Climate Induced Hatchery Upgrades

Kern River Hatchery

Alternatives Analysis Submittal

Final Report
Revision No. 4

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Table of Contents

List of Tables

List of Figures

Distribution

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Revision Log

Revision No.	Date	Revision Description
0	2/26/2024	65% Draft Internal Technical Review
1	3/15/2024	65% Draft for CDFW Review
2	8/30/2024	100% Draft for CDFW and Internal Technical Review
3	10/31/2024	Final Submittal to CDFW
4	2/14/2025	Final Submittal to CDFW, ADA Accessible Document

Appendices

The appendices that accompany this document are not ADA compliant. For access to the following appendices, contact Fisheries@wildlife.ca.gov. If assistance is needed for an ADA compliant version of the appendices, please include that in the email.

- Appendix A. Site Visit Report
- Appendix B. Bioprogramming
- Appendix C. Concept Alternative Drawings
- Appendix D. Design Criteria TM
- Appendix E. Alternatives Development TM
- Appendix F. Cost Estimates
- Appendix G. Meeting Minutes
- Appendix H. LEED and ZNE Evaluations

Executive Summary

McMillen, Inc. (McMillen) was retained by the California Department of Fish and Wildlife (CDFW) to provide an assessment of 21 CDFW fish hatcheries throughout the State of California in the context of their vulnerability to the effects of climate change. Climate modeling was performed by Northwest Hydraulic Consultants (NHC).

Kern River Hatchery has an aging infrastructure and deficiencies that need to be addressed in the near future in order to bring the hatchery back online and to meet fish production goals. The following deficiencies were identified at the hatchery during the site visit:

- The existing siphon is damaged beyond repair and cannot supply river water to the hatchery.
- Groundwater well sources are in uncertain condition requiring inspection and repair.
- The existing raceways and circular tanks have been damaged from floods and lack of maintenance during periods of non-use.
- Rearing infrastructure in the hatchery building is in a state of disrepair due to flood damage.
- The existing effluent gate must be locally closed, allowing river floodwater to back up into the raceways and hatchery building when staff are not present.

The preferred alternative for hatchery upgrades includes upgrading the existing hatchery building to reliably use for incubation and early rearing. The damaged outdoor circular tanks would be replaced and a partial recirculating aquatic system (PRAS) installed for water savings and year-round fish holding capabilities. The production raceways would be refurbished, and the distribution raceways would be replaced. Additionally, a flap gate would be installed on the effluent channel, and standby power would be repaired and updated.

The Class 5 Opinion of Probable Construction Cost (OPCC) for constructing the preferred alternative upgrades can be found in the table below (Table 6-2 provides the Class 5 OPCC summary). The table also includes the estimated cost of photovoltaic systems to offset the energy consumption of the new equipment and to maintain zero net energy. These upgrades would not significantly affect fire or flood risks at the facility, and all work would occur within already-developed areas. Operationally, CDFW would need to update feeding, harvesting, and water quality monitoring protocols to accommodate the partial recirculating aquaculture systems. The proposed upgrades would provide a solid foundation for CDFW to sustain fish production at the hatchery, even as climate change increasingly disrupts current and future operations.

Project Total	Photovoltaic – Zero Net Energy
$27,364,000	$14,134,500

1.0 Introduction

1.1 Project Authorization

McMillen, Inc. (McMillen) was retained by the California Department of Fish and Wildlife (CDFW) to provide a climate change evaluation for 21 hatcheries operated by CDFW throughout the State of California. The contract for this Climate Induced Hatchery Upgrade Project (Project) was executed on March 21, 2023.

1.2 Project Background

California relies on CDFW hatcheries to provide recreational fishing opportunities for the public and for the conservation of endangered or threatened species. However, climate change threatens the business-as-usual production of fish with the existing CDFW hatchery infrastructure. Climate change impacts have already affected many CDFW hatcheries, resulting in altered or inconsistent operation schedules, lowered production, and emergency fish evacuations. These climate impacts include increasing water and air temperatures, changes to groundwater availability, low flows and water shortages, increased flood and fire risks, and other second-hand impacts associated with each of these categories (i.e., emerging pathogens and non-infectious diseases, low adult salmon returns, decreased worker safety, etc.).

A total of 21 hatcheries were visited by McMillen to evaluate the existing infrastructure and fish production operations. During these visits, McMillen assessed the existing hatchery infrastructure deficiencies and replacement needs. The assessment was used to aid in determining the potential upgrades for each hatchery that would maintain the existing program production goals for the various species reared at each facility while providing conceptual alternatives for climate resilience. Climate change has had an impact worldwide and will continue to affect CDFW’s statewide fish production operations. Developing technologies and methods to meet fishery conservation and sport fisheries is critical to CDFW’s goal of maintaining hatchery productivity while conserving precious cold-water supplies for native species.

We have based our detailed work plan on achieving the following project objectives stated in the Request for Proposals (RFP). As presented in Sections 2 and 3 of our proposal, we have intentionally comprised our team of experts in all required disciplines with experience in fish husbandry and hatchery engineering and design to successfully meet all CDFW’s project goals.

- **Objective 1:** Review the state of each facility via data collection, review of documents, site visits, and discussions with hatchery personnel. Identify climate change impacts that are likely to negatively impact operations at each hatchery over the next 40 years.
- **Objective 2:** Develop cost effective and programmatically viable alternatives that will maintain current fish propagation goals given climatic impacts in the future.
- **Objective 3:** Assess the risks of each alternative to natural biological systems, environmental conditions, husbandry techniques for fish health and fish safety, and potential impacts to water quality.
- **Objective 4:** Determine the short- and long-term economic costs for the modifications to each hatchery in current year dollars. Account for construction, permitting, design, operational, and maintenance costs within the overall economic analysis. Prioritize the list of alternatives and associated hatcheries based on limited annual hatchery budgets.
- **Objective 5, Phase 2 Work**: Provide complete designs with issued for construction drawings and specifications for projects at as many hatcheries as are feasible. The focus shall be on those hatcheries that are deemed most susceptible to negative climate change impacts identified from the evaluation in the four previous objectives.

1.3 Project Purpose

The purpose of the Project is to determine the CDFW hatcheries and the existing infrastructure conditions that are most susceptible to reduced fish production attributable to climate change and provide a prioritization of the hatcheries for improvements. With input from CDFW, designs for climate change resiliency upgrades will be advanced for as many facilities as is feasible.

1.4 Site Location Description

The Kern River Hatchery is located in the town of Kernville, CA approximately 54 miles from Bakersfield, CA (Figure 1-1).

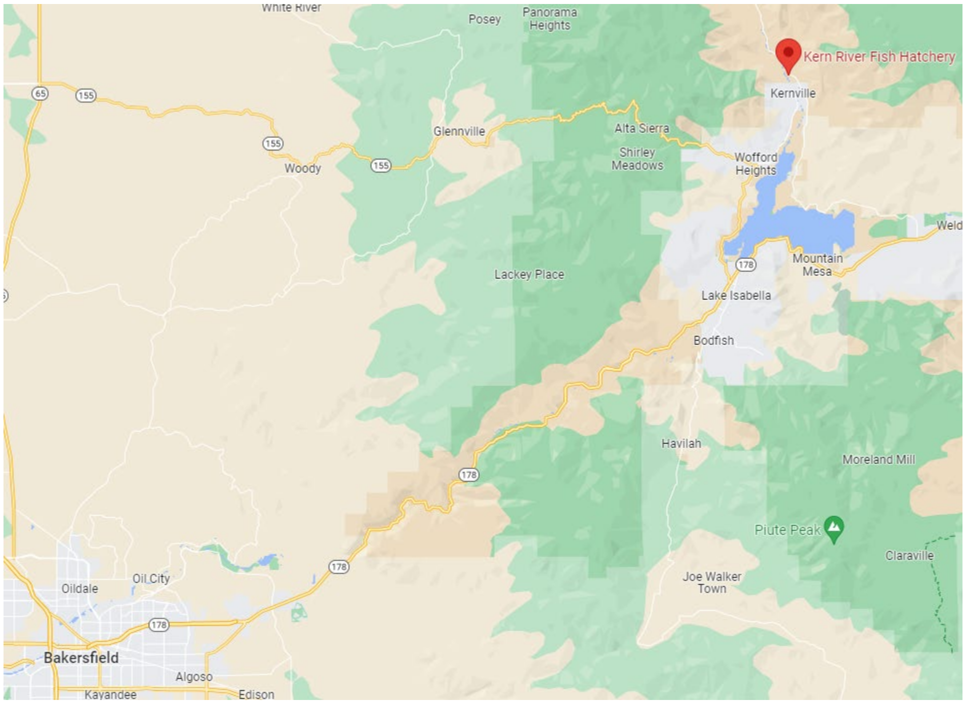

Figure 1-1. Kern River Hatchery Location Map.

The Kern River Hatchery was traditionally used by CDFW as a planting base for fish produced at the San Joaquin Hatchery. The Kern River Hatchery operates as a flow-through facility and is typically supplied with water from the Kern River through a siphon, with an intake located near Southern California Edison's (SCE) Kern River 3 hydroelectric power plant approximately 0.5 miles upriver. Catchable-sized Rainbow Trout (*Oncorhynchus mykiss*) would be transported from the San Joaquin River Hatchery to the Kern River Hatchery and held for several weeks as they were planted out to nearby stocking waters. There are also plans to begin a captive broodstock program to supplement natural populations of the Kern River Rainbow Trout (*O. mykiss gilberti*), or KRRT. This species is classified as a candidate for listing by the U.S. Fish and Wildlife Service (USFWS). The general hatchery facilities are shown in Figure 1-2. See the Site Visit Report (Appendix A) for more details and photos regarding the existing hatchery facilities.

Figure 1-2. Kern River Hatchery Facilities Layout. Google Earth Image Date: 6/22/2023.

2.0 Bioprogram

2.1 Production Goals and Existing Capacity

2.1.1 Inland Fisheries

California's hatchery production goal for inland trout is based on sport fishing licenses sold in the previous calendar year. This requirement sets a production goal for CDFW hatcheries to produce and release 2.75 pounds of trout per sport fishing license sold. The requirement stipulates that the majority of released fish be of a catchable size (2 fish per pound) or larger and requires CDFW to achieve this goal in compliance with certain policies, including the Strategic Plan for Trout Management. Currently, CDFW achieves approximately 35% of the required production based on sport fishing license sales. CDFW is also required, to the extent possible, to establish and maintain native wild trout stocks and protect native aquatic and nonaquatic species. CDFW currently utilizes a trout triploid program (sterile trout) to avoid genetic impacts to native trout populations through the stocking program.

Until it was temporarily closed due to water supply issues, the Kern River Hatchery operated as a distribution station for Rainbow Trout (*Oncorhynchus mykiss*). During operation, fish were grown to approximately 2 fish per pound (fpp), or 10.8 inches, at the San Joaquin Hatchery and transported to the Kern River Hatchery. Fish were held at the Kern River Hatchery for up to two weeks as they were stocked in state waters in the area. Prior to the water supply siphon being irreparably damaged, plans were developed to begin a small captive Kern River Rainbow Trout (KRRT; *O. mykiss gilberti*) broodstock and production program.

The Capacity Biological Program (Capacity Bioprogram) for the facility was developed for the Site Visit Report (Appendix A) and provides a theoretical scenario for the Rainbow Trout distribution and KRRT production program tank volume, operational water flows, and size of the fish. The calculations utilize the density and flow indices previously identified for the preliminary bioprograms which encompass water temperature and elevation criteria to ensure oxygen levels appropriately align with production. The calculations include a 10% safety factor to provide a 90% maximum capacity based on both the density index (DI) and flow index (FI) requirements identified; total capacity is shown in Table 2-1 and Table 2-2.

There is no annual goal for the trout distribution program at the Kern River Hatchery because stocking is directly tied to the San Joaquin Hatchery's production as well as the availability of fish transport trucks and drivers. According to data provided by CDFW, the largest trout distribution year at the Kern River Hatchery since 2001 was in 2008 where approximately 243,200 fish (121,600 lbs approximately 2 fpp) of Rainbow Trout were distributed. Since 2014, infrastructure issues have prevented the facility from exceeding 80,000 lbs of trout distributed. The trout distribution program is not limited by space; only one out of four raceways is used to hold fish while the others remain empty. The operating season for the Kern River Hatchery is limited by rising water temperatures and low water flows in the Kern River from June through September each year. The unique case of this trout distribution program will therefore not be modeled for this report. However, there is a potential Kern River Rainbow Trout Program that has a goal of producing 100 broodstock at 0.5 fpp, which is approximately 200 lbs.

Table 2-1. Production Capacity for the Trout Distribution Program Units at the Kern River Hatchery per the Capacity Bioprogram (Appendix A; assuming current infrastructure).

Rearing Unit (max. fish size)	Total Capacity (Fish)[a]	Limiting Factor
Raceways (2 fpp/10.8 inches)	8,553 (4,277 lbs)	Rearing Volume

[a] This is an estimate of 90% production capacity to allow for a buffer in circumstances where more flexibility is needed for hatchery operations.

Table 2-2. Production Capacity for a Potential Kern River Rainbow Trout Program Units at the Kern River Hatchery per the Capacity Bioprogram (Appendix A; assuming current infrastructure).

Rearing Unit (max. fish size)	Total Capacity (Fish)[a]	Limiting Factor
Deep Tanks (100 fpp/2.9 inches)	32,572 (326 lbs)	Water Flow
Hatchery Round Tanks (100 fpp/2.9 inches)	16,604 (166 lbs)	Rearing Volume
Raceway (2 fpp/10.8 inches)	37,324 (18,662 lbs)	Rearing Volume
Broodstock Outdoor Round Tanks (0.5 fpp/17.1 inches)	1,545 (3,090 lbs)	Rearing Volume

[a] This is an estimate of 90% production capacity to allow for a buffer in circumstances where more flexibility is needed for hatchery operations.

2.2 Bioprogram Summary

The Capacity Bioprogram in the Site Visit Report (Appendix A) demonstrates the total capacity of each rearing area at the Kern River Hatchery for several stages of fish production. The capacity of each rearing area (-10% to provide an additional safety factor), limited by water flow or available rearing volume, is shown in Table 2-1 and Table 2-2. The capacity for this facility is theoretical and subject to change when more information is available as the water supply siphon nears completion. Exact information on water temperature, well production, and designed flow rates for existing rearing systems is not available currently due to the lack of a water supply. The current rearing infrastructure is also in need of repair or replacement, which will affect the facility's production capacity. Details about the various rearing areas and infrastructure are discussed in the Site Visit Report, found in Appendix A. In this report, we provide high-level guidance on what size the KRRT program may be, understanding that it remains in the early planning stages and is subject to significant changes prior to implementation.

2.2.1 Criteria

There are no available criteria for the KRRT program, aside from background genetic analysis of existing populations and their suitability as potential broodstock sources. It is assumed that production levels will remain below the threshold which would require a National Pollutant Discharge Elimination System (NPDES) permit for the facility if it exceeds 20,000 pounds of harvest annually and 5,000 pounds of maximum feed in a single month. The trout distribution program exceeds the total allowable harvest of 20,000 pounds annually for operating without an NPDES permit, therefore the hatchery cannot use 5,000 pounds of feed in a single month without applying for an NPDES permit.

The KRRT production program is still in the early planning stages, and no fish production goal has been set aside from holding approximately 100 captive adult broodstock to achieve sufficient genetic diversity. Some improvements to the rearing areas were made prior to the facility shutting down, but these were installed without consideration for the final size of the program. Ultimately, production will be limited by NPDES regulations; the Kern River Hatchery does not have an NPDES permit because it has never exceeded using 5,000 pounds of feed in a single calendar month. In a 31-day period (1 month), the average amount of feed distributed each day must not exceed 161 pounds (5,000 pounds/31 days = 161.3 pounds per day). Assuming a feed rate of 2% bodyweight per day, a maximum biomass of 8,000 pounds may be held on station at a single timepoint (161 pounds per day / 2% bodyweight per day = 8,050 pounds). Assuming a single feed rate for an entire hatchery for 31 days does not reflect normal operations; fish size is constantly changing, and smaller fish will be fed a higher percentage of bodyweight while larger fish or broodstock will have smaller feed rates. However, important details such as feed, growth, and survival rates of cultured KRRT are unknown; an accurate feed projection model cannot be developed. The maximum biomass calculated (approximately 8,000 pounds) serves as a guide to the upper limit of production at the facility. To provide an additional factor of safety and to account for broodstock holding requirements, it is recommended that production biomass at the facility does not exceed 7,500 pounds. Associated criteria from the Site Visit Report are found in Table 2-3. Additional assumptions for KRRT production are in Table 2-4; assumptions are based off information about Rainbow Trout and are over- or under-estimated to provide additional factors of safety when estimating fish production.

Table 2-3. Criteria Used for the Production Bioprogram. Criteria are Discussed in Detail in Appendix A.

Criteria	Value
Density Index (DI)	0.3
Flow Index (FI)	1.04
Water Temperature	60° to >70° F

Table 2-4. Assumptions Used for the Production Bioprogram.

Criteria	Assumptions
Growth Rate	0.5 inches per month
Condition Factor	C4000 (Rainbow Trout)
Survival Rate	75% from egg to first feeding 80% first feeding to stocking
Fecundity	2,000 eggs per female
Spawning Period	April-May
Broodstock Population	100 fish (1:1 sex ratio)
Maximum Biomass on Station	7,500 pounds

2.2.2 Production Bioprogram

This bioprogram (Appendix B) is meant to view hatchery operations at a high level; there are many important biological factors that are unknown for cultured KRRT. Additionally, nuances of the timing of fish transfers, grading, sorting, or stocking are also unknown for this program. The model is meant to show an example of how production may occur given the criteria and assumptions outlined in the previous section.

Kern River Rainbow Trout typically spawn in the late spring or early summer. For this bioprogram, it is assumed that egg collection will occur in April and that first feeding will begin by the end of May. Approximately 50 females will be spawned, yielding 100,000 green eggs and approximately 75,000 first feeding fry. Fish would be spread among the existing hatchery building tanks (10 round tanks, 8 deep tanks, total volume of 724 ft^3, total flow rate of 320 gpm; Appendix A). Fish would be raised indoors on well water, which is assumed to be a suitable temperature for early rearing of salmonids during the summer months while water temperatures in the Kern River are too elevated.

It is assumed that fish will reach approximately 115 fpp (2.8 inches) by the end of September. In the early fall, water temperatures in the Kern River will begin to drop and fish can be transferred to two outdoor raceways. Fish will remain in the raceways until they are ready to be stocked. Stocking timing will rely on several factors such as water temperatures in the Kern River, total pounds of feed used in a month, and realized DI in the raceways. If water is expected to warm beyond the safe limits for KRRT at the facility, fish will be stocked out as needed. The bioprogram modeled production of up to 7,500 pounds of fish biomass on station (end of May), but other factors may require more feed to be used than projected. If monthly feed use is expected to exceed 5,000 pounds, then stocking must begin to avoid NPDES violations. Finally, the DI will exceed 0.3 if fish are held in two raceways down to 8 fpp (6.8 inches); this could easily be avoided by splitting fish into a third raceway or by stocking fish out.

The broodstock program is not modeled here. It is expected that future broodstock will be raised normally, but instead of being transferred to raceways they will be kept in the hatchery building. Eventually the fish will be transferred to one of the round tanks reserved for other year classes and sex groups of broodstock. The total amount of fish and biomass required for the broodstock program to maintain approximately 100 spawning adults is negligible relative to the overall production modeled in this section. It is expected that all six outdoor circular tanks will be unavailable for production rearing but instead will be used to segregate and hold fish of different sexes and broodstock sources.

Table 2-5. End of Month Production Information for Kern River Rainbow Trout Including Realized DI and FI Values.

Production Stage/Month	Tank Type	Tanks Occupied	fpp	Length (in)	Total Fish (#)	Biomass (lbs)	Max. Flow (cfs)	DI	FI
May	Hatchery Building	All	4,000	0.8	75,000	18.8	0.7	0.03	0.07
Jun	Hatchery Building	All	1,150	1.3	73,750	64.1	0.7	0.07	0.15
Jul	Hatchery Building	All	430	1.8	72,500	168.6	0.7	0.13	0.29
Aug	Hatchery Building	All	205	2.3	71,250	347.6	0.7	0.21	0.47
Sept	Hatchery Building	All	115	2.8	70,000	608.7	0.7	0.30[a]	0.68
Oct	Raceways	2	70	3.3	68,750	982.1	6.0	0.09	0.11
Nov	Raceways	2	45	3.8	67,500	1,500.0	6.0	0.12	0.15
Dec	Raceways	2	31	4.3	66,250	2,137.1	6.0	0.16	0.18
Jan	Raceways	2	22.6	4.8	65,000	2,876.1	6.0	0.19	0.22
Feb	Raceways	2	16.8	5.3	63,750	3,794.6	6.0	0.22	0.27
Mar	Raceways	2	12.8	5.8	62,500	4,882.8	6.0	0.26	0.31
Apr	Raceways	2	10.0	6.3	61,250	6,125.0	6.0	0.30	0.36
May	Raceways	2	8.0	6.8	60,000	7,500.0	6.0	0.34[b]	0.41

[a] This is the maximum allowable DI; it is assumed that as water temperatures cool enough in the Kern River, fish can transfer from the hatchery building to the raceways starting in September.

[b] This exceeds the DI criteria of 0.3, it is assumed that fish will be stocked out at approximately 10 fpp or earlier depending on water temperatures in the Kern River, prior to exceeding the density criteria at the end of May.

The production schedule is an estimate of what may occur; more detailed information about captive spawn timing and growth rates will not be available until the program begins. It is important to note that summer water temperatures exceed suggested levels for trout culture. The bioprogram assumes that well water is used for the broodstock holding and early rearing of KRRT. The well water temperatures, chemistry, and flow rates at the Kern River Hatchery are unknown but are assumed to be suitable for fish culture. The model shows the maximum flow rate of 6 cfs for fish in the raceways (3 cfs per raceway). Operations will likely involve reduced flow rates at the beginning of raceway rearing until fish can handle increased velocities of higher flow rates. The maximum flow rate for the design of the siphon or the total water right for the facility far exceed the requirements for this production. Flow rates are expected to peak during the early spring in March and April during the normal trout distribution season and while KRRT are at their largest biomass prior to being stocked out (Figure 2-1). Once stocking of KRRT begins, flow rates are expected to reduce. Flow rates are expected to be the lowest from July through September when water temperatures are too high for raceway operation. The water demand for broodstock holding (highlighted in red, but the water demand is not depicted in Figure 2-1) is expected to remain constant throughout the year.). Note that the different colored blocks in the following figure correspond to the months for when (projected for Kern River Rainbow Trout) the species are in either the early rearing tanks in the Hatchery Building or in the raceways, along with noting when eggs are received and incubated.

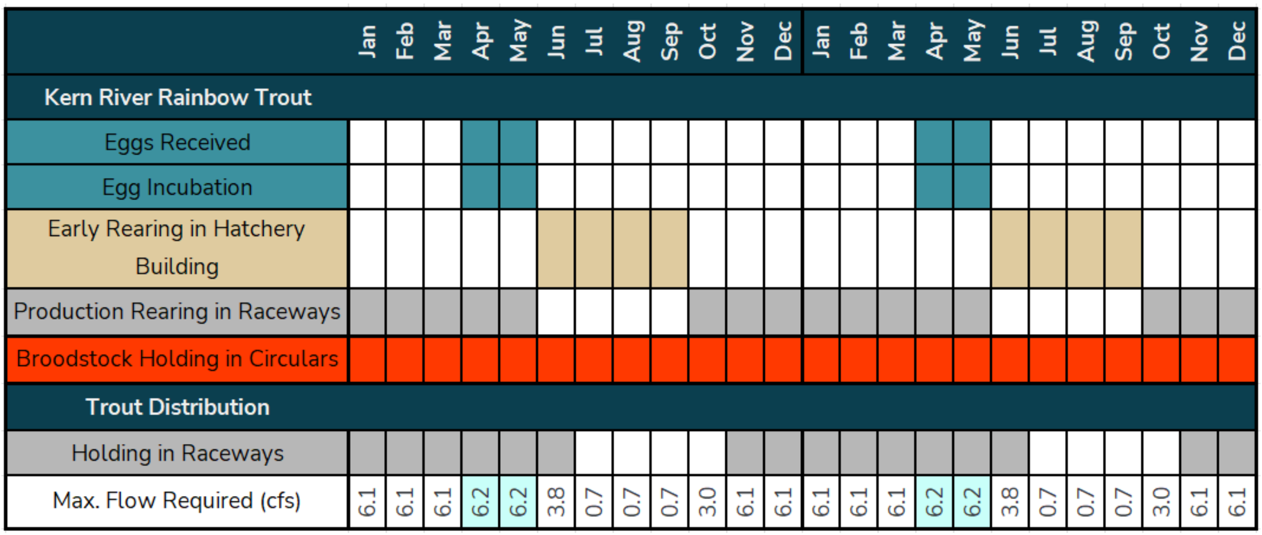

Figure 2-1. Production Rearing Schedule Over 2 Years with Peak Water Demand Occurring Annually in April and May (as highlighted in the Max Flow Required row).

3.0 Climate Evaluation

3.1 Introduction

In this section, climatic and hydrologic projections of conditions at the hatchery are presented for the next 20 years (2024-2043) and the following 20 years (2044-2063). These time horizons are referred to as the near-future period and the mid-century period, respectively. These projections inform the project team of potential needs for adaptive changes. Air temperature projections inform of potentially hazardous working conditions, and water temperature projections inform of risks to fish rearing. Projections of the water balance of precipitation minus evapotranspiration indicate the expected direction of future groundwater recharge that may affect springs and well water supply.

Historically, water temperatures in Kern River have risen into the low 70's °F during low flow summer months. Due to these water temperatures, when in production the facility typically closes between June and September annually to avoid dangerous rearing and stocking conditions for fish. Any prolonged increase in this water temperature due to climate change may lead to a more stressful state and increased risk of disease for the fish (or worst case, elimination of the salmonid culture program in the absence of a costly water chilling system). There has also been flooding in the facility causing serious infrastructure damage. A berm was constructed after a flood in the 1960s to protect the facility unless gates are open at 45,000 cfs. The flood in March of 2023 damaged the steel siphon and multiple portions of the exposed pipes, leaving the hatchery without a sufficient water source.

3.2 Water Sources

The Kern River Hatchery's questionnaire responses indicate that water for the hatchery is siphoned from the Kern River. The 36-inch steel siphon is located approximately ½-mile upstream from the hatchery near Southern California Edison's (SCE) Kern River Powerhouse #3 and penstock tailrace. The siphon is currently inoperable and scheduled to be replaced with a buried HDPE alternative by 2026. Per CDFW, the water temperatures utilized for production between October and May are near 60°F, increasing during late summer and fall. There are also up to five groundwater wells on site to supply the hatchery building, outdoor tanks, and RAS. Only four of the wells have been located, but five are referenced in historic staff notes. Historically, the wells never functioned as designed and were rarely used. There is minimal flow or temperature data available for the well water sources.

3.3 Methodology for Climate Change Evaluation

This study uses future climatic and hydrologic projections based on global climate model (GCM) simulations associated with the data set known as CMIP5, which was part of the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC 2014). The projections in this report are based on results from 10 different global climate models under the Representative Concentration Pathway (RCP) RCP4.5 scenario of future greenhouse gas emissions, which represents a future with modest reductions in global emissions compared to current levels.

An ensemble of 10 global climate models (GCMs), listed in Table 3-1, is used for capturing a wide range of plausible climate projections. Since this project's future time horizon is limited to 40 years, the dominant source of uncertainty in climate projections is expected to be the natural variability of the earth's climate (and the variability present in every GCM model run), with the second major source of uncertainty being differences between GCMs. Using this ensemble will simultaneously address both uncertainty sources. The selection of 10 GCMs was based on tests of their ability to accurately simulate California climate, following the study of 35 CMIP5 models by (Krantz et al., 2021).

Table 3-1. List of Global Climate Models Used in This Study.

No.	GCM	Research Institution
1	ACCESS-1.0	CSIRO, Australia
2	CanESM2	Canadian Centre for Climate Modelling and Analysis, Canada
3	CCSM4	National Center for Atmospheric Research, United States
4	CESM1-BGC	National Science Foundation, Department of Energy, and National Center for Atmospheric Research, United States
5	CMCC-CMS	Centro Euro Mediterraneo per Cambiamenti Climatici, Italy
6	CNRM-CM5	Centre National de Recherches Météorologiques / Centre Européen de Recherche et Formation Avancées en Calcul Scientifique, France/European Union
7	GFDL-CM3	NOAA Geophysical Fluid Dynamics Laboratory, United States
8	HadGEM2-CC	Met Office Hadley Centre, United Kingdom

No.	GCM	Research Institution
9	HadGEM2-ES	Met Office Hadley Centre, United Kingdom
10	MIROC5	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies, Japan

Hydrologic projections utilize daily timestep results from the Variable Infiltration Capacity (VIC) hydrologic model (Figure 3-1) that was driven by the projected daily climate time series. VIC divides the watershed into grid cells (about 5x7 km in this study) where properties of the soil column and land cover and all major fluxes of water and energy are represented. Soil infiltration capacity is spatially variable within each grid cell, and baseflow is represented as a non-linear function of soil water storage.

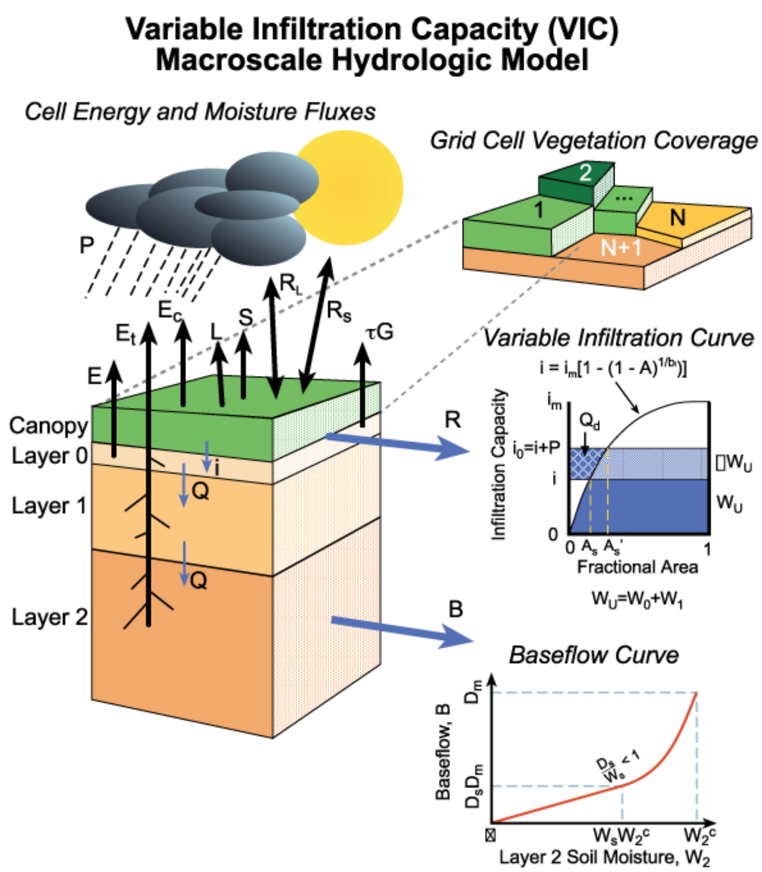

Figure 3-1. The VIC Hydrologic Model (University of Washington Computational Hydrology Group, 2021).

The methodology used for obtaining projections of climate, water temperature, hydrology and flood risk is summarized in Figure 3-2. The sections below provide additional detail, as well as discussion of fire risk:

1. **Projections of climatic variables** (air temperature and precipitation) were based on simulations by the 10 selected CMIP5 global climate models (GCMs). The GCM projections were statistically downscaled (using different methodologies) by a consortium of research institutions and made publicly available for all of California at a grid cell size of 1/16° x 1/16° (about 5 km x 7 km) (Vano et al., 2020). In this report, the downscaling methodology named “Localized Constructed Analogs” (LOCA) is used. The choice of the LOCA data set was guided by its proven ability to represent extreme values of the downscaled climatic variables (important to this study) and because the hydrologic projections made available by the same research consortium (item 2 below) used the LOCA-downscaled climate projections. The difference between greenhouse gas emissions scenarios is small for a time horizon of 20 years; therefore, it is sufficient to use one greenhouse gas emissions scenario in this study, and the moderate scenario RCP4.5 is used.
2. **Projections of daily stream flows in the Kern River** near the hatchery were obtained by aggregating, over the watershed, the grid cell-based streamflow projections made available by the same research consortium as in item (1) above (Vano et al., 2020). These publicly available projections were obtained by driving the VIC hydrologic model with the CMIP5 daily climate projections.
3. **Projections of peak flows** were obtained in this study by extreme-value analysis of the daily streamflow projections. It was assumed that peak flows that historically have been surpassed every 5 years, every 10 years, and every 50 years represent meaningful high-flow threshold peak flow values of interest in terms of flood risk. The projected frequency of violating these flow thresholds is expressed in terms of future return periods for each of these threshold peak flow values. It is important to note that instantaneous streamflow peaks may be considerably higher than daily-scale peaks.
4. **Projections of water temperature** of the source water to the hatchery were obtained using empirical relationships developed in this project between daily observations of air temperature and water temperature. The observed temperature data for the source water were provided by the hatchery, while the air temperature was extracted from the publicly available Livneh gridded data set (Livneh et al., 2013) for the grid cell containing the hatchery. Methods for developing such relationships between air and water temperature were previously applied successfully in climate vulnerability assessments conducted for Washington state hatcheries (McMillen, Inc, 2023; USFWS, 2021). The empirical relationship specific to this hatchery site was used to obtain

projected water temperatures from the projected air temperatures increases determined from item (1) above.

5. **Projections of wildfire risk** at each hatchery site were evaluated at a high level based on the projections by Westerling (2018), which are available through the California government Cal-Adapt.org website (Cal-Adapt, 2023). In addition to the risk that fire poses to the facility, it has the effect of reducing soil permeability, increasing peaks of runoff and stream flows that impact flooding and water quality, and potentially affecting groundwater recharge.

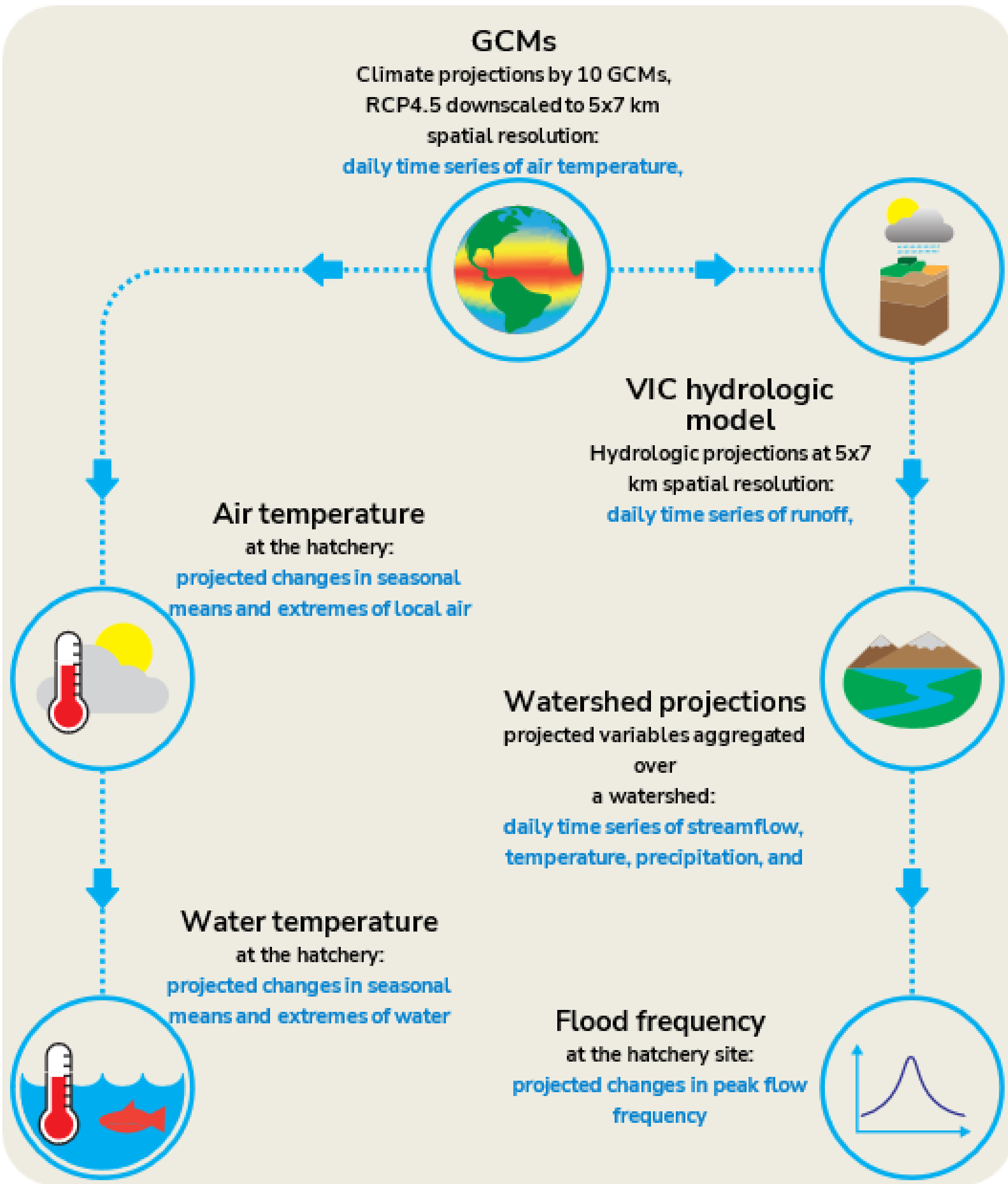

Figure 3-2. Methodology for Obtaining Projections.

3.4 Uncertainty and Limitations

It is important to acknowledge the uncertainty associated with these and any projections of climate and hydrology. While there is a need to provide climate projections for a variety of planning purposes, the underlying projections of climate change are subject to large and unquantifiable uncertainty.

The projections of air temperature, water temperature, precipitation, evapotranspiration, streamflow, and wildfire risk developed in this work should therefore be considered as plausible representations of the future, given the best current scientific information, and do not represent specific predictions. The actual future realizations of these variables over the areas studied will differ from any of the projections considered here, and their differences compared to historical climate may be greater or smaller than the differences in the projections considered.

3.5 Projected Changes in Climate at the Hatchery Site

3.5.1 Air Temperature

Figure 3-3 displays the simulated mean daily air temperature (solid lines) and its range from minimum to maximum (shaded areas) for each day of the year, for the near-future time period (red) and the reference period (blue). All data are simulated by the ensemble of 10 GCMs for each time period. Higher peaks of daily temperature are seen for the near-future compared to the reference period, while the historical period has lower minima.

Table 3-2 and Table 3-3 list the projected mean seasonal air temperature for two future time periods, and the temperature change relative to the reference period. All time horizons, including the reference period, are simulated by the ensemble of 10 GCMs. The lowest and highest of the 10 GCM daily projections define the lower and upper limits of the shaded areas in Figure 3-3, and are given in Table 3-2 and Table 3-3.Table 3-4 and Table 3-5 list the projected percentiles of highest air temperature in each day (T_{max}) for two future time periods, relative to the reference period. All time horizons, including the reference period, are simulated by the ensemble of 10 GCMs.

At the hatchery site, mean annual air temperature is projected to rise by 2.7°F in the near future period compared to the reference period (1984-2003), and by an additional 1.2°F in the mid-century period. The season with the most warming is the summer and the highest temperature rises are projected to occur on the hottest days (Table 3-4 and Table 3-5). Days with temperatures representing the 75th percentile (i.e., the upper quartile of temperatures) are projected to warm by 3.0°F in the next 20 years, relative to the reference period.

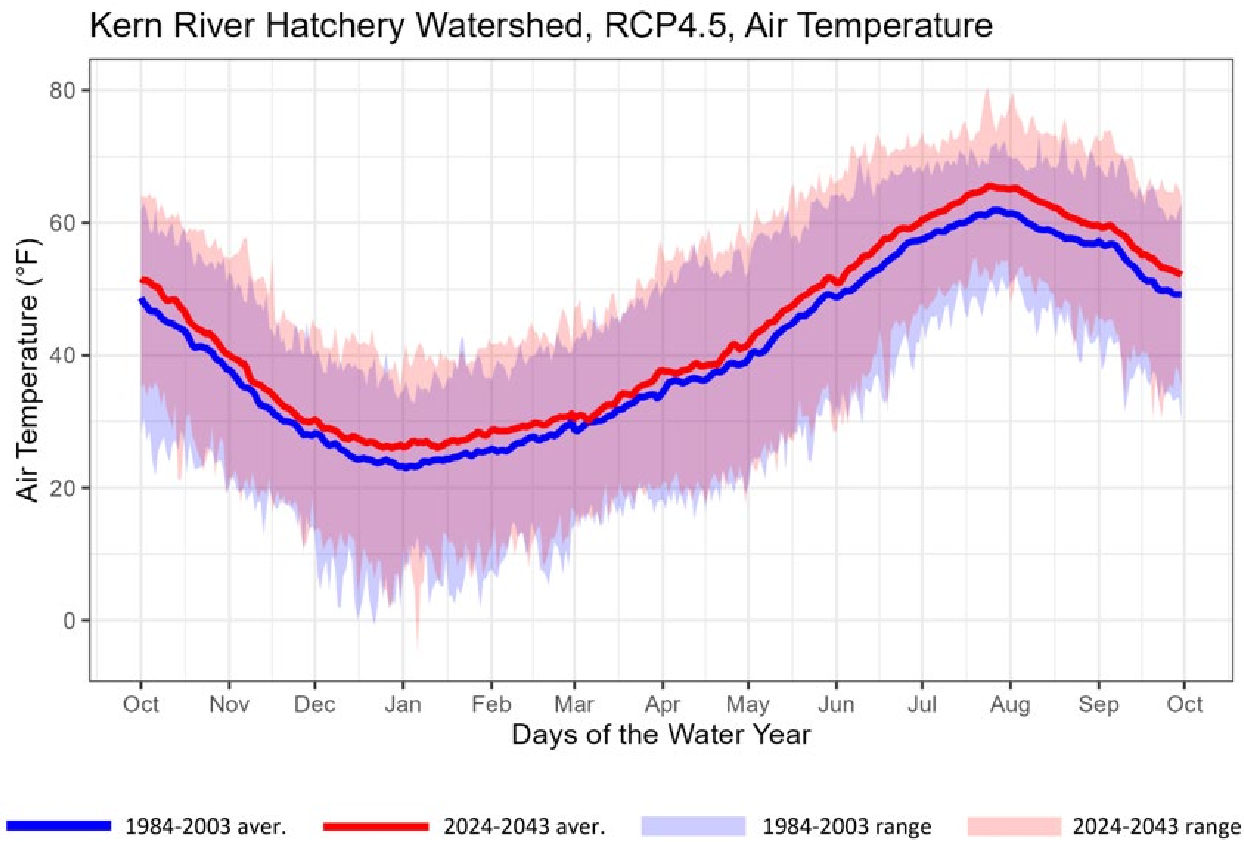

Figure 3-3. Mean Daily Air Temperature and Range for Each Day of the Year.

Table 3-2. Projected GCM 2024-2043 Mean Seasonal Air Temperature (change relative to 1984-2003).

GCM	Annual	Winter (DJF)	Spring (MAM)	Summ. (JJA)	Fall (SON)
Ensemble mean	59.1°F (+2.7°F)	44.1°F (+2.5°F)	55.8°F (+2.1°F)	75.9°F (+3.3°F)	60.6°F (+2.9°F)
Lowest	58.5°F	43.0°F	54.8°F	74.8°F	59.2°F
Highest	59.6°F	44.9°F	57.1°F	77.0°F	61.4°F

Table 3-3. Projected GCM 2044-2063 Mean Seasonal Air Temperature (change relative to 1984-2003).

GCM	Annual	Winter (DJF)	Spring (MAM)	Summ. (JJA)	Fall (SON)
Ensemble mean	60.3°F (+3.9°F)	45.4°F (+3.8°F)	57.0°F (+3.4°F)	77.1°F (+4.5°F)	61.6°F (+3.9°F)
Lowest	59.4°F	44.8°F	55.6°F	76.1°F	59.9°F
Highest	61.1°F	45.9°F	57.7°F	78.5°F	63.0°F

Table 3-4. Projected GCM 2024-2043 Percentiles of Highest Air Temperature in Each Day (T_{max}) (change relative to 1984-2003).

GCM	3rd perc.	25th perc.	50th perc.	75th perc.	97th perc.
Ensemble mean	46.7°F (+2.4°F)	61.3°F (+2.1°F)	74.2°F (+2.5°F)	89.2°F (+3.0°F)	100.7°F (+3.7°F)
Lowest	45.0°F	60.3°F	73.2°F	88.5°F	99.5°F
Highest	48.8°F	62.1°F	74.6°F	89.8°F	102.5°F

Table 3-5. Projected GCM 2044-2063 Percentiles of Highest Air Temperature in Each Day (Tmax) (change relative to 1984-2003).

GCM	3rd perc.	25th perc.	50th perc.	75th perc.	97th perc.
Ensemble mean	48.2°F (+3.8°F)	62.5°F (+3.3°F)	75.6°F (+3.9°F)	90.4°F (+4.2°F)	101.6°F (+4.6°F)
Lowest	47.0°F	61.7°F	73.9°F	89.3°F	100.3°F
Highest	49.7°F	63.3°F	76.4°F	91.7°F	103.3°F

3.5.2 Water Temperature

Projections of water temperature from the hatchery's water sources are obtained based on the empirical relationship between daily water temperature and air temperature. Daily water temperature records are available for the period 1962-1988. This period of time is far removed from present. If it is assumed that land cover and land use, and any other factors affecting the water sources, have remained unchanged, then this data can serve the purpose of characterizing the relationship between daily water temperature and air temperature. The daily air temperature record for the hatchery's location from the Livneh gridded dataset showed reasonably good correlation with the hatchery's daily water temperatures (shown in Figure 3-4) and was therefore used in this work.

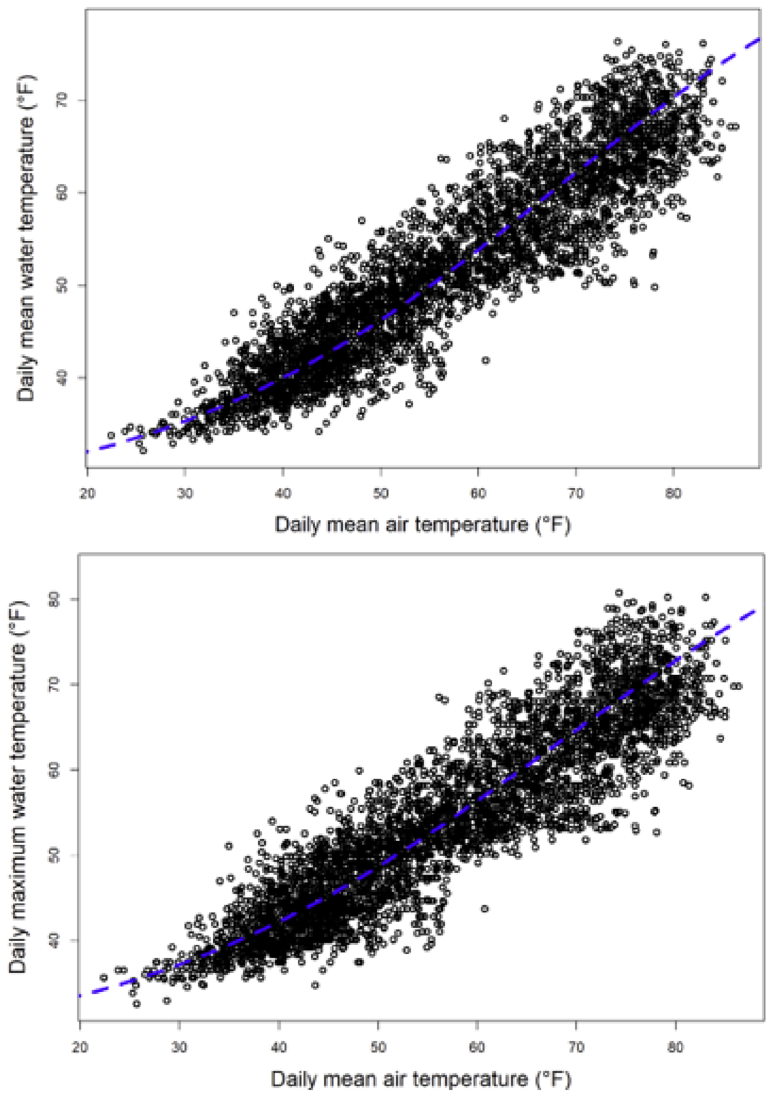

Figure 3-4. Water Temperature's Dependence on Air Temperature.

Top panel: Daily mean water temperature at the hatchery plotted against the mean air temperature on the same day, for the period of overlap of the two data records (2000-2018). The blue dashed logistic curve represents Equation 3-1 fitted to the data. Bottom panel: Same, for the daily maximum water temperature.

Following Mohseni et al. (1998; 1999), a logistic model (Equation 3-1) was fitted to the relationship between water temperature and air temperature. Equation 3-1 was fitted for the mean daily water temperature and separately for the maximum daily water temperature (i.e., the temperature of the hottest hour of each day), yielding the blue dashed curves in Figure 3-4.

Equation 3-1.

$$T_{water} = \mu + \frac{\alpha - \mu}{1 + e^{\gamma \cdot (\beta - T_{air})}}$$

In Equation 3-1, T_{air} is the air temperature; μ and α represent the minimum and maximum water temperature, respectively; β is the air temperature at the inflection point of the "S"-shaped curve; and γ is a function of the slope around the inflection point, given by $\gamma = 4 \cdot slope/(\alpha - \mu)$.

For the mean daily water temperature, the fitted parameters (blue dashed curve in the top panel of Figure 3-4) are: μ = 32°F, α = 95°F; β = 68°F; and slope = 0.84. For the maximum daily water temperature, the fitted parameters (blue dashed curve in the bottom panel of Figure 3-4) are: μ = 32°F, α = 100°F; β = 68°F; and slope=0.84.

Projections of water temperature were obtained based on the projected changes in air temperature from the 10 GCMs combined with the empirical response of water temperature to air temperature shown in Figure 3-4. Table 3-6 and Table 3-5 give the projected mean seasonal water temperature for two future time periods, and the temperature change relative to the reference period 1984-2003. All time horizons, including the reference period, are simulated by the ensemble of 10 GCMs. Table 3-8 and Table 3-9 give the projected number of days with water temperature above thresholds 60°F, 65°F and 70°F.

Table 3-6. Projected GCM 2024-2043 Mean Seasonal Water Temperature (change relative to 1984-2003).

GCM	Annual	Winter (DJF)	Spring (MAM)	Summ. (JJA)	Fall (SON)
Ensemble mean	55.4°F (+2.2°F)	42.6°F (+1.6°F)	51.8°F (+1.6°F)	67.6°F (+2.7°F)	57.6°F (+2.3°F)
Lowest	54.7°F (+1.7)	41.6°F (+0.9)	50.6°F (+0.8)	66.3°F (+1.8)	56.0°F (+1.2)
Highest	56.0°F (+2.6)	43.4°F (+2.1)	53.2°F (+2.6)	68.9°F (+3.6)	58.6°F (+3.0)

Table 3-7. Projected GCM 2044-2063 Mean Seasonal Water Temperature (change relative to 1984-2003)

GCM	Annual	Winter (DJF)	Spring (MAM)	Summ. (JJA)	Fall (SON)
Ensemble mean	56.7°F (+3.1°F)	43.8°F (+2.4°F)	51.9°F (+1.7°F)	69.1°F (+3.7°F)	58.9°F (+3.2°F)
Lowest	55.7°F (+2.4)	43.2°F (+2.0)	50.8°F (+0.9)	67.9°F (+2.9)	56.9°F (+1.8)
Highest	57.7°F (+3.8)	44.4°F (+2.8)	53.4°F (+2.7)	70.7°F (+4.8)	60.5°F (+4.3)

Table 3-8. Projected GCM 2024-2043 Number of Days with Water Temperature Above Thresholds 60°F, 65°F and 70°F (observed in 1962-1988).

GCM	Annual	Winter (DJF)	Spring (MAM)	Summ. (JJA)	Fall (SON)
Percentage of Days > 60°F	33% (27%)	0 (0)	4% (1%)	88% (75%)	41% (28%)
Percentage of Days > 65°F	22% (13%)	0 (0)	0 (0)	71% (42%)	23% (10%)
Percentage of Days > 70°F	8% (3%)	0 (0)	0 (0)	34% (11%)	5% (1%)

Table 3-9. Projected GCM 2044-2063 Number of Days with Water Temperature Above Thresholds 60°F, 65°F and 70°F (observed in 1962-1988).

GCM	Annual	Winter (DJF)	Spring (MAM)	Summ. (JJA)	Fall (SON)
Percentage of Days > 60°F	37% (27%)	0 (0)	4% (1%)	91% (75%)	44% (28%)
Percentage of Days > 65°F	26% (13%)	0 (0)	0 (0)	76% (42%)	27% (10%)
Percentage of Days > 70°F	12% (3%)	0 (0)	0 (0)	45% (11%)	8% (1%)

3.5.3 Snowpack and Streamflow for Kern River Watershed

Rising air temperatures result in projected changes in the hydrologic regime of the Kern River watershed. Figure 3-5 displays the projected mean daily snowpack (solid lines) and range from minimum to maximum (shaded areas) for each day of the year at Kern River near the hatchery, for the near future (red) and the reference time period (blue). Figure 3-6 displays the projected streamflow in a similar manner to Figure 3-5. Data in both figures are simulated by the ensemble of 10 GCMs for each time period, including the reference period. The Kern River watershed upstream of the hatchery site has an estimated 1,006 square miles, according to StreamStats (USGS, 2019).

The differences between the near-future period and the reference period seen in Figure 3-5 and Figure 3-6 occur as a result of the projected air temperature increase. Averaging the air temperature over the Kern River watershed, the number of days in winter (December-February) with above-freezing mean daily temperatures was 28% in the reference period (1984-2003) but is projected to increase to 45% in 2024-2043, and to 53% in 2044-2063. This is a result of the projected winter warming by an average of 2.5°F in 2024-2043 and 3.8°F in 2044-2063 relative to 1984-2003 (Table 3-2 and Table 3-3).

Reflecting the increase in winter rain-to-snow ratio, the projected 2024-2043 snow accumulation is on average smaller and, given the higher spring and summer temperatures, projected snowmelt occurs earlier (Figure 3-5).

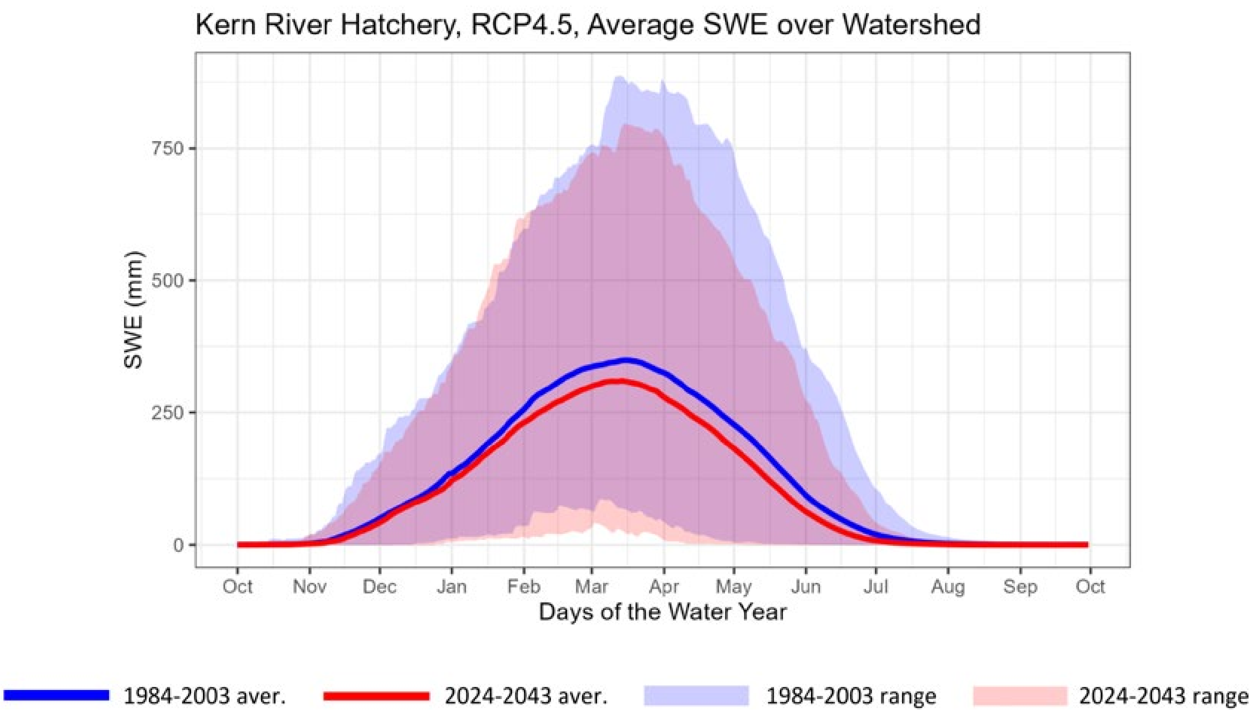

Figure 3-5. Mean Daily Snow Water Equivalent and Range for Each Day of the Year for Kern River Watershed.

The mean daily streamflows (solid lines) displayed in Figure 3-6 show increases in the colder months (November through March) and declines in summer (June-August). Seasonal streamflow changes are summarized in Table 3-10 and Table 3-11, the largest being an increase by 46% of mean winter streamflow and a decline of -27% in mean summer streamflow in the near future period (2024-2043) relative to the reference period (1984-2003). For the mid-century period (2044-2063), these changes are even larger, equal to +60% and -46%, for winter and summer, respectively. Projected winter streamflows show higher peaks due to increase of rainfall relative to snowfall (Figure 3-6). There is also a projected increase in total winter precipitation for 2024-2043 compared to 1984-2003, but it is small (+2.5%), contributing little to the higher winter peak flows. Projected summer low-flows start about two weeks earlier (Figure 3-6)

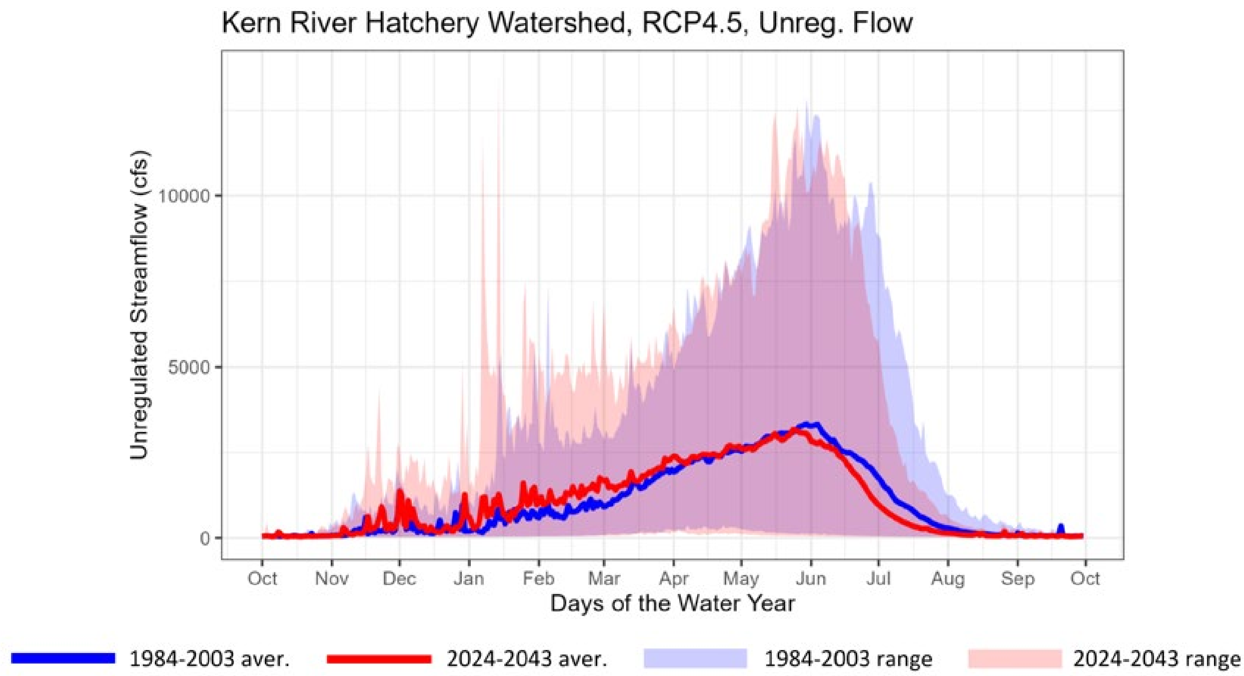

Figure 3-6. Mean Daily Streamflow and Range for Each Day of the Year for Kern River.

Table 3-10. Projected GCM 2024-2043 Percent Change in Annual and Seasonal Streamflow for Kern River (relative to 1984-2003).

GCM	Annual	Winter (DJF)	Spring (MAM)	Summ. (JJA)	Fall (SON)
Ensemble mean	+3%	+46%	+7%	-27%	+20%

Table 3-11. Projected GCM 2044-2063 Percent Change in Annual and Seasonal Streamflow for Kern River (relative to 1984-2003).

GCM	Annual	Winter (DJF)	Spring (MAM)	Summ. (JJA)	Fall (SON)
Ensemble mean	-4%	+60%	+2%	-46%	+15%

The daily streamflow values which in the reference period (1984-2003) had a probability of being exceeded in any given year equal to 1-in-5, 1-in-10 and 1-in-20, i.e., being surpassed once every 5 years, 10 years and 20 years, were determined by frequency analysis of the hydrologic model simulations for the 10 GCMs. These daily peak flows were determined separately for the colder period from October to February and the warmer period from March to September and are given in the header of Table 3-12 and Table 3-13. Streamflow peaks occurring in October-February correspond to heavy rainfall events or rain-on-snow events, while peaks occurring in March-July are likely to have a large snowmelt component.

For a fixed return period, the daily peak flows are considerably higher for the cold season compared to the warm season (Table 3-12 and Table 3-13). For example, the 10-year daily peak flow is estimated as 10,600 cfs for the cold season and 6,900 cfs for the warm season. Sub-daily (e.g., hourly) peak flows are not available from the hydrologic projections and may be considerably higher than daily peak flows. Cold season peak flows are usually associated with rainfall rather than snowmelt and are therefore shorter in duration.

The daily peak flow values, which in the reference period had return periods of 5, 10 and 20 years, are projected to have different future return periods, given in Table 3-12 and Table 3-13. In the cold season, the return period of each streamflow value is shorter in the near-future period (2024-2043) than the reference period (1984-2003). For example, the cold season daily streamflow corresponding to the 10-year return period in 1984-2003 is estimated as 10,600 cfs, a value which in the current period and in 2024-2043 has a return period of 6 years. Thus, this high flow value is projected to occur more frequently, reflecting increasing daily peak flows.

In the warm season, the projections are mixed, indicating a shortening of the 10-year flow return period but a possible increase in the return period of the former 20-year flow. Projections of daily streamflows are uncertain, and daily peaks can be much smaller than instantaneous peaks, therefore projections should be viewed with caution.

Table 3-12. Projected Change in Peak Streamflow Frequency for Kern River, Cold Season (Oct-Feb).

Time Horizon	3,600 cfs Return period (yr)	10,600 cfs Return period (yr)	16,900 cfs Return period (yr)
1984-2003	5	10	20
2004-2023	4	6	18
2024-2043	3	6	17
2044-2063	3	5	10

Table 3-13. Projected Change in Peak Streamflow Frequency for Kern River, Warm Season (Mar-Sep).

Time Horizon	5,000 cfs Return period (yr)	6,900 cfs Return period (yr)	7,900 cfs Return period (yr)
1984-2003	5	10	20
2004-2023	5	9	25
2024-2043	5	8	18

Time Horizon	5,000 cfs Return period (yr)	6,900 cfs Return period (yr)	7,900 cfs Return period (yr)
2044-2063	5	8	23

3.5.4 Wildfire Risk

Historical wildfires have been documented both in the immediate vicinity of the hatchery and within the watershed perimeter, as mapped in Figure 3-7. Large wildfires in 2020 and 2021 burned roughly a quarter of the watershed, and a 2010 fire had burned a similar-sized portion. Up until 2010 some large fires (>20,000 acres) occurred in the uplands surrounding the hatchery, but most of these uplands have not burned since then. These surrounding uplands are covered mainly by shrubland, and the anticipated fuel recovery rate of this vegetation is 5 to 10 years. For the broader watershed, which consists of mostly conifer forests, the fuel recovery rate is typically more than 10 years but varies with burn severity and tree type.

Expressing wildfire risk as a percent chance of occurring at least once in a decade, the projected wildfire risk at the hatchery site is between 24 and 27% through mid-century (Figure 3-7). Across the watershed, the projected fire risk is locally higher, at 33%, increasing to 44% towards the end of this century.

The Kern River Hatchery is currently out of operation due to the catastrophic failure of the siphon system supplying water from the Kern River, which was damaged in a flood event in March of 2023. Historically, turbidity and transported debris have also been concerns, along with seasonally warm water during low flow periods. It is possible that flooding and sedimentation, both of which were documented at the hatchery in March of 2023, were related to the higher runoff potential of the 2020 and 2021 burn scars. Burn scars typically heal within 5 years of a wildfire as new root systems strengthen the soil, but higher burn severity increases soil recovery time. Given the history of large fires in the watershed and surrounding basins, future concerns to the hatchery include burn scar-induced flooding, turbidity, debris (soil erosion), and relatively higher water temperatures while riparian shade trees recover. Given the absence of fire in the surrounding uplands since 2010 or earlier, there is also an increasing risk of fire recurring in the immediate vicinity of the hatchery as time progresses.

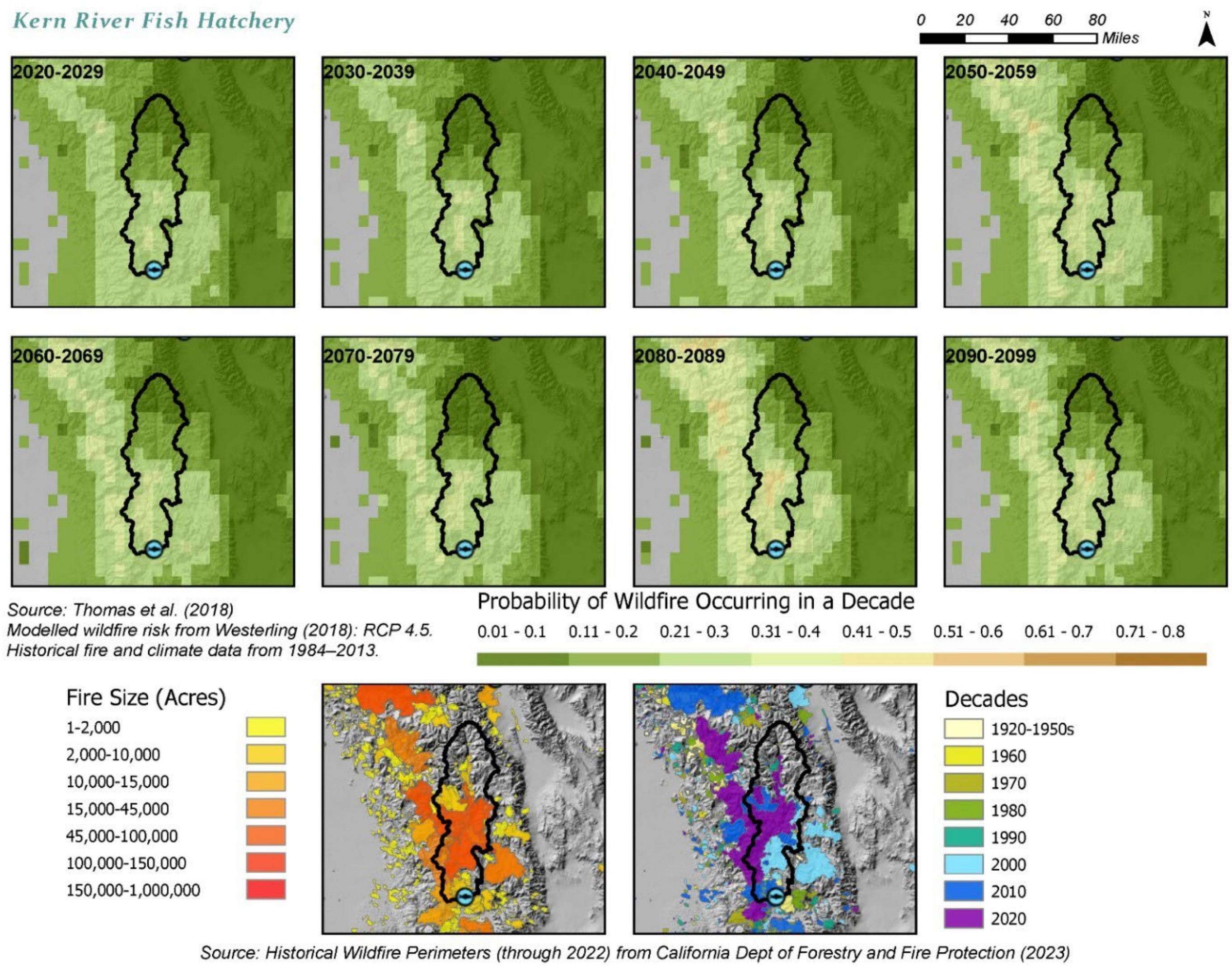

Figure 3-7. Summary of Wildfire Risks and Observations in the Vicinity of Kern River FH.

3.6 Conclusions

Significant increases in air temperature and water temperature are expected for the Kern River Hatchery. Mean annual air temperature is projected to rise by 2.7°F in the next 20 years (2024-2043) and by an additional 1.2°F in the mid-century period (2044-2063), compared to the reference period (1984-2003). The summer will experience the most warming, and the largest temperature increases are projected to occur on the hottest days. Days with temperatures representing the 75th percentile and 97th percentile of daily temperatures are projected to warm by 3.0°F and 3.7°F, respectively, in the next 20 years, relative to the reference period.

The ensemble of 10 GCMs indicates important changes in the hydrologic regime of the Kern River stemming from air temperature rise.

According to the observations-based gridded air temperature dataset used in this study (Livneh et al., 2013), the 75th and 97th percentiles of peak daytime temperature (i.e., the temperature at the hottest time of day) at the hatchery site in the reference period (1984-2003) were 86.2°F and 97.0°F. For the near future period (2024-2043), these percentiles are projected to rise to 89.2°F and 100.7°F, respectively. Such an increase in the peak air daytime temperature requires adaptation measures for protection of hatchery workers against heat stroke and other health effects of heat exposure. Roads and roofs may also need to be replaced using more heat-resistant and reflective materials.

Mean daily water temperature shows a strong dependence on air temperature, and an increase of 2.7°F is projected over the next 20 years (relative to 1984-2003) for the mean summer water temperature. The number of days exceeding water temperature thresholds of 60°F, 65°F and 70°F are projected to increase greatly in the near future period 2024-2043. For example, while in the period of observations (1962-1988) a water temperature of 70°F was exceeded in 11% of summer days, this figure increases to 34% in 2024-2043.

The projected winter air temperature rise (2.5°F in 2024-2043 and 3.8°F in 2044-2063 relative to 1984-2003) will alter the hydrologic regime of the Kern River watershed. In particular, the number of winter days (December-February) with above-freezing mean daily temperatures, which is projected to increase from 28% in the reference period (1984-2003) to 45% in the near future period (2024-2043) and to 53% in mid-century (2044-2063), will lead to an increased rain-to-snow ratio, resulting in lower snow accumulation (only partially offset by a small projected increase in total winter precipitation).

Daily peak flows are projected to increase in winter, with the return period of the 5-year, 10-year, and 20-year peak flows of 1984-2003 declining to 3-year, 6-year, and 17-year, respectively, in 2024-2043. Projections of daily streamflows are uncertain, and daily peaks can be much smaller than instantaneous peaks, therefore projections should be viewed with caution. Snowmelt peaks are projected to not change significantly but to occur on average 2 weeks earlier. Low summer streamflows will initiate earlier and are aggravated by a projected decline in mean summer precipitation. Mean winter streamflow is projected to increase by 46%, while mean summer streamflow is projected to decrease by 27% in the near future period relative to the reference period.

The hatchery is at significant risk of wildfires. There is a history of large fires in the watershed and surrounding uplands and, given the absence of fire at these locations since year 2010, there is increasing risk of fire in the near future. The projected chance of at least one wildfire occurring in a 10-year period at the hatchery site is estimated as one-in-four (24-27%) through mid-century. Across the watershed, this risk is estimated as one-in-three (33%). Post-fire conditions also pose risks to the hatchery, including scar-induced flooding, turbidity, debris, and warmer waters due to loss of riparian tree shade.

4.0 Existing Infrastructure Deficiencies

Multiple deficiencies were identified during the site visit and described in Section 4 of the Site Visit Report (Appendix A). Section 5.4 of the Site Visit Report identified potential technologies and solutions available to address specific deficiencies that would allow the hatchery to meet production goals and provide protection against climate change. The main areas of concern for the hatchery included inadequate filtration and ultraviolet (UV) irradiation systems, lack of water temperature control capabilities, unknown well production, poor condition of hatchery building plumbing, insufficient alarms for the facility, broken rearing infrastructure, and inadequate predator exclusion measures. These issues are superseded by the current state of disrepair of the water supply siphon, leaving the facility inoperable until it is replaced. Biosecurity deficiencies and potential solutions for addressing these concerns were identified in Sections 3.0 and 3.2 of the Site Visit Report, respectively. The details of these deficiencies are further expanded upon in Sections 4.1 and 4.2.

4.1 Water Process Infrastructure

4.1.1 Water Supply Issues

The facility was designed with a siphon water supply to pull water from an upstream location in the Kern River near the Kern River Powerhouse #3. The old siphon had difficulty maintaining suction throughout its operation. A vacuum pump, priming pump, air release valve, and associated piping were included to maintain operation. The old siphon was catastrophically damaged in a March 2023 flood, detaching from its concrete anchors and buckling severely enough that repair was not an option. A new siphon supply is currently in the design phase, led by the California Department of General Services (DGS). Discussions with CDFW indicated that the new design would be a buried HDPE pipe, limiting the potential for floating during flood events. The water supply is also expected to be piped the complete length to the facility instead of flowing into an exposed ditch prior to reaching the hatchery plumbing.

In addition to the water supply infrastructure, the Kern River water source also prevents the ability of the hatchery to operate year-round. During the summer, water temperatures in the Kern River increase beyond the acceptable limit for salmonid culture. As a result, the facility has only operated seasonally from November to June in the past several decades, A lack of chilling equipment at the facility prevents production during the summer.

4.1.2 Well Production Uncertainty

Historical notes from previous hatchery employees refer to five wells, but only four have been located on the facility grounds. Production information for the four known wells is also only available through historical notes; no testing or flow metering documentation is available. The combined production of four wells is estimated to be a maximum of 315 gpm. However, CDFW have confirmed that none of the located wells are operating as designed and are likely producing much lower flow rates. The water quality and chemistry of groundwater is also unknown, as are the temperature characteristics (stable or fluctuating, appropriate for egg incubation, etc.). The wells are currently thought to be plumbed into the hatchery building supply, but the condition of the plumbing is unknown. Ultimately, the wells cannot be relied on for operations with the information currently available.

4.1.3 Hatchery Building Plumbing Upgrades

The plumbing in the hatchery building should be inspected and repaired or replaced as needed. All drain lines should be confirmed to work properly during tank cleaning when multiple standpipes may be removed. Valves should be exercised to test the ability to control and divert flows throughout the building.

4.1.4 Spawning Area Plumbing Upgrades and Reuse

The spawning area was designed for the KRRT program but has never been used and may have damage related to the floods. In an effort to conserve water usage, water could be diverted from the new raceways and circular tanks. The water would then be re-oxygenated and reused in the spawning area. Treating and reusing the chilled water from these systems would eliminate the need for separate or larger chilling systems.

4.1.5 Incorporate Recirculation Pumps and PRAS

Recirculation pumps should be added to reuse water when it is chilled during summer months for efficient use of well water. PRAS equipment, including aerators, filters, disinfection units, chilling systems, and recirculation pumps, should be installed throughout the facility to decrease water consumption and operating costs while maintaining fish production goals. Some areas to consider retrofitting PRAS include the raceways, circular tanks, wells, and hatchery building. Additional information about alternatives available in water reuse systems can be found in Appendix E - Alternatives Development TM.

4.1.6 NPDES Permitting for an Effluent System

The hatchery effluent flows into Gilbert Ditch which eventually flows into the Kern River. This means that Kern River Hatchery is susceptible to NPDES permitting requirements. Historical operations have not required the facility to obtain an NPDES permit. The facility has an annual harvest biomass over 20,000 pounds but does not distribute more than 5,000 pounds of feed in a calendar month; both criteria must be met before an NPDES permit is required. Facility production is limited by the lack of an NPDES permit, as described in Section 2.2.1.

4.2 Rearing Infrastructure

4.2.1 New Hatchery Building

The existing hatchery building has not been used in many years. Therefore, the current state of rearing units is unknown, but it is likely that several require replacement. The condition of valves associated with the well or river water supply is unknown, they are expected to be frozen from non-use over several years.

4.2.2 Deteriorating Raceways

The distribution raceways (10 ft wide by 40 ft long) are older than the other rearing infrastructure at Kern River Hatchery. Only one of these raceways was consistently used prior to the facility shutting down in 2019. The raceway concrete shows signs of deterioration ranging from crazing and cracking to delamination, scaling, and flaking. Production raceways (10 ft wide by 80 ft long) were poured in 2019 and have never been used for fish production. However, flooding has caused some damage to the concrete. The full extent of the damage and any resulting leaks will not be known until the new siphon is in operation.

4.2.3 Replace Circular Tanks

The existing circular tanks were not properly set when installed in 2018 and were reported to not drain correctly. In addition to the poor drainage, several tanks have cracked at the outlet, likely due to improper installation and floating during the 2023 flood event.

4.2.4 Outdoor Rearing Area Roof Cover with Side Enclosures

The outdoor production areas experience predation and in addition to the losses associated with predation, these predators also increase the risk of pathogens. Covering the outdoor rearing area with solid roof structures and enclosing the sides (e.g., fine mesh chicken wire) to eliminate access to predators, ducks, etc. would improve biosecurity. The solid roof structures would also reduce the warming effects of the hot summer sun as the water passes through the raceways and circulates in the tanks. As mean and maximum ambient air temperatures continue to rise in the future, reducing the solar effects on water temperature in the hatchery will be critical to maintain temperatures within the range for salmonids. This is especially important given the current water temperatures at the hatchery are already in the upper range for salmonids.

4.2.5 Upgrade Backup Power Generation

The hatchery's main power is supplied by SCE. There are also three generators on site for the well pumps, RAS area, and flood control pump. The flood control pump is experiencing leakage from the propane tank and needs repair. Upgrades may be required to the other generators as well to remain in compliance with the Eastern Kern Air Pollution Control District. The installation of backup generators for added reuse technology should also be considered as needed.

4.2.6 Operational Adjustments

A few operational adjustments could provide greater biosecurity at Kern River Hatchery. Rotating through the four raceways available for planting operations would allow for more time to fallow, pressure wash, and disinfect raceways before receiving another shipment of fish. It will also be important to develop a biosecurity plan for the KRRT production program prior to initiation. This may include tank cleaning schedules, footbath locations, refresh schedules, standard operating procedures for wild fish care, etc.

4.2.7 Additional Alarms

As the KRRT program develops, alarms should be installed for the hatchery building and captive broodstock. These alarms have the potential to prevent catastrophic losses of an important species during an emergency.

5.0 Alternative Selected

During the site visit several deficiencies were identified that currently limit the hatchery's ability to meet fish production goals. These deficiencies have been summarized in Section 4.0 of this report. Appendix E - Alternatives Development TM provides a discussion of alternative technologies that may be used to address the existing deficiencies and potentially expand production, improve biosecurity, and increase operational efficiencies. The following section presents a summary of the preferred alternative that would best utilize the alternative technologies to respond to the existing deficiencies, maximize fish production and respond to the climate change projections described in Section 3.0. The conceptual layout of the alternative described below is shown in Appendix C.

5.1 Alternative Description

5.1.1 Water Supply Wells

There are up to five wells on site that supply the hatchery building, outdoor hatchery tanks, and the Recirculating Aquaculture System (RAS); however, there is little available data such as flow and temperature. Four wells have been located and the best available records suggest a total production of 315 gpm combined. Testing and refurbishment of these wells is recommended, as chilling requirements for egg incubation, early rearing, and broodstock can be significantly reduced by using the well water supply and potentially incorporating it into the broodstock PRAS (Section 5.1.5).

5.1.2 Water Distribution

The existing water supply siphon was deactivated in 2019/2020 and was catastrophically damaged by the March 2023 flood which detached the siphon from its anchorage and caused irreparable damage. The facility has been out of operation since the 2019/2020 shutdown and will remain inoperable until the new siphon has been constructed. DGS is currently in the design phase performing the environmental review and investigation, with construction anticipated in 2025/2026 and full water supply operations beginning in 2028.

The new pipeline will be a buried HDPE pipe which will limit exposure to flood events and the potential for the pipe to float. The design of the new siphon includes routing the water supply pipe all the way to the hatchery. This bypass of the existing open canal by direct supply pipe routing will eliminate the need for the existing trash rake and debris removal. At the hatchery termination of the pipe, a water treatment area can be built to aerate, filter, disinfect, and chill the incoming surface water, allowing for year-round production as well as a broodstock and egg incubation program.

The proposed improvements are for the entire surface water right (20 cfs) to be aerated. Only water for the production raceways, hatchery building, and circular tanks would be filtered and disinfected; the demand for these systems is approximately 13 cfs. Chilling is proposed for the three systems in use during the summer months, it is assumed that PRAS will reduce the required flow rate to approximately 4.5 cfs. Water temperatures in the Kern River can elevate to the low 70s Fahrenheit in the summer during low flow years. A temperature differential of 10°F is proposed, which requires approximately 1,000 tons of chilling at a flow rate of 4.5 cfs. Once more detailed plans for the production schedule of the KRRT program are developed, the water treatment system design may be refined to reduce costs while maintaining optimal water quality for the program.

5.1.3 Valving and Piping

Various valves and pipes across the hatchery are old and in questionable condition. Valves throughout the hatchery, such as at supply headbox and the head of the distribution raceways, have been left in a constant position and are not regularly operated by hatchery staff.

The preferred alternative is to inspect valves and pipes throughout the hatchery and to replace infrastructure that is leaking, not operable, heavily aged/worn, or likely to fail in the near future. Replacing the valves and pipes would allow for better flow control and would allow for the hatchery to continue operating into the future.

5.1.4 Hatchery Building Upgrades

To accommodate the Kern River Rainbow Trout production program, rearing units in the hatchery building require upgrades. It is assumed that the hatchery building will be supplied with well water; this assumption is only valid after pump tests demonstrate adequate flow, and water chemistry tests determine the well water is safe for fish culture.

KRRT spawn in the late spring and early summer, it is expected that egg incubation will occur while water temperatures in the Kern River are unsuitable for egg development which requires the chilling of supply water, discussed in Section 5.1.2. To maintain optimal incubation conditions, each Heath stack would be outfitted with a sump, pump, and UV disinfection system to recirculate water. Four Heath stacks are proposed, which would provide 60 operational trays (top trays of each stack reserved for aeration and treatment dosing). Assuming each female is its own family group, there would be one tray per family group available with 10 additional trays for overflow or special uses. Each Heath stack would operate on 1 gpm of fresh makeup water (4 gpm total for the incubation system). Recirculation and water treatment equipment may not be required if well water quality is suitable and well production is high enough to meet summer flow demands throughout the facility.

For early rearing, the small circular tanks currently in the building will be removed and replaced with deep tanks. The remaining deep tanks will be assessed and replaced if necessary. There will be 12 deep tanks total, each 2 feet wide, 16 feet long, with a wall height of 3 feet and a water depth of 2 feet; each tank will have a rearing volume of 64 ft^3 (768 ft^3 for all tanks combined). These tanks will have sufficient volume to raise KRRT up to 115 fpp (2.8 inches). Based on the bioprogram in Section 2.2.2 fish will reach this size in September when water temperatures in the Kern River decrease to levels suitable for salmonid culture. The total flow rate required for production in the deep tanks is dependent on the water temperature of the wells, which impacts the FI criteria. To maintain the FI criteria in Section 2.2.1 (1.04, based on a water temperature of 64° F), a maximum flow rate of 210 gpm is required for early rearing, or approximately 17.5 gpm per deep tank. This is expected to be an overestimate, required flow rates are subject to change based on additional information about the well water quality.

5.1.5 Outdoor Circular Tanks

The outdoor circular tanks are proposed as broodstock holding units that will operate year-round. The existing tanks will be repaired or replaced, as necessary. PRAS equipment is proposed to reduce the costs associated with water treatment, primarily chilling during the summer months.

The required flow rates for the tanks (16-foot diameter, 3-foot wall height, and 2-foot water depth) are based on hydraulic residence time (HRT), or how long it takes to completely exchange the water volume in the tank. Timmons et al. (2018) suggest an HRT between 30 and 45 minutes. Fish densities are expected to be relatively low in the broodstock system, therefore an HRT of 45 minutes is sufficient to maintain a quality rearing environment. An HRT of 45 minutes would require a flow rate of approximately 70 gpm for each tank, or 420 gpm for the entire system.

To efficiently use water if well production is limited, operating the tanks as a PRAS is proposed. The tanks would be organized as a single module, it is recommended that early operations begin with a recirculation rate of 50% or less if water availability allows. As culturists gain knowledge of the equipment and systems the rate can be increased up to 75% without the need for a biofilter. Recirculation equipment including pumps, filtration, degassing, oxygenation, and UV disinfection systems would be sized to accommodate a range of flow rates to operate up to a recirculation rate of 75%. The module's recirculation equipment would be sized to treat and recondition a flow rate up to 325 gpm, with 95 gpm of fresh makeup water added to the system for a process flow rate of 420 gpm.

5.1.6 Outdoor Spawning Facility

The newly constructed spawning facilities included the construction of both covered and uncovered concrete diversion channels, diversion slotting, and a metal roof to protect both fish and personnel from the elements during spawning operations. The facility seems unaffected by the recent flooding, with concrete appearing to be in generally acceptable condition with no noted major defects. This facility can be sourced with chilled water diverted from the new raceways and circular tanks to be used for spawning. When combined with oxygenation and reuse, this diversion would eliminate the need for a dedicated separate chilling system.

5.1.7 Planting Raceways

The four (4) 10-foot wide, 40-foot-long, 3-foot-deep concrete raceways were used for maintaining catchable Rainbow Trout prior to regional planting. The raceways are fenced and have single-strand cables over the top to provide avian predator protection. The raceways are supplied by the siphon and have not been functional since 2020. The planting raceways are older than the other hatchery rearing infrastructure. Prior to the siphon damage, only one of the raceways was consistently used, with the current condition of leakage of both raceways being unknown. The raceway concrete is showing signs of deterioration ranging from crazing and cracking to delamination, scaling, and flaking requiring repair. The recommended alternative for these older raceways is to rebuild or replace them with a dedicated distribution raceway pair. Designing and constructing in pair will allow for one raceway to fallow and disinfect while the other can be used throughout the distribution season. This raceway pair would not need connection to chilling or PRAS for water quality during the stocking season.

In addition, the planting raceways would benefit from the installation of a permanent covering. Constructing a stable roof above the planting raceways would provide shade for both workers and fish, eliminate the need for avian cables, reduce algae growth during the summer months, and reduce the yearly water losses from evaporation. An alternative to a roof structure could be the seasonal use of shade cloth (70% opacity) during the summer months.

A new photovoltaic system would be included atop the raceway cover structure to help offset the power requirements of the new hatchery infrastructure while also lowering the overall cost of operating the hatchery.

5.1.8 Outdoor Production Raceways

Local staff have indicated that the four (4) 10-foot-wide, 80-foot-long, 3-foot-deep concrete raceways have leaked since they were rebuilt. However, none of the raceways have been utilized since completing improvements in 2018. Since there are known leakage issues with the reconstructed raceways, the structural integrity of the concrete and the coating should be checked for cracking, spalling, delamination, and other defects. The raceways should be repaired to reduce the potential for water loss from infiltration and subsurface routing of flows.

It is assumed that KRRT will be reared in these raceways during summer months. To reduce the cost of chilling water, a PRAS for each raceway pair is proposed (2 modules). The PRAS treatment will include filtration, UV disinfection, and degassing/oxygenation. It is assumed that the flow rate of each raceway is 3 cfs, or 6 cfs for each pair; the PRAS equipment would be designed to operate up to a 75% recirculation rate. For each PRAS module, a 75% recirculation rate would require a fresh makeup water flow rate of approximately 675 gpm. The PRAS equipment would be designed to treat 2,025 gpm, the approximate recirculated flow rate when operating at 75% reuse.

Constructing a roof as with the planting raceways would provide shade for both workers and fish, eliminate the need for avian cables, reduce algae growth during the summer months, and reduce the yearly water losses from evaporation. If sensitive species like the KRRT are produced, a roof structure or shade cloth (70% opacity) combined with bird netting would reduce predation, minimize stress, and provide a safe environment to allow workers to spend the time needed for a successful rearing program.

A new photovoltaic system would be included atop the raceway cover structure to help offset the power requirements of the new hatchery infrastructure while also lowering the overall cost of operating the hatchery.

5.1.9 Standby Power

There are three generators on site, one that serves four well pumps, one for the RAS area, and one for the flood control pump. There are two automatic transfer switches (ATS), one for the RAS area and one for the wells that has not been installed. The flood pump has a Cummins® propane generator which is currently experiencing leakage from the propane tank and needs repair. The other generators on site are propane powered. It is recommended to repair and replace the existing generators as needed, as upgrades to the generators may be required for the facility to remain in compliance with the Eastern Kern Air Pollution Control District. In addition, backup generators should be installed as needed for additional reuse technologies as they are implemented.

5.1.10 Effluent System

Current effluent from the hatchery discharges into the bypass ditch and either flows into the Gilbert Ditch or comingles with siphon water when the headworks divert water around the hatchery. This water is used downgradient for irrigation and other non-potable agricultural uses. With the functional operation of the hatchery modified to be a planting base only, the current NPDES requirements do not apply. The hatchery must produce a harvest weight of less than 20,000 pounds and feed less than 5,000 pounds of food during a calendar month to stay below the NPDES limits. Implementing a KRRT program would ideally remain below the NPDES limits rather than be designated a Concentrated Aquatic Animal Production facility.

The existing effluent discharges beneath the hatchery flood berm through a locally actuated flood gate. As it is only a locally actuated gate, staff must be present to close the gate in the event of flooding and prevent back flow of flood water into the hatchery itself as happened in the 2023 flood. To prevent similar flooding in the future, a suggested alternative is to install a “flap” style drainage gate to allow effluent discharge into the Gilbert Ditch, but automatically flap close and prevent backflow of ditch water in the event of flooding.

5.2 Pros/Cons of Selected Alternative

Table 5-1 provides a high-level summary of the pros and cons for Kern River Hatchery’s selected alternative.

Table 5-1. Pros/Cons of Selected Alternative – Kern River Hatchery.

Description	Pros	Cons
Test and refurbish the wells.	• Increases water supply if water is acceptable.	• Increases cost.
Add recirculation pumps to reuse water when it is chilled during the summer months or for efficient use of well water.	• Provides cooler production water during periods of elevated water temperatures.	• Requires additional water quality equipment and infrastructure. • Adds maintenance and operating costs.
Rebuild indoor rearing hatchery building with PRAS design and include chilling for egg incubation.	• Allows for year-round production and holding despite warm river temperatures.	• May have permitting challenges.
Rebuild or replace outdoor raceways with purpose-built distribution raceway pair.	• Allows for one raceway to disinfect/fallow while the other is used throughout the distribution season. • Does not require water chilling during the stocking season. • Does not require PRAS during stocking season.	• May have permitting challenges.

Description	Pros	Cons
Replace outdoor circular tanks and rebuild the system with PRAS equipment.	• Allows for year-round production.	• May have permitting challenges. • Increases maintenance demand and operating costs.
Apply skim/epoxy to newer outdoor raceways if needed/required and retrofit with PRAS.	• Allows for year-round production. • Can do high-level cost to replace in-kind.	• Increases maintenance demand and operating costs.
Divert water from new raceways and circular tanks to outdoor spawning.	Eliminates the need for a separate or larger chilling system because chilled water from these systems can be used for spawning.	• Increases demand on the raceway supply water during these times.
Assess and upgrade raceway valving (PVC most likely for replacement), upgrade with PRAS retrofit.	• Increases the reliability of the supply system	• May be difficult to access some valves. • May disrupt production if replacement is performed after hatchery goes back online.
Limit production to 20,000 lbs of fish produced and 5,000 lbs of feed per month.	• Maintains the effluent discharge below NPDES limits.	• May limit the potential of the hatchery, depending on future production goals. • May be susceptible to NPDES requirements because Gilbert Ditch eventually flows into Kern River. • Needs to continue to provide water to the Gilbert Ditch even with PRAS systems operating.
Repair or replace existing emergency backup generators.	• Increases the reliability and consistency of power to the hatchery.	• Could have significant lead time and cost. • Has more stringent air quality control than EPA due to Kern County's regulations. • Has additional restrictions for generators.

Description	Pros	Cons
Upgrade floodgates.	• Prevents backflow into the hatchery.	• Increases maintenance to monitor potential debris build-up. • May have an increase in effluent water level due to throttled flow.

5.3 Alternatives for Short-Term Improvements

In the event that funding is not available to construct the preferred alternative, the following short-term improvements are recommended for continued hatchery operation.

5.3.1 Hatchery Building

The existing hatchery building needs to be assessed to determine the extent of the flood damage and the required repairs to return to operation. This includes all equipment (tanks, incubation stacks, etc.) and infrastructure including the foundation.

5.3.2 Outdoor Planting Raceways

The concrete should be repaired and resurfaced to provide a more fish-friendly rearing environment, improve solids movement, and protect raceways from further deterioration. Repairing and lining the raceways with a low-permeability material will also reduce the potential for water loss through infiltration and subsurface routing of flows. In addition, the supply headbox structure should be refurbished to reduce the risk of flow interruptions.

5.3.3 Outdoor Circular Tanks and Raceway Area

To reduce predation and maintain biosecurity of the outdoor rearing areas, new bird wire with tighter spacing (4-inch) is proposed. Netting may be evaluated further, but there is some slight concern of snow loading at the Kern River Hatchery.

5.4 Natural Environment Impacts

The proposed upgrades to the Kern River Hatchery should have negligible impacts on the natural resources in the surrounding area. All improvements would occur within currently developed areas, avoiding requirements for additional environmental or cultural permits not identified in Section 7.0. An exception may occur if any existing structures fall under the jurisdiction of California's Office of Historic Preservation (OHP).

5.4.1 Fire and Flood Risk

The recommended changes to the Kern River Hatchery will change the existing infrastructure and increase the number of rigid structures on site. However, they will not increase or decrease the fire risk. Based on the climate evaluation, the projected fire risk is generally expected to increase in the area as climate change worsens (Section 3.5.4).

Flooding has already caused severe issues at the facility, and peak streamflow events are projected to occur more frequently during the cold season from October to February (Table 3-12). The existing berm provides protection from direct flooding from the river, though the new siphon may still be at risk of damage during floods. Indirect flooding from the back flow through the effluent gate has previously damaged the facility. The proposed upgrades would install a flap gate for the effluent system to prevent back flow of floodwater, reducing the risk of future damage.

5.4.2 Effluent Discharge

The recommended changes to the hatchery would include additional production goals for the KRRT program. CDFW will have to manage the facility to ensure production does not exceed thresholds that would trigger NPDES requirements. Primarily, feed would have to be limited to less than 5,000 pounds within a calendar month. Otherwise, the proposed upgrades are not expected to alter effluent discharge quality but there will be effluent discharged year-round to support the KRRT broodstock program.

5.5 Hatchery Operational Impacts/Husbandry

The trout distribution program at the hatchery will remain the same except that the proposed upgrades will afford staff to more completely clean and disinfect raceways during the stocking season. Two raceways will be available for trout distribution; one will hold fish that await stocking while the other is cleaned and disinfected. This will help maintain biosecurity and reduce the risk of spreading pathogens to the various groups of fish that are transferred in and out of the Kern River Hatchery.

The major impacts to hatchery operations will revolve around the KRRT program. Since this program does not have a developed plan or goal, the impacts cannot be completely described. Generally, the hatchery will have to operate year-round to accommodate the broodstock population. Year-round operation will require more reliance on the groundwater supply or mechanical chilling equipment to maintain appropriate water quality conditions, thus increasing the operational complexity of the hatchery.

For the eventual operation of the hatchery and the KRRT program, early rearing would occur with standard practices used in other CDFW hatcheries utilizing deep tanks. Ideally, fish would be held indoors on groundwater until temperatures in the Kern River decrease to acceptable levels. Once Kern River water quality is acceptable, fish would be transferred to the outdoor raceways for further growth. The existing hatchery building is less than 200 feet from the production raceways, a reasonable distance to use a fish pump for transfers. The fish pump would reduce fish handling, stress, and staff labor. Once in the production raceways, fish will grow to their target size. The target size will likely be determined by limitations associated with NPDES thresholds, specifically the threshold of 5,000 pounds of fish feed per calendar month. There are several operational scenarios that CDFW may use to reduce fish densities and avoid exceeding the NPDES thresholds:

- Transfer some KRRT to other CDFW hatcheries for advanced grow-out, maintaining a small production cohort at the facility.
- Continually stock groups of KRRT at various sizes to maintain low densities and feed amounts.
- Only maintain KRRT to replenish the captive broodstock population. All KRRT designated for release would be transferred as eggs to other CDFW hatcheries for production.

The scenarios are examples, and not meant to be an exhaustive list. Each scenario has its benefits and limitations, and each would require discussion amongst CDFW staff to determine the best course of action. The chosen scenario may change from year to year based on allotments, budgets, and environmental conditions. Ultimately, operations during the first several years will be limited because of the lack of information on KRRT aquaculture. Basic aquaculture parameters including fecundity, optimal water conditions for various life stages, spawn timing or induction, and incubation requirements are unknown for the species. CDFW's expertise in trout culture will help start the program, but continual refinements are expected in the initial years of the KRRT program.

5.5.1 PRAS Operations and Equipment

The existing circular tanks will be replaced with similar functional units. Operations of the circular tanks would occur as planned for the facility in terms of feeding, handling, and husbandry practices. The PRAS provides tremendous benefits in reducing the water flow requirements, decreasing the amount of water requiring treatment and chilling while increasing the facility's efficiency during year-round operations. However, PRAS are more complex and require additional skillsets to monitor and maintain the equipment to ensure reliable system operations for successful fish production. There are periods throughout the year where surface water from the Kern River will be of acceptable quality and temperature for KRRT. During periods where surface water cannot be used, the PRAS equipment should be bypassed, and preventative maintenance performed. All required upkeep should be programmed into the facilities maintenance and management system to schedule, perform, and document preventative and corrective maintenance.

5.5.2 Feeding

Early rearing feeding techniques in the deep tanks use the CDFW hatchery's standard feeding practices. Fish can be fed in circular tanks utilizing the simplest of methods ranging from hand-feeding to automated systems and the techniques may vary depending on staff preferences, production strategies, or other variables. In addition to staff preferences, there are pros and cons associated with the various feeding options. Hand-feeding requires more staff time compared to automated feeding systems as it is labor intensive but allows staff to observe fish feeding and overall behavior and health. Hand-feeding allows the staff to feed the fish to satiation and minimizes overfeeding reducing wasted feed and maximizing water quality. Automated systems require an initial cost for the purchase and installation of the system. The automated feeding systems providing feed intermittently throughout the day including staff non-duty times to maximize growth, reduces staff labor, but reduces the staff's observations during feeding, requires adjustments to deliver the correct amount of feed, requires preventative and corrective maintenance, and ongoing costs associated with maintenance. It should be noted that hand and automatic feeding systems are not mutually exclusive. Even with automatic feeding systems, culture operations should still involve regular monitoring of fish and their feeding response throughout the day.

5.6 Biosecurity

Information about recent fish health issues at the Kern River Hatchery is limited because of reduced or paused operations. The hatchery most recently operated as a trout planting station, fish were held for very short periods and any instances of disease were likely a result of conditions at the source hatchery, exacerbated by handling and transport stress associated with the transfer to the Kern River Hatchery. As operations begin again, it is expected that common salmonid pathogens found at other CDFW hatcheries will eventually affect the Kern River Hatchery.

The goal of biosecurity measures is to minimize the risk of pathogens entering the facility and spreading between rearing areas at the facility. The proposed upgrades would ensure that any recirculated water is treated with UV disinfection, reducing pathogen loads in the systems. Egg incubation and early rearing would use groundwater sources, significantly reducing the risk of pathogens entering through the water supply. There would be no water treatment for the trout planting operation. However, the rebuilt planting raceways would allow staff to clean more thoroughly and disinfect them between fish transfers, reducing the risk of harboring and spreading pathogens. The proposed alternatives also include roof coverings for the planting and production raceways. The covers would include predator exclusion fencing and netting around the sides to better prevent predators from entering rearing areas and potentially introducing or spreading pathogens.

5.7 Water Quality Impacts

The recommended alternatives will improve the water quality within the existing rearing vessels. As an added benefit, the siphon rebuild project will reduce debris entering the facility by completely piping the water supply to the hatchery. Wells will provide higher quality water for the hatchery building and early life stages of fish. The PRAS equipment will also improve the water quality within the broodstock tanks and production raceways. The microscreen drum filters will remove the solids in the water. The LHOs will ensure the dissolved oxygen levels of the water supply will be at saturation or higher. The carbon dioxide strippers will remove dissolved carbon dioxide as well as other undesirable gases, and the UV unit will reduce the pathogen load of the water that returns to the tanks. Additionally, installing rigid roof structures with bird netting will reduce heat gain during the summer months and algae growth in the outdoor rearing units.

The PRAS will concentrate the fish waste into smaller flows from the center drain and drum filter backwash. This will be discharged through the normal effluent avenues into the Gilbert irrigation ditch. CDFW will have to limit overall production to stay below NPDES thresholds, dilution of the hatchery’s effluent in the Gilbert Ditch should maintain acceptable water quality.

6.0 Alternative Cost Evaluation

6.1 Introduction

McMillen has utilized historical costs as a self-performing general contractor in the performance of similarly-technical projects, as the basis of our Preliminary Concept Planning – Opinion of Probable Construction Cost (OPCC) estimate for this Project. Additionally, McMillen has solicited pricing or utilized recently received material quotes for similar materials and equipment or components. The application of appropriate overhead and profit markups have been included in the presented project pricing. See Appendix F for detailed cost estimate including assumptions and inflation information.

6.2 Estimate Classification

This OPCC estimate is consistent with a Class 5 estimate as defined by the Association for Advancement of Cost Engineering (AACE) classification system, as shown in Table 6-1 below. For purposes of this project, McMillen has utilized an accuracy range of -30% to +50% in the estimates presented in Table 6-2.

Table 6-1. AACE Class 5 Estimate Description (Source: Association for Advancement of Cost Engineering).

Criteria	Details
Description	Class 5 estimates are generally prepared based on very limited information, and subsequently have wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systemic manner. Class 5 estimates, due to the requirements of end use, may be prepared within a very limited amount of time and with little effort expended—sometimes requiring less than an hour to prepare. Often, little more than proposed plant type, location, and capacity are known at the time of estimate preparation.
Level of Project Definition Required	0% to 2% of full project definition.
End Usage	Class 5 estimates are prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning, etc.

Criteria	Details
Estimating Methods Used	Class 5 estimates virtually always use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, and other parametric and modeling techniques.
Expected Accuracy Range	Typical accuracy ranges for Class 5 estimates are -20% to -50% on the low side, and +30% to +100% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.
Effort to Prepare (for US$20MM project)	As little as 1 hour or less to perhaps more than 200 hours, depending on the project and the estimating methodology used.
ANSI Standard Reference Z94.2-1989 Name	Order of magnitude estimate (typically -30% to +50%).
Alternate Estimate Names, Expressions, Synonyms:	Ratio, ballpark, blue sky, seat-of-pants, ROM, idea study, prospect estimate, concession license estimate, guesstimate, rule-of-thumb.

6.3 Cost Evaluation Assumptions

The following assumptions were made while developing the Class 5 cost estimates for this alternatives analysis:

- All unit costs assume the total cost for installation including applicable taxes.
- The cost estimate is at a Class 5 level with an accuracy range of -30% to +50% and includes a 25% contingency. This range accounts for current inflation variability within aquaculture projects, unforeseen conditions, and anticipated cost escalation leading up to the projected construction year.
- Prevailing wages are provided as a general increase based on past construction pricing.
- All Division costs are rounded up to the nearest $1,000.
- Length and area dimensions for the estimate were derived from SCALED AutoCAD drawings of the facility and the property. Survey was not utilized for this initial estimate.
- Geotech investigation cost assumes seven bore holes (20 feet deep), material testing, piezometer installation, and a written report.

- Topographic survey has not been completed. Site survey will be required to establish elevations of all systems to ensure proper hydraulics can be achieved.
- Site geotechnical properties have not been evaluated but are assumed to be good for construction of the hatchery
- A facility condition assessment was performed for the Kern River Hatchery in 2022 by Terracon (Terracon Consultants, Inc., 2022). The assessment included an inventory of all facilities and equipment, code evaluations, and upgrades required to meet the assessment including the detailed replacement value. The cost of all work items generated was $845,580 in 2022 dollars. The work items in the Terracon facility condition assessment are not included within this report, costs, or evaluation of facilities. Some work items from the facility condition assessment may be resolved as part of the proposed upgrades at the Kern River Hatchery, while others may still need to be addressed. The upgrades in the Terracon reports may be included in future design efforts for each facility at CDFW direction.
- Additional division specific cost evaluation assumptions may be found in Appendix F.

6.4 LEED Assessment

RIM Architects (RIM) and STŌK have reviewed and assessed this facility's location along with reviewing the combination of state law and Leadership in Energy and Environmental Building (LEED) eligibility requirements. From this review, it is determined that this location is not eligible or required under state law to pursue LEED due to the lack of human occupancy in the proposed structures and/or square footage requirements. There is insufficient scope to pursue LEED certification. Refer to Appendix H for more information.

6.5 Net Zero Energy Evaluation

Achieving net zero energy for this site is highly improbable due to its small size and challenging location, bordered by Sequoia National Forest on one side and steep, shaded hills on the other. These natural constraints limit available space, allowing for only 10% of the required PV capacity expected to be achieved. To reach net zero energy, an additional 260,000 square feet of greenspace would need to be covered with PV panels. Refer to Appendix H for more information.

6.6 Alternative Cost Estimate

The following tables illustrate the estimated costs for each of the alternatives evaluated and depicted within the figures in Appendix C.

Table 6-2. Alternative Cost Estimate.

Item	Estimate	
Division 01 – General Requirements	$	2,830,000
Division 02 – Existing Conditions	$	112,000
Division 03 – Concrete	$	693,000
Division 05 – Metals	$	145,000
Division 13 – Special Construction	$	6,761,000
Division 23 – Mechanical & HVAC	$	8,000
Division 26 – Electrical	$	4,400,000
Division 31 – Earthwork	$	129,000
Division 32 – Exterior Improvements	$	50,000
Division 40 – Process Water Systems	$	1,849,000
2024 CONSTRUCTION COST	**$**	**16,977,000**
Construction Contingency	$	4,244,000
Overhead	$	1,019,000
Profit	$	1,358,000
Bond Rate	$	170,000
2024 CONSTRUCTION PRICE	**$**	**23,768,000**
Design, Permitting, and Construction Support	$	3,566,000
Geotechnical	$	25,000
Topographic Survey	$	5,000
PROJECT TOTAL	**$**	**27,364,000**
Accuracy Range +50%	$	41,046,000
Accuracy Range -30%	$	19,155,000
Photovoltaic (Full kW Required)	$	14,134,500
Photovoltaic (Roof kW Available)	$	708,000

7.0 Kern River Hatchery Environmental Permitting

7.1 Anticipated Permits and Supporting Documentation

The proposed Project would involve the modification to the existing hatchery or construction of a new hatchery facility and associated infrastructure. It would potentially involve the development of new water supply/intake/pumpstation, requiring instream construction, for the hatchery operations. A list of anticipated permits, agency review time, submittal requirements, and supporting documentation for the proposed project regardless of which alternative is selected are summarized in Table 7-1, Table 7-2, and Table 7-3. The review timeframes are estimated and are based on the recommendations presented in permit guidance documentation and experience with other permitting projects in California.

We reviewed the location through online mapping tools (U.S. Fish and Wildlife Service [USFWS] Information Planning and Consultation [IPaC] and California Biogeographic Information and Observation System [BIOS]) to determine if species listed under the Endangered Species Act (ESA) and the California Endangered Species Act (CESA) potentially occur at the site. The results indicated that the site has the potential for species to be present identified as endangered or threatened. The site does not contain critical habitat. The results of these mapping tools indicate that a Biological Assessment of the area would need to be prepared prior to consultation with the USFWS, National Oceanic and Atmospheric Administration (NOAA), and other state agencies.

The list is developed at a high level and additional permits may need to be assessed as the project is advanced.

Table 7-1. Anticipated Federal Permits and Approvals for Selected Location

Agency and Permit/Approval	Submittal / Document Type	Supporting Documentation	Anticipated Time Frame	Notes
USFWS National Environmental Policy Act (NEPA) Compliance	Environmental Assessment	Analysis of potential impacts on various natural resources, Design Package	12 – 18 months	Evaluation of the selected alternative to identify if there would be a significant impact

Agency and Permit/Approval	Submittal / Document Type	Supporting Documentation	Anticipated Time Frame	Notes
U.S. Army Corps of Engineers (USACE) Clean Water Act (CWA) Section 404 - Nationwide Permit Authorization	Pre-Construction Notification Application	Wetland and Stream Delineation, Design Package	3 months	Required if jurisdictional waters of the U.S. or wetlands are affected by the project area
USFWS ESA Section 7 Consultation	Biological Assessment	Field surveys of affected area, Design Package	4 months	The site has potential for species listed under the ESA to occur
National Oceanic and Atmospheric Administration (NOAA) Section 10(a)(1)(A) of the ESA	Application	Supplemental information to include description of proposed project, analysis of potential take and potential impact to species, proposed minimization and mitigation measures, and funding source	4 months	Authorization for scientific purposes or to enhance the propagation or survival of an endangered or threatened species

Table 7-2. Anticipated State Permits and Approvals for Selected Location

Agency and Permit/Approval	Submittal / Document Type	Supporting Documentation	Anticipated Time Frame	Notes
Lead Agency TBD California Environmental Quality Act (CEQA)	Environmental Impact Report	Analysis of potential impacts on various natural resources, Design Package	12 – 18 months	Required for issuing State permits. Potential to be coordinated with the NEPA compliance for efficiency

Agency and Permit/Approval	Submittal / Document Type	Supporting Documentation	Anticipated Time Frame	Notes
California Department of Fish and Wildlife (CDFW) California Fish and Wildlife Code Section 2081 Incidental Take	Application	Supplemental information to include description of proposed project, analysis of potential take and potential impact to species, proposed minimization and mitigation measures, and funding source	4 months	Required for the authorization to take any species listed under the California Endangered Species Act
California Department of Fish and Wildlife (CDFW) California Fish and Wildlife Code Section 1600 Lake and Streambed Permits	Application/ Notification	N/A	1-3 months	Required for hatchery intake diversions
Central Valley Regional Water Quality Control Board (RWQCB) 401 Water Quality Certification	Application	Wetland and Stream Delineation USACE Review NEPA/CEQA Compliance	3 months	Required if jurisdictional waters of the US or wetlands are affected by the project area
California Office of Historic Preservation Section 106 Review	Concurrence Request Letter	Cultural Resources Survey, Design Package	3 months	Required as part of the NEPA/CEQA process
California Division of Water Rights Water Rights	Application or Transfer	N/A	4 months	N/A

Agency and Permit/Approval	Submittal / Document Type	Supporting Documentation	Anticipated Time Frame	Notes
California State Water Resources Control Board (SWRCB) National Pollutant Discharge Elimination System (NPDES)	Application	N/A	1 month	Required if hatchery effluent is discharged to a jurisdictional waterway
SWRCB Construction General Permit	Application	Stormwater Pollution Prevention Plan (SWPPP)	2 months	Required if construction activities disturb greater than one acre

Table 7-3. Anticipated Kern County Permits and Approvals for Selected Location

Agency and Permit/Approval	Submittal / Document Type	Supporting Documentation	Anticipated Time Frame	Notes
Kern County Public Works Construction Permits	Grading, Building, Electrical, Mechanical, Pumping Applications	Project Summary and Design Package	2 months	N/A

7.2 National Pollutant Discharge Elimination System (NPDES) Permitting

The Kern River Hatchery is not classified as a cold water Concentrated Aquatic Animal Production (CAAP) facility. EPA recommends coordinating with CDFW to determine NPDES coverage needs for non-CAAP facilities.

7.3 Water Rights

Water rights documentation can be obtained from the client if requested by an agency.

8.0 Conclusions and Recommendations

The report provides valuable information on the impacts that the Kern River Hatchery could experience as a result of climate change and provides modifications that can be made to increase the resiliency of the hatchery. The in-depth analysis of the available climate data performed by NHC provides projections to forecast changes that may be experienced. In general, significant increases in air and water temperatures are expected at Kern River Hatchery. Information about the current groundwater supply is limited; though, projections indicate that the groundwater is not expected to warm appreciably. Flows in the Kern River are projected to decrease during summer months, and the risk of wildfire in the surrounding area is significant.

To meet CDFW's goal of continuing to provide recreational fishing opportunities for the public and for the conservation of endangered or threatened species as the climate changes, the resiliency of existing hatcheries will need to be increased. Increased resiliency will also require updating existing infrastructure that is nearing the end of its effective lifespan.

Some recommendations that would help to achieve this goal include the following:

- Testing the production (flow rate), temperature, and water quality of the four on-site wells. Refurbishing the wells as needed to use groundwater for incubation and early rearing purposes.
- Refurbishing the headbox structure to incorporate new intake pipe routing and demolishing the existing traveling screen filter.
- Constructing a new water treatment area to include aeration, chilling, filtration, and disinfection of water to be used for KRRT production.
- Assessing and repairing flood damage of the existing hatchery building. Refurbishing to include new incubation and early rearing systems.
- Replacing outdoor circular tanks and retrofitting with PRAS equipment to provide broodstock optimal rearing conditions throughout the year.
- Modifying existing effluent pipes to divert chilled water used in the hatchery building, broodstock PRAS, and production raceways to the outdoor spawning facility.
- Repairing production raceways to prevent leaking. Outfitting production raceways with PRAS equipment to reduce water chilling costs during summer months.
- Replacing distribution raceways in-kind to maintain trout stocking operations of the facility and reduce the San Joaquin Hatchery's stocking workload for the region.

- Installing “flap-style” drainage gate on the effluent discharge to prevent back-flooding of the facility.
- Installing backup power generators to service proposed equipment. Installing solar panels atop new structures will offset some of the power demands associated with new hatchery equipment.

The proposed upgrades to the Kern River Hatchery would have negligible impacts on the natural resources in the surrounding area. All improvements would occur within currently developed areas, which lessen the permit requirements. The total cost estimate of the proposed design modifications is $27,364,000.

9.0 References

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