Climate Induced Hatchery Upgrades

San Joaquin Hatchery

Alternatives Analysis Submittal

Final Report
Revision No. 4

February 2025

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Revision Log

Revision No.	Date	Revision Description
0	3/29/2024	65% Draft Internal Technical Review
1	4/5/2024	65% Draft for CDFW Review
2	8/30/2024	100% Draft CDFW and Internal Technical Review
3	10/31/2024	Final Submittal to CDFW
4	2/7/2025	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).

San Joaquin Hatchery has an aging infrastructure and deficiencies that need to be addressed in the near future in order to meet fish production goals. Water treatment limitations, an inadequate water distribution structure (SCARF connection), lack of mid-pond aeration, effluent drain line issues, aged plumbing, raceway deterioration, exposure and predation issues in the raceways, nonfunctioning garage doors on the kokanee building, and limited backup power generation are all items that have been noted to hinder current production. The effects of which will magnify with climate change.

The preferred alternative for hatchery upgrades includes rebuilding the water distribution structure (including water treatment capabilities and temperature control), upgrading aged hatchery valving and piping, replacing asbestos-cement transite piping, incorporating a raceway water reuse system and mid-pond water treatment, covering the production raceways with permanent roof structures including solar panels, repairing and coating raceways, installing circular tanks for the broodstock program, installing water temperature control in the hatchery building, adding chilling capabilities in the kokanee and photoperiod building, repairing the garage door, upgrading the drain piping for effluent systems, and the installing backup power generators.

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. Some operational adjustments may be required to accommodate water reuse systems. The proposed upgrades would provide a solid foundation for CDFW to sustain fish production at the hatchery, even as climate change increasingly disrupts current and future operations.

Project Total	Photovoltaic – Zero Net Energy
$73,822,000	$20,007,000

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 San Joaquin Hatchery is located in the town of Friant, CA along the San Joaquin River and approximately 18 miles north of Fresno, CA (Figure 1-1).

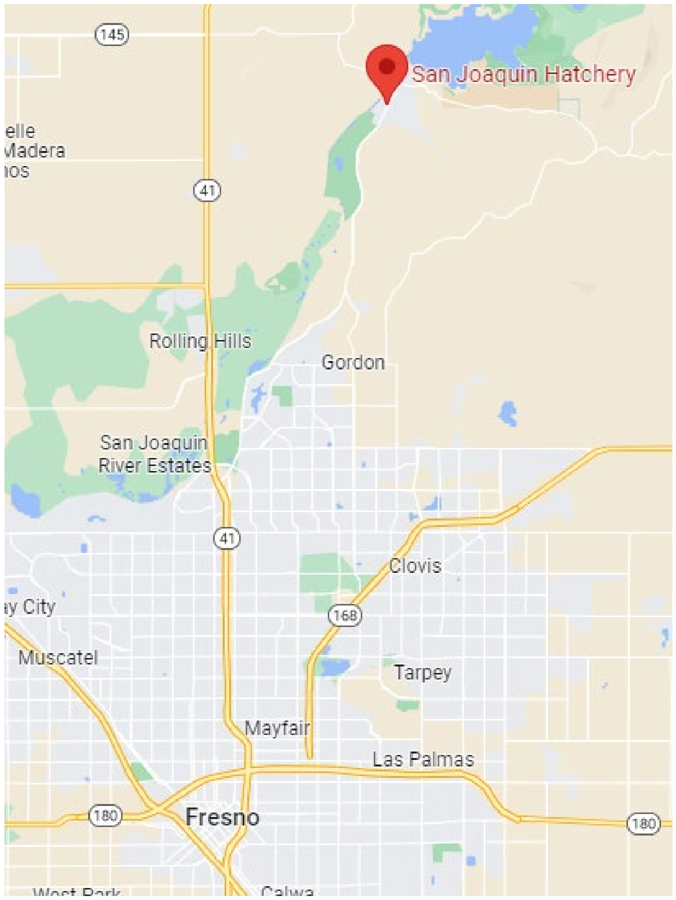

Figure 1-1. San Joaquin Hatchery Location Map.

The San Joaquin Hatchery construction began in 1948, and the hatchery opened in 1954. When opened, the hatchery had 36 ponds, a hatchery building with 104 troughs, and 12 redwood tanks. In 1960, 12 more ponds were built. Currently, the hatchery operates eight 600-foot production raceways, two 400-foot broodstock raceways, a hatchery building containing 22 deep tanks and 60 troughs, and a kokanee and photoperiod building containing 12 deep tanks, 24 hatchery troughs, and six 10-foot-diameter circular tanks. The hatchery is located just downstream of Friant Dam which impounds Millerton Lake. The hatchery's water supply comes from Millerton Lake (via Friant Dam), and two valves (high and low elevations in the lake) provide limited ability to control water temperature for fish rearing. This surface water source is utilized for all fish production activities. The water supply is shared with the Salmon Conservation and Research Facility (SCARF), which is located on site and downstream of the San Joaquin Hatchery. The San Joaquin Hatchery raises Rainbow Trout (*Oncorhynchus mykiss*), Brown Trout (*Salmo trutta*), and kokanee salmon (*O. nerka)* with a production goal of up to approximately 500,000 pounds annually. Additionally, the hatchery is temporarily raising Golden Trout (*O. aguabonita)* for the Moccasin Creek Hatchery until maintenance work performed by the San Francisco Public Utility Commission (SFPUC) is completed in 2026. The hatchery also raises a small number of Brook Trout (*Salvelinus fontinalis)* that are released as a means for biological control of parasitic copepods in the brood ponds. The general hatchery facilities are shown in Figure 1-2. See the Site Visit Report (Appendix B) for additional details regarding descriptions and photos of the existing hatchery.

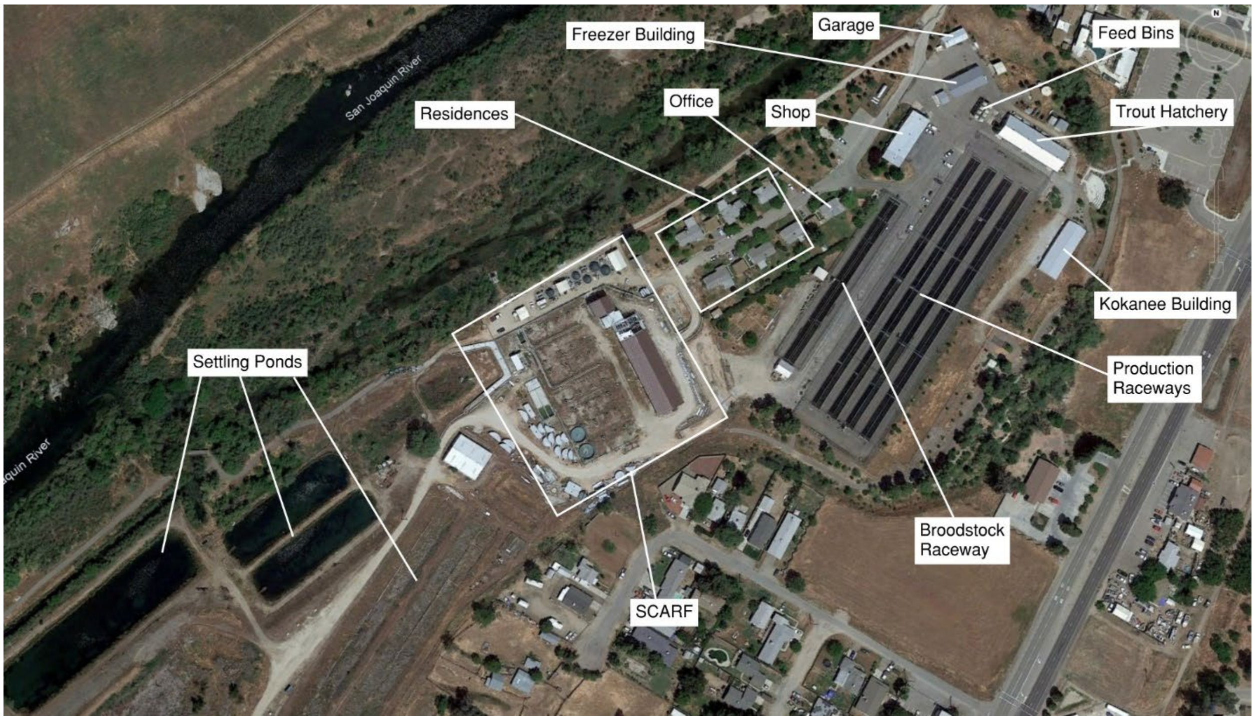

Figure 1-2. San Joaquin Hatchery Facility Layout. Google Earth Image Date: 4/26/2021.

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 San Joaquin Hatchery produces Rainbow Trout, Brown Trout, and kokanee. 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 (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 annual production goal at the San Joaquin Hatchery is 500,000 lbs. of fish released, as provided by CDFW in the initial questionnaire. The production goal for each species is as follows:

- Rainbow Trout: 900,000 fish, weighing 450,000 lbs.
- Brown Trout: 111,000 fish, weighing 11,000 lbs.
- Kokanee: 250,000 fish, weighing 2,500 lbs.

The rearing capacity determined by the Capacity Bioprogram for each species is shown in Table 2-1, Table 2-2, and Table 2-3.

Table 2-1. Production Capacity of the Rainbow Trout Rearing Unit at the San Joaquin Hatchery per the Capacity Bioprogram (Appendix B).

Rearing Unit (max. fish size)	Total Capacity (Fish)[a]	Limiting Factor (Flow or Volume)
Troughs (250 fpp/2.20 inches)	115,830 (463 lbs)	Rearing volume
Deep tanks (100 fpp/2.90 inches)	64,149 (641 lbs)	Rearing volume
600' Raceways (2 fpp/10.8 inches)	251,195 (125,598 lbs)	Water flow
400' Raceway (0.5 fpp/17.1 inches)	27,702 (55,404 lbs)	Water flow

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

Table 2-2. Production Capacity of the Brown Trout Rearing Unit at the San Joaquin Hatchery per the Capacity Bioprogram (Appendix B).

Rearing Unit (max. fish size)	Total Capacity (Fish)[a]	Limiting Factor
Troughs (250 fpp/2.20 inches)	115,830 (463 lbs)	Rearing volume
Deep tanks (100 fpp/2.90 inches)	64,149 (641 lbs)	Rearing volume
600' Raceways (10 fpp/6.30 inches)	91,581 (9,158 lbs)	Water flow

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

Table 2-3. Production Capacity of the Kokanee Rearing Unit at the San Joaquin Hatchery per the Capacity Bioprogram (Appendix B).

Rearing Unit (max. fish size)	Total Capacity (Fish)[a]	Limiting Factor
Troughs (250 fpp/2.40 inches)	50,544 (202 lbs)	Rearing volume
Deep tanks (100 fpp/3.20 inches)	38,610 (386 lbs)	Rearing volume

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

2.2 Bioprogram Summary

The Capacity Bioprogram in the Site Visit Report (Appendix A) demonstrates the total capacity of each rearing area at the San Joaquin 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, Table 2-2, and Table 2-3. At a high level, the total capacity for the San Joaquin Hatchery falls short of the production goal, though nuances of the timing of egg arrivals and fish stocking allows for annual production to exceed this total capacity. 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 San Joaquin Hatchery can be found in Appendix A. For reference, the established criteria are shown in Table 2-4. To model the production cycle schedule for the Production Bioprogram, several assumptions are made and included in Table 2-5. Additional assumptions include the following:

- CDFW will have the ability to have Rainbow Trout eggs available throughout the year by either purchasing eggs from private vendors or through CDFW's own photoperiod programs. This does not account for the Eagle Lake strain of Rainbow Trout which will arrive when eggs are available.

- There will be optimal conditions for egg development and fish growth given the existing water temperatures at the facility.
- All infrastructure is working as intended; in the case of San Joaquin, this assumes that the mid-pond aeration system sufficiently reconditions water for the lower 300-foot raceway sections. Raceways will be organized into 16 sections, each 300 feet long with 3 cubic feet per second (cfs) of available flow based on an optimal mid-pond aeration system.

Klontz (1991) provided optimal growth rates for Rainbow Trout (0.0012 inches per Temperature Unit [TU]) and Brown Trout (0.0007 inches per TU) at designated water temperatures. A TU is defined as 1° F over freezing (32° F) for 24 hours. For kokanee, the optimal growth rate is 0.0007 inches per TU. Survival rates were provided in the questionnaire completed by San Joaquin Hatchery staff.

Table 2-4. Criteria Used for the Production Bioprogram; Discussed in Detail in Appendix B.

Criteria	Value
Density index (DI)	0.3
Flow index (FI)	1.2
Water temperature	Varied 40 to >70°F

Table 2-5. Survival Assumptions Used for the Bioprogram.

Species	Survival
Rainbow Trout	Egg-to-fry: 90% Fry-to-juvenile (250 fpp): 80% Juvenile-to-outplant (2fpp): 95%
Brown Trout	Egg-to-fry: 90% Fry-to-juvenile (250 fpp): 80% Juvenile-to-outplant (2 fpp): 95%
Kokanee	Egg-to-fry: 70% Fry-to-juvenile (100 fpp): 92%

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 the 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 also includes an additional group of production Rainbow Trout which arrives in August based on the assumption of available eggs throughout the year from private purchases or CDFW photoperiod programs.

2.2.2.1 Eagle Lake Rainbow Trout

Eagle Lake Rainbow Trout eggs typically arrive in March and are incubated in hatching jars. In this bioprogram, it is assumed that approximately 282,800 eggs will result in 254,500 fry hatched in late April or early May. Fry will be split evenly among the 60 troughs in the hatchery building (Table 2-6). Ideally, fish are transferred into deep tanks at approximately 400 fpp (1.8 inches). Rainbow Trout are expected to reach 400 fpp size in early June, and their transfer to deep tanks is coordinated with the movement of Brown Trout to the raceways (Table 2-7) to ensure rearing space is available. The Rainbow Trout will require all tank space in the hatchery building to allow the cohort (approximately 203,600 fish) to reach an approximate size of 200 fpp (2.3 inches) in June prior to being transferred to the raceways. The 203,600 fish will then be split evenly among six 300-foot raceway sections in July; initially they will not require the full 300 feet of length or the full 3 cfs of water flow available per raceway. As fish grow, they will be given additional water flow and rearing space. It is expected that fish will reach a catchable size (2 fpp and 10.8 inches) in May, 12 months after first feeding, and can be stocked out after reaching the target size.

Table 2-6. End of Month Production Information for the Eagle Lake Rainbow Trout 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
Apr/May	Trough	60	4,900	0.80	254,500	51.9	0.7	0.08	0.22
May	Trough	60	740	1.51	229,050	309.5	0.7	0.26	0.68
Jun	All Hatchery Tanks	70	200	2.27	203,600	1,018.0	1.4	0.28[a]	0.71
Jul	Raceways	6	84	3.10	202,675	2,412.8	18.0	0.01	0.10
Aug	Raceways	6	39	3.97	201,750	5,173.1	18.0	0.02	0.16
Sep	Raceways	6	22.6	4.83	200,825	8,886.1	18.0	0.03	0.23
Oct	Raceways	6	12.8	5.81	199,900	15,617.2	18.0	0.04	0.33
Nov	Raceways	6	8.0	6.77	198,975	24,871.9	18.0	0.06	0.45

Production Stage/Month	Tank Type	Tanks Occupied	fpp	Length (in)	Total Fish (#)	Biomass (lbs)	Max. Flow (cfs)	DI	FI
Dec	Raceways	6	5.7	7.62	198,050	34,745.6	18.0	0.07	0.56
Jan	Raceways	6	4.4	8.31	197,125	44,801.1	18.0	0.09	0.67
Feb	Raceways	6	3.5	8.88	196,200	56,057.1	18.0	0.10	0.78
Mar	Raceways	6	2.9	9.47	195,275	67,336.2	18.0	0.11	0.88
Apr	Raceways	6	2.4	10.09	194,350	80,979.2	18.0	0.13	0.99
May	Raceways	6	2.0	10.80	193,425	96,712.5	18.0	0.14	1.11

[a] All troughs and deep tanks in the hatchery are required to provide necessary rearing space to maintain the DI criteria for this stage of production.

2.2.2.2 Brown Trout

Brown Trout eggs arrive in January, it is assumed that approximately 130,000 fry hatch into the troughs in late January or early February (Table 2-7). Fish are held in the troughs until mid-April, when they reach approximately 400 fpp (1.8 inches), and 100,500 fish are transferred to deep tanks. Brown Trout transfers from troughs to deep tanks must be coordinated with the receival and hatching of Rainbow Trout fry in troughs to ensure there is enough hatchery space when production overlaps between these species. Brown Trout are only held in the deep tanks during April and May, to provide room in the troughs for incoming Rainbow Trout. At the end of May, the remaining 104,000 fish reach approximately 200 fpp (2.3 inches) and are transferred into a single 300-foot raceway section. Initially, fish may be crowded into a smaller section of raceway and given more room downstream as they grow. Approximately 98,800 fish will reach the target stocking size of 10 fpp (6.3 inches) by the end of January. There is enough space and water flow in the 300-foot raceway section to accommodate the entire population of Brown Trout.

Table 2-7. End of Month Production Information for the Brown Trout 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
Jan/Feb	Trough	60	4,900	0.80	130,000	26.5	0.7	0.04	0.11
Feb	Trough	60	1,880	1.13	123,500	65.7	0.7	0.07	0.19
Mar	Trough	60	740	1.48	117,000	158.1	0.7	0.14	0.36

Production Stage/Month	Tank Type	Tanks Occupied	fpp	Length (in)	Total Fish (#)	Biomass (lbs)	Max. Flow (cfs)	DI	FI
Apr	Deep Tanks	22	364	1.85	110,500	303.6	0.7	0.20	0.50
May	Deep Tanks	22	200	2.27	104,000	520.0	0.7	0.28[a]	0.69
Jun	Raceways	1	127	2.72	103,350	813.8	3.0	0.03	0.22
Jul	Raceways	1	76	3.21	102,700	1,351.3	3.0	0.04	0.31
Aug	Raceways	1	49	3.73	102,050	2,082.7	3.0	0.05	0.42
Sep	Raceways	1	34	4.24	101,400	2,982.4	3.0	0.07	0.52
Oct	Raceways	1	22.6	4.82	100,750	4,458.0	3.0	0.09	0.69
Nov	Raceways	1	15.9	5.39	100,100	6,295.6	3.0	0.11	0.87
Dec	Raceways	1	12.2	5.89	99,450	8,151.6	3.0	0.13	1.03
Jan	Raceways	1	10.0	6.30	98,800	9,880.0	3.0	0.15	1.17

[a] Fish approach the DI criteria in this month, the troughs are unavailable because Eagle Lake Rainbow Trout are hatching during May.

2.2.2.3 Kokanee

Kokanee eggs typically arrive in October and are incubated in a separate hatchery building from the Rainbow and Brown Trout, eliminating potential overlap between the species. Current operations consist of incubating between 1.3 and 1.5 million green eggs to achieve kokanee production goals. This scenario requires hatchery operations to exceed the identified DI and FI criteria or transferring fish to other rearing areas prior to fish reaching their ideal size. Advanced designs would take the egg incubation requirements and the tolerance for planned hatchery operations to deviate from established industry practices into account

For this bioprogram, it is assumed that approximately 100,700 eggs received will result in 70,505 fry hatched and feeding in early December (Table 2-8). Fish are initially spread into 24 troughs and are held until they reach approximately 360 fpp (2 inches) at the end of February. At this point, production reaches the DI threshold in the troughs, and the population of 68,036 fish must be spread into the 12 additional deep tanks, occupying all available tanks in the building. Fish reach approximately 100 fpp (3.2 inches) at the end of May and can be stocked out prior to exceeding the DI criteria.

Table 2-8. End of Month Production Information for the Kokanee 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
Nov/Dec	Trough	24	6,500	0.80	70,505	10.8	0.3	0.04	0.11
Dec	Trough	24	1,520	1.30	69,682	45.8	0.3	0.11	0.29
Jan	Trough	24	678	1.72	68,859	101.6	0.3	0.19	0.49
Feb	Trough	24	360	2.05	68,036	189.0	0.3	0.29[a]	0.77
Mar	All Hatchery Units	36	240	2.41	67,213	280.1	0.7	0.15	0.39
Apr	All Hatchery Units	36	150	2.78	66,390	442.6	0.7	0.21	0.53
May	All Hatchery Units	36	100	3.20	65,567	655.7	0.7	0.27	0.68

[a] Fish approach the DI criteria this month and must be spread into all available early rearing tanks in the building.

2.2.2.4 Additional Production Rainbow Trout

In this bioprogram, an additional production Rainbow Trout group was added to maximize the use of existing rearing infrastructure while staggering production to avoid bottlenecks associated with early rearing. The assumptions for population size, growth, and survival of this group are identical to the Eagle Lake Rainbow Trout (Table 2-6). However, fish size at the end of each month is slightly different because of the varying water temperatures throughout the year. The variability in growth illustrates the potential benefit of accessing warmer water for early rearing; mainly, increasing growth rates in the hatchery building and moving fish into the raceways sooner.

For this group of fish, eggs would be received in August, and fry would be ready to feed by late September or early October (Table 2-9). Approximately 305,400 fish would hatch into troughs, but they would quickly be split into all rearing tanks in the hatchery building by the end of October as they reach 430 fpp (1.8 inches). Fish would reach 200 fpp (2.3 inches) in mid-November and be transferred to six 300-foot sections of raceways; there would be approximately 203,600 fish in the raceways at the end of November. Initially, fish would not require the entire 300 feet in length of each raceway. Spreading the fish into six raceways allows staff to pull screens and provide more downstream space without handling fish and exposing them to additional stress. Fish will remain in the raceways until they reach stocking size in mid-October; the bioprogram demonstrates production to the end of October when approximately 193,425 fish will reach 1.8 fpp (11 inches). This size exceeds the target of 2 fpp (10.8 inches), which provides some flexibility for staff to either stock fish out before the end of October or hold fish slightly longer, if necessary, without exceeding the FI criteria. However, the next cohort of production Rainbow Trout will be stocked into the raceways in November which requires the previous year's cohort to be partially stocked out to free up enough raceways.

Table 2-9. End of Month Production Information for the Production Rainbow Trout 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
Sep/Oct	Trough	60	4,900	0.80	305,400	62.3	0.7	0.10	0.26
Oct	All Hatchery Units	82	430	1.78	254,500	591.9	1.4	0.21[a]	0.53
Nov	Raceways	6	125	2.74	203,600	1,628.8	18.0	0.01	0.04
Dec	Raceways	6	53	3.58	202,675	3,824.1	18.0	0.01	0.08
Jan	Raceways	6	31	4.28	201,750	6,508.1	18.0	0.02	0.12
Feb	Raceways	6	22.6	4.84	200,825	8,886.1	18.0	0.02	0.15
Mar	Raceways	6	15.8	5.44	199,900	12,651.9	18.0	0.02	0.19
Apr	Raceways	6	11	6.06	198,975	18,088.6	18.0	0.05	0.37
May	Raceways	6	7.9	6.77	198,050	25,069.6	18.0	0.06	0.46
Jun	Raceways	6	5.9	7.53	197,125	33,411.0	18.0	0.07	0.55
Jul	Raceways	6	4.2	8.36	196,200	46,714.3	18.0	0.09	0.69
Aug	Raceways	6	3.2	9.23	195,275	61,023.4	18.0	0.10	0.82
Sep	Raceways	6	2.4	10.09	194,350	80,979.2	18.0	0.13	0.99
Oct	Raceways	6	1.8	11.00	193,425	107,458.3	18.0	0.16	1.21

[a] All troughs and deep tanks in the hatchery are required to provide necessary rearing space to maintain the DI criteria for this stage of production and into early November.

2.2.2.5 Summary

The production scenario described here maximizes the use of the hatchery building, where rearing volume in the hatchery building limits the total number of fish that can be transferred to the raceways. The annual Rainbow Trout production of the combined groups (Eagle Lake strain and generic production fish) yields approximately 386,850 catchable fish at 2 fpp (193,425pounds). Brown Trout production totals are 98,800 sub-catchable fish at 10 fpp (9,880 pounds). Operations in the kokanee building would produce approximately 65,567 fish at 100 fpp (655.7 pounds). These totals fall well short of the production goals outlined in Table 2-1, Table 2-2, and Table 2-3 but maintain the established criteria in Table 2-4. Actual operations involve more active culture management strategies, not captured in this high-level analysis, which allow for production to exceed this model.

Staggering the arrival of Rainbow Trout eggs maximizes the use of the hatchery building. An egg shipment that arrives in August also results in more rapid growth during the early life stages because of the warmer water. Average monthly water temperatures from 2019 to 2023 were collected by the California Data Exchange Center (CDEC) at the Friant Dam station. Average water temperatures in August (54.3°F) and September (55.1°F) are at the upper end of the optimal range for Rainbow Trout egg incubation. Performance of Rainbow Trout hatched under summer conditions at the San Joaquin Hatchery is unknown at this time, adoption of this production schedule may require alterations to existing rearing processes at the facility.

A maximum of 13 raceway sections (300 ft each) out of 16 available will be used at a single time in this bioprogram schedule (Figure 2-1). This will allow for multiple opportunities to clean, disinfect, and maintain unused raceways; raceway use can also be rotated on an annual basis to schedule regular maintenance for all raceways. It also provides the staff flexibility to keep fish longer if stocking is delayed without affecting other production programs. The 400-foot broodstock raceways are not included in this model but may be used for super-catchable or trophy production or future broodstock holding if necessary. The total estimated capacity of the 400-foot raceways for adult Rainbow Trout was modeled in the Site Visit Report (Appendix A) and is shown in Table 2-1, Table 2-2, and Table 2-3. Due to limited space in the hatchery building and the relatively cool water temperatures during the winter incubation and hatching period, it is difficult to fully stock raceways without experiencing bottlenecks during the early rearing phase. Water use is expected to peak in October each year with a maximum flow demand of 22.4 cfs (Figure 2-1). Actual water use will be flexible and change throughout the month as determined by staff. Note that the different colored blocks in Figure 2-1 correspond to the months in which each species (Eagle Lake Trout, Brown Trout, kokanee, and production Rainbow Trout) is in either the deep or round tanks or in the raceways, along with noting when eggs are received and incubated.

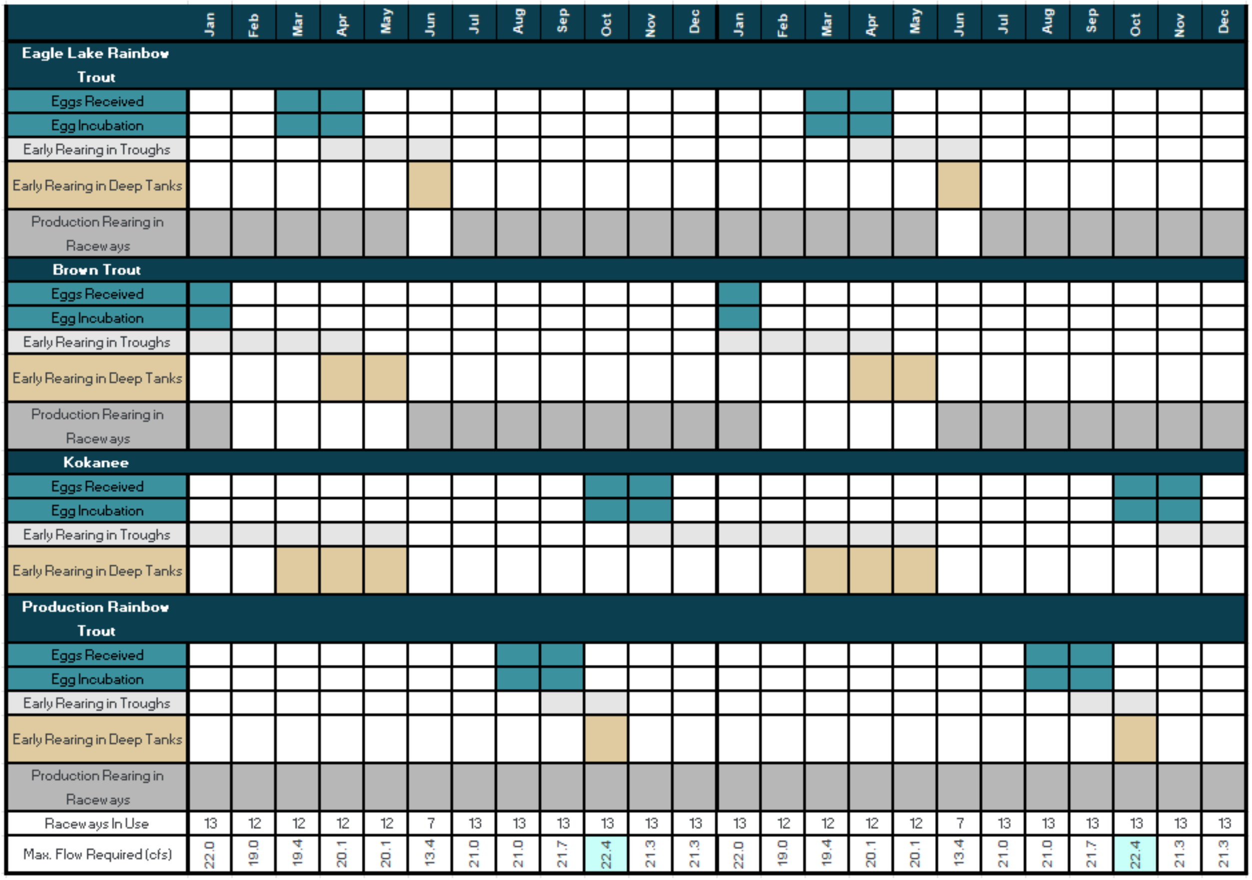

Figure 2-1. Production Rearing Schedule Over 2 Years with Peak Water Demand Occurring Annually in October (as highlighted in the Max Flow Required row).

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). 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 us 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 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

No.	GCM	Research Institution
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.

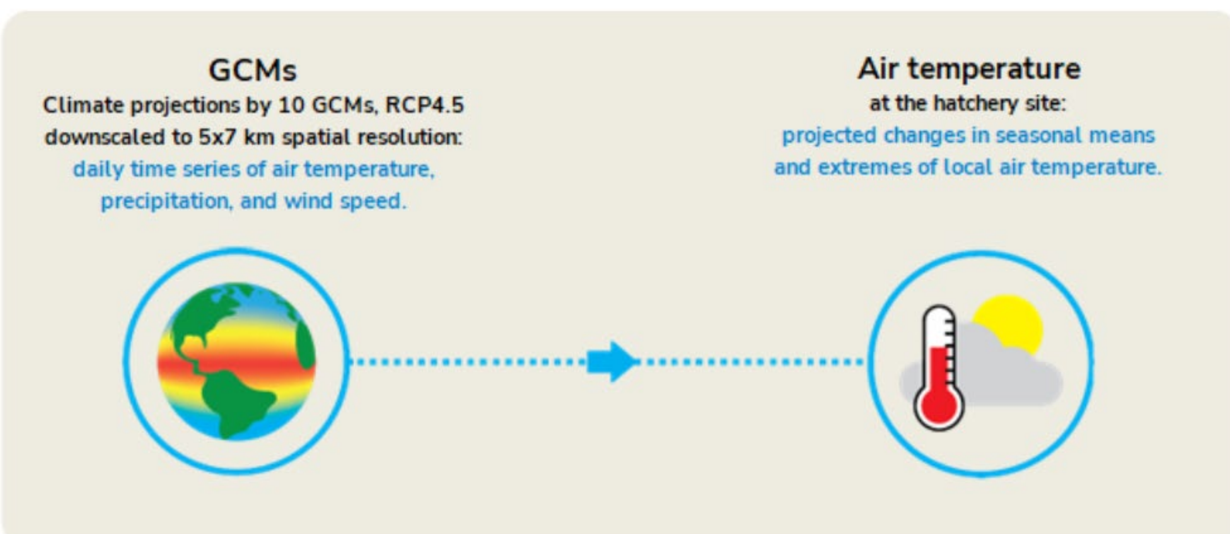

Figure 3-1. Methodology for Obtaining Air Temperature Projections.

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.

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 3-4 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 2.5°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, 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). 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, 3.6°F, reaching 108.6°F. These projections represent potentially hazardous outdoor working conditions at the hatchery.

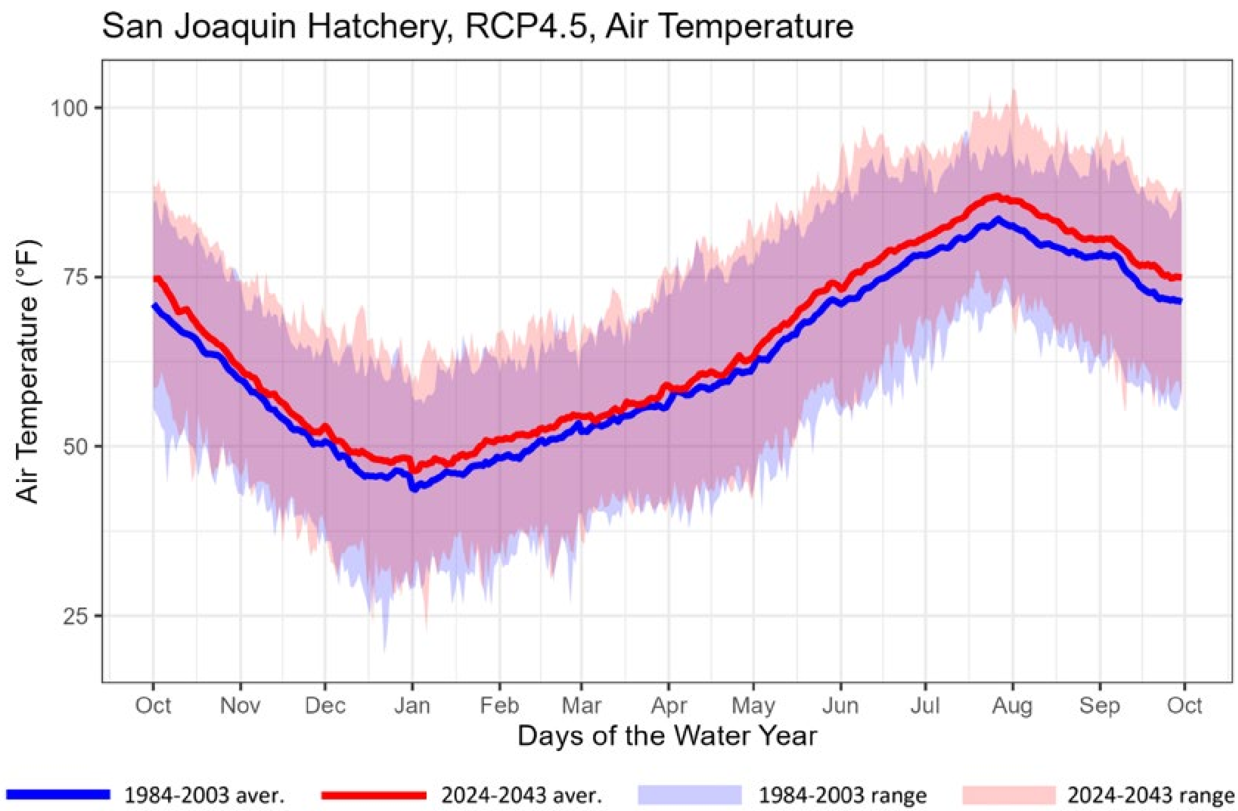

Figure 3-2. Mean Daily Air Temperature and Range for Each Day of the Water Year.

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	65.6°F (+2.5°F)	50.5°F (+2.4°F)	62.4°F (+1.8°F)	81.4°F (+3.2°F)	67.6°F (+2.6°F)
Lowest	65.0°F (+1.9°F)	49.6°F (+1.5°F)	61.8°F (+1.2°F)	80.3°F (+2.1°F)	66.3°F (+1.3°F)
Highest	66.0°F (+2.9°F)	51.0°F (+2.9°F)	63.5°F (+2.9°F)	82.3°F (+4.1°F)	68.5°F (+3.5°F)

Table 3-3. Projected 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	66.7°F (+3.6°F)	51.7°F (+3.6°F)	63.4°F (+2.8°F)	82.8°F (+4.6°F)	68.4°F (+3.4°F)
Lowest	66.0°F (+2.9°F)	50.6°F (+2.5°F)	62.4°F (+1.8°F)	81.4°F (+3.2°F)	67.0°F (+2.0°F)
Highest	67.3°F (+4.2°F)	52.8°F (+4.7°F)	64.0°F (+3.4°F)	84.2°F (+6.0°F)	69.2°F (+4.2°F)

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

GCM	3rd perc.	25th perc.	50th perc.	75th perc.	97th perc.
Ensemble mean	50.4°F (+2.1°F)	64.9°F (+1.9°F)	79.6°F (+2.1°F)	96.6°F (+3.0°F)	108.6°F (+3.6°F)
Lowest	49.4°F (+1.1°F)	64.4°F (+1.4°F)	79.1°F (+1.6°F)	96.1°F (+2.5°F)	107.2°F (+2.2°F)
Highest	51.4°F (+3.1°F)	65.2°F (+2.2°F)	80.3°F (+2.8°F)	97.5°F (+3.9°F)	110.7°F (+5.7°F)

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

GCM	3rd perc.	25th perc.	50th perc.	75th perc.	97th perc.
Ensemble mean	50.4°F (+2.1°F)	64.9°F (+1.9°F)	79.6°F (+2.1°F)	96.6°F (+3.0°F)	108.6°F (+3.6°F)
Lowest	49.4°F (+1.1°F)	64.4°F (+1.4°F)	79.1°F (+1.6°F)	96.1°F (+2.5°F)	107.2°F (+2.2°F)
Highest	51.4°F (+3.1°F)	65.2°F (+2.2°F)	80.3°F (+2.8°F)	97.5°F (+3.9°F)	110.7°F (+5.7°F)

3.5 Fire Risk

Historical wildfires have been documented both in the immediate vicinity of the hatchery and within the watershed perimeter, as mapped in Figure 3-3. About half of the watershed burned in the 2020 Creek fire, while half of the watershed has not burned within the past century (Figure 3-3). Vegetated land cover transitions from grasslands near the hatchery to mostly forested land in the uplands, with anticipated fuel recovery rates ranging from 2 to 5 years in grasslands to more than 10 years in the uplands (depending on the type).

Expressing wildfire risk as a percent chance of occurring at least once in a decade (Westerling, 2018), the projected wildfire risk at the hatchery site is 15% through mid-century (Figure 3-3). Across the uplands, the projected fire risk is higher, with local zones increasing to 40% toward the end of this century.

The primary risks to the hatchery operations include infrastructure impacts from local fires, as well as sedimentation and flooding. Regulated rivers are typically shielded from extreme floods that can impact hatcheries along running rivers, although a major flooding event was reported in 1997. Wildfires can overwhelm intake pipes at dams by increasing runoff and turbidity along burn scars in the basin. Watersheds are most sensitive to flooding and suspended sediment impacts in the first 5 to 10 years after the fire, or the time it takes for new vegetation to mature. The largest risks to the hatchery are therefore increased turbidity and flooding, as well as localized fire-related infrastructure hazards to the hatchery itself.

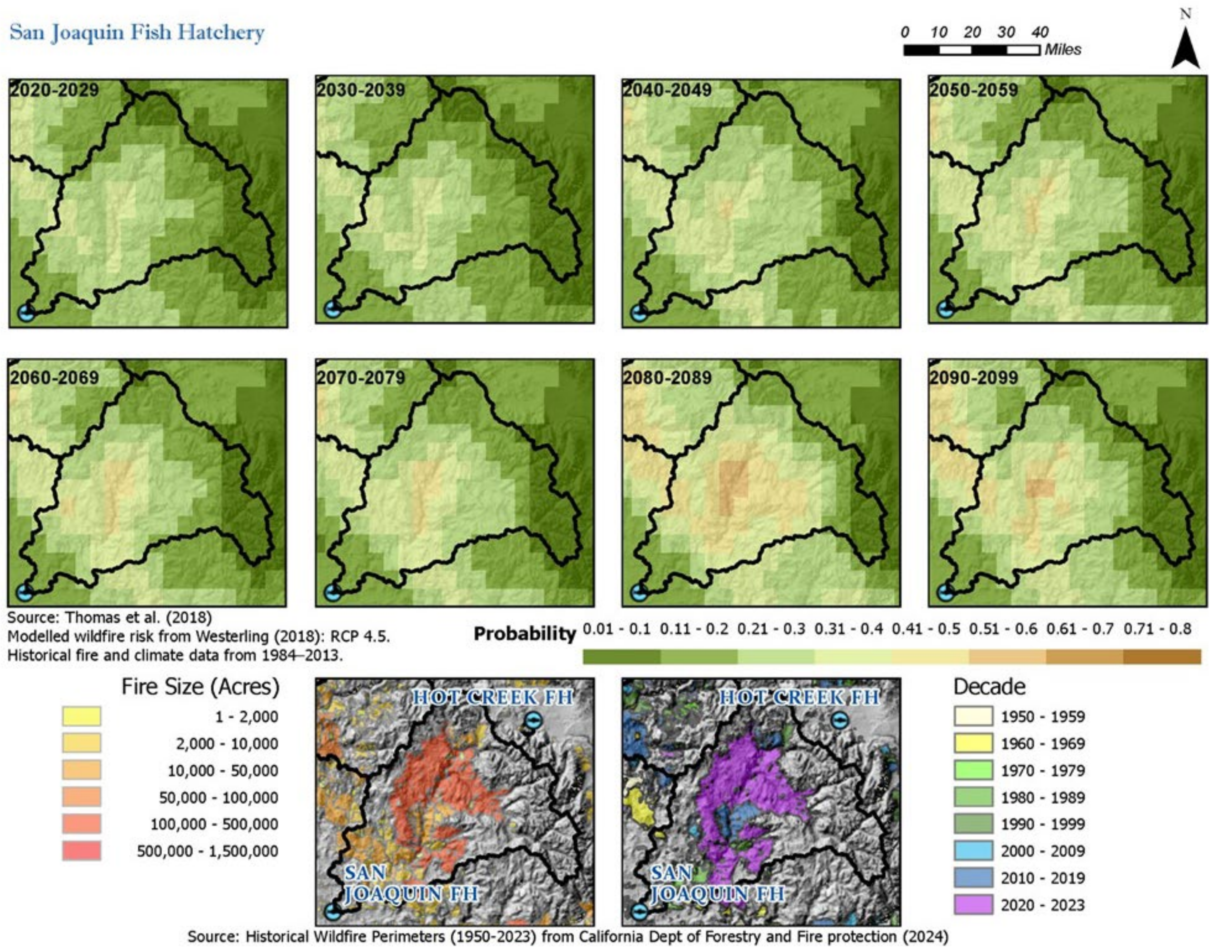

Figure 3-3. Wildfire Risk as Probability of Future Occurrence and Known Historical Fire.

3.6 Conclusions

Significant increases in air temperature are expected for the San Joaquin 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. Days with temperatures representing the 75th percentile and 97th percentile of daily temperatures are projected to warm by 3.0°F and 3.6°F, respectively, in the next 20 years, relative to the reference period.

According to gridded air temperatures for the reference period (1984-2003), the 75th and 97th percentiles of peak daytime temperature (i.e., the temperature at the hottest time of day) were 93.6°F and 105.0°F. For the near-future period (2024-2043), these percentiles are projected to rise to 96.6°F and 108.6°F, respectively. Such an increase in the peak air daytime temperature requires adaptation measures for protection of hatchery workers against heat stroke and other health effects of heat exposure. Roads and roofs may also need to be replaced using more heat-resistant and reflective materials.

The hatchery is at moderate to high risk of wildfires. The projected chance of at least one wildfire occurring in a 10-year period at the hatchery site is estimated as 15% through mid-century. There is a history of fire both within the immediate vicinity of the hatchery, as well as frequent moderate to large fires in the watershed. Post-fire conditions also pose risks to the hatchery, including scar-induced flooding, turbidity, and debris.

4.0 Existing Infrastructure Deficiencies

While the San Joaquin Hatchery is an operational facility, multiple deficiencies were identified during the site visit and described in Section 4 of the Site Visit Report (Appendix A). Section 5.4 of the Site Visit Report identified potential technologies and solutions available to address specific deficiencies that would allow the hatchery to meet production goals and provide protection against climate change. The main areas of concern for the hatchery included insufficient water treatment, inadequate predator exclusion, and outdated plumbing. 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 treating the hatchery water supply using filtration and ultraviolet (UV) disinfection, placing footbaths at the entrance of each hatchery building with Virkon™ Aquatic (Lanxess) alternative, cooperative management plan with SCARF operators, and covering the outdoor rearing vessels with solid roof structure and enclosing the sides. Additional considerations include rebuilding the shared head tank, plumbing upgrades, mid-pond aeration upgrades, the addition of chilling capabilities, effluent drain line upgrades, raceway design using partial recirculating aquaculture systems (PRASs), skim and epoxy coating of raceways, repairing garage doors in the kokanee building, and backup power upgrades. The details of these deficiencies are further expanded upon in Sections 4.1 and 4.2.

4.1 Water Process Infrastructure

4.1.1 Water Treatment Limitations

The hatchery staff have reported several fish health concerns within the hatchery. This has included copepods, bacterial coldwater disease (causative agent *Flavobacterium psychrophilum*), bacterial gill disease (causative agent *F. branchiophilum*), *Gyrodactus* spp., and Ich (causative agent *Ichthyopthirius multifiliis*). One likely pathway for these pathogens to enter the hatchery is through the water supply. There are no water treatment systems to treat incoming water to San Joaquin Hatchery except for an aeration tower that provides small increases in dissolved oxygen concentrations. This leaves the facility susceptible to pathogen exposure, increased turbidity, dissolved oxygen levels below saturation, and large changes in water temperature. The facility experiences slow growth inside the hatchery building when eggs are received during the winter, limiting overall production. However, the cold-water pool in the reservoir can disappear during the summer of severe drought years, which has led to high water temperatures and fish evacuations.

4.1.2 Inadequate Water Distribution Structure (SCARF Connection)

The CDFW-operated Salmon Conservation and Research Facility (SCARF) is constructed in a way that its intake plumbing diverts water from the intake pipe before it reaches the San Joaquin Hatchery aeration tower. The aeration tower acts as the head box and water distribution structure. Water flows through packed columns into a concrete sump and is then diverted throughout the hatchery. The existing shared intake negatively affects the head pressure generated in the aeration tower and limits the water flow to other areas of the hatchery. Additionally, the water right for the San Joaquin Hatchery is 35 cfs, but the hatchery typically gets 37 cfs to compensate for fluctuation at the meter. The SCARF can take up to 20 cfs. The steel pipe intake from Friant Dam was designed to provide 50 cfs, a 5 to 7 cfs deficit if full water rights were required at both facilities simultaneously. More recent information suggests that the pipe is not capable of providing the full 50 cfs, leading to an even larger potential flow deficit.

4.1.3 Lack of Mid-Pond Aeration System

There is a mid-pond aeration system, but it has been shut down due to the presence of asbestos in the piping and disease concerns from mixing the water from all raceways. Additionally, a lack of backup power generation to supply power to the mid-pond aeration equipment resulted in an unreliable system in the event of a power outage. There is no aeration apart from the initial aeration/distribution tower for the hatchery. The lack of additional aeration leads to dangerously low dissolved oxygen levels in the raceways when water temperatures and rearing densities are high. Aeration is less of a concern in the shorter broodstock raceways because rearing densities are typically lower and ample water flows through the ponds.

4.1.4 Effluent Drain Line Issues

The effluent piping has improper draining and backs up effluent water into the raceways. This prevents the full use of the raceways and presents a biosecurity risk for the facility. All effluent from both hatchery buildings and raceways comes to a shared effluent pipe that leads to a distribution box shared with the SCARF. From the distribution box, water splits to lower settling ponds 1 and 2. Other pipes connect the lower settling ponds to the upper settling ponds, wetland ponds, and the final pond before discharge, however, these ponds are not currently in use due to missing infrastructure.

4.1.5 Aged Plumbing

CDFW reported that the water conveyance piping and valves throughout the hatchery are functioning, but should be replaced due to aging, not being exercised regularly, and containing asbestos in some areas. One area of specific concern is the asbestos-coated steel pipe carrying water from the aeration tower, which is functioning, but clearly flaking above ground. There have not been catastrophic failures of the systems, but there is a need for preventative maintenance to avoid issues in the future.

4.2 Rearing Infrastructure

4.2.1 Raceway Deterioration

The concrete raceways are showing signs of deterioration due to age. According to CDFW, raceway sinkholes require frequent filling. Additionally, subsurface drainage through the degrading concrete has been reported in some of the raceways.

4.2.2 Exposure and Predation Issues in Raceways

The raceways are enclosed in chain-link fencing with bird netting and wire strung across the top. However, fish in the raceways still experience predation. In addition to 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 predation netting and wire above, the raceways experience direct sunlight during increased temperature periods in the summers. Prolonged exposure to sunlight and UV rays warms the water, can cause sunburn on the fish, and damages the infrastructure. As noted in Section 3.0, air temperatures at San Joaquin Hatchery are projected to increase in the future among the highest of all California hatcheries studied. Additionally, current operating water temperatures have already been reported to reach the upper range for salmonids during drought years and when the cold-water supply in the reservoir is depleted.

4.2.3 Nonfunctioning Garage Doors on Kokanee Photoperiod Building

The garage doors for the photoperiod area in the kokanee building do not work and limit access to the rearing tanks within. This limited access provides operational challenges, specifically when transferring fish to and from the photoperiod tanks.

4.3 Limited Backup Power Generation

The primary electrical loads are the water treatment equipment and the photoperiod system, including lighting control and automatic feeders. No backup generators are available to provide backup power to the hatchery equipment. Additionally, CDFW reported the facility's power from Pacific Gas and Electric (PG&E) to be a significant economic burden on the hatchery's operations.

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 Rebuild Aeration Tower

The existing aeration tower acts as the headbox and water distribution structure. The SCARF is constructed in a way that its intake plumbing diverts water from the shared intake pipe before it gets to the San Joaquin Hatchery aeration tower. This limits the head pressure generated in the aeration tower and limits the water flow to other areas of the San Joaquin Hatchery. Rebuilding the aeration tower with a shared head tank for SCARF and San Joaquin Hatchery is recommended. The new aeration tower and head tank would be designed to accommodate up to 60 cfs of constant flow, to accommodate potential future changes to the water supply infrastructure at the Friant Dam that would provide both the SCARF and San Joaquin Hatchery with their full water right. Overflow water would be diverted back to the San Joaquin River. The head tank would include separate chambers for each hatchery with the water surface elevation (WSEL) in each chamber controlled by stoplogs. Throttling valves would be incorporated into the head tank design to allow for additional control over water flows to each facility. The reconfiguration of the SCARF connection to the hatchery supply pipe could reduce impacts on inflow and associated fluctuations. Drafting a cooperative management plan with the operators from the SCARF is also recommended for better management of the shared water supply for both programs. Best management practices should be specified with the goal of maintaining consistent operations and biosecurity for both facilities and any shared infrastructure.

It is assumed that there would be multiple packed columns and that the water would discharge into the head tank below. Based on standard packed column design, an average of 100 gpm of flow needs 1 square foot of packed column area for proper aeration/stripping. Outdoor-rated exhaust-type blowers would be mounted to the packed columns to pull air up through the packed column media, improving the gas exchange rate from air to water.

5.1.2 Valving and Piping

Various valves and pipes across the hatchery are more than 50 years old. 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 the hatchery to continue operating into the future.

5.1.2.1 Replace Transite Asbestos Piping

Water travels through an asbestos-coated steel pipe from the aeration tower. The pipe is currently functioning but flaking above ground. The selected alternative is to upgrade the old piping throughout the hatchery. The entire transite asbestos piping would be replaced. Replacing the piping would secure operation for 40+ years and improve the safety of the workers.

5.1.3 Raceway Upgrades

5.1.3.1 Water Reuse System for Broodstock and Production Raceways

High water temperatures in the raceways have resulted in fish evacuations from the raceways, and temperatures are expected to worsen in the future (see Section 3.0). Year-round chilling of water is not expected to be necessary in the next 30 years; however, the period of dangerously high water temperatures is expected to lengthen in this time frame. A dedicated chiller and water reuse system is proposed for the production raceways to allow the facility to maintain operations during these periods of high water temperatures.

For all raceways (production and broodstock) to operate at full capacity, the required flow rate is approximately 31 cfs. To reduce the size and operational costs of the chiller, the raceways will also be paired with water reuse systems. These reuse systems will operate between a 50% and 75% recirculation rate, this will reduce the total flow required from the chiller so that it is between 7.75 (75% recirculation) and 15.5 (50% recirculation) cfs. It is assumed that a temperature differential of 10°F would be required for severe drought years when water temperatures can reach the mid-70s. The water chiller would be sized to chill a portion of the required flow to maintain adequate grow-out temperatures and would only be used intermittently to avoid fish evacuations.

From the chiller, or through a bypass, water would be conveyed to the raceway PRAS modules. For production raceways each with a flow of 3 cfs, there would be two modules with four raceways per module (12 cfs total flow per module). Each of these PRAS modules would be designed with water reconditioning and treatment equipment to process up to 9 cfs of water flow to provide a recirculation rate of 75%. The recirculation equipment would include pumps, filters, UV disinfection, degassing, and oxygenation and be able to pull water from the mid-pond, or the bottom of each raceway. A separate PRAS module would be outfitted for the broodstock raceway pair. The broodstock raceways receive approximately 3.4 cfs each, or 6.8 cfs for the entire PRAS module. The broodstock PRAS module would have the same water treatment components as the production raceway modules, but they would be sized to treat approximately 5.1 cfs of recirculated water for a 75% reuse rate. All modules will be designed to operate at lower recirculation rates; it is recommended that CDFW does not exceed a 50% recirculation rate until staff are familiar with the equipment and processes. All PRAS modules would have the ability to operate with water supplied to the raceways directly from the aeration tower, bypassing the chiller when water temperatures are acceptable for trout production.

5.1.3.2 Mid-Pond Water Treatment

Due to asbestos exposure concerns and a lack of a backup power supply, the aeration system at San Joaquin Hatchery was shut down. The dissolved oxygen levels in raceways are dangerously low when water temperatures and rearing densities are high. There is currently only limited water reconditioning equipment at the San Joaquin Hatchery consisting of in-house made aeration screens. The current mid-pond aeration system previously used at the facility and currently used at other CDFW hatcheries mixes water from all raceways before discharging it to lower sections. This system poses a biosecurity risk by potentially transmitting pathogens among the raceways. To maintain separation between the raceways, a new mid-pond oxygenation system is proposed.

The preferred alternative is to install low-head oxygenators (LHOs) at the midpoint in each raceway to improve oxygen levels throughout the length of the raceways. LHOs require an oxygen source, and it is assumed that the facility will generate its own oxygen gas. Advanced designs would evaluate the feasibility and cost of bulk oxygen sources to determine what, if any, cost savings are available. The system will also require supply lines to the LHOs (for the mid-pond system and raceway PRASs) and oxygen flow meters. Installing LHOs in the raceways would increase oxygen levels and improve the overall water quality. Additionally, the hatchery may be able to increase production and maximize the use of the existing raceways. If the drop in the raceways is not sufficient for LHOs, a series of airlift systems would be installed as a secondary alternative.

5.1.3.3 Production Raceways Building with Solar Panels

The construction of a new 105,600 SF building is proposed to cover and provide protection to the production raceways. The proposed building will shelter the eight existing 600-foot-long production raceways as well as the proposed PRAS treatment units (see Section 5.1.3.1). The cover will also include chain-link fencing and predation netting around the sides to exclude potential predators. The roof cover has the potential to significantly reduce predation and provide a relatively cooler area for fish and staff. The climate analysis in Section 3.0 forecasted some of the most significant air temperature increases at the San Joaquin Hatchery out of the 21 included in the Project. The roof cover over the raceways will help mitigate some of the climate change impacts in the future, keeping workers safe and providing more protection for the fish. This would be a pre-engineered metal building (PEMB) with standard finishes.

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

5.1.3.4 Cover Broodstock Raceways with Permanent Roof Structures with Solar Panels

Covering the broodstock raceways with a solid roof structure 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 400-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 maintaining temperatures within the range for salmonids.

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

5.1.3.5 Raceway Skim Coating and Epoxy Coating

The concrete in the raceways is showing signs of aging, including sinkholes and subsurface drainage. The abrasive surface caused by aging can be harmful to fish as well as providing 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. At this time, sinkholes would be filled, and ground penetrating radar could be used to provide a pre-survey (see Section 5.3.2). 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 to 15 years. Applying a coat to the concrete creates a surface which is easier to clean, provides for a smoother rearing environment, improves solids movement to the tail end of the raceways, does not promote algae growth, reduces sun and water exposure to the aging concrete underneath, and protects the tanks from further deterioration. Additional reconstruction may be required in the broodstock ponds where much of the rock in the concrete is missing.

5.1.4 Rearing Building Upgrades

5.1.4.1 Hatchery Building

Production at the facility can be limited during early rearing due to the relatively cold water received from the Friant Dam intake. SCARF operations with threatened and endangered species take priority in terms of water quality needs for the intake system. As a result, relatively cool water is supplied to both facilities in the winter when the San Joaquin Hatchery performs its egg incubation and early rearing. The cold water reduces the ability of culturists at the San Joaquin Hatchery to grow fish quickly and transfer them to the raceways, which impacts their ability to accept additional egg shipments. This creates a production bottleneck that affects all aspects of production.

The selected alternative is to provide water tempering control for the hatchery building to allow for heating to optimal production temperatures based on temperature fluctuation in the water supply. The flow rate for the entire building at full operation is approximately 1.3 cfs; the water tempering equipment would be sized to treat up to 1.8 cfs by increasing the water temperature up to 5° Fahrenheit to allow for potential future expansion and provide an additional factor of safety.

5.1.4.2 Kokanee and Photoperiod Building

The San Joaquin Hatchery has made recent upgrades to prepare for the start of a photoperiod broodstock program. This will have positive impacts on production timing and flexibility for all CDFW inland hatcheries and reduce the strain on CDFW hatcheries that supply eggs. However, water temperatures in Millerton Lake are not suitable for broodstock holding when the cold-water pool is depleted during drought years.

The selected alternative is to install a water chiller for the photoperiod broodstock system. The current system requires a flow rate of 30 gpm for each of the six tanks, or 180 gpm total. Due to broodstock water temperature requirements being more stringent, the proposed temperature differential is assumed to be 15°F. The proposed chilling system would be sized to treat a flow rate of up to 250 gpm for potential future expansion, requiring a 200-ton chiller.

Alternatively, to reduce chilling requirements the system may be outfitted as a PRAS. This would require an adjacent structure to house water treatment equipment that would include pumps, filtration, UV disinfection, degassing, and oxygenation. All tanks would be included in the PRAS, the equipment would be sized to treat up to 135 gpm for a recirculation rate of 75%; this would require only 45 gpm of fresh makeup water for the PRAS. It is recommended that recirculation rates begin at 50% or below until staff are familiar with operations and equipment.

5.1.4.3 Garage Door Repair

The garage doors for the photoperiod area do not work and limit access to the tanks. There have been recent upgrades to the electrical system in the building to prepare for the photoperiod program. The selected alternative is to repair or replace the garage doors to ensure access to the photoperiod tanks is available.

5.1.5 Upgrade Drain Piping for Effluent Systems

Eight effluent ponds accommodate flows from the San Joaquin Hatchery and SCARF. The effluent drain line has improper draining and backs up effluent into the raceways. All effluent from both hatchery buildings and raceway sets comes to a shared effluent pipe that leads to a distribution box shared with the SCARF. From the distribution box, water splits to lower settling ponds 1 and 2. Other pipes connect the lower settling ponds to the upper settling ponds, wetland ponds, and the final pond before discharge. The solids settle out before final discharge. The selected alternative would be to upgrade the drain piping to size/grade for appropriate drainage all the way to the effluent ponds or separate from SCARF. Coordination between SCARF and San Joaquin Hatchery operators will be required.

5.1.6 Install Backup Power Generation

The primary power draws at the facility include the photoperiod lighting control and the automatic feeders, as well as the proposed water treatment and reuse equipment. Currently, there are no standby emergency generators at the San Joaquin Hatchery. For the power source and the primary load sources, there is no power used to distribute the water from the Friant Dam. The selected alternative would be to install necessary generators to ensure that adequate backup power is available to accommodate the water treatment equipment and photoperiod system. Additionally, solar panels would be installed on each of the proposed raceway cover structures to offset the power requirements (see Sections 5.1.3.3 and 5.1.3.4).

5.2 Pros/Cons of Selected Alternative

Table 5-1 provides a high-level summary of the pros and cons for San Joaquin Hatchery's selected alternative.

Table 5-1. Pros/Cons of Selected Alternative – San Joaquin Hatchery.

Description	Pros	Cons
Rebuild aeration tower.	• Resolves issues with SCARF by reducing head pressure with the current configuration. • Increases the efficiency of the water distribution system. • Improves oxygenation of production water.	• Increases cost due to redesign and installation. • Disrupts hatchery operations during construction.
Replace defective valving and piping.	• Improves operability and control of flow. • Increases hatchery infrastructure lifespan.	• Increases cost due to installation. • Disrupts hatchery operations during construction.
Replace transite asbestos piping.	• Secures operation for 40+ years. • Improves worker safety.	• Disrupts hatchery operation during construction. • Increases cost due to the replacement of piping and the removal and disposal of asbestos.
Install a water reuse system, using PRAS, for broodstock and production raceways	• Increases water quality. • May maintain production, while decreasing water consumption. • Prevents fish evacuations and lost production time because of chilled water. • Helps maintain water temperatures and lower energy costs by reusing chilled water with the PRAS.	• Increases operating costs. • Increases cost due to treatment equipment, installation, and continued maintenance of equipment. • Disrupts hatchery operations during construction.

Description	Pros	Cons
Add mid-pond water treatment.	• May increase production capacity of raceways due to mid-pond oxygenation. • Provides optimal rearing conditions the entire length of the raceways.	• Disrupts hatchery operations during installation. • Requires on-site oxygen generation for the LHOs and increases operating costs.
Cover production and broodstock raceways with permanent roof structures that have rooftop solar panels.	• Provides better working conditions for staff and fish as air temperatures are forecasted to increase. • Reduces the warming of water during recirculation. • Reduces predation exposure. • Offsets expensive energy requirements with solar panels.	• Increases cost due to cover structure installation.
Apply skim coating and epoxy coating to the raceway.	• Provides a smoother rearing environment. • Reduces algae growth. • Protects concrete from further deterioration.	• Disrupts hatchery operations during raceway resurfacing. • Has unknown subsurface conditions.
Increase the temperature of the water in the hatchery building.	• Eliminates production bottleneck. • Provides flexibility for the production schedule. • Is controlled by San Joaquin Hatchery and not subject to SCARF requirements.	• Increases operational costs.
Add a water chiller to the PRAS for the kokanee and photoperiod building.	• Provides an optimal environment for broodstock. • Expands CDFW’s trout egg supply and increases programmatic redundancy.	• Increases operational costs.
Upgrade drain piping for effluent systems.	• Improves biosecurity. • Ensures the entire raceway length is available for fish production.	• Requires coordination to maintain compliance with SCARF because the system is shared between facilities. • Increases costs associated with rerouting.

Description	Pros	Cons
Repair garage door.	• Provides direct access to transfer fish. • Increases efficiency in transferring fish.	• Increases cost.
Install backup power generation.	• Provides backup power in case of potential disruptions. • Increases operational reliability.	• 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 Rebuild Aeration Tower

The shared distribution and aeration structure requires rebuilding to ensure that both San Joaquin Hatchery and the SCARF receive adequate water to run their facilities. The SCARF is constructed in a way that its intake plumbing diverts water from the intake pipe before it gets to the San Joaquin Hatchery aeration tower. This limits the head pressure generated in the aeration tower and limits the water flow to other areas of the San Joaquin Hatchery. For more information about the proposed rebuild, refer to Section 5.1.1. The additional water treatment and temperature control are not included in this short-term improvement.

5.3.2 Refurbish Raceway Deterioration

Currently, there are sinkholes in four of the eight raceways. The short-term solution is to pressure grout the sinkholes in the affected raceways. In the dry raceways, ground-penetrating radar would be used to pre-survey potential impact. After raceway repairs, the application of a skim coating is recommended. See more details regarding coating alternatives and general refurbishment in Section 5.1.3.5.

5.3.3 Upgrade Drain Piping for Effluent Systems

Due to the biosecurity concern of effluent backing up into the raceways, the effluent drain piping requires an upgrade. The size/grade of the drain line should be modified for appropriate drainage all the way to the effluent ponds, or separate drains for the hatchery and the SCARF should be installed. For more information about the proposed effluent upgrades, refer to Section 5.1.5.

5.4 Natural Environment Impacts

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

5.4.1 Fire and Flood Risk

The recommended changes to the San Joaquin Fish Hatchery will change the existing infrastructure and the number of rigid structures on site. However, they will not have an impact on fire risk at the facility. The climate change evaluation did not include an assessment of fire risk for the hatchery but based on general trends it is expected that fire risk will either remain similar to current conditions or slightly increase as a result of climate change impacts.

The hatchery previously experienced a major flood event in 1997 caused by heavy rains that overwhelmed Millerton Lake and the Friant Dam. Flood risk remains in the event of high runoff periods or a dam failure. Generally, flooding severity in the San Joaquin watershed is expected to increase as a result of climate change impacts (DWR 2022).

5.4.2 Effluent Discharge

The current effluent system for the San Joaquin Hatchery does not effectively convey wastewater to the effluent ponds. Aside from effluent water backing up into the hatchery, no other issues were identified with the effluent system that prevents the hatchery from maintaining their NPDES requirements. The proposed upgrades for the facility do not include an overall increase in production goals and should not have a significant impact on the effluent water quality. Additionally, the implementation of mid-pond water treatment will result in a net increase in dissolved oxygen for water discharged from the raceways ultimately improving effluent water quality. 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

Implementing a raceway reuse system will require some slight changes to hatchery operations. Consistent communication with the Bureau of Reclamation to determine potential changes in water temperatures would be required to start the reuse system when water temperatures are forecasted to increase beyond acceptable levels. The reuse system would require more consistent monitoring of water quality characteristics to ensure that dissolved oxygen and ammonia levels do not increase to dangerous levels. Monitoring would also apply to the mid-pond aeration system to ensure it is working as intended during production. Upgrades to valving and piping throughout the hatchery will help ensure that staff can accurately adjust water flows to specific areas when changing between flow through and reuse operations. Early rearing, fish transfers throughout the hatchery, stocking operations, and feeding would continue as normal.

5.5.1 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. The PRAS modules will be operated seasonally during times when water temperatures approach the upper threshold for salmonids. This provides a wide window for maintenance activities to occur throughout the remainder of the year. All PRASs should be programmed into the facilities maintenance and management system to schedule, perform, and document preventative and corrective maintenance.

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 San Joaquin Fish Hatchery reported several pathogens of concerns at the facility that include bacterial coldwater disease (causative agent *Flavobacterium psychrophilum*), other mixed bacterial infections, and a variety of external parasites. The most likely pathways for pathogens to enter the San Joaquin Hatchery and spread through the facility is through the incoming water supply or environmental exposure within the hatchery.

5.6.1 Incoming Water Supply

The San Joaquin Hatchery currently has limited measures to prevent pathogens from entering the facility. However, the recommended alternatives improve biosecurity by managing and treating the incoming water supply before it enters the facility. Filtration and UV disinfection will improve the quality of supply water, reducing debris loads and pathogen abundance.

5.6.2 Environmental Exposure/Bio Vectors

The existing facility has several areas that are potential pathways for pathogens due to environmental exposure. The existing concrete raceways are enclosed by perimeter fencing with bird netting overtop, but these structures are minimally effective in excluding predators from accessing the raceways. The hatchery also has issues with effluent water backing up into raceways, potentially exposing fish to poor water quality conditions and higher pathogen loads. The recommended alternatives reduce the risk of pathogens entering the rearing areas by adding solid roof covers and fencing for more substantial predator exclusion infrastructure. Additionally, repairing the drainage of the effluent system will eliminate the risk of water backing up into raceways.

5.7 Water Quality Impacts

The recommended alternatives will improve the water quality within the rearing vessels as well as the effluent leaving the facility. Treating the incoming water will result in significantly improved quality throughout the facility from egg incubation to broodstock holding. Additionally, incorporating mid-pond water treatment in the raceways will provide a better environment for fish at the downstream end of the raceways which currently receive the lowest quality water in the facility. Both of these treatment systems, incoming and mid-pond, will improve the quality of water discharged to the effluent ponds and ultimately back into the San Joaquin River. Operation of the raceway reuse system will result in a higher concentration of waste in the effluent stream. However, the turnover time of water in the effluent ponds would be proportionally decreased, allowing adequate time for settling of suspended solids. Combined with the added benefit of initial filtration and disinfection of the water supply, operation of the raceway reuse system is not anticipated to impact the hatchery’s ability to maintain NPDES guidelines.

6.0 Alternative Cost Evaluation

6.1 Introduction

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

6.2 Estimate Classification

This OPCC estimate is consistent with a Class 5 estimate as defined by the Association for Advancement of Cost Engineering (AACE) classification system, as shown in Table 6-1 below. As stated in the estimate description below, "Class 5 estimates are generally prepared based on very limited information and subsequently have wide accuracy ranges." 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.

Criteria	Details
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.
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/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 San Joaquin Fish 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 $2,365,119 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 San Joaquin Fish 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 STOK have reviewed and assessed the 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

This small site faces considerable challenges in achieving net zero energy due to its potentially high energy demands and limited space. Although a large parking lot could accommodate a photovoltaic shading array, ownership issues may restrict its use, complicating efforts to meet energy requirements. Only 21% of capacity is currently achieved on proposed roof structures. To reach net zero energy, an additional 300,000 square feet of greenspace would need to be covered in PV panels.

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	$	7,638,000
Division 02 – Existing Conditions	$	85,000
Division 03 – Concrete	$	3,079,000
Division 05 – Metals	$	170,000
Division 07 – Thermal and Moisture Protection	$	20,000
Division 08 – Openings	$	20,000
Division 13 – Special Construction (Buildings and Aquaculture Equipment)	$	26,214,000
Division 23 – Mechanical & HVAC	$	207,000
Division 26 – Electrical	$	6,870,000
Division 31 – Earthwork	$	357,000
Division 32 – Exterior Improvements	$	190,000
Division 40 – Process Water Systems	$	981,000
2024 CONSTRUCTION COST	**$**	**45,831,000**
Contingency	$	11,458,000
Overhead	$	2,750,000
Profit	$	3,666,000
Bond Rate	$	459,000
2024 TOTAL CONSTRUCTION COST	**$**	**64,164,000**
Design, Permitting and Construction Support	$	9,625,000

Item		Estimate
Geotechnical	$	25,000
Topographic Survey	$	8,000
PROJECT TOTAL	**$**	**73,822,000**
Accuracy Range +50%	$	110,733,000
Accuracy Range -30%	$	51,676,000
Photovoltaic (Full kW required)	$	20,007,000
Photovoltaic (Roof kW available)	$	3,601,800

7.0 San Joaquin 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 conveyance infrastructure but would only impact areas downstream from the Friant Dam. 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 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

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

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

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

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

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

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

Agency and Permit/Approval	Submittal / Document Type	Supporting Documentation	Anticipated Time Frame	Notes
Fresno County Building and Safety	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 San Joaquin Hatchery is classified as a cold water Concentrated Aquatic Animal Production (CAAP) facility and is eligible to operate under General Order R5-2019-0079-012 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 April 26, 2019.

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)

7.3 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 San Joaquin 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 hydrologic data performed by NHC provides projections to forecast changes that may be experienced. In general, significant increases in air and water temperature are expected at San Joaquin Hatchery. Additionally, there is an increasing risk of wildfire in the near future and as the climate changes.

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. Increasing 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:

- Replacing the existing head tank with a new aeration tower and head tank sized to accommodate both the San Joaquin Hatchery and the SCARF.
- Installing chilling and boiler capabilities to provide added control over production water temperatures.
- Constructing new pre-engineered metal buildings to cover the production and broodstock raceways.
- Installing new PRAS modules to improve water quality when the facility experiences high temperatures.
- Installing new mid-pond oxygenation to increase DO levels throughout the length of the raceways.
- Performing raceway repairs including skim or epoxy coating.
- Installing PRAS equipment for photoperiod broodstock system to allow fish to be held at optimal temperatures.
- Upgrading the existing effluent pipe to maintain positive drainage to the effluent ponds.
- Providing new backup power generators to ensure that hatchery staff can maintain production operations during periods of power outages.
- Adding centralized monitoring to allow for improved control and oversight of flows throughout the facility.

- Installing solar panels atop new structures to offset some of the power demands associated with new hatchery equipment.

The proposed upgrades to the San Joaquin Hatchery would have negligible impacts on the natural resources in the surrounding area. All improvements would occur within currently developed areas, which lessen the permitting requirements. The total cost estimate of the proposed design modifications is $73,822,000.

9.0 References

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