, and Stantec would have spent more time and resources developing these inputs for CalSim III than was allowed by the current budget. The 82-year period of CalSim II should provide a statistically robust record.

<u>Initial Discussion on Limiting Factors</u>

The group brainstormed potential limiting factors that could affect fish productivity in the Trinity River.

- Flow
  - Ken Lindke stated that the TRRP has not conducted a formal limiting factors analysis on the Trinity River. The Winter Flow Variability EA captures their current understanding of factors affecting fish production. The flow in the upper river does not change as much compared to the lower river. In the upper river, the highest peak flows occur in the early winter and spring and management is at 300 cfs baseflow. There are efforts to move water earlier in the year. He cautioned that the work was developed on perceived constraints on how much volume they could adjust by water year type, so the flow schedule may not provide the maximum benefits possible. The Winter Flow Variability EA is currently under review and anticipated to be converted to a technical report in August. Regarding flow volume constraints, they remained within the ROD water allocations per water year type; just the timing of release was changed. The volume change prior to April depended on the B-120

forecast of water year type in March, and the Trinity forecast became available in February or March. In the past, that was not used for management because of uncertainty from forecast accuracy. February forecasts were used to determine volume. When the next forecast came in March, more water may or may not have been added to elevated prior releases. There was also a 60 TAF synchronized release from December 15 to February 15 if natural runoff of a certain magnitude was predicted. That is essentially the winter flow proposal.
    - Craig Tucker stated that this was similar to what the County, Yurok Tribe, and Hoopa Valley Tribe and the Services came up with in 2018 – that winter pulse flow events are important.
- Water temperature
    - Mary Paasch noted that the Klamath Long-Term Plan to Protect Adult Salmon in the Lower Klamath River Draft EIS (LTP EIS) identified that higher releases in August to September resulted in detrimental effects to fish due to elevated water temperatures in the fall (September/October), especially in dry and critical years when LTP EIS releases were more likely. She followed up with a question to the group on their opinions about water temperature as a limiting factor in the Trinity River.
    - Ken Lindke noted that water temperature in the fall is an issue, but more so recently in the Trinity River during low reservoir levels because the thermocline is lower, resulting in warmer release temperatures. This is a real possibility this year. Spring and summer releases are colder than ambient temperature, while fall releases are warmer than ambient temperature. Warmer fall and winter temperatures have not been an issue for incubating eggs for coho salmon. Furthermore, cold water can suppress growth in the spring and summer. A goal of the Winter Flow Variability EA was moving some water from the spring to winter to reduce negative impacts on growth from cold water suppression. Temperature as a limiting factor is seasonal.
    - Kyle De Julio added that release temperature is critically important and can limit production in various ways depending on context. Under low storage conditions, fall temperatures are likely to be a primary limiting factor.
    - Seth Naman stated that low reservoir storage resulted in many unsuccessful embryos if releases from Lewiston Dam were too warm, such as last year. This is likely to occur again this year. Normal or high spring reservoir storage combined with high flows can result in situations where temperatures are so cold that they are outside optimal juvenile growth conditions. A critical relationship is reservoir storage, flow, and time of year, and they are only starting to understand this.
- Further discussions
    - Mike Orcutt noted that while the County is being well-served by technical capacity, formalization of what is being talked about, especially on roles and coordination, should be considered. There are multiple different ongoing initiatives/activities in the basin right now, including TRRP refinement, fall FARs releases, and ESA consultation, and formalization of this process could lead to a more coordinated approach. How everyone prioritizes and interacts is critical, since there are some processes working counter to this process currently.
- Economic benefits
    - Mike Orcutt asked if the group is only looking at fishery enhancement and protection for Proviso 2 or if they are also evaluating economic benefits.

- Hank Seemann stated that the County developed a robust flow proposal two years ago, and they chose to focus on instream flows that would benefit fisheries but not preclude other beneficial users. They considered a phased approach focusing on fisheries first, followed by using Contract Water for other purposes. The Water Management Plan and compliance strategy would be the first phase, and that to be successful the strategy is to not do everything all at once.
- Mike Orcutt strongly urged the group to formalize linkages between collaboration. It may be more time than benefit, but there are many competing efforts underway. The group should add to and inform consultation undertaken by Reclamation.
- Amy Cordalis echoed Mike Orcutt's comments about formalizing the consultation and coordination among other stakeholders and noted that the Yurok is interested in the use of this water. The last time the Yurok Tribe, Hoopa Valley Tribe, and County met, they discussed a Memorandum of Understanding and considered other uses of this water source. It was good that the County was proactive and applied for the grant, and that they are committing to technical analysis and governance. But the horse may be ahead of the cart since there is not consensus among the County, Yurok Tribe, and Hoopa Valley Tribe on how this water should be used. There was a lot of work in the technical application, but not in regard to legal issues and water use.
- Craig Tucker suggested an in-person meeting between the County, Yurok Tribe, and Hoopa Valley Tribe.

Action Items:

- Stantec will add additional events and references as discussed above relevant to the project background, including the Yurok Tribe and Hoopa Valley Tribes roles under Proviso 2, within the baseline conditions memorandum
- Craig Tucker will organize and coordinate a parallel workstream to address legal aspects and coordination between the County, Yurok Tribe, and Hoopa Valley Tribe, and will follow-up with each group with more information
- Stantec will send draft presentation to the group by 07/15/2022 with a request for feedback on data sources (e.g., studies and reports) and limiting factors.
- Stantec will create a link to a SharePoint site to share data and files across all workshop members by 07/15/2022.
- Craig Tucker will send polls by 07/22/2022 to find the best dates for the next two workshops in August and September.

FINAL Meeting Summary

Date/Time: September 1, 2022 / 9:00 AM PT

Subject: Water Management Plan for Utilization of Humboldt County Contract Water, Workshop #2

Place: Zoom

Attendees:

Attendee	Affiliation	Attendee	Affiliation
Hank Seemann	Humboldt County	Scott Bergstrom	DOI
Craig Tucker	Suits and Signs Consulting	Allison Mitchell	DOI
Amy Cordalis	Yurok Tribe	Elizabeth Hadley	Reclamation
Mike Orcutt	Hoopa Valley Tribe	Mike Dixon	Reclamation
Nick Som	USFWS	Adam Witt	Stantec
Bill Pinnix	USFWS	Mary Paasch	Stantec
Josh Boyce	USFWS	Paul Uncapher	Stantec
Justin Ly	NMFS	Stephanie Theis	Stantec
Seth Naman	NMFS	Arielle Gervasi	Stantec
Ken Lindke	CDFW	Derek Morimoto	Stantec
Russell Perry	USGS	Thomas Gast	Thomas Gast & Associates
John Plumb	USGS		

Agenda:

Item	Responsible Party
1. Introduction and Project/Workshop Objective	Hank Seeman
2. Flow and Temperature Overview	Adam Witt/Thomas Gast
3. Group Discussion	Adam Witt

Purpose and Objectives:

The purpose of this workshop was to review a synthesis of flow and temperature data in the Trinity River with an emphasis on recent data, studies, flow modifications, and flow proposals, review limiting factors to fish productivity identified in recent years and have a group discussion to begin drafting objectives for the release of Contract Water (50,000 AF annually from Trinity Lake).

The objectives of this workshop were to:

- Identify the most important limiting factors for fish productivity to target with Contract Water releases
- Translate limiting factors list into release objectives (e.g., identify annual hydrograph component, water year type, life stage, and limiting factor that could be targeted by a Contract Water release)

Note: This Meeting Summary documents the discussions that followed the presentation. The content presented during the workshop can be viewed from the presentation distributed to meeting participants.

Workshop Summary:

Introduction

Adam Witt presented the workshop agenda. Hank Seemann discussed project objectives, emphasizing that the goal of this project is to optimize instream use of Contract Water for the benefit of commercial, Tribal, and sport fisheries without precluding other future uses. This workshop is to aid in identifying the current limiting factors in the Trinity River for fish production, which will help inform the Contract Water release scenarios developed.

- Potential Fish Kill Event in Klamath
    - Craig Tucker mentioned that this year pathogens are being observed at high levels and the Yurok Tribe has been reporting *Flavobacter columnare* (Columnaris) infections in dead fish on the Klamath River, so a potential fish kill event is anticipated for this year. Because of this, biologists are on high alert and several participants that would have been in this meeting are probably currently out in the field. This highlights the timely importance and relevance of this project.
- Access to Workshop 1 Notes
    - Mike Orcutt mentioned that Hoopa Valley Tribe had not been able to access the slides from the previous workshop. Adam Witt mentioned that other Workshop participants had problems accessing these materials and **Stantec would follow up by sending out a new link and ensure all participants can access the Workshop 1 and 2 materials**.
- Mike Orcutt echoed sentiments from the previous Workshop: while being aware that these Workshops are meant to focus on the technical aspects of the project like fisheries and river health, the Hoopa Valley Tribe would like to ensure that there will be policy and legal discussions focused on other factors like economic benefits and water uses.
    - Hank and Craig emphasized that the initial focus on this effort is to identify ways to use Contract Water to support a fishable surplus and create fishing opportunities for tribal, recreation, and commercial fishing that is consistent with Proviso 2. Craig stated there will be a parallel track for legal and policy questions, and he will reach out to the Hoopa Valley Tribe, Yurok Tribe, and Reclamation to coordinate further discussion.
    - Mike Orcutt thanked them for the explanation and concluded by asking that the Hoopa Valley Tribe be kept in communication during this process, adding that this will be an important part of executing the project, so it's important that it is done correctly.
- Mike Orcutt raised the question of how this group will be coordinating the project with the Trinity River Restoration Program (TRRP), Trinity Management Council (TMC), and other federal agencies. Mike suggested formalizing coordination because there is a lot of overlap with this project and the work of these agencies. Mike acknowledged that, although Hank reached out to agencies for technical assistance, this seems too informal. Many agencies have rigid project guidelines, so federal agencies may decline participation or be directed not to proceed later in the project if participation is not formalized.
    - Craig agreed, but noted that some of that interaction depends on the modeling scenarios developed. The modeling scenarios should inform how much connection there will be between this project and other projects, such as implementation of the 2000 Record of Decision (ROD) and the 2022 Reinitiation of Consultation (ReROC) for the long-term operations of the Central Valley Project (CVP).

- Mike Dixon noted there is a topic on the agenda for this workshop that explains how this project will interact with ROD flow management. Additionally, Reclamation has asked Hank to present the Water Management Plan project and timeline at the September TMC meeting, and the TMC will have the opportunity to weigh in then.

Flow and Temperature Overview

Adam discussed the project timeline and the compiled historical flow and temperature data for the Trinity River.

- Coordinating With Other Workgroups
  - Mike Orcutt asked if Stantec has been checking in with the newly established Trinity River Flow and Temperature Workgroups for the TRRP on current temperature issues in the Trinity River.
  - Adam confirmed that Stantec has been reviewing the Temperature Workgroup's data and reports and asked if anyone in the workshop that is also in the Workgroup wanted to add more to what Stantec had reviewed and collected.
  - Mike Dixon is a member of the Trinity River technical Workgroup, and stated that the data gathered seems to have come from the most recent information, so did not have anything to add.
  - Mike Orcutt wanted to make Stantec aware that there are new consensus reports on temperature completed that look at the Trinity River system and how it is integrated with the Central Valley, as well as a newly established Trinity River Division (TRD) Workgroup.
  - Adam asked Mike Orcutt to recommend any additional individuals from the new workgroups that Stantec should meet with.

Tom Gast presented the findings from the study/report completed by Thomas Gast and Associates in 2021 on the effects of flow and temperature on timing of Chinook salmon outmigration in the Trinity River. Temperature threshold at Pear Tree (above the confluence with the North Fork Trinity River) was the best predictor of outmigration timing. The study found that juvenile populations have been trending upwards since implementation of the TRRP and subsequent flow modifications of the Spring hydrograph components. Therefore, Tom recommended that efforts should be focused on targeting adult returns rather than juveniles by augmenting flow components outside the Spring flows. Additionally, Tom proposed that earlier outmigration should help increase the survival rates of fish.

- Targeting Adult Return
  - Mike Dixon asked if Tom had specific ideas on how to modify flows to target adult returns. Would fall freshets or focusing on spawning flows be preferable?
    - Tom agreed that those two flow scenarios would be good options to consider. A larger size juvenile improves survival.
  - Mike Orcutt asked whether factors in the Klamath River that affect survival were considered.
    - Thomas clarified that the study used data from the Willow Creek trap and only extended to the Trinity River. The assumption is that earlier outmigration and larger fish size will support survival through both the Trinity and Klamath Rivers and out into the ocean.
    - Mike Orcutt mentioned that the Hoopa Valley Tribe has been studying chronic diseases and infection zones in the Klamath River, so disease is another important consideration as it relates to outmigration.

- Nick Som indicated that changes to Spring water temperatures to benefit juveniles would only come about by altering water management of the Spring peak runoff and recession and asked for clarification of the recommendation.
- Tom stated that augmentation of Spring flows to increase the pulse flow magnitude would not be beneficial.

Adam Witt provided the summary of recent (2011-2021) ROD flow modifications implemented by the TMC and TRRP Flow Workgroup.

- Craig asked whether the analysis would differentiate or think about tradeoffs between the needs of the fall-run Chinook versus the spring-run Chinook. The concern was that manipulating thermal regimes might not preserve some of the natural conditions that separate the two distinct runs.
    - Seth Naman asked if Craig could clarify whether the concern was addressing adults versus juvenile life stages.
    - Craig responded that it seemed the group is looking at the benefits of increasing juvenile growth, so the question was whether spring-run Chinook versus fall-run Chinook should be analyzed separately because the spawning occurs at different times.
    - Seth elaborated on the timing of the life cycle stages. Spring-run juvenile emerge from gravels first in January, while fry from the fall-run Chinook emerge more in February. Therefore, flows that arrive earlier in the year from Lewiston would probably benefit the two runs slightly differently; however, it's difficult to tease the two runs apart and prescribe flow separately. For adult spawning, flows from Lewiston need to be cold enough at the time of year to support spawning of both runs and Seth was not sure how something different could be done for each run. This year, releases are targeted to get river temperatures to 50°F or lower around September 15 which is near the start of spring-run spawning. In general, what's going to benefit one run will benefit the other.
    - Ken Lindke agreed with Seth, adding more explanation as to why it is difficult to manage the spring- and fall-runs separately under current management constraints and also why the runs are not highly distinct from each other. Ken stated releases are typically limited to 300 cfs in Winter from October 15 until April when the Bulletin 120 water year type designation is determined. Therefore, there is no ability to prescribe flows that could distinguish between the fall-and spring-runs under the current management. Additionally, by maintaining elevated summer flows, both the spring- and fall-run Chinook are able to migrate freely all the way up into their spawning habitat, which results in a lot of intermixing between the two runs. Spring-run spawn earlier, so theoretically they'd be larger and able to take more advantage of Spring releases, but there is evidence from the Central Valley that by the time the juveniles are big enough to move around, there's really not a distinction in size between the two runs. This is why it would be difficult to try to target anything in the juvenile life history stage, especially under the current flow management constraints.

Adam summarized the two recent flow proposals: the 2018 Humboldt County Draft Proposal and the Trinity River Winter Flow Variability Project Draft Environmental Assessment (EA).

- Mike Dixon posted in the meeting chat that the information from the unfinalized draft Winter Flow Variability EA, as well as some additional analyses, were included in a recently completed report. It

would be better to reference the Trinity River Winter Flow Project final report[1] moving forward, rather than the incomplete NEPA document. The Winter Flow Variability report was left somewhat ambiguous. It provides volumes of flow to move but tried not to focus on specific objectives. The objectives Stantec listed in the presentation could be enacted if chosen and are consistent with the proposal, but there were no specific hydrograph recommendations; just volumes of water, dependent on real-time conditions.

- Recent Flow Proposals Summary
    - Adam compared the recent flow proposals to the recent ROD flow modifications. As Ken mentioned, releases from October - April are limited to 300 cfs, which explains why the 2011-2021 ROD flow modifications did not target the Winter baseflows and flood peaks; however, these were the main hydrograph components targeted in the Winter Flow Variability and 2018 Humboldt County Proposals.
        - Mike Orcutt corrected that the group should not assume that the Winter flows were not considered in the past by the TMC and Trinity River Flow Workgroup. The ROD flow modifications have to be agreed upon by both the TMC and Reclamation and approved by vote. There have been times where Reclamation has decided to change the flow schedule during implementation.
    - Ken stated the flow proposal in the Winter Flow Variability Draft EA was intentionally left ambiguous and only focused on releasing and shifting specific volumes under certain conditions, assisted by a flow management decision tree. It wasn't focused on specific objectives as the slides suggest. The table (see slide #38) is suggesting the Winter Flow Variability flow proposal is only considering changes to the Winter baseflow and flood peaks by increasing the rate of the Snowmelt recession to shift that Spring recession volume to the following Winter. In actuality, there are a whole host of additional flow modifications that would be consistent with that proposal. Ken said to keep in mind the flow proposal is not a hydrograph suggestion—the shape of the peak flow and timing can change. There could be a flow scenario that looks very different from the 2016 example hydrograph figure that was pulled from the draft EA (see slide #37). There's a synchronization period, and that has a specific volume, but the shape of that Winter peak flow is up for debate and the timing of the peak flow is dependent on real-time flow conditions. During the Winter baseflow period, the baseflow would be elevated, but the shapes of those hydrographs could look like anything. In fact, the proposal that was brought to the TMC last December had hydrographs that were quite a bit different than the one shown in the Draft EA.
        - Adam Witt thanked Ken for the clarification and noted that Stantec had interpreted that the Winter Flow Variability proposal wasn't explicit in prescribing a specific hydrograph for that specific year type.
    - Mike Orcutt asked to revisit the Recent ROD Flow Adaptations Summary slide (slide #34) which indicated that some of the ROD flow modification objectives with increased flows on the Snowmelt peak rising limb and Snowmelt recession were to help disperse the steelhead and Chinook hatchery fish. It's worth noting that the natural and hatchery produced fish would be managed differently—naturally produced fish are included in the Trinity River Restoration program while the hatchery and mitigation functions are managed by a voluntary hatchery technical team. Therefore, the steelhead statement in the presentation may have reflected the opinion of an individual and not necessarily the whole team.

[1] Trinity River Restoration Program (TRRP). 2022. Trinity River Winter Flow Project Report for the TRRP. Weaverville, California. Available at: https://www.trrp.net/library/document?id=2566.

Group Discussion

Adam presented a quick overview of the list of limiting factors generated by Stantec and asked the group to discuss types and timing of flow augmentations, keeping in mind that the flows must be additive (cannot change the timing or subtract from the ROD flow magnitude). The following discussion and comments were added during the Workshop to the Group Exercise table on slide #45, categorizing potential hydrograph component modifications.

- Adam identified that Summer baseflow modifications generally had a different objective than the other modifications, as they were non-Restoration flows associated with the Klamath River late summer flow augmentation or emergency flows. Are just these four hydrograph components (Winter baseflows, Winter flood peaks, Snowmelt peak runoff, and Snowmelt recession) the ones to consider targeting with Contract Water?
- Ken strongly recommended against putting any additional volume in the Spring period, given that the Proviso 2 water is additive to the ROD volumes. One of the primary objectives of the Winter Variability Flow proposal was to get more water out of the Spring period (mid-April when ROD releases increase above Winter baseflow, through end of Snowmelt recession) so that temperatures could rise into the optimal range for juvenile rearing earlier. It's been generally agreed upon that more water should be taken out of that period to benefit the fish. In the Winter Flow Variability EA example from the 2016 water year, this is done by taking that volume out of the Snowmelt recession limb to return to Summer baseflows earlier.
    - Mike Dixon, in a typed comment, added that the ROD covers flow releases all year round, with the Winter and Summer baseflows constituting the Proviso 1 Restoration allocation volume from the ROD. The volume to be released has been historically constrained until after the April 1 Bulletin 120 water year designation, but that is not the only period when ROD water is or can be released. The ROD was clear on this: "Based on subsequent monitoring and studies guided by the Trinity Management Council, 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."
    - Craig asked if Ken would consider the 2018 Humboldt County flow proposal modifying Winter baseflows and flood peaks to be complimentary to the Winter Flow Variability proposal.
    - Ken agreed that the flow proposals are complimentary. Both Winter hydrograph component modifications (baseflows and flood peaks) are very important for slightly different reasons. Ken recommended against putting Proviso 2 on top of ROD water from mid-April through the end of the snowmelt peak recession, adding that flows should be scheduled so they can increase as early as possible at the beginning of the initiation of ROD restoration, but not adding more water to the Spring period.
    - Adam asked Ken what he thought about the TRRP flow modification from 2021 (see figure on supplemental slide #66) where there were large peaks increasing volume on the rising limb leading up to the Snowmelt peak. Adam asked if the Flow Workgroup is constrained in the timing of how early that rise could start.
    - Ken reiterated that this constraint is due to waiting for the Bulletin 120 report. The TRRP has tried to schedule the flows to increase as early as possible, but ROD flows are generally not increased above the 300 cfs Winter baseflow until the Bulletin 120 report comes out with the water year type. The report is complete April 1, but it typically isn't made public until the

8th or 9th of the month, so April 15 is the target to start elevating baseflows. It makes sense to supplement the period up to April 15 with Contract Water.
    - Seth agreed with Ken, adding that Ken's comment fits well with Thomas Gast's recommendation that additional flows in Spring wouldn't be beneficial for Chinook. Seth agreed with Ken's comments regarding how to manage the water based on the current restrictions of the ROD flows.
- Seth highlighted other issues with the Summer and Winter baseflows. Under the ROD releases, a baseflow of 450 cfs is released all summer, which is generally a higher flow than any August or September in the natural historical record. Secondly, under the ROD hydrograph, the flow is dropped from 450 cfs to 300 cfs in mid-October, when really the flows should be increasing to align with the natural stream flow regime. Those are flow components of the hydrograph that could be targeted and likely provide benefits to Chinook salmon. Damon Goodman and USFWS biologists have shown that increasing baseflows in the Fall benefits adult spawners by helping to better distribute them[2].
    - Adam asked if one augmentation scenario might be to provide some additional baseflow above the ROD flows for some period of time starting in mid-October to get rid of the baseflow drop. Seth agreed that this idea would make more sense than adding water where there is already enough (Spring period).
- Craig stated that one thing learned on the Klamath is the importance of threshold flow events in the Winter. Craig asked what others thought about needing geomorphic Winter peak flows. In the 2018 Humboldt County flow proposal and the last round of flow proposals, the County wanted to add water on top of a natural flood event in the Winter to create a high magnitude event to provide geomorphic benefits.
    - Seth responded generally in favor of this idea, adding that the geomorphic flows can be straightforward in showing the riverine and geomorphic benefits, since the relationship between flow and sediment transport is well understood. Additionally, it is one of the objectives of the ROD flows and the TRRP to provide a certain level of sediment transport. In the Fish and Flow Workgroups, the importance of disturbing the bed so insects can colonize gravels at the correct time of year to provide a food resource for juvenile fish in the Spring are being highlighted. It is best to provide that peak flow disturbance in January or February. This helps reset the biofilm and smaller benthic insects that colonize it, making those insects available to juveniles. This is an important portion of the hydrograph that's entirely missing right now, and it could provide benefits for fish.
- John Plumb asked to see the ROD hydrographs on the Reference slide (slide #46) and pointed out that the figure seems to show that, in the wet and extremely wet years, flows are lower for a longer period of time in the Spring before they are increased to reach the Spring peak runoff, and then a lot of water is released all at once. John asked if it would be better to release less water all at once and move some flows earlier in the year to better match the natural pre-dam flow regime.
    - Seth agreed that this would be better than the current ROD flow, and that the TRRP Workgroups have been assessing this for years but are running into hurdles due to flow management constraints.
    - Ken pointed out that the original ROD hydrographs do not closely match what is currently being implemented in most years, as the workgroups have made substantial modifications to the different water year type hydrographs on an annual basis. Ken explained that the

[2] Goodman, D.H., Som, N., Hetrick, N.J. 2018. Increasing the availability and spatial variation of spawning habitats through ascending baseflows: Ascending baseflows and spawning habitats. River Research and Applications 34 (7) DOI: 10.1002/rra.3302.

main issue constraining this type of modification is that currently the flow cannot be increased above 300 cfs until the Bulletin 120 report comes out in early April.

- Adam asked about the recent research highlighting the benefits of the geomorphic pulse flow and bed disturbance. Adam asked if there is any differentiation between water year types or antecedent conditions that would help indicate if there are specific years when the geomorphic pulse flow would be more or less beneficial to implement (i.e., if there's a correlation on insects colonizing the gravel at the right time and water year type, or if in a wet year the biofilm could reset without the need for augmentation).
    - Seth indicated the research done so far only looked at 2019 data, which was a dry year. Seth emphasized that there is common misconception that in dry and critically dry years there are no flows high enough to be considered a geomorphic flow. While a critical or dry year may not have a high year-end volume, there are usually at least 1 or 2 flow events with a high enough peak flow to do geomorphic scouring.
    - Ken added that water year types can change the mechanism through which the fish obtain food. Fish get food through two main mechanisms: 1) drift feeding from benthos, which is highly dependent on macroinvertebrate productivity in the channel, and 2) inundation of lateral habitat (floodplains and side channels). While the first mechanism is directly related to the bed disturbance regime, the second occurs mainly in wet years. The second mechanism may be more important so that productivity is affected more broadly by increasing the lateral extent of wetted area and habitat. Therefore, there isn't necessarily a need to focus on having a geomorphic flow every year. Geomorphic flows are always going to be good in the appropriate time of year to provide ecosystem benefits, but it's important to understand which components of the hydrograph are missing and what ecological services they provide. Peak flows provide the disturbance and geomorphic functions, but the elevated Winter baseflows can provide more lateral inundation, which is also highly important.
- Magnitude required to initiate geomorphic flows
    - Craig brought up the concern of finding the proper threshold for geomorphic flows and acknowledged that reaching this flow may not be achievable in all years. In the models, it appeared that 6000 cfs was the minimum flow needed to have a significant amount of sediment transport to create a beneficial geomorphic flow. The problem is, in some years, this flow wasn't achieved because there wasn't a Winter storm event to supplement the flow. Therefore, the County proposed that in those years there wouldn't be a geomorphic pulse flow.
    - Ken noted that in the Winter Flow proposal, a 4,500 cfs minimum at the North Fork was assessed as a trigger for a geomorphic pulse flow release, and that condition occurred in 7 of the 16 years analyzed. But, that doesn't mean that that hydrograph component isn't as important; it probably just means there is currently a loss of geomorphic processes and resetting of macroinvertebrate communities. In the analyses, releases of 3,500 cfs at Lewiston was set as the minimum threshold for when geomorphic work occurs. However, this is still very low and would entrain mostly sand and silt and maybe small gravel at most. Nevertheless, significant geomorphic flows can still be common in dry and critically dry years on the Trinity River.
- Seth reiterated that including an increasing baseflow in the Fall for spawning salmonids should be considered as an action. That action, combined with the geomorphic pulse and increasing Winter baseflows in March, could form three main hydrograph component augmentation actions that could be analyzed in terms of their benefits.

- Adam asked if Seth could clarify whether this Winter baseflow modification should occur during/after the mid-October drop to 300 cfs.
- Seth confirmed that this would be a good time to start modifying and augmenting the flow, adding that increasing the flows in Fall could really help reduce redd superimposition, especially in wetter years when the spring-run has high spawning numbers.
- Ken agreed with Seth's recommendation to target the Winter baseflows, but added an important note of caution for modification. If flows are elevated in the Fall, then they should not be allowed to drop back to 300 cfs before fish have emerged from the gravel, to prevent dewatering redds. Therefore, flows would need to remain elevated from October to April.

- Ken reminded the group that through that Winter Flow Variability EA process, the TRRP developed some great tools and a decision tree to help with synchronizing peak flows, which could help with conserving water. Additionally, more geomorphic work occurs further downstream when peak flow releases are combined with naturally elevated flows in the system. The tool is in place but has not been used yet. Ken reiterated Mike Orcutt, saying it would be beneficial to coordinate with the Flow Workgroup when deciding the shape and timing of these releases. If there is room in the NEPA process to provide that flexibility, there should be coordination with the program so the added 50 TAF is augmented on top of the ROD volumes, but still consistent with the way releases are currently managed.
  - Mary Paasch explained that from a NEPA perspective, the modeling needs to reflect something specific; however, disclosures in the environmental document can show flexibility and bookend the potential impacts.
  - Mike Orcutt stated that there's a real pressing need to go back and take a look at the original ROD and Restoration program objectives. It's important not only look at the modifications made, but also how the river and channel responded to those actions. Many people are frustrated because even since the ROD implementation, the fish population hasn't responded as desired. Also, discussion is needed about the barriers that have existed over the years. Carryover may be a need for this project and the limited October 15 - April 1 flows have been a limitation in the past, and changing those things requires discussion and involvement with legal and policy folks. There is a need for policy adjustment and discussion to refine the Restoration program, as well as the legal constraints. It's likely the CVP ReROC is going to be done concurrently during the course of this project—the official recognition of this project's Proviso 2 water in that forum will be important.
- Using carryover to optimize release temperatures
  - Seth believed the hydrograph components 3 and 4 (Snowmelt peak runoff and Snowmelt recession) are probably satisfied by current ROD flow allocations. Regarding Summer baseflows, there are several scientists within the program that want to see lower Summer baseflows during certain times of year because as it stands now there's a riparian bathtub ring at 450 cfs and more flow than what the river would naturally have at that time of year. Seth reminded the group that having colder water in the Summer can exacerbate overlap of the spring and fall runs. Therefore, adding Contract Water to the Summer baseflow won't provide benefits. Seth asked if Stantec clarify what is meant by carryover.
  - Adam explained that the modeling scenarios could involve carryover of the 50 TAF of Proviso 2 water as storage in Trinity Reservoir until the next water year. This could create a surplus of water to: 1) release a high volume of water in the following year and 2) expand the reservoir cold-water pool to provide temperature benefits for releases made during the Snowmelt recession in September and August. It would be necessary though to work through the policy and legal implications of this decision.

- Mary supported Adam's explanation by adding that the dozens of analyses Stantec completed for a project in Lake Shasta showed that the most beneficial use of the project water was to expand the cold-water pool in the reservoir. While Shasta is a different system, this project showed that an increased cold-water pool improved suitable release temperatures for fish.
- Seth pointed out that the 50 TAF volume of Contract Water may not be enough to affect temperatures. The relationship between storage and temperature of release for Trinity Reservoir is well known. Seth was uncertain what the change in elevation and depth would be, but was confident that 50 TAF would not be a large enough volume to alter temperature in the reservoir significantly, due to its large 2.4 MAF capacity.
- Mary countered that in dry and critically dry years, the cold-water pool was essentially evacuated at Shasta—and in those years the additional volume from the project was enough to make meaningful change in the temperatures in the reservoir.
- Seth stated that Trinity Dam does not have a temperature control device so currently it's difficult to control the temperature of the releases. Certainly there's a strong relationship between storage and water temperature released, particularly at storages <1 MAF, but 50 TAF is likely not enough to significantly change the temperatures.
- Adam suggested that Contract Water could be carried over during two years—for example, not released during wet years—so that there could be 100 TAF of Contract Water available for augmentation.
- Ken asked if there is currently anything that would legally guarantee that that 50-100 TAF of water would not be exported to the Central Valley.
- Mary offered that Stantec would be looking into the operational rules and CVP allocations. Mary stated that would need to be some revisions on operating rules to secure this agreement, but that would be the case for any of the flow scenarios evaluated.
- Seth said that if it was possible for the County to carry over 100 TAF, that that volume would likely make a difference in the reservoir temperatures, and that would definitely be a scenario worth considering.
- Following this temperature discussion, Craig reminded that group that the Proviso 2 water right is for <u>not less than</u> 50 TAF, and the group should think about whether scenarios applying more than 50 TAF would be beneficial.

- Hank asked if either Ken or Seth could elaborate more on the risks of redd dewatering and if they could point the group towards any previous documented analyses on this or clarify what safeguards could be exercised to avoid this.
  - Ken suggested the USFWS paper (previously referenced by Seth) which demonstrated that variable and increased flows in Fall increased the amount of spawning habitat available relative to a static baseflow[3]. **Ken indicated he would send this paper to the group after the meeting.** The main concern is that if flows are increased above 300 cfs and fish are granted more access laterally above the baseflow channel, redds will likely be constructed at higher elevations in the channel. If the flow is dropped back down to a 300 cfs baseflow, there's potential for those redds at higher elevations to become dewatered. The system historically had naturally variable Fall/Winter flows due to rain on snow events and, on average, the baseflow increased through that period so that fish were not constrained by that minimum baseflow. The fish have evolved to take advantage of how the system worked for thousands of years so they are programmed to distribute their redds based on variability.

[3] Goodman, D.H., Som, N., Hetrick, N.J. 2018. Increasing the availability and spatial variation of spawning habitats through ascending baseflows: Ascending baseflows and spawning habitats. River Research and Applications 34 (7) DOI: 10.1002/rra.3302.

- Adam asked if there were certain times of the year when redd dewatering risk would decrease.
- Ken responded that as long as eggs or alevin are in the gravel, the risk is present.
- Mike Dixon added that steelhead in the Trinity River can have eggs in redds all the way into April. However, if the Winter Flow Variability Project moves forward, and a big portion of that project helps increase Fall and March baseflows, the 50 TAF of Contract Water could be enough to supplement these flows to ensure flow does not drop to 300 cfs between October and March.
- Bill Pinnix expressed additional concern that the redds stay hydrologically connected to the river all the way through from the time the eggs are laid to emergence and doubted that 50 TAF would be enough to maintain increased flow and connectivity for 5 months between October and March.
- Ken agreed with Bill that the Contract Water alone would probably not be enough to bridge that 5-month period, but if it was added onto additional water from the Winter Flow Variability Project and other efforts, as Mike Orcutt also emphasized, then there may be enough water.
- Adam and Mike Dixon commented that they both did some back-of-the-envelope calculations and that 50 TAF of water could provide 140 cfs for 180 days, or 150 cfs for 166 days. Therefore, the Contract Water would be enough to provide a static 150 cfs increase in flow starting October 15 and lasting until mid- to late March.

- Stephanie Theis asked whether there was any concern in the group about Winter peak/geomorphic pulse flows resulting in redd scouring.
  - Seth responded that this is not a major concern, as observations have shown that the redds are quite resilient up to flows of about 6,000 to 8,000 cfs, depending on the time of year and flows released from Lewiston[4]. Determining a maximum flow threshold to avoid redd scouring should be assessed, but where fish typically place them in the Trinity River tends to be highly resilient to scouring.

Concluding Remarks:

- Adam concluded the workshop by letting participants know that Stantec will make sure all documents and materials are accessible through a file sharing link and access password. Workshop 3 or 4 will be an in-person workshop, and these will both focus on scenario development. Workshop 3 will be in 4 to 6 weeks, and Workshop 4 will happen before the end of year so that there is time to refine and iterate between scenarios. **Additionally, a draft of the Baseline Conditions Memo will be submitted to Humboldt County for review by the end of this month, and workshop participants will also have a chance to review and provide comments**.
- Craig and Hank thanked Stantec for leading the presentation and thanked the workshop participants for providing thoughtful input. They expressed excitement that this project is gaining momentum. Craig will follow up with participants to find a date for the next Workshop. Due to other meetings in September (Klamath IFRMP and TMC meeting), the first week of October should be the target for Workshop 3.

[4] May, C.L., B. Pryor, T.E. Lisle, and M.M. Lang. 2007. Assessing the Risk of Redd Scour on the Trinity River. Final report submitted to the Trinity River Restoration Program. 63pp. Available at: https://www.trrp.net/library/document/?id=240.

Action Items:

- Stantec will send out a new link to the Workshop 1 slides and materials to facilitate access for all Workshop participants.
- Stantec will distribute Workshop 2 materials and meeting notes.
- Stantec and Humboldt County will finalize a draft of the Baseline Conditions Memo and send to the group for review.
- Ken Lindke to send the referenced USFWS report relating variable Fall flows to increased spawning habitat to the group.

Meeting Summary

Date/Time: October 11, 2022 / 9:00 AM PT

Subject: Water Management Plan for Utilization of Humboldt County Contract Water, Workshop #3

Place: USFWS Arcata Office, 1655 Heindon Road, Arcata, CA, and on Microsoft Teams

Attendees:

Attendee	Affiliation	Attendee	Affiliation
Hank Seemann	Humboldt County	Seth Naman	NMFS
Craig Tucker	Suits and Signs Consulting	Allison Mitchell	USDOI
Mike Belchik	Yurok Tribe	Ken Lindke	CDFW
Kyle de Julio	Yurok Tribe	Elizabeth Hadley	Reclamation
Mike Orcutt	Hoopa Valley Tribe	Mike Dixon	Reclamation
Jason Reed	Hoopa Valley Tribe	Adam Witt	Stantec
Darren Mierau	CalTrout	Mary Paasch	Stantec
Nick Som	USFWS	Paul Uncapher	Stantec
Bill Pinnix	USFWS	Stephanie Theis	Stantec
Russ Perry	USGS	Arielle Gervasi	Stantec
John Plumb	USGS	Thomas Gast	Thomas Gast & Associates

Agenda:

Item	Responsible Party
1. Introduction and Project/Workshop Objectives	Adam Witt/Hank Seemann
2. Contract Water Release Scenario Introduction	Adam Witt
3. Group Scenario Development	Adam Witt

Purpose and Objectives:

The purpose of this workshop was to formulate potential release scenarios building upon the release recommendations from workshop 2 and facilitate a group discussion assisted by a spreadsheet tool providing visualizations and volumetric calculations of different proposed release patterns.

The objective of this workshop was to develop up to four release scenarios including a daily release pattern, differentiation by water year type (if necessary), and limiting factors or objectives targeted by releases.

Note: This meeting summary also documents discussions that followed the presentation. The full content presented during the workshop can be viewed from the presentation and spreadsheet tool distributed to meeting participants.

Workshop Summary:

Introduction

Adam presented the workshop agenda. Hank discussed project objectives, noting that Contract Water releases are intended to complement, and be additive to, the TRRP's ROD flows in order to achieve additional fishery benefits, and that Humboldt County intends to collaborate closely with the Trinity River Restoration Program (TRRP) in the implementation of this project to ensure consistency and avoid any potential conflicts. The ultimate outcome of the project is to develop a water management plan covering a 20-year planning period that allows for an adaptive management approach.

Contract Water Release Scenario Introduction

Adam presented the final table of hydrograph components and augmentation recommendations from workshop 2. Adam stated that the objective for this workshop would be to develop four individual sets of release scenarios (a set of release patterns that may vary by year type) which could provide ranges and bookends of results.

Adam introduced the spreadsheet tool developed by Stantec, noting that the visualizations are meant to provide examples of different potential release patterns. The tool comes with four main dashboards: 1) "Static baseflow" which allows the user to specify a total volume and the months over which to release the volume and the volume is divided evenly across those months; 2) "Variable baseflow" which allows the user to specify a different flow release in cubic feet per second (cfs) per month, and choose which months to release; 3) "Pulse" allows users to specify a peak magnitude and duration for pulse flow; and 4) "Base + peaks" combines features of the variable baseflow and pulse dashboard and allows users to add baseflow as well as a single peak for each month, constrained by the maximum ramping rates recommended by the Flow Workgroup[1]. Recommendations from workshop 2 included not releasing additional water during the spring and summer periods.

- A discussion followed regarding whether differentiation by water year types should or could be integrated into the scenarios.
    - Ken asked whether the group thought that it would be feasible to distinguish patterns and scenarios by water year type, given management constraints and lack of certainty regarding hydrology early in the season. Ken was uncertain as to whether water year type really matters when it comes to deciding on the scenarios and modeling benefits.
    - Adam acknowledged that from previous discussion in workshop 2 it had been determined ideal timing of additional releases would be prior to when water year type is known. Stantec ran an analysis using cumulative monthly inflow volumes across the pre-Trinity River Division (TRD) years and estimated the probability that cumulative monthly inflow volume for that year was consistent with the final predicted water year type (see slide #15). By November 1 there was only a 30% chance of correctly predicting the water year type based on cumulative volume, and it increased to only about 60% by April 1. By June, the water year type is known with 90% certainty. Therefore, scenarios generated using water year type predicted in December would only have about a 1 in 3 chance of matching the final water year type.
    - Ken pointed out that better tools exist now for hydrology prediction and that the group is aware that the DWR Bulletin 120 April water year type prediction isn't highly accurate. DWR starts predicting in January and begins to have some idea of the year type even though the ROD release is determined by the April 1 prediction. As part of the Winter Flow Variability

[1] Buxton. 2018. Recommendations for safety of dams and reservoir storage management releases to increase benefits to the Trinity River ecosystem. Technical memorandum to Caryn Huntt DeCarlo. November 5.

Environmental Assessment (EA)[2], an analysis was completed using years since 2004, when the DWR reports became available. The analysis compared a deterministic prediction versus the 90% forecast in each year to see how well either predicted. The 90% forecast never overpredicted. The 50% prediction was usually good. That analysis should be in the report. Ken also pointed out that it is better to use the most recent inflow hydrology rather than the pre-dam hydrology to get the statistics. The current hydrology volumes and timing are quite different from pre-dam hydrology.

  - Craig suggested altering the set-up of the scenario tables to have additional columns which note which patterns or scenarios are dependent on water year type. For example, changing the winter baseflow would likely be independent of water year whereas the pulse flow might change with or depend on water year type.
  - Adam and Mary agreed with Craig that the pulse flow pattern would probably depend on water year type.
  - Craig worried, however, that it would be difficult to divorce the hydrograph decisions and benefits from the water year type.
  - Nick offered that most of the hydrograph components the group has identified and the fish benefits during those times of year would not be dependent on water year type.

- Discussion shifted to the logistics of how these scenarios and patterns might be decided on and implemented once the water management plan is put into place, as well as other management considerations.
  - Ken added, regarding management of water, Reclamation can often make a decision on a release and execute within about 72 hours.
  - Mike Dixon clarified in the chat that 72 hours is typically the amount of time needed to schedule power deliveries, but it also helps with allowing for public notifications.
  - Hank offered that there can and should be more discussion between Humboldt County and Reclamation about the timeline for release decisions and implementation. One potential approach would be to develop a preferred scenario in the summer and present it to the Reclamation in October. Other potential timelines and approaches should be explored.
  - Mary noted that other CVP water contracts typically start in March.
  - Ken noted that the Flow Workgroup typically starts planning about two months prior to April. The volume depends on water year type. However, this Contract Water under Proviso 2 allows for 50 TAF every year and the volume will be independent of water year type.
  - Mary stated that the timing of releases could affect water temperatures in the Sacramento basin. In terms of future compliance efforts, it will be pertinent to think about coming up with best- and worst-case scenarios to bookend effects on the Trinity and Sacramento basin.
  - Ken wanted to acknowledge that the idea of relying on the availability of carryover as a scenario made him nervous. Ken suggested the group pursues getting assurance from Reclamation that the water could stay in the reservoir for carryover without getting exported.
  - Mary provided a cautionary note that from a water budget perspective, typically if a reservoir spills, the carryover spills first.
  - Craig noted that he believed Trinity Reservoir almost never fills or spills, but this could be reviewed.

[2] TRRP and Reclamation. 2021. Trinity River Winter Flow Variability Project Draft Environmental Assessment. CGB-EA-2021-51. September.

- Thomas suggested some alternatives to the water year type designations, such as establishing rules based on cumulative 6-month inflow or precipitation, which may be better indicators of the conditions in the river.
- Kyle pointed out that because the Contract Water allotment is dependent only on reservoir storage regulation, not precipitation or water year type, water year type should not be considered an important factor. Additionally, there is a problem in trying to differentiate the scenarios or establish any new hydrologic rules for management of water in the fall and winter periods, such as those suggested by Thomas, because during the fall period there is very low certainty on the amount of precipitation that can be expected for the water year. While predictive management from February onwards isn't as much of a problem, there is not a solid ability to manage water between October and February in a way that is water year dependent.

- As it was determined that the scenarios would not be highly dependent on water year type, the group discussed changing the formatting for the scenario development table(s).
  - Mary suggested adding a blank slide where the group could then discuss and write up a range of 5 to 6 scenarios that could be focused on without water year type.
  - Adam suggested that a surrogate metric for water year type to be added later could be an indicator of the storage in the reservoir at the beginning of the water year and the natural inflow to Trinity Reservoir.
  - Bill noted that it might be best to not get too hung up on separating scenarios by water year type for now. The water year type is only important right now in that it will designate the amount of ROD volume and hydrograph for the year when each scenario is modeled. The present goal is to marry the Contract Water and the ROD flow.
  - Bill then asked whether the 50 TAF volume is going to be a hard limit on the scenarios, and whether developing these scenarios could help justify the use of more than 50 TAF of Contract Water. Bill asked whether and how a scenario could be developed that might have the ability to demonstrate greater fish and ecosystem benefits beyond 50 TAF.
  - Adam confirmed that the goal is to get at least one scenario developed that uses more than 50 TAF to look at the range of benefits that could be expected.
  - Ken agreed with the idea that the fish and ecological benefits need to be a focus, suggesting that the patterns and scenarios should specify the ecological need to be met. Up until now, management has not been able to make releases in the fall except for the emergency Klamath fish health releases, and these are not actually fulfilling an ecological need.
  - Ken expressed concern in using the ROD hydrographs as the base for the analysis because, in reality, most years the TRRP modified the hydrograph and what is actually released tends to be significantly different from the ROD hydrograph. The ROD hydrograph assumes flows stay at the minimum baseflow of 300 cfs October – April and if the flows deviate from this it could change the significance of releases during different times of the year and how those should be prioritized.
  - Seth agreed with not trying to differentiate the scenarios by water year type at present. He suggested setting up the scenario development table in the workshop slides differently to accommodate this. Seth pointed out that the tables in slides 10-11 of the presentation containing the previous workshop 2 recommendations separated by hydrograph component might be a better starting point. Rather than by month or water year type, it would be best to simply create 4 columns for the scenarios, with the hydrograph components to be modified as the rows.
  - Mary suggested adding a column for the objective of each scenario.

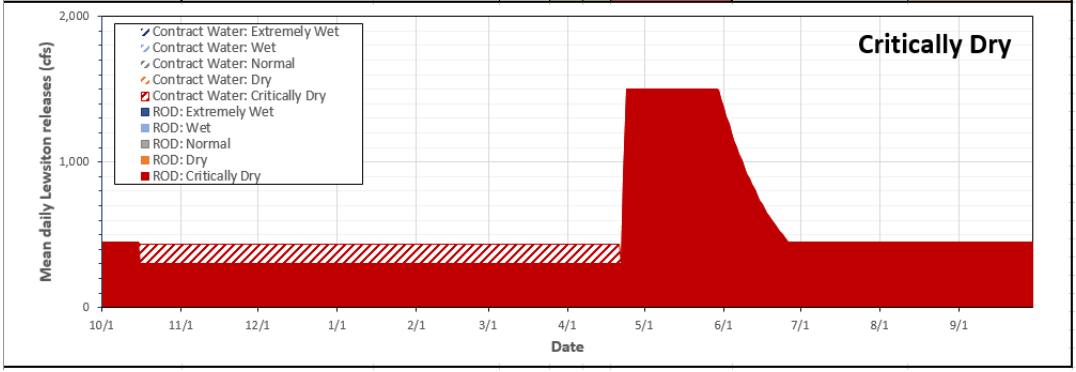
- Seth said that rather than adding columns for the objectives, it would make more sense to have the objective or environmental services within each cell containing a modification, since one scenario might have more than one objective addressed by different patterns.
- Mary asked whether the group would envision scenarios as focused on one type of pattern modification (i.e., a winter flood peaks-focused scenario or carryover-focused scenario) or objectives-focused (i.e., determine an objective and then reverse engineer what combination of patterns would be needed to meet this objective).
- Ken interjected that it would be good to set a bookmark to later discuss the inflow hydrology and time period that would be used for the modeling.
- Adam suggested that for now the group focus on the different patterns that might make up each scenario and then under what conditions those release patterns would be made. The table was reformatted per the discussion.

<u>Group Scenario Development</u>

- The group began discussion to develop the first scenario, which focused on elevating baseflows.
  - Bill suggested a first scenario with 50 TAF evenly distributed across fall and winter. This scenario could consist of increasing the baseflow in all years, sustained from January – April, or at least through March 15 when most fry have emerged, to avoid dewatering redds. The objective of this action would be to provide more spawning and rearing habitat.
  - Mike Dixon noted in the chat that 50 TAF should be able to increase the baseflow by 150 cfs from 300 cfs up to 450 cfs from October 15 until sometime in March. Mike asked why flow would be limited to the October – December period?
  - Ken added on to this idea, saying that adding water between October 15 and December 1 would probably not be beneficial, because that would not leave much additional Contract Water to be used December 1 - April 15, and once the baseflow has been increased, it should not be decreased below this point until the end of the winter baseflow period. Adding flow earlier in the season takes it away from later months.
  - Nick agreed with this idea, saying that the group should not consider a scenario where the baseflow is increased before December 1.
  - Adam used spreadsheet tool to demonstrate how additional monthly baseflow volumes could be calculated using the static and variable baseflow dashboards.
  - Nick noted that the static baseflow dashboard and scenario is also not something that should be considered. A completely static baseflow would not achieve much ecologically relative to other ways the water could be used.
  - The example scenario discussed was a static baseflow added December 16 – April 22, requiring an additional 135 cfs/month, shown below:

Static Baseflow Calculator: Set volume for baseflow, distribute volume equally over specified months

1. Select Water Year Type	2. Specify release parameters		Months	Start Day	End Day	Additional Baseflow Active? (1 or 0)	3. Check monthly releases	Additional Mean Monthly Baseflow Magnitude (cfs)
☐ Extremely Wet	User Input	Release Volume (AF)	10	16	31	1	Flow Days	135
☐ Wet	Computed Value	50,000	11	0	30	1	187	135
☐ Normal			12	0	31	1		135
☐ Dry			1	0	31	1		135
☑ Critically Dry			2	0	28	1		135
			3	0	31	1		135
			4	0	21	1		135
			5	0	31	0		0
			6	0	30	0		0
			7	0	31	0		0
			8	0	31	0		0
			9	0	30	0		0



- Ken agreed with Nick, noting that in the scenario example (shown above), an additional 135 cfs/month would only add a half inch to an inch of water in the river. Static baseflow should not be considered because it is very unnatural as well. The variable baseflow dashboard is a better place to start, to provide a more natural hydrograph with increasing baseflows.
- Bill asked whether the group wanted to create scenarios that could serve as more extreme bookends to provide contrast.
- Hank proposed that with the four scenarios there could be two representing more bookends and two that provide more of a middle ground.
- Craig asked whether the group thought it would be valuable to imagine the desired benefits or outcome and then determine the scenario needed to get there.
- Ken said that while this might be a good idea, this might end up necessitating much more than 50 TAF to accomplish and was too concerned and doubtful as to whether practically they'd be able to secure more than 50 TAF of water under Proviso 2.
- Craig said the group should assume that more than 50 TAF of water could be acquired if the modeling could demonstrate a significant increase in benefits, reminding the group of the Contract Water language says "not less than 50 TAF of water."
- Ken noted that if the Winter Flow Project[3] is approved, then he would feel more comfortable that additional (more than 50 TAF) will be available for use between October 15 and April 15.
- Kyle agreed with the sentiments of Mike Dixon, Nick, and Ken regarding not elevating baseflows until late in or after the fall period. Kyle said that elevating baseflow right away (after October 15) would not be as beneficial as allowing the flows to decrease from the ROD summer baseflow of 450 cfs to the ROD fall baseflow of 300 cfs, and then elevating afterwards, because allowing a drop and then an increase in flow should help distribute spawners. Spring-run Chinook start spawning at the end of summer and fall run Chinook start to spawn later around November 1. If the baseflow increase is moved closer to the

[3] TRRP and Reclamation. 2022. Trinity River Winter Flow Project Final Report. August. Weaverville, CA. 100 pp.

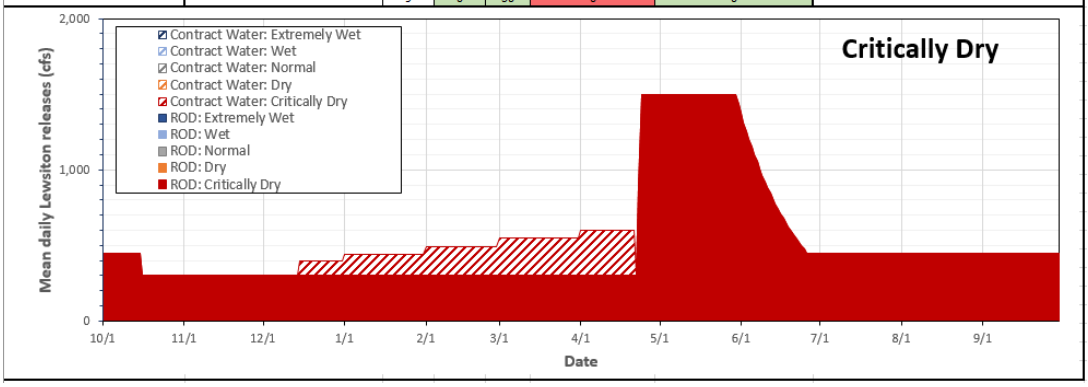
November 1-15 time period this should help to reduce redd superimposition between fall-run and spring-run.

- Kyle added that the increase in baseflow and water levels will help with habitat augmentation, as fish can be distributed across a wider lateral area. Also, it would be beneficial to try push for large enough increases in baseflow to see changes in the hydraulics.
- Ken stated that the baseflow increase should then be pushed until later in the year in order create a larger increase in flow. Ken suggested the baseflow increase occur in mid-December to get a more meaningful increase in volume. Ken asked Kyle whether an increase of 200 cfs would be enough to see an appreciable difference in available habitat and hydraulics.
- Kyle said that an increase of 150-200 cfs should be enough, given that there is a significant enough difference in the 300 cfs and 450 cfs baseflow to change hydraulics.
- Mike Dixon asked in the chat, to what extent is there a habitat dip in the upper river? Is there a risk of hitting an inflection point where baseflow increases could decrease juvenile Chinook habitat (especially if these stack on re-scheduled ROD flows)?
- Kyle responded in the chat that there is good information on this in the 40-mile capacity synthesis.[4]
- Jason asked in the chat whether Stantec could provide example hydrographs of past critically dry water years to reference.
- Kyle said the ROD flow for the critically dry year (shown in dark red in the figure from the spreadsheet tool) is a good example of a typical hydrograph for that year.
- Jason clarified that he was looking to see pre-TRD critically dry hydrographs.
- Adam said the pre-TRD hydrographs can be viewed within the previous Workshop 2 slides as well as the Baseline Conditions Report which will be distributed within the next few weeks to workshop participants.
- Mary asked if the group would like to specify an objective for the first pattern/scenario.
- Nick specified that the first scenario focuses on increasing rearing habitat for Chinook.
- Ken said additionally it would increase spawning habitat for Coho and steelhead.
- Kyle said that because the scenario could increase inundated area and increase the amount of food drift flux, this should also increase the quality of rearing habitat.
- The following release pattern below constitutes Scenario 1 (shown for a Critically Dry year, but the release pattern would be the same in all year types):

[4] Bradley, D.N. 2018. Trinity River 40 Mile Hydraulic Model: Update with 2016 Topography, Technical Report No. SRH-2018-11, Prepared for Trinity River Restoration Program, March 2018.

Variable Baseflow Calculator: Set baseflow magnitude by month, calculate total volume in AF

1. Select Water Year Type	2. Specify release parameters	Months	Start Day	End Day	Additional Baseflow Active? (1 or 0)	Additional Mean Monthly Baseflow Magnitude (cfs)	3. Check volume required and flow days
☐ Extremely Wet	User Input	10	0	31	0	0	Total Volume (AF)
☐ Wet	Computed Value	11	0	30	0	0	50,114
☐ Normal		12	15	31	1	100	
☐ Dry		1	0	31	1	140	Flow days
☑ Critically Dry		2	0	28	1	190	127
		3	0	31	1	250	
		4	0	21	1	300	
		5	0	31	0	0	
		6	0	30	0	0	
		7	0	31	0	0	
		8	0	31	0	0	
		9	0	30	0	0	



- Scenarios 2 and 3 were developed together through a discussion of additional scenarios incorporating biologically or geomorphologically significant pulse flows.
    - Ken discussed incorporating peaks and triggers into additional scenarios. It's important to note that different magnitude peaks can provide different benefits. The geomorphologically significant peak occurs at 6,000 cfs which is enough to provide sediment transport, but 3,000 cfs is a peak that can help with cueing salmon, recruiting leaf litter, and distributing juveniles.
    - Arielle asked whether it would be worthwhile to incorporate several smaller magnitude, short-duration peaks on top of baseflows that could provide environmental cues or increase habitat.
    - Ken said that as long as the peaks are short (< 2 days), the low-magnitude peaks can be used as cueing events and fish won't start building redds based on this (relative to a sustained peak that would be interpreted as stable baseflow by fish).
    - Nick said he didn't believe the small magnitude peaks would provide significant spawning benefits.
    - Ken suggested more water earlier in the season should provide greater separation of spawning habitats for spring-run and fall run Chinook. In general, spawning habitat increases laterally with increasing baseflow.
    - Kyle said there is a difference in the flow and habitat increase resulting from the pulses and baseflow increase depending on where this is measured longitudinally along the river. A decrease in habitat at higher flows occurs farther downstream in the river, especially near Junction City. There is longitudinal variation in habitat and geomorphology in the river that should be acknowledged. However, if pulse and additional flows are focused in the winter period, downstream tributary accretions in the winter can help with reducing that dip in habitat.
    - Adam said the modeling tools extend only through the upper 40 miles of the river in Restoration Reach and so benefits downstream from Helena at the confluence with the North Fork Trinity River will not be modeled (however, Junction City is above this point).

- Mary asked if just adding pulse flows could constitute a scenario and whether the group thought that it would be more beneficial to add pulses in the fall or winter period.
- Craig said the original development of the pulse flow scenario for the 2018 draft proposal[5] chose the peak magnitude and the ramp up and ramp down schedule needed to achieve a geomorphology objective and move sediment of a specific size. For the trigger, they recommended a flow of 4,500 cfs at the North Fork Trinity River and added an additional release from Lewiston to increase the flow to 6,000 cfs with a cap at 8,000 cfs.
- Mike Dixon wrote in the chat that for the Winter Flow Project, the geomorphic pulse rule set was pretty conservative; if accretion was forecasted to exceed 12,000 cfs, the 6,000 cfs wouldn't be released until after the tributary event had receded.
- Ken added that under the Winter Flow Project, the geomorphic pulse would only occur during the Flow Synchronization period (December 15 – February 15), and then after that period the focus would be on increasing baseflow. Within that is embedded the idea that around mid-February to March there is much more certainty as to what the water year type will be, and managers are comfortable releasing more water. It would be better to have the 6,000 cfs peaks earlier in the year, because these are the flows that can reset the macroinvertebrate community, so it should be timed so that the macroinvertebrate community resets and has to time to reestablish before the salmon are coming out of the gravel. Possibly a flow as low as 3,000 cfs would be enough for resetting the macroinvertebrate community.
- Adam asked if the pulse flows should be synchronized with high flow events and what trigger should be used.
- Kyle said that he believed 4,500 cfs partially mobilizes the bed. He proposed that there could be two scenarios with pulses. One with geomorphic intent prior to rearing which should be high enough to reset the macroinvertebrate community and scour the channel. The second scenario would contain smaller magnitude, biologically significant pulses that focus on increasing inundation in the fall period; the first pulse would be during the rearing period at 1,200-1,500 cfs to entrain litter and food. These smaller pulses can be used to alleviate competition between natural and hatchery fish by dispersing the fish. The pulses attract natural and hatchery fish to the hatchery earlier in fall, and that intermixing improves the genetic diversity.
- Kyle said with the Winter Flow Project, there is a lack of certainty that there will be water to release later in the year if flow is expended early. This is the advantage of Contract Water in that it can be used regardless of water year type. Releases should both augment the hydrology and respond to it, by synchronizing with high flow events.
- Ken suggested for Scenario 3, a synchronized pulse of 6,000 cfs could occur up until mid-February if the North Fork flow trigger of 4,500 cfs occurs. However, if the trigger doesn't occur, then instead there could be lower magnitude biological release pulses.
- Kyle said those biological pulses should be timed with the hatchery release of steelhead and Coho.
- Seth said because the least amount of hydrologic information is known earlier in the water year season, water in the fall would be more useful. Additionally, the 6,000 cfs flow event can be achieved through other means later in the season.
- Bill suggested the group should take into account that while these hydrologic scenarios will likely add benefits to the river system, the modeling tools to assess the scenarios are not going to pick up the impacts to the base of the food-web generated by the pulses. The fish

[5] Naman, S. 2018. Humboldt County Trinity River Flow Meeting, October 8, 2018. PowerPoint presentation.

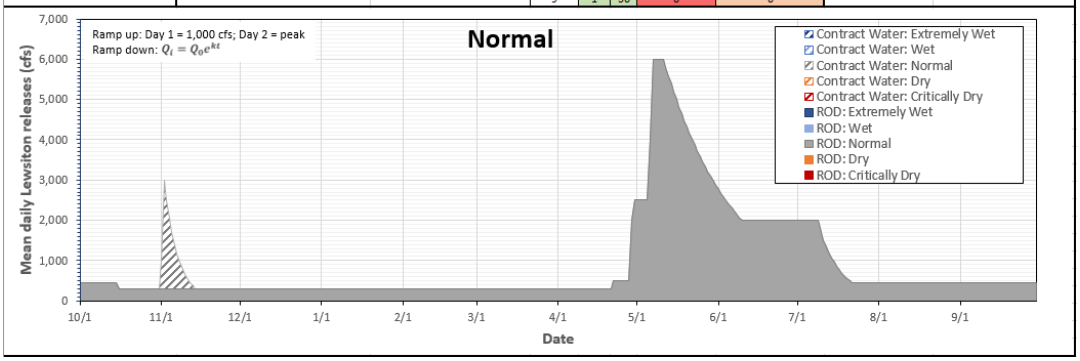
habitat production model measures habitat and production but does not pick up the changes to the macroinvertebrate community.

- Adam said even though the fish habitat production model does not account for the resetting of the macroinvertebrate community, that he believed in the hydraulic model (SRH-2D), they determined surrogate variables such as a critical shear stress which was incorporated in the Winter Flow Variability EA to measure this impact indirectly.
- Bill acknowledged that if this impact and benefit was incorporated indirectly into the modeling through a means such as shear stress, that could go a long way in showing benefit with these pulse scenarios.
- Adam offered that Scenario 2 could focus on a set of biologically significant low magnitude pulses for the fall period. Adam asked what the group thought should be the conditions or trigger for this event.
- Seth added that while he believed large flow events do happen in the fall, they are more rare than they are in the December to February period, hence why he agreed with Kyle that the Contract Water could be most valuable to use in the fall period. Between October and January it would definitely be rarer for a high magnitude bed resetting pulse flow to occur. In terms of a fall trigger, potentially it could be a high rainfall event, as described in the Winter Flow Variability EA. However, this action would require management to track conditions in real-time. But that would be one option.
- Kyle added that an option would be that if the fall period triggers aren't met for Scenario 2, then the Contract Water could be preserved for the winter period, at which point management could decide whether it should be used for increasing winter baseflow (Scenario 1), or for pulse flows (Scenario 3).
- Seth, returning to the question of the fall pulse triggers for Scenario 2, suggested the trigger could be when the flow is a 1 to 1 ratio at Coffee Creek.
- Ken suggested that the Coffee Creek recurrence intervals be used.
- Seth agreed with Ken, and suggested it be set to a low flow, such as between the 1-year to 2-year recurrence flow.
- Ken said the 1.5-year recurrence interval should be the trigger then, adding that the fall freshets are the most difficult to get enough water for. In terms of objectives, recruitment of leaf litter should be listed as one.
- Seth said that fall redistribution of juveniles is another objective for these fall pulses, and this is supported by studies on Klamath showing greater migration of juveniles during fall storm events, and a study done by Damon Goodman and others showing that this can help with lamprey distribution. Another objective that can be met by these fall pulses is to increase distribution of spawners and provide the velocities needed for oxygen saturation in redds.
- Kyle said because the flow trigger is set low, the trigger is going to be met in at least half the years. Doing this scenario would probably preclude having the remaining volume to add on the geomorphic pulse flow events. The ideal scenario in terms of management and making the decision then on these scenarios is to get together in the summer to decide what could be done, then the final calls would be determined by the environmental conditions at the start of the period.
- Adam asked if that means the winter scenarios (1 and 3) would depend on whether the fall pulses (Scenario 2) occur.
- Ken said this would be the case if there wasn't enough volume to do both. Ken asked whether the group would consider doing a second pulse or pattern if there was enough, noting that this approach would be analogous to the Winter Flow Variability EA.

- Kyle proposed that if there were to be multiple pulses, they should not have the same peak magnitude.
- Adam noted that, referencing the spreadsheet tool pulse dashboard, a 3,000 cfs with a 13-day duration (pattern shown below) would leave ~25,000 AF, or about half of the Contract Water.

Pulse Flow Calculator: Set pulse flow magnitude, calculate pulse shape and volume

1. Select Water Year Type	2. Specify release parameters		Months	Start Day	End Day	Pulse Active? (1 or 0)	Additional Flow During Month (cfs)	3. Check volume and ramping rates	
☐ Extremely Wet	User Input	One-day Pulse Peak (cfs)	10	1	31	0	0	Total Volume (AF)	
☐ Wet	Computed Value	3,000	11	1	30	1	12,564	24,877	
☑ Normal		Total Flow Days	12	1	31	0	0		
☐ Dry		13	1	1	31	0	0	Ramp up rate, k	Ramp up rate (cfs/day)
☐ Critically Dry			2	1	28	0	0	1.151	1,350
		Fall/Winter Baseflow (cfs)	3	1	31	0	0	Ramp down rate, k	Ramp down rate (cfs/day)
		300	4	1	21	0	0	-0.192	245.5
		Ramp up duration, t (days)	5	1	31	0	0		
		2	6	1	30	0	0		
		Ramp down duration, t (days)	7	1	31	0	0		
		11	8	1	31	0	0		
			9	1	30	0	0		



- Bill suggested that there be one scenario with a single fall pulse and the rest used for baseflows and another with 50 TAF released entirely in the fall.
- Adam suggested looking at a range of things that could be accomplished with 25,000 AF, asking whether the group thought that was enough volume to consider.
- Ken said it may be best to look at fall and winter separately, in order to focus the different scenarios on a specific ecological need, and to provide clear bookends for the results. Additionally, Ken felt that 25,000 AF wouldn't be enough to fill large gaps in the hydrograph. As such, the fall period for Scenario 2 should be set at October 15 – December 15.
- Kyle suggested taking into account the timing of the date of leaf fall, which should be confirmed with the riparian ecologist, but Kyle believed this to occur in the November 1 – November 15 timeframe. The idea is that one low pulse could be targeted for after leaf fall to recruit the leaf litter into the stream.
- Ken proposed setting the observation period for the flow trigger for the 3,000 cfs pulse (1.5-year recurrence flow at Coffee Creek) from October 15 to November 15, and synchronizing this pulse if possible.
- Craig, moving back to the geomorphic pulse proposed for Scenario 3, suggested that the pulse be modeled based off the 2018 draft proposal flow schedules. Craig noted that a lot of analysis went into how proposed trigger and flow pattern for the geomorphic pulse, so building off that would be ideal.
- Ken added that the Winter Flow Variability EA geomorphic pulse scenario was very similar to the 2018 draft proposal and the trigger for that flow event was a flow of 4,500 cfs at North Fork.
- Mike Dixon added that the same flow trigger at Junction City does not protect infrastructure which is why the Winter Flow Variability EA used North Fork as the trigger.

This kept flow below the flow at which infrastructure at Junction City starts flooding (18,500-19,000 cfs at Junction City).
    - Craig suggested Humboldt County should recirculate the 2018 draft proposal documents which explain the trigger points.

- Discussion shifted to developing the fourth scenario, and how to incorporate carryover or scenarios using volumes greater than 50 TAF.
    - There was general consensus that it is uncertain if Humboldt County would be able to reliably carryover large volumes of Contract Water.
    - Seth suggested Stantec look at the historic record for the end of September storage amounts and check whether there is a threshold set for minimum volume or reservoir level.
    - Kyle said likely carryover could occur after a wet or extremely wet year depending on the reservoir storage.
    - Mary said it would depend on how the water year type for Trinity is defined.
    - Craig pointed out that asking what can be done with 100 TAF for baseflows is the wrong question; instead benefits and objectives should be the focus and working backwards to find the volume needed to meet those.
    - Hank asked Nick whether he had ideas on how to maximize benefit with more than 50 TAF of water.
    - Nick said there are certain benefits that could be targeted with modifying one component of the hydrograph but many benefits are maximized through the coordination of all of these patterns throughout the entire year. One option is to continue increasing the volume for each of these scenarios until it looks as though the benefit of adding volume to that one pattern is exhausted. This would result in four different volumes, one for each scenario, where the benefits have been maximized.
    - Mary noted that proposing a range of alternatives is required for a NEPA document; for now, however, the group may just want to think about tradeoffs.
    - Kyle agreed with Craig and proposed that Scenario 4 be a combined scenario modeling implementation of all the ideas proposed in Scenarios 1-3. As far as optimizing for habitat, habitat can be increased almost indefinitely with more water volume. So likely maximizing that benefit would dictate the optimal volume to be released. Increased baseflow should occur every year because it doesn't have a trigger, while keeping the rules for the triggers for the other patterns.
    - Adam proposed that Scenario 4 could be a volume-independent scenario.
    - Ken, restating Bill's earlier concern, noted that a primary issue with this scenario is that there are a lot of benefits to the system which are not captured by the models. For example, there are assumptions regarding food recruitment, but not an applicable tool. In reality, there would be more benefits in the river than would be shown in the models.
    - Nick suggested the group could make some additional assumptions to incorporate into the modeling scenarios to address this.
    - Hank asked whether bringing increased fall baseflow should be considered for Scenario 4 since it is volume independent.
    - Kyle said to not consider adding a fall baseflows pattern, as the biological/geomorphic pulses and increased winter baseflows alone are already going to require about 100 TAF to 200 TAF of water.
    - The group concurred that the fourth scenario should be volume independent, and should always release 50 TAF for fall flow peaks, 50 TAF for winter baseflows, 50 TAF for biologic

pulses, and 50 TAF as a geomorphic pulse when the North Fork trigger is met. This would result in 150 TAF to 200 TAF being released each year. This scenario would provide a comparative assessment for how implementing all release patterns together provides benefits versus implementing only one of them.

Final Scenario Development Table

Hydrograph Component	Potential Contract Water Release Pattern	1	2	3	4
Scenario		Increase baseflow in all years	Fall pulse in some years	Geomorphic/Biologic pulse in all years	Combo (no volume limit)
Fall baseflows	When baseflow drops to 300 cfs October 15, add increasing levels of baseflow until December 1				
	Add flow peaks synchronized with storm events (release less than 3,000 cfs from Lewiston Dam)		Oct 15 – Nov 15 Nov 15 – Dec 15 Release 3,000 cfs pulse if flow trigger met (Coffee Creek, 1.5-year recurrence); if not, release at end of each period. Objectives: recruitment of leaf litter, fall redistribution of juveniles, lamprey, distribution/velocities for spawners, inundate delta deposits to allow access into tribs		Same as scenario 2
Winter baseflows	Add increasing levels of baseflow from December 1 until April 15	Increase baseflows in all years per variable baseflow increases in tool (Dec 15 – Apr 15) Objectives: increase rearing habitat area and quality and available spawning habitat for Coho/steelhead			Same as scenario 1
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.			Synchronized geomorphic pulse of 6,000 cfs Dec 15 through Feb 15 if trigger met at North Fork; if not, 3,000 cfs biologic pulse release Mar 15 and April 15	Same as scenario 3 but always release biologic pulse

Concluding Remarks:

- Mary noted the next steps for Stantec will be to develop the CalSim and HEC5Q models, then share results with the USFWS and USGS modeling team, and work together to develop preliminary model results for all scenarios to be reviewed in the next workshop.
- Adam concluded by reviewing the models and the primary analysis variables to be used in the modeling (slide #23). The daily timeseries of flow releases will be converted into monthly flow to be used in CalSim.
    - Ken asked about modeling period of record.
    - Adam said the modeling period of record would be the 1980-2003 period since that would align each model's overlapping period of record. Further details on this could be found in the previous workshop 1 materials and the forthcoming Baseline Conditions Report.
    - Ken reiterated this period of record does not capture current conditions in the river.
    - Mary noted that the climate change scenario developed for the Klamath LTP will cover the future scenario, and the climate change model was calibrated for this period of record, which is a major part of the rationale for using this period of record.
- Mike Orcutt raised a question or concern about the relationship and coordination between this technical working group and the TRRP and his recommendation to formalize connection and ensure integration of overlapping management strategies. Mike also brought up coordination of discussion with Reclamation, adding that typically they are the main entity restricting the release of water. Mike suggested that whoever is doing the NEPA and EIS documentation work should set up a line of

connection and dialogue with Reclamation, because there are still questions to be addressed on the legal and policy side of things. Mike added that he would be willing to continue this conversation offline.
    - Craig responded to Mike to let him know that Suits and Signs and Humboldt County is planning to set up a meeting between the County and tribes to establish an MOU and co-management of contract. Until the scenarios are developed, it is unclear if and what might trigger the NEPA and CEQA process. Craig believed that coordination with outside agencies may not be needed unless the goal was to exercise Proviso 2 water beyond the Contract limit and then it would depend on what is considered appropriate use of the water.
    - Mike Orcutt noted that Proviso 1 covers several types of releases including flow augmentation releases (FARS) and the emergency flow pulses for fish health and wondered about how separation between Proviso 1 and 2 water would be determined.
    - Craig noted that these technical workshops are focused on how to use Contract Water (Proviso 2) to produce more harvestable fish to benefit the residents of Humboldt County.
    - Mary noted that earlier she mentioned that a proposed range of alternatives is required under NEPA, but the need for NEPA and an EIS analysis for this project still needs to be confirmed.
- Adam shared the next steps for Stantec will be to translate these four scenarios developed in this workshop into input for the modeling tools. Workshop 4 will be targeted for the end of December to early January. At that workshop, initial modeling results from these scenarios will be presented.

Action Items:

- Stantec will distribute Workshop 3 materials and meeting notes.
- Humboldt County will distribute the Baseline Conditions Report to workshop participants.
- Workshop participants interested in Humboldt County 2018 draft proposal documents should request a copy from Humboldt County.

FINAL Meeting Summary

Date/Time: February 9, 2023 / 9:00 AM PT

Subject: Trinity River Water Management Plan, Workshop #4

Place: Microsoft Teams

Attendees:

Attendee	Affiliation	Attendee	Affiliation
Hank Seemann	Humboldt County	Ken Lindke	CDFW
Craig Tucker	Suits and Signs Consulting	Monty Larson	CDFW
Kyle de Julio	Yurok Tribe	Elizabeth Hadley	Reclamation
Jason Reed	Hoopa Valley Tribe	Allison Mitchell	DOI Solicitor's Office
Mike Orcutt	Hoopa Valley Tribe	Scott Bergstrom	DOI Solicitor's Office
Darren Mierau	CalTrout	Adam Witt	Stantec
Nick Som	USFWS	Mary Paasch	Stantec
Bill Pinnix	USFWS	Paul Uncapher	Stantec
Russ Perry	USGS	Stephanie Theis	Stantec
John Plumb	USGS	Arielle Gervasi	Stantec
Seth Naman	NMFS	Thomas Gast	Thomas Gast & Associates

Agenda:

Item	Responsible Party
1. Introduction and Project/Workshop Objectives	Adam Witt
2. Contract Water Release Scenario Review	Adam Witt
3. Modeling Results	Adam Witt
4. Scenario Refinement Discussion	Adam Witt/All

Purpose and Objectives:

The objectives of this workshop were to:

- Evaluate model output variables and non-modeled factors and determine which scenarios are meeting Project objectives.
- Develop two refined scenarios with sufficient detail to begin a second round of technical analysis.
- Identify any additional variables (i.e., model outputs) needed to assess scenarios

Note: This meeting summary documents the discussions that occurred during the presentation. The full content presented during the workshop can be viewed from the presentation distributed to meeting participants.

Workshop Summary:

Introduction

Adam presented the project objectives, timeline, and workshop agenda, which addressed the goal of this workshop leading to a refinement of scenarios in order to produce two refined scenarios for additional technical analysis. Additionally, the group may identify any additional variables needed to assess the scenarios and evaluate them in an appropriate way.

Contract Water Release Scenario Review

Adam reviewed the four scenarios developed in Workshop #3 and illustrated with example hydrographs. The objectives of each scenario were reviewed as well as the major modeling assumptions.

- Seth asked whether further explanation could be provided regarding the climate change perturbations included in the CalSim hydrology.
    - Adam explained that the CalSim modeling previously done for the Klamath LTP EIS used a range of climate models with different future global warming scenarios. The models are combined to produce a coarse hydrology that is downscaled locally to each watershed in the CVP/SWP system by Reclamation. The historical hydrology is adjusted by a climate change factor. Inflow and air and water temperatures either increase or decrease, but the hydrological patterns are not statistically modified—i.e., the climate adjustment doesn't extend droughts or adjust the wet/dry period oscillations.

Results Overview

Adam led an overview of the modeling results and highlighted that the group should consider, while reviewing results, three potential paths forward to: 1) maintain and modify the existing release patterns, 2) create a combination scenario, or 3) construct a new type of release.

Hank brought up that as the group evaluates the scenarios, the focus should be on what the models tell us about the system and should be distinguished from the models' limitations. The objectives developed originally for each scenario were very broad and the models cannot actually model some of the metrics.

Adam presented a summary table of averaged modeled results to begin as an overview. Adam noted that this table shows that generally the flow and sediment transport metrics were correlative to flow. Scenario 4 was the only scenario to show a significant (>5%) increase in habitat (parr capacity) and productivity (fish mass).

- Seth asked the period of March-May was the only highlighted period for fry and parr
    - Russ clarified that models were run through all months and years, but that the months chosen to highlight in the table were those that corresponded with the timing of spawning and primary rearing periods for the modeled species.
    - Seth pointed out that for Scenarios 1 and 2, there wouldn't be flow modification March-May, so any changes to the fish results would be due to indirect effects.
    - Mary noted that in the modeling, when releases were made earlier in the year, it changed releases later in the year. Usually in wetter years, this translated to lower safety of dams releases from Trinity Reservoir. These changes in operations are captured in CalSim.
    - Adam added that there is a rule curve for storage in Trinity Reservoir. If CalSim shows inflows are high and the reservoir is close to being full, a safety of dams release is initiated to evacuate water for flood control.

    - Seth said based on this summary table alone, it would suggest that 50 TAF of water isn't creating a significant benefit for fish habitat and capacity.
- Kyle commented that the summary table (slide 17) shows that the fall releases in Scenario 2 are showing increased egg survival. But in October there's also a yearling hatchery Chinook release—do the model results offer any insight into the effects on the yearling release or whether this helped with successful outmigration?
    - Russ clarified that the yearling release of hatchery fish in the fall is currently not in the model and the model is focused on production of natural fish. Smolt outmigration is size-dependent and not flow-dependent so wouldn't be largely affected by flow releases. The relationship between river flow and migration rates is currently being studied and could hopefully be integrated into the model in the future.
    - Kyle noted that the hatchery can't currently access higher inflows and managers also don't influence additional releases. Because the Contract Water volume doesn't have the restriction of Proviso 1 water it could potentially alleviate competition of natural and hatchery fish and this should be considered. The hatchery produces about half of the fish harvested.
- Nick noted that it wasn't surprising that the habitat model did not show a significant increase relative to baseline for Scenario 1, given that the magnitude of flow increase is quite small when spread out over such a prolonged period from December to April.
    - Adam suggested that Scenario 1 be modified to shorten the release period and increase the magnitude of flows based on the periods when juvenile and parr are utilizing habitat.
    - Nick noted that this flow only needs to last for about 2 months.
- Seth cautioned against shifting the actions due to limitations of the models and limited understanding. The group should not shift the action to make the model show the desired results, but instead focus conceptually on formulating a release based on objectives.
    - Adam agreed, highlighting the importance of clearly identifying the objectives and the benefits associated with those objectives and which ones the team can quantitatively analyze.
    - Seth added that existing telemetry studies could help identify water to target for hatchery releases, and help identify structured study designs on how flows affect fall hatchery releases of Chinook salmon. There are some important metrics the model does not capture, such as the invertebrate community and its effects on productivity.
    - Ken noted the benefit of the geomorphic release to improve food availability by resetting the benthos and invertebrate community is not captured in the model. Potentially this benefit could be analyzed qualitatively with descriptions? We don't have the tools in the models right now but in the literature there are estimates for the duration of the flow needed to reset communities which we could reference. Ken also agreed with having water available to alleviate hatchery impacts on natural stocks is valuable, and the fall pulse releases could do this. Additionally, higher fall flows are a missing component of the natural hydrology. Between offering more natural flows adding flow for the yearling releases, there's more value to releasing in the fall.
- Craig asked if the model measured whether the habitat or production benefits increased when only averaging over the dry years or if there was a difference across water year types.
    - Adam noted that Russ and John would elaborate on that in the description of the habitat model and S3 results.
- Kyle pointed out that because the Winter Flow Project action was approved this year, ROD water will be available to be released in about a week. For Scenario 1, maybe the elevated baseflow should only occur over two months in December and January, when there is no ability to use ROD water?

From October to February, there's very limited access to additional water for environmental purposes. Also, in these results we see that some scenarios increase capacity, but in those same scenarios the biomass and fish mass are less. Abundance is increased in Scenarios 2 and 4 with increased egg survival. Getting flow released earlier means there is a potential to influence the fish earlier in the life cycle. The earlier we can create an effect, the more fish are affected because there are more still alive, since mortality continues over time. Additionally, flow releases when they are young help them during a vulnerable period in their life cycle.

- Darren asked for clarification on the meaning of the objective for Scenario 3 to reset the macroinvertebrate community, and why this would be considered a benefit.
    - Adam explained that the intent of resetting the community and bio film was to stimulate change in the channel to increase food production. As Kyle mentioned, it's difficult to model that. We modeled the partial bed mobilization to quantify this but it isn't in the fish models.
    - Kyle added that there is literature that confirms bed disturbances dislodge larger macroinvertebrates into the drift where they are more easily predated and the fry can feed on these.

<u>Fisheries, Habitat, and River Temperature Results</u>

Russ presented the S3 and habitat model results. Russ highlighted that S3 is spatially explicit and breaks the Restoration Reach into habitat units for analysis. A higher than median number of spawners was used as the population size for each year to trigger redd superimposition and other density dependent movement/effects. No juveniles from the tributaries were included, only juveniles from the mainstem and hatchery. Results are only analyzed for natural production fish, not hatchery fish.

The abundance by water year type result showed high year-to-year variability in the number migrating (400K range among years, or 20% difference). However, across scenarios the difference is generally smaller than the year-to-year variability. Scenario 2 had more years when biomass and fish size were higher than baseline. Scenario 4 resulted in higher abundance, but smaller size fish. Scenario 2 was the only scenario that produced larger average size.

- Ken asked about the timing and triggers for the fall pulses in Scenario 2. Fall releases are occurring when fish eggs are still in the gravel. If these pulses are before February 15 they shouldn't be affecting growth. One of the mechanisms that would benefit biomass is the geomorphic releases which reset the macroinvertebrate community and increase food—but again this is not captured in S3 model. Is what's driving growth and fish size in these models is flow and temperature only?
    - Russ noted that fish growth is temperature-dependent. Smaller fish at Pear Tree means there was an earlier outmigration. And the model is not accounting for the macroinvertebrate community as there is a constant consumption rate in the model.
    - Adam clarified the 13-day fall pulses would be released between October 15 and December 15, so they would be over by the end of December.
    - Ken asked whether that means the effects in Scenario 2 on fish production or size only result from indirect effects through later releases?
    - Adam agreed that the effects from January onwards would be indirect in this Scenario 2.
    - Russ noted that some temperature differences occurred relative to baseline due to earlier releases, and that those dynamics influence the outcome.
    - Ken highlighted Scenario 2 is showing collateral effects and not the direct effect of the releases on production. If the mechanisms are not being captured by the model then are the fall flows actually affecting the system as intended?

    - Adam noted that the temperatures can change as a result of changes to releases but also in operations—the model releases Contract Water, which changes the timing of CVP exports from Lewiston to Clear Creek which changes temperature, though these changes are minimal for the scenarios.
- Kyle asked whether increased egg survival could be considered a direct effect? Is this due to fish spawning earlier? It could be considered a direct effect here since the fish are in the model at the time of release.
    - Russ agreed that higher egg survival is a direct effect in Scenario 2, but maybe not the intended effect, since the objectives were specifically "recruitment of leaf litter, redistribution of juveniles and lamprey, distribution/velocities for spawners, inundate delta deposits."
- Russ concluded with some key takeways for the habitat model and S3 results:
    - Juvenile survival is highest under Scenario 4.
    - Scenarios 1 and 4 have later timing in outmigration based on the water year type.
    - Fry capacity has short duration increases from pulse flows. However, differences in habitat area were for short duration.
    - Water year differences showed that wet and extremely wet years there was a higher abundance, but smaller fish size and later migration times. Scenarios 2 and 3 had larger fish in extremely wet years than the other scenarios and baseline. More water creates greater differences in the model metrics. The differences in the metrics were greater between water years were greater than between scenarios.
    - Differences in water temperature decreased farther downstream.
    - Fry are more sensitive to density than parr.
    - Scenario 2 had a greater fraction of years with higher abundance, biomass, and fish size relative to the baseline due to more years with higher egg survival.
    - Scenario 4 also had a greater fraction of years with higher fish metrics relative to baseline for three of the five metrics (egg survival, juvenile survival, and abundance)
    - Modeling tools cannot evaluate effects of leaf litter recruitment and sediment changes on salmon production.
- Seth asked about the mechanisms contributing to higher egg survival.
    - Russ noted that higher redd capacity, which is affected by pulse flows occurring during spawning, reduces superimposition. Temperature influences incubation time, and longer incubation during colder conditions is associated with higher mortality.
    - Seth noted that this seemed like a favorable result and the model seems to be able to capture the mechanisms and effects well for this metric.
    - Russ noted that higher than median number of spawners used for the population size helped make that benefit more apparent in the model.
- Darren asked if the fall pulse flows allowed fish to spawn further downstream or is it a more lateral change in spawning habitat.
    - Russ clarified that the model sets the spawners in the same location each year, so the model isn't capturing behavioral redistribution.

<u>Sediment, Reservoir Storage, and Water Temperature Results</u>

Arielle summarized the key takeaways from modeling of the bedload transport and partial streambed mobilization. Scenarios 1 and 2 showed no increase in either of these sediment metrics. Scenarios 3 and 4, which incorporated geomorphic pulses, showed increases in these sediment metrics, which varied

greatly longitudinally within Restoration Reach, and by year, with only a few years accounting for the majority of geomorphic work over the modeling period.

Adam presented the results from CalSim and HEC5Q calculating reservoir storage, CVP exports, and release temperatures below Lewiston and in the Sacramento River below Clear Creek. Trinity Reservoir storage showed relatively low variability between scenarios, but was lower than the baseline in dry water years. In consecutive dry years, low inflows caused a greater effect over time in dry periods. For Lewiston release temperatures, most of the variation is plus or minus 1.5 degrees Fahrenheit, an ~3% variation, and cooler temperatures in March-April on average for Scenarios 1, 3, and 4. CVP allocations were cut in Scenario 4. On average, the change to operations resulted in reductions of CVP deliveries to contractors of 10 TAF in Scenarios 1-3 and 210 TAF in Scenario 4. Shasta releases increased and lowered Shasta storage by ~0.5% on average.

- Seth asked if Shasta releases were adjusted.
    - Adam explained that there are two primary ways CalSim can be modified: 1) either cut CVP allocations and therefore deliveries to CVP contractors, which reduced releases required from Shasta or 2) allow Shasta storage to be lower relative to baseline. For Scenario 4, allocations were cut so that contractors received less delivery in a manner that would keep Shasta storage at similar levels to the baseline.

<u>Scenario Refinement Discussion</u>

Adam reiterated some of the guiding questions for discussion: Are the scenarios meeting project objectives? How can patterns be improved? Are there suggested Scenario 1 and 2 modifications?

- Seth said that the proposed Winter Flow action was adopted by the TRRP within the last week. Therefore, proposed use of the Contract Water should assume this action can be implemented with adaptive management. The Winter Flow action will allow the TRRP to release water before April 15, which was not previously possible.
    - Seth said Scenario 1 spreads out the water over too long of a time period. This building baseflow action is already a part of the Winter Flow action. If Scenario 1 was implemented, the release should definitely be constrained so it is a higher magnitude over a shorter period of time. There is no method to provide water earlier in the year due to uncertainty of the water year type in October. Targeting the Contract Water earlier in the water year is a better plan. The results for egg survival are encouraging—maybe we can tease out the mechanisms to better understand this result. Overall, I'm not surprised that there were not large differences in results across scenarios, which according to Russ could be the case, as 50 TAF is not a lot of water. Kyle's idea of releasing in the fall with consideration for timing of hatchery releases is good. In the future model results could be used to see if there is a benefit to fall releases aligned with the release of hatchery juvenile and combine that with a study of the dilution of smolts in the fall. Targeted telemetry studies could show whether the fall pulses have a positive effect on outmigration so that the model could be modified to show the additional benefit of these fall flows.
    - Craig added that targeting the fall hatchery releases and find ways to develop models that allow the TRRP to pose this question and capture more benefits in the models.
    - Adam asked whether the group knew of any of modeling tools that capture the hatchery releases, which the group seemed to think there were not currently.

- Ken asked whether the yearling releases in spring were incorporated into Scenario 3, even though all the metrics presented are taken from natural origin component.
    - Ken asked if the yearling releases are included, and is there capability to look at density-dependent movement and how that varies across scenarios? Maybe the model isn't calibrated for fish of that size (hatchery fish are typically larger than natural)?
    - Ken said that if the group would like to pursue fall releases, releases when the reservoir is low can be detrimental and we may want to put a caveat on the releases. For example, this year the temperatures were close to exceeding suitable temperatures for Coho eggs. So fall releases may need to include a minimum storage level to account for temperatures. Coho have more sensitive temperature requirements than Chinook. Kyle and Seth recently established a new temperature target for releases. The fall releases scenario is probably the best. Fall releases is a functional flow component of the natural flow regime that is currently not present and it has the benefit of coinciding with hatchery releases. But the reservoir storage and temperature should be taken into consideration for fall releases.
    - Adam, proposed a scenario with the reservoir storage as a trigger or constraint for the fall release, and if the water is not released in the fall, use it for something else later in winter or spring.
    - Kyle suggested that if the fall releases did not occur, the biological pulses could occur in spring. Those releases should roughly coincide with hatchery Coho and steelhead releases. Focusing on hatchery fish could help distinguish this Proviso 2 water to benefit downstream users and fisheries. It could also be worth looking at releasing a single pulse in the fall roughly timed with release of yearlings. The hatchery technical team would be interested and would probably consider changing timing of the hatchery fish release in order to coincide with water release timing. The Coho release in March could benefit from a similar release, one in fall and one in spring to target hatchery fish. Radio tag information could then help determine whether there are increased rates of Coho and Chinook survival with flow.
- Bill said the release of hatchery fish could be included in Scenario 3 to track. It might be useful to look at past data from rotary screw traps. Unfortunately, at Pear Tree, there are less data to validate the timing of migration. There are good monitoring records between the 1990s and 2000s at Willow Creek which describes the timing of migration of hatchery fish.
    - Russ noted that it would be easy to add more fish into the Scenario 3 model to represent the hatchery fish. However, the proper parameters are not known. Smolts have a size-dependent migration rate, but movement is density independent (not dependent on flow and velocity). Survival is time-dependent based on travel times. Hatchery fish were included for the spring releases and estimated migration and survival using the Pear Tree trap data. Estimating the proper parameter values to represent the hatchery fish dynamics would be a challenge. The model could include the hatchery fish but these values would need to be assessed. The Willow Creek data could be used, or just test and then validate. A few years ago, there was a telemetry study from the fall release at Iron Gate on the Klamath. The Hoopa Valley tribe has started to do some telemetry studies on Trinity and perhaps we could look through their studies.
    - Adam asked whether this model development in S3 could occur within the timeframe of the water management plan.
    - Russ estimated that the model development and parameterization could probably not be done within the timeframe needed for this project. Flow migration rate relationships for the fall fish would need to be researched and cited.

- Adam noted that it seems like there is some consensus for focusing on the fall period and considering the Winter Flow action will be starting this year on February 15, to keep Contract Water independent of that action. Timing fall releases with fall hatchery releases would be good, but this would be challenging using the modeling tools. What about modifying the fall releases in another way, such as extended the pulse flows
    - Kyle cautioned against increasing the length and timing of fall flow to avoid a cue that might cause the spawners to prematurely create redds and lay eggs. The idea of keeping the fall releases as short pulses is better. A secondary benefit of pulse flows would likely be attracting natural adults to the fish ladder and increasing use of the ladder—I believe this has been demonstrated in other systems.
- Craig asked whether the pulse flows could help separate the spring- and fall-runs and provide additional benefit that way (reduce redd superimposition).
    - Kyle noted that there might be a possibility that high flows in summer through fall, if done too early, might allow more fish to get upstream and exacerbate this. However, October 1 should likely be late enough to avoid this.

- Hank suggested that it may be beneficial for the group to discuss the hypothetical hydrograph that was developed by NMFS and USFWS in the 2018 technical memo (i.e., a stair-step increase in the spring leading up to the ROD releases).
    - Seth said using all the Contract Water for one pulse 6,000 cfs geomorphic pulse is less desirable, considering all the other potential project objectives.
    - Ken said there might be overlap with the Winter Flow action and so the geomorphic pulse scenario shouldn't move forward.
- Adam proposed new Scenario 5 with fall pulses or a fall and spring pulse timed with release of hatchery yearlings.

- Kyle asked for elaboration on the biologic pulses and the 1.5-year recurrence trigger. What does the team think of the trigger?
    - Seth thought the idea of using a 1.5-year trigger is a good call, as the 4,500 cfs threshold for the geomorphic pulse is very high, such that the pulse is not released very much.
    - Arielle noted that the biologic trigger flow criteria in the model was met in 16 out of 24 years for Period 1 and 15 out of 24 years for Period 2, so at about 60% for each period.
- Ken said he likes Scenario 2, but the only modification would be to set a limit based on the storage to protect water temperature in the reservoir (and thus released water temperatures).
    - Adam asked what should be done with the water if it is not released.
    - Seth disagreed with setting a limit on holding the water in the reservoir, adding that Reclamation should manage the reservoir to account for this. He did not like the idea that this action is dependent on whether Trinity Reservoir is managed correctly.
    - Ken countered that it would be good to put an agreement in place if this happens. A severe drought just occurred, so scenarios that can be applied in the future should be considered. It is up to Reclamation that all these releases can occur without causing harm before other diversions made.
    - Kyle agreed setting the constraint on the reservoir temperature and storage. If the storage is below 750 TAF, then it may be better to hold the water in the reservoir for different objectives. Carryover storage may be preferable when storage in Trinity is low

In these years, perhaps the water is held through the wet winter season and then make a decision later.

- Adam reminded the group that these scenarios and the water management plan aren't intended to replace the other plans. Maybe if don't release fall pulses are not released, then maybe apply the stair-stepped baseflow? There would still be two fall releases of 3,000 cfs with the check on storage during the fall. In the 2018 technical memo, the baseflow increases mid-March through the end of April—is this a good timeframe to target?
    - Craig asked whether the group thought that this action and timing would be too close/similar to the Winter Flow action.

- Seth noted that he would edit Scenario 5 to be closer to the original Scenario 2, rather than proposing moving any water to spring.
    - Adam asked the group if there should be any modifications to that Scenario 2.
    - Seth said that potentially it could be modified, but not move the 3,000 cfs pulse to spring.
    - Craig asked whether the group might felt modifying the model to include the fall hatchery release.
    - Adam cautioned that it seemed unlikely that there would be the time and resources to incorporate the hatchery fish into the S3 model, based on Russ's feedback earlier.
    - Craig asked whether the group agreed with having two fall pulses.
    - Kyle said that this seemed fine; if more smaller pulses were added, then may not be able to achieve a high enough magnitude at or above 3,000 cfs to get water out onto the floodplain.
    - Kyle noted that the only other piece to modify would be the trigger. There should be a review on how well these pulses synchronized with natural flood events.
    - Ken agreed it would be interesting to see the sensitivity of trigger. He is more inclined to keep things simple and open-ended to leave room for future changes. Potentially leave open the ability to adjust triggers?
    - Seth said that the EIS can frame the big picture and should allow for adaptive management to adjust on a year-to-year basis as more data/information becomes available.
    - Ken added that while it could be interesting to look at the sensitivity of the trigger, the analytical tools may not exist to tease out the benefits. There are no models for the food production benefit from the pulses for example. Things should be kept simple. The 3,000 cfs peaks was not analyzed. Perhaps just implement and collect empirical data. The triggers and periods in Scenario 2 are good as they are. When it comes to writing the EIS, there's value in leaving room for changes in the future, such as for the magnitudes and timings and triggers of the pulses.
    - Kyle proposed to measure the inundated area to evaluate the acreage from where leaf litter could be recruited to pursue quantifying the ability of the fall pulses to meet a food recruitment objective.
    - Seth noted that even if the flows aren't synchronized perfectly, it's already an improvement over the static baseline flow conditions. Seth agreed with Ken to keep things open-ended. The EIS should frame the bigger picture and leave room for adaptive management. Perhaps different scenarios are applied as more data is gathered, including from telemetry studies. This modeling exercise is about getting the general bounds set and presenting multiple scenarios in an open-ended way. We should manage adaptively based on learning and knowledge.

- Adam asked to finalize the development of the two modified scenarios ("scenario 5 and 6" in the slides). Is there any preference for a spring pulse flow at this point, given the discussion?
    - Seth's recommendation was to not target the spring period. Historically, most of the volume is released in spring and it is heavily skewed towards this period already with 80% of the flow released after April 1. Focus on fall releases.
    - Kyle noted agreement with Seth on this principle and in order to target fall hatchery releases. However, releasing 50 TAF in the fall if Trinity storage is very low probably isn't desirable. There needs to be a plan if this occurs.
    - Ken suggested that if this issue occurs, then hold onto the water until at least December. Temperature shouldn't be an issue in December once the reservoir turns over. Then, default to the 6,000 cfs synchronized release of Contract Water prioritized above the ROD volume so that it is adding to the Winter Flow action. What about carryover storage? There must be assurances from Reclamation that the water would remain in storage and not be exported. But that might be another use of the water that doesn't conflict with Proviso 1 and 2, especially if we include a component to help the hatchery fish in the fall when there is sufficient water to do so.
    - Adam noted that Scenario 4's results help show the benefits that can be modeled by releasing more volume than 50 TAF on an annual basis.
    - Kyle agreed with Ken's suggestion of what to do with unreleased water from the fall period, with a modification. If the lake turns over around the second week December and there is less than 750 TAF storage in Trinity, you keep the 1.5-year trigger event and the 3,000 cfs peaks in that time period rather than copy the 6,000 cfs pulse release from the Winter Flow action. So release the biologic pulses in the December 15 – February 15 period, since we know that after December 15 storage has no effect on temperature in that year.

<u>Concluding Remarks</u>:

- Adam noted that, in adding the objective of targeting the fall release of hatchery fish, the potential to add the hatchery fish into new modeled scenarios will be assessed.
- Ken noted that release of biologic pulses in December 15 – February 15 timeframe may require a change of the recurrence interval trigger to a 1-year recurrence flow, to ensure the synchronized trigger occurs each year.
    - Seth noted that is the 50 TAF is released between December 15 - February 15, it would be important to note that this is in the same period as the first Winter Flow action.
    - Ken agreed we should only add the Contract Water into the Winter Flow action set if the Contract Water was to become a 6,000 cfs geomorphic pulse. This is important to resolve. As Mike Orcutt has said, there needs to be communication and coordination between these efforts. If Scenario 5 was advanced formally then we'd need to coordinate with the TRRP to see who does what when.
- Adam concluded the meeting, noting that the technical team will take the next few weeks to look again at the triggers and may reach out again to team members as needed to refine modeling tools. The summary notes will be distributed to the team as well.

Action Items:

- Stantec to distribute Workshop 4 summary notes and presentation slides to group members.

- Stantec to lead further refinement of scenarios 5 and 6 with technical team, including a review of flow triggers and possible S3 development to integrate hatchery fish.

FINAL Meeting Summary

Date/Time: May 4, 2023 / 10:00 AM PT

Subject: Trinity River Water Management Plan, Workshop #5

Place: Microsoft Teams

Attendees:

Attendee	Affiliation	Attendee	Affiliation
Hank Seemann	Humboldt County	Ken Lindke	CDFW
Craig Tucker	Suits and Signs Consulting	Monty Larson	CDFW
Kyle de Julio	Yurok Tribe	Elizabeth Hadley	Reclamation
Jason Reed	Hoopa Valley Tribe	Allison Mitchell	DOI Solicitor's Office
Seth Naman	NMFS	Scott Bergstrom	DOI Solicitor's Office
Eric Peterson	TRRP	Adam Witt	Stantec
Nick Som	USFWS	Mary Paasch	Stantec
Russ Perry	USGS	Stephanie Theis	Stantec
John Plumb	USGS	Arielle Gervasi	Stantec
		Thomas Gast	Thomas Gast & Associates

Agenda:

Item	Responsible Party
1. Introduction and Project/Workshop Objectives	Adam Witt
2. Refined Contract Water Release Scenario Review	Adam Witt
3. Refined Scenario Modeling Results Review	Adam Witt
4. Data Informed Decision Making for Water Call	Adam Witt/All

Purpose and Objectives:

The objectives of this workshop were to:

- Evaluate model output variables and non-modeled factors and determine which scenarios are meeting Project objectives.
- Reach concurrence on which scenarios (initial and/or refined) to move forward into the Water Management Plan that Humboldt County will use to make a water call
- Identify types of available data that could be used to support selection of an annual release scenario

Note: This meeting summary documents the discussions that occurred during the presentation. The full content presented during the workshop can be viewed from the presentation distributed to meeting participants.

Workshop Summary:

Introduction

Adam presented the project objectives, timeline, and workshop agenda.

Refined Contract Water Release Scenario Review

Adam reviewed the initial four Scenarios developed in Workshop #3. Adam then described the additional three scenarios developed in Workshop #4 and in discussion following that workshop, illustrated with example hydrographs. The release pattern and objectives of each scenario were reviewed.

- Scenario 5: fall pulse with storage check.
    - Kyle and Ken both noted that the storage check (ie., do not release water October 15-December 15 if storage in Trinity Reservoir is less than 750 TAF) is something that ideally should be implemented in any fall scenario that is moved forward to ensure water that is released is not too warm for fish.
- Scenario 6: fall baseflows. Adam reviewed the justification for the release pattern of the ascending baseflow and drop in January. The rationale for the drop is to conserve water while keeping flows high enough to minimize any risk of redd dewatering. Chinook generally do not spawn in depths <0.5 feet, based on observation data and literature review, and a drop from 700 cfs to 390 cfs represents a stage drop below Lewiston of 0.5 feet.
    - Craig noted that there is currently high concern in the Klamath about dewatering redds in January. Craig asked if the fish biologists of the group could offer their opinions on the Scenario 6 design and estimate the risk of dewatering redds that might be present.
    - Seth noted that the fish in the Trinity River would have evolved to be adaptable to high magnitude, low duration (i.e., days) ramp ups and drops from the natural hydrograph; however, if large baseflows of 700 cfs were maintained for a month and then dropped, this would not be representative of a natural hydrograph drop.
    - Kyle emphasized that while the rationale presented showed no risk for Chinook redds, it would be pertinent to look at the spawning depths for Coho salmon and steelhead as well to ensure they do not spawn in shallower depths. Additionally, while the drop in water elevation might not completely dewater the redds, there could be negative impacts from changing the amount of water passing over the redds causing changes in head pressure, changes in dissolved oxygen reaching the eggs, and reduced evacuation of waste products. Ideally flows wouldn't be heavily dropped until 60 days after both Chinook and Coho are finished spawning, which occurs around January 1. Steelhead spawn later though, so the group would need to decide if releases should account for their spawning timing as well. Between Chinook, Coho, and steelhead, fish are spawning, incubating, and emerging in Trinity River from the middle of September until early April.
    - John suggested one approach to determining the risk to redds from the drop in flow would be to compare it to drops in the hydrographs in nearby natural unregulated streams—if flows naturally drop in similar proportion to the Scenario 6 drop, it could be considered a natural drop, and in the realm of flow changes the fish would be adapted to cope with.
    - Craig expressed concern with this proposal in that the fish in Trinity River did not evolve to spawn in these areas farther downstream below the dam.
    - Russ noted that this could be studied and modeled further to get at some of these questions. Using the detailed 2D hydrodynamic model and setting spatially explicit redd locations, other redd models might have assumptions to better inform the effects of different flows on the redds. However, that's beyond the scope of this project.

- Adam noted that the 2012-2014 surveyed redd locations had been geotagged and incorporated into the 2018 SRH-2D hydrodynamics evaluation, so some of this data should be available.
- Ken noted that, in regards to the baseflow drop, the fish evolved with baseflow that would increase through the end of Winter. Therefore, dropping from 700 cfs to 390 cfs in January wouldn't be considered a natural flow drop. In regards to using the previously georeferenced redd locations from the 2012-2014 surveys, the problem with using that dataset applied to these higher flow scenarios is that the surveys were collected during a 300 cfs baseflow, so the additional redd locations that we'd expect at higher flows wouldn't be captured in that data.
- Seth added that the rapid flow variability that fish are used to typically occurs within a 24-hour period.

- Scenario 7: Carryover. Adam noted that this Scenario does not have a planned release from Trinity Reservoir, but accumulates 50 TAF of Contract Water each year as carryover rather than releasing it into Trinity River. The Contract Water is lost whenever the reservoir spills or has a safety-of-dams release. The scenario represents a bookend for the maximum water temperature reductions (via increased storage and associated cold-water pool) that could be expected due to use of Contract Water.

Refined Scenario Results Overview

Adam showed the summary table for Scenarios 1-7 for all metrics presenting the average percent change relative to the Baseline. For the refined Scenarios 5-7, Adam highlighted that Scenario 5 results were similar to Scenario 2 because fall pulses were only delayed in two of the twenty three years in the simulation period. Scenario 6 fall baseflows showed the most benefits to fish productivity in S3 relative to all other modeled scenarios. Scenario 7 had significant sediment transport and fry/parr habitat increases due to larger safety-of-dams releases but did not show correlative increases in fish population variables.

- Kyle asked if Adam could elaborate on how the reservoir release temperatures were modeled.
  - Adam explained that the temperature in Trinity and Lewiston reservoirs is a function of air temperature, storage, and other variables, modeled in HEC-5Q. HEC-5Q generates detailed temperature profiles in the reservoir so that using the known outlet elevations, the release temperatures from the reservoirs can be represented in the models.

John presented the fisheries results output from S3 for Scenarios 5-7. Scenario 6 showed notable increases in egg survival, juvenile salmon abundance, and juvenile salmon biomass; however, there was little to no increase in fish size and juvenile survival.

- Craig asked for clarification whether dewatered redds were accommodated by the Habitat or S3 models.
  - Russ noted that the model doesn't include mortality due to redd dewatering, so the reason for increased egg survival is mainly due to reduced redd superimposition.
- Kyle noted that it was encouraging to see that the fall releases show a benefit, but wondering if it might indicate Chinook in the Trinity River could be spawning habitat limited rather than rearing habitat limited.
  - John and Russ noted that the population size is the same in all years, and came from the 2007 brood year, which was in the 70th percentile of spawning abundance. The high brood

number helped to show density dependent effects. However, we would expect to potentially see less benefit in a low spawner abundance year, where reducing redd superimposition isn't as necessary to enhance egg survival.
    - Nick stated the previous scenarios that targeted increasing rearing habitat in the spring were spread over several months, and that a larger increase in rearing habitat could potentially have been obtained if those flows had been concentrated in a two-month period. So it is not an equal comparison to look at the spring and fall baseflow release scenarios to make a determination about limiting habitat.
    - Ken asked what was the mechanism that provided higher egg survival in the fall pulse flows (Scenarios 2 and 5).
    - Russ indicated that the pulses briefly increase spawning habitat area allowing for some reduced redd superimposition, the same mechanism as seen in Scenario 6.
- Ken asked if they could elaborate on how S3 determines the locations of the redds—if the redd depositions were deterministic based on locations of actual surveyed redds or if the locations in the model are simulated.
    - John explained that the quantity of spawners are assigned to each reach proportionally using surveyed data of spawning abundance within each reach. But for spatial placement, each week they are randomly distributed with the reaches according to habitat available and habitat suitability.
    - Ken speculated that we then might expect to see more redd superimposition in real life than in the model. Gaeuman has done some work on this and found that fish look at more factors than just flow depth and velocity in determining where to lay their redds. Scenario 6 shows the best performance in that regard but is probably missing some non-modeled biological mechanisms in determining the most suitable or utilized spawning habitat.
    - Russ added that from a flow-based standpoint, there's strong evidence to show that peaks and ascending baseflow reduces redd superimposition by changing the locations of where fish spawn on a day to day or week to week basis, so that would be something important to incorporate into the release pattern.
    - Ken was concerned that that still only incorporates the flow and velocity-based mechanisms of redd placement, but the fish are known to also prefer channel locations that exhibit shear stresses reversals which is a mechanism to avoid redd scour. Ken added that the fish are likely cued into more factors than we currently have an understanding of.
    - Nick noted that the habitat preference in the S3 model is driven by more factors than just depth and velocity. The variables in the spawning habitat model include: substrate size, distance to transition (proxy for interstitial flow), distance to shore, distance from Lewiston dam (interacts with a few other variables), depth, and velocity. These are all good things to keep in mind, as the modeling helps illuminate limiting factors for fish production.

Data Informed Decision-Making Discussion

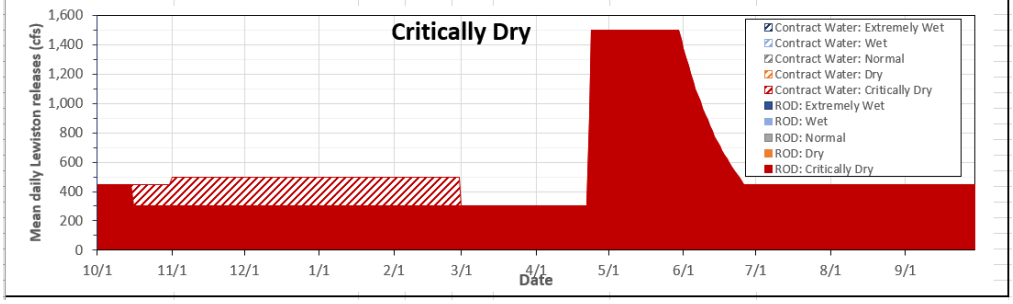
Adam skipped ahead to this section in the interest of providing time for discussion of the potential decision-making framework and data needs to drive decisions on use of Contract Water. Adam noted that all group members should have a PDF copy of the presentation available to review the results for sediment transport, temperature, and CVP deliveries individually, if desired. In integrating the modeled scenarios as a basis for the Water Management Plan, a decision tree could aid in determining annually which scenario to implement. The draft decision tree in the presentation assumes one release per year unless carryover is made available. Humboldt County would coordinate with the TRRP and other agencies in the decision-making process.

- Adam suggested starting at the first decision point, and what would determine whether a fall pulse or a fall baseflow was released. This led to a discussion as to the benefits and limitations of the fall baseflow and pulses alternatives.
    - Craig noted that implementing the fall baseflow scenario seems attractive based on the modeled fish benefits results, and it should be relatively simple to evaluate through the NEPA process. However, we should consider modifying the release to address the concerns about dewatering redds.
    - Adam suggested that fall baseflow could be the default scenario, adding that the intent with the Water Management Plan is to allow the modeled scenario to be modified in practice as long as the modification does not deviate significantly enough to alter the benefits or impacts.
    - Kyle suggested that releasing more than 50 TAF of water or increasing the release through carryover could help address this concern with the Scenario 6 fall baseflow drop in flow. For the determination whether to do the fall baseflow or fall pulses, Kyle recommended setting a Trinity Reservoir storage threshold—if the storage is above that then release the fall pulse flows and if it's below, then carryover the water to implement increasing baseflows the next year using 100 TAF. Ideally use the end of December storage for the determination since October, November, and December are hardest months to manage water when storage is low.
    - Adam asked whether it would be preferable to extend the release for Scenario 6 and create a fall baseflow that wouldn't drop at any point. Adam asked whether that scenario should try to account for implementation of the Winter Flow Project elevated baseflow period.
    - Kyle noted that the decision on how to modify or extend the fall baseflow would depend on whether we want to account for the timing of steelhead spawning and emergence, which occurs after Chinook and Coho. Also, if the Winter Flow Project is being implemented or the TRRP ROD flows start earlier, then we should account for that as well. There is relatively large uncertainty as to the flows that will be released mid-February through April. Extended releases through March would cover Chinook and Coho through spawning and emergence at least.
    - Craig asked whether the Habitat and S3 models only account for Chinook
        - Nick confirmed that Chinook are the only species modeled.
        - Craig asked whether there might be more benefits seen for Chinook if the fall baseflows were shifted to be higher in November and lower in December, since they spawn earliest and typically spawning peaks in November.
        - Nick agreed that the most benefit to spawning habitat for Chinook is seen from increased flow in November.
        - Craig suggested that dropping the flow earlier, i.e., at the end of November, in order to extend a reduced but elevated baseflow, could help stretch out the Contract Water while also providing benefits to spawning Chinook.
    - Kyle asked whether the benefit from the fall release scenario was only due to reduced superimposition or if there were any benefits from temperature changes in those scenarios.
    - John noted that temperature does factor into fish survival in the model but mostly the changes in the timing of the flows and placement of redds seemed to be the driving factors.
    - Russ added the water year type has a large effect on the benefits seen in the results. Egg incubation time is very important to determining egg survival. Warmer water leads to shorter egg incubation time which usually increases survival.

- Adam opened the scenario release simulator tool in order to show a few different modification options for Scenario 6.
    - Adam noted that maintaining a sustained additional 200 cfs from November to March would only need a little over 50 TAF:

Variable Baseflow Calculator: Set baseflow magnitude by month, calculate total volume in AF

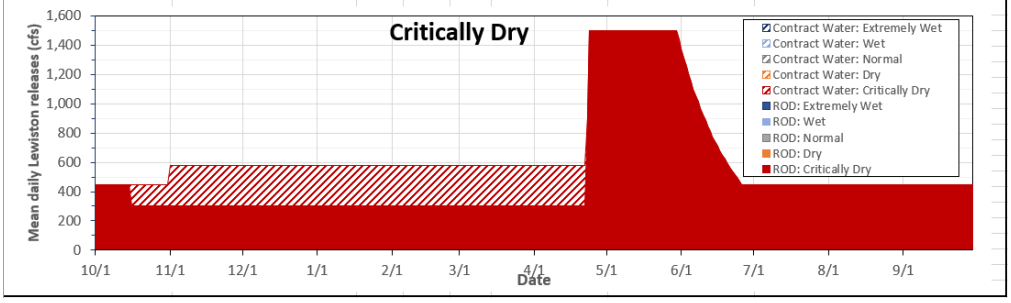
1. Select Water Year Type	2. Specify release parameters	Months	Start Day	End Day	Additional Baseflow Active? (1 or 0)	Additional Mean Monthly Baseflow Magnitude (cfs)	3. Check volume required and flow days
☐ Extremely Wet	User Input	10.1	0	15	0	0	Total Volume (AF)
☐ Wet	Computed Value	10.2	16	31	1	150	53,163
☐ Normal		11	0	30	1	200	
☐ Dry		12	0	31	1	200	Flow days
☑ Critically Dry		1	0	31	1	200	138
		2	0	31	1	200	
		3	0	31	0	0	
		4	0	22	0	0	
		5	0	31	0	0	
		6	0	30	0	0	
		7	0	31	0	0	
		8	0	31	0	0	
		9	0	30	0	0	



    - Ken expressed concern over seeing any large drop in the baseflows before the beginning of the spring ROD flows due to uncertainty regarding the Winter Flow Project or TRRP flow modifications in winter and spring.
    - Nick expressed it was likely that in the future ROD water will be available prior to April.
    - Adam showed an example release that would use ~100 TAF to maintain a flow of 580 cfs from November to the start of the ROD release in a Critically Dry year:

Variable Baseflow Calculator: Set baseflow magnitude by month, calculate total volume in AF

1. Select Water Year Type	2. Specify release parameters	Months	Start Day	End Day	Additional Baseflow Active? (1 or 0)	Additional Mean Monthly Baseflow Magnitude (cfs)	3. Check volume required and flow days
☐ Extremely Wet	User Input	10.1	0	15	0	0	Total Volume (AF)
☐ Wet	Computed Value	10.2	16	31	1	150	102,029
☐ Normal		11	0	30	1	280	
☐ Dry		12	0	31	1	280	Flow days
☑ Critically Dry		1	0	31	1	280	191
		2	0	31	1	280	
		3	0	31	1	280	
		4	0	22	1	280	
		5	0	31	0	0	
		6	0	30	0	0	
		7	0	31	0	0	
		8	0	31	0	0	
		9	0	30	0	0	

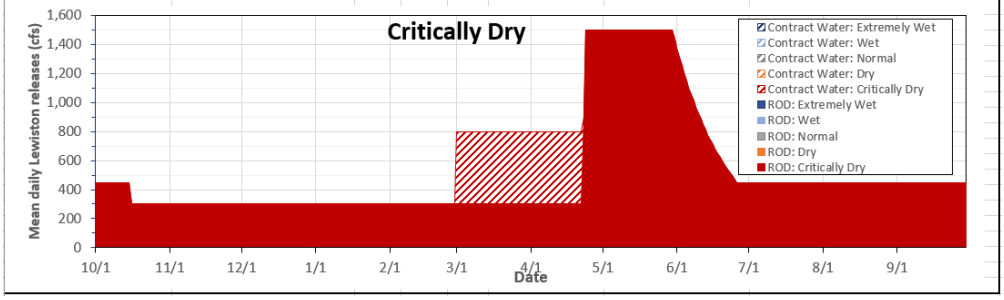


    - Ken asked how much water it would take to maintain the flow at a flat 450 cfs from mid-October to the start of the ROD.
        - Adam showed in the scenario tool that maintaining the flow at 450 cfs up from the ROD baseflow of 300 cfs would require approximately 56.7 TAF of Contract Water in a Critically Dry year.

- Adam asked the group to consider if and under what conditions it would be desirable to release a concentrated spring baseflow.
    - Kyle noted that it would be difficult to release water in that time of year without causing a negative impact from cold water suppression. If Trinity Reservoir had a temperature control device to allow the release of warmer water, then it would be worth considering. Although there would be a habitat benefit, Kyle felt the temperature suppression effect might outweigh that benefit. Another option to consider for a spring release is to review a recent Reclamation release done in 2021 for attracting spring Chinook. Reclamation demonstrated a willingness to perform this kind of a release.
    - Ken highlighted that under the Winter Flow Project, an elevated baseflow pattern was implemented this year with variability and peaks mid-February to mid-March and increased magnitude of flow mid-March to mid-April. Something to note was that this release schedule had a notable amount of public opposition.
- Adam asked whether spawner abundance from previous years or a forecast of run size for the coming year would be a factor to consider in the decision-making process for which type of flow release to implement.
    - Kyle said that, in general, if it is known that the run size will be lower than average, then the focus should be on releasing flows to attract fish upstream.
        - Ken noted that using the average run size as the threshold might not be appropriate. We'd need to establish a run size to use as an appropriate threshold to determine whether abundance is "high" or "low". Ken noted that the TRRP has some data regarding observed redd superimposition in the upper reach directly below Lewiston and some estimates on carrying capacity for each reach based on the data. Additionally, escapement abundance should be considered as a factor.
    - Kyle highlighted that in regards to a spawner abundance forecast, the forecast is only for spring-run Chinook for the coming year and does not include the fall-run Chinook or Coho.
    - Arielle asked whether there would be merit in looking backward in the winter period at spawner abundance from the previous fall to determine whether to make a spring baseflow release. If the fall spawner abundance was very high could the habitat benefit for that brood outweigh the temperature suppression impact?
        - Kyle noted that looking at the previous fall spawner abundance could be useful and that releasing in the spring could help support a higher run. However, if it's a wet year, the release shouldn't extend into April.
    - Adam displayed a potential spring habitat release, concentrating flow into March and April:

Variable Baseflow Calculator: Set baseflow magnitude by month, calculate total volume in AF

1. Select Water Year Type	2. Specify release parameters	Months	Start Day	End Day	Additional Baseflow Active? (1 or 0)	Additional Mean Monthly Baseflow Magnitude (cfs)	3. Check volume required and flow days
☐ Extremely Wet	User Input	10.1	0	15	0	0	Total Volume (AF)
☐ Wet	Computed Value	10.2	16	31	0	0	52,470
☐ Normal		11	0	30	0	0	
☐ Dry		12	0	31	0	0	Flow days
☑ Critically Dry		1	0	31	0	0	53
		2	0	31	0	0	
		3	0	31	1	500	
		4	0	22	1	500	
		5	0	31	0	0	
		6	0	30	0	0	
		7	0	31	0	0	
		8	0	31	0	0	
		9	0	30	0	0	



- John noted that functionally in the S3 model, a high spring baseflow would create more habitat, so the fish would stay longer and grow more, but there would be increasing juvenile mortality from that.
- Adam asked if the biologists could note which year or years were considered exceptionally high for spawner abundance or run size.
    - John noted that 2007, the year used as the brood size in the simulation, was the second highest spawner abundance year.

Adam asked if the group could provide information about any ongoing monitoring or additional monitoring needs not mentioned in the slides that could provide useful data for the decision-making framework.

- Macroinvertebrate sampling
    - Ken noted that the Yurok Tribe is leading an effort to sample and monitor macroinvertebrates which will occur this year from June to October.
    - Kyle explained that this effort will help assess macroinvertebrate colonization after disturbance.
- Redd surveys
    - Ken added that there are ongoing spawner surveys which will geotag redds and can be cross referenced with the 2D model to help assess redd superimposition and placement.
- Outmigrant monitoring
    - Russ noted that there is currently outmigration monitoring at Pear Tree and Willow Creek which can be used to assess the outmigration timing, fish growth, and migrating fish abundance.
- Temperature
    - Ken added that there is in-stream temperature monitoring at gages on Trinity and an RBM10 temperature model as well.
- Salmon egg mortality study
    - Kyle noted that an upcoming pilot study this fall will assess Chinook salmon egg mortality using methods similar to the San Joaquin River Restoration program.
    - Russ noted that this data would be a very useful missing component in the S3 model, and can be used for model validation.

- Telemetry studies on juvenile salmon
    - John added that there are currently several ongoing telemetry studies with juvenile salmon.
    - Kyle noted that Justin Alverez should have results from the pilot year study and that this is a joint study between the tribes, USGS, and USFWS being led by the Hoopa tribe in the Trinity River.

Concluding Remarks:

- Adam concluded the discussion by outlining the next steps following this Workshop 5.
    - Adam explained that this feedback will be used to begin creating the Water Management Plan to determine how a water call to Reclamation for Contract Water could be made each year based on the modeled scenarios. There is ongoing discussion with Reclamation to inform them of the outcomes of this Water Management Plan.
    - Adam added that there will be one more workshop in the next month or two to finalize the details of the Water Management Plan with the group.
- Adam noted that over the next month Stantec and Humboldt County will be incorporating the scenarios and feedback into the Water Management Plan and group members are encouraged to reach out during this time if there are additional comments or feedback regarding the decision-making framework and the Water Management Plan.
- Kyle expressed gratitude to the technical team for the modeling efforts and that it was encouraging to see benefits to the fish from flows in the fall period.

Action Items:

- Stantec to distribute Workshop 5 summary notes and edited presentation slides to group members.
- Craig to reach out to group members to establish a date for the final Workshop 6.
- Stantec and Humboldt County to develop a draft Water Management Plan for discussion at the next workshop.
- Stantec, USGS, and USFWS to complete the Modeling Report.

DRAFT Meeting Summary

Date/Time: November 29, 2023 / 9:00 AM PT

Subject: Trinity River Water Management Plan, Workshop #6

Place: Microsoft Teams

Attendees:

Attendee	Affiliation	Attendee	Affiliation
Hank Seemann	Humboldt County	Monty Larson	CDFW
Steve Madrone	Humboldt County	Elizabeth Hadley	Reclamation
Craig Tucker	Suits and Signs Consulting	Allison Mitchell	DOI Solicitor's Office
Kyle de Julio	Yurok Tribe	Scott Bergstrom	DOI Solicitor's Office
Nick Som	USFWS	Adam Witt	Stantec
Bill Pinnix	USFWS	Mary Paasch	Stantec
Seth Naman	NMFS	Stephanie Theis	Stantec
John Plumb	USGS	Arielle Gervasi	Stantec
Darren Mierau	CalTrout	Paul Uncapher	Stantec
Ken Lindke	CDFW	Thomas Gast	Thomas Gast & Associates

Agenda:

Item	Responsible Party
1. Introduction and Project/Workshop Objectives	Hank Seemann/Adam Witt
2. Contract Water Release Scenario Selection	Adam Witt
3. Preliminary Draft Water Management Plan Elements	Adam Witt
4. Comments and Discussion/Next Steps	Adam Witt/All

Purpose and Objectives:

The objectives of this workshop were to:

- Provide an overview of selection of Contract Water release scenarios for inclusion in preliminary draft Water Management Plan
- Provide overview of main elements of preliminary draft Water Management Plan
- Discuss comments and questions from workshop participants for consideration in finalization of Water Management Plan

Note: This meeting summary documents the discussions that occurred during the presentation. The full content presented during the workshop can be viewed from the presentation distributed to meeting participants.

Workshop Summary:

Introduction

Hank reviewed the project background, highlighting the origin of the Contract Water to be used within the Water Management Plan. Language contained in both the 1955 Trinity River Division (TRD) Act and 1959 Water Delivery Contract between Humboldt County and Reclamation provided for "not less than 50,000 acre-feet" of water to be available for Humboldt County and downstream water users. Humboldt County had opposed out-of-basin diversions unless provisions were made to address the County's water needs. The 2014 Solicitor's memo affirmed Reclamation's obligation to release water under Proviso 2 of the 1955 Act and provided guidance to Reclamation for responding to a request for Contract Water Releases. A grant to Humboldt County from the Wildlife Conservation Board (Stream Flow Enhancement Program) secured in 2021 provided the funding to develop this Water Management Plan to utilize Contract Water with the objective of benefitting Tribal, recreational, and commercial fisheries by supporting a harvestable surplus. Adam gave a brief overview of the overall project objectives, timeline, and workshop agenda.

Contract Water Release Scenario Selection

Adam reviewed the seven release scenarios which were modeled using the suite of analytical tools. A summary table on slide 13 presented the primary metrics from the CalSim II, sediment transport, habitat, and Stream Salmonid Simulator (S3) models used to assess the effectiveness of releases in meeting objectives benefitting Chinook Salmon. Adam noted that additional results and more detail on the modeling can be found in the Modeling Report, which was distributed to the group on August 21, 2023. As a note, an update was made to the results summary table within the Modeling Report—the most up to date version is contained within the draft Water Management Plan and shown in the Workshop 6 slide deck (slide 13). Adam noted that the Scenario 5 and 6 had clear biological benefits (both modeled and presumptive non-modeled benefits) and met the project objectives. Scenario 5 and 6 release patterns were selected for integration into the Water Management Plan with a modified version of Scenario 1 used to provide elevated baseflows to bridge the gap between Contract Water releases and initiation of Record of Decision (ROD) restoration flows.

- John commented in the chat: "Adam, just a thought, we should correlate our S3 estimates of egg survival with your total sediment mobilized. It's not something we've done with these results yet."
- Ken asked when the Building Baseflow releases (modified from Scenario 1) would begin and end.
    - Adam explained that in the modeled Scenario 1, Building Baseflow releases started in December and ended at the start of ROD restoration releases in mid-April, but that in the proposed Contract Water releases the timing would vary.
- Ken then asked if the modelers could explain what caused the negative average percent changes in biomass and fish mass in some of the scenarios relative to the baseline.
    - John explained that some of the lower biomass is explained by the lower fish mass. John noted that because the summary table is averaged across all years, it is difficult to know what's going on in the S3 model from only looking at this summary table. The annual results of the model and results of the S3 metrics by water year type, which are contained in the Modeling Report, help illuminate the results. Temperature and timing of maturation and outmigration is important. In general, if temperatures during the fish growth period were colder, they outmigrated sooner and had less mass. Additionally, the survival rate affects the overall biomass, and the fish tend to have higher survival rates if they move out of the model domain faster.
    - Ken noted that this explanation made sense, but highlighted concern that S3 might not accommodate the mechanisms being targeted by building baseflow releases, such as the secondary effects from the addition of more inundated habitat. Ken said he doesn't believe the effects would be negative.

- John agreed that there are a lot of assumptions in the S3 model and some mechanisms which remain uncaptured, but that the model uses the best available science on Chinook Salmon in the Trinity River system. Because the model was very sensitive to different water year types and showed significant differences in the metric results from year to year, he felt confident the model is capturing the mechanisms correctly, emphasizing that the full picture is not explained by only looking at the averages in the summary table.
- Adam showed model results, which indicated in scenarios 1 and 4, water temperatures released from Lewiston in March and April were colder than the baseline, and this is probably correlated with the fish mass reduction seen in those scenarios.
- Nick put out a reminder to workshop participants that the Scenario 1 Building Baseflows timing and pattern are not similar to the building baseflow modeled in the Scenario 6 Fall Baseflow.
- Ken additionally pointed out that releases in the fall and winter prior to reservoir stratification are typically going to be warmer than ambient temperatures, while after stratification in the winter, releases are colder.
- Seth noted that this typically only becomes an issue when the reservoir storage is low.

- Kyle asked why several of the modeled scenarios show releases of ~1,000 cfs from August to October.
  - Adam explained that the modeled baseline condition is representative of monthly Reclamation operations under the benchmark CalSim model. Therefore, it includes authorized emergency releases of 450 cfs from mid-August – September (on top of the 450 cfs ROD summer baseflow releases, bringing the total flow to 900 cfs). Since CalSim simulates a monthly timestep, the emergency releases are represented as a constant 450 cfs for each month, for a total volume of 50,000 acre-feet across two months. All water year types except Extremely Wet years have those releases.
- John asked to confirm whether Scenario 6 was the scenario which produced the highest average increase in abundance at Pear Tree.
  - Adam confirmed that Scenario 6 had the highest increase in abundance relative to the other scenarios.
  - John noted that the table on slide 13 shows that this increase in abundance in Scenario 6 is related to the increase in egg survival.
  - Kyle asked if the increase in biomass in Scenario 6 should be interpreted as being due to there being more fish of the same size.
  - Adam confirmed Kyle's observation: in Scenario 6 fish mass stayed about the same as the baseline, so the higher biomass is tied to the increase in abundance rather than fish size.

Adam moved forward with an overview of the reinitiation of consultation under Section 7 of the Endangered Species Act on the Long-Term Operation of the Central Valley Project and State Water Project (2021 LTO Consultation). Reclamation has released six draft preliminary alternatives for TRD operations. Alternative 2 is being considered for implementation and includes changes to the timing and magnitude of ROD restoration releases from Trinity Reservoir. The Water Management Plan releases were proposed to be complimentary to Alternative 2. The three main components of flow operations include changes to Trinity Lake storage management, variable instream flows, and temperature management. The proposed restoration flow releases under the variable instream component includes elevated baseflows and synchronized baseflows. The alternative proposes synchronized pulses in the fall to winter period, and elevated baseflows winter to spring which do not occur in very dry years. The decision tree for whether elevated baseflows are released under Alternative 2 is shown on slide 20. The pathways which would result in no elevated baseflows between February 15 and April 15 were

identified in order to determine when releasing Contract Water would be desired to bridge gaps in flow (to avoid dropping flows). The goal of this exercise was to determine how to release Contract Water in such a way as to preserve the benefits and release patterns of the modeled scenarios 2, 5, and 6 as much as possible, avoid duplicating releases proposed under the 2021 LTO Consultation, and fill in any gaps in flow between an elevated baseflow and April 15.

- Kyle noted that this overview of the 2021 LTO Consultation alternatives is consistent with his understanding of the alternatives. Kyle asked for clarification whether the management period of the Contact Water allows it to be modified by the water year type because it is expending water from the previous year.
    - Adam confirmed Kyle's observation, noting that some examples will be provided subsequently illustrating the alignment of the water year and contract year. The contract year begins March 1 and ends at the end of the following February, so the Contract Water is made available at the beginning of March. Therefore, the Contract Water release decision tree process begins in March. A decision can be made from February to April using the water from that current contract year; after February, then any releases are being made with the next contract year's water.
- Kyle asked to look at the two 2021 LTO Consultation Alternative 2 hydrograph examples on slide 21. Kyle asked whether the hydrograph on the right shows one contract year or a combination of contract years.
    - Adam confirmed that the hydrograph on the right shows Contract Water releases across two contract years, whereas the graph on the left only show releases from one contract year.
    - Ken raised the concern that, if 50 TAF was released between March in April, no Contract Water would remain for use in the October-February period of that same contract year (following water year). If the Contract Water releases are limited to 50 TAF for the contract year, this wouldn't leave any water for release in the fall and winter period of the contract year.
    - Adam clarified the decision tree proposes releasing a portion of the 50 TAF in March and April only in certain year types, and the remainder for October through February. Adam noted that there will be a decision tree with the exact volumes of water for each release period shown in the following slides to illustrate this.
- Kyle added to the chat: "John, it would be great to better understand the sources of egg mortality (scour, temperature, superimposition, etc.) and how they differ in Alternative 6 compared to the other alternatives."
    - John replied in the chat: "Kyle, S3 does incorporate superimposition mortality, but scour mortality is definitely an area that we've long sought to improve and incorporate into the model. We've recently come up with a few new ideas on how to better incorporate scour effects that we're planning to incorporate into the model."
    - Kyle replied in the chat: "John, in case you were not aware, myself, Dave Gaeuman and Todd Buxton worked on a paper that estimated scour impacts to redds across a range of flows throughout the restoration reach on the same SRH-2D model that underlies the current version of S3. The link to that paper is here: https://www.trrp.net/library/document?id=2588"[1]

[1] Gaeuman, D., K. De Juilio, and T. Buxton. 2023. Stream bed disturbance and risk of salmonid redds scour in the Trinity River, CA. Report for the Trinity River Restoration Program (TRRP). Yurok Tribe Fisheries Department, Weaverville, California. Available: https://www.trrp.net/library/document?id=2588.

Preliminary Draft Water Management Plan Elements

Adam shifted into an overview of the Water Management Plan elements and guiding assumptions. Adam explained the process and timing for the proposed decision tree for making Contract Water releases, shown on slide 25. Next, Adam showed four different release examples highlighting the different possible outcomes from the decision tree based on whether elevated ROD baseflows are scheduled to start February 15. The first two examples show that when elevated ROD baseflows are scheduled to start February 15, the Contract Water is held until fall for a fall pulse and supplemental fall/winter baseflow—the baseflow length of release may vary depending on when the fall pulse gets released. The next two examples illustrated releases over one contract year (two water years) where elevated ROD baseflows are not scheduled to start February 15, and Contract Water is released between February 15 and April 15 to keep baseflow elevated at 450 cubic feet per second (cfs). In the example on slide 28, elevated ROD baseflows are scheduled to start in February 15 of the following year, whereas in the example on slide 29, elevated ROD baseflows are not scheduled to start February 15 for two years in a row (typically only when there are two Critically Dry years in a row).

- Hank asked in the chat: "Elizabeth, is there precedent for the Bureau starting to release contract water a week or two before a contract year starts?"
    - Elizabeth messaged Hank directly to suggest they could discuss this individually the following week.
    - Ken pointed to Hank's question in the chat and noted that he was wondering this as well. Since the contract year starts at the beginning of March, beginning Contact Water releases in February 15 would start 2 weeks before the contract year.
    - Adam addressed this by noting that the timing of the decision tree decision points were selected to ensure no gap (decrease) in restoration releases between October and April. The assumption here is still that Contract Water becomes available March 1. There is a concept called "preuse" defined in some CVP contracts to request water earlier than the start of the contract year, but whether this agreement could be made in order to allow Humboldt County to release their Contract Water before March 1 is still to be discussed with Reclamation. Humboldt County would request a "preuse" of Contract Water for the ~15 days between February 15 and March 1; if that is not an option, then the volumes would need to be adjusted slightly to extend the previous contract year's water to March 1.
- Seth asked if we could elaborate on the integration of the 2021 LTO Consultation Alternative 2 and the Contract Water. In the 2021 LTO Consultation, there is a schedule planned for the coming year. However, for Contract Water, the timing of the synchronized pulse flows are not known in advance. To what extent is Reclamation comfortable with real-time management of the Contract Water? How and when will it be known whether there will be elevated ROD baseflows starting February 15?
    - Adam answered that, based on the 2021 LTO Consultation Alternative 2 decision tree (shown on slide 20), the 90% exceedance forecasts in the February and March Bulletin 120 report guide the determination and the decision is assumed to be made early February. Further discussion and confirmation is needed with Reclamation on that timing. Specific coordination details for the synchronized pulse flow are still to be determined. In previous workshops, participants discussed the possibility of synchronizing the fall pulse with a release of fish from the Trinity River Hatchery (TRH). Additionally, if a storm event was forecasted, Contract Water may need to be delayed to avoid exceeding the safety-of-dams criteria or, conversely, it may be beneficial to synchronize with a storm event. Coordination

will be needed amongst Reclamation, the Trinity River Restoration Program (TRRP), the Trinity Management Council (TMC), and Humboldt County to implement this.
    - Adam noted that it was assumed Reclamation has the ability to act and implement within a 3-5 day window. Adam asked if others who have worked on plans with a flow synchronization component have additional information or insight about whether providing a 3-5 day advance notice to Reclamation provided enough time to implement release actions.
    - Seth expressed confidence that a 3-5 day time period should be sufficient to determine whether to release or delay Contract Water, depending on Reclamation's willingness to be flexible.

Comments and Discussion

Adam moved forward to discuss the proposed management structure and annual implementation details. Adam showed summary tables containing existing data sources and ongoing and proposed monitoring that could be used to inform future adaptations of the Contract Water release schedule.

- Kyle suggested that escapement be added as a category within the ongoing monitoring table and within this category, the spawning stock biomass and stock–recruitment relationships should be considered. CDFW publishes these metrics in a table as well as an annual report.
- Darren commented that the assumptions mention that Humboldt County would retain the right to reevaluate releases of Contract Water based on conditions in the Trinity River, but what about the Klamath conditions? The dams are coming out of the Klamath River soon and conditions will change on the Klamath. Should we consider that in the future?
    - Adam noted that effects of the Klamath dam removal were not considered. The spatial extent of modeling tools covered only the Restoration Reach of Trinity River; therefore, effects of the Contract Water were only measured in the Trinity. The Water Management Plan tried to preserve flexibility in how releases are described, so that if conditions or population sizes begin changing due to conditions on the Klamath, that should be considered when making adjustments to releases. The plan can be modified to state the Klamath River future conditions may guide changes to magnitudes or timing of Contract Water releases in the future.
    - Craig noted that the Klamath Irrigation Project is also part of the 2021 LTO Consultation process and a new BiOps will be issued. Operational changes for this project may also have some effect on fisheries in the future.
- Darren asked whether the Water Management Plan includes a date for reassessment or reanalysis of the plan—i.e., assessing whether or not the releases are meeting the objectives.
    - Adam noted that the Water Management Plan has a 25-year planning period. The time it takes to see the effects of the Contract Water might depend on the frequency and distribution of the water year types that get encountered over those 25 years. Ideally, there would be both variation in water year types and sufficient time to capture the effects following those years.
    - Ken added that he expects there will be significant changes to the Klamath River flow management after the 2021 LTO Consultation process. Therefore, effects from the implementation of those changes are going to confound the monitoring of changes due to the Water Management Plan, since those changes in flow management will both be occurring around the same time. It may be impossible to parse out the changes from those two projects separately. Further, changes in the flow management due to the Water

Management Project are relatively small in comparison to all the changes in flow management in the Trinity River and Klamath River that are happening right now, so the contribution and effects from the Water Management Plan alone are likely to be somewhat small relative to the overall changes compounded by large change in flow. In regards to how long it may take to see changes in the system, Pinnix et al (2022)[2] found a shift in stock-recruitment relationship pre-ROD and post-ROD. This analysis covered 15 years of data since 2005 (the first year the ROD releases began being implemented at the full annual volumes) and saw significant changes in population sizes. But the change in annual volumes through the ROD implementation relative to the pre-ROD flows was a significant change; the Water Management Plan implementation would not be as significant of a change, so we might not necessarily expect to see changes within the same period of 15 years.

Next Steps

Adam closed the meeting by thanking the participants for their thorough input and feedback over the last year and half to develop and improve the Water Management Plan. Adam outlined the next steps moving forward (listed on slide 40). The Water Management Plan draft was provided a few weeks ago to all participants and feedback from participants was requested by December 8. Humboldt County will incorporate the feedback and finalize the Water Management Plan by the end of December. There will be continued efforts by Humboldt County to incorporate Contract Water releases into 2021 LTO Consultation based on the Water Management Plan description, and continued efforts to discuss co-management of Contract Water with the Hoopa Valley Tribe and Yurok Tribe.

Hank gave closing remarks and thanked participants for their excellent contributions. Hank reminded participants that this project focused on supplemental fisheries releases as the beneficial use of Humboldt County Contract Water. In the future, additional beneficial uses of Contract Water may be identified, and the Water Management Plan may be updated or modified accordingly. This Water Management Plan is coming at an important time with lots of changes happening in the system, including the Winter Flow Project, 2021 LTO Consultation, and Klamath Dam removal. Craig expressed a similar sentiment, commenting that salmon in this system are at a pivot point—with the dam removals and river restoration, now is the time to turn things around for salmon. Adam opened the floor for final comments and feedback.

- Ken asked for a clarification on the third bullet point on slide 40 ("Continued efforts to incorporate Water Management Plan into proposed action for NEPA and ESA review for 2021 LTO Consultation"). There will not be a separate NEPA process for the Contract Water releases under the Water Management Plan?
    - Adam explained that this is why the Water Management Plan closely considered the alternatives included in the 2021 LTO Consultation. Humboldt County provided Reclamation a memo back in June of 2023 requesting inclusion of Contract Water within the 2021 LTO Consultation. By working collaboratively with Reclamation to address the planned alternatives for TRD operations under the 2021 LTO Consultation, the hope was to have the Contract Water releases included in the alternatives. Humboldt County has requested that

[2] Pinnix, W. D., S. P. Boyle, T. Wallin, T. Daley, and N. A. Som. 2022. Long-Term Analyses of Estimates of Abundance of Juvenile Chinook Salmon on the Trinity River, 1989-2018. Arcata Fisheries Technical Series Report TS 2022-40, report for the Trinity River Restoration Program (TRRP). U.S. Fish and Wildlife Service, Arcata, California. Available: https://www.trrp.net/library/document?id=2571.

Contract Water be included in the NEPA review at a project level for the 2021 LTO Consultation, but discussions with Reclamation are ongoing.
    - Ken noted that this seemed like an efficient way to go about the NEPA process.
- Ken asked whether and how much outreach has occurred between Humboldt County and Trinity County on this Water Management Plan.
    - Hank highlighted that there were conversations with Trinity County a few years ago as part of TMC decisions and county to county consultation, although there haven't been recently.
- Ken concluded by noting that this process seemed well-executed and reiterated what Craig said about now being a turning point for salmon in the Klamath and Trinity rivers.
- Seth agreed with Ken, noting that he felt the project had turned out well. When it first started, we proposed a lot of different iterations of the Contract Water releases. The fall period has been really problematic from an ecological standpoint and we've wanted to target flows during this period for a while. The analysis and constraints that were developed really helped to push forward this action which will finally add flows in the fall period. In regards to the NEPA process, Reclamation will determine what they need to do to release the Contract Water with their attorneys. NEPA coverage will probably be required, whether they perform this separately or as part of the LTO Consultation.
    - Mary noted that there is potential for Contract Water to be included at a programmatic level in the 2021 LTO Consultation, in which case, a site-specific NEPA review at a later time would be needed.
- Hank concluded by sharing that the Water Management Plan will be finalized in the coming months, and Humboldt County plans to stay engaged in the 2021 LTO Consultation process to complete the necessary compliance documentation.

Action Items:

- Stantec to distribute Workshop 6 summary notes and edited presentation slides to group members.
- Stantec and Humboldt County to incorporate participant feedback and finalize the Water Management Plan by the end of December.