Climate Induced Hatchery Upgrades

Darrah Springs Hatchery

Alternatives Analysis Submittal

Final Report
Revision No. 3

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Revision Log

Revision No.	Date	Revision Description
0	2/15/2024	65% Draft Submittal
1	8/9/2024	Draft Final Submittal
2	10/31/2024	Final Report
3	1/31/2025	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
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- 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).

Darrah Springs Hatchery has an aging infrastructure and deficiencies that need to be addressed in the near future to meet fish production goals. Low oxygen levels in the raceways due to broken low head oxygenator (LHO) equipment hinders production, water treatment facilities (drum screen and UV) are currently non-functional, incoming water contains high levels of debris which damages water treatment facilities, the raceway pump-back system exposes fish to additional pathogens, there is a lack of functional early rearing space, difficulty of operating and maintaining broodstock ponds, sun exposure, and predation issues 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 replacing existing concrete raceways with circular culture tanks supplied with partial recirculating aquaculture systems (PRASs), adding early rearing circular culture tanks with PRASs, and moving the broodstock into new concrete raceways connecting to a new spawning building. All rearing spaces would be covered with a solid roof and include predation netting and fencing on the sides. Additionally, the intake structures would be modified to allow for debris management and potential spring source water collection.

The Class 5 Opinion of Probable Construction Cost (OPCC) for constructing the preferred alternative upgrades can be found in the table below (Table 6-2 provides the Class 5 OPCC summary). The table also includes the estimated cost of photovoltaic systems to offset the energy consumption of the new equipment and to maintain zero net energy. These upgrades would not significantly affect fire or flood risks at the facility, and all work would occur within already developed areas. Operationally, CDFW would need to update feeding, harvesting, and water quality monitoring protocols to accommodate the transition to partial recirculating aquaculture systems with circular tanks. These 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.

Total Cost Estimate	$99,544,000
Photovoltaic for ZNE	$22,810,000

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 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 to achieve 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

Darrah Springs Hatchery is located approximately 35 miles southeast of Redding, CA (Figure 1-1).

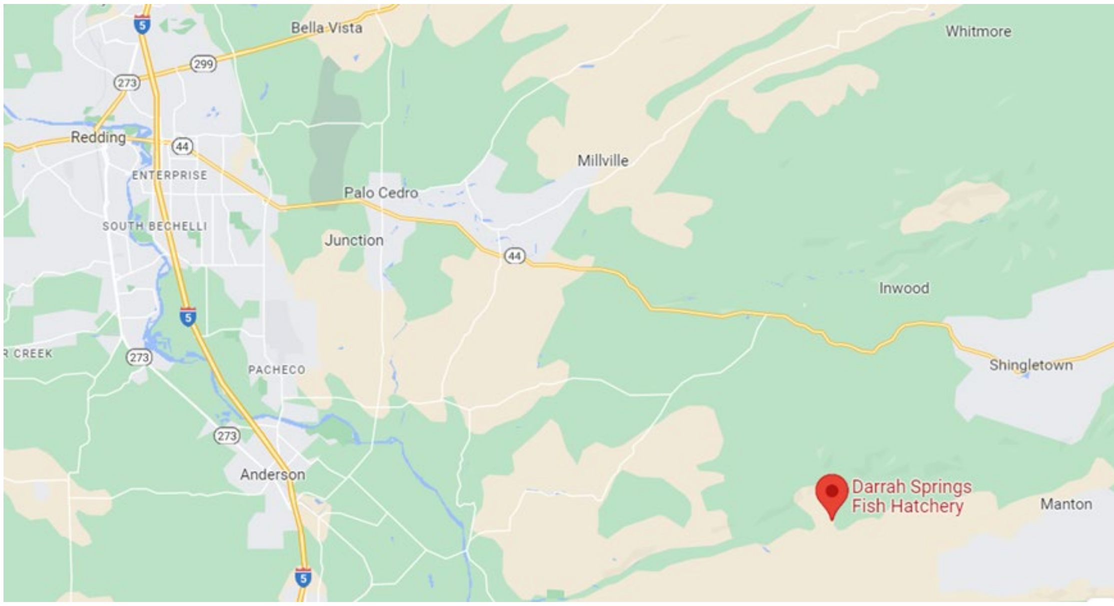

Figure 1-1. Hatchery Vicinity Map.

The Darrah Springs Hatchery raises 3-4 strains of Rainbow Trout (Oncorhynchus mykiss) with a production goal of 400,000 pounds. The hatchery utilizes a spring-fed gravity flow-through system for the early rearing tanks (i.e., troughs and deep tanks) and for the raceways. The exception to the use of this system is the two mid-pond aeration stations located at the mid-point of both the upper and lower raceways to increase oxygen levels of the water before flowing by gravity to the lower halves of raceways. The hatchery also utilizes a single pump located below the broodstock ponds to add water to the lower raceways (i.e., pump station to lower raceways). The general hatchery facilities are shown in Figure 1-2. See the Site Visit Report (Appendix A) for more details and photos regarding the existing hatchery facilities.

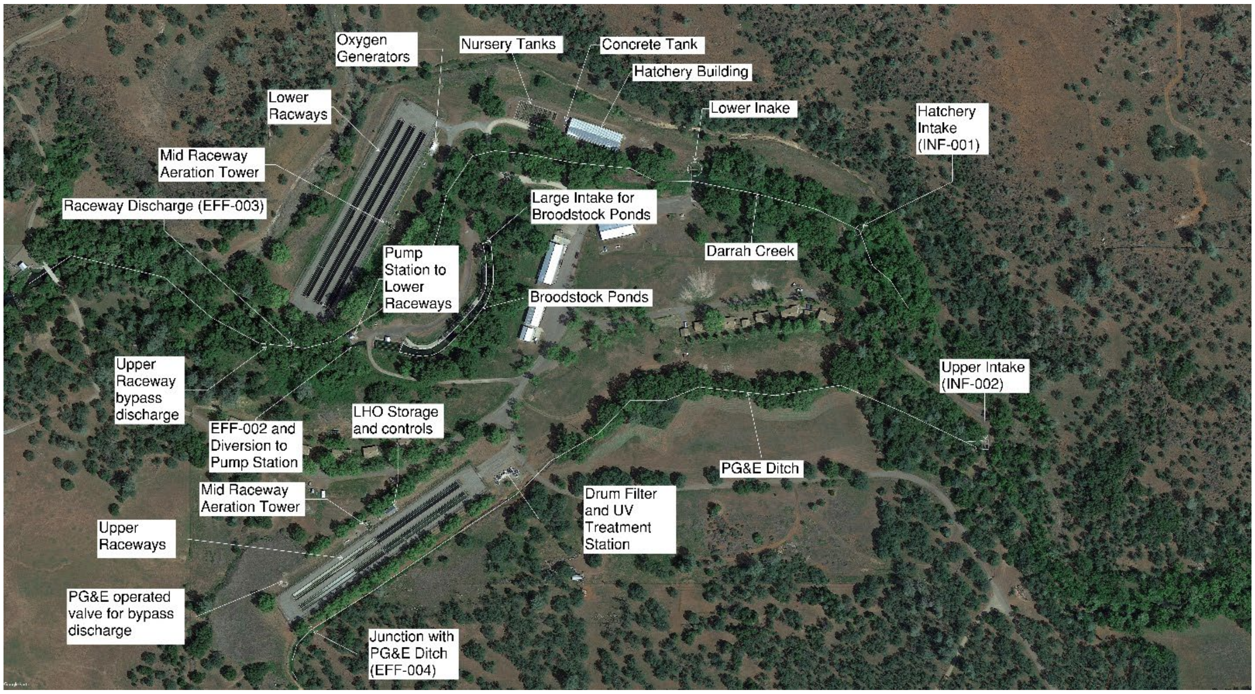

Figure 1-2. Darrah Springs Facility Layout. Google Earth image date: April 28, 2021.

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 most 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 Darrah Springs Hatchery produces several strains (i.e., Colorado, West Virginia, and Eagle Lake strains) of Rainbow Trout. The current production goals for the Darrah Springs Hatchery are shown in Table 2-1.

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 Darrah Springs Hatchery is 400,000 pounds of catchable Rainbow Trout at 2 fish per pound (fpp) each (800,000 fish total), as provided by CDFW in the initial questionnaire. The fish production rearing capacity determined by the Capacity Bioprogram is shown in Table 2-1.

Table 2-1. Production Capacity of Various Rearing Units at the Darrah Springs Hatchery per the Capacity Bioprogram (Appendix A).

Rearing Unit (max. fish size)	Total Capacity (Fish)[a]	Limiting Factor
California Troughs (60 fpp/3.47 inches[b])	6,698	Rearing Volume
Deep Tanks (60 fpp/3.47 inches)	250,152	Rearing Volume
Total Hatchery Building (60 fpp/3.47 inches)	256,850	Rearing Volume
Raceways (2 fpp/10.8 inches)	437,260	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.
[b] This is the size requested by CDFW to allow for vaccinations for enteric redmouth disease (100 fpp) and Lactococcus and to cover the size window when bacterial coldwater disease typically occurs. The preferred method of treatment of bacterial coldwater disease is “Pen G” via bath treatment, which is most feasible prior to the fish being transferred into the raceways.

2.2 Bioprogram Summary

The Capacity Bioprogram in the Site Visit Report (Appendix A) demonstrates the total capacity of each rearing area at the Darrah Springs Hatchery for several stages of fish production. The capacity of each rearing area (-10% to provide an additional safety factor), limited by water flow or available rearing volume, is shown in Table 2-1. At a high level, the total capacity for the Darrah Springs 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 a 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 Darrah Springs Hatchery can be found in Appendix A. For reference, the established criteria are shown in Table 2-2. To model the production cycle schedule for the

Production Bioprogram, several assumptions were made and included in Table 2-3. 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 to maximize fish production at the facility.
- The mid-pond aeration systems for the upper and lower raceways are operational and restore oxygen levels to saturation for the lower 300-foot sections of the 10 raceways.
- There will be optimal conditions for egg development and fish growth given the existing water temperatures at the facility.

Klontz (1991) provided optimal growth rates (0.04 inches per day) for Rainbow Trout at designated water temperatures. Survival rates were provided in the questionnaire completed by Darrah Springs Hatchery staff.

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

Criteria	Value
Density Index (DI)	0.5
Flow Index (FI)	1.32
Water Temperature	Consistent 57° to 59°F

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

Stage	Value
Egg-to-fry	67%
Fry-to-juvenile (250 fpp)	67%
Juvenile-to-outplant (2 fpp)	80%

2.2.2 Production Bioprogram

This bioprogram (Appendix A) 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 uses three separate Rainbow Trout egg receivals, pulse 1 (Eagle Lake-Hatchery Origin), pulse 2, and pulse 3, to stagger early rearing and maximize annual production.

2.2.2.1 Eagle Lake Rainbow Trout Pulse 1

Assuming that eggs are received in early January (pulse 1), it takes approximately 1.5 months from fertilization (i.e., green eggs) to first feeding which would begin in mid-February when fish are approximately 4,218 fpp (0.84 inches). These fish should reach approximately 60 fpp (3.5 inches) in mid-April (Table 2-4). At this time, fish may be transferred to outdoor raceways per CDFW's preferences following any procedures for vaccinations and/or bath treatments and broodstock selection. In this exercise, it is assumed that approximately 560,000 eggs are incubated, 373,000 fry are hatched from those eggs, and approximately 250,000 juvenile fish are transferred to the raceways based on survival rates provided by Darrah Springs Hatchery staff. The 250,000 juveniles are started equally in two raceways (125,00 fish each) initially, but as they grow, they will occupy six raceways to achieve their final target release size of approximately 2.0 fpp (10.8 inches) in October.

Table 2-4. End of Month Production Information for the Pulse 1 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
Early Rearing Feb/Mar	Deep Tanks	50	109.1	2.8	277,778	2,546.1	3.3	0.34	0.60
Apr 15	Deep Tanks	50	60.0	3.5	250,000	4,166.7	3.3	0.45	0.80
Apr	Raceways[a]	2	37.9	4.0	245,715	6,483.2	6.5	0.11	0.55
May	Raceways	2	17.0	5.3	241,430	14,201.8	6.5	0.18	0.92
Jun	Raceways	4	9.2	6.5	237,145	25,776.6	13.0	0.13	0.68
Jul	Raceways	4	5.4	7.7	232,860	43,122.2	13.0	0.19	0.96
Aug	Raceways	6	3.5	9.0	228,575	65,307.1	19.5	0.16	0.83
Sep	Raceways	6	2.4	10.2	224,290	93,454.2	19.5	0.20	1.05
Oct	Raceways	6	1.7[b]	11.4	224,290	131,935.3	19.5	0.26	1.32

[a] Calculations for the raceways are based on 300-ft length assuming the mid-pond aerators restore oxygen levels for the lower 300-ft sections.

[b] This size fish exceeds the target of 2 fpp, which pushes the FI to the maximum established for the hatchery. Fish should be stocked out promptly when they achieve 2 fpp size.

2.2.2.2 Rainbow Trout Pulse 2

Once pulse 1 fish are transferred out of the hatchery building, a new cohort of eggs arrives approximately May 1 (pulse 2). It is assumed that this cohort has the same fish and survival numbers as pulse 1 and that the water temperature is relatively constant at Darrah Springs. Additionally, we assume incubation timing and growth rates used for this exercise are the same. Assuming that eggs are received approximately May 1, it takes approximately 1.5 months from fertilization (i.e., green eggs) to first feeding which would begin in mid-June when fish are approximately 4,218 fpp (0.84 inches). These fish should reach approximately 60 fpp (3.5 inches) in mid-August (Table 2-5). As with pulse 1, fish may be transferred to outdoor raceways per CDFW's preferences following any procedures for vaccinations and/or bath treatments and broodstock selection. In this exercise, it is assumed that approximately 560,000 eggs are incubated, 373,000 fry are hatched from those eggs, and approximately 250,000 juvenile fish are transferred to the raceways based on survival rates provided by Darrah Springs Hatchery staff. The 250,000 juveniles are started equally in two raceways (125,00 fish each) initially, but as they grow, they will occupy six raceways to achieve their final target release size of approximately 2.0 fpp (10.8 inches) in February.

Table 2-5. End of Month Production Information for the Pulse 2 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
Early Rearing Jun/Jul	Deep Tanks	50	109.1	2.8	277,778	2,546.1	3.3	0.34	0.60
Aug 15	Deep Tanks	50	60.0	3.5	250,000	4,166.7	3.3	0.45	0.80
Aug	Raceways[a]	2	37.9	4.0	245,715	6,483.2	6.5	0.11	0.55
Sep	Raceways	2	17.0	5.3	241,430	14,201.8	6.5	0.18	0.92
Oct	Raceways	4	9.2	6.5	237,145	25,776.6	13.0	0.13	0.68
Nov	Raceways	4	5.4	7.7	232,860	43,122.2	13.0	0.19	0.96
Dec	Raceways	6	3.5	9.0	228,575	65,307.1	19.5	0.16	0.83
Jan	Raceways	6	2.4	10.2	224,290	93,454.2	19.5	0.20	1.05
Feb	Raceways	6	1.7[b]	11.4	224,290	131,935.3	19.5	0.26	1.32

[a] Calculations for the raceways are based on 300 ft length assuming the mid-pond aerators restore oxygen levels for the lower 300 ft sections.

[b] This size fish exceeds the target of 2 fpp, which pushes the FI to the maximum established for the hatchery. Fish should be stocked out promptly when they achieve 2 fpp size.

2.2.2.3 Rainbow Trout Pulse 3

Once pulse 2 fish are transferred out of the hatchery building, a new cohort of eggs arrives approximately September 1 (pulse 3). It is assumed that this cohort has the same fish and survival numbers as pulses 1 and 2 and that the water temperature is relatively constant at Darrah Springs. Additionally, we assume incubation timing and growth rates used for this exercise are the same. Assuming that eggs are received approximately September 1, it takes approximately 1.5 months from fertilization (i.e., green eggs) to first feeding which would begin in mid-October when fish are approximately 4,218 fpp (0.84 inches). These fish should reach approximately 60 fpp (3.5 inches) in mid-December (Table 2-6).

As with pulse 1, fish may be transferred to outdoor raceways per CDFW's preferences following any procedures for vaccinations and/or bath treatments and broodstock selection. In this exercise, it is assumed that approximately 560,000 eggs are incubated, 373,000 fry are hatched from those eggs, and approximately 250,000 juvenile fish are transferred to the raceways based on survival rates provided by Darrah Springs Hatchery staff. The 250,000 juveniles are started equally in two raceways (125,00 fish each) initially, but as they grow, they will occupy six raceways to achieve their final target release size of approximately 2.0 fpp (10.8 inches) in June.

Table 2-6. End of Month Production Information for the Pulse 3 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
Early Rearing Oct/Nov	Deep Tanks	50	109.1	2.8	277,778	2,546.1	3.3	0.34	0.60
Dec 15	Deep Tanks	50	60.0	3.5	250,000	4,166.7	3.3	0.45	0.80
Dec	Raceways[a]	2	37.9	4.0	245,715	6,483.2	6.5	0.11	0.55
Jan	Raceways	2	17.0	5.3	241,430	14,201.8	6.5	0.18	0.92
Feb	Raceways	4	9.2	6.5	237,145	25,776.6	13.0	0.13	0.68
Mar	Raceways	4	5.4	7.7	232,860	43,122.2	13.0	0.19	0.96
Apr	Raceways	6	3.5	9.0	228,575	65,307.1	19.5	0.16	0.83

Production Stage/Month	Tank Type	Tanks Occupied	fpp	Length (in)	Total Fish (#)	Biomass (lbs)	Max. Flow (cfs)	DI	FI
May	Raceways	6	2.4	10.2	224,290	93,454.2	19.5	0.20	1.05
Jun	Raceways	6	1.7[b]	11.4	224,290	131,935.3	19.5	0.26	1.32

[a] Calculations for the raceways are based on 300 ft length assuming the mid-pond aerators restore oxygen levels for the lower 300 ft sections.

[b] This size fish exceeds the target of 2 fpp, which pushes the FI to the maximum established for the hatchery. Fish should be stocked out promptly when they achieve 2 fpp size.

2.2.2.4 Summary

It should be noted that the FIs and DIs at the end of each month for pulse 1, 2, and 3 are within the criteria specified in Table 2-2 (with the exception of the final month of rearing where fish potentially exceed the target size which drives the FI to the facilities maximum); this provides additional flexibility to reduce flows for smaller fish or to hold fish in a raceway for longer to accommodate other logistical needs. Ultimately, production is limited by the water flow available in each raceway when fish reach a catchable size.

The three-pulse cycle continues year after year on the same schedule. This staggered production allows for several opportunities to depopulate and clean rearing areas, perform routine maintenance, and so on, while producing approximately 672,870 catchable size fish weighing approximately 395,806 pounds. The modeled production is just below the hatchery's goal without making any infrastructure changes based on the assumptions for the bioprogram (Table 2-3) and the recommended DI and FI criteria for the water temperatures at the facility.

There is flexibility within the program to rear fish in the hatchery building to a larger size if required, but flows limit the total number of fish transferred to the raceways to reach a catchable size. Once fish reach the target stocking size, they should be stocked out relatively soon to open rearing space for the next cohort of fish and because the FI criteria will be exceeded if fish continue to grow (Table 2-5 and Table 2-6).

Water demand will be the highest on the months each cohort achieves its target release size (i.e., February, June, and October) as shown in Figure 2-1. The water flow specified in Figure 2-1 is meant to show the flow requirement assuming all rearing areas are supplied with the maximum water flow. In practice, once fish have been transferred from the hatchery building to the raceways, they will likely not require the maximum water flow until they reach a larger size, at which time, flow will limit the production in the raceways. Note that the different colored blocks in the following figure correspond to the months for when each species/pulse group is in the deep tanks or the raceways, along with noting when eggs are received and incubated.

ELT-H Pulse 1, RBT Pulse 2, and RBT Pulse 3	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ELT-H Pulse 1: Eggs Received																								
ELT-H Pulse 1: Egg Incubation																								
ELT-H Pulse 1: Early Rearing in Deep Tanks																								
ELT-H Pulse 1: Production Rearing in Raceways																								
RBT Pulse 2: Eggs Received																								
RBT Pulse 2: Egg Incubation																								
RBT Pulse 2: Early Rearing in Deep Tanks																								
RBT Pulse 2: Production Rearing in Raceways																								
RBT Pulse 3: Eggs Received																								
RBT Pulse 3: Egg Incubation																								
RBT Pulse 3: Early Rearing in Deep Tanks																								
RBT Pulse 3: Production Rearing in Raceways																								
Max. Flow Required (cfs)	27.0	**36.8**	16.3	29.3	27.0	**36.8**	16.3	29.3	27.0	**36.8**	16.3	29.3	27.0	**36.8**	16.3	29.3	27.0	**36.8**	16.3	29.3	27.0	**36.8**	16.3	29.3

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

3.0 Climate Evaluation

3.1 Introduction

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

There is a risk of flooding posed by locally generated runoff during intense rainstorms. The hatchery reports that *"Our water problem tends to be too much water coming through during storm events. We are in the neck of the drainage for the surrounding area, so we receive runoff from several square miles."* Examination of the local drainage using the StreamStats website map from USGS (2019) shows a small watershed (3 square miles), located between Baldwin Creek and Battle Creek, which drains in the direction of the hatchery. Projections of daily peak flows are highly uncertain for such a small watershed and instead are presented for the larger Baldwin Creek (ca. 13 square miles) to obtain an indication of the direction of change in peak flows. Projections of daily streamflows are uncertain, and daily peaks can be much smaller than instantaneous peaks; therefore, projections should be viewed with caution. Snowfall is infrequent at the hatchery or over the surrounding watersheds; therefore, snowfall projections were not considered for this hatchery.

3.2 Water Sources

The Darrah Springs Hatchery's questionnaire responses indicate that water for the hatchery comes exclusively from two naturally occurring water springs, while a well supplies potable water to the offices, fire hydrants, and eleven residences. The hatchery staff report that these springs *"have been a reliable water source for decades,"* adding that *"even in drought years when wells and ditches above us in Monton have been drying up, our water has remained plenty to raise fish and supply our domestic water needs."*

3.3 Methodology for Climate Change Evaluation

This study uses future climatic and hydrologic projections based on global climate model (GCM) simulations associated with the data set known as CMIP5, which was part of the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC 2014). The projections in this report are based on results from 10 different global climate models under the Representative Concentration Pathway (RCP), RCP 4.5 scenario of future greenhouse gas emissions, which represents a future with modest reductions in global emissions compared to current levels.

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

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

No.	GCM	Research Institution
1	ACCESS-1.0	CSIRO, Australia
2	CanESM2	Canadian Centre for Climate Modelling and Analysis, Canada
3	CCSM4	National Center for Atmospheric Research, United States
4	CESM1-BGC	National Science Foundation, Department of Energy, and National Center for Atmospheric Research, United States
5	CMCC-CMS	Centro Euro Mediterraneo per Cambiamenti Climatici, Italy
6	CNRM-CM5	Centre National de Recherches Météorologiques / Centre Européen de Recherche et Formation Avancées en Calcul Scientifique, France/European Union
7	GFDL-CM3	NOAA Geophysical Fluid Dynamics Laboratory, United States
8	HadGEM2-CC	Met Office Hadley Centre, United Kingdom
9	HadGEM2-ES	Met Office Hadley Centre, United Kingdom
10	MIROC5	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies, Japan

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

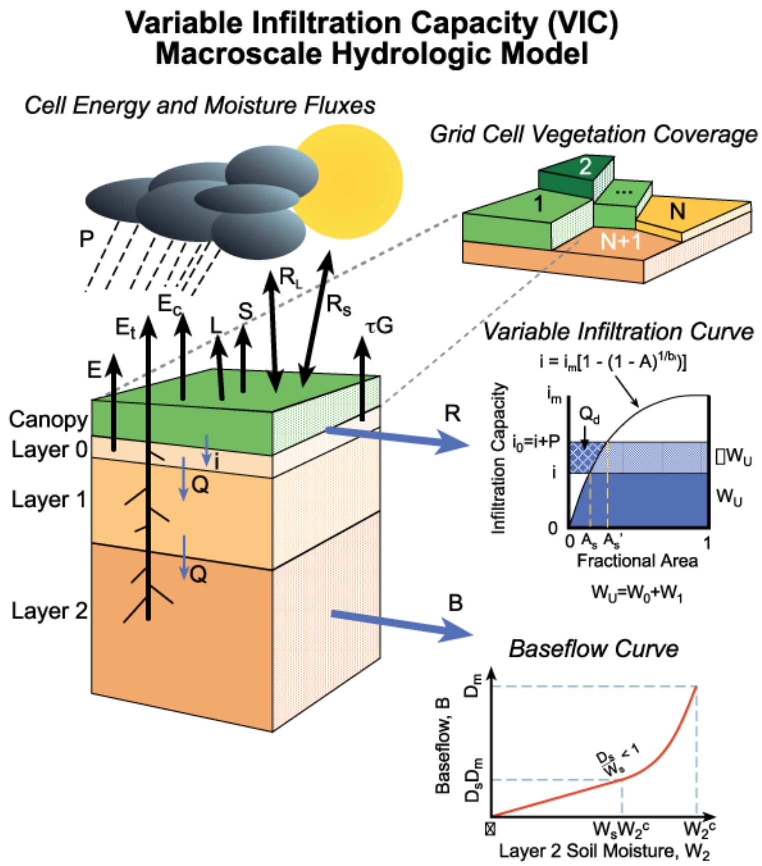

Figure 3-1. The VIC Hydrologic Model (University of Washington Computational Hydrology Group, 2021).

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

1. **Projections of climatic variables** (air temperature and precipitation) were based on simulations by the 10 selected CMIP5 global climate models (GCMs). The GCM projections were statistically downscaled (using different methodologies) by a consortium of research institutions and made publicly available for all of California at a grid cell size of 1/16° x 1/16° (about 5 km x 7 km) (Vano et al., 2020). In this report, the downscaling methodology named “Localized Constructed Analogs” (LOCA) is used. The choice of the LOCA data set was guided by its proven ability to represent extreme values of the downscaled climatic variables (important to this study) and because the

hydrologic projections made available by the same research consortium (item (2) below) used the LOCA-downscaled climate projections. The difference between greenhouse gas emissions scenarios is small for a time horizon of 20 years; therefore, it is sufficient to use one greenhouse gas emissions scenario in this study, and the moderate scenario RCP4.5 is used.

2. **Projections of daily stream flows for neighboring Baldwin Creek** were obtained by aggregating, over the watershed, the grid cell-based streamflow projections made available by the same research consortium as in item 1 above (Vano et al., 2020). These publicly available projections were obtained by driving the VIC hydrologic model with the CMIP5 daily climate projections. Projections of daily peak flows for the watershed were obtained in this study by extreme-value analysis of the daily streamflow projections. It was assumed that peak flows that historically have been surpassed every 5 years, every 10 years, and every 50 years represent meaningful high-flow threshold peak flow values of interest in terms of flood risk. The projected frequency of violating these flow thresholds is expressed in terms of future return periods for each of these threshold peak flow values. It is important to note that instantaneous streamflow peaks may be considerably higher than daily-scale peaks.
3. **Projections of water temperature** of the natural spring water that is source to the hatchery were obtained using empirical relationships developed in this project between daily observations of air temperature and water temperature. The observed temperature data for the spring water were provided by the hatchery, while the air temperature was extracted from the publicly available Livneh gridded data set (Livneh et al, 2013) for the grid cell containing the hatchery. Methods for developing such relationships between air and water temperature were previously applied successfully in climate vulnerability assessments conducted for Washington state hatcheries (McMillen, Inc, 2023; USFWS, 2021). The empirical relationship specific to this hatchery site was used to obtain projected water temperatures from the projected air temperatures increases determined from item 1 above.
4. **Projections of precipitation minus evapotranspiration** are used in this study as an indicator of the likely direction of future groundwater recharge, which will affect the natural spring water and well water. No information concerning groundwater recharge source areas was found for this hatchery, and no quantitative information was found for spring water flow or well water levels in public data bases including CDWR SGMA (2023) and the USGS NWIS (2023).
5. **Projections of wildfire risk** at each hatchery site were evaluated at a high level based on the projections by Westerling (2018), which are available through the California government Cal-Adapt.org website (Cal-Adapt, 2023). In addition to the risk that fire

poses to the facility, it has the effect of reducing soil permeability, increasing peaks of runoff and stream flows that impact flooding and water quality, and potentially affecting groundwater recharge.

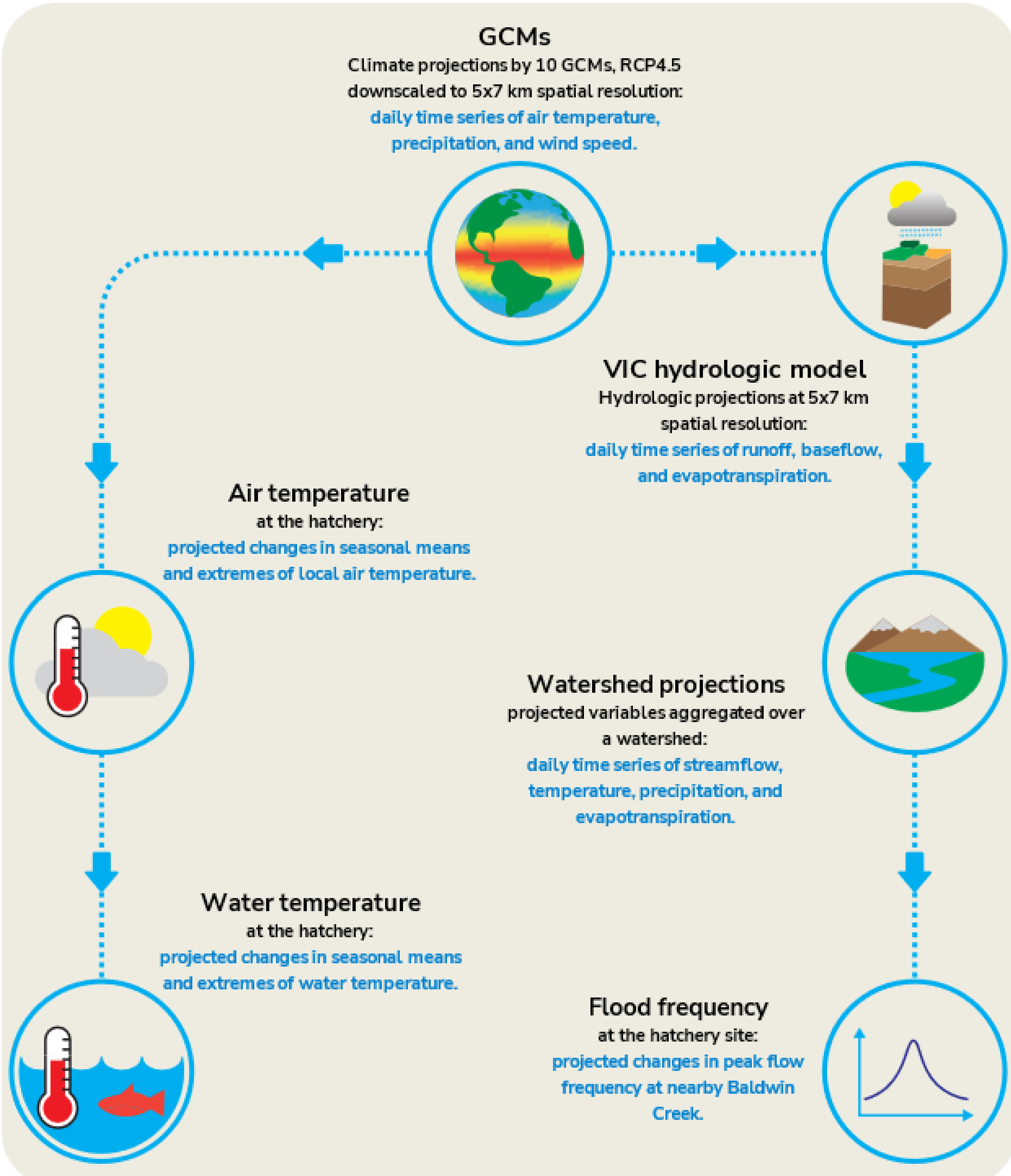

Figure 3-2. Methodology for Obtaining Projections.

3.4 Uncertainty and Limitations

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

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

3.5 Projected Changes in Climate at the Hatchery Site

3.5.1 Air Temperature

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

According to the observations-based gridded air temperature dataset used in this study (Livneh et al., 2013), the mean annual temperature at the hatchery site in the reference period was 59.7°F. At this site, mean annual air temperature is projected to rise by 2.5°F in the near-future period (2024-2043) compared to the reference period (1984-2003), and by an additional 1.1°F in the mid-century period (2044-2063). The season with the most warming is the summer (Figure 3-3, Table 3-2, and Table 3-3), and the highest temperature rises are projected to occur in the hottest days (Table 3-4 and Table 3-5).

Days with temperatures representing the 75th percentile (i.e., the upper quartile of temperatures) are projected to warm by 3.1°F in the next 20 years, relative to the reference period, reaching 91.4°F. The lowest and highest of the 10 GCM daily projections define the lower and upper limits of the shaded areas in Figure 3-3 and are given in Table 3-2 and Table 3-3. Table 3-4 and Table 3-5 list the projected percentiles of highest air temperature in each day (T_{max}) for two future time periods, relative to the reference period. All time horizons, including the reference period, are simulated by the ensemble of 10 GCMs.

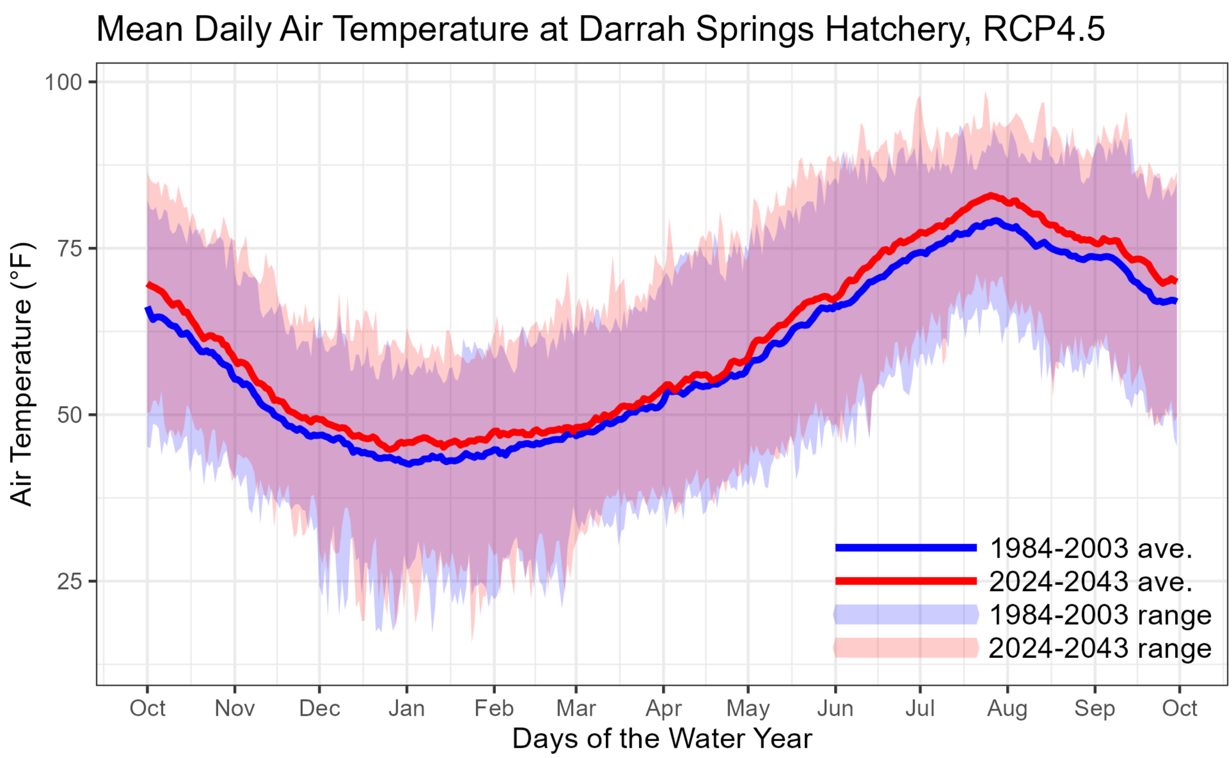

Figure 3-3. Mean Daily Air Temperature and Range for Each Day of the Year.

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

GCM	Annual	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
Ensemble mean	62.2°F (+2.5°F)	47.4°F (+2.2°F)	58.7°F (+1.6°F)	78.8°F (+3.2°F)	63.6°F (+2.9°F)
Lowest	61.6°F	46.1°F	57.9°F	78.1°F	62.1°F
Highest	62.9°F	48.5°F	59.4°F	80.0°F	64.6°F

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

GCM	Annual	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
Ensemble mean	63.3°F (+3.6°F)	49.2°F (+3.4°F)	59.8°F (+2.7°F)	80.0°F (+4.5°F)	64.7°F (+4.0°F)

GCM	Annual	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
Lowest	62.3°F	47.3°F	59.3°F	78.7°F	62.8°F
Highest	64.6°F	51.0°F	60.6°F	82.1°F	66.5°F

Table 3-4. Projected 2024-2043 Percentiles of Daily Maximum Air Temperature (T_{max}) (change relative to 1984-2003).

GCM	3rd percentile	25th percentile	50th percentile	75th percentile	97th percentile
Ensemble mean	48.1°F (+2.2°F)	60.3°F (+1.9°F)	74.2°F (+2.3°F)	91.4°F (+3.1°F)	103.8°F (+3.2°F)
Lowest	46.9°F	59.4°F	73.4°F	90.9°F	103.0°F
Highest	49.4°F	61.1°F	74.9°F	92.8°F	104.8°F

Table 3-5. Projected 2044-2063 Percentiles of Daily Maximum Air Temperature (T_{max}) (change relative to 1984-2003).

GCM	3rd percentile	25th percentile	50th percentile	75th percentile	97th percentile
Ensemble mean	49.4°F (+3.6°F)	61.4°F (+3.0°F)	75.5°F (+3.5°F)	92.7°F (+4.4°F)	104.8°F (+4.2°F)
Lowest	47.9°F	60.5°F	74.4°F	91.7°F	103.7°F
Highest	51.4°F	62.3°F	76.4°F	94.8°F	106.4°F

3.5.2 Water Temperature

Temperature data for the spring water sources was provided by the hatchery for 2019-2023. Both sources have identical temperature records, which are measured approximately once weekly. Throughout the five years, water temperature has remained in the range 55° to 59°F, except for a few colder measurements (54° and 52°F). Assuming that warming of groundwater stores in the near-future time period approximately corresponds to mean annual air temperature increase, which is projected to be 2.5°F, then water temperatures in the range 57.5° to 61.5°F may occur, but higher values are not expected.

3.5.3 Precipitation Minus Evapotranspiration

Projected annual precipitation minus evapotranspiration aggregated over the Baldwin Creek watershed is projected to increase by 4% in the next 20 years. This variable is an indicator of future direction of change in groundwater recharge rates but has large associated uncertainty given that precipitation in California is subject to great natural variability, experiencing large departures from the mean in any given year or multi-year period. Mimicking this natural variability, precipitation projections for the next 20 years vary widely between different GCM runs and are subject to great uncertainty. The seasonal average projections of the 10 GCMs are given in Table 3-6 and Table 3-7 for two future periods relative to the reference period. All time periods, including the reference period, are simulated by the ensemble of 10 GCMs.

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

GCM	Annual	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
Ensemble mean	+4%	0	+5%	-15%	+1%

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

GCM	Annual	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
Ensemble mean	+11%	+10%	+15%	-23%	-14%

3.5.4 Streamflow and Flood Risk

While there is a need to evaluate the future flooding risk posed to the hatchery by Baldwin Creek, as mentioned in Section 3.1, the flood risk projections presented in this section should be viewed with caution since peak streamflows at Baldwin Creek are mostly determined by high rainfall intensity. And as mentioned in Section 3.5.3, precipitation projections are subject to high uncertainty. In a small (13.9 square mile) watershed like Baldwin Creek, daily precipitation projections may not capture potential changes in sub-daily precipitation or peak intensity.

Figure 3-4 displays the mean daily streamflow (solid lines) and range from minimum to maximum (shaded areas) for each day of the year at Baldwin Creek near the hatchery, for the near future (red) and reference (blue) time periods. The Baldwin Creek watershed has an estimated 13.9 square miles. All data are simulated by the ensemble of 10 GCMs for each time period. Higher daily streamflow peaks are seen for the near-future time period compared to the reference period.

Table 3-8 and Table 3-9 show the projected percentage change in the seasonal streamflow in the two future periods relative to the reference period. gives the projected percent change in percentiles of daily streamflow for the near future and mid-century periods, relative to the reference period. All time periods, including the reference period, are simulated by the ensemble of 10 GCMs. All streamflow projections, and especially peak flows, have high associated uncertainty.

Mean annual streamflow in Baldwin Creek is projected to increase only slightly in the next 20 years, by 3% compared to the reference period (Table 3-8), but the highest streamflows (such as the 97th percentile of daily streamflows) are projected to increase by 10% (Table 3-10).

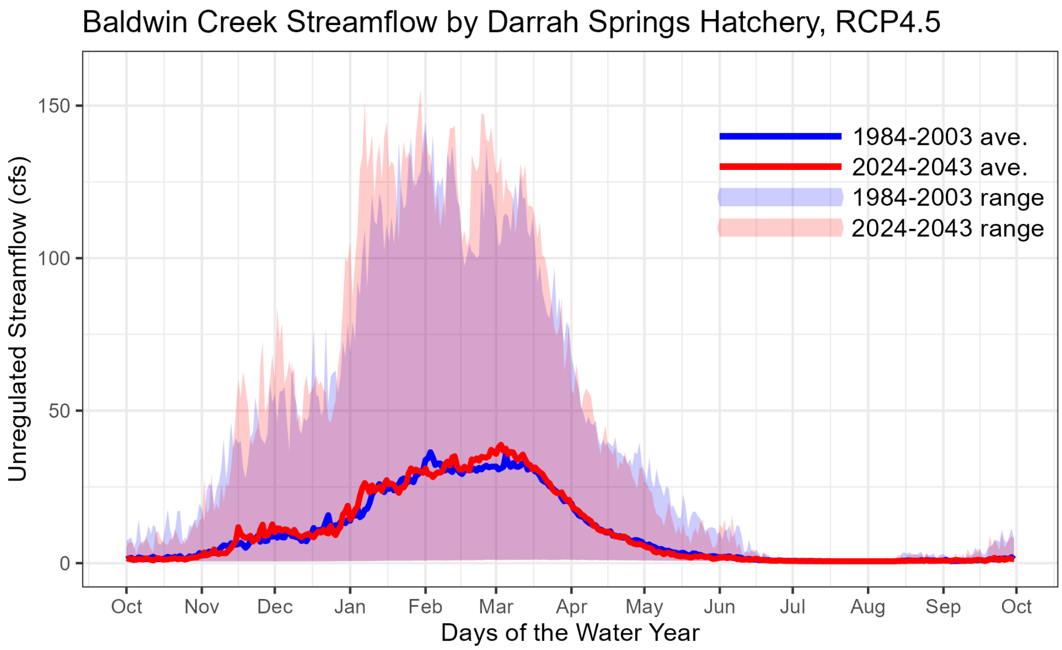

Figure 3-4. Mean Daily Streamflow and Range for Each Day of the Year for Baldwin Creek.

Table 3-8. Projected Percent Change in Annual and Seasonal Streamflow for Baldwin Creek in 2024-2043 (relative to 1984-2003).

GCM	Annual	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
Ensemble mean	+3%	+4%	+3%	-6%	+5%

Table 3-9. Projected Percent Change in Annual and Seasonal Streamflow for Baldwin Creek in 2044-2063(relative to 1984-2003).

GCM	Annual	Winter (DJF)	Spring (MAM)	Summ. (JJA)	Fall (SON)
Ensemble mean	+7%	+19%	-6%	-12%	-7%

Table 3-10. Projected 2024-2043 Percent Change in Percentiles of Daily Streamflow for Baldwin Creek (relative 10 1984-2003).

GCM	3rd percentile	25th percentile	50th percentile	75th percentile	97th percentile
Ensemble mean	0	0	-7%	-10%	+10%

Table 3-11. Projected 2044-2063 Percent Change in Percentiles of Daily Streamflow for Baldwin Creek (relative to 1984-2003).

GCM	3rd perc.	25th perc.	50th perc.	75th perc.	97th perc.
Ensemble mean	0	0	-11%	-11%	+16%

The streamflow projections for Baldwin Creek were analyzed by fitting the generalized extreme-value (GEV) distribution to time series of annual peaks for each 20-year period. For each year, there are 10 peak flow values, corresponding to the 10 GCMs, making a total sample size of 200 peak flow values for the 20 years.

The estimated flood frequency is reported in Table 3-12. The daily streamflow values chosen for study in this table are 172, 234, and 434 cfs that correspond to the quantiles with 5, 10 and 50 years return period in the reference period. The table shows a projected decline in return periods. For example, the peak flow value 234 cfs, which in the reference period had a 10-year return period (i.e., a 10% probability of exceedance in any year), in the contemporary period (2004-2023) has a 7-year return period (i.e., a 14.3% probability of exceedance), and is projected to be exceeded with increasing frequency in future, reaching a return period of only 5 years by mid-century.

Table 3-12. Projected Change in Peak Streamflow Frequency at Baldwin Creek.

Time Horizon	172 cfs Return period (yr)	234 cfs Return period (yr)	434 cfs Return period (yr)
1984-2003	5	10	50
2004-2023	4	7	25
2024-2043	4	7	29
2044-2063	3	5	17

3.5.5 Wildfire Risk

Historical wildfires have been documented in the vicinity of the hatchery, including some large fires in the surrounding uplands (>20,000 acres), but none have occurred in the past 10 years. Most of the watershed (as defined by StreamStats; USGS, 2019) has not burned this century, but two small fires are known to have occurred close to the hatchery, in 2008 and 1962. Given that the groundwater springs are sourced from the Lassen Aquifer, the recharge area is likely much larger than the watershed area at the hatchery itself. Figure 3-5 shows known historical fires within the vicinity of the watershed, as well as the probability of future fires occurring.

Expressing wildfire risk as a percent chance of occurring at least once in a decade, the projected wildfire risk at the hatchery site is between 20% and 30% through mid-century. Over Baldwin Creek, the watershed fire risk is 21%, increasing to 33% probability of fire occurring through 2060, then increasing to 38% through 2099.

Existing concerns at the hatchery include reports of flooding of the facilities from overland flow of the surrounding area during large precipitation events. If a large fire were to occur in the surrounding area, then flooding potential would be expected to increase at the hatchery due to increased runoff potential. Given that the hatchery's primary water supply are ditches that capture springs from the Lassen Aquifer, water supply may be less sensitive to wildfire, leaving the facility infrastructure as the main concern in case of fire.

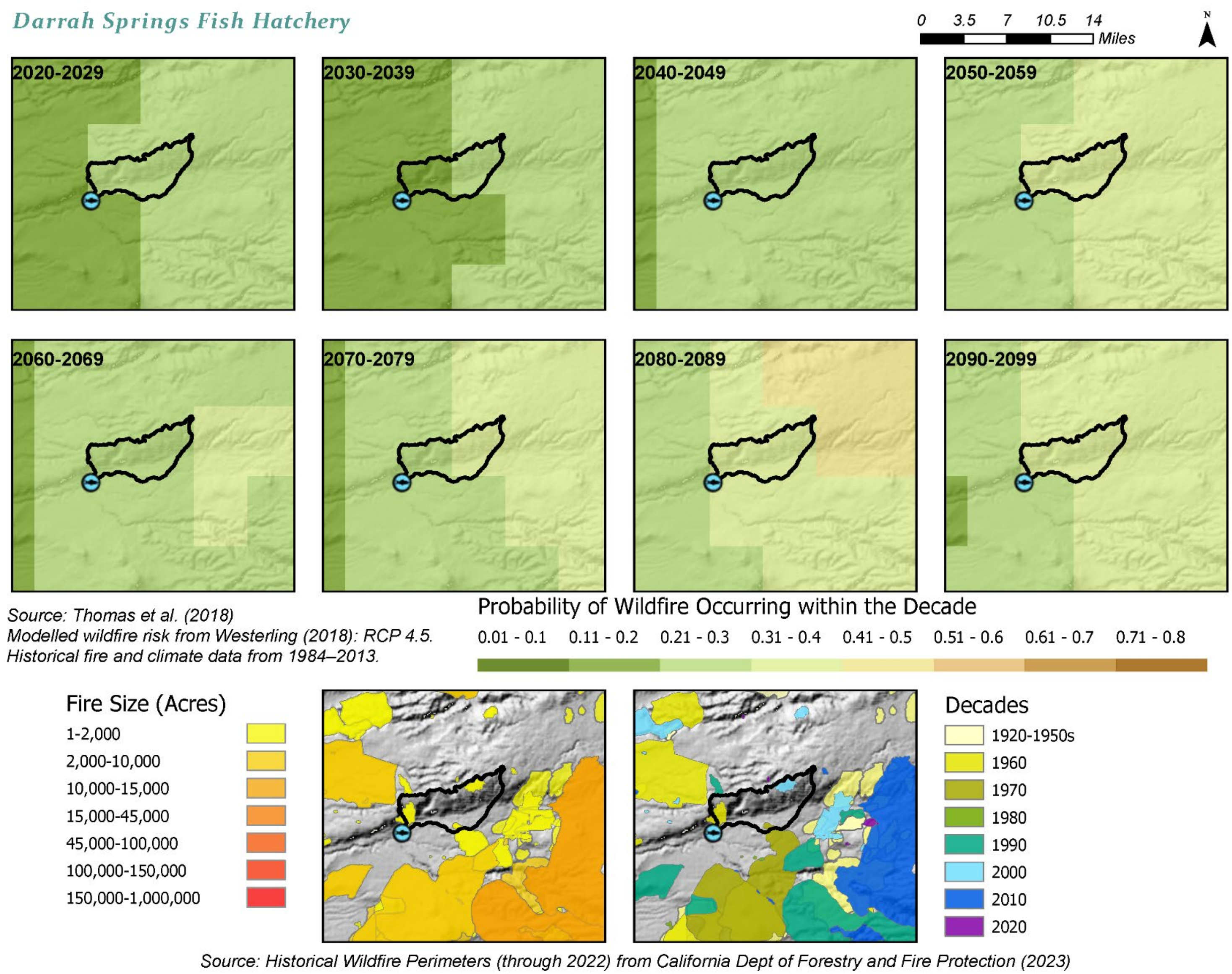

Figure 3-5. Summary of Wildfire Risks and Observations in the Vicinity of Darrah Springs FH,

3.6 Conclusions

Significant increases in air temperature and water temperature are expected for the Darrah Springs Hatchery. Mean annual air temperature is projected to rise by 2.5°F in the next 20 years and by an additional 1.1°F in the mid-century period, compared to the reference period (1984-2003). The summer will experience the most warming, and the largest temperature increases are projected to occur on the hottest days. Days with temperatures representing the 75th percentile and 97th percentile of daily temperatures are projected to warm by 3.1°F and 3.2°F, respectively, in the next 20 years, relative to the reference period.

According to the observations-based gridded air temperature dataset used in this study (Livneh et al., 2013), the 75th and 97th percentiles of peak daytime temperature (i.e., the temperature at the hottest time of day) at the Darrah Springs Hatchery site in the monitoring period (2000-2023) were 89.6°F and 101.0°F, respectively. For the near-future period, the 75th percentile of projected peak daytime temperature is 91.4°F, and the 97th percentile is 103.8°F.

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.

Temperature measurements of spring water taken approximately once weekly in 2019-2023 show stable values in the range 52° to 59°F and mostly within 55° to 59°F. Assuming that warming of groundwater stores in the near-future time period approximately corresponds to mean annual air temperature increase, which is projected to be 2.5°F, then water temperatures in the range 57.5° to 61.5°F may occur, but higher values are not expected.

While projections of precipitation are very uncertain, due in large part to its large natural variability, the average of projections from the 10 GCMs studied indicates a small increase in mean annual precipitation and a significant increase in precipitation extremes, leading to increased flooding risk from Baldwin Creek. A peak flow event at Baldwin Creek near the hatchery that in the reference period represented a 10-year event is expected to become a 7-year event in the near-future time period.

The projected wildfire risk at the hatchery site is between 20% and 30% through mid-century. Over Baldwin Creek, the watershed fire risk is 21%, increasing to 33% probability of fire occurring through 2060, then increasing to 38% through 2099.

4.0 Existing Infrastructure Deficiencies

While the Darrah Springs 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 identified hatchery deficiencies included the following:

- Low oxygen levels in the raceways
- Broken water treatment equipment on upper raceways
- Lack of incoming water treatment in the hatchery building
- Limited early rearing space
- Inadequate broodstock holding and rearing space at the facility

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 repairing the existing filtration and UV disinfection system for the upper raceways (identified in both Sections 3.2 and 5.4 in the Site Visit Report), treating the hatchery building water using filtration and UV, reusing water at the end of the lower raceways instead of the broodstock pond or using a UV system on the reuse water from the tail end of the broodstock pond, and covering the outdoor rearing vessels with solid roof structure and enclosing the sides. The details of the existing deficiencies are further expanded upon in Section 4.1 and 4.2.

4.1 Water Process Infrastructure

4.1.1 Low Oxygen Levels in Raceways

Maintaining adequate oxygen levels and water flow are the limiting factors for fish production in the 600-foot-long Darrah Springs raceways. Low head oxygenators (LHO) were previously purchased and installed in both the upper and lower raceways. The upper raceways were supplied with oxygen using individual cylindrical, liquid oxygen tanks for each LHO, and the lower raceways were supplied with oxygen via the oxygen generator(s). The oxygen generators failed in 2017; therefore, the LHOs have remained offline since that time. Hatchery staff were not comfortable using the smaller liquid oxygen tanks for the LHOs on the upper raceways due to safety concerns and venting issues. Without the LHOs in operation, the hatchery uses mid-pond aeration towers on both the upper and lower raceways. The aeration towers provide minimal oxygenation to the raceway, only increasing the oxygen levels 0.5 to

1 ppm. Additionally, the towers are over 40 years old and showing signs of aging and deterioration.

4.1.2 Non-functional Upper Raceway Treatment Equipment

A microscreen drum filter and UV system was installed for the upper raceways in 2018 after the hatchery experienced an outbreak of whirling disease (causative agent *Myxobolus cerebralis*). Within a year of installation, the treatment equipment was out of service after a large storm event. During high-water events, large debris loads made up primarily of organic matter were released from the point of diversion and overloaded the existing filters. However, without any treatment the debris and sediment are flushed into the raceways during these high-water events. Additionally, the incoming water for the upper raceways is routed through an open canal prior to diversion point. This open canal may allow pathogens to enter the supply water, and there is no disinfection prior to the water entering the raceways.

4.1.3 Lack of Incoming Water Treatment for the Hatchery Building

The hatchery staff have reported several pathogens of concern within the hatchery building. This has included bacterial gill disease (causative agent *Flavobacterium* spp.), ich (causative agent *Ichthyophthirius multifiliis*), bacterial coldwater disease (causative agent *Flavobacterium psychrophilum*), and enteric redmouth disease (causative agent *Yersinia ruckeri*). One likely pathway for these pathogens to enter the hatchery building is through the water supply. Spring sourced supply water is typically biosecure; however, at Darrah Springs there are a few locations before the water is collected that might allow pathogens to enter the facility. There is no incoming water treatment to disinfect the water before it is used for early fish rearing.

4.1.4 Pathogen Exposure Via the Raceway Pump-Back System

Current operations include pumping approximately 3,000 gallons per minute (gpm) from the tail end of the brood pond to the head end of the lower raceways. The water undergoes some aeration but is not treated. Captive broodstock are developed from eggs that are hatched on-station; however, there is potential pathogen risk for the production Rainbow Trout reared in the lower raceways reusing water pumped from the tail end of the brood pond. Since the water is not disinfected, if the adult fish are carrying a pathogen, it would be passed on via the pump-back system. Furthermore, smaller fish that are typically placed in the head of the raceways tend to be more sensitive to diseases. The adult fish may be carrying a pathogen but are not impacted by it. However, if smaller fish are exposed to the same pathogen, there may be a disease risk. Reusing water from the brood ponds without disinfection creates biosecurity issues at Darrah Springs.

4.2 Rearing Infrastructure

4.2.1 Limited Early Rearing Space

As identified in the Site Visit Report, early rearing in the California troughs and deep tanks is limited by rearing space (i.e., tank volume). The intermediate rearing area previously utilized was the series of concrete nursery tanks that are no longer in use due to their deteriorated condition, water supply and valving issues, and the reduction in water flows to the adjacent (upstream) hatchery building when they were in use. The hatchery staff recognize the early rearing space limitations and have proactively replaced the smaller California troughs with the larger deep tanks to increase early rearing capacity. However, the hatchery staff still must move fish out into the raceways at 250 fpp. The fish perform better in the raceways at a larger size, and hatchery staff have indicated that they would prefer to move fish to the raceway once they reach 60 fpp.

4.2.2 Broodstock Ponds Operation and Maintenance Issues

The existing broodstock ponds are one long curved concrete raceway located at the end of the spring to maximize water use. However, the existing configuration creates some issues for fish rearing and for the hatchery staff. The head end of the raceway is too shallow which prevents the hatchery from utilizing this space for fish rearing. The raceway is 20 feet wide and has a low flow that creates an opportunity for particles to settle and algae to grow. The algae growth was most notable at the end of the raceway. The width and shape also make it very difficult for staff to clean. The raceway is open to the environment and at the time of the site visit had very limited predation protection. Fallen trees have damaged the fence surrounding the brood ponds.

4.2.3 Exposure and Predation Issues in Raceways

Both the upper and lower raceways are enclosed in chain-link fencing with bird wire strung across the top. However, fish in the raceways still experience predation. In addition to the losses associated with predation, predators also increase the risk of spreading pathogens to the fish. Birds and other animals can carry diseases and cause stress in the fish that can result in fish loss. With only bird wire above, the upper and lower raceways experience direct sunlight during temperature periods peaking as high as 105°F 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, both air and water temperatures at Darrah Springs are projected to rise in the future, and current operating water temperatures are already in the upper range for salmonids.

5.0 Alternative Selected

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

5.1 Alternative Description

5.1.1 Upper Intake

The existing upper intake structure does not provide sufficient filtering or management of the debris that is present in the PG&E canal, which serves as the source water for the upper raceways. Replacement of the intake structure is recommended to improve the effectiveness of debris removal, improve water management, and increase protection against high flows.

The preferred alternative will replace this structure with a new concrete diversion structure fitted with a self-cleaning debris screen. A traveling screen (Hydrolox or International Water Screens) would allow for the continual removal of the debris from the flow. In addition to improved debris removal, automatic gates and weirs would provide improved flow control and measurement.

5.1.2 Lower Intake

Water for the lower raceways and hatchery building are collected at two diversion dams. Both dams impound water that is seeping from springs and divert flow to the hatchery. Watercress and other similar vegetation are plentiful in these impoundments and create the risk of fouling the screens and choking the flow to the hatchery.

The preferred alternative is dependent on hydrogeologic studies that may demonstrate the viability of collecting the spring water below ground in a radial well (Ranney collector) or other spring water collection system. The benefits would include decreased maintenance, increased protection against the risk of reduced flow, and the potential for increased flow.

5.1.3 Water Budget

Table 5-1 provides a water budget comparison between water requirements for the existing facility relative to the proposed preferred alternatives including expanding intermediate rearing capacities with PRAS and using PRAS for the final rearing of Rainbow Trout. Water requirements for incubation will remain the same utilizing up to 30 jars at a flow rate of 15 gpm. Water requirements for early rearing will also remain the same in the hatchery building, utilizing the 50 deep tanks and 8 troughs for a total of 1,620 gpm. The new intermediate rearing PRAS circular tanks will replace the old concrete nursery tanks that have been out of service for several years. These intermediate rearing tanks address the limitation in rearing volume at the hatchery, allowing young fish to be grown to a larger size to accommodate the need for vaccination(s), chemical treatments, and broodstock selection.

Table 5-1 does not include flows for the existing concrete nursery tanks since they have not been utilized for production for several years. The upper and lower raceways will be replaced with dual-drain circular tanks fitted with PRAS, and the brood ponds will be replaced with raceway style brood ponds. Data for the water budget in Table 5-1 were generated from the information provided by CDFW in the questionnaire relative to maximum flow rates for the various rearing facility components. Overall, a decrease of 8,215 gpm could occur with the implementation of the preferred alternatives.

Table 5-1. Water Requirements for the Existing and Proposed Facility Components.

Characteristics	Existing Facility Component Flows (gpm)	Proposed Facility Component Flows (gpm)
Incubation Jars	450	450
Early Rearing	1,620	1,620
Concrete Nursery Tanks/Intermediate Rearing PRAS	0	560
Upper Raceways/PRAS Circulars	6,800	2,600
Lower Raceways/PRAS Circulars	7,200[a]	3,900
Brood Pond(s)	3,000	1,725
Miscellaneous Water Use	300	300
Total GPM	**19,370**	**11,155**

[a] The flow rate was reduced to account for the 3,000-gpm reused from the brood ponds in the lower raceways.

5.1.4 Valving and Piping

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

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

5.1.5 Filtration and UV Treatment System

The hatchery installed a microscreen drum filter and a UV unit on the incoming line for the upper raceways in 2018. The system was installed to prevent whirling disease in the upper raceways. A surge of incoming water and debris following a rain event damaged the system. The hatchery staff also reported issues with flow fluctuations and backwashing issues. The system has not been used since the storm event. The hatchery has plans in place to restore function to the filtration system at Darrah Springs Hatchery.

The preferred alternative is to replace the existing drum filter and UV systems that treat water from the upper intake with a new 40-micron drum filter and UV disinfection at 126 mJ/cm^2 to provide protection to the facility. A new treatment facility for the lower intake consisting of a 40-micron drum filter and UV disinfection at 126 mJ/cm^2 to provide protection to the facility. Although the facility may be susceptible to Costia (*Ichtyobodo necator*), it is more cost effective to treat Costia than to purchase and maintain the UV disinfection equipment to prevent it from entering the facility (per CDFW guidance). UV disinfection will be required at a higher dosage (170 mJ/cm^2) for egg incubation to control *Saprolegnia* spp., which occurs in jars in the hatchery building; therefore, a separate UV will be included for that purpose.

The proposed treatment equipment will be located under a rigid roof structure. The building should cover the equipment and provide space to complete maintenance on the units, including replacing UV bulbs and drum filter panels. Covering the treatment equipment will protect it from the weather and damage done by direct sunlight. These upgrades should be completed after the intakes have been renovated to prevent additional damage to the equipment.

5.1.6 Replace Concrete Nursery Tanks with PRAS Circular Tanks

The existing concrete nursery tanks are out of service due to their dilapidated condition and associated piping/valving/water supply issues. The preferred alternative is to replace the concrete nursery tanks with PRAS utilizing circular tanks. The concrete nursery tanks previously provided 6,720 ft^3 of rearing space when they were in an operable condition.

A standard size for dual-drain circular tank is 10 feet in diameter with a 3-foot operating depth. Each 10-foot tank provides 235.6 ft^3 of rearing volume. A total of 28 tanks would be required to replace the rearing volume of the concrete nursery tanks. There will be a total of 4 PRAS modules, each with 7 tanks. This will provide 6,597 ft^3 of rearing volume (Table 5-2).

Table 5-2. Proposed Circular Tanks for Replace the Concrete Nursery Tanks.

Characteristics	Concrete Nursery Tanks	Circulars
Dimensions (ft)	21 ft long; 4 ft wide	10-ft diameter
Operating Depth (ft)	2.5	3
Volume Per Rearing Vessel (ft^3)	210	235.6
Number of Rearing Vessels	32	28
Total Volume (ft^3)	**6,720**	**6,597**

The total flow for each tank is based on hydraulic retention times (HRT). Typical HRT for 10-foot-diameter circular tanks is less than 30 minutes to maintain water quality and ensure efficient solids flushing from the tank. For 10-foot-diameter tanks, if each tank has a flow of 80 gpm, then the resulting HRT would be 22 minutes. The entire flow for a 7-tank PRAS module would be 560 gpm. If the system is operated at 75% reuse rate, the total make-up flow per module would be 140 gpm. All four modules would require a total of 560 gpm of make-up water. The PRAS that is recommended to be installed at the lower raceways (Section 5.1.8) will require 864 gpm less than the existing lower raceway minimum flow. This difference is sufficient to provide 560 gpm to the PRAS nursery tanks.

Each PRAS module would require microscreen drum filters (40-micron), CO_2 removal, LHO, and UV disinfection (126 mJ/cm^2). Appendix E covers the details for each treatment equipment item. Additionally, the tanks and equipment should be covered with an open-sided roof structure with predator netting surrounding the open sides (at minimum).

Installing circular tanks on PRAS to replace the concrete nursery tanks can reduce the overall water usage and improve water quality within the rearing environment. Dual-drain circular tanks provide a completely mixed environment as opposed to a linear tank/raceway that has a gradient of high to low dissolved oxygen (DO) along its length. This characteristic of circular tanks makes the entire volume available to the fish, as opposed to fish crowding at a raceway's head end, thereby not using the entire raceway volume. Other benefits include self-cleaning of fish waste, concentration of fish waste in a small center drain flow that can be treated continuously, and capacity for providing exercise velocities for fish. Covering the tanks with a rigid roof structure will also reduce heat gain and enclosing the sides will improve biosecurity.

Initial early rearing will still occur in the hatchery building's deep tanks on single-pass water until the fish reach approximately 250 fpp or larger and will then be transferred into the PRAS module(s). The new system will be designed to allow fish to be reared to 60 fpp while following the industry standards for fish culture. Therefore, any bath style treatments to administer vaccinations or therapeutic treatments for disease or parasites may be conducted prior to the fish being transferred into larger rearing vessels (e.g., raceways or larger PRAS circulars). Four standard size deep tanks will be included in the intermediate rearing area to serve as a location for staff to perform bath/dip vaccination treatments and holding/transfer tanks to the final rearing tanks. These tanks will be plumbed as single-pass flow-through tanks that will allow staff to vaccinate the fish in one tank (bath/dip vaccination) and load directly into a fish transfer tank to be released via gravity directly into final rearing tanks to minimize handling.

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

5.1.7 Replace Upper Raceways with PRAS Circular Tanks

The concrete in the upper raceways is approximately 40 years old and showing signs of aging. The rough and cracked concrete surfaces are not ideal for fish rearing as the surfaces can irritate fish when they contact the walls, and cracks and spalling are difficult to disinfect. It is uncertain how long the raceways can continue to function as a viable rearing space due to age and to the onset of the warming temperatures of climate change. The preferred alternative is to replace the existing concrete raceways with a PRAS utilizing circular tanks. The upper raceways consist of four concrete raceways that are each 600 feet in length. Each raceway is 10 feet wide and has a water depth of 2.5 feet. This provides a total of 15,000 ft^3 of rearing space per raceway and a total of 60,000 ft^3 for the entire upper series.

A standard size of dual-drain circular is a 20-foot-diameter tank with 6 feet of operating depth. Each 20-foot tank provides 1,885 ft^3 of rearing volume. A total of 32 tanks would be required to replace the existing rearing volume. There will be a total of four PRAS modules, each supporting eight tanks. This will provide 60,319 ft^3 of rearing volume (Table 5-3).

Table 5-3 Proposed Circular Tanks for Replacement of Upper Raceways.

Characteristics	Existing Raceway	Circulars
Dimensions (ft)	600 ft long; 10 ft wide	20-ft diameter
Operating Depth (ft)	2.5	6
Volume Per Rearing Vessel (ft^3)	15,000	1,885
Number of Rearing Vessels	4	32
Total Volume (ft^3)	**60,000**	**60,319**

The total flow for each tank is based on hydraulic retention times (HRT). Typical HRT for circular tanks is between 30 to 45 minutes to maintain water quality and ensure efficient solids flushing from the tank. For 20-foot-diameter tanks, if each tank has a flow of 325 gpm, then the resulting HRT would be 43 minutes. The entire flow for an 8-tank PRAS module would be 2,600 gpm. If the system is operated at a 75% reuse rate, the total make-up flow per module would be 650 gpm. All four modules would require 2,600 gpm of make-up water. The existing raceways require a range of flows depending on the time of year and life stage of the fish. The minimum flow required is 3,176 gpm, and the maximum flow is 6,800 gpm. The amount of make-up water for PRAS would be less than the total flow required to operate all four existing raceways at the minimum flow of 3,176 gpm. Furthermore, it would reduce the amount of water during maximum flows from 6,800 gpm to 2,600 gpm, saving 4,200 gpm.

Each PRAS module would require microscreen drum filters (40-micron), CO_2 removal, LHO, and UV disinfection (126 mJ/cm^2). Appendix E provides details for each treatment equipment. Additionally, the tanks and equipment should be covered with an open-sided roof structure with predator netting surrounding the open sides (at minimum).

Installing circular tanks on PRAS in the upper raceways can reduce the overall water usage and improve water quality within the rearing environment. Dual-drain circular tanks provide a completely mixed environment as opposed to a raceway that has a gradient of high to low dissolved oxygen (DO) along its length. This characteristic of circular tanks makes the entire volume available to the fish, as opposed to fish crowding at a raceway's head end, thereby not using the entire raceway volume. Other benefits include self-cleaning of fish waste, concentration of fish waste in a small center drain flow that can be treated continuously, and capacity for providing exercise velocities for fish. Covering the tanks with a rigid roof structure will also reduce heat gain and improve biosecurity.

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

5.1.8 Replace Lower Raceways with PRAS Circular Tanks

Similar to the upper raceways, the lower raceways are also showing signs of aging and deterioration. The preferred alternative to ensure continued operations well into the future is to replace the existing concrete raceways with PRAS utilizing circular tanks. The lower raceways consist of six concrete raceways that are each 600 feet in length. Each raceway is 10 feet wide and has a water depth of 2.5 feet. This provides a total of 15,000 ft^3 of rearing space per raceway and a total of 90,000 ft^3 for the entire lower series.

To match the tank size in the upper raceways a 20-foot-diameter tank with 6 feet of operating depth will also be used in the lower raceways. A total of 48 tanks would be required to replace the existing rearing volume with each 20-foot tank providing 1,885 ft^3 of rearing volume. There will be a total of six PRAS modules, each with eight tanks. This will provide 90,478 ft^3 of rearing volume (Table 5-4).

Table 5-4 Proposed Circular Tanks for Replacement of Lower Raceways.

Characteristics	Existing Raceway	Circulars
Dimensions (ft)	600 ft long; 10 ft wide	20-ft diameter
Operating Depth (ft)	2.5	6
Volume Per Rearing Vessel (ft^3)	15,000	1,885
Number of Rearing Vessels	6	48
Total Volume (ft^3)	**90,000**	**90,478**

Since the tank sizes are the same as the upper raceways, the hydraulic retention time for each tank will be the same. Each 20-foot-diameter tank will have a flow of 325 gpm and an HRT of 43 minutes. The entire flow for an eight tank PRAS module would be 2,600 gpm. If the system is operated at a 75% reuse rate, the total make-up flow per module would be 650 gpm. All six modules would require 3,900 gpm of make-up water. This amount of make-up water would be less than the total flow required to operate all six existing raceways at the minimum flow of 4,764 gpm. During maximum flows, the existing raceways require 10,200 gpm. Installing PRAS would reduce the amount of supply water from 10,200 gpm to 3,900 gpm, which would save 6,300 gpm.

Each PRAS module would require microscreen drum filters (40-micron), CO_2 removal, LHO, and UV disinfection (126 mJ/cm^2). This equipment will be the exact same size as the upper raceway to ensure consistency across the hatchery. Appendix E provides details for each treatment equipment item. Additionally, the tanks and equipment should be covered with an open-sided roof structure with predator netting surrounding the open sides (at minimum).

Installing circular tanks on PRASs in the lower raceways will have similar advantages as discussed in Section 5.1.7. Overall, installing PRASs will improve water quality and reduce the amount of water required to create resiliency in operations.

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

5.1.9 Replace Brood Ponds with Raceway Style Broodstock Ponds

Darrah Springs Hatchery has one long curved concrete pond that it uses for broodstock. The pond is 20 feet wide and 450 feet long. It is divided into multiple sections and ranges in depth from less than 1 foot at the head to 3.5 feet at the tail end. The first two hundred feet are not used because of the shallow depth of the pond. The configuration of the ponds makes it very difficult for staff to clean. Additionally, the ponds are open to the environment and have issues with predation.

The preferred alternative for the brood ponds is to replace the concrete structure with new rectangular raceways, a crowding lane, and spawning building attached. The new configuration will be placed on the lower end of the lower raceways in the space not used after circular tanks are installed. The existing brood ponds hold three different strains of Rainbow Trout including Rainbow Trout Eagle Lake-T, Rainbow Trout-WVPR, and Rainbow Trout-CO (Hofer). The hatchery has approximately 6,000 fish of each strain at a maximum size of 2.2 pounds each. At a maximum density index of 0.1, the required volume for each strain of Rainbow Trout is 7,479 ft^3 of rearing space. All three Rainbow Trout strains would require 22,436 ft^3 of rearing volume.

Each strain of Rainbow Trout will be held in a separate raceway for a total of three raceways. Each raceway will be 300 feet long, 10 feet wide, and have an operating water depth of 3 feet. This will provide 9,000 ft^3 of rearing volume per strain of Rainbow Trout. The larger raceways will provide the hatchery with flexibility to expand the broodstock program in the future, if needed. The wall height of the raceway will be 5 feet to prevent the adults from jumping out and to allow the hatchery to change the operating depth as needed. The total broodstock holding volume will increase from 18,000 ft^3 to 27,000 ft^3 (Table 5-5). Raceway wall thickness will be 8 inches, and the raceway floor thickness will be 10 inches.

Table 5-5 Proposed Raceways to Replace Existing Broodstock Raceway.

Characteristics	Existing Raceway	New Raceways
Dimensions (ft)	450 ft long; 20 ft wide	300 ft long; 10 ft wide
Operating Depth (ft)	2	3
Volume Per Raceway (ft^3)	18,000	9,000
Number of Rearing Vessels	1	3
Total Volume (ft^3)	**18,000**	**27,000**

Darrah Springs Hatchery requires a flow index of 1.32 for each raceway. To maintain this flow index, each raceway would require a flow of 575 gpm, and all three raceways would require 1,725 gpm. This flow would come from the incoming flow to the upper raceways that is no longer used when PRAS is implemented. According to flow data provided by Darrah Springs Hatchery, the average flow to the upper raceways between 2021 and 2023 was 10 cfs or 4,488 gpm. The PRASs that are recommended to be installed at the upper raceways will require 2,600 gpm of make-up flow leaving 1,888 gpm for use in the raceways. This is enough flow to meet the required 1,725 gpm for the new broodstock raceways.

Two crowder channels will be located between the three raceways. These channels will be similar to the design at Mt. Shasta Fish Hatchery. The channel will allow staff to crowd the fish from the raceway down to a “slot” and into this channel. The fish are then directed to the lower end and directly into the spawning house. The spawning house will be located at the end of the raceways. The raceways should be covered to reduce heat gain and include predator netting surrounding the open sides.

Installing spawning raceways tied directly to the spawning house will improve efficiency of moving fish and reduce fish handling. Additionally, three raceways allow the hatchery to keep the strains separate, and the increased rearing volume will provide flexibility to increase broodstock holding.

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

5.1.10 Effluent System

In 2019, a general order NPDES permit was issued that covered most of the CDFW hatcheries. The permit did not outline average monthly or daily maximum effluent limitations but did state "the Discharger shall minimize the discharge of total suspended solids through implementation of best management practices established in Special Provision VII.C.3 of this order." The hatchery has a Best Management Practices Plan and is in compliance with their current NPDES permit.

With the implementation of PRAS in the lower and upper raceways, a decrease flow with a higher concentration of solids will be leaving the facility. This flow will need to be addressed with additional treatment before it is discharged into Baldwin Creek. It is recommended that the treatment include a microscreen drum filter, lift station, and settling pond for both the upper and lower raceways.

The effluent from each PRAS module will consist of the bottom flow from the circular tank as well as the backwash from each PRAS drum filter. An effluent system should be implemented that is capable of treating the flow from both the lower raceways and the intermediate rearing areas. The combined flow from this will be approximately 4,550 gpm. The effluent system will require a micro screen drum filter that is sized to treat this flow and have a screen size of 60 microns. The treated water from the drum filter can be discharged directly to the creek, but the backwash from the drum filter will require additional treatment. A lift station will be needed to direct the backwash water from all the drum filters to the proposed settling ponds. Two settling ponds, each sized approximately 60 feet by 15 feet, should be installed to manage the backwash flow from the effluent drum filter. With the addition of raceway style broodstock ponds to the lower series, the proposed settling ponds for the lower series PRAS modules will be located outside of the old lower raceway footprint.

The upper raceways will also require a drum filter, lift station, and settling ponds. The effluent flow from the bottom drain of each tank and the drum filter backwash would be approximately 2,600 gpm. The effluent system would require a microscreen drum filter that can treat this flow and has a screen size of 60 microns. Additionally, it will also likely require a lift station to pump the backwash from the effluent drum filter to the settling pond for additional treatment. It is recommended to have two settling ponds, so that one can be taken offline during cleaning. The two settling ponds for the upper raceways should be approximately 40 feet by 15 feet. The proposed location of the drum filter for both the upper and lower raceways is shown in Appendix C. For the upper series, the proposed settling ponds will be located within the old raceway footprint.

5.1.11 Backup Power Generator(s)

An electrical assessment will be conducted for the facility to include the existing electrical requirements along with additional components encompassing the suite of alternatives selected to determine the electrical requirements for the facility to appropriately size backup generators.

5.2 Pros/Cons of Selected Alternative

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

Table 5-6. Pros/Cons of Selected Alternative – Darrah Springs.

Description	Pros	Cons
Replace upper intake screen.	• Improves debris removal. • Improves water flow control.	• Requires continual power for debris removal. • Needs back up power. • Adds O&M duties.
Develop spring collection system.	• Improves biosecurity. • Reduces risk of debris screen fouling.	• Adds an uncertainty of hydrogeologic characteristics.
Replace valves and pipe throughout hatchery.	• Improves operability and control of flow. • Increases hatchery infrastructure lifespan.	• Costs more due to installation. • Disrupts hatchery operations during construction.
Repair upper raceway filter and UV system.	• Reduces sediment and pathogen load entering the raceways. • Improves biosecurity. • Improves water quality in the raceways and reduces stress events for fish.	• Costs more due to installation. • Increases maintenance requirements of staff.

Description	Pros	Cons
Install circular tanks and PRAS in enclosed building for intermediate rearing.	• Provides space for intermediate rearing that is not currently available (replaces old concrete nursery tanks). • Improves flow control. • Allows fish to be vaccinated prior to being transferred into larger rearing tanks. • Allows for broodstock development and isolation at appropriate size. • Provides a healthier rearing environment for fish. • Reduces labor as the tanks are self-cleaning. • Protects fish from sunburn and reduces heat gain. • Protect fish from predation and improves biosecurity due to roof and enclosed sides. • Concentrates waste for effluent treatment for NPDES permit compliance.	• Costs more due to installation and increases cost for operation/ maintenance (UV bulb replacement, drum filter panels, etc.). • Requires additional training for staff. • Increases pumping on site. • Requires additional components (e.g., drum screen, UV, LHO, CO_2 removal). • Increases complexity. • Increases power requirements (commercial and backup power). • Disrupts hatchery operations during construction.
Replace upper and lower raceways with circular PRAS and solid roof.	• Reduces total water required and provides flexibility. • Replaces aging infrastructure. • Improves flow control. • Provides a healthier rearing environment for fish. • Reduces staff labor because the tanks are self-cleaning. • Protects fish from sunburn and reduces heat gain. • Protect fish from predation and improves biosecurity due to roof and enclosed sides. • Concentrates waste for effluent treatment for NPDES permit.	• Costs more due to installation and increases cost for operation/maintenance (UV bulb replacement, drum filter panels, etc.). • Requires additional components (e.g., drum screen, UV, LHO, CO_2 removal). • Requires additional training for staff. • Increases pumping on site. • Increases complexity. • Increases power requirements.

Description	Pros	Cons
Replace brood ponds with new raceways and solid roof.	• Improves rearing environment for broodstock. • Improves biosecurity. • Increases efficiency for handling fish and reduces hours spent cleaning vessels. • Increases total broodstock rearing volume.	• Costs more due to system installation. • Can only be installed if circulars are utilized in upper raceways.
Install a drum filter to treat effluent.	• Reduces sediment load entering the creek. • Ensures effluent will meet future discharge limits.	• Cost more due to system installation. • Can only be installed if circulars are utilized in lower raceways.
Add backup power generator(s).	• Provides power to all life support systems in the event of a power outage. • Enables the hatchery to use modern technology to produce healthier fish.	• Increases cost. • Increases complexity. • Increases maintenance. • Increases risk of fish loss if system fails in a power outage.

5.3 Alternatives for Short-Term Improvements

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

5.3.1 LHO Installation

The oxygen levels in the raceways can limit fish production. The hatchery previously had low head oxygenators (LHO) installed at the head and at the halfway point of each raceway, but they are not using the LHOs due to difficulties with oxygen supply. It is recommended to reinstall the LHOs in the upper raceways and to install a liquid oxygen (LOX) bulk tank to supply oxygen to both the upper and lower raceways. A bulk liquid storage tank will provide a reliable source of oxygen with less maintenance compared to the oxygen generator. The addition of a new LOX bulk storage tank will require a storage tank, vaporizers, a concrete pad, fencing, and supporting equipment. To provide additional control and monitoring, dissolved oxygen probes could be placed at the end of each raceway. Oxygen flow to each LHO could then be adjusted based on those readings. The bulk LOX storage tank will be able to provide oxygen for the LHOs as well as future installation of PRAS.

Typical agreements with oxygen suppliers include delivery of the liquid oxygen as well as maintaining the equipment required for the bulk storage oxygen tank. This ensures the tank operates as needed. The hatchery staff would be required to maintain the piping and controls to the LHO. LOX bulk storage tanks have the advantage over oxygen generators because they can still provide oxygen during a power outage. Restoring the LHOs in the upper and lower raceways will improve the overall water quality and potentially increase production.

5.3.2 Intermediate Rearing Facility

A scaled down version of preferred alternative discussed in Section 5.1.6 to replace the concrete nursery tanks with 28 circular tanks with PRAS, would be a smaller facility with an open-sided rigid roof with predation netting protecting the open sides. Sixteen circular tanks with PRAS would provide additional intermediate rearing space before the fish are transferred into their final rearing tanks. These tanks will be dual-drain circular tanks that are 10 feet in diameter with a 3-foot operating depth. Each 10-foot tank would provide 235.6 ft^3 of rearing volume. There would be a total of 2 PRAS modules, each with 8 tanks. This short-term improvement would provide rearing space to produce 200,000 Rainbow Trout to a size of 60 fpp resulting in a DI of .25. This expansion would provide an additional 3,770 ft^3 rearing volume.

Table 5-7. Proposed Circular Tanks in the Intermediate Rearing.

Characteristics	Concrete Nursery Tanks	Circulars
Dimensions (ft)	21 ft long; 4 ft wide	10-ft diameter
Operating Depth (ft)	2.5	3
Volume Per Rearing Vessel (ft^3)	210	235.6
Number of Rearing Vessels	32	16
Total Volume (ft^3)	**6,720**	**3,770**

The total flow for each tank is based on hydraulic retention times (HRT). Typical HRT for 10-foot-diameter circular tanks is less than 30 minutes to maintain water quality and to ensure efficient solids flushing from the tank. For 10-foot-diameter tanks, if each tank has a flow of 80 gpm, then the resulting HRT would be 22 minutes. The entire flow for an 8-tank PRAS module would be 640 gpm. If the system is operated at a 75% reuse rate, the total make-up flow per module would be 160 gpm. Operating these two modules would require a total of 320 gpm of make-up water. The PRAS that is recommended to be installed at the lower raceways will require 864 gpm less than the existing lower raceway minimum flow. This difference is sufficient to provide 160 gpm to the PRAS intermediate rearing tanks.

Each PRAS module would require microscreen drum filters, CO_2 removal, LHO, and UV disinfection. Appendix E covers the details for each treatment equipment item. Additionally, the tanks and equipment should be covered with an open-sided roof structure with predator netting surrounding the open sides (at minimum).

Installing circular tanks on PRAS to replace the concrete nursery tanks can reduce the overall water usage and improve water quality within the rearing environment. Dual-drain circular tanks provide a completely mixed environment as opposed to a linear tank/raceway that has a gradient of high to low dissolved oxygen (DO) along its length. This characteristic of circular tanks makes the entire volume available to the fish, as opposed to fish crowding at a raceway's head end, thereby not using the entire raceway volume. Other benefits include self-cleaning of fish waste, concentration of fish waste in a small center drain flow that can be treated continuously, and capacity for providing exercise velocities for fish. Covering the tanks with a rigid roof structure will also reduce heat gain and enclosing the sides will improve biosecurity.

Initial early rearing will still occur in the hatchery building deep tanks on single-pass water until the fish reach approximately 250 fpp or larger and will then be transferred into the PRAS module(s). The new system will be designed to allow fish to be reared to 60 fpp while following the industry standards for fish culture. Therefore, any bath style treatments to administer vaccinations or therapeutic treatments for disease or parasites may be conducted prior to the fish being transferred into larger rearing vessels (e.g., raceways or larger PRAS circulars).

5.3.3 UV Unit to Treat Pump Back Flow

Darrah Springs has a reuse system that pumps water from the tail end of the broodstock rearing pond to the top of the lower raceways. The water is untreated. Reusing the water on smaller fish in the lower raceways is a potential pathway to spread pathogens within the facility. It is recommended that a channel UV unit be installed to treat the water before it is pumped to the raceways. The hatchery has an existing concrete channel located just before the pump that could be used to install a UV channel.

5.3.4 Skim Coat Concrete in the Upper and Lower Raceways

The concrete in the lower series raceways is showing signs of aging. The underlying aggregate in the floor and walls of the raceways is exposed due to wear which creates an abrasive surface that can be harmful to fish as well as a surface that promotes algae growth. The upper series raceways were recoated with epoxy approximately 3 years ago, and the hatchery staff have reported a noticeable increase in the ease of cleaning. Recoating the concrete in both the upper and lower raceways would help extend the life of the infrastructure, promote a healthier and safer environment for fish rearing, and would allow for maintenance to be more easily performed.

Raceway coatings are typically epoxy, polyurethane, or mortar based, but they all serve the same general purpose. Prior to coating the raceways, they must be emptied, cleaned, and completely dried. Additionally, any large cracks in the existing concrete will need to be fixed prior to coating. After applying, the coating will need to cure which can take anywhere from 1 to 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, does not promote algae growth, and reduces sun and water exposure to the aging concrete underneath.

5.3.5 Vacuum System for Solids in Lower Raceways

There was a previous concern regarding the total suspended solids discharged during raceway cleaning events in the lower raceways. The hatchery cleans the lower raceways using a "brush and flush" method. During these cleaning events, a large quantity of solids are flushed out of the system and into the receiving water. During a 2012 assessment done at Darrah Springs, samples were taken during a cleaning event and found the TSS peaked at 230 mg/L. This was the sample taken upon release of the stored water from cleaning operations. The TSS is around 1 mg/L during normal flow though operations.

Instead of using the "brush and flush" method, the hatchery could utilize a vacuum system to collect the solids. A vacuum system would allow the hatchery to collect the solids and dispose of them into the settling pond. The last 15 feet of the existing raceway would not be used for fish rearing and be turned into a quiescent zone. This quiescent zone would allow solids to settle, and the hatchery would then be able to vacuum out the solids. The settling pond would need to be located next to the lower raceways. A vacuum system would not reduce the workload of the staff but prevent the large TSS loads from entering the creek where the effluent is discharged.

5.4 Natural Environment Impacts

The proposed upgrades to the Darrah Springs 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 Darrah Springs Fish Hatchery will change the existing infrastructure and the number of rigid structures on site; however, these changes are not anticipated to increase or decrease the fire risk. Based on the climate change evaluation, the projected fire risk will likely increase slightly over the following decades.

The hatchery staff expressed existing concerns regarding flooding of the facilities from the overland flow of the surrounding area during significant precipitation events. The recommended changes will slightly increase the total impervious surface of the site but decrease the impact of flooding on the facility. This is primarily done by moving rearing vessels out of flood-prone areas and changing the type of rearing vessel from concrete raceways to fiberglass circular tanks. The existing broodstock system is located in the flow of the springs. By moving the broodstock out of the spring area into the lower raceway footprint, the system is removed from the flood-prone area, providing additional protection against flooding. Installing circular tanks for intermediate and final rearing will also provide some additional flood protection. The tanks will be placed with the tank tops located 30 to 36 inches above ground. The tank height will provide protection from overland flow entering the fish rearing vessels, and the ground will be graded to carry water away from the tanks to the extent feasible.

Additionally, replacing the intakes, valves, and piping will provide the hatchery with better flow control into the facility. The hatchery staff will be able to manage surges in flow and prevent flooding of the rearing vessels.

5.4.2 Effluent Discharge

The recommended changes to the hatchery do not include an overall increase in fish production goals at Darrah Springs. This will ensure there will be no change to the NPDES permit requirements. However, the recommended alternatives will likely improve the water quality of the effluent discharge. The hatchery meets current NPDES permit requirements, but the staff expressed concerns regarding discharge during cleaning events of the lower raceways. Installing dual-drain circular tanks and effluent treatment will improve the water quality of the discharge. The drum filter and settling pond will reduce the solids loading on the natural environment and reduce the overall impacts of the hatchery.

It is important to note that changes to existing aquaculture programs (renovations, new construction) may trigger (administratively) the requirement for new and/or updated NPDES permits. Acknowledging that waste load (fish biomass) is not anticipated to change with the proposed alternatives, we assume that the increase in effluent removal efficiencies provided by the PRAS systems will result in net effluent "gains" to the overall aquaculture program.

5.5 Hatchery Operational Impacts/Husbandry

Multiple groups (pulses) of Rainbow Trout will be produced starting at various times throughout the year to maximize production capability at the hatchery. Early rearing fish culture practices will continue as the hatchery has operated previously with single-pass flow-through in the deep tanks. As the fish outgrow the deep tanks, they will be transferred into the intermediate rearing PRAS circular tanks. A small fish pump (e.g., 2.5-inch hose diameter) would minimize handling and stress on the fish as they are transferred. If enumeration of the fish is desired, a fish counter may be utilized in conjunction with the fish pump. The intermediate rearing tanks are approximately 1,200 feet and 600 feet from the upper and lower final rearing circular PRAS tanks, respectively. Pumping fish these distances would require considerable amounts of hose and the space to store it. It is more feasible to pump the fish into a fish transfer tank equipped with an oxygen system and off-load them directly (via gravity) into the final rearing tanks which will be recessed into the ground. Linear distances from origin to destination rearing tanks will limit how fish can be transferred throughout the hatchery. Once the fish are in the final rearing PRAS circular tanks, the fish will be grown to their target release size at which time they will maximize the biomass and DI capacity of the system. Truck loading for fish release will continue as the hatchery has operated in the past utilizing fish pumps and dewatering towers with a few minor adjustments unique to circular tanks relative to traditional raceways.

One of the benefits of this proposed design is to provide the means for staff to maintain fish health and welfare. The intermediate rearing tanks enable the hatchery to raise young fish to a larger size to allow for vaccinations (i.e., enteric redmouth disease), administer chemical treatments as needed (e.g., coldwater disease), and select captive broodstock. Prior to the fish being transferred into the final rearing tanks, the fish will need to be vaccinated (enteric redmouth). The hatchery can continue to use their current methods for vaccination treatment (i.e., baskets dipped in a tank with vaccine) for enteric redmouth disease. Four vaccination/transfer tanks will be included in the intermediate rearing area to use for bath/dip vaccination treatments and as short-term holding tanks for other fish culture activities (i.e., harvest, enumeration, etc.). Immediately after the vaccination dip, the fish may be loaded directly into a fish transfer tank and delivered to their final rearing tanks. Alternatively, vaccinated fish can be placed in one of the extra vaccination/transfer tanks with flowing water for short-term monitoring until they are pumped into a fish transfer tank and offloaded via gravity into the final rearing PRAS tanks.

5.5.1 PRAS Circular Tank Operations

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

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

5.5.2 PRAS Equipment

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

5.5.3 Feeding

Early rearing feeding techniques in the deep tanks can continue using the hatchery's standard feeding practices. Hatchery staff will need to transition away from the blower-style feeding systems typically used for linear raceways to a feeding system designed for circular tanks. Fish can be fed in circular tanks utilizing the simplest of methods ranging from hand-feeding to automated systems, and the techniques may vary depending on the size of the circular tanks and staff preferences. In addition to staff preferences, there are pros and cons associated with the various feeding options. Hand-feeding requires more staff time, compared to automated feeding systems, as it is labor intensive but allows staff to observe fish feeding and overall behavior and health. Hand-feeding allows the staff to feed the fish to satiation and minimizes overfeeding, reducing wasted feed and maximizing water quality.

Automated systems require an initial cost for the purchase and installation of the system. The automated feeding systems intermittently provide feed throughout the day to maximize growth. This system reduces staff labor (but also reduces the staff's observations during feeding); however, it requires adjustments for delivering the correct amount of feed and requires preventative and corrective maintenance, which is a continued cost associated with these maintenance requirements. It should be noted that hand and automatic feeding systems are not mutually exclusive. Even with automatic feeding systems, culture operations should still involve regular monitoring of fish and their feeding response throughout the day.

5.6 Biosecurity

The goal of biosecurity measures is to minimize the risk of pathogens entering the facility and spreading between rearing areas at the facility. Darrah Springs Fish Hatchery reported several pathogens of concerns at the facility. This included Costia (*Ichthyobodo* spp.), bacterial gill disease (causative agent *Flavobacterium* spp.), ich (causative agent *Ichthyophthirius multifiliis*), bacterial coldwater disease (causative agent *Flavobacterium psychrophilum*), and whirling disease (causative agent *Myxobolus cerabralis*). The most likely pathways for pathogens to enter Darrah Springs and spread through the facility is through the incoming water supply or environmental exposure within the hatchery.

5.6.1 Incoming Water Supply

Darrah Springs 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 entering the facility. Upgrading the upper and lower intakes and replacing outdated valves and piping will improve the hatchery's ability to control the flow and reduce the debris load entering the rearing vessels. Surges of high flow and debris entering the facility could be a pathway for pathogens to enter. The preferred alternative includes filtration and UV disinfection on all incoming water and will reduce the pathogen load and solids content of the water entering the facility, thereby improving water quality and biosecurity.

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 wires overtop, but these structures are minimally effective in excluding otters, raccoons, and avian predators from accessing the raceways. The hatchery also has a pump-back system that reuses untreated water in the lower raceways, potentially exposing fish to water with higher pathogen loads. The recommended alternatives reduce the risk of pathogens entering the rearing areas by reducing environmental exposure. Implementing PRAS in covered structures will limit potential pathogen vectors, such as birds, otters, and the like from entering the rearing vessels. Predators can be a significant source of stress, and they can transmit pathogens into the facility. Additionally, installing PRAS will eliminate the need for the hatchery's pump-back system, ensuring high-quality, treated water for all rearing vessels.

5.7 Water Quality Impacts

The recommended alternatives will improve the water quality within the existing rearing vessels as well as the effluent leaving the facility. Replacing the existing concrete raceways with dual-drain circular tanks can improve the water quality of the rearing environment. Dual-drain circular tanks provide a completely mixed environment as opposed to a raceway that has a gradient of high to low dissolved oxygen (DO) along its length. This characteristic of circular tanks makes the entire tank volume available to the fish, instead of fish crowding at a raceway's head end, thereby not using the entire raceway volume. The dual-drain system in circular tanks aids waste removal, allowing for more effective removal of solid waste and uneaten feed. This can contribute to better overall water quality.

The other PRAS equipment will also improve the water quality within the system. The microscreen drum filters will remove the solids in the water. The LHOs will ensure the dissolved oxygen levels enter the tanks at saturation or higher. The carbon dioxide strippers will remove dissolved carbon dioxide as well as other undesirable gases, and the UV unit will reduce the pathogen load of the water that returns to the tanks. Additionally, installing a rigid roof structure with bird netting will reduce heat gain during the summer months and algae growth in the rearing tanks.

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

The recommended alternatives also include improving the incoming water quality. The improved intake structures will reduce the debris entering the facility. This will improve the water quality in the hatchery building, production areas, and broodstock rearing. Furthermore, the repaired drum screen and UV water treatment system on the upper raceways will reduce solids and risk of pathogens.

6.0 Alternative Cost Evaluation

6.1 Introduction

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

6.2 Estimate Classification

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

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

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

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

6.3 Cost Evaluation Assumptions

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

- All unit costs assume total cost for installation including any applicable taxes.
- 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 costs assume seven bore holes (20 feet deep), material testing, piezometer installation, and a written report.
- Topographic survey cost assumption is based on $1,000/acre.

- Building joist/eve height will be 18 feet.
- Additional division specific cost evaluation assumption may be found in Appendix F.

6.4 LEED/Zero Net Energy Assessment

RIM Architects (RIM) and STŌK 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.

RIM and STŌK also prepared a zero net energy (ZNE) assessment of the facility. This assessment summarizes the power anticipated to be needed at the facility and estimated the size of photovoltaic (PV) system that would be required to offset the power use. Refer to Appendix H for more information.

6.5 Alternative Cost Estimate

The following tables illustrate the estimated costs for the alternative evaluated and depicted within the figures in Appendix A.

Table 6-2. Alternative Cost Estimate.

Item	Estimate
Division 01 – General Requirements	$ 10,292,000
Division 02 – Existing Conditions	$ 1,738,000
Division 03 – Concrete	$ 4,955,000
Division 05 – Metals	$ 700,000
Division 07 – Thermal and Moisture Protection	$ 20,000
Division 08 – Openings	$ 320,000
Division 13 – Special Construction (Buildings and Tanks)	$ 31,722,000
Division 23 – Mechanical & HVAC	$ 402,000
Division 26 – Electrical	$ 4,100,000
Division 31 – Earthwork	$ 1,946,000
Division 32 – Exterior Improvements	$ 255,000
Division 33 – Utilities	$ 1,455,000
Division 35 – Waterways and Marine Construction	$ 503,000
Division 40 – Process Water System	$ 3,342,000
DIRECT CONSTRUCTION COST	**$ 61,750,000**
Construction Contingency	$ 15,438,000
Overhead	$ 3,705,000
Profit	$ 4,940,000
Bond Rate	$ 618,000
TOTAL CONSTRUCTION PRICE	**$ 84,451,000**
Design, Permitting and Construction Support	$ 13,093,000
TOTAL COST ESTIMATE	**$ 99,544,000**
Accuracy Range +50%	$ 149,316,000
Accuracy Range -30%	$ 69,681,000
Photovoltaic	$ 22,810,000

7.0 Darrah Springs Trout Hatchery Environmental Permitting

7.1 Anticipated Permits and Supporting Documentation

The proposed project would involve the modification to the existing hatchery or construction of a new hatchery facility and associated infrastructure. It would potentially involve the development of new water supply/intake/pumpstation, which would require instream construction for the hatchery operations. A list of anticipated permits, agency review time, submittal requirements, and supporting documentation for the proposed project, regardless of which alternative is selected, are summarized in Table 7-1, Table 7-2, and Table 7-3. The review periods 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 (USFWS IPAC and California 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 that are 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, 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 US 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.
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.

Agency and Permit/Approval	Submittal / Document Type	Supporting Documentation	Anticipated Time Frame	Notes
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 U.S. 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
California State Water Resources Control Board (SWRCB) National Pollutant Discharge Elimination System (NPDES)	Facility renovation/ construction may trigger “New Source”	N/A	6 months	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 Shasta County Permits and Approvals for Selected Location.

Agency and Permit/Approval	Submittal / Document Type	Supporting Documentation	Anticipated Time Frame	Notes
Shasta County Building Division	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 Darrah Springs Trout Hatchery is classified as a cold water Concentrated Aquatic Animal Production (CAAP) facility and is eligible to operate under General Order R5-2014-0161-027 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 September 28, 2010.

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 Darrah Springs Fish Hatchery could experience as a result of climate change and provides proposed facility design modifications that can be made to increase the resiliency of the hatchery. The in-depth analysis of the available hydrologic data performed by NHC provide projections to forecast changes that may be experienced. In general, significant increases in air and water temperature are expected at Darrah Springs. Additionally, there will be an increasing risk of wildfire 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:

- Improving the treatment of the incoming water will provide improved flow control and protection against pathogens.
- Replacing pipes and valves that are near the end of their effective lifespan or are currently inoperable due to age.
- Replacing flow-through style raceways with circular dual-drain tanks utilizing partial recirculating aquaculture systems (PRASs) to reduce the amount of water that is required to raise fish and to provide for improved effluent handling and treatment.
- Covering all rearing vessels with solid roofs will reduce the impacts of increased heat for both the fish and the employees.

The proposed upgrades to the Darrah Springs Fish Hatchery would have negligible impacts on the natural resources in the surrounding area. All improvements would occur within currently developed areas, which lessen the permit requirements. The total cost estimate of the proposed design modifications is $99,544,000.

9.0 References

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