# Climate Induced Hatchery Upgrades

## Feather River Annex

## Alternatives Analysis Submittal

**Final Report**
**Revision No. 4**

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# Distribution

To: Daniel Niederberger, PE
CDFW

Kenneth Kundargi, Hatchery Program Manager
CDFW

From: Joy Terry, PE
McMillen, Inc.

Prepared By: Joy Terry, PE
Brent Welton
Andrew Leman
Evan Jones
Megan Wilmott
McMillen, Inc.

Reviewed By: Marcelo Cerucci
Jeff Heindel
McMillen, Inc.

# Revision Log

| Revision No. | Date | Revision Description |
|---|---|---|
| 0 | 03/21/2024 | 65% Draft Internal Technical Review |
| 1 | 04/01/2024 | 65% Draft for CDFW Review |
| 2 | 8/14/2024 | 100% Draft for CDFW and Internal Technical Review |
| 3 | 10/31/2024 | 100% Final Submittal to CDFW |
| 4 | 2/07/2025 | 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
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# 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).

Feather River (Thermalito) Annex has aging infrastructure and multiple deficiencies which currently prevent operation of the facility. Its inability to operate limits opportunities to perform preventative maintenance at nearby hatcheries, primarily the Feather River Hatchery. Inadequate backup power generation, reduced well production, lack of a backup water supply from the Thermalito Afterbay, nonfunctional sumps and pump controls for wastewater removal, minor deterioration and leaking in production raceways, and unoccupied administrative space in a state of disrepair have been identified as obstacles to sustainable operation of the facility. Climate change effects are expected to exacerbate many of the identified issues in the future.

The preferred alternative for upgrades to the facility includes rehabilitating existing wells, improving water treatment to provide optimal conditions for fish rearing, replacing raceways with circular fish culture tanks organized as partial recirculating aquaculture systems (PRASs), and constructing additional PRASs outside of the existing raceway footprint to increase operational flexibility. All rearing areas would be covered with a solid roof and include predator exclusion netting and fencing. The proposed alternatives would greatly increase the operational flexibility of the Feather River Annex, allowing it to support multiple CDFW hatcheries in production and maintenance efforts.

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 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 return the facility to operational status, benefiting the Feather River Hatchery and other CDFW hatcheries in the region. The upgrades would be able to sustain fish production even as climate change increasingly disrupts hatchery facilities and CDFW operations.

| Maintain Production | Cost |
|---|---|
| Project Total | $62,705,000 |
| Photovoltaic – Net Zero Energy | $32,753,700 |

# 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 fish 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 existing program production goals for the various species reared at each facility while providing conceptual alternatives for climate resilience. Climate change has had an impact worldwide and will continue to affect CDFW's statewide fish production operations. Developing technologies and methods to meet fishery conservation and sport fisheries is critical to CDFW's goal of maintaining hatchery productivity while conserving precious cold-water supplies for native species.

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

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

## 1.3 Project Purpose

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

## 1.4 Site Location Description

The Feather River Annex is located approximately 65 miles north of Sacramento, CA and 10 miles west of the Feather River Hatchery in Oroville, CA (Figure 1-1).

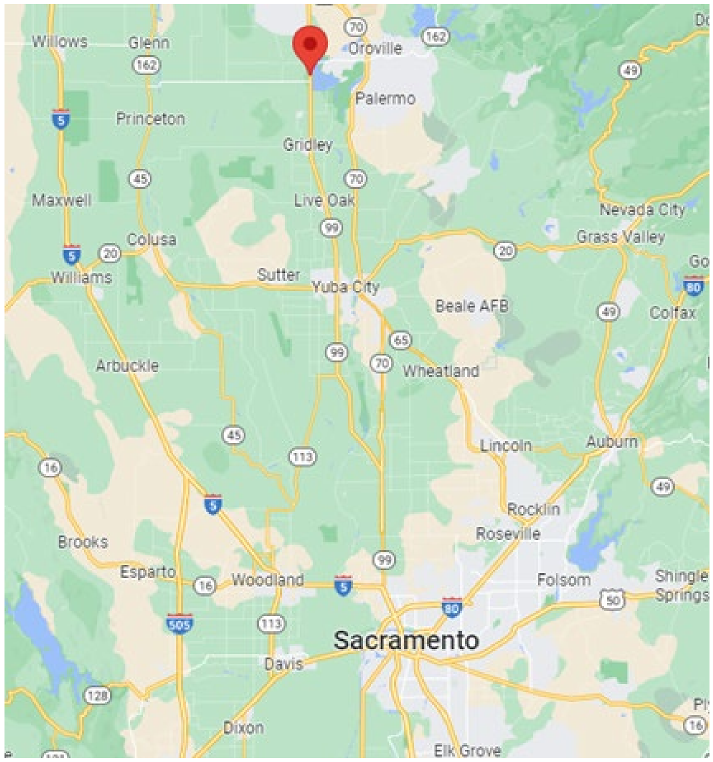


**Figure 1-1. Feather River Annex Location Map.**

The Feather River Annex was last used for fish production in 2018 when fish at the Feather River Hatchery were evacuated due to water quality concerns during the Oroville Dam spillway incident. Historically, the Feather River Annex was used to hold Chinook Salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*) from the Feather River Hatchery on an as needed basis for fish welfare concerns and preventative maintenance requirements at the Feather River Hatchery. The facility operates as a flow-through system and has four production raceways. Water is supplied by several wells owned and operated by the California Department of Water Resources (DWR). Historically, a siphon supplied water directly from the Thermalito Afterbay; though, this water source was abandoned due to uncertainties of the water quality. The general facilities are shown in Figure 1-2. See the Site Visit Report (Appendix A) for additional details regarding the existing facilities.

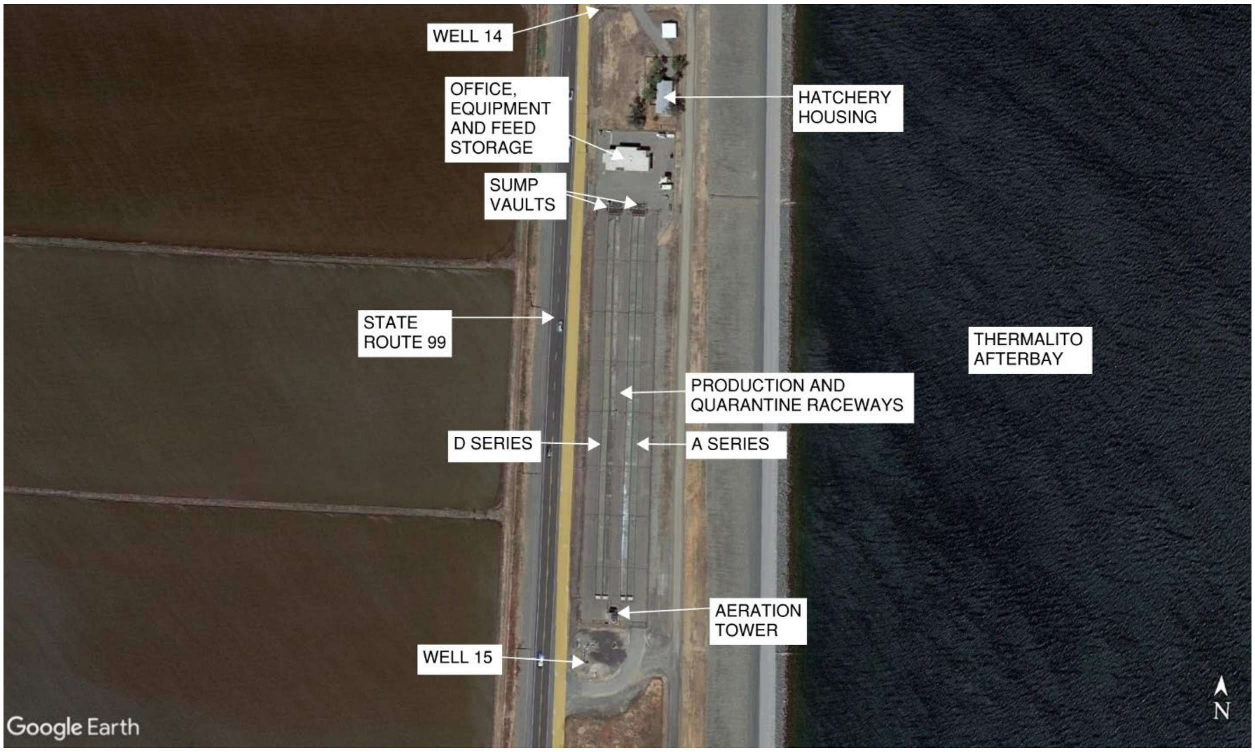


**Figure 1-2. Feather River Annex Facility Layout. Google Earth Image Date: 05/05/2021.**

# 2.0 Bioprogram

## 2.1 Production Goals and Existing Capacity

### 2.1.1 Anadromous Fisheries Mitigation

The Feather River (Thermalito) Annex (Annex) is a satellite facility of the main Feather River Hatchery (FRH), located approximately 10 miles from the main hatchery along the Thermalito Afterbay. The Annex was built to increase the production capacity of the FRH and has been used for additional production, disease management, and as a holding facility during routine and emergency FRH maintenance. Historically, the hatchery was used to hold all species and runs produced at the FRH: spring- and fall-run Chinook Salmon, inland Chinook Salmon, and steelhead. Concerns about straying in the anadromous populations led the California Hatchery Scientific Review Group (California Hatchery Scientific Review Group 2012) to recommend that CDFW stop rearing anadromous fish at the Annex unless they are released in the vicinity of the Annex and an adult collection facility is constructed at the downstream outlet of the Thermalito Afterbay. As designs for the facility advance, a main feature will be the flexibility to safely hold a variety of fish species at the facility, including the potential for anadromous fish in cases of emergencies.

### 2.1.2 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 [fpp]) 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 Annex was also used to raise inland Chinook Salmon, non-anadromous sterile fish that are produced as part of DWR's requirements in the 1986 Delta Fish Agreement between DWR and CDFW. Future production of the inland Chinook Salmon seems appropriate for this facility considering the HSRG's concerns about anadromous fish at the facility. CDFW prefers to maximize the flexibility of the Annex to accommodate both anadromous and inland culture operations based on the programmatic needs of California's fish hatchery system. The Annex has several potential uses including, but not limited to, emergency holding for fish affected by drought or other environmental issues, temporary holding to perform maintenance at CDFW's main hatcheries, or as a grow-out facility to supplement CDFW's inland fisheries program. It is expected that any planned use of the facility would require approval from DWR to ensure that the 1984 agreement is upheld, and mitigation requirements are still fulfilled.

The Site Visit Report modeled several biological programming options due to the uncertainty about the future operations of the Annex in the Capacity Bioprogram (Appendix A). The Capacity Bioprogram provides the total numbers of fish and biomass that can be produced for all rearing tanks based on tank volume, operational water flows, fish size, and species. 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 (Appendix A). 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 facility is currently inoperable and there is no associated production goal. For this report, only the inland Chinook Salmon grow-out program will be evaluated as part of the Production Bioprogram because of its predictability and limited assumptions relative to other previous or potential uses of the facility. Other uses of the facility may be modeled as the project progresses and more details and criteria are confirmed. The fish production goal, and rearing capacity determined by the Capacity Bioprogram from the Site Visit Report is shown in Table 2-1.

**Table 2-1. Inland Chinook Salmon Production Goal and Capacity of the Feather River Annex per the Capacity Bioprogram (Appendix A).**

| Rearing Unit (max. fish size) | Total Capacity (Fish)[a] | Limiting Factor | Goal |
|---|---|---|---|
| Raceways (3 fpp/10.4 inches) | 245,800 | Water Flow | 125,000 Fish |

[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 the raceways at the Annex for several stages of fish production and multiple species and strains. 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.

For this report, the bioprogram will focus on inland Chinook Salmon production because it has the most consistent historical information available. The Annex has sufficient rearing volume and water flow to nearly double the FRH's production goal of 125,000 fish. Details about the rearing area and infrastructure at the Annex are discussed in the Site Visit Report, found in Appendix A. In this report, we develop a Production Bioprogram to illustrate the potential maximum production capacity 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 Annex 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:

- Inland Chinook Salmon are transferred to the Annex at the beginning of May at approximately 25 fpp (5.1 inches)
- The Feather River Hatchery can produce the required number of inland Chinook Salmon to fulfill the Annex's requirements.

This bioprogram also assumes optimal fish growth (approximately 0.025 inches/day based on information provided by CDFW) given the water temperatures experienced at the facility. Survival rates and information to calculate approximate growth rates were provided by Feather 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) | 0.38 |
| Flow Index (FI) | 1.22 |
| Water Temperature | Consistent 58 – 62 °F |

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

| Life Stage | Value |
|---|---|
| Juvenile (25 fpp)-to-outplant (3 fpp) | 99% |

### 2.2.2 Production Bioprogram

This bioprogram (Appendix B) is meant to view 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.

**Table 2-4. End of Month Production Information for the inland Chinook Salmon Bioprogram Including Realized DI and FI Values.**

| Production Stage/Month | Tank Type | Tanks Occupied | fpp | Length (in) | Total Fish (#) | Biomass (lbs) | Max. Flow (cfs) | DI | FI |
|---|---|---|---|---|---|---|---|---|---|
| Late April/Early May - Transferred from FRH | Raceway | 4 | 25.0 | 5.1 | 248,250 | 9,930.0 | 16.0 | 0.03 | 0.27 |
| May | Raceway | 4 | 17.1 | 5.8 | 247,900 | 14,497.1 | 16.0 | 0.03 | 0.35 |
| June | Raceway | 4 | 12.1 | 6.5 | 247,550 | 20,458.7 | 16.0 | 0.04 | 0.44 |
| July | Raceway | 4 | 8.6 | 7.3 | 247,200 | 28,744.2 | 16.0 | 0.05 | 0.55 |
| Aug | Raceway | 4 | 6.3 | 8.1 | 246,850 | 39,182.5 | 16.0 | 0.07 | 0.67 |
| Sep | Raceway | 4 | 4.9 | 8.8 | 246,500 | 50,306.1 | 16.0 | 0.08 | 0.80 |
| Oct | Raceway | 4 | 3.8 | 9.6 | 246,150 | 64,776.3 | 16.0 | 0.09 | 0.94 |
| Nov | Raceway | 4 | 3.0 | 10.4 | 245,800 | 81,933.3 | 16.0 | 0.11 | 1.10[a] |

a The FI criteria will be exceeded the following month; this provides a 10% buffer for flexibility and an additional safety factor.

The inland Chinook Salmon at the Feather River Hatchery reach approximately 25 fpp (5.1 inches) by May. At this size, the total population is limited by available space in the raceways at the main hatchery and are transferred to the Annex. For the purposes of the Capacity Bioprogram, it is assumed that approximately 248,250 fish are transferred to the Annex and spread evenly among the four raceways. The total number of fish transferred is determined by the final capacity of the Annex raceways and the assumed 99% survival rate for fish of this size (in the absence of any abnormal disease, environmental, or mechanical failure associated mortalities). There is excess rearing volume and flow in the early stages of the grow-out cycle (low DI and FI values in Table 2-4); staff may adjust flow rates down and crowd fish in the heads of the raceways to promote feeding responses and help raceway cleaning efforts as necessary. Fish reach the target release size of 3 fpp (10.4 inches) by the end of November and will require the total 16 cfs of water flow to the facility to maintain an FI within the criteria specified (Table 2-4). A 10% capacity buffer was included and provides some flexibility, but it is assumed that fish will be stocked out shortly after reaching the target size. This bioprogram assumes the harvest will include the maximum number of fish that can be held in the Annex raceways per the Capacity Bioprogram (Table 2-1). This bioprogram would nearly double the existing production goal for inland Chinook, from 125,000 to 245,800 fish produced. The limiting factor for this bioprogram, apart from available rearing space and water supply, is likely the ability for the main Feather River Hatchery to produce approximately 250,000 juvenile fish (25 fpp, 5.1 inches) for transfer to the Annex.

This bioprogram is bound by egg availability of an anadromous species; there is only one opportunity each year for production and the grow-out cycle does not overlap with the previous year. As a reference, the production schedule is shown in Figure 2-1 over a single calendar year. Other opportunities for production strategies exist for this facility; for example, to meet the production goal of 125,000 fish only two raceways are required, leaving two raceways available for other uses described previously. Any strategies that include multiple cohorts of fish being held at the Annex would require strict biosecurity protocols to avoid pathogen transmission among populations. The maximum required flow rate is assumed to be 16 cfs, or 4 cfs per raceway. Initially this will not be required based on relatively low FIs when fish are transferred to the Annex (Table 2-4). The potential for 16 cfs to be used will only occur when fish are at the Annex from May through November of each year (Figure 2-1). Note that the different colored blocks in the following figure correspond to the months for when fish are in the Feather River Hatchery or Feather River Annex early rearing (Feather River main), inland raceway (main hatchery), or annex raceways, along with noting when eggs are received and incubated.

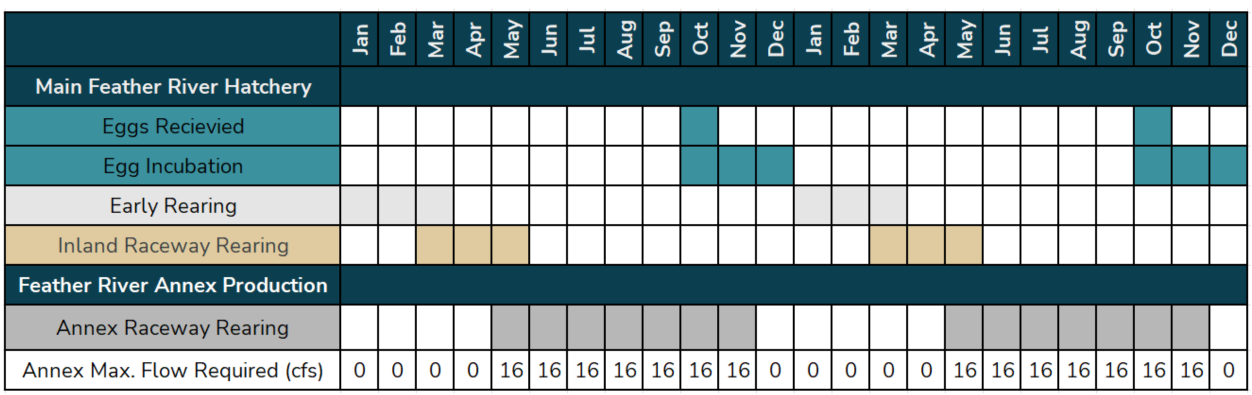


**Figure 2-1. Production Rearing Schedule Over One Year Including Early Rearing at the Main Feather River Hatchery.**

# 3.0 Climate Evaluation

## 3.1 Introduction

In this section, projections of air temperature conditions at the hatchery are presented for the next 20 years (2024-2043) and the following 20 years (2044-2063) and will be compared against the reference period 1984-2003. 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. Projections of air temperature extremes are included to inform of potentially hazardous working conditions.

## 3.2 Methodology for Projecting Air Temperature

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 |

| No. | GCM | Research Institution |
|---|---|---|
| 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 |

The methodology used for obtaining projections of air temperature, which is summarized in Figure 3-1, was 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 spatial resolution 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 used for other California fish hatchery studies were based on 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.

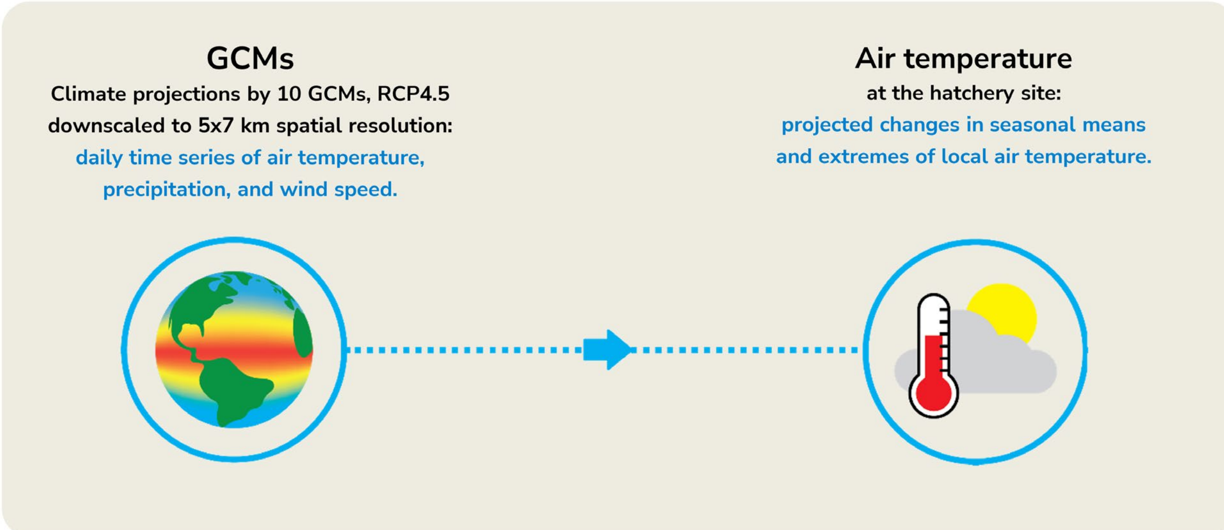


**Figure 3-1. Methodology for Obtaining Air Temperature Projections.**

## 3.3 Uncertainty and Limitations

It is important to acknowledge the large and unquantifiable uncertainty associated with these and any climate projections. The projections of air temperature presented here 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 air temperature over this hatchery area 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.

## 3.4 Projected Changes in Air Temperature at the Hatchery Site

Figure 3-2 displays the simulated mean daily air temperature (solid lines) and its range from minimum to maximum (shaded areas) for each day of the year, for the near-future time period (red) and the reference period (blue). All data are simulated by the ensemble of 10 GCMs for each time period. Higher peaks of daily temperature are seen for the near-future compared to the reference period, while the historical period has lower minima.

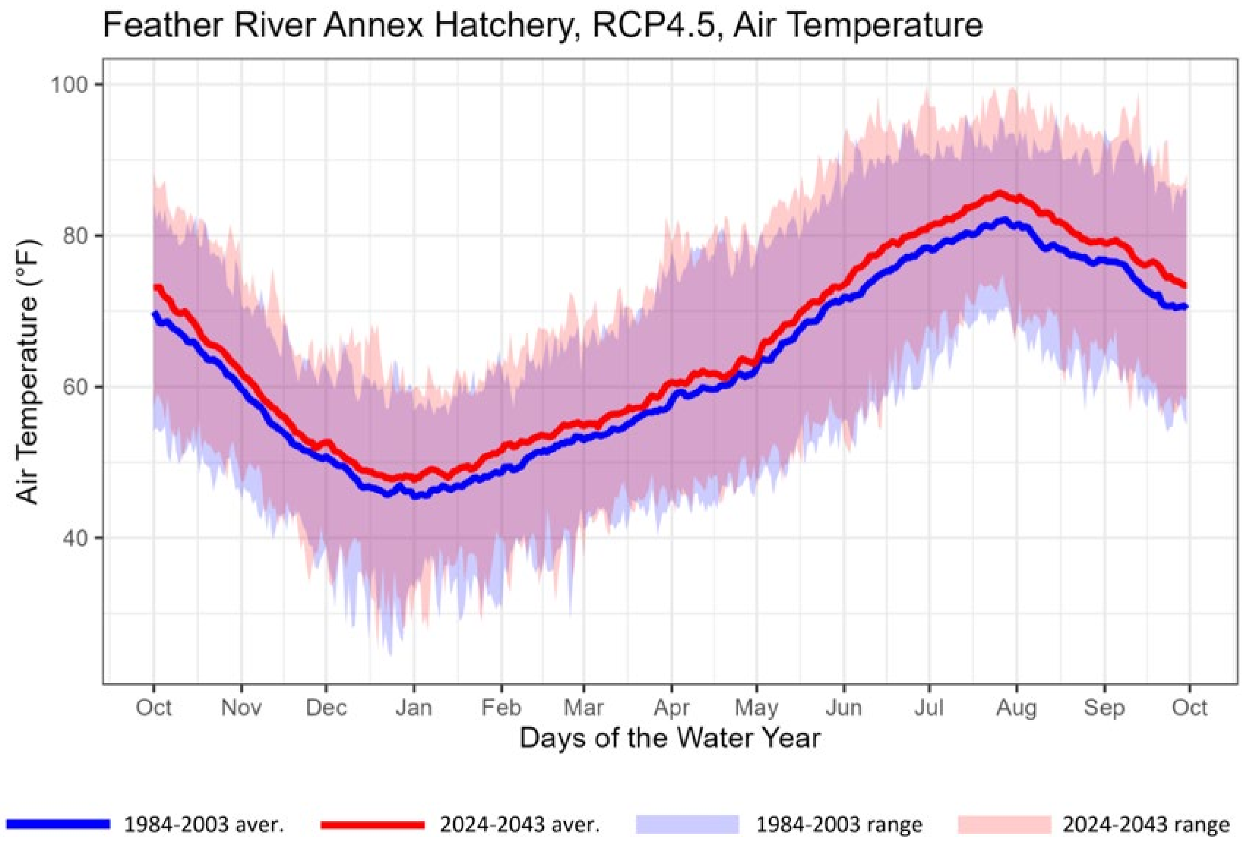


**Figure 3-2. Mean Daily Air Temperature and Range for Each Day of the Water Year.**

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 3-2 and are given in Table 3-2 and Table 3-3.

**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) | Summ. (JJA) | Fall (SON) |
|---|---|---|---|---|---|
| Ensemble mean | 65.0°F (+2.5°F) | 50.7°F (+2.2°F) | 62.8°F (+1.9°F) | 80.0°F (+3.2°F) | 66.3°F (+2.6°F) |
| Lowest | 64.5°F (+2.0°F) | 49.9°F (+1.4°F) | 62.1°F (+1.2°F) | 78.7°F (+1.9°F) | 65.1°F (+1.4°F) |
| Highest | 65.5°F (+3.0°F) | 51.2°F (+2.7°F) | 63.9°F (+3.0°F) | 81.1°F (+4.3°F) | 67.2°F (+3.5°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) | Summ. (JJA) | Fall (SON) |
|---|---|---|---|---|---|
| Ensemble mean | 66.1°F (+3.6°F) | 51.8°F (+3.3°F) | 64.0°F (+3.1°F) | 81.2°F (+4.4°F) | 67.2°F (+3.5°F) |
| Lowest | 65.4°F (+2.9°F) | 50.9°F (+2.4°F) | 63.4°F (+2.5°F) | 79.6°F (+2.8°F) | 65.7°F (+2.0°F) |
| Highest | 66.8°F (+4.3°F) | 52.8°F (+4.3°F) | 64.8°F (+3.9°F) | 82.7°F (+5.9°F) | 68.3°F (+4.6°F) |

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.

**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 perc. | 25th perc. | 50th perc. | 75th perc. | 97th perc. |
|---|---|---|---|---|---|
| Ensemble mean | 52.4°F (+2.1°F) | 63.9°F (+1.9°F) | 77.4°F (+2.1°F) | 93.1°F (+3.0°F) | 105.6°F (+3.3°F) |
| Lowest | 51.8°F (+1.5°F) | 63.5°F (+1.5°F) | 76.9°F (+1.6°F) | 92.7°F (+2.6°F) | 104.5°F (+2.2°F) |
| Highest | 53.8°F (+3.5°F) | 64.4°F (+2.4°F) | 78.0°F (+2.7°F) | 94.1°F (+4.0°F) | 107.7°F (+5.4°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 perc. | 25th perc. | 50th perc. | 75th perc. | 97th perc. |
|---|---|---|---|---|---|
| Ensemble mean | 53.6°F (+3.3°F) | 65.0°F (+3.0°F) | 78.7°F (+3.4°F) | 94.4°F (+4.3°F) | 106.6°F (+4.3°F) |
| Lowest | 52.4°F (+2.1°F) | 64.3°F (+2.3°F) | 78.1°F (+2.8°F) | 93.1°F (+3.0°F) | 105.0°F (+2.7°F) |
| Highest | 54.9°F (+4.6°F) | 65.5°F (+3.5°F) | 79.3°F (+4.0°F) | 95.6°F (+5.5°F) | 108.0°F (+5.7°F) |

At the hatchery site, mean annual air temperature is projected to rise by 2.5°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 3-2 and Table 3-3) and the highest temperature rises are projected to occur in the hottest days (Table 3-4 and Table 3-5). According to gridded air temperatures for the reference period 1984-2003 (Livneh, et al. 2013), the 75th and 97th percentiles of peak daytime temperature (i.e., the temperature at the hottest time of day) were 90.1°F and 102.3°F. Days with maximum daytime temperatures representing the 75th percentile (i.e., the upper quartile of temperatures) are projected to warm by 3.0°F in the next 20 years, relative to the reference period. The 97th percentile of the daytime maximum temperature is projected to rise by even more, 3.3°F, reaching 105.6°F. These projected temperatures represent potentially hazardous outdoor working conditions at the hatchery.

## 3.5 Conclusions

The climate change evaluation for the Feather River Annex Fish Hatchery was restricted to air temperature projections given instructions by CDFW that streamflow or water temperature evaluations were not requested for this hatchery.

Significant increases in air temperature and water temperature are expected for the Feather River Annex Fish Hatchery. The projected increases in seasonal means and extremes are among the highest of all California hatcheries studied. Mean annual air temperature is projected to rise by 2.5°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.

The distribution of daily air temperatures will change, and the upper end of this distribution is of most interest. Therefore, we looked at changes in the 75$^{th}$ and 97$^{th}$ percentiles of the daily temperature distribution and found that the 75$^{th}$ percentile will increase by 3.0°F and the 97$^{th}$ percentile will increase by 3.3°F in the next 20 years, relative to the reference period.

According to gridded air temperatures for the reference period 1984-2003, the 75$^{th}$ and 97$^{th}$ percentiles of peak daytime temperature (i.e., the temperature at the hottest time of day) were 90.1°F and 102.3°F. For the near-future period (2024-2043), these percentiles are projected to rise to 93.1°F and 105.6°F, respectively. Such an increase in the peak air daytime temperature requires adaptation measures for the 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.

# 4.0 Existing Infrastructure Deficiencies

Multiple deficiencies were identified and summarized in Section 5.4, Potential Technologies to Maintain Production, of the Feather River Annex Site Visit Report. These deficiencies include emergency generator replacement, well replacement or rehabilitation, siphon repair contingent on additional water treatment equipment, motor control center replacement, sump pump replacement, and other property and building improvements necessary for regular operations. The details of these deficiencies are further expanded upon in Section 4.1 and 4.2.

## 4.1 Water Process Infrastructure

### 4.1.1 Aeration/Distribution Tower

The existing aeration and distribution tower degasses the total available water right. Since the system has not been operational recently, repair or replacement of components may be necessary. The structure has no direct oxygenation system, instead it relies on water cascading over wood slats to aerate and degas. Its current ability to operate and convey water to the raceways is unknown.

### 4.1.2 Valving and Piping

Due to extended periods of non-use, it is likely that the various valving and piping throughout the facility has frozen or deteriorated. The throttling ability of the current valves is unknown.

### 4.1.3 Well Deterioration

Approximately 12 to 16 cfs of water flow are required for optimal operation of the Annex and wells were originally developed to provide this. Over time, well production has decreased to lows of approximately 5 to 6 cfs during the summer. This was likely caused by deterioration of the well infrastructure, but also the presence of new well development in nearby agricultural areas. The exact reason for the well production decrease is unknown without further investigation. There are also no flow meters at the facility; accurate water use monitoring is a stipulation in the 1984 agreement between DWR and CDFW for the facility’s use.

### 4.1.4 Siphon

The Annex used to be supplied with additional water directly from the Thermalito Afterbay through a siphon. This provided an additional 4 cfs of water flow on top of the 12 cfs produced by the wells according to a 1984 agreement between DWR and CDFW. The siphon was later abandoned because of concerns with pathogens, primarily *Yersinia ruckerii* (causative agent of enteric redmouth disease) entering the facility; CDFW’s Fish Pathology Department no longer approves the use of this water source. The condition of the siphon and intake is unknown and would require an evaluation to determine what use, if any, it may have in its present state.

#### 4.1.5 Effluent System

All water flowing down raceways at the Annex is collected in a sump vault and pumped into the Thermalito Afterbay. The vault for each pair of raceways is connected by a common pipe, and the water level is maintained at 6 feet. A series of four pumps operate through a motor control center to maintain water levels. The motor control center is unreliable and has the potential to overflow the sump and backup effluent water into the raceways. The effluent pumps have been unused for several years, one pump was previously identified for replacement, but it is possible others have failed since then.

### 4.2 Raceway Condition

The only rearing infrastructure at the Annex are four 600-foot-long raceways. Aside from issues with the water distribution and effluent infrastructure, the raceways are in relatively good condition. The valves have been replaced in the last 10 years, though they have not been exercised or tested in several years. Staff noted that one raceway, D-series, leaks but not significantly enough to cause other damage. The predator exclusion netting and fencing around the raceways appears to be in fair condition but has not been carefully inspected since the facility was last regularly used.

### 4.3 Building and Property Issues

Since the facility has not been used or had a full-time position assigned to it for several years, some aspects of the buildings and property require updates to restore operations. One building on site includes office space, feed storage, and a garage shop; the building currently has pests (mice) and associated hygiene issues. The HVAC system has been identified as broken, and the interior and exterior lighting is no longer up to CDFW or DWR standards. The property fencing is deteriorated in some areas, and vegetation has overgrown in some areas around the facility.

### 4.4 Emergency Generator

The original standby emergency generator (SEG) at the Annex is over 35 years old and is no longer trusted by CDFW to provide a reliable source of backup power. Backup power at the Annex is an absolute necessity because of its reliance on pumped well water to supply its rearing areas. The supply wells are connected to separate sources of power, but the raceway sump vaults must be continuously pumped out during operation. If power were to fail without sufficient backup, the raceways would overflow and flood the facility, potentially leading to a catastrophic loss of fish and major damage to the facility.

# 5.0 Alternative Selected

## 5.1 Alternative Description

The proposed upgrades will require additional buildings and structures at the site. The existing perimeter fence for the facility would be enlarged to accommodate any new fish rearing systems or water treatment equipment to ensure the facility remains secure.

### 5.1.1 Water Supply Improvements

#### 5.1.1.1 Well Rehabilitation

The preferred alternative is to rehabilitate the existing wells that supply the facility to return their production to historic levels and allow for the full water right of 16 cfs to be supplied. This alternative would involve pre-rehabilitation test pumping before removing pumps and electrical equipment. A video survey of the existing well would be conducted to identify any severe issues that require more substantial upgrades before the well is cleaned.

#### 5.1.1.2 Construct New Water Distribution Tower with Additional Treatment Capabilities

A new water distribution structure is proposed and would include degassing, oxygenation, and chilling of the supply water. Water would flow down through packed columns; at the top of the column a fan would blow air horizontally across the columns to disperse any dissolved gas stripped from the water. After flowing down the column, water would fall into low head oxygenators (LHOs) and be injected with oxygen. For this report, it is assumed that oxygen will be supplied by oxygen generators on site. In future design phases, the feasibility of bulk liquid oxygen (LOX) will be evaluated and compared to on-site oxygen generation on a cost-benefit basis. Water would then be routed through chillers designed to provide a temperature differential of 4°F for a flow rate up to 16 cfs. Chilling would be required for the facility to safely hold a captive salmon broodstock, which CDFW expressed interest in during previous meetings. Once water is chilled, it would be split and conveyed to specific rearing areas throughout the facility. Each treatment component, besides degassing, would be designed with an associated bypass to allow for maintenance activities without dewatering the facility.

### 5.1.2 Fish Rearing and Holding Improvements - Replace Raceways with Circular Tanks Utilizing PRAS

Discussions with CDFW highlighted the need for operational flexibility of the Annex. This will be accomplished with a variety of tank sizes and several PRAS modules for the multiple uses of the facility. The proposed fish culture systems include production space for inland Chinook Salmon, a small system for emergency wild fish transfers, an intermediate sized system, and a large system. Each PRAS module would include its own recirculation equipment including pumps, degassing, oxygenation, filtration, and ultraviolet (UV) disinfection.

#### 5.1.2.1 Egg Incubation System

In the interest of creating a facility capable of serving multiple purposes for the CDFW hatchery system, an egg incubation system is also proposed. Eggs would be incubated in a Heath stack system; it is assumed that full stacks would be used to maximize capacity. Within the full stack, the top tray would be left empty as a sediment or treatment mixing tray, leaving 15 trays for egg incubation. Based on CDFW and industry standard practices, a conservative recommendation is for densities in each egg tray to not exceed 5,000 Chinook Salmon eggs per tray, or 75,000 eggs per full Heath stack (15 trays). The proposed alternative is to provide 30 full Heath stacks with a total egg incubation capacity of approximately 2.25 million Chinook Salmon eggs. The Heath stacks can also incubate eggs from other species; Chinook generally have the largest eggs so the capacity of eggs per tray for other species (steelhead or inland trout) would likely increase.

To operate as a flow-through system, 5 gpm of fresh water is required for each Heath stack. In this alternative, the total water demand is 150 gpm. Eggs and alevins of salmon generally require cooler water temperatures relative to juvenile and adult life stages. Well water temperatures at the Annex experienced in the past (up to 62°F) are generally not suitable for salmon egg incubation. The existing water chillers proposed for the facility’s influent water can treat water for the egg incubation flows to optimal temperatures at or below 56°F. The chilling capacity should ensure safe and stable operations for the next 30+ years even as groundwater temperatures may slightly increase and provide flexibility for future egg incubation expansion if CDFW desires.

Alternatively, CDFW has successfully used recirculating egg incubation systems at its Silverado Fisheries Base (SFB). A similar design could be implemented at the Annex to reduce the water demand and subsequent chilling costs. The recirculating system at SFB operates at a water reuse rate of approximately 95%. This reuse rate would decrease the water demand for 30 Heath stacks to approximately 7.5 gpm.

#### 5.1.2.2 Small Holding and Early Rearing

Another proposed system used for emergency holding of wild fish or for early rearing of production fish would consist of 24 tanks each with a 6-foot-diameter, 2-foot-water depth, and 3-foot wall height for an approximate volume of 1357.2 $ft^3$ (56.5 $ft^3$ per tank). The system would be located west of the current administrative building. The system would be fully enclosed in a Pre-Engineered Metal Building (PEMB) to provide a rearing space insulated from adjacent highway noise and adequate biosecurity for potentially sensitive species. The PEMB would also house the egg incubation system to provide an efficient workflow for hatchery operations.

This system would include PRAS equipment to operate four tanks on a single PRAS module, creating six modules each capable of isolating production from the others and maintaining a high degree of flexibility for this system. To maintain an HRT of 30 minutes, recommended for smaller circular tanks (Timmons, Guerdat and Vinci 2018), a flow rate of 15 gpm is required for each tank (60 gpm per module, 360 gpm total). Assuming a recirculation rate of 50%, the fresh make-up flow requirement would be 30 gpm per module and 180 gpm (0.4 cfs) for the entire system. Once staff are familiar with the recirculation equipment and processes, tanks may operate at a recirculation rate of 75% without a biofilter. A 75% recirculation rate would require 15 gpm of fresh make-up water per module (90 gpm, 0.2 cfs for the entire system). Equipment for each module would be sized to recirculate and recondition a flow rate of 45 gpm.

#### 5.1.2.3 Intermediate Long-Term Holding or Additional Production

The intermediate system would include twenty-four (24) circular tanks, each with a 15-foot-diameter, 5-foot water depth, and 6-foot wall height; the approximate rearing volume of this system is 21,205 $ft^3$ (883 $ft^3$ per tank). This system would be located within the fenced area surrounding the existing raceways. Tanks and equipment would be covered with a solid roof structure and enclosed in fencing and predator exclusion netting. The production area would be organized into four distinct PRAS modules each with six tanks. A recommended HRT of 30 minutes would require a flow rate of 225 gpm for each tank (1,350 gpm per module). The entire system would require 5,400 gpm (12 cfs) of process flow.

Assuming a 50% recirculation rate, the fresh make-up water requirement would be 675 gpm (1.5 cfs) per module and 2,700 gpm (6.0 cfs) for the entire system. Once staff are familiar with the recirculation equipment and processes, tanks may operate at a recirculation rate of 75% without a biofilter. A 75% recirculation rate would require 340 gpm (0.8 cfs) of fresh make-up water per module (1,350 gpm, 3 cfs for the entire system). Recirculation equipment would be sized to recirculate and recondition a flow rate of 1,025 gpm (2.3 cfs) for each module.

#### 5.1.2.4 Large Long-Term Holding or Additional Production

To accommodate larger transfers from other CDFW hatcheries, a system of twenty-four (24) 20-foot-diameter tanks each with a water depth of 6 feet and a wall height of 7 feet for a total rearing volume of approximately 45,240 $ft^3$ is proposed (1,885 $ft^3$ per tank). This system would be located within the fenced area surrounding the existing raceways. Tanks and equipment would be covered with a solid roof structure and enclosed in fencing and predator exclusion netting. The tanks would be organized into four separate PRAS modules each with six tanks, like the intermediate sized holding system. The grow-out holding system uses identical tanks to the inland Chinook Salmon production system and could be used for additional production space if desired.

A recommended HRT of 45 minutes would require a flow rate of 325 gpm per tank, or 7,800 gpm (17.4 cfs) of total process flow for the system. Each module would require 1,950 gpm (4.3 cfs) of total process flow.

Assuming a recirculation rate of 50%, the fresh make-up water requirement for each module would be 975 gpm (2.2 cfs), or 3,900 gpm (8.7 cfs) for the entire system. Once staff are familiar with the recirculation equipment and processes, tanks may operate at a recirculation rate of 75% without a biofilter. A 75% recirculation rate would require 490 gpm (1.1 cfs) of fresh make-up water per module (1,950 gpm, 4.3 cfs for the entire system). Recirculation equipment would be sized to recirculate and recondition a flow rate of 1,475 gpm (3.3 cfs) for each module.

CDFW has also expressed desire for the ability to maintain a captive broodstock population of Chinook Salmon. The National Marine Fisheries Service (NMFS) suggests that vessels for long-term adult salmon holding are sized to hold fish at 0.5 $ft^3$/lb of fish suggested flow rate of 1.34 gpm per fish (NMFS 2022). The tanks proposed for this system could accommodate up to 242 adult fish, based on the available flow of 325 gpm. An entire module could hold up to 1,452 fish. Tank depths of 6 feet are appropriate for holding adult salmon, netting or other covers would be used to prevent fish from jumping out of the tanks. It should be noted that there is limited information available on Pacific salmon captive broodstock populations held in recirculating aquaculture systems; CDFW would be at the forefront of these techniques. There are likely additional criteria and demands associated with this type of captive broodstock system that may not be realized until production has begun.

#### 5.1.2.5 Summary of New Rearing Systems

The new production systems would provide a total approximate rearing volume of approximately 67,800 $ft^3$. This is a slight increase from the existing raceways which have a total estimated volume of 72,000 $ft^3$ (18,000 $ft^3$ per raceway). The emergency short-term holding system may be used for fish rescues, endangered species, or quarantine for genetic and disease testing in the development of new broodstock strains. A proposed rearing strategy for the long-term holding systems would be to use the intermediate long-term holding system for pre-marked anadromous fish and the large long-term holding system for post-marked anadromous fish. The biomass capacity of the systems, assuming a maximum DI of 0.3, is shown in Table 5-1, Table 5-2, and Table 5-3 for Chinook Salmon and steelhead at marking and release sizes. The long-term holding systems may be used to provide a temporary refuge for anadromous fish from other CDFW hatcheries undergoing preventative maintenance operations that require partial depopulation of facilities. Maintenance schedules may rotate among hatcheries, and concerns of straying are reduced because the water at the Feather River Annex is supplied from the ground and not surface waters. The number of modules and different tank sizes allows for a wide range of operational flexibility for what best suits the CDFW hatchery in need of depopulation. In years where maintenance is not required, the rearing systems at the Feather River Annex may be used as additional grow-out space for inland fisheries production.

**Table 5-1. Biomass and Fish Capacity of Proposed Long-Term Holding Systems Assuming a DI of 0.2.**

| Rearing Stage | Per Module Capacity | Total System Capacity |
|---|---|---|
| Egg Incubation | 8,000 eggs per tray<br>120,000 eggs per Heath stack | 3 million eggs |

**Table 5-2. Biomass and Fish Capacity of Proposed Intermediate Long-Term Holding Systems Assuming a DI of 0.2.**

| Rearing Stage | Per Module Capacity | Total System Capacity |
|---|---|---|
| Chinook Salmon at Marking Size<br>(170 fpp; 2.7 inches) | 2,863 pounds<br>(486,672 fish) | 11,451 pounds<br>(1.94 million fish) |
| Steelhead at Marking Size<br>(170 fpp; 2.6 inches) | 2,756 pounds<br>(468,647 fish) | 11,027 pounds<br>(1.87 million fish) |

**Table 5-3. Biomass and Fish Capacity of Proposed Large Long-Term Holding Systems Assuming a DI of 0.2.**

| Rearing Stage | Per Module Capacity | Total System Capacity |
|---|---|---|
| Chinook Salmon Smolts<br>(60 fpp; 3.8 inches) | 8,595 pounds<br>(515,724 fish) | 34,382 pounds<br>(2.06 million fish) |
| Steelhead Smolts<br>(4 fpp; 8.9 inches) | 20,131 pounds<br>(80,525 fish) | 80,525 pounds<br>(322,101 fish) |

The freshwater make-up flow rate required to operate all proposed systems and tanks simultaneously (at a 50% recirculation rate) would be approximately 15.4 cfs (6,915 gpm). The new production system would essentially require the entire historic maximum water use of 16 cfs to operate all systems at once. Operating at a recirculation rate of 75% would require approximately 7.8 cfs (3,500 gpm) of fresh make-up water (Table 5-4). The organization of the new production systems allows for greatly increased flexibility and isolation when rearing or holding fish transferred from other locations. The total rearing volume of all proposed systems would be 67,802 $ft^3$. This significantly increases the potential uses of the Annex to benefit a wide range of CDFW goals, as opposed to its historic use as an occasional production space and temporary holding exclusively for the Feather River Hatchery.

**Table 5-4. Total Flow Requirements for Proposed Rearing Systems.**

| System | Tank Diameter (feet) | Number of Tanks | Modules | Total Rearing Volume ($ft^3$) | Make-up Water Requirement 50% Reuse | Make-up Water Requirement 75% Reuse |
|---|---|---|---|---|---|---|
| Egg Incubation | 15 Trays per Heath Stack | 375 Trays | 25 Heath Stacks | NA | 0.3 cfs[a] | 0.3 cfs[a] |
| Emergency Short-Term Holding | 6 | 24 | 6 | 1,357 | 0.4 cfs | 0.2 cfs |
| Intermediate Long-Term Holding | 15 | 24 | 4 | 21,205 | 6 cfs | 3 cfs |
| Large Long-Term Holding | 20 | 24 | 4 | 45,240 | 8.7 cfs | 4.3 cfs |

a This is the water requirement for a flow-through system

### 5.1.3 Effluent System Improvements

A new effluent vault is proposed for the facility, capable of processing wastewater from all production and holding areas for the full water right of 16 cfs. The effluent system would include two cells, each capable of isolation, to allow for appropriate waste management if drugs or chemicals are used during fish culture activities. All production and holding systems would be processed through this common effluent system and would use a single point of discharge back into the Thermalito Afterbay. Detailed designs will maintain NPDES requirements outlined in the permitting process.

### 5.1.4 Backup Generator Replacement

The current backup generator is not a reliable source of power. Additionally, the proposed alternatives would require additional power loads to be backed up by a generator. New backup power generators are preferred to operate all new PRAS equipment. The generators would be powered by liquid propane, as opposed to diesel, to maintain air emission regulations.

### 5.1.5 Auxiliary Building Improvements

CDFW and DWR have acknowledged that the office building requires some maintenance before it is fully functional. Interior cleaning and furnishing are required for new full-time staff positions. Additionally, the HVAC system requires replacement. Other improvements may be required because of the building remaining vacant for several years.

Similarly, the on-site residence may require upgrades because of prolonged vacancy. For this report, it is assumed that the residence must be demolished and replaced. The domestic water system will be tested to ensure clean water is available. The proposed rearing upgrades would require a staff member to reside on site whenever fish are held at the facility. Fish may be on site year-round depending on how CDFW chooses to use the facility.

## 5.2 Pros/Cons of Selected Alternative

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

**Table 5-5. Pros/Cons of Selected Alternatives- Feather River Annex.**

| Description | Pros | Cons |
|---|---|---|
| Rehabilitate the wells. | • Provides entire water right from groundwater source.<br>• Increases pumping efficiency. | • Increases operational cost.<br>• Well production may be affected due to nearby agricultural wells. |
| Construct a new water distribution tower. | • Allows for maintained fish production for 30+ years.<br>• Provides better degassing.<br>• Allows for potential upgrades if water quality or temperature changes in the future. | • Increases capital cost. |

| Description | Pros | Cons |
|---|---|---|
| Improve fish rearing and holding using PRASs | • Increases operational flexibility significantly.<br>• Decreases water consumption. | • Increases costs due to equipment/infrastructure purchases and installation.<br>• Increases operating costs.<br>• Increases operational complexity. |
| Improve effluent system. | • Provides more flexibility to use drugs or chemicals while maintaining NPDES requirements.<br>• Allows for continued facility use for 30+ years. | • Increases capital cost.<br>• Increases complexity.<br>• May require significant footprint depending on design requirements. |
| Replace backup generator. | • Provides backup power for all new PRASs.<br>• Follows air emissions regulations. | • Increases capital cost.<br>• May need multiple generators to provide power to all proposed equipment. |
| Improve auxiliary building. | • Allows staff to use this required facility comfortably and safely. | • Increases capital cost. |

## 5.3 Alternatives for Short-Term Improvements

Based on discussions with CDFW, short-term improvements for the Annex focus on returning the facility to a functional state. To restore use of the Annex, the proposed alternatives from Sections 5.1.1, 5.1.4, and 5.1.5 are considered short-term improvements. The upgrades would provide the facility with a reliable water supply, backup power, and administrative building improvements; all of which are required to operate the Annex while meeting CDFW's standards for environmental, animal, and worker conditions.

In addition to the previously proposed alternatives, the raceways would require refurbishment prior to their use. Refurbishment includes repairing any spalling or sections with exposed aggregate with a concrete skim coat, patching any leaks, and ensuring a smooth finish. Once the concrete surface is repaired, a coating is applied which protects the concrete from further deterioration and provides a smooth surface that reduces the risk of abrasion injuries in fish. More information about concrete coating systems is available in Appendix E. Additionally, a roof cover structure is proposed to provide shade for workers and fish, an important safety feature as air temperature is expected to increase significantly. The existing effluent sump pumps and motor control center would also require partial or complete replacement depending on the condition of the equipment.

## 5.4 Natural Environment Impacts

The proposed upgrades to the Feather River Annex 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 upgrades to Annex will change the existing infrastructure and the number of rigid structures on site. However, they will not significantly impact the risk of fire. Historically, the area was managed for flooding through DWR's wells along Highway 99. Operating the facility will increase the well water demand of the area, providing a slight reduction in flood risk of the adjacent highway. Other flood risks are primarily associated with the Thermalito Afterbay and DWR's operation of the Oroville-Thermalito Complex; the proposed upgrades will have no impact on these operations. The recommended changes will slightly increase the total impervious surface of the site, but advanced designs would ensure proper stormwater drainage and discharge throughout the facility. Additionally, replacing the valving and piping will provide the Annex with better flow control into the facility.

### 5.4.2 Effluent Discharge

The recommended changes would result in increased production at the facility. The facility already falls under the General Order NPDES permit as a Cold Water Concentrated Aquatic Animal Production Facility with more than 100,000 pounds of fish produced annually. Based on the NPDES General Order for the Central Valley Regional Water Quality Control Board, there is no specific total maximum daily load of total suspended solids (TSS) but best management practices (BMPs) must be used to limit the impact on waters receiving effluent discharge. Any changes to the facility operation requires amendment of the existing BMP Plan. As such, the proposed upgrades to the Annex would require an updated BMP Plan at a minimum to remain compliant with the NPDES permit. The increase in production and use of PRAS will increase the solids concentration in the effluent water; to limit impacts on the Thermalito Afterbay, additional effluent treatment may be required. The short-term improvements would not alter the operations of the facility outlined in the existing NPDES permit and therefore would not require significant changes or amendments to the BMP Plan.

It is important to note that changes to existing aquaculture programs (renovations, new construction) may trigger (administratively) the requirement for new and/or updated NPDES permits. Acknowledging even a modest increase in waste load (fish biomass) due to increased rearing flexibility provided by the proposed alternatives, we assume that the increase in effluent removal efficiencies provided by the PRASs will result in net effluent “gains” to the overall aquaculture program.

## 5.5 Hatchery Operational Impacts/Husbandry

The proposed upgrades would allow for significantly increased operational flexibility. CDFW is still determining potential best uses of the Annex to assist with overall goals of the hatchery system. Ultimately, egg incubation operations would not be different from those at other CDFW facilities. Fish would have to be manually stocked into the PRAS circular tanks from the Heath stacks, the same processes used at the Feather River Hatchery could be used at the Annex. Fish production in the PRAS circular tanks will result in some changes to existing operations. In the event that fish require transfer from the intermediate system to the large system, a fish pump would minimize handling and stress on the fish during the transfer. If enumeration of the fish is desired, a fish counter may be utilized in conjunction with the fish pump. The proposed design has the intermediate and large PRASs comingled, which provides easy access for the fish pump hose to reach all tanks within both intermediate and large modules. 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.

### 5.5.1 PRAS Circular Tank Operations

The intermediate and large PRASs will operate by 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. Seine 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. It will be important to ensure that maintenance windows are scheduled to service the equipment of each module. All PRASs should be programmed into the facilities maintenance and management system to schedule, perform, and document preventative and corrective maintenance.

### 5.5.3 Feeding

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 of 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, reduce staff labor (but reduces the staff’s observations during feeding), requires adjustments to deliver the correct amount of feed, requires preventative and corrective maintenance and continued cost 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. When surface water from the Thermalito Afterbay was used for operations, vaccination against enteric redmouth disease (causative agent *Yersinia ruckerii*) was required. No other pathogens of concern were specifically identified, though as a salmonid facility there are potential negative impacts associated with costia (*Ichthyobodo* spp.), bacterial kidney disease (causative agent *Renibacterium salmoninarum*), ich (causative agent *Ichthyophthirius multifiliis*), and bacterial coldwater disease (causative agent *Flavobacterium psychrophilum*), among other common fish pathogens. The most likely pathways for pathogens to enter the Annex is through surface water from the Thermalito Afterbay. The proposed upgrades would not require the use of surface water, significantly decreasing the risk of pathogens entering through the water supply. The primary source of introduced pathogens during operation will likely be the transfer of fish from CDFW hatcheries or the wild. Having enough PRAS modules to accommodate these transfers is essential, and it is recommended that staff do not mix groups of fish from different sources or watersheds within the same module.

### 5.6.1 Incoming Water Supply

The proposed upgrades for the Annex capitalize on available groundwater in the area. Typically, groundwater is relatively safe for aquaculture in terms of pathogen loads but water chemistry and quality must be tested to confirm it is within acceptable parameters for fish culture. However, water treatment and distribution equipment are still susceptible to contamination of various pathogens. It is recommended that the facility have maintenance windows scheduled to clean and disinfect the incoming water supply infrastructure.

### 5.6.2 Environmental Exposure/Bio Vectors

The facility has chain link fencing and bird netting covering the raceways, though the structure is aging and does not completely exclude potential predators. Additionally, the facility is located directly adjacent to a busy highway; this increases the risk of members of the public potentially entering the facility. The proposed upgrades would include roof structures for all rearing areas, completely enclosed in fencing. This will significantly reduce the risk of avian predators from entering the rearing areas and transmitting pathogens. Egg incubation would occur in a fully enclosed building, like other CDFW hatcheries. Additional locks will be placed on each rearing area to ensure that members of the public are only allowed entry at the discretion of hatchery staff. A perimeter fence surrounding the entire site will be maintained to provide an additional layer of security.

## 5.7 Water Quality Impacts

The recommended alternatives will improve the water quality within the existing rearing vessels as well as the effluent leaving the facility. Replacing 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 UV disinfection prior to water being discharged into the Thermalito Afterbay. The backwash from the drum filters would be captured in an offline setting pond or concrete vault (septic tank) where solids can be dried (or vacuumed out) and transported to an approved location compliant with all applicable regulations.

# 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 the 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 appropriate overhead and profit markups have been included in the project pricing. The detailed cost estimates, 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 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 assumption is based on $1,000/acre.

- Building joist/eve 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.
- PRAS treatment equipment will be in enclosed non-conditioned areas with sheet metal systems for walls and doors. Ventilation for humidity will be included.
- Four 500kW backup generators are proposed for the new equipment and facilities. It is assumed all existing equipment will be replaced for this facility.
- A facility condition assessment was performed for the Feather River Annex in 2022 by Terracon (Terracon Consultants, Inc. 2022). The assessment included an inventory of all facilities and equipment hatchery, code evaluations, and upgrades required to meet the assessment including the detailed replacement value. The cost of all work items generated was approximately $351,531 in 2022 dollars (not including work items specific to the main Feather River Fish Hatchery). 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 Feather River Annex, 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.

## 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

The narrow site is characterized by limited available space, making it difficult to achieve net zero energy. However, the presence of large open and barren land along the Thermalito Afterbay provides an opportunity to host substantial photovoltaic arrays. Despite this, the remaining 500,000 square feet required to meet energy demands represents a significant obstacle.

## 6.6 Alternative Cost Estimate

The following table illustrates the estimated costs for the preferred improvements evaluated and depicted within the worksheets in Appendix F.

**Table 6-2. Alternative Cost Estimate.**

| Item | Estimate |
|---|---|
| Division 01 - General Requirements (Includes Mobilization/Demobilization) | $ 6,488,000 |
| Division 02 – Existing Conditions | $ 393,000 |
| Division 03 - Concrete | $ 2,137,000 |
| Division 05 - Metals | $ 420,000 |
| Division 07 – Thermal and Moisture Protection | $ 20,000 |
| Division 08 - Openings | $ 60,000 |
| Division 12 – Furnishings | $ 50,000 |
| Division 13 – Special Construction | $ 21,177,000 |
| Division 23 - Mechanical & HVAC | $ 401,000 |
| Division 26 - Electrical | $ 3,910,000 |
| Division 31 - Earthwork | $ 712,000 |
| Division 32 – Exterior Improvements | $ 374,000 |
| Division 33 - Utilities | $ 200,000 |
| Division 40 - Process Water Systems | $ 1,996,000 |
| Division 44- Pumps | $ 590,000 |
| **2024 DIRECT CONSTRUCTION COST** | **$ 38,928,000** |
| Construction Contingency | $ 9,732,000 |
| Overhead | $ 2,336,000 |
| Profit | $ 3,114,000 |
| Bond Rate | $ 390,000 |
| **2024 CONSTRUCTION PRICE** | **$ 54,500,000** |
| Design, Permitting and Construction Support | $ 8,175,000 |
| Geotechnical | $ 25,000 |
| Topographic Survey | $ 5,000 |
| **PROJECT TOTAL** | **$ 62,705,000** |
| Accuracy Range +50% | $ 94,058,000 |
| Accuracy Range -30% | $ 43,894,000 |
| Photovoltaic (Full kW required) | $ 32,753,700 |

# 7.0 Feather River Annex Environmental Permitting

The proposed Project would involve the modification to the existing hatchery or construction of a new hatchery facility and associated infrastructure. 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 Information for Planning and Consultation [USFWS 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 |
| 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 |

| Agency and Permit/Approval | Submittal / Document Type | Supporting Documentation | Anticipated Time Frame | Notes |
|---|---|---|---|---|
| USFWS<br>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)<br>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<br>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 | NA | 1-3 months | Required for hatchery intake diversions |
| Central Valley Regional Water Quality Control Board (RWQCB) 401 Water Quality Certification | Application | Wetland and Stream Delineation USACE Review NEPA/CEQA Compliance | 3 months | Required if jurisdictional waters of the US or wetlands are affected by the project area |
| California Office of Historic Preservation Section 106 Review | Concurrence Request Letter | Cultural Resources Survey, Design Package | 3 months | Required as part of the NEPA/CEQA process |

| Agency and Permit/Approval | Submittal / Document Type | Supporting Documentation | Anticipated Time Frame | Notes |
|---|---|---|---|---|
| California Division of Water Rights<br>Water Rights | Application or Transfer | NA | 4 months | NA |
| California State Water Resources Control Board (SWRCB)<br>National Pollutant Discharge Elimination System (NPDES) | Application | NA | 1 month | Required if hatchery effluent is discharged to a jurisdictional waterway |
| SWRCB<br>Construction General Permit | Application | Stormwater Pollution Prevention Plan (SWPPP) | 2 months | Required if construction activities disturb greater than one acre |

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

| Agency and Permit/Approval | Submittal / Document Type | Supporting Documentation | Anticipated Time Frame | Notes |
|---|---|---|---|---|
| Butte County Development Services | Grading, Building, Electrical, Mechanical, Pumping Applications | Project Summary and Design Package | 2 months | NA |

## 7.1 National Pollutant Discharge Elimination System (NPDES) Permitting

The Feather River Fish Hatchery – Thermalito Annex is classified as a cold water Concentrated Aquatic Animal Production (CAAP) facility and is eligible to operate under General Order R5-2014-0161-032 issued by the Regional Water Quality Control Board, Central Valley (Region 5) and NPDES Permit No. CAG135001. This general order supersedes the previous NOA issued February 1, 2011.

The permit identifies formaldehyde and chlorine as potential pollutants from the hatchery. The following limitations for formaldehyde and chlorine effluent are specified:

- Formaldehyde: 0.65 mg/L (monthly average), 1.3 mg/L (daily maximum)
- Chlorine: 0.018 mg/L (daily maximum)

## 7.2 Water Rights

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

# 8.0 Conclusions and Recommendations

This report provides a summary of the state of the Feather River Annex, identifies and quantifies the main impacts the hatchery could experience as a result of climate change, and provides a set of proposed facility design modifications, along with the associated costs and potential impacts, that would allow the facility to return to operation while protecting it against future climate change.

The in-depth analysis of the available hydrologic and climatologic data performed by NHC provides projections to forecast changes that may be experienced at the hatchery. In general, increases in air temperature are expected at Feather River Annex. The groundwater supply is not expected to warm appreciably, but given current temperatures in the upper range for some stages of fish rearing (i.e., eggs and broodstock), additional warming may require further modifications to the proposed upgrades.

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:

- Rehabilitating the existing wells that supply water to the facility, which may include re-sleeving, repacking, and replacing pumps and/or valves as needed.
- Replacing the existing aeration tower and water distribution. The new structure would include direct oxygenation and chilling to provide optimal rearing conditions for fish of all life stages.
- Replacing the raceways with PRAS modules that would allow for significant flexibility in the Annex's operations. The systems could be used for fish rescue, supplemental production of trout or salmon, research, or development of captive broodstock.
- Constructing a new hatchery building to support egg incubation and early rearing.
- Improving effluent processing. Solids from the concentrated waste flow from PRAS modules would be captured and released off site at approved locations. This would allow for increased production while maintaining NPDES compliance.
- Replacing the existing backup generator and adding more standby generators to ensure new equipment can function during power outages.
- Making general improvements to the administrative areas, including replacing HVAC, paint, furniture, and the construction of a new residence for on-site staff.

The proposed upgrades to the Feather River Annex 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 construction cost estimate of the proposed design modifications is $62,705,000.

# 9.0 References


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