Climate Induced Hatchery Upgrades

Mojave River Hatchery

Alternatives Analysis Submittal

Final Report
Revision No. 4

February 2025

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Revision Log

Revision No.	Date	Revision Description
0	2/22/2024	65% Draft Internal Technical Review
1	3/1/2024	65% Draft for CDFW Review
2	9/4/2024	100% Draft Internal Technical Review
2	9/4/2024	100% Draft for CDFW 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 NZE 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).

Mojave River Hatchery has an aging infrastructure and deficiencies that need to be addressed in the near future in order to meet fish production goals. Existing wells requiring refurbishment, ineffective raceway recirculation treatment leading to biosecurity risk, erosion to the effluent discharge channel, inefficient mid-pond water treatment, aged plumbing throughout the hatchery, limited incubation and early rearing space, raceway deterioration, abandoned structures, insufficient facility security, and insufficient backup power generation are all identified items that hinder current production. The effects of which will magnify with climate change.

The preferred alternative for hatchery upgrades includes replacing the lower 500 feet of existing concrete raceways with circular culture tanks supplied with partial recirculating aquaculture systems (PRASs) and building a new hatchery building for incubation, early, and intermediate rearing with PRASs. All outdoor rearing spaces would be covered with a solid roof and include predation netting and fencing on the sides. The new building and structure would have rooftop solar panels to offset some of the power demands associated with new hatchery equipment. Additionally, another well would be evaluated to provide sufficient flows for the new hatchery building, and valving and piping would be upgraded throughout the facility. The effluent discharge channel would be modified to stop erosion, and additional fencing would be implemented to increase security. Finally, backup power generation would be evaluated to ensure consistent power to the facility and PRAS equipment considering any negative impacts climate change may have on the power supply.

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 transition to partial recirculating aquaculture systems with circular tanks. 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
$42,604,000	$6,037,200

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 Project Location Description

The Mojave River Hatchery is located in Victorville, CA in the western Mojave Desert, approximately 83 miles from Los Angeles, CA. Figure 1-1 shows the Mojave River Hatchery location map.

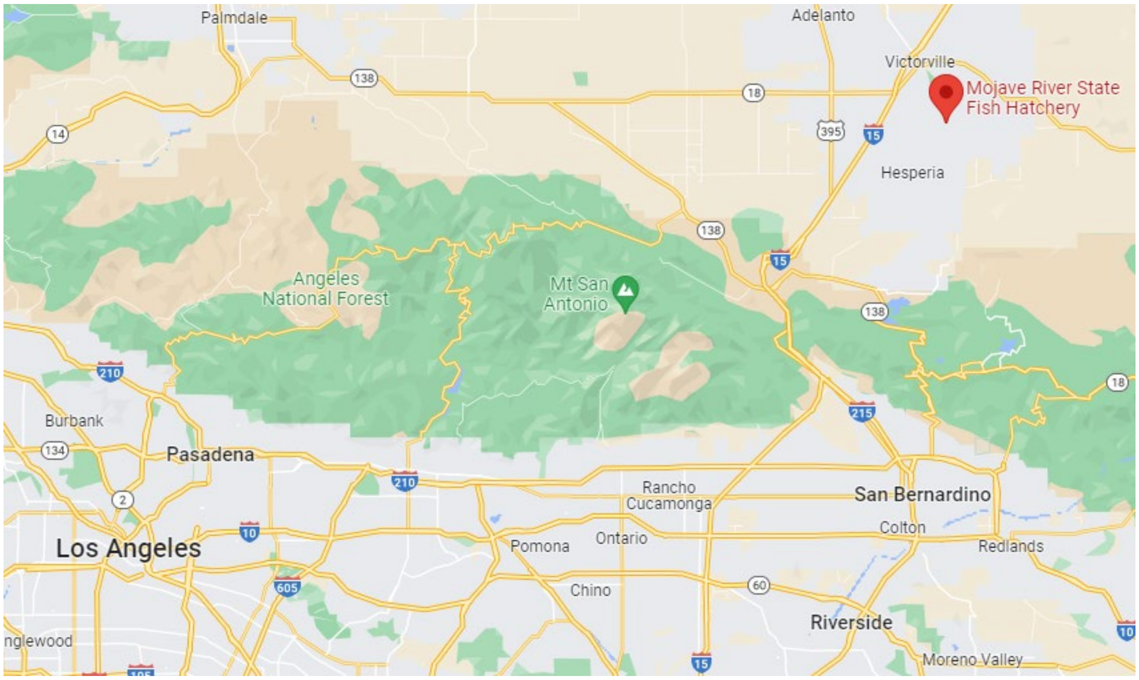

Figure 1-1. Mojave River Hatchery Location Map.

The Mojave River Hatchery was originally constructed in 1947 with only four ponds. The hatchery was expanded, adding sixteen additional ponds in 1949, and twenty more ponds in 1952. Current operations consist of six, 1,000-foot raceways run as a flow-through facility supplied by the Mojave River aquifer utilizing four production wells. The Mojave River Hatchery rears catchable Rainbow Trout (*Oncorhynchus mykiss*) with an annual production goal of 700,000 fish weighing 350,000 pounds. These fish are stocked into southern California waters for recreational fishing opportunities. The general facilities are shown in Figure 1-2. See the Site Visit Report (Appendix A) for additional details regarding the existing facilities.

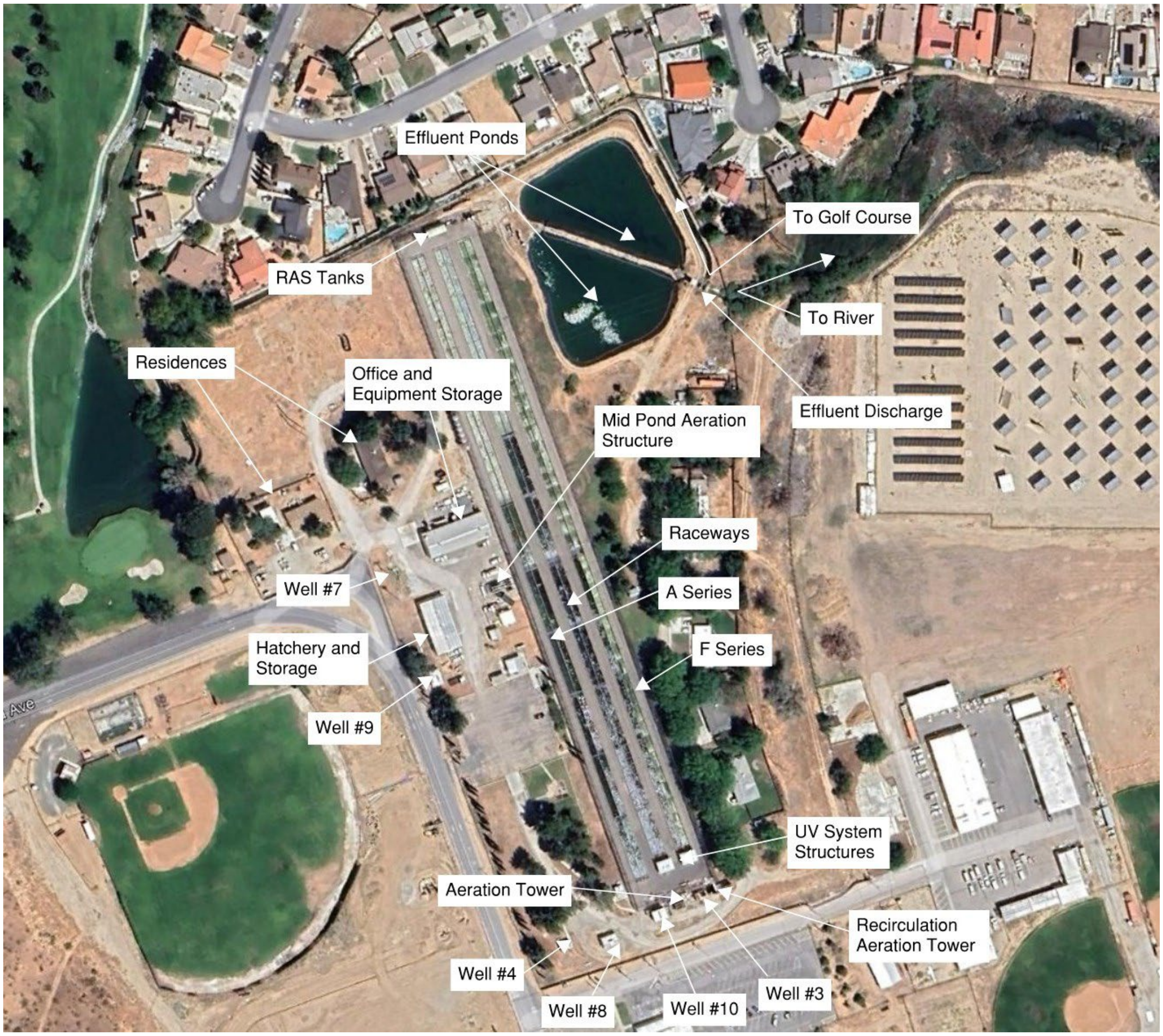

Figure 1-2. Mojave River Hatchery Facility Layout. Google Earth Image Date: May 2023.

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.

The Mojave River Hatchery primarily produces Rainbow Trout. The Capacity Biological Program (Capacity Bioprogram) for the facility was developed for the Site Visit Report (Appendix A) and provides the total numbers of fish and biomass that can be produced for all rearing tanks based on 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. This information is available in the Site Visit Report. 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. The annual production goal at the Mojave River Hatchery is 350,000 lbs. of catchable Rainbow Trout at 2 fish per pound (fpp) each (700,000 fish total), as provided by CDFW in the initial questionnaire. The fish production goal and rearing capacity determined by the Capacity Bioprogram is shown in Table 2-1.

Table 2-1. Production Goal and Capacity of Various Rearing Units at the Mojave River Trout Hatchery per the Capacity Bioprogram (Appendix A).

Rearing Unit (max. fish size)	Total Capacity (Fish)[a]	Limiting Factor	Goal
Raceways (2 fpp/10.8 inches)	114,169 (57,085 lbs)	Water Flow	700,000 fish (350,000 lbs)

[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 Mojave 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. At a high level, the total capacity for the Mojave River Hatchery falls short of the production goal shown in Table 2-1, though nuances of the timing of egg arrivals and fish stocking allows for annual production to exceed this total capacity. Of particular importance to the Mojave River Hatchery's production limits is the lack of a hatchery building; fish are transported to the Mojave River Hatchery from Fillmore Hatchery when they are approximately 60 fpp (3.5 inches). Fish are reared exclusively in the raceways until they reach the catchable target size. Details about the various rearing areas and infrastructure are discussed in the Site Visit Report, found in Appendix A.

In this current report, we developed an initial Production Bioprogram (Appendix B) to illustrate the potential maximum production that the facility is capable of while remaining within the limits set by the Capacity Bioprogram.

2.2.1 Criteria

The methods and reasoning used to determine the criteria associated with biological programming for the Mojave River Hatchery can be found in Appendix A. For reference, the established criteria are shown in Table 2-2. To model the production cycle schedule for the Production Bioprogram, several assumptions are made and included in Table 2-3. Additional assumptions include the following:

- Rainbow Trout fingerlings will be available throughout the year by either purchasing from private vendors or through CDFW's own production programs. Fingerling availability is not directly tied to Fillmore Hatchery production.
- There will be optimal conditions for fish growth given the existing water temperatures at the facility.
- Wells can supply 2.5 cfs (1,122 gpm) to each raceway.
- The mid-pond aeration system will recondition the water for the lower 500 feet of each raceway so that it provides the same carrying capacity as water supplied to the upper 500-foot sections.

Klontz (1991) provided optimal growth rates for Rainbow Trout at designated water temperatures, and survival rates were provided by Mojave River Hatchery staff.

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

Criteria	Value
Density index (DI)	0.35
Flow index (FI)	1.09
Water temperature	Constant 60-62°F

Table 2-3. Assumptions Used for the Production Bioprogram.

Criteria	Value
Growth rate	0.04 inches per day (Klontz, 1991)
Survival rate	Juvenile (60 fpp)-to-outplant (2 fpp): 95%

2.2.2 Production Bioprogram

This bioprogram (Appendix B) is meant to view hatchery operations at a high level and does not capture the nuances of specific timing of fish transfers, grading, sorting, or stocking. The model is meant to show an example of how production may occur given the criteria and assumptions outlined in the previous section. This program uses two separate Rainbow Trout fingerling receivals, pulse 1 and pulse 2, to stagger early rearing and maximize annual production.

Approximately 300,000 fingerlings (60 fpp, 3.5 inches) are received at the beginning of January (pulse 1) and are spread evenly throughout the six upper raceway sections upon arrival (Table 2-4). Fish will not require the entire length of the upper raceways initially; staff may organize them in fewer 100-foot sections as needed. Once fish reach a size of 7 fpp (7.1 inches) at the end of March, they will require the entire 1,000-foot-long section of the raceways; this is necessary because the upper 500-foot sections will be flow limited. Transferring fish to the lower 500-foot sections will provide them with reconditioned water from the mid-pond aeration system, increasing available rearing capacity. Fish will occupy all available raceway space until they reach a catchable size of 2 fpp (10.8 inches) at the end of June; approximately 285,000 fish will be available for harvest. Catchable fish should be stocked out by the end of June to make room for the next arrival of fingerlings. However, there is space available to maintain approximately 120,000 fish in the six lower 500-foot sections through the end of July, allowing for a more flexible stocking schedule.

In July, the pulse 2 group of approximately 300,000 fingerlings (60 fpp) will arrive and be spread throughout the six upper 500-foot sections of raceways. These fish will reach a size of 7 fpp (7.1 inches) at the end of September and will be moved to occupy all upper and lower 500-foot sections of raceways. These fish will reach a catchable size by the end of December and will be stocked out prior to the arrival of pulse 1 fingerling fish in January.

Table 2-4. End of Month Production Information for the Bioprogram of Both Pulses Including Realized DI and FI Values.

Pulse 1: Production Stage / Month	Pulse 2: Production Stage / Month	Tank Type	Tanks[a] Occupied	fpp	Length (in)	Total Fish (#)	Biomass (lbs)	Max. Flow (cfs)	DI	FI
Fish arrive (Jan 1)	Fish arrive (Jul 1)	Raceways	6	60.0	3.50	300,000	5,000.0	15.0	0.02	0.21
Jan (end of month)	Jul (end of month)	Raceways	6	24.0	4.70	297,500	12,395.8	15.0	0.04	0.39
Feb	Aug	Raceways	6	12.4	5.86	295,000	23,790.3	15.0	0.05	0.60
Mar	Sep	Raceways	6	7.0	7.10	292,500	41,785.7	15.0	0.08	0.87
Apr	Oct	Raceways	12[b]	4.4	8.30	290,000	65,909.1	30.0	0.05	0.59
May	Nov	Raceways	12	2.9	9.54	287,500	99,137.9	30.0	0.07	0.77
Jun	Dec	Raceways	12	2.0	10.74	285,000	142,500.0	30.0	0.09	0.99[c]
Jul	Jan	Raceways	6	1.5	11.98	120,000	80,000.0	15.0	0.09	0.99

[a] Each tank is a 500-foot raceway section (either upper or lower), fish may be crowded into smaller sections to promote an improved feeding response. Flows may be adjusted based on the size of the fish in the upper and lower sections.
[b] At this point, fish are spread to the lower 500-foot sections, taking up all available space in the raceways.
[c] This FI is still below the biological criteria set forth but allows for additional flexibility of when fish may be stocked out.

Flexibility in when catchable fish are stocked out and when fingerling fish arrive at the Mojave River Hatchery allows for some maintenance of the raceways between pulses. This maintenance would be limited to routine disinfection. Other maintenance projects, such as resurfacing, would require more substantial delays to fingerling arrivals. The production cycle would result in approximately 570,000 fish at 2 fpp and 285,000 lbs of fish produced annually. There is excess space available to raise fish in the raceways, but the available water flow limits overall production based on FI requirements. Water demand will remain relatively constant since all raceways will have flowing water throughout the year. The mid-pond aeration system will be required from April through June and October through December of each year, when fish are stocked into the lower raceway sections (Figure 2-1). The maximum flow rate for each raceway will only be required as the FI threshold is approached in March, June, September, and December of each year (Table 2-4); during other periods the flow rate may be reduced to conserve water based on the loading density of each raceway. Note that the different colored blocks in the following figure correspond to the months in which different raceways are used for the two pulses and the maximum flow requirements.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pulse 1																								
Raceway Production																								
Pulse 2																								
Raceway Production																								
Raceways in Use	6	6	6	12	12	12	6	6	6	12	12	12	6	6	6	12	12	12	6	6	6	12	12	12
Max. Flow Required (cfs)	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15

Figure 2-1. Production Rearing Schedule Over 2 Years.

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.

3.2 Water Sources

The hatchery's water source is wells. The hatchery staff reports that its well water has remained at a constant 60°F throughout the year, and at the end of the raceways it may reach 62°F during the hottest summer days. The hatchery raises Rainbow Trout, which have an optimal temperature range between 50°F and 60°F. Current temperatures are at the upper end of this optimal range, producing strong fish growth rates. If extreme air temperatures became higher, or just more common and more prolonged in future, the increase in water temperature through the facility may become more pronounced, resulting in a more stressful environment given it has not in the past responded to rising air temperatures.

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
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 5 km x 7 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.

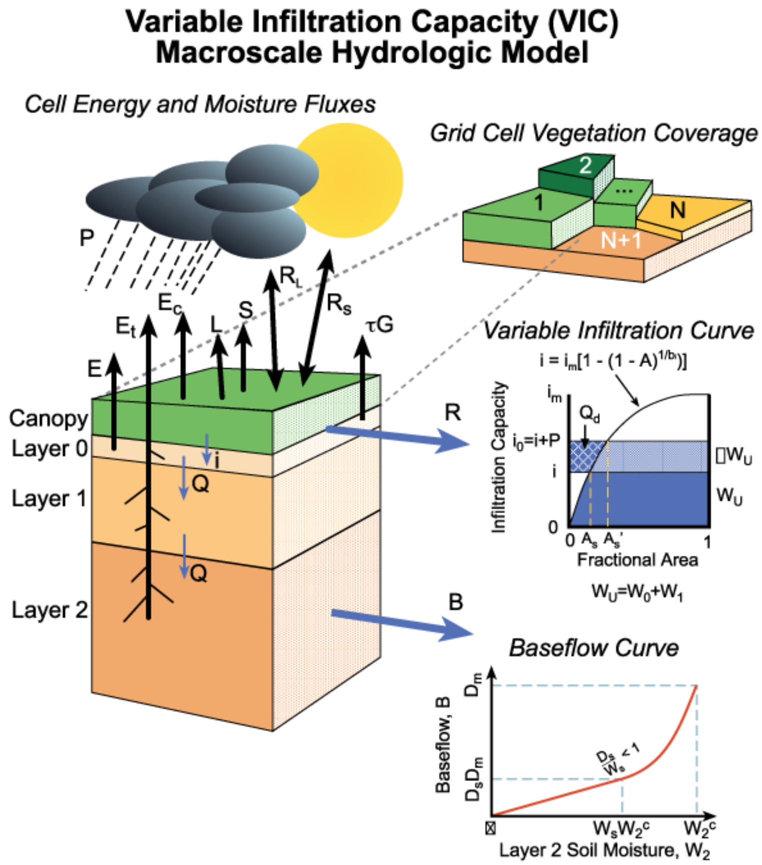

Figure 3-1. The VIC Hydrologic Model (University of Washington Computational Hydrology Group, 2021).

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, precipitation, and evapotranspiration) 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 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 decreasing groundwater recharge.

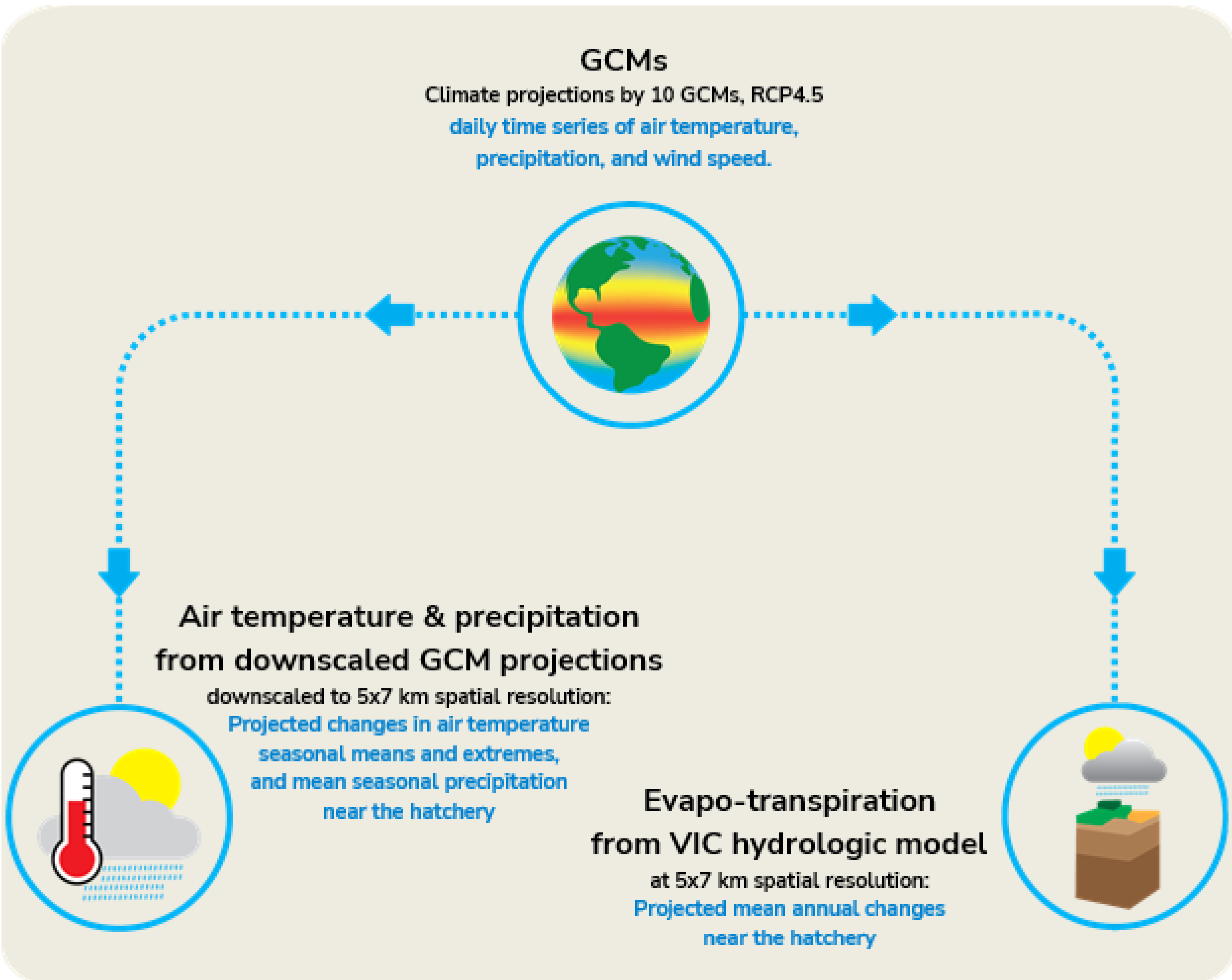

Figure 3-2. Methodology for Obtaining Projections.

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, 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, at the hatchery site. The near-future time period and the reference period are represented in red and blue, respectively. 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 period 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 1.1°F in the mid-century period. The season with the most warming is the summer (Figure 3-3, Table 3-2, and Table 3-3) and the highest temperature rises are projected to occur in the hottest days (Table 3-4 and Table 3-5). Dates with maximum daytime temperatures representing the 75th percentile (i.e., the upper quartile of temperature) are projected to warm by 3.1°F in the next 20 years, relative to the reference period. The 97th percentile of the daytime maximum temperature is projected to rise by even more, 3.5°F, reaching 106.5°F. These projected temperatures represent potentially hazardous outdoor working conditions at the hatchery.

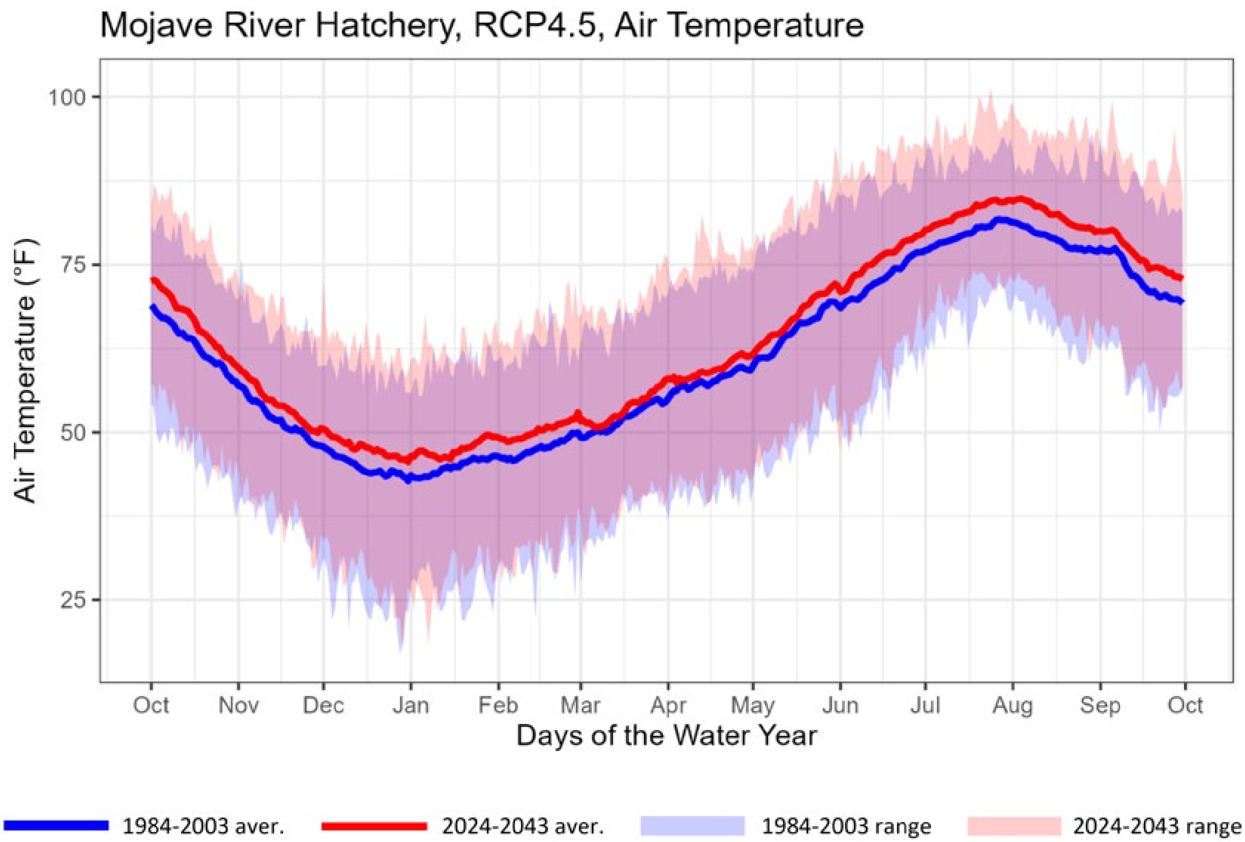

Figure 3-3. Mean Daily Air Temperature and Range for Each Day of the Year at the Hatchery Site.

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

GCM	Annual	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
Ensemble mean	63.9°F (+2.7°F)	48.7°F (+2.7°F)	60.9°F (+1.8°F)	80.3°F (+3.3°F)	65.6°F (+3.0°F)
Lowest	63.1°F (+1.9°F)	47.1°F (+1.1°F)	60.9°F (+0.8°F)	79.1°F (+2.1°F)	64.1°F (+1.5°F)
Highest	65.2°F (+4.0°F)	49.8°F (+3.8°F)	62.0°F (+2.9°F)	82.4°F (+5.4°F)	66.4°F (+3.8°F)

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

GCM	Annual	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
Ensemble mean	65.0°F (+3.8°F)	50.2°F (+4.2°F)	62.0°F (+2.9°F)	81.4°F (+4.4°F)	66.5°F (+3.9°F)
Lowest	64.1°F (+2.9°F)	49.0°F (+3.0°F)	60.8°F (+1.7°F)	80.3°F (+3.3°F)	64.8°F (+2.2°F)
Highest	66.1°F (+4.9°F)	50.7°F (+4.7°F)	62.8°F (+3.7°F)	83.6°F (+6.6°F)	68.2°F (+5.6°F)

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

GCM	3rd percentile	25th percentile	50th percentile	75th percentile	97th percentile
Ensemble mean	51.9°F (+2.6°F)	65.6°F (+2.2°F)	79.4°F (+2.3°F)	94.6°F (+3.1°F)	106.5°F (+3.5°F)
Lowest	50.6°F (+1.3°F)	64.5°F (+1.1°F)	78.9°F (+1.8°F)	93.6°F (+2.1°F)	105.1°F (+2.1°F)
Highest	53.8°F (+4.5°F)	66.8°F (+3.4°F)	80.4°F (+3.3°F)	95.8°F (+4.3°F)	108.5°F (+5.5°F)

Table 3-5. Projected GCM 2044-2063 Percentiles of Highest Air Temperature in Each Day (T_{max}) at the Hatchery Site (change relative to 1984-2003).

GCM	3rd percentile	25th percentile	50th percentile	75th percentile	97th percentile
Ensemble mean	53.3°F (+4.0°F)	66.9°F (+3.5°F)	80.6°F (+3.5°F)	95.7°F (+4.2°F)	107.4°F (+4.4°F)
Lowest	51.9°F (+2.6°F)	65.6°F (+2.2°F)	79.3°F (+2.2°F)	94.4°F (+2.9°F)	106.0°F (+3.0°F)
Highest	55.1°F (+5.8°F)	67.9°F (+4.5°F)	81.7°F (+4.6°F)	97.2°F (+5.7°F)	109.5°F (+6.5°F)

3.5.2 Precipitation Minus Evapotranspiration

Projected annual precipitation minus evapotranspiration (P-ET) aggregated over the hatchery vicinity (an area of 4,426 sq. miles surrounding the hatchery) is projected to decline, a change by -7%, in the next 20 years, and by -11% in the mid-century period, relative to the reference period (Figure 3-4, Table 3-6, and Table 3-7), where all time periods, including the reference period, are simulated by the ensemble of 10 GCMs).

This variable E-ET is an indicator of future direction of change in groundwater recharge rates but has large associated uncertainty giver the precipitation in California is subject to great natural variability, experiencing large departures from the mean in any given year or multi-year period. Mimicking this natural variability, precipitation projections for the next 20 years vary widely between different GCM runs and are subject to great uncertainty.

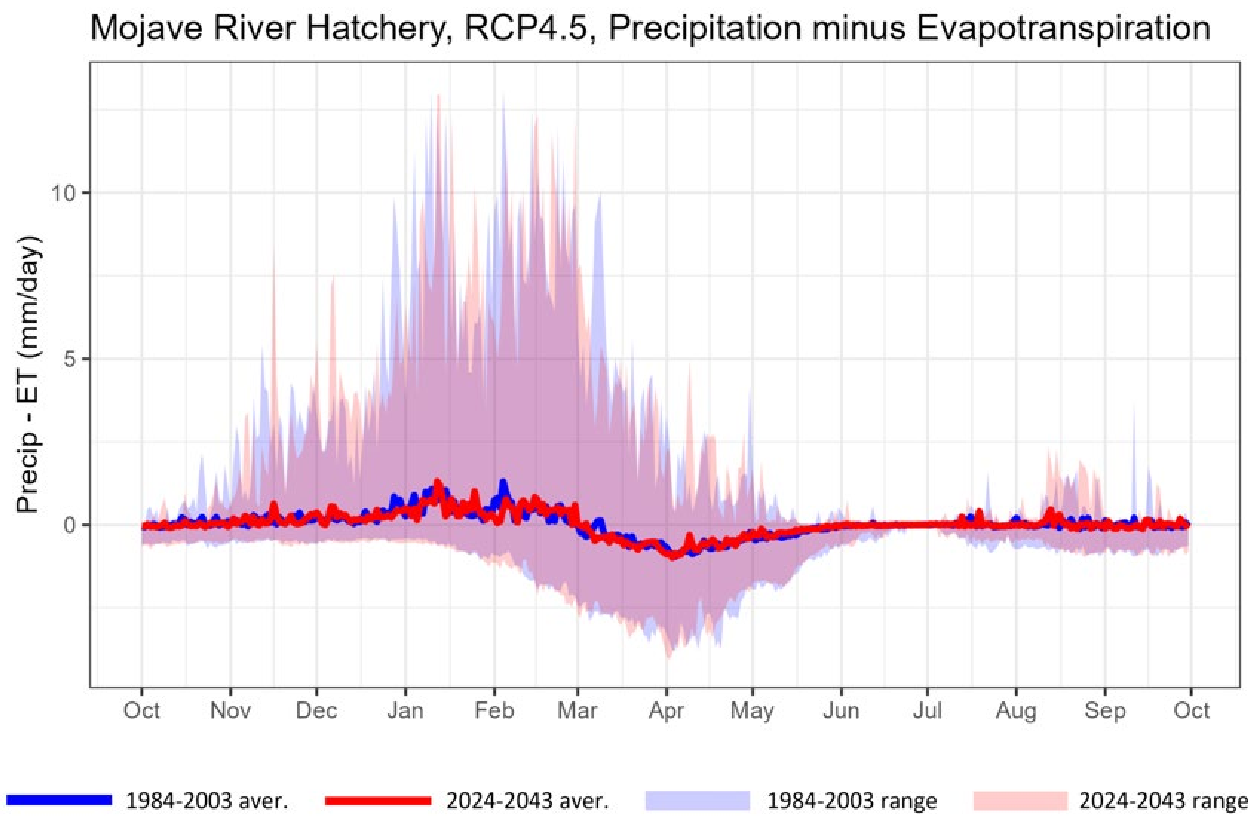

Figure 3-4. Mean Daily Precipitation Minus Evapotranspiration and Range for Each Day of the Year in the Vicinity of the Hatchery.

Table 3-6. Projected GCM 2024-2043 Change in the Seasonal Total Precipitation Minus Evapotranspiration (change relative to 1984-2003).

GCM	Annual	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
Precipitation mean	-2%	=0	-7%	+10%	-9%
Evapotransp (ET) mean	-2%	+3%	-5%	+1%	-5%
Precip-ET mean	-7%	-3%	-3%	+1%	-26%

Table 3-7. Projected GCM 2044-2063 Change in the Seasonal Total Precipitation Minus Evapotranspiration (change relative to 1984-2003).

GCM	Annual	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
Precipitation mean	-5%	-5%	-11%	+29%	-6%
Evapotransp (ET) mean	-5%	+1%	-14%	+20%	+2%
Precip-ET mean	-11%	-15%	-17%	+1%	-39%

3.5.3 Fire Risk

There is a gradient of historical wildfires near the hatchery, from almost no reported fires near the hatchery grounds to frequent wildfires in the hatchery's watershed uplands (Figure 3-5). These fires are cyclical in nature, occurring on decadal timescales or even shorter depending on the severity of the burn. Fire size varies between over 100,000-acre large fires to small but more frequent scattered burns. The surrounding desert and urban land cover put the hatchery facility at lower risk for fire, with the highest risk in the shrub and woodland hillslopes.

Expressing wildfire risk as a percent change of occurring at least once in a decade, the projected wildfire risk at the hatchery site has not been determined, but the projected risk immediately north and west is less than 10% (Figure 3-5). The risk increases to more than 30% in the watershed uplands.

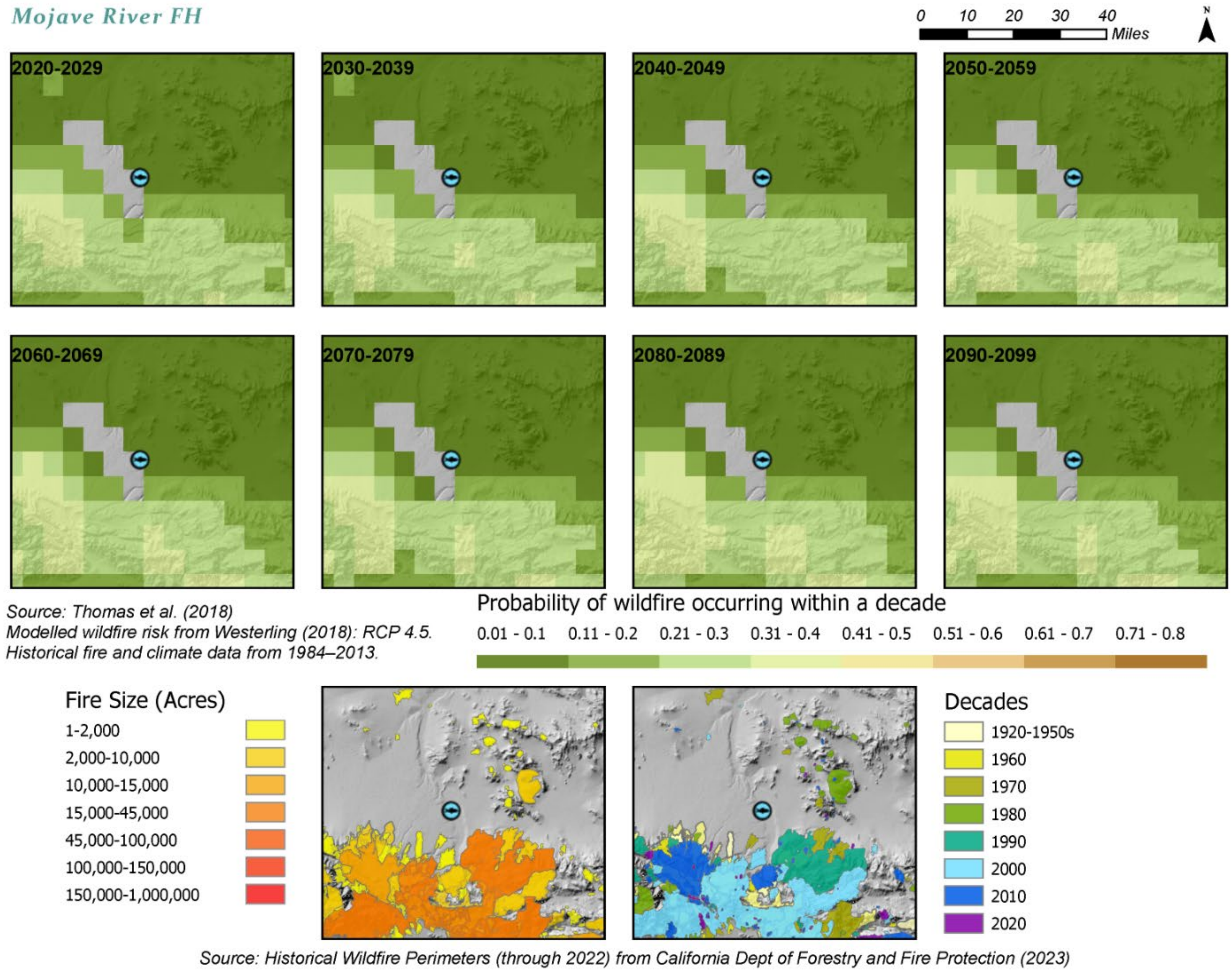

Figure 3-5. Wildfire Risk as Probability of Future Occurrence and Known Historical Fires.

3.6 Conclusions

Significant increases in air temperature are expected for the Mojave River Hatchery location. Mean annual air temperature is projected to rise by 2.7°F in the next 20 years (2024-2043) and by an additional 1.1°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 3.1°F and 3.5°F, respectively, in the next 20 years, relative to the reference period, reaching 106.5°F and representing potentially hazardous outdoor working conditions at the hatchery. 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.

The hatchery reports that well water temperature has remained at a steady 60°F and has not responded to rise in air temperature so far. Therefore, atmospheric warming in future may not elevate summer water temperature beyond this range. With shallow groundwater, it is generally the case that mean annual water temperature will increase by the same amount as the increase in mean annual air temperature (projected to be 2.7°F at this location in the next 20 years under scenario RCP4.5), but it appears that in these wells no water temperature rise has been experienced so far.

The hatchery is at low risk of wildfires. The projected chance of at least one wildfire occurring in a 10-year period in the immediate surroundings of the hatchery site is estimated as less than 10% through mid-century. Wildfires are more common in the watershed uplands and occur cyclically. Risks to the hatchery are relatively low at the Mojave River Hatchery site because it is in a desert urban environment and relies primarily on groundwater, which is less susceptible to detrimental wildfire impacts.

4.0 Existing Infrastructure Deficiencies

While the Mojave River Hatchery is an operational facility, multiple deficiencies were identified during the site visit and described in Section 4.0 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 insufficient early rearing space, inadequate water treatment, inefficient well production, insufficient backup power, and insufficient water reuse.

Biosecurity deficiencies and potential solutions for addressing these concerns were identified in Sections 3.0 and 3.2 of the Site Visit Report, respectively. These measures include covering the outdoor rearing vessels with solid roof structure and enclosing the sides, incorporating solid waste filtration, designing, and building a new hatchery building, additional fencing, and repair of the effluent discharge channel. Other considerations include developing an additional well, refurbishing existing wells, PRAS upgrades, plumbing and valving upgrades, mid-pond aeration upgrades, and replacing raceways with circular tanks. The details of these existing deficiencies are further expanded upon in Sections 4.1 and 4.2.

4.1 Water Process Infrastructure

4.1.1 Existing Wells

There are four existing wells on site with water depths at approximately 66 ft. Multiple wells are in need for refurbishment. The main production well is #10 which was recently refurbished. Well #7 is also regularly used, with Well #8 acting as backup in case of issues with Wells #7 or #10. Well #9 has not been operated in several years due to the possibility that Wells #7 and #9 draw from the same aquifer. CDFW also reported that Wells #8 and #10 may be drawing from the same aquifer. According to CDFW, there is currently a project to refurbish Wells #7-10, including new backup generators, pumps, and motors with the implementation of variable frequency drives (VFDs).

4.1.2 Ineffective Raceway Recirculation Treatment Equipment

There is an existing raceway recirculation system including UV disinfection, underground piping, aeration, and recirculation pumps. The system was abandoned and has not been used in 10 years due to disease issues encountered during operation. Ultimately, this system was abandoned due to poor fish health conditions and increases in the prevalence of diseases including bacterial coldwater disease (causative agent *Flavobacterium psychrophilum*) and enteric redmouth disease (causative agent *Yersinia ruckeri*). The efficacy of the UV system was likely decreased because of the lack of solids filtration prior to UV disinfection which would reduce UV transmittance and ultimately lower the UV dose. Since the water was not properly disinfected, if the adult fish carried a pathogen, it would be passed on via the pump-back system. Furthermore, smaller fish that are typically placed in the head of the raceways tend to be more sensitive to diseases. The adult fish may be carrying a pathogen but are not impacted by it; however, if smaller fish are exposed to the same pathogen, there may be a disease risk. Aside from the lack of effective solids filtration and UV disinfection, the water likely increased in temperature during flow through effluent ponds, contributing to increased disease issues when operational.

4.1.3 Effluent Discharge Channel Erosion

The effluent discharge has the option to be routed from the settling ponds to the dry Mojave Riverbed. The apron that carries the water to the river is eroding and could cause erosion of the settling ponds. Uncontrolled water release and contamination to adjacent properties is a potential risk if not addressed. Coordination with adjacent landowners has been attempted by CDFW; this coordination would be necessary to prevent further erosion since the eroding apron is currently outside of the hatchery property.

4.1.4 Mid-pond Water Treatment

Maintaining adequate oxygen levels and water flow are limiting factors for fish production in the 1,000-foot-long Mojave River Hatchery raceways. The existing mid-pond aeration system includes nine packed columns. This system was upgraded 5 years ago at the same time as the primary aeration tower; including new piping and a new backup generator. Water from all raceways is mixed in the mid-pond aeration system, which poses a biosecurity risk and increases the potential transmission of pathogens among the raceways. Additionally, water is not filtered and when staff clean raceways it can result in high loads of suspended solids being released to fish in the lower raceway sections.

4.1.5 Aged Plumbing

While no specific issues were explicitly identified by CDFW, it was noted that water conveyance valving is not regularly exercised and is likely due for repair or replacement. Staff noted operating the raceways without adjusting individual valves in an effort to avoid breakage.

4.2 Rearing Infrastructure

4.2.1 Limited Incubation and Early Rearing Space

The hatchery building is in a state of semi-repair after renovations were put on hold indefinitely due to building size constraints. The facility was in the process of renovating this building with the installation of new deep tanks and plumbing when the initial *Lactococcus garvieae* outbreak occurred. The existing building space is too small for any significant amount of early rearing to sizes required for the vaccination program developed by CDFW’s Fish Pathology Department. Hatchery production has since been abandoned and egg incubation/early rearing now takes place at Fillmore Hatchery.

4.2.2 Raceway Deterioration

The concrete raceways are showing signs of deterioration with signs of seepage and leaking near the head boxes of multiple raceways. According to CDFW staff, these raceways were resurfaced with epoxy in 2017, but still show signs of wear.

4.2.3 Exposure and Predation Issues in Raceways

The raceways are enclosed in chain-link fencing and bird netting with bird wire strung across the top. However, fish in the raceways still experience predation. In addition to the losses associated with predation, predators also increase the risk of spreading pathogens to the fish. Birds and other animals can carry diseases and cause stress in the fish, which can result in fish loss. With only bird wire and netting above, the raceways experience direct sunlight during temperature periods peaking above 100°F in the summers. Prolonged exposure to sunlight and UV rays warms the water, can cause sunburn on the fish, and damages infrastructure. As noted in Section 3.0, both air and water temperatures at Mojave River Hatchery are projected to rise in the future, and current operating temperatures are already in the upper range for salmonids.

4.2.4 Abandoned Structures and Uncovered Equipment

There are several structures on the hatchery property that house old well equipment (Wells #3 and #4) and other unused equipment such as the UV disinfection units, the raceway recirculation aeration tower, and the fish rescue RASs. Sun can damage equipment stored outdoors so providing shaded areas to store equipment has the potential to extend usable life.

4.2.5 Facility Security

CDFW staff noted after-hour public access concerns with existing enclosure infrastructure. Fish rearing units, equipment, and residence areas are susceptible to tampering by the public without more secure fencing around the facility.

4.2.6 Backup Power Generation

There are backup power generators for Wells 8, 9, and 10 but none for Well 7. There is also a newer backup generator for the mid-pond aeration system. Without backup power for Well 7, hatchery staff cannot rely on it exclusively.

5.0 Alternative Selected

5.1 Alternative Description

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 Technical Memorandum (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.

5.1.1 Hatchery Building

The construction of a new 15,360 SF hatchery building is proposed in the northwest corner of the property. The proposed hatchery building will house incubation and early rearing, intermediate rearing, and five (5) dedicated PRAS equipment rooms. Bringing egg incubation and early rearing production back to Mojave River Hatchery has the potential to reduce production requirements for the Fillmore Hatchery. The hatchery building would be a pre-engineered metal building (PEMB) with standard, easy to clean finishes. Each production room would have a dedicated HVAC system to maintain temperature and humidity, as well as lighting controls to aid production as needed.

Each system within this building will be equipped with sensors to track water quality and flow, and alarms to alert staff when a problem is detected. A supervisory control and data acquisition (SCADA) system would also be included to allow hatchery staff to record and adjust flows and water quality parameters as needed to maintain optimal rearing environments. This system could be set up to allow staff to monitor and make system adjustments remotely or from the hatchery office.

Effluent could be treated and used in the bottom half of the raceways (see Section 5.3.1.2). The use of additional water in the lower raceways has the potential to provide an improved rearing environment by increasing water flow.

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

5.1.1.1 Incubation and Early Rearing

Survival rates for early rearing are not known for the Mojave River Hatchery since there is currently no hatching or early rearing at the facility. Assumptions for survival are based on data from the Fillmore Hatchery and an added factor of safety; it is assumed that from egg to hatching survival is 67%, from hatching to 200 fpp (2.3 inches) is 67%, from 200 fpp to 60 fpp (3.5 inches) is 85%, and from 60 fpp to 2 fpp (10.8 inches) is 95%. Additionally, a maximum DI of 0.3 is used for all new rearing systems proposed, this is a slight decrease from the 0.35 DI used in Section 2.0 and provides a factor of safety for new equipment and facilities.

To produce the maximum number of fish at 2 fpp in the raceways described in Section 2.0 (Table 2-4; 285,000 fish), approximately 787,000 eggs are required. To streamline operations, one hatching jar per deep tank is proposed for a total of 50 hatching jars and deep tanks. This will avoid extra transfers of eggs or fry to other deep tanks, allowing a group of fish to hatch and be raised in a single deep tank until they are ready for transfer to the next system.

Approximately 527,000 fish will hatch out of the jars directly into the deep tanks based on a 67% survival rate from the 787,000 eggs initially incubated. These fish will be raised in deep tanks until they reach 200 fpp (2.3 inches), approximately 353,000 fish will reach this size based on a survival rate of 67% from hatching. A total of 50 deep tanks (2.6 feet wide, 16 feet long, with a water depth of 1.3 feet and a wall height of 2.5 feet; tank volume of 54 ft^3) are proposed for early rearing while maintaining a DI of 0.3, with an added 5% rearing volume safety factor (total system volume of 2,700 ft^3). Deep tanks will be supplied with flow-through water instead of recirculating water; this is necessary because of the relatively high feed rates and mortality associated with early rearing. Recirculation equipment can easily become fouled by crumble feed types typically given to small fish. To maintain an FI of 1.09, a total flow rate of 750 gpm (1.7 cfs) is required for the system, or 15 gpm per tank.

5.1.1.2 Intermediate Rearing

Once the 353,000 fish in the early rearing system reach 200 fpp, they are transferred to an intermediate rearing area and grown to an approximate size of 60 fpp (3.5 inches). This intermediate rearing area will be designed as a PRAS with five modules capable of a recirculation rate between 50 and 75%. Assuming a survival rate of 85% from 200 fpp to 60 fpp, approximately 300,000 fish will reach a size of 60 fpp.

To accommodate 300,000 fish at 60 fpp and a DI of 0.3, 25 circular tanks are proposed. Each circular tank in the intermediate rearing system would be 10-feet in diameter with 3.33 feet of water depth and a wall height of 5 feet for a tank volume of 262 ft^3 (total system volume of 6,550 ft^3). It is proposed that the system is organized into five, 5-tank modules, each isolated from the other with its own recirculation equipment. PRAS design recommends a hydraulic residence time (HRT) of 30 minutes, or a flow rate that provides two complete water exchanges per hour in each tank (Timmons et al., 2018). For an HRT of 30 minutes, each tank would require a total flow rate of 70 gpm, and a total flow rate of 350 gpm for each module (1,750 gpm or 3.9 cfs for the entire intermediate system).

It is recommended that early operations begin with a recirculation rate of 50% or less. 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, chilling, and UV disinfection systems would be sized to accommodate a range of flow rates to operate up to a recirculation rate of 75%. Operating at a recirculation rate of 50%, the fresh make-up water requirement would be 175 gpm per module (875 gpm [1.9 cfs] for all five modules). At a recirculation rate of 75%, the fresh make-up water requirement would be approximately 90 gpm per module (450 gpm [1 cfs] for all five modules).

5.1.2 Raceway Improvements

5.1.2.1 Replace Lower 500 feet of Raceways with PRAS Circular Tanks

The concrete in the raceways is showing signs of aging. The rough and cracked concrete surfaces are not ideal for fish rearing as the surfaces can irritate fish when they contact the walls, and cracks and spalling are difficult to disinfect. It is uncertain how long the concrete can continue to act as a viable rearing space due to age and the onset of warming temperatures of climate change. Rather than attempting to repair and refurbish the entirety of the existing raceways, the preferred alternative is to replace the lower 500 feet of each raceway with circular tank PRAS modules. This modification would allow for a reduction in leakage and space needed. A permanent roof structure and chain-link fencing with bird netting surrounding the circular tanks is recommended to reduce predation. While more costly than retrofitting the existing raceways, this alternative has the potential to allow for 40+ years of operation.

The existing production space consists of six concrete raceways that are each 1,000 feet in length. Each raceway is 10 feet wide and has a water depth of 2.5 feet. This provides a total of 25,000 ft^3 of rearing space per raceway and a total of 150,000 ft^3 of rearing volume (Table 5-1). A standard size dual-drain circular is a 20-foot diameter tank with a 6-foot operating depth. Each 20-foot tank provides 1,885 ft^3 of rearing volume. A total of 28 tanks would be required to replace the existing production and provide additional space for flexibility as culturists familiarize themselves with the equipment. There will be a total of four PRAS modules, each supporting seven tanks. This will provide 52,780 ft^3 of rearing volume (Table 5-1). Since the facility is flow limited and climate change is likely to exacerbate this, the proposed rearing volume is decreased from existing. Less rearing volume will be required to produce the same number of fish based on FI and DI.

Table 5-1 Proposed Circular Tanks for Replacement of Raceways

Characteristic	Existing Raceways	Circulars
Dimensions (ft)	1,000-ft long; 10-ft wide	20-ft diameter
Operating Depth (ft)	2.5	6
Volume Per Rearing Vessel (ft^3)	25,000	1,885
Number of Rearing Vessels	6	28
Total Volume (ft^3)	**150,000**	**52,780**

Once fish reach 60 fpp in the intermediate rearing system, they can be transferred to the proposed grow-out area with circulars for final grow-out. This system is designed to hold 285,000 fish at 2 fpp (10.8 inches) with some additional flexibility, based on a survival rate of 95% from 60 fpp to 2 fpp.

The proposed system will have 28 circular tanks; each circular tank will be 20-foot in diameter with 6 feet of water depth and a wall height of 7 feet for a tank volume of 1,885 ft^3 and a system volume of approximately 52,780 ft^3. The grow-out system can be set up in seven modules, each with four tanks and independent recirculation equipment. It is acceptable for PRAS designs to operate with an HRT of 45 minutes for larger tanks (Timmons et al., 2018); each tank would then require a process flow of 325 gpm, and each module would require a flow rate of 1,300 gpm (2.9 cfs). The total process flow to operate the entire production system would be 9,100 gpm (20.3 cfs). Operating at a recirculation rate of 50%, the fresh make-up water requirement would be 650 gpm per module (4,550 gpm [10.1 cfs] for all seven modules). At a recirculation rate of 75%, the fresh make-up water requirement would be 325 gpm per module (2,275 gpm [5.1 cfs] for all seven modules).

Rearing densities in circular tanks are dependent on the species raised, HRT (flow rate), amount of oxygen added to the system, water quality in the tank (primarily unionized ammonia and carbon dioxide build up), and the effluent nitrogen limitations. Based on conversations McMillen has had with other facilities, the recommended maximum density for Rainbow Trout approximately 12 inches long in dual-drain circular tanks is 55 kg/m^3 (1.6 lbs/ft^3) which corresponds to a density index near 0.3. Having acknowledged a recommended maximum for sportfish/conservation aquaculture of Rainbow Trout, it is important to note that there are food fish producers that operate with densities double or triple of this recommendation.

Operating at the maximum density requires trained hatchery staff familiar with the system, and likely several seasons of optimization. Initial rearing densities are suggested to begin at a DI of

0.15. This allows staff to gain experience with the system with the facility's water quality, fish stocks, and other factors that influence fish culture in ways that can be difficult to quantify when comparing production among hatcheries. Table 5-2, Table 5-2, Table 5-3, and Table 5-4 present current rearing densities and various scenarios of circular tanks based on different density indices: low (0.15), medium (0.22), and maximum (0.3).

Table 5-2. Rearing Density Scenarios for Rainbow Trout: Current Operations (4,000 lbs of Fish/100-ft Raceway Section).

Fish Size	Density Index	Tank Size	Density (kg/m^3)	Fish Per Tank
10 fpp, 6.3 inches	0.25	2,500 ft^3	25.6 (1.60 lbs/ft^3)	40,000
2 fpp, 10.8 inches	0.15	2,500 ft^3	25.6 (1.60 lbs/ft^3)	8,000

Table 5-3. Low-Density Rearing Density Scenarios for Rainbow Trout.

Fish Size	Tank Size	Density (kg/m^3) and Density Index	Fish Per Tank
60 fpp, 3.5 inches	10' diameter x 3.33' deep (262 ft^3)	8.3 (0.51 lbs/ft^3) DI: 0.15	8,175
10 fpp, 6.3 inches	20' diameter x 6' deep (1,885 ft^3)	15.2 (0.95 lbs/ft^3) DI: 0.15	17,813
2 fpp, 10.8 inches	20' diameter x 6' deep (1,885 ft^3)	25.9 (1.62 lbs/ft^3) DI: 0.15	6,092
10 fpp, 6.3 inches	20' diameter x 6' deep (1,885 ft^3)	30.3 (1.89 lbs/ft^3) DI: 0.15	35,625
2 fpp, 10.8 inches	20' diameter x 6' deep (1,885 ft^3)	51.9 (3.23 lbs/ft^3) DI: 0.15	12,184

Table 5-4. Medium-Density Rearing Density Scenarios for Rainbow Trout.

Fish Size	Tank Size	Density (kg/m^3) and Density Index	Fish Per Tank
60 fpp, 3.5 inches	10' diameter x 3.33' deep (262 ft^3)	12.2 (0.76 lbs/ft^3) DI: 0.22	11,990
10 fpp, 6.3 inches	20' diameter x 6' deep (1,885 ft^3)	22.2 (1.39 lbs/ft^3) DI: 0.22	26,125
2 fpp, 10.8 inches	20' diameter x 6' deep (1,885 ft^3)	38 (2.37 lbs/ft^3) DI: 0.22	8,935

Table 5-5. Maximum-Density Rearing Density Scenarios for Rainbow Trout.

Fish Size	Tank Size	Density (kg/m^3) and Density Index	Fish Per Tank
60 fpp, 3.5 inches	10' diameter x 3.33' deep (262 ft^3)	16.7 (1.04 lbs/ft^3) DI: 0.3	16,350
10 fpp, 6.3 inches	20' diameter x 6' deep (1,885 ft^3)	30.3 (1.89 lbs/ft^3) DI: 0.3	35,625
2 fpp, 10.8 inches	20' diameter x 6' deep (1,885 ft^3)	51.9 (3.23 lbs/ft^3) DI: 0.3	12,184

Improved water quality in the circular tanks relative to the tail end of raceways, where large fish are currently held at the Mojave River Hatchery, should allow for increased rearing densities. However, it will take time and careful operation to maximize efficiency and fish quality of any new rearing system. Circular tanks are the industry standard for many newly constructed commercial fish farms, with reported densities exceeding 80 kg/m^3 (5 lbs/ft^3), though significant fin erosion has been described in fish held at densities of 40 kg/m^3 (North 2006). For conservation and recreational hatcheries, use of circular tanks is gaining popularity but information about standard densities has not been consolidated. Information regarding rearing density and its effect on variables less important to food fish production, such as fin erosion, post-release survival and natural recruitment, and return-to-creel, is not well characterized and requires careful consideration when implementing circular tanks and PRASs.

A new photovoltaic power generation system would be included atop the PRAS circular tanks roof structure to help offset the power requirements of the new hatchery infrastructure while also lowering the overall cost of operating the hatchery.

5.1.2.2 Raceway Improvements for Upper 500 feet of Each Raceway

While the proposed production PRAS circular modules will be sufficient to rear Mojave River Hatchery's current production goals, the upper 500 feet of each raceway can be utilized for increased flexibility, emergency evacuations from nearby CDFW hatcheries, or increased production. To continue using the upper 500 feet of the existing concrete raceways, valving and piping adjustments will need to be made. Valves should be replaced to allow for the manipulation of water for future options. A new effluent line will need to connect the new raceways' discharge point to the settling ponds. Additionally, new concrete walls will require being retrofitted at the end of each 500-foot raceway. The existing concrete to remain will also require coating and improvements to extend its usable life.

The concrete raceways have aged and deteriorated over time resulting in pitting, roughness, and cracking. The rough and cracked concrete surfaces are not ideal for fish rearing as the surfaces can irritate fish when they contact the walls, and cracks and spalling are difficult to keep clean and disinfect. Adding a coating to the existing concrete can help alleviate the present issues and reduce the rate at which the concrete surface deteriorates. Raceway coatings are typically epoxy, polyurethane, or mortar based, but they all serve the same general purpose. Prior to coating the raceways, they must be emptied, cleaned, and completely dried. Additionally, any large cracks in the existing concrete will need to be fixed prior to coating. After applying, the coating will need to cure, which can take anywhere from 1-14 days depending on the manufacturer's instructions and base component of the coat. Depending on factors such as weather and sun exposure, raceway coatings can last anywhere from 5-15 years. Applying a coat to the existing concrete creates a surface which is easier to clean, does not promote algae growth, and reduces sun and water exposure to the aging concrete underneath.

5.1.3 Install Additional Well

To account for the possible decline in well production and supply the potential new hatchery building, Mojave River Hatchery would benefit from an additional water supply to their facility. An additional well could be drilled in the northwest corner of the property. According to CDFW, this location is expected to draw groundwater from a different aquifer than the existing wells, ensuring efficiency of existing wells. Hydraulic studies should be conducted to determine if 1,650 gpm of production water could be sourced from underground without affecting the existing wells' production. The installation of an additional well, with a backup generator, would provide Mojave River Hatchery with resiliency against climate change impacts on its water supply and provide the opportunity to increase production and early rearing.

5.1.4 Valving and Piping

Various valves and pipes across the hatchery may be more than 50 years old. Valves throughout the hatchery, such as at the heads of each raceway, have been left open and are not operated by hatchery staff due to fear of breaking the aged valve.

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. Valving upgrades could be paired with other raceway designs (see Sections 5.1.2.2 and 5.3.1).

5.1.5 Effluent Discharge Channel

Discharge can be routed from the settling ponds to the dry Mojave Riverbed. However, the apron that carries the water to the river is eroding and could cause erosion of settling ponds and uncontrolled water release to adjacent areas including private property if not addressed. The apron is located outside of the hatchery property. The installation of sheet pile could be designed to prevent erosion from affecting hatchery property. Coordination with adjacent landowners will be required to prevent further erosion.

5.1.6 Additional Fencing Around Facility

During the site visit, CDFW hatchery staff identified a concern with having the public access the hatchery outside of business hours. There is fencing around the raceways themselves, but minimal fencing around the entire facility. More secure fencing around the entirety of the facility is recommended to prevent after-hours public access to fish rearing units, equipment storage, and residence areas.

5.1.7 Increase Backup Power Generation

New propane-fed backup power generators would be installed to maintain production operations in the hatchery building, grow-out area, and Well #7 during periods of power outages. The generators will be chosen to meet current air quality standards required for this area and sized to meet the power needs of the hatchery during temporary outages.

5.2 Pros/Cons of Selected Alternative

Table 5-6 provides a high-level summary of the pros and cons for Mojave River Hatchery's selected alternative.

Table 5-6. Pros/Cons of Selected Alternative – Mojave River Hatchery.

Description	Pros	Cons
Design and build a new hatchery building, which include PRAS equipment and rooftop solar panel installation.	• Brings egg incubation and early rearing back to Mojave River Hatchery, reducing the load on Fillmore Hatchery. • Maintains production capacity (higher flow rates and oxygen) while decreasing water use. • Increases production flexibility at early life stages. • Increases biosecurity. • Reduces loss from predation and direct exposure to sunlight. • Offsets the power requirements of the new hatchery infrastructure while also lowering the overall cost of operating the hatchery.	• Increases cost due to construction, installation, and operation. • Increases pumping needs to operate intermediate rearing PRAS. • May have permitting challenges.

Description	Pros	Cons
Replace lower 500 feet of raceways with circular tanks, PRAS, and a solid roof.	• May maintain production while significantly decreasing water use. • Decreases footprint. • Reduces total water required and provide flexibility. • Increases biosecurity. • Replaces aging infrastructure that would allow for 40+ years of operation.	• Is more costly than retrofitting existing raceways. • Requires additional training for staff. • Increases pumping on site. • May have permitting challenges.
Install an additional well.	• Increases efficiency of existing wells, if the evaluation confirms, as the new well would draw from a different aquifer.	• May not have appropriate hydrogeologic characteristics. • May have permitting challenges.
Replace valves and piping throughout hatchery.	• Improves operability and control of flow. • Increases hatchery infrastructure lifespan.	• Increases cost due to installation. • Disrupts hatchery operations during construction.
Repair effluent discharge channel.	• Ensures further erosion will not lead to settling pond release to adjacent areas.	• Requires coordination with adjacent landowners.
Provide additional fencing around the facility.	• Increases security from public access after business hours. • Increases biosecurity.	• Requires coordination with adjacent landowners.
Increase backup power generation.	• Provides power redundancy in case of potential climate change effects on power supply.	• Increases cost due to system installation. • Has long distribution lead-time on large generators.

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 Raceway Improvements

5.3.1.1 Skim Coating and Epoxy Coating

The concrete in the raceways is showing signs of aging. The concrete raceways were recoated with epoxy approximately 7 years ago, but still show signs of wear. The abrasive surface caused by aging can be harmful to fish as well as a surface that promotes algae growth. Adding a coating to the concrete can help alleviate the present issues and reduce the rate at which the concrete surface deteriorates. Raceway coatings are typically epoxy, polyurethane, or mortar based, but they all serve the same general purpose. Prior to coating the raceways, they must be emptied, cleaned, and completely dried. Additionally, any large cracks in the existing concrete will need to be fixed prior to coating. After applying, the coating will need to cure which can take anywhere from 1-14 days depending on the manufacturer's instructions and base component of the coat. Depending on factors such as weather and sun exposure, raceway coatings can last anywhere from 5-15 years. Applying a coat to the concrete creates a surface which is easier to clean, does not promote algae growth, and reduces sun and water exposure to the aging concrete underneath.

5.3.1.2 Raceway Recirculation System

The existing raceway recirculation system is not utilized due to concerns with disease transmission. Replacement of the existing recirculation system for the raceways could include a redesigned sump at the tail end, filtration, UV disinfection, degassing, oxygenation, and potential for biofiltration. The implemented raceway recirculation system may also include mechanical chilling or energy recovery to maintain water temperatures. This would reduce pumping requirements for the facility and potentially provide cost savings.

5.3.1.3 Mid-pond Water Treatment Upgrades

The incorporation of oxygenation into mid-pond aeration through LHOs, Speece cone, or another design is recommended. Oxygenation has the potential to allow for increased rearing densities in the lower 500 feet of the raceways, contributing to increased overall production capacities. Additionally, the incorporation of drum filtration prior to mid-pond aeration would remove solids and suspended particulates, increasing overall water quality for the lower half of the raceways.

5.3.1.4 Roof Structure with Side Enclosures

Covering the raceways 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 1,000-foot-long raceways. 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.

5.3.2 Demolish Unused Structures and Provide Equipment Covers

There are several structures on the property that house old well equipment (Wells #3 and #4) and other unused equipment such as the UV disinfection units and raceway recirculation aeration tower. These structures should be demolished and removed from the property for safety purposes and to make room for new infrastructure if needed. Sun exposure can damage equipment stored outdoors. This space could be used for new sheds and coverings which would provide shaded areas to store equipment and extend usable life.

5.3.3 Well Refurbishment

It is recommended that Wells #7 through #9 be refurbished including well pump upgrades. Additional backup power to Well #7 is also recommended. This will provide redundancies and increased efficiency for hatchery operations. A project is actively underway with the California Department of General Services to evaluate Wells #7 through #10 and determine which wells can be upgraded with the funds allocated to this project.

5.4 Natural Environment Impacts

The proposed upgrades to the Mojave 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 Mojave River Hatchery will change the existing infrastructure and the number of rigid structures on site. However, they will not increase or decrease the fire risk. Based on the climate change evaluation, the projected fire risk at the hatchery facility is low with the highest risk in the shrub and woodland hillslopes.

The recommended changes will slightly increase the total impervious surface of the site. By changing the type of rearing vessels from concrete raceways to fiberglass circular tanks and replacing valves and piping, the impact of flooding on the facility has the potential to decrease.

The flood risk for the Mojave River Hatchery was not evaluated in the climate evaluation but is assumed to be low risk in this desert climate. Installing circular tanks for production rearing will provide some additional flood protection. The tanks will be placed with the tank tops located 30 to 36 inches above ground. The tank height will provide protection from overland flow entering the fish rearing vessels, and the ground will be graded to carry water away from the tanks to the extent feasible. Additionally, replacing the valves and piping will provide the hatchery with better flow control into the facility. The hatchery will be able to manage surges in flow and prevent flooding of the rearing vessels.

5.4.2 Effluent Discharge

The recommended changes to the hatchery do not include an overall increase in production goals at the Mojave River Hatchery. This will ensure no or limited changes to the NPDES permit requirements. The hatchery meets current NPDES permit requirements, but the staff expressed concerns regarding apron erosion at the dry Mojave Riverbed discharge point. The proposed discharge apron repair and installation of sheet pile to prevent erosion will decrease the likelihood of uncontrolled water release. The settling ponds will continue to reduce the solids loading on the natural environment and reduce the overall impacts of the hatchery. It is important to note that changes to the existing aquaculture programs (renovations, new construction) may trigger (administratively) the requirement for new and/or updated NPDES permits. Acknowledging that waste load (fish biomass) is not anticipated to change with the proposed alternatives, we assume that the increase in effluent removal efficiencies provided by the PRAS systems will result in net effluent “gains” to the overall aquaculture program.

5.5 Hatchery Operational Impacts/Husbandry

Multiple groups (pulses) of Rainbow Trout will be produced starting at different times throughout the year to maximize production capability at the hatchery. Early rearing fish culture practices in the proposed hatchery building will be operated with single pass flow-through the deep tanks. As the fish outgrow the deep tanks, they will be transferred into the intermediate rearing PRAS circular tanks. A small fish pump (e.g., 2.5-inch hose diameter) would minimize handling and stress on the fish as they are transferred. If enumeration of the fish is desired, a fish counter may be utilized in conjunction with the fish pump. There are a few options for transferring fish from intermediate rearing tanks to final rearing PRAS circular tanks. One alternative is to pump fish directly into the final rearing tanks utilizing a fish pump, hose, and optional fish counter. Another alternative is to pump the fish into a fish transfer tank equipped with an oxygen system and off-load them directly (via gravity) into the final rearing tanks which will be recessed into the ground. Linear distances from origin to destination rearing tanks will limit how fish can be transferred throughout the hatchery. Once the fish are in the final rearing PRAS circular tanks, the fish will be grown to their target release size at which time they will maximize the biomass and DI capacity of the system. Truck loading for fish release will basically continue as the hatchery has operated in the past utilizing fish pumps and dewatering towers with a few minor adjustments unique to circular tanks relative to traditional raceways.

One of the benefits of this proposed design is to provide the means for staff to maintain health and welfare. The hatchery building including the intermediate rearing tanks enables the hatchery to raise young fish to a larger size to allow for staff to perform vaccinations (i.e., *Lactococcus garvieae*) and/or administer chemical treatments as needed. Prior to the fish being transferred into the final rearing tanks, the fish may need to be vaccinated as determined by CDFW policy.

5.5.1 PRAS Circular Tank Operations

The intermediate and final rearing tanks will operate as PRAS systems reusing up to 75% of their water flow. The hydraulic self-cleaning characteristics of the circular tanks will reduce labor associated with tank cleaning. Additional tank sweeper systems are also available and can further reduce staff labor associated with maintaining tank hygiene. Staff time will be required for monitoring PRAS components including routine water quality checks, flow adjustments, and monitoring LHO and CO_2 systems to ensure a high-quality rearing environment. Staff will make routine flow adjustments as fish grow to maintain a maximum velocity of approximately two body lengths/second. Sein nets, clamshell crowders, or other crowder types can be used to concentrate fish for collection and handling.

Transfer of fish between tanks and for truck loading will utilize fish pumps and hosing to minimize handling and stress on the fish and decrease physical labor for staff transferring fish between tanks or loading trucks. For transferring fish into other rearing tanks requiring enumeration, a fish counter can be included at the receiving tank to obtain an accurate inventory of the fish. For fish being loaded onto a transport tanker for stocking, a dewatering tower will allow for the removal of the water through a screen prior to the fish entering the fish transport tanker. This is consistent with current hatchery practices as well as industry standards and practices and allows the hatchery to quantify fish biomass based on water displacement in the fish transport tanker. The return of the water from the dewatering tower to the PRAS module sump will be necessary to maintain the water balance within the PRAS module. Another option is to increase the fresh make-up water flow to compensate for this water loss in the module during the fish pumping process.

5.5.2 PRAS Equipment

The PRAS provides tremendous benefits in reducing the water flow requirements to produce large numbers/biomass of fish while maximizing water quality. However, these systems are more complex and require additional skillsets to monitor and maintain the equipment to ensure reliable system operations for successful fish production. Given the staggered production cycle using multiple groups of Rainbow Trout, the PRAS modules will not all be occupied at the same time, providing maintenance windows and opportunities for cleaning and disinfection. All PRASs should be programmed into the facility's maintenance and management system to schedule, perform, and document preventative and corrective maintenance.

5.5.3 Feeding

Early rearing feeding techniques in the deep tanks can continue using the hatchery's standard feeding practices. Hatchery staff will need to transition away from the blower style feeding systems typically used for linear raceways to a feeding system designed for circular tanks. Fish can be fed in circular tanks utilizing the simplest methods ranging from hand-feeding to automated systems and the techniques may vary depending on the size of the circular tanks and staff preferences. 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 provide feed intermittently throughout the day including staff non-duty times to maximize growth and reduce staff labor. However, automated feeding systems reduce the staff's observations during feeding, require adjustments to deliver the correct amount of feed, require preventative and corrective maintenance, and have continued costs associated with these maintenance requirements. 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

The goal of biosecurity measures is to minimize the risk of pathogens entering the facility and spreading between rearing areas at the facility. The Mojave River Hatchery reported *Lactococcus garvieae* as the primary fish health issue. The most likely pathways for pathogens to enter Mojave River Hatchery and spread through the facility has been through environmental exposure due to the lack of a hatchery building. Well water sources typically have low risk potential relative to pathogens and parasites. The proposed improvements for the facility will improve biosecurity and may reduce or eliminate the fish health challenges associated with *Lactococcus garvieae* and reduce the risk of other pathogens entering the facility.

5.6.1 Incoming Water Supply

The Mojave River Hatchery's water source is wells. No treatment has been proposed for the well water source as wells typically do not require treatment and are low risk relative to pathogen and parasite infestations. The addition of the hatchery building including early and intermediate rearing in an enclosed building maximizes biosecurity. Both intermediate and final rearing will utilize PRAS systems which include UV disinfection for all water being recirculated within each PRAS module along with CO_2 strippers and LHOs to maximize water quality.

5.6.2 Environmental Exposure/Bio Vectors

The existing facility is subjected to pathogens due to environmental exposure. The existing concrete raceways are enclosed by perimeter fencing with bird wires overtop, but these structures are minimally effective in excluding otters, raccoons, and avian predators from accessing the raceways. The recommended alternatives reduce the risk of pathogens entering the rearing areas by reducing environmental exposure. The addition of the hatchery building including early and intermediate rearing in an enclosed building maximizes biosecurity. Implementing PRAS in covered structures will limit potential pathogen vectors, such as birds, otters, etc., from entering the rearing vessels. Predators can be a significant source of stress, and they can transmit pathogens into the facility.

5.7 Water Quality Impacts

The recommended alternatives provide deep tanks and single pass flows appropriate for early rearing to maintain good water quality. The addition of intermediate rearing tanks with PRAS and the replacement of the existing concrete raceways with dual-drain circular tanks can improve the water quality of the rearing environment. Dual-drain circular tanks provide a completely mixed environment as opposed to a raceway that has a gradient of high to low dissolved oxygen (DO) along its length. This characteristic of circular tanks makes the entire tank volume available to the fish, instead of fish crowding at a raceway's head end, thereby not using the entire raceway volume. The dual-drain system in circular tanks aids in waste removal, allowing for more effective removal of solid waste and uneaten feed. This can contribute to better overall water quality.

The other PRAS equipment will also improve the water quality within the system. The microscreen drum filters will remove the solids in the water. The LHOs will ensure the dissolved oxygen levels enter the tanks 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 a rigid roof structure with bird netting will reduce heat gain during the summer months and algae growth in the rearing tanks.

Each PRAS module will concentrate the fish waste into smaller flows from the center drain and drum filter backwash. The recommended alternatives include treating this effluent waste with a drum filter and settling pond. This will reduce the solids and improve the water quality of the effluent being discharged.

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. The detailed cost estimate, including assumptions and inflation information are presented in Appendix F.

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 total cost for installation including any 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 cost was assumed based on $1,000/acre.

- Building joist/eave height will be 18 feet.
- Site geotechnical properties have not been evaluated but are assumed to be good for construction of the hatchery.
- Topographic survey has not been completed. Site survey will be required to establish elevations of all systems to ensure proper hydraulics can be achieved.
- A facility condition assessment was performed for the Mojave 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 $2,900,560 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 Terracon facility condition assessment may be resolved as part of the proposed upgrades at the Mojave 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

By replacing the current raceway area with 100,000 square feet of PV panels, the site comfortably achieves net zero energy. The surplus of available area (20,000 square feet) not only ensures energy efficiency but also provides flexibility for the arrangement of PV panels and potential future growth or increased energy demands.

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	$ 4,407,000
Division 02 – Existing Conditions	$ 430,000
Division 03 – Concrete	$ 1,170,000
Division 05 – Metals	$ 170,000
Division 08 – Openings	$ 80,000
Division 13 – Special Construction	$ 12,681,000
Division 23 – Mechanical & HVAC	$ 717,000
Division 26 – Electrical	$ 3,320,000
Division 31 – Earthwork	$ 233,000
Division 32 – Exterior Improvements	$ 523,000
Division 33 – Utilities	$ 500,000
Division 40 – Process Water Systems	$ 2,125,000
Division 44 – Pumps	$ 88,000
2024 CONSTRUCTION COST	**$ 26,444,000**
Construction Contingency	$ 6,611,000
Overhead	$ 1,587,000
Profit	$ 2,116,000
Bond Rate	$ 265,000
2024 CONSTRUCTION PRICE	**$ 37,023,000**
Design, Permitting, and Construction Support	$ 5,554,000
Geotechnical	$ 25,000
Topographic Survey ($1000/acre)	$ 2,000
PROJECT TOTAL	**$ 42,604,000**
Accuracy Range +50%	$ 63,906,000
Accuracy Range -30%	$ 29,823,000
Photovoltaic (Full kW Required)	$ 6,037,200
Photovoltaic (Roof kW Available)	$ 2,173,500

7.0 Mojave 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 for 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
Lahontan 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 San Bernardino County Permits and Approvals for Selected Location

Agency and Permit/Approval	Submittal / Document Type	Supporting Documentation	Anticipated Time Frame	Notes
San Bernardino County Building and Safety 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 Mojave River Hatchery is classified as a cold water Concentrated Aquatic Animal Production (CAAP) facility and is eligible to operate under General Order R6V-2017-0025 issued by the Regional Water Quality Control Board, Lahontan (Region 6) and NPDES Permit No. CA0102814.

Wastewater is discharged through the following discharge points:

- 001: Latitude 34° 28' 50" N, Longitude 117° 15' 36" W
- 002: Latitude 34° 28' 47" N, Longitude 117° 15' 45" W

The following limitations for effluent are specified:

- Fluoride: 0.44 mg/L (daily maximum)
- Manganese: 50 µg/L (monthly average), 100 µg/L (daily maximum)
- Formaldehyde: 0.65 mg/L (monthly average), 1.3 mg/L (daily maximum)
- Hydrogen peroxide: 1.3 mg/L (daily maximum)
- Settleable solids: 0.1 mL/L (monthly average)
- Total suspended solids: 6.0 mg/L (monthly average), 15 mg/L (instantaneous maximum)

7.3 Water Rights

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

8.0 Conclusions and Recommendations

This report provides valuable information on the impacts that the Mojave 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 temperature are expected at the Mojave River Hatchery. Groundwater supply is not expected to warm appreciably, but given current temperatures in the upper range for fish rearing, additional warming may require adaptation.

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:

- Constructing a new hatchery building to accommodate egg incubation, early rearing, and intermediate rearing that currently takes place at the Fillmore Hatchery. Intermediate rearing would use PRASs to achieve production goals.
- Replacing the lower 500 feet of existing raceways with a new production area with several PRAS modules for grow-out. The area would be covered and protected with fencing and netting to prevent predation and increase biosecurity.
- Refurbishing the concrete of the upper 500 feet of existing raceways and rerouting the drain piping to allow for their continued use.
- Conducting hydrologic studies to determine feasibility of another well location to serve the proposed hatchery building without affecting the production of existing wells.
- Repairing effluent discharge channel and upgrading to prevent further erosion.
- Demolishing and removing unused structures throughout the site including old raceway recirculation equipment and well houses.
- Installing solar panels atop new structures will offset some of the power demands associated with new hatchery equipment.

The proposed upgrades to the Mojave 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 $42,604,000.

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