Hatchery and Genetic Management Plan

Draft Final Revised- August 5, 2016

HATCHERY AND GENETIC MANAGEMENT PLAN (HGMP)

Draft Final Revised – August 5, 2016

Hatchery Program:	San Joaquin River Salmon Conservation and Research Program
Species or Hatchery Stock:	San Joaquin River Experimental Population of Spring-run Chinook Salmon
Agency/Operator:	California Department of Fish and Game
Watershed and Region:	Middle San Joaquin-Lower Chowchilla Watershed USGS Unit: 18040001. Hatchery location: 36° 59'11.57" N, 119° 43'02.11"W
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Date Submitted:	
Date Last Updated:	August 5, 2016

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Abbreviations and Acronyms

°F	Degrees Fahrenheit
CDFW (CDFG)	California Department of Fish and Wildlife, previously the California Department of Fish and Game
cfs	Cubic Feet per Second
CFSG	Conservation Facility Subgroup
Conservation Program	San Joaquin River Salmon Conservation and Research Program
CV	Central Valley
CVP	Central Valley Project
CWT	Coded Wire Tag
Delta	Sacramento-San Joaquin Delta
DO	Dissolved Oxygen
DWR	California Department of Water Resources
EPA	U.S. Environmental Protection Agency
ESU	Evolutionarily Significant Unit
FESA	Federal Endangered Species Act
FL	Fork Length
FMP	Fisheries Management Plan
FMWG	Fisheries Management Work Group
FR	Federal Register
FRH	Feather River Hatchery
g	Grams
g/d	Grams per Day
GSG	Genetics Subgroup
HCT	Hatchery Coordination Team
HGMP	Hatchery and Genetic Management Plan
HOR	Hatchery Origin
HSRG	Hatchery Scientific Review Group
km	kilometer
m^2	Square Meters
mg N/L	Milligrams Nitrogen per Liter
mg/L	Milligrams per Liter
mi	miles
mm	Millimeter
N_b	Breeding Population Size
N_e	Effective Population Size
N_{eh}	Hatchery Broodstock Effective Population Size
N_{eh+w}	Combined Hatchery Broodstock and Wild Population Effective Population Size
N_{ew}	Wild Population Effective Population Size
NMFS	National Marine Fisheries Service

NOR	Natural Origin
NPDES	National Pollutant Discharge Elimination System
NRDC	Natural Resources Defense Council
O&M	Operations and Maintenence
PBT	Parentage Based Tag
PFMC	Pacific Fishery Management Council
pHOS	Proportion effective Hatchery Origin spawners on spawning grounds
PIT	passive integrated transponder
PNI	Proportionate Natural Influence
pNOB	Proportion Natural Origin spawners in Broodstock
pNOS	Proportion Natural Origin spawners on spawning grounds
ppm	parts per million
ppt	parts-per-thousand
PY	personnel year
RA	Returning Adults
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Restoration Area	San Joaquin River from Friant Dam to confluence with Merced River
RM	River Mile
RST	Rotary Screw Trap
RWQCB	Regional Water Quality Control Board
Settlement	Stipulations of the Settlement Agreement
SCARF	Salmon Conservation and Research Facility
SJH	San Joaquin Fish Hatchery
SJRRP	San Joaquin River Restoration Program
SWP	State Water Project
TAC	Technical Advisory Committee
UC Davis	University of California, Davis
USFWS	U.S. Fish and Wildlife Service

Executive Summary

The San Joaquin River Restoration Program (SJRRP) will restore a spring-run Chinook Salmon population in the San Joaquin River, as agreed upon in the Stipulation of Settlement in *Natural Resources Defense Council v. Rodgers* (Settlement), which was approved by the United States District Court for the Eastern District of California in October 2006, and approved by Congress in 2009 through the San Joaquin River Restoration Settlement Act (Pub. L. No. 111-11, 123 Stat. 1349).

The historical San Joaquin River spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) population was extirpated and remaining Central Valley (CV) spring-run populations are at varying risk of extinction. Both fall- and spring-run Chinook salmon were extirpated from the San Joaquin River following the completion of Friant Dam and resultant channel dewatering over 60 years ago. The last documented run of spring-run Chinook salmon in the upper San Joaquin River Basin was observed in 1950 and consisted of only 36 individuals (Warner 1991). Since the 1950s, only fall-run Chinook salmon remained in the San Joaquin River, found in major tributaries to the river (SJRRP 2010a).

The California Department of Fish and Wildlife (CDFW), in coordination and partnership with the SJRRP, is developing a San Joaquin River Salmon Conservation and Research Program (Conservation Program). The Conservation Program consists of Salmon Conservation and Research Facility (SCARF) currently planned to begin construction in the summer of 2016, and an interim SCARF (Interim Facility) currently in operation. The Conservation Program is intended to help meet fisheries management objectives towards achieving the Restoration Goal in the Settlement, "to restore and maintain fish populations in 'good condition' in the main stem of the San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally-reproducing and self-sustaining populations of salmon and other fish." The SJRRP has chosen a conservation hatchery as the primary strategy for reintroduction for spring-run Chinook Salmon.

The CV spring-run are listed as threatened under both the Federal Endangered Species Act (FESA) and the California Endangered Species Act (CESA). Collection of fish from this Evolutionarily Significant Unit (ESU) for broodstock is pursuant to FESA 10(a)1(A) Enhancement of the Species Permits 14868 and 17781, which expire in 2018 and 2019, respectively. The reintroduced salmon, taken from one or more out-of-basin stocks, are designated as an experimental San Joaquin River spring-run Chinook Salmon population under the FESA Section 10(j), and have associated 4(d) take provisions (78 Fed. Reg. 79622-79633).

This spring-run Chinook Salmon Hatchery Genetic Management Plan (HGMP) provides guidance on the management and operation of the SCARF and Interim Facility. While extensive analysis and expertise are used to predict restoration success, these predictions are potentially fallible due to variables associated with the massive scale of the SJRRP. Therefore, this HGMP and decisions made under this plan are guided by an adaptive management strategy, as described in the SJRRP Fisheries Management Plan (FMP;

SJRRP). Hatchery operations are subject to revision based on this adaptive management approach and will be guided by a Conservation Facility Subgroup (CFSG), meeting twice a year or more to review program success and critical actions including: production numbers, newly restored habitat sites, results of previous reintroduction efforts, direction of the Conservation Program, release locations, and other monitoring results. The HGMP will be revised and circulated every 5 years as part of the adaptive management process.

To capture the most genetic diversity while minimizing impacts to the source populations, broodstock collections will continue every year for at least two generations (i.e. six years), as guided by population growth of the wild SJR population and source population status. Annual broodstock collections will initially be focused on CV spring-run from Feather River Hatchery (FRH), and will expand to include collections from wild stocks in Butte Creek and the San Joaquin River in 2018. Depending on escapement numbers, returning adults and any stray spring-run that enter the Restoration Area may be available for use as broodstock beginning in 2018. Genetic analysis of these returns will inform fish crosses and reintroduction strategies. Broodstock collection from returns generally should not exceed 10% of the estimated in-river escapement (as determined to maintain population viability) unless river conditions preclude successful spawning. All broodstock used for spawning will be genotyped for parentage-based tagging (PBT) and to prepare breeding matrices to maximize genetic diversity, as described in more detail in Section 8.

Facility planning has been ongoing since 2009 through a multi-agency effort. As of February 2016, the Budget Package, Preliminary Plans and Working Drawings have all been complete, and final construction approval is pending, with construction expected to be complete by the end of 2017. Once SCARF is completed, the Interim Facility will be integrated into SCARF operations, perhaps being repurposed for quarantine or research. With the SCARF operational, broodstock collection can ramp up to the higher levels identified in HGMP Sections 1.11.1 and 6, as permitted.

The Conservation Program Timeline in Figure ES.1 describes the roll-out of interim and full-scale facilities and their relationship to reintroduction strategies. The Interim Facility will be the primary location of hatchery operations until the full-scale SCARF is operational, which is scheduled to for late 2017. In fall 2010, the small-scale Interim Facility began operation using fall-run Chinook Salmon to provide the Conservation Program with practical experience with captive rearing. Spring-run Chinook Salmon were reared there beginning in 2012.

The first spawn at the Interim Facility occurred in November of 2012 as part of an experimental fall-run Chinook captive rearing study to help refine spawning protocols and techniques for the Conservation Program. The following year, the same 2010 year-class of fall-run Chinook were spawned at age-3. The first time spring-run were spawned at the Interim Facility was in the fall of 2015. A total of 43 females were spawned, producing approximately 80,000 eggs. Egg survival to the eyed-stage was 81% from the 2015 spring-run spawn, which met the production goal of 80% survival. This was despite the ongoing drought conditions which resulted in influent temperature reaching 67 degrees Fahrenheit (°F), well above the target temp of 55°F. Water recirculation and

chiller equipment was used to successfully reduce temperatures to between 55-58°F.

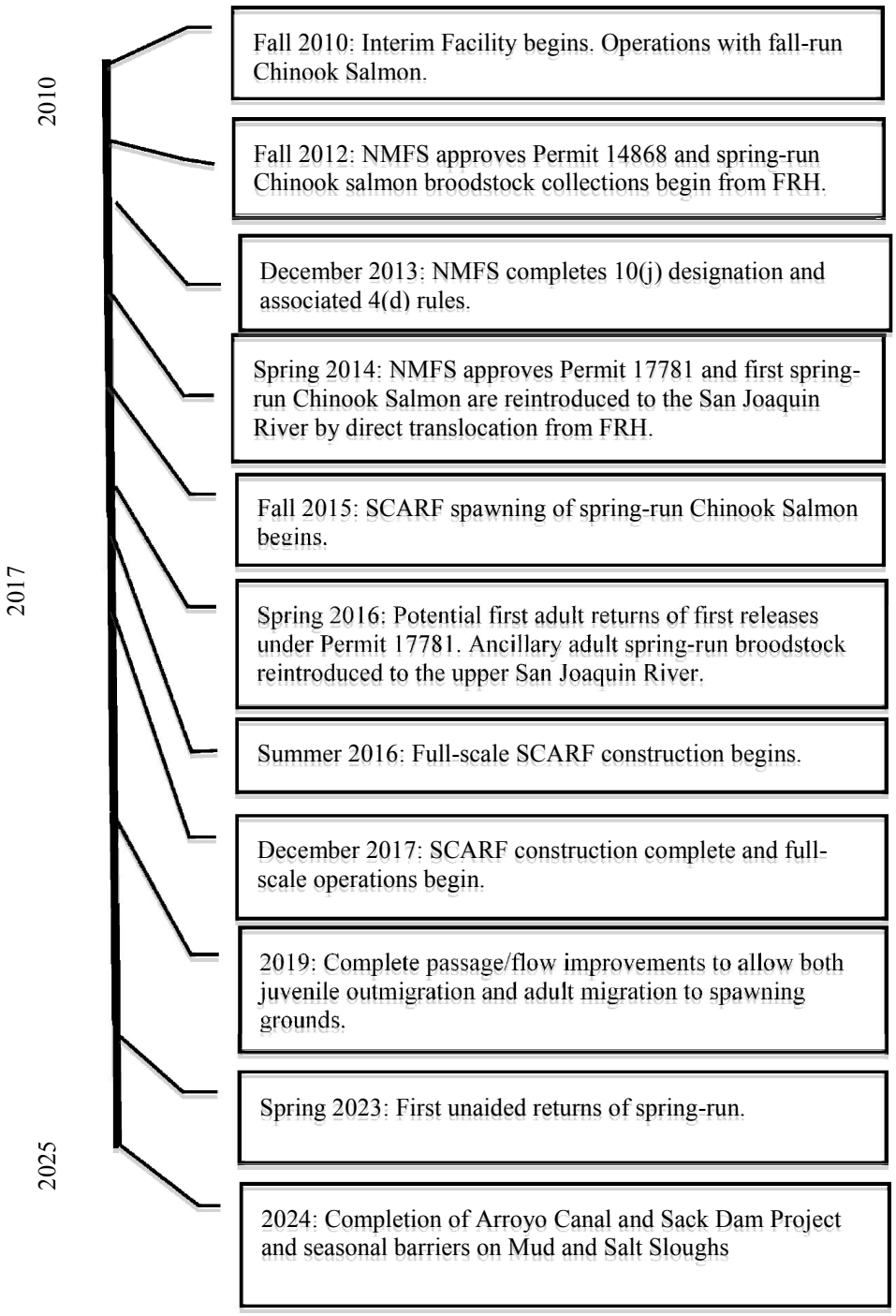

Figure ES.1. Conservation Program/SJRRP Timeline, 2010 to 2025. Projected dates are contingent upon funding availability.

Future smolt production at SCARF in any year will probably not exceed one million smolts, as this is the facility's designed production capability. However, this number may be increased somewhat if required to meet the reintroduction goals (see Section 9). Offspring will be reintroduced to the San Joaquin River as dictated by river conditions and size and genetic diversity of the reintroduced population (see Section 10). Once the Restoration Goal is achieved, the SCARF would be phased out, but may be operated for research or as required in years when river conditions may be insufficient to support the salmon population.

SECTION 1 GENERAL PROGRAM DESCRIPTION

1.1 Name of hatchery or program

This Hatchery and Genetic Management Plan (HGMP) presents information on the San Joaquin River Salmon Conservation and Research Program (Conservation Program) and its hatchery facility, the Salmon Conservation and Research Facility (SCARF). The Conservation Program consists of two phases: an interim phase during construction of the SCARF and a full-scale operational phase, commencing with the SCARF's full-scale operation near the end of 2017. See Appendix A for a year-by-year overview of the Conservation Program.

1.2 Species and population (or stock) under propagation, and status

The SCARF will propagate Central Valley (CV) spring-run Chinook Salmon (spring-run), *Oncorhynchus tshawytscha*, as part of an effort to reintroduce the extirpated population on the San Joaquin River. The source populations are all part of the CV spring-run Evolutionarily Significant Unit (ESU), listed as threatened under both the Federal Endangered Species Act (FESA) and the California Endangered Species Act (CESA), and will be collected under a FESA 10(a)1(A) enhancement of the species permit. The reintroduced population is designated as a nonessential experimental population under the FESA Section 10(j) and has an associated FESA 4(d) take provisions (78 Fed. Reg. 79622-79633).

1.3 Responsible organization and individuals

The Conservation Program is led by the California Department of Fish and Wildlife (CDFW) as part of the San Joaquin River Restoration Program (SJRRP). CDFW will receive guidance and direction from various SJRRP working groups, including the Conservation Facility Subgroup (CFSG), the Genetics Subgroup (GSG), and the Fisheries Management Workgroup (FMWG). In addition, the Hatchery Coordination Team (HCT) is tasked with evaluating and implementing recommendations in the 2012 California Hatchery Review Statewide Report. The HCT will promote best management practices (BMPs) to maintain and recover healthy and sustainable fish populations while achieving mitigation objectives.

The SJRRP work groups and the HCT will be composed of representatives from the SJRRP Implementing Agencies:

- United States Bureau of Reclamation (Reclamation)
- California Department of Fish and Wildlife
- National Marine Fisheries Service (NMFS)
- United States Fish and Wildlife Service (USFWS)
- California Department of Water Resources (DWR)

Representation from each agency may change over time, and additional organizations may become involved in the restoration and reintroduction process. Level of involvement of each will depend on funding availability and permitting.

1.4 Funding source, staffing level, and annual hatchery program operational costs

Short-term operational and equipment funding for fall 2010 through fall 2012 of the interim phase and capital funding for SCARF construction (pending approval) is Proposition 84 California State Bond Funds (i.e., Safe Drinking Water, Water Quality and Supply, Flood Control, and River and Coastal Protection Bond Act of 2006), administered by the California Natural Resources Agency. Initial staffing consisted of one Environmental Scientist and 1-2 part-time personnel. Additional help was needed periodically to deal with seasonal fluctuations in demand (e.g., fish tagging and spawning). Operational costs ranged from $50,000-$150,000 annually in 2010-2012. Since the 2012-2013 State Fiscal Year, operational and maintenance (O&M) funding has been provided by Reclamation through a Cooperative Agreement. Reclamation has committed to funding O&M for a ten-year period through the 2021-2022 fiscal year. Actual and projected O&M costs are shown in Tables 1.1 and 1.2.

Table 1.1: Previous Costs of Interim Facility and SCARF Operations and Maintenance

	2012-2013	2013/2014	2014/2015
Hatchery Operation & Maintenance[1]	**$113,000**	**$257,000**	**$403,500**
Personnel Salaries	**$128,500**	**$148,500**	**$236,500**
Environmental Program Manager (0.2 PY)	*$18,000*	*$13,000*	*$25,500*
Senior Environmental Scientist (0.5 PY)	*$16,000*	*$16,000*	*$50,000*
Environmental Scientist(s) (1.5 PY)	*$68,500*	*$70,000*	*$98,000*
Fish and Wildlife Scientific Aids (Hourly)	*$18,000*	*$42,500*	*$52,500*
Office Technician (Hourly)	*$8,000*	*$7,000*	*$10,500*
Total Hatchery Operational Costs	**$241,500**	**$405,500**	**$640,000**

[1] Includes CDFW reimbursable overhead charge (≅ 37-47%) which has increased each year since fiscal year 2012-2013

Table 1.2: Projected Costs of Interim Facility and SCARF Operations and Maintenance

	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	2020/2021	2021/2022
	Interim Facility		SCARF Operations				
Permanent Personnel	$180,000	$190,000	$300,000	$300,000	$300,000	$300,000	$300,000
Permanent Staff Benefits (47.66%)	$ 85,788	$ 90,554	$ 142,980	$ 142,980	$ 142,980	$ 142,980	$ 142,980
Temporary Personnel	$ 65,000	$ 65,000	$ 65,000	$ 65,000	$ 65,000	$ 65,000	$ 65,000
Temporary Staff Benefits (15.65%)	$10,172	$10,172	$10,172	$10,172	$10,172	$10,172	$10,172
O&M Costs	$300,000	$300,000	$410,000	$410,000	$410,000	$350,000	$350,000
Subtotal	$640,960	$655,726	$928,152	$928,152	$928,152	$868,152	$868,152
Overhead (38.40%)	$246,129	$251,799	$356,410	$356,410	$356,410	$333,370	$333,370
Total	$887,089	$907,525	$1284,562	$1284,562	$1284,562	$1201,522	$1201,522

The reimbursable O&M Agreement covers 100% of operations and maintenance costs as well personnel services of up to 1.5 personnel year (PY) for Environmental Scientist, 0.5 PY for a Senior Environmental Scientist – Supervisor, and 0.2 PY for Environmental Program Manager to cover personnel contributions towards O&M. The Agreement also covers hourly wages for other classifications (i.e., scientific aids, office technician).

1.5 Location(s) of hatchery and associated facilities

The Interim Facility is and the SCARF will be located along the San Joaquin River adjacent to the CDFW's San Joaquin State Fish Hatchery in Friant, California (San Joaquin River Basin, river miles (RM) 265-266; GPS 36° 59'11.57" N, 119° 43'02.11"W). A small, satellite incubation and rearing facility (SIRF) to the SCARF is located 0.75 miles upstream of the SCARF on Reclamation's Friant Dam property. See Figure 1.1.

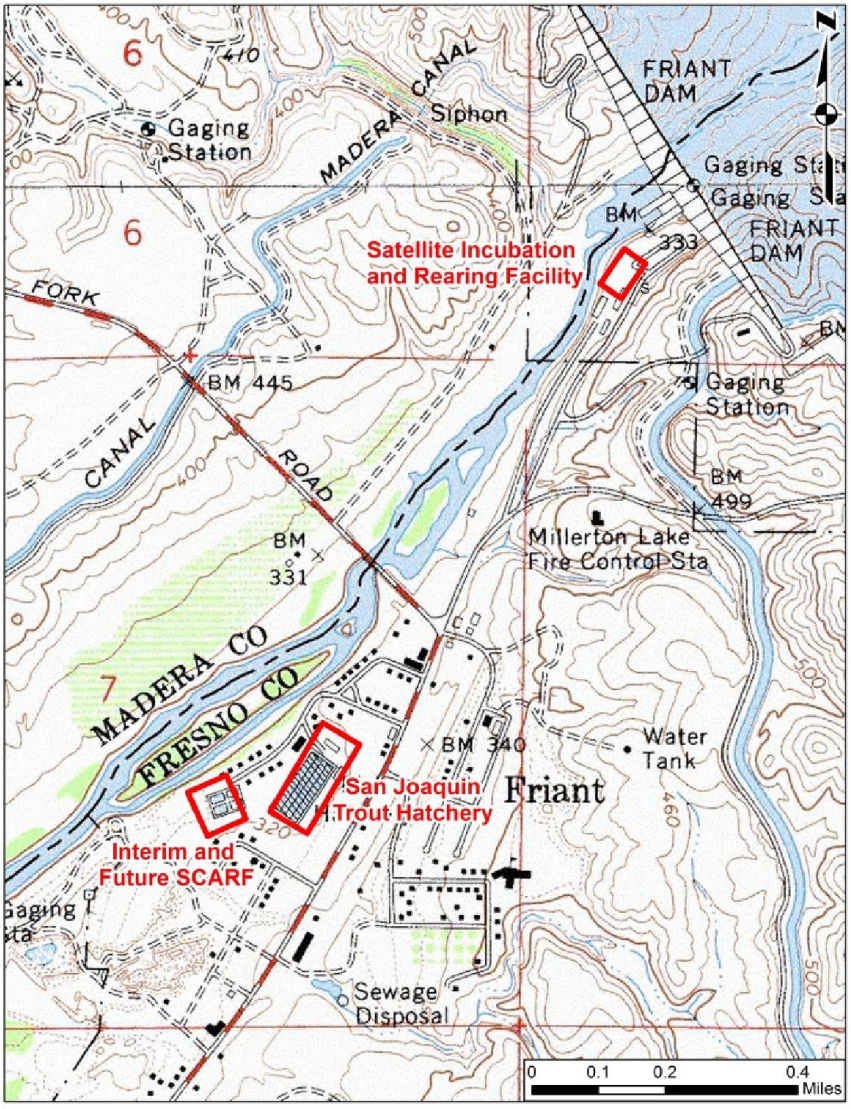

Figure 1.1: Location of future SCARF, current Interim Facility, and SIRF

1.6 Type of program

The Conservation Program is an integrated recovery program.

1.7-8 Purpose (Goal) and Justification of program

The historical San Joaquin River spring-run Chinook Salmon population was extirpated and remaining CV spring-run populations are at varying risk of extinction. Both fall-run and spring-run Chinook salmon were extirpated from the San Joaquin River following the completion of Friant Dam and resultant channel dewatering over 60 years ago. The last documented run of spring-run Chinook salmon in the upper San Joaquin River Basin was observed in 1950 and consisted of only 36 individuals (Warner 1991). Since the 1950s, only fall-run Chinook salmon remained in the San Joaquin River, found in its major tributaries (SJRRP 2010a). The Conservation Program will produce CV spring-run for reintroduction in order to restore a self-sustaining population in the San Joaquin River. The SCARF anticipates limited collections from extant CV spring-run populations (e.g., Feather, Butte) and will use artificial propagation of a captive broodstock to attain sufficient fish numbers for reintroduction.

The SJRRP is the result of a legal settlement to a lawsuit challenging renewal of long-term water service contracts between the United States and the Central Valley Project (CVP) Friant Division. The Stipulation of Settlement in *Natural Resources Defense Council (NRDC), et al., v. Kirk Rodgers, et al.* (Settlement) requires the reintroduction of spring-run Chinook Salmon into the San Joaquin River.

The goals established by the Settlement drive the development of measurable objectives designed to assure achievement of those goals. The Settlement reads:

> [T]he Restoration Goal of this Settlement shall include the reintroduction of spring-run and fall-run Chinook Salmon to the San Joaquin River between Friant Dam and the confluence with the Merced River by December 31, 2012, consistent with all applicable law.

Based on the Settlement goals, the Restoration Administrator developed three population goals (Meade 2007), and the Fisheries Management Working Group (FMWG) developed two more. These five population goals are presented in the Fisheries Management Plan (FMP; SJRRP 2010), with the first four being directly relevant to management of the hatchery:

1. Establish natural populations of spring-run and/or fall-run Chinook Salmon that are specifically adapted to conditions in the upper San Joaquin River. Allow natural selection to operate on the population to produce a strain that has its timing of upstream migration, spawning, outmigration, and physiological and behavioral characteristics adapted to conditions in the San Joaquin River. In the case of spring-run Chinook Salmon, the initial population would likely be established from Sacramento River Basin stock.

2. Establish populations of spring-run and/or fall-run Chinook Salmon that are genetically diverse so they are not subject to the genetic problems of small populations, such as founder's effects, inbreeding, and the high risk of extinction from catastrophic events. The minimum population threshold established in the Settlement was set with this goal in

mind and suggests genetic and population monitoring will be required.

3. Establish populations of spring-run and fall-run Chinook Salmon that are demographically diverse in any given year, so returning adults represent more than two age classes. Given the vagaries of ocean conditions, the likelihood of extreme droughts, and other factors that can stochastically affect Chinook Salmon numbers in any given year, resiliency of the populations requires that multiple cohorts be present. Chinook Salmon populations in the Central Valley are dominated by 3-year-old fish, plus 2-year-old jacks, partly as the result of the effect of fisheries harvest [and hatchery mating practices]. Both population resiliency and genetic diversity require that 4-, 5-, and even 6-year-old Chinook Salmon be part of the population each year.

4. Each population (spring-run and fall-run) should show no substantial signs of hybridizing with the other. In addition, each population should show no substantial signs of genetic mixing with non-target hatchery stocks.

The FMWG also developed the genetic management goals for the SJRRP which are to:

1. Promote and protect genetic diversity within the reestablishing populations while safeguarding against negative genetic effects to out-of-basin source and non-target populations.

2. Reestablish self-sustaining San Joaquin River spring- and fall-run salmon populations.

From these goals, the FMWG developed the FMP population objectives. Not all of the nine population objectives listed below are directly relevant to hatchery operations, but all are presented here to provide context. As noted in the FMP, the population goals should be treated as preliminary recommendations, subject to revision as the system and its capacity to support CV spring-run is better understood. The Conservation Program is a necessary component of achieving these goals, but river and ocean conditions will affect whether they can be achieved. The FMP Sections 3.2.1 - 3.2.2 provide a detailed justification for these objectives:

1. A 3-year target of a minimum of 2,500 naturally produced adult spring-run Chinook Salmon and 2,500 naturally produced adult fall-run Chinook Salmon.

2. Each year, a minimum of 500 naturally produced adult spring-run and [500 naturally produced] adult fall-run Chinook Salmon each should be in adequate health to spawn successfully. Thus, the minimum annual effective population target would be 500 adult Chinook Salmon of each run. Note, the expectation is that there will be a 50:50 sex ratio.

3. Ten years following reintroduction, less than 15% of the Chinook Salmon population should be of hatchery origin.

4. A growth population target of 30,000 naturally produced adult spring-run Chinook Salmon and 10,000 naturally produced fall-run Chinook Salmon.

5. Prespawn adult Chinook Salmon mortality related to any disease should not exceed 15%.

6. Mean egg production per spring-run Chinook Salmon female should be 4,200, and egg survival should be greater than or equal to 50%.

7. A minimum annual production target of 44,000 spring-run Chinook Salmon juveniles and 63,000 fall-run Chinook Salmon juveniles and maximum production target of 1,575,000 spring-run Chinook Salmon juveniles and 750,000 fall-run juveniles migrating from the Restoration Area. Juvenile production includes fry, subyearling smolts, and age 1+ yearling smolts. Estimated survival rate from fry emergence until they migrate from the Restoration Area should be greater than or equal to 5%. Ten percent of juvenile production for spring-run Chinook Salmon should consist of age 1+ yearling smolts.

8. The incidence of highly virulent diseases should not exceed 10% in juvenile Chinook Salmon.

9. A minimum growth rate of 0.[0]4* grams per day (g/d) during spring and 0.07 g/d during summer should occur in juvenile Chinook Salmon in the Restoration Area.

   * listed as 0.4 in FMP

The Conservation Program has adopted these, but notes that meeting objectives will be dependent on activities outside the scope of the SCARF. Restoration of passage and habitat within the San Joaquin River will be necessary to meet population targets, and the sources of broodstock will depend on health of other CV spring-run populations and conditions outside of the SJRRP Restoration Area. For example, the fourth population goal presented in the FMP, that the spring-run and fall-run fish in the river should show no substantial signs of hybridizing with each other, will be effected by the likelihood of using Feather River spring-run Chinook Salmon as a source population. The Feather River population is addressed in more detail in HGMP Sections 2 and 6, below. The SCARF will instead seek to minimize the introgression between spring-run and fall-run fish through run segregation and genetic analysis of all broodstock.

Additionally, the third FMP Population Objective, that less than 15% of the Chinook Salmon population should be of SCARF origin 10 years following reintroduction, should be measured from the end of the reintroduction period or the beginning of full-scale releases from the SCARF, and after passage and habitat restoration projects are complete in 2022. River conditions prior to that time are likely to stunt growth of a natural population, and production capacity at the Interim Facility will limit releases prior to full-scale operation of the SCARF.

Fish representing the first full-scale release in 2022 will be produced from the fall 2021 spawning event. Those fish will not return in significant numbers until 2024, and thus wild production will probably not be very significant until then. By 2031, the fish from the first full-scale release will have spawned in the wild three times, and the population should be able to meet the third FMP Population Objective.

Additionally, FMP Population Objective 7 states that "Ten percent of juvenile production for spring-run Chinook Salmon should consist of age 1+ yearling smolts," but the actual percent will depend on river conditions. This may not be possible to accomplish if river conditions in a given year preclude release of fry or other ages of fish, or if the SCARF has not yet reached full capacity. Releases will also be evaluated based on success, as established through the studies

outlined in HGMP Section 12.

Finally, in regards to FMP Population Objective 8, while measures can and will be taken to minimize risk of disease and pathogens, an epizootic form of a highly virulent pathogen cannot be controlled to stay within a percentage of survival or mortality.

Acknowledging these confounding factors, these goals and objectives drive the HGMP Objectives, Performance Standards, and Performance Indicators in HGMP Section 1.9, below.

1.9 List of program "Performance Standards" and program "Performance Indicators"

The Conservation Program Objectives are based on the FMP objectives and the NMFS recommendations for HGMP objectives (NMFS 2000, NPPC 2001). "Performance Standards" are designed to achieve these objectives and are measurable, realistic, and time specific. "Performance Indicators" are the specific parameters to be monitored and evaluated in order to determine the degree that program standards have been achieved. Many of these indicators are already measured and will continue to be measured as part of ongoing monitoring programs outside of the San Joaquin River; these indicators are marked as "*Ongoing Non-Program Monitoring*" in the list below. Data collected from ongoing monitoring efforts used by and/or incorporated into the Conservation Program will be gathered by the CFSG and GSG and, to the extent this information is available, will be included in Annual Reports submitted to NMFS in compliance with 10(a)1(A) Permit requirements.

In support of the FMP objectives and as funding becomes available, the Program will:

HGMP Objective 1. Select and collect broodstock for reintroduction from existing CV spring-run source stock(s) that capture(s) phenotypic and genotypic diversity of the source population(s). Collections in this manner are intended to produce an experimental population with the capability of producing a self-sustaining naturally reproducing population in the San Joaquin River Restoration Area, while minimizing impacts to wild source stocks. The populations (potentially including strayed fish as available) providing fish for artificial propagation in the SCARF are termed the "source populations," and the fish collected and reared in the SCARF for the purpose of hatchery spawning are termed "broodstock." This objective addresses protection of the source population; while some fish returning to the San Joaquin River may be integrated into the hatchery population, protection of this experimental population is covered in HGMP Objectives 2 and 3.

Standard 1.A. Source population(s) selected for use as broodstock are genetically diverse and either at low risk of extinction or have risk factors that would not be substantially increased by removal of fish for broodstock.

Indicator 1.A.i. Periodic viability and extinction risk analyses of extant Central Valley spring-run populations and evaluation of the indicators outlined by Allendorf et al. (1997), including effective population size, census size, and hatchery influence. *Ongoing Non-Program Monitoring*.

Indicator 1.A.ii. Periodic assessment of life history characteristics,

genetic diversity, disease prevalence, hatchery influence, and transplantation history into and out of source river system. *Ongoing Non-Program Monitoring*.

Standard 1.B. Fish collected for broodstock provide a representative sample of the range of genetic diversity found in the source population(s).

Indicator 1.B.i. Comparison of broodstock genetic diversity with the diversity of the source population. *Program and Ongoing Non-Program Monitoring*

Indicator 1.B.ii. Temporal and spatial distribution of broodstock collection relative to the temporal and spatial distribution of the source population. *Program and Ongoing Non-Program Monitoring.*

Standard 1.C. Stock selection decisions are adaptively managed through ongoing evaluation of the hatchery program.

Indicator 1.C.i. The success of progeny from each source population in the upper San Joaquin River, measured as a percentage of the escapement gene pool that each source is contributing.

Indicator 1.C.ii. The impact of broodstock collection on source populations (based on Standards 1.D-1.F). *Program and Ongoing Non-Program Monitoring.*

Indicator 1.C.iii. Program is guided by the CFSG, meeting regularly to review annual production numbers, results of previous reintroduction efforts, determination of direction of program into new sites and/or continued planting in current reintroduction areas, success of efforts, or other monitoring results as they may pertain to the Conservation Program. The CFSG incorporates requirements/mandates from NMFS, and recommendations from the SJRRP Technical Advisory Committee (TAC), and the Hatchery Scientific Review Group (HSRG), as needed.

Standard 1.D. Broodstock collection does not significantly reduce the source populations' potential juvenile production in natural rearing areas.

Indicator 1.D.i. Number of individuals, by life history stage, of natural origin removed from source populations for broodstock, both in total and as a percentage of source population life history stage in question.

Indicator 1.D.ii. Broodstock collection is ended when Program broodstock goals are achieved.

Standard 1.E. Collection of broodstock does not adversely impact the genetic diversity of the naturally spawning source population.

Indicator 1.E.i. Reduction in effective population size of the source population that is attributable to broodstock collection, based on estimated survival ratios from the life history stage collected to adult escapement.

Standard 1.F. Mortality rates in weir/trap/collection operations do not exceed allowable limits in FESA and CESA permits.

Indicator 1.F.i. Mortality rates in traps.

Indicator 1.F.ii. Prespawn mortality rates of trapped fish in hatchery or after release.

Indicator 1.F.iii. Best management practices employed in collecting/handling fish/maintaining equipment.

Indicator 1.F.iv. Traps are checked at least once per day.

Indicator 1.F.v. Collection of eggs occurs during the less sensitive eyed egg stage.

HGMP Objective 2. Conduct SCARF operations to minimize domestication selection and to maximize effective population size in the broodstock (N_{eh}), experimental population (N_{ew}), and the combined population (N_{eh+w}) (Meade 2007, Meade 2008).

Standard 2.A. Breeding protocols for SCARF operations maximize N_{eh} and, once the wild population is established, N_{ew} and N_{eh+w}.

Indicator 2.A.i. Effective population size and genetic diversity for the broodstock.

Indicator 2.A.ii. Use of genetically-defined breeding matrices to avoid matings between closely related individuals. Selected cut-off for relatedness coefficient will depend on the genetic characteristics of the collected broodstock and will be included in Annual Reports. The spawning matrix will be organized by female, with all potential male mates listed below her in order of preference based on their coefficient of relatedness (most desirable male is the least genetically-related).

Indicator 2.A.iii. Once established, effective population size and genetic

diversity of the combined hatchery and natural origin experimental population.

Standard 2.B. Reintroduction protocols should emphasize returns of adult spawners.

Indicator 2.B.i. Genetic pedigree analyses (PBT, per Anderson and Garza (2006), and other marking and tagging methods, as appropriate) and well-designed propagation experiments evaluating which reintroduction methods achieve the greatest success in returning adult spawners and in overall fitness.

Standard 2.C. Conservation hatchery approaches, as established in this HGMP, are used as appropriate throughout all stages of SCARF operations.

Indicator 2.C.i. Compliance with this HGMP discussed in Annual Reports.

HGMP Objective 3. Establish a self-sustaining, naturally produced population of CV spring-run Chinook Salmon.

Standard 3.A. The Conservation Program supports growth of the naturally spawning San Joaquin River population, in support of FMP Population Objectives.

Indicator 3.A.i. Annual number and percentage (pNOH), and trends of hatchery- (HO) and natural-origin (NO) spawners on spawning grounds (actual count and moving geometric mean, including calculated age at return).

Indicator 3.A.ii. Spawner-recruit ratios.

Indicator 3.A.iii. Annual number of redds in selected natural production index areas (actual count and moving geometric mean).

Indicator 3.A.iv. Trends in percent natural-origin composition of spawning adults.

Indicator 3.A.v. Annual number of outmigrants, by origin (hatchery or wild).

Standard 3.B. SCARF production/releases are 100% marked, allowing for accurate evaluation of program contribution to natural production and of effects of the program on the natural populations in the San Joaquin basin. Marks may include coded wire tags (CWT), Parentage Based Tag (PBT), passive integrated transponders (PIT), or other agency approved tag or mark.

Indicator 3.B.i. Marking rates and type of mark.

Standard 3.C. Annual release numbers do not exceed estimated habitat carrying capacity, including spawning, freshwater rearing, and migration corridor in the Restoration Area.

Indicator 3.C.i.	Carrying capacity criteria for available habitat in the Restoration Area, based on current and future monitoring programs.
Indicator 3.C.ii.	Annual release numbers from SCARF, including size and life-stage at release, and release location.
Indicator 3.C.iii.	Annual estimates of naturally produced juveniles present
Indicator 3.C.iv.	Migration behavior and survival of hatchery origin salmon, compared to source populations and compared to the San Joaquin natural origin salmon, once established. *Program and Ongoing Non-Program Monitoring*

Standard 3.D. To maximize homing ability to intended return locations, juveniles are released on-station, as river conditions permit, or, for off-site releases or releases of any direct-transfer fish, as far upstream as feasible based on river connectivity and expected survival out of the Restoration Area.

Indicator 3.D.i.	Location of releases relative to natural rearing areas.
Indicator 3.D.ii.	For off-site releases, reason for off-site release.
Indicator 3.D.iii.	Experimental program to evaluate effectiveness of various in-river release strategies.
Indicator 3.D.iv.	Proportion of adult returns to spawn naturally in the San Joaquin River, compared to returns to unintended areas. *Program and Non-program Monitoring*

HGMP Objective 4. Once the experimental population is established, minimize the influence of hatchery origin fish on wild fish in the experimental population, which includes progeny of repatriated, recolonizing, or returning spring-run Chinook Salmon spawners, by maintaining a four-year mean Proportionate Natural Influence (PNI) above 0.67, in keeping with HSRG recommendations (HSRG 2007). PNI is the proportion natural origin spawners in broodstock (pNOB) divided by the sum of the proportion effective hatchery origin spawners on spawning grounds (pHOS) and pNOB (HSRG 2007).

Note on the use of HSRG recommendations in a reintroduction effort.

The HSRG has produced guidelines for integrated hatcheries, with the goal of ensuring that natural selection outweighs domestication selection while a population is augmented

by hatchery production. The HSRG has not explicitly considered the unique problems presented in a reintroduction effort and does not have explicit goals for such programs. While the HSRG recommendations would apply to a reintroduction after a wild population has been established, the recommendations are not appropriate for the early years of a reintroduction and should not be the goals for the initial stages of such efforts. The Conservation Program's goals, during the Reintroduction Period (2012-2020) and Interim Period (2020-2025), are different for two primary reasons. First, the HSRG work is predicated on the existence of natural population, and there is no natural population in the Restoration Area. A natural population must be established by the hatchery before the HSRG recommendations can be used to evaluate hatchery practices. Second, in a reintroduction, it is desirable that the genetics of the broodstock dominate for the first two generations to avoid founder effects and to ensure that as much diversity as possible is captured from the source populations (Fraser et al. 2008), before natural selection becomes the primary selective force. This contrasts with a typical hatchery situation, where the HSRG recommendations seek to minimize the hatchery influence on the natural population. After a natural origin population is established and begins adapting to the new river system, the HSRG recommendations will become applicable to the Program. The timing of the applicability of the HSRG recommendations will depend on the success of the reintroduction effort, but will almost certainly be applicable after the Interim Period and may begin to be applicable at the middle or end of the Reintroduction Period. The HCT will evaluate the appropriateness of the HSRG recommendations annually, assess how they are being addressed in SCARF operations, and with the involvement of the CFSG and GSG determine how best to integrate them as appropriate.

Standard 4.A. Unique marks are used for release groups, in a manner consistent with information needs and protocols, to sufficiently enable determination of impacts to natural- and hatchery-origin fish in fisheries.

Indicator 4.A.i. Marking rate by mark type for each release group.

Indicator 4.A.ii. Number of marked fish produced by the SCARF observed in any fishery samples, including available information from river and ocean catches. *Program and Ongoing Non-Program Monitoring.*

Indicator 4.A.iii. Evaluation of hatchery contribution to the census size of returning upper San Joaquin River Chinook Salmon populations based on physical marks, genetic assignment tests, or otolith analysis, as appropriate.

Standard 4.B. Once the experimental population is established, life history characteristics of the natural population are not controlled by hatchery production but are allowed to adapt to the conditions in the restored San Joaquin River. Four-year mean PNI is above 0.67.

Indicator 4.B.i. Periodic and four-year mean PNI, pNOS, and pNOB.

Indicator 4.B.ii. Assessment of adaptation of successive generations of naturally spawning fish to conditions in the San Joaquin River to determine performance of the experimental population. This will be done via development of a monitoring program that will collect biological data and samples. Biological data will be collected from monitoring of multiple life history stages and characteristics. Data to be collected in the experimental population may include:

- Juvenile dispersal/outmigration timing
- Juvenile size at outmigration, and outmigration age composition
- Adult return timing
- Adult return age and sex composition
- Adult size at return
- Spawn timing and distribution
- Fry emergence timing
- Juvenile rearing densities, distribution, and behaviors
- Juvenile growth rate, condition factors, and survival at several growth stages prior to final release
- Diet composition and availability
- Adult physical characteristics (length, weight, condition factors)
- Fecundity and egg size
- Spawning behavior and success

Indicator 4.B.iii. Annual genetic analyses indicate natural- and hatchery-origin fish are genetically similar.

Standard 4.C. Hatchery produced adults in natural production areas do not exceed appropriate proportion of the total natural spawning population. The appropriate portion will vary based on the phase of reintroduction and the performance of the Conservation Program, with interim targets established by the CFSG, but the four-year average pHOS should be trending down beginning in 2032. Per FMP recommendations, the four-year mean pHOS is less than 15% ten years after the reintroduction period. Origin of adults will be based on physical marks, genetic analysis, otolith analysis, and/or identifying tags of a representative sample of the population.

Indicator 4.C.i. Observed and estimated total numbers of naturally produced and known artificially produced adults passing a counting station (if present) close to natural spawning areas, if available.

Indicator 4.C.ii. Proportion of adults spawning in natural spawning areas that are of hatchery origin.

HGMP Objective 5. Conservation Program operates in such a manner as to not increase pathogens and disease risk to the natural population, and to outside entities.

Standard 5.A. SCARF is operated in compliance with CDFW's fish health policies and guidelines, including that hatchery releases do not introduce pathogens not already existing in the local populations and do not significantly increase the levels of existing pathogens. Fish health assessments are conducted pre-hatchery transfer and pre-river release and by analyzing ovarian fluid from all adult spawners. Testing includes pathogen screening, blood plasma protein, hematocrit, fat index, smolt index, etc. performed by CDFW Fish Health Lab. Eggs are culled if spawners are detected to be positive for BKD and IHNV. Carcasses with known detrimental pathogens (BKD, IHNV, whirling disease etc.) are not distributed in river.

Indicator 5.A.i. Number of broodstock sampled for pathogens. Types and frequencies of observed infections. Rearing survival rates: 1) egg to fry; and, 2) fry to juvenile fish released, both by family group and in population as a whole.

Indicator 5.A.ii. Number of juveniles sampled and pathogens observed immediately prior to release.

Indicator 5.A.iii. Assessment of juvenile fish health immediately prior to release, including pathogens present.

Indicator 5.A.iv. Results of fish health examinations.

Standard 5.B. Any distribution of carcasses is accomplished in compliance with appropriate disease control regulations and guidelines, including state, tribal, and federal carcass distribution guidelines.

Indicator 5.B.i. Number and location(s) of carcasses or other products distributed for nutrient enrichment.

Indicator 5.B.ii. Statement of compliance with applicable regulations and guidelines.

HGMP Objective 6. Maintain or further isolate the genetic and phenotypic characteristics of the experimental CV spring-run population.

Standard 6.A. River and SCARF management emphasize segregation of fall- and spring-run spawning.

Indicator 6.A.i. Estimated carrying capacity of the San Joaquin River for supporting naturally spawning spring- and fall-run Chinook populations. Segregation protocols in place to prevent introgression of fall- and spring-run, such as

physical or environmental barriers, river flow management, or other methods.

Indicator 6.A.ii. Management release strategies that encourage homing to the upper San Joaquin River and discourage straying, such as releasing juveniles as far upstream as feasible based on river connectivity and expected survival out of the Restoration Area.

Standard 6.B. San Joaquin River spring-run Chinook Salmon do not show increasing levels of introgression with fall-run Chinook Salmon.

Indicator 6.B.i. Genetic analysis of San Joaquin River Chinook Salmon population status conducted periodically to evaluate the degree of hybridization between spring- and fall-run salmon on multiple spatial and temporal scales.

Standard 6.C. San Joaquin River spring-run Chinook Salmon show an array of life history strategies similar to those found in the source populations, as appropriate to the Restoration Area.

Indicator 6.C.i. Source population phenotypes and life histories are represented in broodstock, unless those life histories are incompatible with the restored San Joaquin River conditions. *Program and Ongoing Non-Program Monitoring*

Indicator 6.C.ii. Multiple strategies used during spawner and early life history stages to favor reestablishing a diverse spring-run Chinook Salmon population.

Indicator 6.C.iii. Life stage of broodstock at collection.

HGMP Objective 7. Phase out SCARF operations based on an adaptive management approach and achievement of restoration objectives.

Standard 7.A. Beginning in 2025, hatchery proportion of the total natural spawning population is declining measured by a four-year moving average, expressed as pHOS. pHOS is less than 15% in 2032.

Indicator 7.A.i. Observed and estimated total numbers, and the ratio, of naturally produced and artificially produced adults, estimated per Standard 4.C.

Indicator 7.A.ii. Proportion of hatchery origin fish carcasses on natural spawning areas.

Indicator 7.A.iii.

Standard 7.B. Quantitative natural population targets (e.g. N_e, census size, genetic diversity) and other community and ecosystem indicators of reintroduction success are derived and periodically evaluated to determine the schedule for phase out of SCARF production.

Indicator 7.B.i. Natural portion of San Joaquin River spring-run Chinook Salmon population evaluated annually against SJRRP targets and for long-term viability.

Indicator 7.B.ii. Hatchery production needs are evaluated annually against estimated natural production.

HGMP Objective 8. Meet all applicable legal requirements.

Standard 8.A. Program addresses FESA and CESA responsibilities.

Indicator 8.A.i. FESA consultation(s) under Section 7 and 10 of the ESA have been completed and NMFS has approved this associated HGMP by December 31, 2017.

Indicator 8.A.ii. CESA consultations and permitting completed by December 21, 2017, as necessary.

Standard 8.B. The Conservation Program is monitored and evaluated on an appropriate schedule and scale to address progress toward achieving the restoration goals and effects on natural populations.

Indicator 8.B.i. Monitoring and evaluation framework including detailed time line.

Indicator 8.B.ii. Annual reports reporting on all indicators.

Standard 8.C. Effluent from the SCARF will not detrimentally affect natural populations.

Indicator 8.C.i. Reported dates, locations and number of water samples collected.

Indicator 8.C.ii. Samples analyzed and results reported.

Indicator 8.C.iii. Effluent water quality compared to the hatchery's current National Pollutant Discharge Elimination System (NPDES) permit.

Standard 8.D. Water withdrawals and water diversion structures for SCARF operation will not prevent access to natural spawning areas, affect spawning behavior of natural populations, or impact juvenile rearing environment. If water is taken

directly from Friant Dam, as planned, Indicators 7.D.ii – iv will not apply.

Indicator 8.D.i. Water withdrawals and impacts on instream flow.

Indicator 8.D.ii. Number of adult fish aggregating and/or spawning immediately below water intake point.

Indicator 8.D.iii. Number of adult fish passing water intake point.

Indicator 8.D.iv. Proportion of diversion of total stream flow between intake and outfall.

Standard 8.E. Data on SCARF operations will be collected, reviewed and reported in a consistent and scientifically rigorous manner.

Indicator 8.E.i. Annual reports are produced, reviewed, and finalized each year in compliance with NMFS 10(a)1(A) Permit requirements..

Indicator 8.E.ii. Reports are available for public review.

Indicator 8.E.iii. Reports and, if requested, all raw data are distributed in electronic or hard copy to all participating State and Federal agencies.

HGMP Objective 9. Conduct effective public outreach on the San Joaquin River restoration generally and on SCARF's role in the reintroduction of spring-run Chinook Salmon.

Standard 9.A. SCARF personnel are available to lead public tours during appropriate, specified days/hours, with limited fish/human contact.

Indicator 9.A.i. Hours and dates for public tours.

Indicator 9.A.ii. Public outreach is managed to avoid conflict with the Conservation Facilities primary duties.

Standard 9.B. The Conservation Program provides educational materials on San Joaquin River restoration generally and on the SCARF's role in the reintroduction of the spring-run Chinook Salmon.

Indicator 9.B.i. Examples of educational materials will be provided to interested parties upon request.

Indicator 9.B.ii. Amount of material distributed and to whom.

1.10 Expected size of Conservation Program

1.10.1 Proposed annual broodstock collection level

Broodstock will be collected as eggs or juveniles from up to three CV spring-run populations (i.e., Feather River, Butte Creek, and the San Joaquin River) and reared to maturity at the SCARF. Adult CV spring-run may be collected from the San Joaquin River, but it is unlikely that adult fish from other populations will be used due to their limited availability and the difficulty in capturing, transporting and holding adult spring-run Chinook Salmon. Adult fish would be used for the collection of gametes, broodstock spawning, or transfer and release into the river for natural spawning.

The quantity of broodstock collected from each extant population will be based on several factors related to population viability and extinction risk, including the number of returning adults, genetic diversity, ability to collect unrelated fish, and the anticipated survival of broodstock to adulthood. In the short term, the Conservation Program will collect sufficient numbers of relatively unrelated broodstock to obtain 50 gravid adult females and 100 fertile males from all stocks combined. Fish collected from the FRH or natural populations will be reared in the Interim Facility and/or SCARF, and their offspring will be released to the San Joaquin River. The long-term goal of the full-scale SCARF will be to propagate sufficient numbers of broodstock to provide 50 to 150 relatively unrelated gravid adult females and 100 to 300 fertile males from each source population, per year, for a minimum of four to eight years. Based solely on genetic considerations for the experimental population, 150 unrelated gravid adult females and 300 fertile males from each population per year for four years would provide a better representation of the genetic diversity in the source populations. The rationale for these figures is explained in HGMP Section 6. The actual number of fish collected each year from each source population will depend on the status of the source populations and restoration progress on the San Joaquin River. If the larger numbers of fish cannot be obtained, the Conservation Program will require a longer duration to ensure capture of significant diversity from each population. Ultimately, however, the maximum allowable yearly collection from each of the source populations will be based on each stock's viability and the NMFS permitting decisions. Proposed maximum annual broodstock collection numbers from all source population are shown in Table 1.3.

Table 1.3: Anticipated collections among brood years and populations to meet genetic and Conservation Program goals based on SCARF activities.

Population	Targeted Life Stage	Total Collection[1]	Brood Years
Feather River Hatchery	Eggs or Juveniles	600	2012-2014
Feather River Hatchery	Eggs or Juveniles	2,700	2015-2016
Butte Creek, San Joaquin River, and Feather River Hatchery	Eggs or Juveniles	5,400	2017-2021
Butte, Deer and Mill Creeks, San Joaquin River, and Feather River Hatchery	Eggs or Juveniles	5,400	2022+

[1] Number of individuals from each source population will depend on annual returns and environmental conditions. Does not include individuals necessary for pathology testing, i.e., 70 per collection event.

1.10.2 Proposed annual fish release levels (maximum number) by life stage and location

Release levels will be determined at the time of release based on river conditions and the restoration progress and will not exceed the river's carrying capacity after accounting for natural production. FMP Population Objective 7 states that "Ten percent of juvenile production for spring-run Chinook Salmon should consist of age 1+ yearling smolts," but the actual percent will depend on river conditions. The carrying capacity will be estimated as part of the river conditions monitoring, described in HGMP Section 11. If, based on initial calculations, the carrying capacity is determined to be significantly higher than anticipated natural and hatchery production, carrying capacity may not be calculated annually. Table 10.1 in Section 10 provides a range of possible release levels, by year. HGMP Section 10 provides additional details on the methods to be used for release.

1.11 Current program performance, including estimated smolt-to-adult survival rates, adult production levels, and escapement levels. Indicate the source of these data

Though survival rates vary between hatchery programs, the SCARF will seek to achieve 85% survival from egg to hatchery to match that experienced at FRH in recent years (Cavallo et al. 2009) and 75% or better survival from egg to smolt stages over the duration of the program and greater than 49% survival from smolt to adult (Pollard and Flagg 2004).

During the fall of 2013, experimental fall-run Chinook broodstock were spawned at age-3 at the Interim Facility. Approximately 187,500 eggs were produced and survival to the eyed-stage was approximately 81%. However, egg to emergence was approximately 50%. The lower survival rate was likely due to the higher water temperatures (up to 62°F) that occurred during spawning. The high temperatures accelerated fungus growth, which reduced survival. Also, for reasons unknown, a high number of fry became emaciated and died, and never successfully transferred to the commercial diet (Ewos). The high water temperatures were due to the ongoing regional drought, and, in response, the Conservation Program installed water chilling and water recirculation equipment. Also, there may have been a problem with the feed or particular batch of feed.

Spawning again occurred in the fall of 2015 at the Interim Facility with the first mature pairs of spring-run broodstock. Approximately 84,400 eggs were produced which resulted in a survival to the eyed-stage of 77% and a survival from spawn to emergence of 63%. From emergence to juvenile releases, survival increased to 95.5% with a total survival from spawn to release of 60.2%. The number of emaciated fish was greatly reduced compared to the previous spawn. This was despite the ongoing drought conditions which resulted in ambient water temperature reaching 67°F. Water recirculation equipment was used to successfully reduce temperatures to between 55-58°F. In the fall of 2016, the Interim Facility will spawn the first age-4 adults, and it is anticipated that average body weight will increase and, as a result, fecundity and egg survival will continue to improve.

1.12 Date program started (years in operation), or is expected to start

The Interim Facility began rearing CV spring-run Salmon in 2013 and will continue to rear spring-run until 2017, when the full-scale SCARF will begin operations. The first full-scale releases are expected to occur in 2022.

1.13 Expected duration of program

The duration of the Conservation Program will depend on the SJRRP's success in establishing a self-sustaining population of CV spring-run in the San Joaquin River. As the natural population establishes, hatchery production would be phased out. Less than 15% of the Chinook Salmon population should be of hatchery origin ten years following full-scale releases from the SCARF in 2022, per the FMP (SJRRP 2010a).

1.14 Watersheds targeted by program

Middle San Joaquin-Lower Chowchilla Watershed, USGS Hydrologic Unit: 18040001.

1.15 Indicate alternative actions considered for attaining program goals, and reasons why those actions are not being proposed

A primary goal of the SJRRP, mandated by the Settlement, is restoration of a naturally reproducing and self-sustaining population of spring-run Chinook Salmon in the San Joaquin River. The FMWG and GSG have evaluated potential source populations and reintroduction strategies. Since all source populations are considered 'threatened' under the FESA and CESA, the FMWG and GSG recommendations are aimed at minimizing the risks to these populations while meeting the Settlement.

Natural recolonization is unlikely to achieve the SJRRP goals because all local stocks of spring-run Chinook Salmon have been extirpated from the southern portion of the Central Valley and there have not been consistent natural runs of salmon in the upper San Joaquin River for almost 60 years. Moreover, natural recolonization would likely lead to low genetic diversity and bottleneck effects that would undermine a new population's ability to adapt to the San Joaquin River. Managed reintroduction of fish from selected source populations can promote genetic diversity and ensure the genetic integrity of the reintroduced San Joaquin River population. Artificial propagation in the SCARF, assuming genetic diversity is maintained, can allow for significantly higher survivorship (higher progeny to parent ratios) than is experienced in the wild, thereby amplifying the number of individuals released into the San Joaquin River while maintaining the genetic characteristics similar to the source population.

Alternative actions that have been considered include direct transfer and reintroduction of wild eggs, juveniles, and/or adults from source populations to San Joaquin River. These actions would be limited to a relatively small number of juveniles from the FRH prior to completion of the full-scale SCARF. Direct wild egg or fish transfers are not being proposed as the primary reintroduction method because they are higher risk, higher effort, and less likely to meet the restoration objectives due to the limited availability of source fish. In order to grow a population

to the size necessary for a successful near-term reintroduction goal (e.g., 500-2,500 adults), the Conservation Program needs to initially introduce 200,000-1,120,000 juveniles (SJRRP 2010a). Collecting this number of juveniles from the threatened source populations would be infeasible and would have greater potential impacts to source populations.

SECTION 2 PROGRAM EFFECTS ON NMFS ESA-LISTED SALMONID POPULATIONS

2.1 List all ESA permits or authorizations in hand for the hatchery program

The Conservation Program obtained two 10(a)1(A) enhancement of the species permits, one for collection of source broodstock (Permit #14868, authorized October 2012) and the second for the release of translocation fish, broodstock, and offspring (Permit #17781, authorized March 2014). Permit #14868 will expire at the end of 2017 and Permit #17781 will expire at the end of 2019. Prior to their expiration, the SJRRP anticipates obtaining a single permit encompassing all previously authorized activities in addition to collections of wild individuals in Butte Creek and the San Joaquin River. Future permit applications may also include collections from Mill and/or Deer creeks, depending on the condition of those populations. The reintroduced population is designated as a nonessential experimental population under the FESA Section 10(j) and has an associated FESA 4(d) take provisions (78 Fed. Reg. 79622-79633).

2.2 Provide descriptions, status, and projected take actions and levels for NMFS FESA-listed natural populations in the target area

Other than the experimental San Joaquin River population of CV spring-run, there are no FESA-listed fish populations in the Restoration Area (San Joaquin River between Friant Dam and the confluence with the Merced River). The broodstock will come from listed populations in the Feather River and Butte Creek, as well as the experimental population in the San Joaquin River.

2.2.1 Description of NMFS ESA-listed salmonid population(s) that may be directly affected by the program

Two NMFS ESA-listed populations, Feather River and Butte Creek, will be directly affected by the Conservation Program through broodstock collections. In the future, pending additional analysis, the Deer/Mill Creek Complex may be a potential third source population and is therefore included in the analysis for impacted populations. This section provides some background on these populations and presents spatial distribution information based on data from the Stock Selection Strategy attachment to the FMP. Please see the FMP for more detailed information. Section 6, Broodstock Origin and Identity, compares the potential source populations and discusses the final selection of broodstock for the Conservation Program. Indirect effects, including increased competition and other interactions with listed fish during outmigration and ocean rearing, are discussed in Section 3. Table 2.1 provides an overview of available life history data for the ESA-listed potential source populations.

In addition to the source populations, the experimental San Joaquin River CV spring-run population will be affected by the Conservation Program. Because this population does not yet exist, a detailed review is not possible at this time. Information on the experimental San Joaquin River spring-run Chinook Salmon, including population size, adult age class structure, sex ratio, size range, migration timing, spawning range, spawn timing, juvenile life history strategies, and spatial and temporal distribution will be

developed as a part of the ongoing monitoring and research identified in the standards and indicators presented in Section 1.

Table 2.1: General Life History Characteristics for Feather River, Butte Creek, and Deer/Mill Creek spring-run Chinook Salmon Populations (from SJRRP 2010b)

Life History Characteristics	Feather River		Butte Creek		Deer/Mill Creeks	
Adult Run Timing	April - May		February – June, peaking in mid-April		March – early July	
Spawning Timing	September		Late-September to early-November, peaking in early-October.		September	
Spawning adult age class structure[a]	Age 2	10.9%	Age 2	0%[e]	Age 2	Unknown
	Age 3	46.9%	Age 3	53%	Age 3	Unknown
	Age 4	41.2%	Age 4	47%	Age 4	Unknown
	Age 5	0.68%	Age 5	0%	Age 5	Unknown
Sex Ratio (M:F)[b]	1.2:1		1:1.18		Unknown	
Size Range (FL)	Females[d] - 782 mm Males[d] - 829 mm		Females[c] - 762 mm. Males[c] - 793 mm.		410 mm to 1002 mm with the majority 600-800 mm.	
Outmigration Timing (all three population show two primary life histories for young, fry emigrating within weeks of emergence and juveniles remaining in the river for roughly one year before emigrating)	Emergence: Nov. – Apr., peaking in Jan. Outmigration of yearlings: Unk. Outmigration of fry: Dec. – June, peaking Feb. to Apr.		Emergence: Nov. – Apr., peaking in Jan. Outmigration of yearlings to the Delta: Nov. – Apr. Initial outmigration of fry to Sutter Bypass – Nov. to Feb. Final outmigration of fry from Sutter Bypass to the Sac. River and Delta – Feb. to May		Emergence: Nov.- Apr. peaking around Feb. Outmigration of yearlings: Oct. – Apr. Outmigration of fry: Feb. – June	
Straying Rate	High		Low		Unknown	

[a] Feather River data are average percent by age of spring-run returning to hatchery during the fall, 2000-2004. Butte Creek data based on tag recoveries in 2007, although age varied widely in the Butte Creek population. Age 3 fish were a much higher percentage in 2002, '02, '04, and '05, and Age 4 were much higher in 2003 and '06. 2007 data based on scale aging for all fish, including untagged fish suggested a much higher percentage of age 3 returns for both the Feather River and Butte Creek, at 68% and 72%, respectively (Grover and Kormos 2007).
[b] Feather River data are averaged from 1997 through 2007. Butte Creek data averaged 2001-2006, from carcass surveys.
[c] 2001-2007 Averages.
[d] Based on 2006-2008 spring-run broodstock (pers. comm. Ryon Kurth, CA DWR).
[e] Recent data from Butte Creek shows a small percentage (<5%) of Age-2 returns (CDFW Unpublished Data).

2.2.1.1 Feather River Population

Background Information

Part of the CV spring-run ESU, the spring-run population within the Feather River is difficult to characterize. First, the population consists of both hatchery-spawned and naturally spawned individuals, and there is a general lack of data on the naturally spawned portion of the population. Second, it is not a historical entity in that the

population of spring-running Feather River fish only began spawning below the Oroville Dam as a single population after construction of the Thermalito Dam in 1968 (Lindley et al. 2004). Third, Feather River spring-run have significant historical and ongoing hybridization with fall-run Chinook Salmon, although the FRH is taking steps to create a more genetically isolated spring-run. Genetic analyses suggest that the remaining spring-run fish are heavily introgressed with fall-run genes (Garza et al. 2008). Given that Feather River spring-run Chinook Salmon are not genotypically distinguishable from fall-run Chinook Salmon, Feather River spring-run may be more accurately described as a spring-running fish, not necessarily a spring-run Chinook Salmon. However:

> the FRH "spring-run" run retains remnants of the phenotype and ancestry of the Feather River spring-run [and] it may be possible to preserve some additional component of the ancestral Central Valley spring-run genomic variation through careful management of this stock that can contribute to the recovery of the ESA-listed Central Valley spring-run ESU, although it will not be possible to reconstitute a "pure" spring-run stock from these fish [Garza et al. 2008].

For this reason, FRH spring-run Chinook Salmon have been included as a broodstock for the Conservation Program.

The hatchery broodstock for Feather River spring-running salmon consists of fish from up to two sources and is reviewed in detail in the FRH HGMP (Cavallo et al. 2009). First, the FRH fish ladder is opened from April through June, and all fish entering the fish ladder during this period are marked with two individually numbered Hallprint external tags and then returned to the Feather River. The ladder is closed from the end of June and then reopened around September 15. This practice, opening the ladder during the spring-run period and marking the fish that enter, began in 2004 (Cavallo et al. 2009). Prior to that time, the FRH did not have a dependable method of distinguishing early spring arrivals (spring-run) from those arriving during the latter fall run period (fall-run).

Fish entering the ladder with the Hallprint tags, indicating that they first entered the ladder during the open April to June period, are the primary source of fish for the FRH spring-run Chinook Salmon Program and make up the majority of the FRH spring-running broodstock. Fish entering the FRH ladder in September or later are not Hallprint tagged, are all considered fall-run, and are used for the FRH's fall-run broodstock regardless of their actual parentage or time of entry into the river. The only exception to this practice occurs when marked spring-run fish are insufficient to meet required spring-run production.

When an insufficient number of spring-run tagged fish enter in the fall, the FRH integrates a second set of fish into the spring-run broodstock. These fish are identified as spring-run by CWT, meaning that their parents expressed the spring-run phenotype. While these fish do have spring-running parents, it is unknown if these fish are phenotypically spring-run because they did not enter the ladder in the spring. Offspring of spring-running parents return in the fall at high rates (CDFG 1998, Lindley et al. 2004).

Between 2004 and 2007, an average of 82.4% of offspring from spring-running fish and 49.1% of fall-run offspring were correctly identified based on run timing (Cavallo et al. 2009). The level of mixing between spring-run- and fall-run fish in the naturally spawning portion of the population is unknown, although the genetic analysis indicates significant introgression has occurred in the past. The impact of the recent changes to hatchery practices designed to protect and enhance the spring-running phenotype is not yet known.

Spatial Distribution

Feather River Chinook Salmon migrate upstream until they reach the Fish Barrier Dam, 1 kilometer (km) (0.6 miles [mi]) below Oroville Dam. Adults begin holding at the Thermalito Afterbay Outlet and the Fish Barrier Dam as early as April (CA DWR 2007, NMFS 2009). See watershed map in Figure 2.1. Natural spawning occurs in the river from late September to late October (Reynolds et al.1993, Yoshiyama 2001) from the Fish Barrier Dam downstream approximately 13 km (8 mi) to the Thermalito Afterbay Outlet (NMFS 2009). Approximately two-thirds of natural Chinook Salmon spawning in the Feather River occurs in the Low Flow Channel (LFC) between the Fish Barrier Dam and the Thermalito Afterbay Outlet (NMFS 2009), with the greatest portion crowded in the upper three miles of the LFC (Sommer et al. 2001). The remaining spawning occurs between the Thermalito Afterbay Outlet and Honcut Creek (RM 59 to 44) (CA DWR 2007).

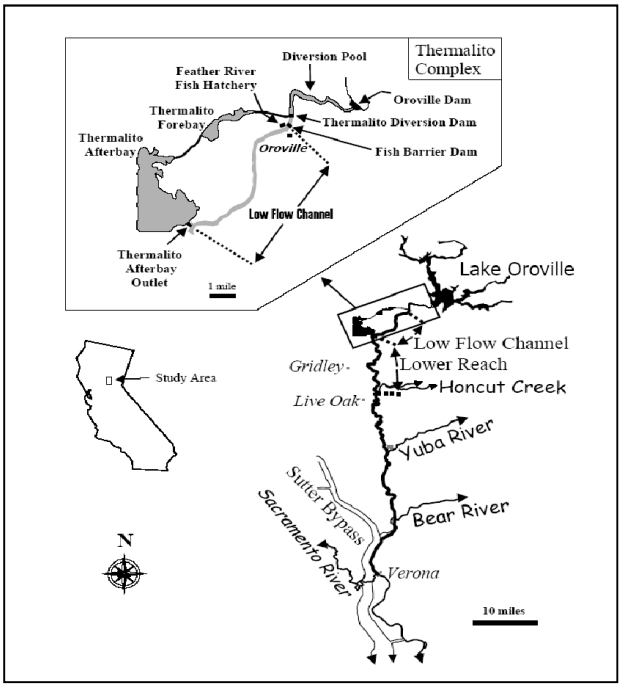

Figure 2.1: Feather River below Lake Oroville

There are two primary life history patterns for offspring. Most juveniles outmigrate as fry (DWR unpublished data), but some juveniles hold over the summer in deep pools within the LFC five miles below Oroville Dam and the downstream Thermalito Afterbay Outlet (Reynolds et al. 1993, Yoshiyama 2001). The primary rearing location(s) is unknown, although in wetter years it appears that many young salmon rear for weeks to months in the Yolo Bypass floodplain immediately downstream of the Feather River before migrating to the estuary (Sommer et al. 2001).

2.2.1.2 Butte Creek Population

Background Information

Butte Creek has a genetically distinct and independent CV spring-run population (NMFS 2009). See watershed map in Figure 2.2. Genetic analysis of the Butte Creek population shows no hatchery influence despite of the addition of 200,000 juvenile spring-run from FRH in the 1980s to supplement low returns (Garza et al. 2008, Moyle et al. 2008, CDFW 1998). Based on the analysis thus far, the planted fish appear to have made no significant genetic contribution to the natural Butte Creek population. Aside from the 1986 planting, Butte Creek has not been planted with hatchery fish, and surveys consistently fail to detect significant straying into Butte Creek from other populations (McReynolds and Garman 2008). Small numbers of fall-run, late fall-run, and/or winter run fish may also spawn annually in Butte Creek, although no introgression with these other runs has been detected.

Spatial Distribution

Adults migrate up Butte Creek to holding pools in two primary locations, within the upper most 5 km (3 mi) nearest Quartz Pool and directly below the Centerville Powerhouse. From 2001-2005, approximately 61% of the fish held above the Centerville Powerhouse and 39% held below it. The best spawning habitat for the spring-run is within the approximately 18-km (11-mi) stretch of the river from Quartz Pool downstream to the Centerville Covered Bridge. Approximately 82% of that habitat is within the first 8 km (5 mi) directly below the Centerville Powerhouse. Between 2001 and 2005, approximately 48% of the fish spawned above the Centerville Powerhouse and 52% below (Ward et al. 2007).

Butte Creek spring-run juveniles follow two general life history patterns. Many outmigrate as fry from November through February and rear below the Parrott-Phelan Diversion Dam. The Sutter Bypass offers the highest quality and quantity of juvenile rearing habitat for Butte Creek spring-run Chinook salmon, and most juveniles rear there from February through May. In May, those juveniles move to the Sacramento-San Joaquin River Delta (Delta). A smaller number of juveniles rear above Parrott-Phelan Diversion Dam in the main stem of Butte Creek. These fish grow to approximately 150 mm fork-length and remain in Butte Creek above the Parrott-Phelan Diversion Dam for 12 months or more before leaving Butte Creek and outmigrating to the Delta as yearlings (Ward et al. 2004).

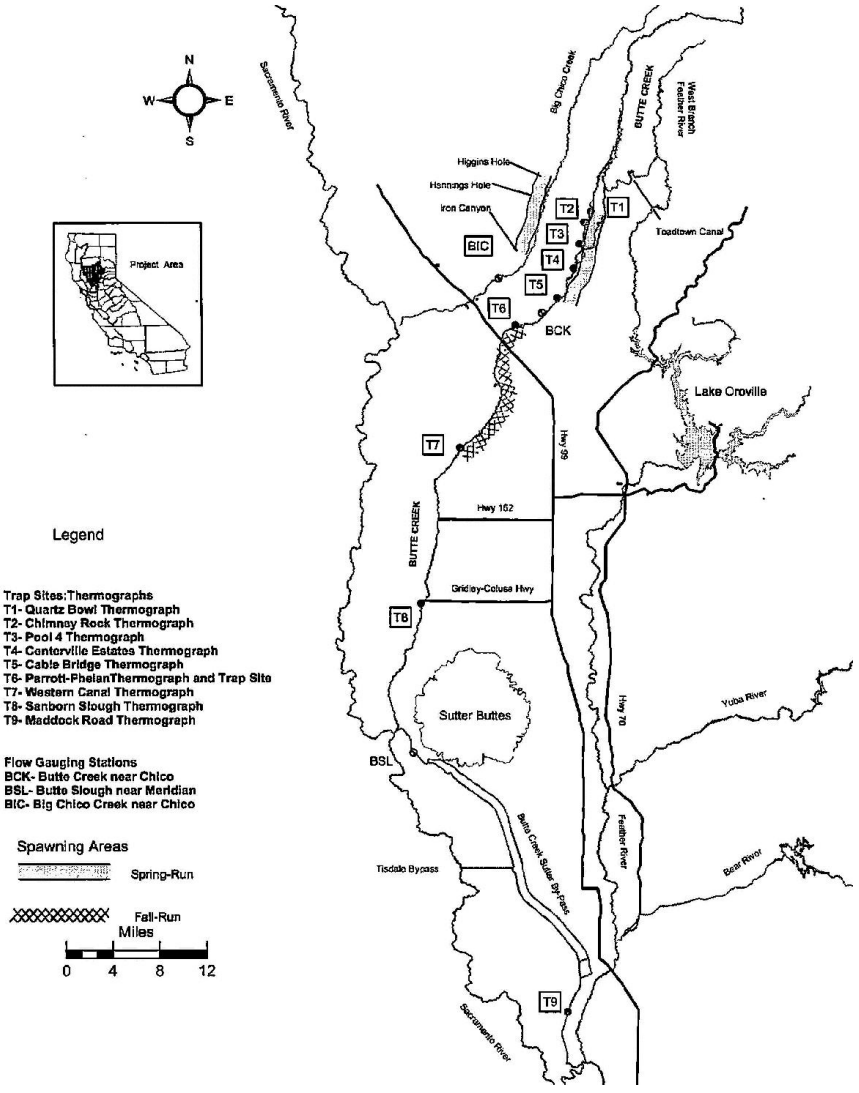

Figure 2.2: Butte Creek and Big Chico Creek watersheds with trap locations, gauging stations, and salmon spawning areas (from McReynolds et al. 2007)

2.2.1.3 Deer and Mill Creek Complex Population

Introduction

Deer and Mill creeks are eastside tributaries to the upper Sacramento River. See Maps in Figures 2.3 and 2.4. Deer Creek enters the Sacramento River at River Mile (RM) 220 and Mill Creek enters at RM 230. They both support populations of CV spring-run that are genetically distinct from spring-run populations in Butte Creek and the Feather River (CDFG 1998, Lindley et al. 2007). While the Mill and Deer Creek stocks are marginally genetically distinct, it is not clear that the slight differences in observed allele frequencies are biologically significant and due to anything other than family structure. As such, Banks et al. (2000) and Garza et al. (2008) concluded that the two stocks should be treated as a single complex due to the high degree of gene flow and similar phenotypes.

These two stocks do have a higher degree of genetic differentiation than that found between the Feather River fall- and spring-run fish, which some geneticists suggest warrants their treatment as two separate populations. However, Mill and Deer creeks appear genetically similar compared to the other genetically distinct, self-sustaining CV spring-run populations and likely function together demographically as a metapopulation (Garza et al. 2008).

There is currently no hatchery program supplementing the populations on either Deer or Mill Creek. Between 1902 and 1940, the U.S. Bureau of Fisheries established a hatchery on Mill Creek near Los Molinos, but no spring-run Chinook salmon were spawned (Hanson et. al. 1940). Between 1941 and 1946, about 13,000 adult spring-run from the upper Sacramento River were introduced into Deer Creek (Cramer and Hammack 1952). According to Harvey (1997) some of these may have been winter- and/or fall-run Chinook Salmon. Small numbers of fall-run and/or late fall-run may also spawn annually in Deer and Mill Creeks (Harvey-Arrison 2007). In spite of these additions and other populations, there does not appear to be introgression between the Deer and Mill Creek spring-run fish and other runs.

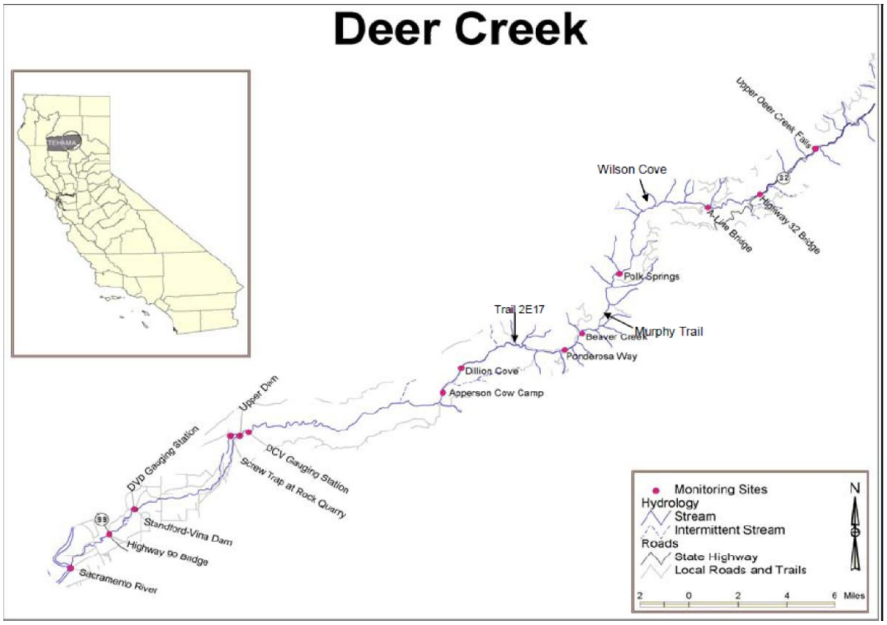

Figure 2.3: Spring-run Chinook salmon holding and spawning habitat in Deer Creek (from Harvey-Arrison 2008)

<u>Deer Creek Spatial Distribution</u>

Deer Creek is 60 miles long and its watershed drains 200 square miles (520 square km) (USFWS 1995). Deer Creek originates on the northern slopes of Butte Mountain at an elevation of approximately 7,320 feet (2230 meters). It initially flows through meadows and dense forests and then descends rapidly through a steep rock canyon into the Sacramento Valley. Deer Creek flows for 11 miles across the Sacramento Valley floor, entering the Sacramento River at approximately 180 feet (55 meters) elevation (USFWS 1995) where most of the flow is diverted. In many years, diversions at three dams deplete all of the natural flow from mid-spring to fall. Each of these diversion structures have fish passage structures and screens, so Deer Creek spring-run Chinook Salmon have access to 100% of their historic habitat when flows permit (NMFS 2009).

Deer Creek spring-run Chinook Salmon migrate upstream from March through early July, ending when flows are insufficient to pass adults and water temperatures begin to

approach lethal limits low in the watershed. Spring-run Chinook Salmon hold over a 25 mile (40 km) reach from Upper Falls downstream to near the confluence of Rock Creek. Thirty percent of the area is represented by pools. Of 166 total pools, 98 (or 60%) are greater than 6 ft deep and suitable for adult holding. Because maturing adult spring-run Chinook Salmon enter streams during the spring months and spend the summer holding in deep pools prior to fall spawning, they are present in the stream system during July and August when temperatures are generally at their peak. Spawning occurs throughout the holding area, with locations varying based on water flow and changes in bed composition.

Monitoring data indicate that juvenile spring-run Chinook Salmon emergence begins in November, peaks around February, and ends in April. These data are derived from an egg-temperature model to predict emergence based on redd placement and also from direct observation of newly emerged juveniles (Harvey-Arrison 2007).

Deer and Mill Creek young generally follow one of two basic life history patterns. First, some fish outmigrate shortly after emergence. This fry outmigration occurs from February through June, but since traps are located within fall-run spawning area, these fry migrations are a mix of fall-run and spring-run progeny. Second, many juveniles stay in the river for a significant period of time. These fish emigrate during the wet season more than a year after being spawned (Big Chico Creek Watershed Alliance 2000). Based on annual surveys by the CDFG, outmigration of yearling spring-run typically occurs from October or November through March or April, depending on the year.

Mill Creek Spatial Distribution

Mill Creek originates from spring runoff in Lassen Volcanic National Park at an elevation of approximately 8,200 feet (2500 meters) and descends to 200 feet (60 meters) at its confluence with the Sacramento River. Mill Creek initially flows through meadows and dense forests, descends rapidly through a steep canyon, and then flows 8 miles (13 km) across the Sacramento Valley floor. Its total length is approximately 58 miles (93 km) to its confluence with the

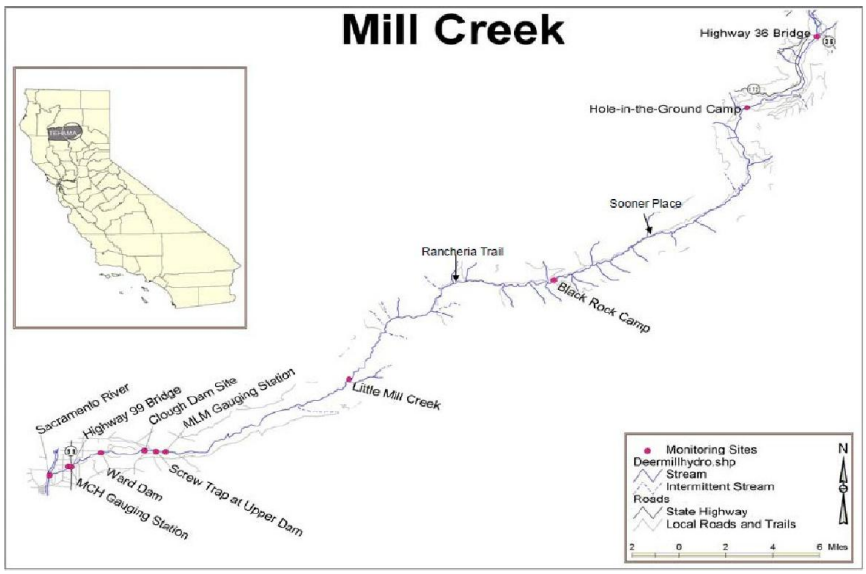

Figure 2.4: Spring-run Chinook salmon holding and spawning habitat in Mill Creek (from Harvey-Arrison 2008)

Sacramento River. The Mill Creek watershed encompasses 134 square miles (347 square km). During the irrigation season, three dams on the lower 8 miles (13 km) of the stream divert most of the natural flow, particularly during dry years.

While adult spring-run have been observed migrating in Mill Creek as early as February, a 10-year study from 1953 to 1964 (CDFG 1966) documented the majority of upstream migration as occurring between mid-April and the end of June.

There are two geographically important sections of holding habitat available on Mill Creek, Upper Mill Creek, defined as the upper 7.6 miles (12 km) of Mill Creek between the Lassen Volcanic National Park boundary and Mill Creek campground, and Lower Mill Creek, which is the canyon reach downstream of the Mill Creek campground (Figure 2.4). Spring-run Chinook Salmon holding habitat appears to be limited in Upper Mill Creek, based on stream survey data collected in 1990 that found pools made up only 5% of the area, none were classified as holding pools. Holding habitat is more abundant in Lower Mill Creek; surveys covering roughly 13 of approximately 20 miles (32 km) of stream found 13% of the area consisted of pools, 23% of which were holding pools. Additional suitable holding habitat may also be present (Airola and Marcotte 1985).

Mill Creek spring-run Chinook Salmon are unique for spawning at an elevation of more than 5,000 feet (1,500 m), the highest elevation known for salmon spawning in North America (Armentrout et al. 1998). In Mill Creek, sediment loading is greater than in Deer Creek and fines are notable especially in areas of deposition. High gravel embeddedness has been observed in some areas of spawning use (M. McFarland 1990, memo to the files). The conditions observed, however, do not appear to limit salmon from spawning. Spring-run Chinook spawning surveys are conducted in Mill creek from the Hwy 36 Bridge crossing downstream to Pape Place, below Black Rock Camp (Figure 2.4). Timing for emergence and outmigration are as outlined in the Deer Creek section, above.

2.2.2 NMFS ESA-listed population(s) that may be indirectly affected by the program

Chinook Salmon, Winter-run, *Oncorhynchus tshawytscha* (Endangered). The winter-run Chinook Salmon are a state and federally listed endangered species. Reintroduction of spring-run Chinook Salmon may impact these fish through competition or indirect ecological interactions in the Delta. HGMP Section 3 discusses these impacts in more detail.

Steelhead, Central Valley, *Oncorhynchus mykiss* (Threatened). There is little data on the Central Valley Steelhead in the San Joaquin River, although a small number are present in the system, particularly in the Stanislaus, Tuolumne, and possibly the Merced river systems (SJRRP 2009). Escapement estimates are not available. Currently, returning Steelhead are directed away from the restoration area by the Hills Ferry Barrier, when in place (SJRRP 2009). As the restoration progresses, Steelhead are likely to stray or be reintroduced into the San Joaquin, where they may be encountered during monitoring activities; any fish incidentally collected would be released unharmed. The Steelhead population is likely to benefit from the improved habitat conditions in the restored river,

but in the interim, the potential for impacts of the hatchery operations on Central Valley Steelhead is unknown due to the lack of data on this population. General impacts to Steelhead are discussed in Section 3.

Green Sturgeon, *Acipenser medirostris* (Endangered). While Green Sturgeon are occasionally present in the lower reaches of the San Joaquin, they are not generally known to be present in the Restoration Area. Given their transitory presence and the general lack of interactions between the hatchery operations and sturgeon, it is unlikely that hatchery operations would negatively impact the Green Sturgeon. Improved river conditions are likely to benefit the Green Sturgeon.

2.2.3 Status of NMFS ESA-listed salmonid population(s) affected by the program

Lindley et al. (2007) surveyed the CV spring-run ESU and concluded that it was not viable in its current state, although the status of individual populations varied widely. See Table 2.2, modified from Table 6-4 in the Stock Selection Document (SJRRP 2010b). However, an updated assessment should be completed to assess current viability. Moyle et al. (2008) also concluded that there was a high likelihood of spring-run Chinook Salmon going extinct in the next 50-100 years due to both their vulnerability to catastrophic events and their narrow physiological tolerances in the summer, which leaves them vulnerable to climate change.

Table 2.2. Estimated population levels for Deer/Mill Creek, Butte Creek, and Feather River spring-run Chinook Salmon populations, 1960-2014. Data from GrandTab 2015.

	Deer/Mill Creeks		Butte Creek[c]	Feather River		Year	Deer/Mill Creeks		Butte Creek	Feather River	
	Deer[a]	Mill[b]		River	Hatchery		Deer	Mill		River	Hatchery
1960	2,368		8,700			**1988**	572	371	1,290		6,833
1961	1,245		3,082			**1989[d]**	563	84	1,300		5,078
1962	1,692		1,750			**1990**	844	496	250		1,893
1963	1,315	2,302	6,100	600		**1991**	319	479			4,303
1964	1,539	2,874	600	2,908		**1992**	237	209	730		1,497
1965			1,000	738		**1993**	61	259	650		4,672
1966			80	297		**1994**	723	485	474		3,641
1967			180		146	**1995**	320	1,295	7,500		5,414
1968			280		208	**1996**	253	614	1,413		6,381
1969			830		348	**1997**	202	466	635		3,653
1970	1,500	2,000	285		235	**1998**	424	1,879	20,25		6,746
1971	1,000	1,500	470		481	**1999**	560	1,591	3,679		3,731
1972	500	400	150		256	**2000**	544	637	4,118		3,657
1973	1,700	2,000	300		205	**2001[e]**	1,100	1,622	9,605		4,135
1974	1,500	3,500	150		198	**2002**	1,594	2,185	8,785		4,189
1975	3,500	8,500	650		691	**2003**	1,426	2,759	4,398		8,662
1976			46		699	**2004**	998	804	7,390		4,212
1977	460	340	100		185	**2005**	1,150	2,239	10,62		1774
1978	925	1,200	128	2	202	**2006**	2,432	1,002	4,579		2,061
1979			10		250	**2007**	644	920	4,943		2,674
1980	500	1,500	226	400	269	**2008**	140	362	3,935		1,418
1981			250	531	469	**2009**	213	220	2,059		989
1982	700	1,500	534	90	1,910	**2010**	262	482	1,160		1,661
1983		500	50		1,702	**2011**	271	366	2,130		1,969
1984	191		23		1,562	**2012**	734	768	8,615		3,738
1985	121	301	254		1,632	**2013**	708	644	11,47		4,294
1986	291	543	1,371		1,433	**2014**	830	679	3.616		2,776
1987	90	200	14		1,213	**2015**					

[a] For the CVPIA doubling period 1967-1991, the average spawning escapement of spring-run Chinook Salmon in Deer Creek was 1,300 (USFWS 1995). From 1991 to present the average is 673. Various methodologies have been used to obtain escapement estimates over time. Most recently, video weir counts replaced snorkel surveys in 2014.
[b] For the CVPIA doubling period 1967-1991, the average spawning escapement of spring-run Chinook Salmon in Mill Creek was 800 (USFWS 1995). From 1991 to present the average is956. Various methodologies have been used to obtain escapement estimates over time. Most recently, video weir counts replaced snorkel surveys in 2012.
[c] Butte Creek population averages for the last thirty, twenty, and ten years are4,300, 5,900, and 5,000, respectively.
[d] Surveys prior to 1989 used various methods with varying precision. For the non-Feather River populations, snorkel surveys implemented since 1989 are thought to significantly underestimate the actual population size and should only be used as an index. Spawning surveys results for 2001 – 2006 were generated by a modified Schaefer Model carcass survey. Feather river estimates since 2004 are based on the fish entering the fish ladder during the spring-run period.
[e] Butte Creek number previously reported for 2001 (22,744) in error (Ward et al. 2004).

Note on the Feather River Population Estimates: Overall census size information for this population is not available. There are essentially four components to the population, but no count covers all four (pers. comm. Ryon Kurth, CA DWR).

First, some spring-running fish enter the fish ladder during the April – June period and then return to the hatchery after September 15 and are used in the spring-run hatchery spawning. Second, some spring-running fish enter the fish ladder during the April – June period and then are not seen again, either spawning in the river, migrating out, dying before spawn, or being taken by fishermen. Third, some spring-running fish do not enter the ladder during the April-June period, even though they are in the river during this time and then enter the hatchery during the fall period. These fish may be spawned as spring-run fish if the hatchery needs additional spring-run fish to meet its targets, but, if not, the hatchery may not take the steps to determine the origin of these fish. If they do not determine the origin, the fish may be spawned as fall-run fish. Finally, some spring-running fish never enter the hatchery but spawn in the river (pers. comm. Ryon Kurth, CA DWR).

Data are only available for the fish that enter the hatchery in the spring, and the spawning escapement reported here is the number of fish that entered the hatchery during the April-June period. We do not have reliable estimates of the total number of spring-run fish, but scientists working with this population believe that the natural portion of the population is larger than the hatchery escapement (pers. comm. Ryon Kurth, CA DWR).

2.2.3.1 Describe the status of the listed natural population(s)

Based on Lindley et al.'s (2007) analysis, Butte Creek and Deer Creek spring-run were then at low risk of extinction. See Table 2.3 for information on the classification system used in this analysis. Lindley et al. (2007) found that the Mill Creek spring-run population was at moderate extinction risk based on a Population Viability Assessment (PVA), although other criteria classify it as a low risk population. Considered together, the Mill/Deer creek complex as a whole is

Table 2.3: PVA terms and definitions (From Lindley et al.

	Risk of Extinction		
Criterion	High	Moderate	Low
Extinction risk from PVA	> 20% within 20 years	> 5% within 100 years	< 5% within 100 years
	– or any ONE of –	– or any ONE of –	– or ALL of –
Population size[a]	$N_e \leq 50$	$50 < N_e \leq 500$	$N_e > 500$
	–or–	–or–	–or–
	$N \leq 250$	$250 < N \leq 2500$	$N > 2500$
Population decline	Precipitous decline[b]	Chronic decline or depression[c]	No decline apparent or probable
Catastrophe, rate and effect[d]	Order of magnitude decline within one generation	Smaller but significant decline[e]	not apparent
Hatchery influence[f]	High	Moderate	Low

[a] Census size N can be used if direct estimates of effective size N_e are not available, assuming $N_e/N = 0.2$.
[b] Decline within last two generations to annual run size $\leq$ 500 spawners, or run size > 500 but declining at $\geq$ 10% per year. Historically small but stable population not included.
[c] Run size has declined to $\leq$ 500, but now stable.
[d] Catastrophes occuring within the last 10 years.
[e] Decline < 90% but biologically significant.
[f] See Figure 1 for assessing hatchery impacts.

at a low risk of extinction. Finally, due to the data deficiencies for the naturally spawning component of the Feather River spring-run, Lindley et al. (2007) was unable to assign an extinction risk to the population.

Since 2007, escapement to these streams has dropped substantially, coincident with declines of other salmon populations in California and an updated status review is currently being prepared, which will provide additional guidance on the status of these populations.

2.2.3.2 Provide the most recent 12-year (e.g. 2002-present) progeny-to-parent ratios, survival data by life-stage, or other measures of productivity for the listed population. Indicate the source of these data

Progeny-to-parent ratios and survival data by life-stage are not available for all populations. However, Lindley et al. (2007) documented population annual growth rates for Butte Creek, Mill Creek, and Deer Creek of 11.4%, 17.9%, and 7.65%, respectively, although these rates are being updated by Lindley et al. Spawning escapement data were obtained from California Department of Fish and Wildlife's 2005 and 2015 GrandTab database, available from the Fisheries Branch, 830 S Street, Sacramento, CA 95814. Data deficiencies prevent productivity assessments for the Feather River.

2.2.3.3 Provide the most recent 12-year (e.g. 2002-2014) estimates of annual proportions of direct hatchery-origin and listed natural-origin fish on natural spawning grounds, if known

There does not appear to be any hatchery influence on the Butte and Deer/Mill Creek populations, suggesting a negligible proportion of hatchery-origin fish on those natural spawning grounds or negligible success for any fish that are present.

We do not have reliable estimates of the total number of spring-run fish in the Feather River generally, and there are no data on the proportion of natural origin- vs. hatchery-origin fish, but biologists working with the population believe that the natural portion of the population is at least larger than the hatchery escapement (pers. comm. Ryon Kurth, CA DWR). No instream counts are available to verify this.

2.2.4 Describe hatchery activities, including associated monitoring and evaluation and research programs, that may lead to the take of NMFS listed fish in the target area, and provide estimated annual levels of take

2.2.4.1 Describe hatchery activities that may lead to the take of listed salmonid populations in the target area, including how, where, and when the take may occur, the risk potential for their occurrence, and the likely effects of the take

Initially, taking of listed salmon should only occur during broodstock collection. Once the spring-run are reestablished in the San Joaquin River, take of the San Joaquin River experimental population will also occur during broodstock collection and in connection with research, management, and monitoring activities.

Broodstock collection will result in take of listed spring-run Chinook Salmon in the selected populations through collection of wild and hatchery juveniles and eggs to be reared for broodstock. In addition to the direct take of fish and eggs for rearing, trapping and handling devices and methods may lead to injury of listed fish through descaling, delayed migration and spawning, or latent mortality as a result of stress, injury, or increased susceptibility to predation. Finally, if research is conducted on gene expression related to thermal tolerance, disease resistance, and/or susceptibility to contaminants, it will lead to lethal take on a small number of juveniles and adults from broodstock populations.

Once the San Joaquin River population is reestablished, these same kinds of take could occur with respect to those fish in the experimental population and may be authorized in future 10(a)1(A) permits. A maximum of 10% of the naturalized run in the San Joaquin River may be collected to serve as broodstock, unless returns are so low that the naturalized run is unlikely to produce enough offspring to expect an escapement in future years. This can be accomplished by collecting every tenth natural origin (NO) return for use in the broodstock.

Handling of naturalized adults for research purposes has a high potential to result in take, although most take should be sublethal. Handling will include taking fin clips for genotyping the returning adults. Lethal take associated with research activities is expected to be minimal, well less than 1%. Post mortem, scales and otoliths will be collected from spawned fish and in-river carcasses.

2.2.4.2 Provide information regarding past takes associated with the hatchery program, (if known) including numbers taken, and observed injury or mortality levels for listed fish

In 2012 the SJRRP began broodstock collections from FRH as authorized under 10(a)1(A) Permit #14868. Table 2.4 outlines the maximum take numbers requested each year. During the first three years of the permit (2012-2015) the SJRRP collected the maximum number of 560 eggs each year. Collections may increase beginning in 2016, year 4 of the permit, and will continue until Permit #14868 expires in 2017.

For pathology purposes, 60 fish are sacrificed each year to assess the health of the group, and the remaining fish are then transferred to the SCARF.

Table 2.4 Maximum collection targets by year, location, lifestage and disposition (2012-2015)

Collection Type	Collection Source	Targeted Lifestage	Disposition Location	Max Years 1-3	Max Years 4-
Primary	Feather River Fish Hatchery	Juveniles	Conservation Facility	560	2,760
	Feather River Fish Hatchery	Eyed Eggs	Conservation Facility	560	2,760
	Feather River Fish Hatchery	Juveniles	Translocation to SJR	54,400	54,400
	Feather River Fish Hatchery	Eyed Eggs	Translocation to SJR	80,000	80,000

2.2.4.3 Provide projected annual take levels for listed fish by life stage (juvenile and adult) quantified (to the extent feasible) by the type of take resulting from the hatchery program (e.g. capture, handling, tagging, injury, or lethal take)

Table 1.3 outlines direct take levels that result from capture: 600 eggs or juveniles harvested from Feather River Hatchery annually from 2012-2014; 2,700 eggs or juveniles harvested from Feather River Hatchery annually in 2015-2017; 5,400 eggs or juveniles harvested from the San Joaquin River, Butte Creek, and Feather River Hatchery in 2018-2021. For pathology testing, an additional 70-280 eggs or juveniles would be collected per source population per year. Beyond 2023, the Conservation Program may pursue collections from these three populations, as well as additional collections from Deer and Mill Creeks. Those collections would be addressed in the 5-year update of the HGMP.

The harvest of these numbers will also result in the incidental take of a small number of additional fish, due to bycatch or redd disturbance, among other factors, and the level of incidental take is difficult to estimate or measure.

2.2.4.4 Indicate contingency plans for addressing situations where take levels within a given year have exceeded, or are projected to exceed, take levels described in this plan for the program

The take should be limited since the number of broodstock collected will be consistent with guidelines and protocols in the HGMP and the 10(a)1(A) permit. Given the relatively low numbers of fish or eggs to be collected and the non-automated manner of collection, excess take is unlikely and take can be suspended once the targets are achieved. Any excess take would be communicated to NMFS via email and letter, per 10(a)1(A) permit conditions. Collection operations will be suspended pending discussions with NMFS.

SECTION 3 RELATIONSHIP OF PROGRAM TO OTHER MANAGEMENT OBJECTIVES

3.1 Describe alignment of the Conservation Program with any ESU-wide hatchery plan Explain any proposed deviations from the plan or policies

There is no ESU-wide hatchery plan for the CV spring-run Chinook Salmon. More broadly, NMFS has published a technical memorandum establishing a conceptual framework for conservation hatchery strategies for Pacific salmon (Flagg and Nash 1999). This conceptual framework establishes recommendations for a conservation hatchery. These recommendations, organized by the considerations they address and any proposed deviations from these are identified below. Details on the hatchery conditions are presented in Section 9. These plans are also consistent with the existing conservation hatchery guidelines for Coho Salmon (*O. kisutch*) in the Coho Salmon Recovery Strategy (CDFG 2004).

Inbreeding, Outbreeding, Domestication Selection, and Other Genetic Considerations
Conservation hatcheries should provide fish with minimal genetic divergence from their natural counterparts to maintain long-term adaptive traits. It is recommended that they:

- *Identify and follow hatchery protocols which avoid or minimize the processes of domestication selection, inbreeding, and outbreeding; and*
- *Release only smolts which have the fitness and diversity characteristics of their wild cohorts.*

The Conservation Program will follow hatchery protocols to minimize domestication selection and inbreeding. In order to maximize the genetic diversity of the experimental population and facilitate local adaptation, the hatchery mating protocols may allow for crossing of broodstock from multiple source populations during operation of the SCARF and Interim Facility. This may be implemented if preliminary instream observations indicate a benefit in crosses between source populations, if the practice is supported by the HCT and deemed appropriate by the SJRRP CFSG and GSG. Even if the fish are not crossed in the SCARF, using multiple broodstock will likely lead to eventual outcrossing in the San Joaquin River. Allowing outcrossing in the hatchery allows researchers to gather data on the performance and the presence of possible spring-run "hybrids" with genetics from multiple source populations. While this does increase the risk of outbreeding depression, the added genetic diversity created in the experimental population should counterbalance any risks, and the adult returns from these crosses will inform future mating practices. In addition, controlled crosses would allow researchers to learn about the nature of hybrid vigor, outbreeding depression, and inbreeding depression in these populations. If the outcrossed fish perform poorly (e.g., return in proportionately smaller numbers, rate higher in stress evaluations of percent eye up, fair worse in early life stage survival and performance), the in-hatchery outcrossing would be eliminated.

Initially, there will be few wild smolt cohorts for comparison with the fish produced by the SCARF. Fall-run Chinook Salmon smolts from the Merced River may provide a baseline for comparison for some parameters, such as percent return. Once significant natural spawning occurs in the San Joaquin River, the wild smolts may be significantly different than the hatchery smolts in genetic makeup and fitness, based on the notion that they or their parents would have been exposed to natural selection in the San Joaquin River system during at least part of their

life-cycle. The hatchery smolts will come predominantly from the source populations. This may slow adaptation of the experimental population to the San Joaquin River, but continued inter-basin transfers are vital to maximize donor stock genetic diversity. After eight years (two full generations) of inter-basin transfers, the Conservation Program will seek to release smolts that have the fitness and diversity characteristics similar to that of wild smolts from the naturally spawning San Joaquin River population. This will be accomplished in part by collecting broodstock that represent the genetic diversity of the wild population and rearing them in a manner designed to result in a size and condition comparable to wild fish of the same age.

Broodstock Sourcing

Conservation hatcheries should use locally adapted broodstock to maintain long-term fitness traits. It is recommended that they:

- *Select broodstock after careful analysis of environmental relationships and life history parameters, following the best genetic principles.*
- *Provide options, such as captive broodstock for critical populations.*
- *Integrate wild and hatchery populations to avoid divergence and selection of maladaptive traits. and*
- *Maintain the necessary management and security of the stocks.*

The Conservation Program will follow these recommendations (see Section 6). The SCARF will integrate natural-origin and hatchery-origin populations once naturalized adults begin returning in sufficient numbers.

Broodstock Maturation and Reproduction

Conservation hatcheries should manage and rear broodstock to maintain appropriate seasonal timing of maturation, ensure high quality gametes, and minimize precocious maturation of male fish. It is recommended that they:

- *Maintain broodstock on natural photoperiod and water temperature below 12°C; and*
- *Select a diet and growth regime which reduces excessive early maturation of male fish.*

The Conservation Program will generally follow these recommendations. However, water temperatures within the SCARF may, on occasion, exceed 12°C based on the SCARF's water source. See Section 4 for more information concerning the water source for the SCARF.

Enriched Environments

Conservation hatcheries should have incubation and rearing vessels with options for habitat complexity to produce fish more wild-like in appearance, and with natural behaviors and higher survival. It is recommended that they:

- *Provide matrix substrates and darkened environments for egg incubation and alevin development;*
- *Promote development of body camouflage coloration in juvenile fish by creating more natural environments in hatchery rearing vessels, for example, overhead cover, and in-stream structures and substrates;*
- *Condition young fish to orient to the bottom rather than the surface of the rearing vessel by using appropriately positioned feed delivery systems;*
- *Exercise young fish by altering water-flow velocities in rearing vessels to enhance their ability to escape predators;*

- *Improve foraging ability of young fish by supplementing diets with natural live foods; and*
- *Reduce rearing densities to more natural spatial distributions.*

The Program will pursue methods for incorporating enriched rearing environments by carefully investigating approaches that will not alter the self-cleaning efficiency of rearing vessels.. Any proposed enrichments would be determined by the CFSG and listed in the SCARF's Annual Reports. Broodstock that are reared their entire life in the SCARF and are never released into the wild would receive less benefit from enriched environments. As a result, less emphasis will be placed on providing enriched environments for hatchery broodstock.

Growth Rate Modulation

Conservation hatcheries should base their goals for growth patterns of hatchery fish and size at emigration on natural population parameters. It is recommended that they:

- *Determine spawning, hatching and emergence times of local populations, and duplicate these in the hatchery by controlling water temperature to natural profiles;*
- *Measure growth rates, body size, and proximate composition of fish in the local population at critical periods: viz., first summer and fall prior to over-wintering, and spring-run growth/smolt size at migration; and*
- *Simulate growth rate, body size, and proximate composition by controlling water temperature, diet composition, and feeding rates.*

The Conservation Program will follow these recommendations once naturalized adults begin returning in significant numbers. In the interim, fall-run Chinook Salmon smolts from the Merced River may provide a baseline for comparison to develop strategies to minimize competition between these two populations. Growth rates will be managed on an adaptive basis as natural spawning begins to occur in the San Joaquin River. Before naturalized adults return, the water temperatures in the SCARF will follow the water temperatures in the San Joaquin River near the SCARF. The exception would be during periods when river temperatures exceed those recommended for life stages held within the facility (e.g., spawning, egg incubation, early rearing), which occurs in some years when the SCARF water supply from Millerton Lake's cold water pool becomes depleted. In those cases, chillers would be used to reduce water temperatures.

Rearing Density

Conservation hatcheries should use low rearing densities to improve juvenile survival during rearing and to increase adult return percentage. It is recommended that:

- *Density criteria for rearing juveniles in conservation hatcheries should be hatchery-specific, as the potential impact of density may depend strongly on the incidence of existing clinical and sub-clinical infections [Until further data are available, the maximum density index proposed by Banks (1994), and Ewing and Ewing (1995) is 0.15 lb/ft^3/in for spring-run and fall-run Chinook Salmon. . . . Banks (1994) speculated that the adult return of spring-run Chinook Salmon might be further improved in the range of 0.08-0.11 lb/ft^3/in.]; and*
- *Rearing densities are reduced to produce quality smolts.*

The Conservation Program will follow these recommendations for fish that will be released. Because the lower speculative density indices have not been evaluated, the Conservation Program will use a maximum density of 0.15 lb/ft^3/in and will seek to achieve lower densities if

space and broodstock population levels permit. Broodstock that will not be released may be raised at higher densities. In case of low survival, densities will be lowered to ensure that crowding is not impacting survival rates.

Anti-Predator Conditioning

Conservation hatcheries should have options to apply anti-predator conditioning methods in hatchery rearing vessels. It is recommended that they:

- *Foster higher in-stream survival by exposing fish to a variety of anti-predation and training exercises; and*
- *Evaluate and improve various training methods.*

The Conservation Program will investigate these recommendations for fish that will be released to the San Joaquin River. Anti-predation training may include chemical stimuli, artificial predator simulations, and/or actual predator encounters, with the actual method selected via experimental trials using fall-run Chinook Salmon, as discussed in Section 12. Broodstock that will not be released will not be involved in anti-predator conditioning.

Release Size

Conservation hatcheries should release smolts at a size which equals the size distribution of smolts in the wild population. It is recommended that they:

- *Release smolts within the size range of wild smolts from which the population is derived, except a case when imminent extinction requires maximal survival.*

The Conservation Program will follow these recommendations for fish that will be released once naturalized adults begin returning in sufficient numbers. Before naturalized adults return, smolts released will be targeted to the size range of wild smolts from the source populations. Because all three source populations have at least two primary emigration life history strategies, releases will accommodate both young-of-year and yearling migrants. Smolt size at the time of release will be reported in the Annual Report, and any plans to change average smolt size will be subject to NMFS review and approval.

Release Time and Volitional Release

Fish from conservation hatcheries should be released on their own volition and out-migrate during windows for natural downstream migration of the stock. It is recommended that conservation hatcheries:

- *Practice volitional release strategies which maintain within-population variability in out-migration timing by programming liberation windows which mimic the natural time and age patterns found in wild populations of the fish under culture; and*
- *Allow non-smolts (parr) to remain, and either smolt, residualize, or perish through natural selection.*

The Conservation Program will follow these recommendations for fish that will be released once river conditions in the Restoration Area are suitable for volitional salmon outmigration to the Pacific Ocean. The SCARF will use fish holding facilities that allow for volitional release to mimic the natural time and age patterns in fish migration. After leaving the facility, fish will be allowed to remain in-river until they emigrate of their own accord.

Imprinting and Homing

Conservation hatcheries should adopt practices to reduce straying, such as on-site rearing and release, and other promising imprinting or homing techniques. It is recommended that they:

- *Rear fish for their entire juvenile freshwater lives in water from the intended return location to imprint natural odors and reduce straying of returning adults; and*
- *Acclimate juveniles at selected release sites where this approach is not possible.*

The Conservation Program will follow these recommendations. Most fish will be reared for their entire juvenile freshwater lives in San Joaquin River water. Initially, while the restoration process in the Restoration Area is still underway, releases downstream in the San Joaquin River may be necessary to accommodate limited passage opportunities.

Habitat Carrying Capacity

Conservation hatcheries should program their production to accommodate the natural spatial and temporal patterns of abundance in wild fish populations. It is recommended that they:

- *Adopt strategies for releasing numbers of hatchery-reared juveniles to equal (or not exceed) carrying capacities of receiving waters; and*
- *Formulate an Ocean Productivity Index as the basis of modulating fish hatchery production in fisheries management plans.*

The Conservation Program will pursue achieving the objectives for juvenile production found in the FMP and the TAC recommendations. These objectives, highlighted in Section 1, are based on historical and current estimates of San Joaquin River and Ocean carrying capacity. Hatchery production will be moderated when natural returns begin to accommodate the natural production without exceeding the carrying capacity.

3.2 List all existing cooperative agreements, memoranda of understanding, memoranda of agreement, or other management plans or court orders under which program operates

The Conservation Program is part of the SJRRP, which is charged with executing a legal settlement from the lawsuit *NRDC v. Rodgers* (Settlement). The Settling Parties, including NRDC, Friant Water Users Authority, and the U.S. Departments of the Interior and Commerce, agreed on the terms and conditions of the Settlement, which was subsequently approved on October 23, 2006. The Settling Parties also signed a concomitant Memorandum of Understanding (MOU) with the State of California. This document is consistent with the Settlement Agreement and with the enabling act for the Settlement Agreement, Omnibus Public Land Management Act of 2009 Public Law 111-11, Title X. Other cooperative agreements, MOUs, or memoranda of agreement may be developed as the restoration and reintroduction progresses. Any additional agreements will be included here and in the annual hatchery reports discussed in Section 11.

3.3 Relationship to harvest objectives

The Pacific Fishery Management Council (PFMC), established by the 1976 Magnuson/Stevens Fishery Conservation and Management Act to manage near-shore ocean fisheries, works with the CDFW to manage the ocean salmon fishery off the California Coast. The PFMC manages fisheries based on a number of objectives detailed in its Salmon Fishery Management Plan and

evaluated annually in its Review of Ocean Salmon Fisheries. The objectives include stock-specific conservation objectives (e.g., Sacramento River fall-run Chinook spawner escapement goal of 122,000 to 180,000 hatchery and natural adults, Klamath basin natural area spawning escapement of no less than 40,700 fall-run Chinook adults and a spawner reduction rate of no more than 67%). The Salmon Fishery Management Plan does not offer conservation objectives for any CV spring-run fish because (1) harvest related take is regulated through annual ESA consultation and seasonal closures, and (2) gear and location restrictions influence the escapement of spring-run Chinook Salmon in the CV (Cavallo et al. 2009). Finally, ocean fishing restrictions are often based on protecting the most vulnerable stocks because the stocks co-occur in the ocean. For example, fishing along the California coast was restricted in 2006 to protect Klamath River Chinook Salmon, and in 2008 and 2009 to protect Sacramento River fall-run Chinook Salmon.

3.3.1 Describe fisheries benefiting from the program, and indicate harvest levels and rates for program-origin fish for the last twelve years (2003-2015), if available

The SCARF is an integrated recovery hatchery, which is not primarily intended to produce adult salmon for harvest but rather to promote recovery. Harvest may be an ancillary benefit as the San Joaquin River populationg grows. There are active ocean commercial and ocean and inland recreational fisheries for salmon in California. As a result, some San Joaquin River spring-run Chinook Salmon will likely be taken in those fisheries. Estimates of the spring-run Chinook Salmon ocean harvest are available from 1995 to 2006 (Table 3.1). As noted in the FMP (SJRRP 2010a), harvest rates of CV spring-run likely ranged from 55% to nearly 80% between 1975 and 1995. From 1995 to 2005, estimated harvest rates ranged from 17.4% to 60.2%, with a mean of 28.8%. This harvest rate may be an overestimate because the escapement estimates include only the three largest runs of spring-run Chinook Salmon in the CV. Ocean and most freshwater salmon fishing in California were prohibited in 2008 and 2009 due to low returns of CV fall-run Chinook Salmon.

The CDFW seeks to minimize take of CV spring-run Chinook Salmon in freshwater fisheries via special regulations in Mill, Deer, Butte, and Big Chico creeks. Further, the regulations developed for Sacramento River winter-run Chinook Salmon provide some additional protection (CDFG 1998). Estimates are not available for the freshwater recreational take of spring-run Chinook Salmon.

Estimated future harvest rates on fish propagated by the Conservation Program are difficult to calculate. Although ocean (commercial) harvest rates may remain similar to those estimated between 1995 and 2006, ocean harvest rates can vary annually based on the regulations established by the Pacific States Marine Fisheries Commission and CDFW. Although freshwater recreational harvest is currently prohibited, a recreational fishery may develop under 4(d) regulations when salmon begin returning in the significant numbers anticipated in the Settlement. Even if allowed under the 4(d) regulations, the USFWS has recommended the consideration of special regulations and closures on the San Joaquin River at least through the reintroduction period. The CA Fish and Game Commission has the power to establish such special regulations. If returns do not meet the numerical objectives identified in Section 1, seasonal, gear, or location

restrictions on ocean and freshwater fishing may be considered.

Table 3.1. Estimated ocean landings (harvest) of CV spring-run Chinook Salmon by brood year and age (calculated from Cramer et al. 2005 and Table 2-2 in Cavallo 2009)

	Ocean Landings				Percent of Potential Source Population Escapement*
Brood Year	**Age 3**	**Age 4**	**Age 5**	**Total**	
1995	1,571	6,785	196	8,552	37.1%
1996	816	3,599	258	4,674	35.1%
1997	1,318	5,796	378	7,491	60.2%
1998	1,379	4,998	445	6,822	18.9%
1999	769	3,456	562	4,786	33.4%
2000	802	3,559	321	4,681	34.3%
2001	486	2,236	756	3,478	17.4%
2002	718	3,271	710	4,700	21.9%
2003	610	2,782	633	4,025	18.9%
2004	1,021	4,490	292	5,803	30.2%
2005	3,624	4,751	323	8,698	35.5%
2006	3,914	5,131	349	9,393	48.3%
Totals	17,028	50,854	5223	73,103	30.6%
Mean	1,419	4,238	435	6,092	28.8%

*Calculated as harvest/(harvest+escapement)

3.4 Relationship to habitat protection and recovery strategies

The FMP provides detailed information on factors limiting natural production and the habitat protection efforts that should be considered in the Restoration Area. The FMP also establishes six Habitat Goals and thirteen Habitat Objectives to measure achievement of those goals (SJRRP 2010a):

Habitat Goals

1. *Restore a flow regime that (1) maximizes the duration and downstream extent of suitable rearing and outmigration temperatures for Chinook Salmon and other native fishes, and (2) provides year-round river habitat connectivity throughout the Restoration Area.*
2. *Provide adequate flows and necessary structural modifications to ensure adult and juvenile passage during the migration periods of both spring-run and fall-run Chinook Salmon.*
3. *Provide suitable habitat for Chinook Salmon holding, rearing, and outmigration during a variety of water year types, enabling an expression of a variety of life-history strategies. Suitable habitat will encompass appropriate holding habitat, spawning areas, and seasonal rearing habitat.*
4. *Provide water-quality conditions suitable for Chinook Salmon and other native fishes completing their life cycle without lethal or sublethal effects.*
5. *Reduce predation losses in all reaches by reducing the extent and suitability of habitat for nonnative predatory fish.*

6. *Restore habitat complexity, functional floodplains, and diverse riparian forests that provide habitat for spawning and rearing by native resident species during winter and spring-run.*

Habitat Objectives

1. *A minimum of 30,000 square meters (m^2) of high-quality spring-run Chinook Salmon holding pool habitat.*
2. *A minimum of 78,000 m^2 of quality functioning spawning gravel in the first 5 miles of Reach 1 should be present for spring-run Chinook Salmon.*
3. *A minimum of 88,000 m^2 of floodplain rearing habitat for spring-run subyearling smolts and 126,000 m^2 of floodplain rearing habitat for fall-run subyearling smolts.*
4. *Provide passage conditions that allow 90% of migrating adult and 70% of migrating juvenile Chinook Salmon to successfully pass to suitable upstream and downstream habitat, respectively, during all base flow schedule component periods and water year types of the Settlement, except the Critical-Low water year type.*
5. *Provide appropriate flow timing, frequency, duration and magnitude enabling the viability of 90% of all life-history components of spring-run Chinook Salmon.*
6. *Water temperatures for spring-run Chinook Salmon adult migrants should be less than 68 °F in Reaches 3, 4, and 5 during March and April, and less than 64°F in Reaches 1 and 2 during May and June.*
7. *Water temperatures for spring-run Chinook Salmon adult holding should be less than 59°F in holding areas between April and September.*
8. *Water temperatures for spring-run Chinook Salmon spawners should be less than 57°F in spawning areas during August, September, and October.*
9. *Water temperatures for spring-run Chinook Salmon incubation and emergence should be less than 55°F in spawning areas between August and December.*
10. *Water temperatures for spring-run Chinook Salmon juveniles should be less than 64°F in the Restoration Area when juveniles are present.*
11. *Selenium levels should not exceed 0.020 milligrams per liter (mg/L) or a 4-day average of 0.005 mg/L in the Restoration Area.*
12. *Dissolved Oxygen concentrations should not be less than 6.0 mg/L when Chinook Salmon are present.*
13. *Total ammonia nitrogen should not exceed 30-day average of 2.43 milligrams nitrogen per liter (mg N/L) when juvenile Chinook Salmon are present or exceed a 1-hour average of 5.62 mg N/L when Chinook Salmon are present.*

3.5 Ecological interactions.

The FMP provides presence and absence data on fish in the Restoration Area (Table 3.2), which has been updated using additional data collected in the Restoration Area since 2010.

Table 3.2. Fish Species with Possible Historic and Current Presence in the Restoration Area. Modified from FMP Table 2-1 (SJRRP 2010a).

Species	**Scientific Name**	**Native (N) or Introduced (I)**	**Current Presence***
Spring-run Chinook Salmon	*Oncorhynchus tshawytscha*	N	Yes
Fall-run Chinook Salmon	*Oncorhynchus tshawytscha*	N	Periodic
Rainbow Trout/Steelhead	*Oncorhynchus mykiss*	N	Yes
Chum Salmon	*Oncorhynchus keta*	N	Periodic
Pacific Lamprey	*Lampetra tridentata*	N	Yes
River Lamprey	*Lampetra ayersi*	N	Unknown
Kern Brook Lamprey	*Lampetra hubbsi*	N	Yes
Western Brook Lamprey	*Lampetra richardsoni*	N	Unknown
White Sturgeon*	*Acipenser transmontanus*	N	Yes
Green Sturgeon	*Acipenser medirostris*	N	No
Hitch	*Lavinia exilicauda*	N	Yes
California Roach	*Lavinia symmetricus*	N	Yes
Sacramento Blackfish	*Orthodon microlepidotus*	N	Yes
Sacramento Splittail	*Pogonichthys macrolepidotus*	N	Yes
Hardhead	*Mylopharodon conocephalus*	N	Yes
Sacramento Pikeminnow	*Ptychocheilus grandis*	N	Yes
Speckled Dace	*Rhinichthys osculus*	N	Extirpated
Sacramento Sucker	*Catostomus occidentalis*	N	Yes
Threespine Stickleback	*Gasterosteus aculeatus*	N	Yes
Prickly Sculpin	*Cottus asper*	N	Yes
Riffle Sculpin	*Cottus gulosus*	N	Yes
Sacramento Perch	*Archoplites interruptus*	N	Extirpated
Tule Perch	*Hysterocarpus traski*	N	Yes
Brook Trout	*Salvenlinus fontinalis*	I	Yes
Bigscale Logperch	*Percina macrolepida*	I	Periodic
American Shad	*Alosa sapidissima*	I	
Threadfin Shad	*Dorosoma petenense*	I	Yes
Common Carp	*Cyprinus carpio*	I	Yes
Goldfish	*Carassius auratus*	I	Yes
Fathead Minnow	*Pimephales promelas*	I	Yes
Mosquitofish	*Gambusia affinis*	I	Yes
Inland Silverside	*Menidia beryllina*	I	Yes
Red Shiner	*Cyprinella lutrensis*	I	Yes
Golden Shiner	*Notemigonus crysoleucas*	I	Yes
Bullhead Catfish	*Ameiurus sp.*	I	Yes
White Catfish	*Ameiurus catus*	I	Yes
Channel Catfish	*Ictalurus punctatus*	I	Yes
Striped Bass	*Morone saxatilis*	I	Yes
Black Crappie	*Pomoxis nigromaculatus*	I	Yes
Bluegill Sunfish	*Lepomis macrochirus*	I	Yes
Green Sunfish	*Lepomis cyanellus*	I	Yes
Pumpkinseed	*Lepomis gibbosus*	I	Yes
Warmouth	*Lepomis gulosus*	I	Yes
Redeye Bass	*Micropterus coosae*	I	Yes
Largemouth Bass	*Micropterus salmoides*	I	Yes
Redear Sunfish	*Lepomis microlophus*	I	Yes
Spotted Bass	*Micropterus punctulatus*	I	Yes

Table 3.2. Fish Species with Possible Historic and Current Presence in the Restoration Area. Modified from FMP Table 2-1 (SJRRP 2010a).

Species	**Scientific Name**	**Native (N) or Introduced (I)**	**Current Presence***
White Crappie	*Pomoxis annularis*	I	Yes
Shimofuri Goby	*Tridentiger bifasciatus*	I	Yes

* CDFG Report Card Data, 2009

Of the species currently present in the San Joaquin River, only CV spring-run and CV Steelhead are currently listed under the FESA (63 FR 13347, March 19, 1998 and 71 FR 834, January 5, 2006). The San Joaquin River population of CV spring-run is designated by NMFS as an experimental population as part of reintroduction of the species to its historical habitat. Escapement data for the Steelhead in the main stem San Joaquin River are not available. In general, Steelhead may be excluded from much of the Restoration Area based on the presence of multiple fish passage barriers coupled with inadequate river flow. However, Steelhead may eventually be reintroduced or recolonize naturally once the river is restored.

3.5.1 Salmonid and non-salmonid fishes or other species that could negatively impact program

The FMP (SJRRP 2010a) identifies several fish that are risk factors for the reintroduction effort:

> Key predators to [juvenile] salmonids are thought to include native Sacramento pikeminnow, which feeds all year, introduced striped bass, which typically begins migrating into tributary habitats in April, and introduced centrarchids, when they begin feeding in April or May as water temperatures rise. These fish tend to use dredged habitats in the Restoration Area and Delta, including captured mine pits, the Stockton Deepwater Ship Channel, and canals leading to the CVP and [State Water Project] SWP pumping facilities. Nonnative submerged aquatic vegetation provides habitat for nonnative predators.
>
> Improvements in habitat conditions related to restoration flows and floodplain restoration may limit risk of predation by many of the key predators described above. Other predators may include birds or aquatic mammals like seals, sea lions and otters. The FMP also notes that stocking of hatchery-reared catchable-sized Steelhead or Rainbow Trout in the Restoration Area could negatively impact the Conservation Program through predation, although the 2010 Fish and Game Policies prohibit such releases in the Restoration Area, noting, "Domesticated or non-native fish species will not be planted, or fisheries based on them will not be developed or maintained, in drainages of salmon waters, where, in the opinion of the Department, they may adversely affect native salmon populations by competing with, preying upon, or hybridizing with them. Exceptions to this policy may be made for stocking

drainages that are not part of a salmon restoration or recovery program" (SJRRP 2010a).

3.5.2 Salmonid and non-salmonid fishes or other species that could be negatively impacted by program

The San Joaquin River above the Merced River does not have a persistent population of Chinook Salmon or Steelhead, although some strays likely enter the river each year. Beginning in 2012, the SJRRP has annually trapped some of these fall-run Chinook Salmon strays below barriers in the Restoration Area and released them in a reach containing suitable spawning habitat below Friant Dam to study behavior and habitat use. However, lack of river connectivity for volitional outmigration of juveniles and migration of returning adults will prevent a self-sustaining population from establishing prior to SJRRP channel and passage improvement projects being completed. Because the San Joaquin River spring-run are going to be reintroduced to a portion of the river without existing fall- or spring-run populations, many of the normal concerns with hatchery operations (e.g., introgression, predator attraction (Collis et al. 2001), behavioral influences) should not be a concern for other Chinook Salmon in the river during the initial stages of the reintroduction. As more significant numbers of naturalized fish return to the system, these potential impacts may be realized. However, the Conservation Program will implement the reintroduction with the intent of minimizing these impacts. The continued reintroductions are likely to benefit the naturalized Chinook Salmon elsewhere in the system by bolstering their numbers and their genetic diversity. As outlined in Section 1, when the naturalized populations are well enough established that they do not require the support of the hatchery, SCARF operations will be discontinued.

While the reintroduced salmon will not initially encounter other spring-run salmon in the river, they are likely to interact with fall-run Chinook Salmon, Steelhead, and other salmonids while outmigrating or rearing in the San Francisco Estuary and ocean. The reintroduced fish are likely to interact with other listed salmonid populations, including the endangered winter-run Chinook Salmon, and the threatened CV Steelhead. The reintroduced fish may negatively impact other salmonids through a variety of interactions, most notably induced behavioral changes in wild fish, competition for limited resources, depensatory predation, and disease transfers in areas where they co-occur (Reisenbichler et al. 2004). While in freshwater, juvenile salmon feed predominantly on aquatic insects and other invertebrates and should not be significant predators on other salmonids (Unger 2004, Rundio and Lindley 2007).

Finally, returning adults may stray into other San Joaquin River tributaries, where they may interbreed with other Chinook Salmon. The small numbers of spring-run Chinook Salmon in the San Joaquin River tributaries and the lack of genetic analysis on them makes analysis of potential genetic effects very difficult. The hatchery will be employing conservation hatchery protocols to reduce domestication selection, and the salmon will be in the hatchery at some point in their lives for one or a maximum of two generations, so there may be some reduction in fitness relative to the wild population (Reisenbichler and McIntyre 1977; Leider et al. 1990, Sekino et al. 2002; Araki et al. 2007).

3.5.3 Salmonid and non-salmonid fishes or other species that could positively impact program

If fall-run Chinook Salmon or Steelhead begin returning to the San Joaquin River in significant numbers, they would benefit the Conservation Program via ecosystem enrichment with marine-derived nutrients. Segregation protocols would be implemented to limit fall-run and spring-run interactions, but the carcasses from the fall-run would enrich the system as a whole. Other ecological interactions may directly or indirectly benefit the program, but are not well documented.

3.5.4 Salmonid and non-salmonid fishes or other species that could be positively impacted by program.

Ecosystem enrichment via inputs of nutrients from smolts and eventually returning adults should benefit other fish populations in the San Joaquin River, particularly the predatory fish that would benefit from an increased prey base. Aquatic and nearby riparian ecosystems generally benefit from the nutrients brought into the system via returning adult salmon (Cederholm et al. 1999). Other salmonids in the San Joaquin River, the San Francisco Estuary, or the ocean may benefit from compensatory fishing and predation, if the presence of reintroduced fish reduces their mortality. Straying of returning adults may increase the genetic diversity of recipient populations.

SECTION 4 WATER SOURCE

4.1 Provide a quantitative and narrative description of the water source (spring-run, well, surface), water quality profile, and natural limitations to production attributable to the water source

Water for the Conservation Program facilities (i.e., Interim Facility, SCARF, and SIRF) will be supplied from Millerton Lake behind Friant Dam, which has a total capacity of 520,500 acre-feet (642,027,300 cubic meters). The watershed above Friant Dam drains 1,638 square miles (4,242 square km) on the western slope of the Sierra Nevada in Fresno and Madera counties and is bounded by the watersheds of the Merced and Fresno rivers on the north and the Kings River on the south. The geology of the watershed is primarily granitic. It extends east to the crest of the Sierra Nevada with a general ridge elevation of about 10,000 feet above mean sea level (3,048 meters), and occasional peak elevations greater than 13,000 feet (3,962 meters), and westward to Friant Dam about 25 miles (40 km) north from Fresno at an elevation of about 350 feet (107 meters) (SJRRP 2009).

The SCARF will be located adjacent to the existing CDFW San Joaquin State Fish Hatchery (SJH) in Friant, California. Water flow at the SJH has been exceptionally reliable in its 65 years of operation, with only one disruption due to an underground pipe break. Water flow at the SCARF is anticipated to be equally as reliable. The SJH has successfully hatched and raised trout at the site since 1955 due to favorable water temperature and water quality conditions. The source water for the SJH is a continuous 35 cubic feet per second (cfs) supply of water that is gravity fed directly from Friant Dam. The water is delivered first to a Fish Release Hydropower Plant via two different pipelines: a 24-inch diameter pipeline from two Friant Dam penstocks, and a 30-inch diameter pipeline that takes water from the Friant Kern Canal near the left dam abutment. The temperature of the water in each pipeline varies throughout the year, and valves are used to control the flows to maintain favorable temperature conditions for the SJH.

The SJH supply water and the adjacent river water are of the same origin and are fairly similar in temperature. During the late summer/fall period when water temperatures are a concern, the entire supply may come from the base of Friant Dam because water from the Friant-Kern Canal is too warm to use. Water supply is typically maintained between 45-55 °F (7.2-12.8 °C) throughout the year, historically dipping as low as 42 °F (5.6 °C) or as high as 58 °F (14.4 °C). However, during the recent drought when Millerton Lake's cool water pool was depleted, the San Joaquin River and temperatures at the hatchery have reached 60 °F in 2013, 70°F in 2014, and 67°F in 2015 (see Figure 4.1). In response, the Conservation Program installed water recirculation and water chiller systems to maintain temperatures at acceptable levels at the Interim Facility (see Section 5).

The SJH effluent is regulated under Clean Water Act NPDES permit No. CA0004812 Order No. R5-2004-0118 (General Order), administered by the Central Valley Regional Water Quality Control Board (RWQCB). The SCARF will submit a Notice of Applicability to be covered under the General Order as a separate facility. Because of planned flow rates at the SCARF to provide sufficient flushing and optimal conditions for fish rearing, temperature increase is anticipated to be minimal and will remain within the guidelines provided by the RWQCB.

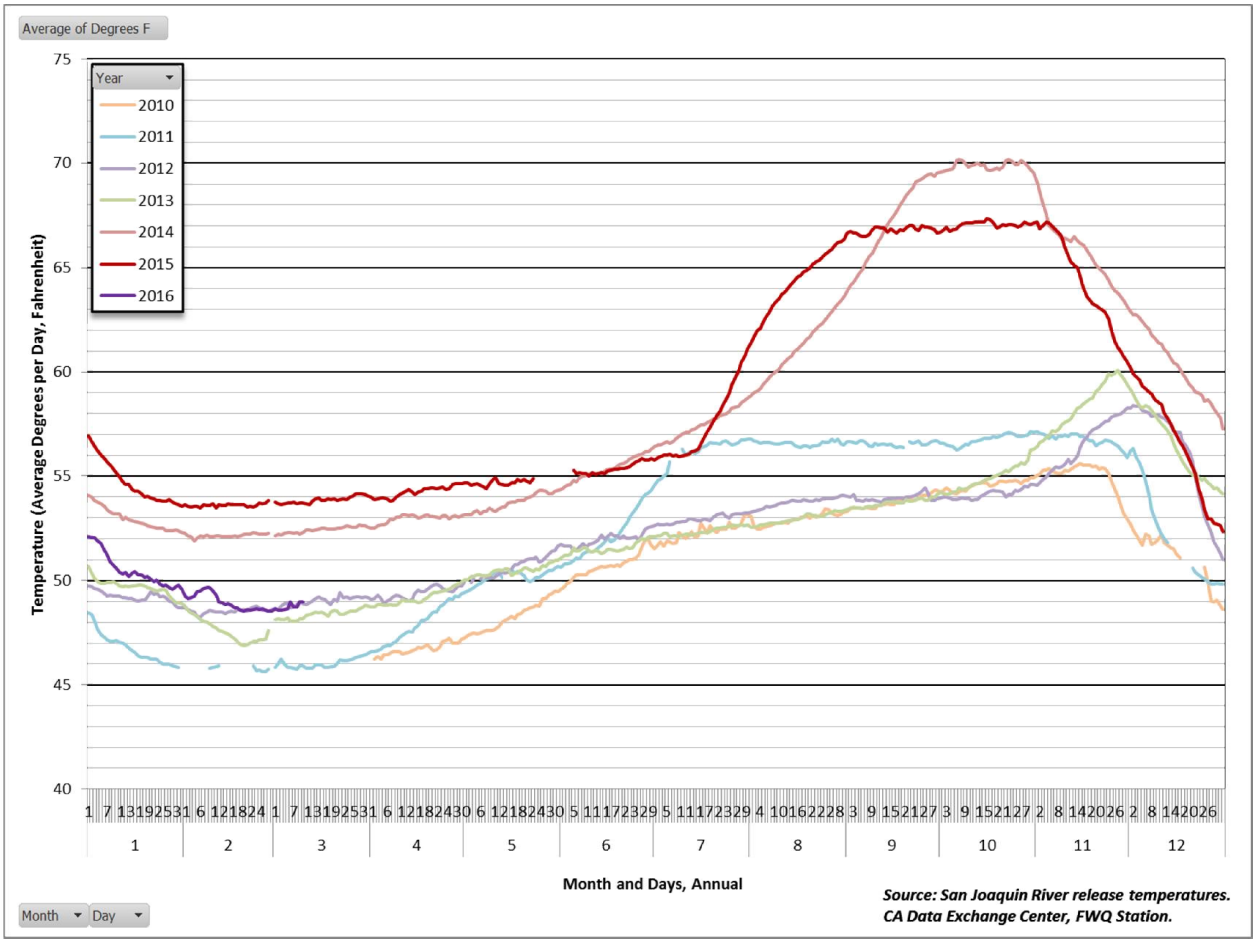

Figure 4.1: Water Temperature Data, Friant Release, 2010-2016

4.2 Indicate risk aversion measures that will be applied to minimize the likelihood for the take of listed natural fish as a result of hatchery water withdrawal, screening, or effluent discharge

The SCARF will be designed to conform to NMFS screening guidelines for effluent discharge. The SCARF's intake line will originate in Lake Millerton above Friant Dam, where there are no known listed fish species. Solid waste from fish culture tanks from the full-scale SCARF will be separated from the effluent using micro screen filtration, stored in a solid waste sump, dried, and removed from the premises. The Interim Facility is small enough to fall below the NPDES permit requirements. As noted above, the full-scale SCARF will obtain NPDES permit coverage, to ensure effluent discharge will not impact the San Joaquin River. Effluent discharge from the Interim Facility has been monitored since mid-2014. Water quality parameters the samples are analyzed for include total suspended solids (TSS) and biochemical oxygen demand (BOD). Since July 2014, most of the results have been "non-detect" for both TSS and BOD, except on two occasions when BOD was measured at 1.0 mg/l. Regarding these water quality parameters, the hatchery effluent hasn't had any significant effect on receiving waters.

SECTION 5 FACILITIES

This HGMP includes operations of three related facilities: (1) the SCARF, currently in the design planning stages (Figure 5.1), (2) the Interim Facility, designed to allow salmon production at a smaller scale until the full-scale SCARF becomes operational, and (3) a Satellite Incubation and Rearing Facility (SIRF) located just below Friant Dam, 3/4 miles upstream of the SCARF location. It is anticipated the SCARF will be operational by the end of 2017. The Interim Facility is expected to meet Conservation Program goals in the meantime and will be repurposed after SCARF is operational. This HGMP is the guidance document for CV spring-run broodstock collection and the management, artificial spawning, egg incubation, juvenile rearing, and smolt release operations at all three facilities.

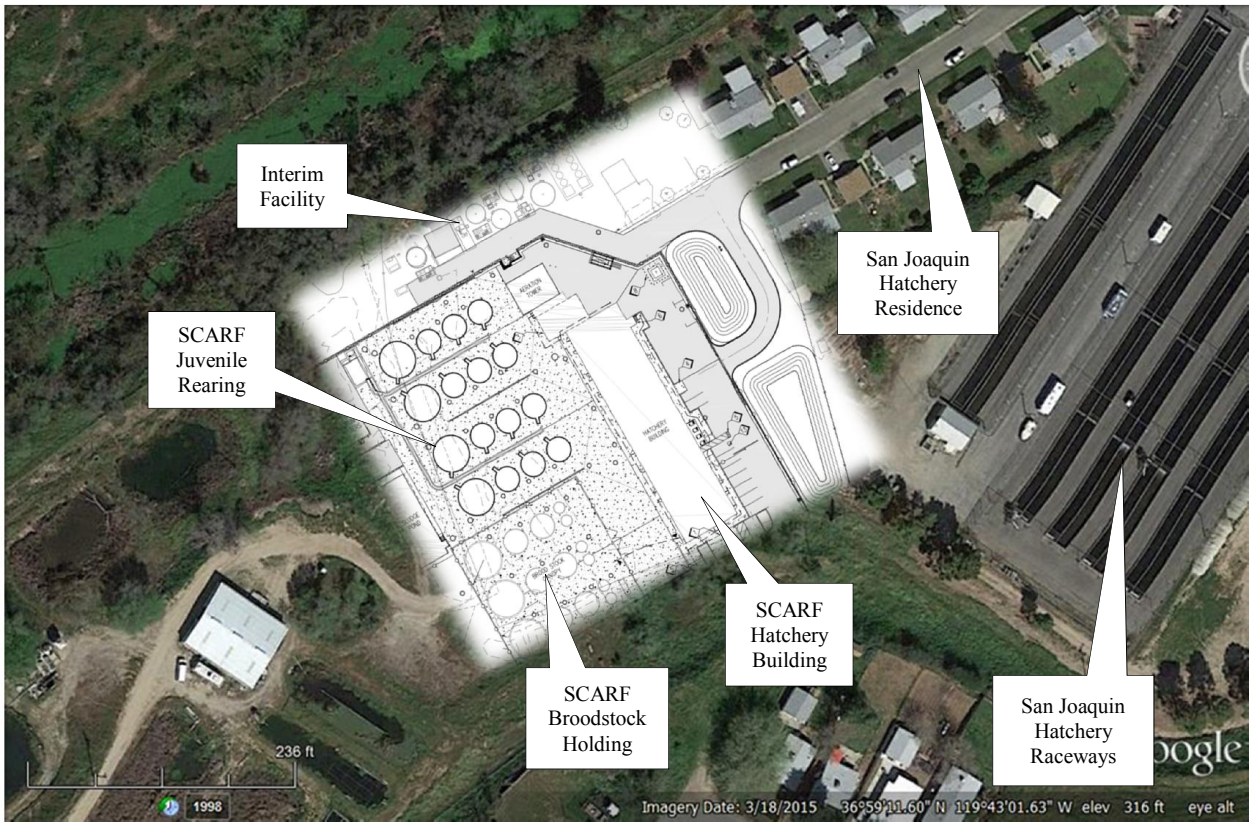

Figure 5.1: SCARF Design Plan Drawing Aerial Overlay

5.1 Broodstock collection facilities (or methods)

The SCARF may use multiple methods to collect broodstock at several life stages. Broodstock has been collected from FRH since 2012 and will likely be collected from Butte Creek and the San Joaquin River populations beginning in 2018. Depending on the size and status of wild populations in the Deer and Mill Creek Complex, the Conservation Program anticipates limited collection of individuals from that population as early as 2022. As the Program progresses and the desired level of genetic diversity is reached, broodstock collections will shift to focus on individuals from the San Joaquin River.

Broodstock collection methods will depend on the specific objectives of the collection, life-stage targeted, take guidelines provided by NMFS, potential impacts to the source populations, and specific site conditions. Broodstock collection methods will aim to maximize broodstock genetic diversity by collecting over the spatial and temporal range of the targeted life-stage.

5.1.1 Adult Broodstock Collection

Since 2012, the Conservation Program has spawned returning spring-run adults to the FRH to obtain eggs and juveniles for broodstock. This activity will continue using existing FRH facilities, as described in Section 2. To reduce disease transfer potential, disinfected eyed-eggs and juveniles are subject to quarantine and pathology screening by the CDFW Fish Health Lab prior to being transferred to the SCARF or Interim Facility.

Some adult spring-run returning to the San Joaquin River would be collected for incorporation into Conservation Program broodstock. Returning adults may be collected at various locations along the river above the confluence with the Merced River. Collection options include fyke traps, seines, dip nets, and collection weirs in the San Joaquin River and its tributaries. If captured adults are not yet ready to spawn, they may be held temporarily in net pens the river or in tanks at the SIRF or Interim Facility, outside of the SCARF for quarantine purposes, until they could be genetic tested for incorporation into the breeding matrices and artificially spawned. Fertilized eggs would be incubated at either the Interim Facility or the SIRF, and, after pathology clearance, the resulting juveniles would either be incorporated into SCARF broodstock or released to the San Joaquin River.

5.1.2 Juvenile Broodstock Collection

In order to minimize the impacts to the source populations, the Conservation Program will target relatively small numbers of juvenile fish for use as broodstock through captive rearing. Juveniles may be collected from Butte Creek or the San Joaquin River using methods designed to minimize harm, while at the same time allowing collections from a wide temporal and spatial distribution. Such collection methods may include rotary screw traps (RSTs), fyke traps, emergence traps, or seines, Collection of broodstock as juveniles as opposed to targeting redds or adults would benefit the Conservation Program's captive rearing program by further reducing the effects of hatchery-induced selection. However, using emergence traps to collect juveniles allows the Conservation Program to target specific spring-run redds if it is difficult to identify spring-run versus fall-run juveniles using other methods. Further details on collection methods are presented in Section 7.

5.1.3 Egg Broodstock Collection

Collection of eyed eggs from naturally spawned redds provides potential benefits for pathology and broodstock health, and also allows the Conservation Program to target specific redds for collection. Egg extraction methods include redd pumping and redd excavation, each having benefits depending on the collection location and in-river conditions. Due to the significant pre-collection monitoring requirements (e.g., redd surveys conducted no less frequently than once per week) and accessibility of collection

sites, egg collection via redd extraction will initially only occur from the San Joaquin River population.

5.2 Fish transportation equipment (description of pen, tank truck, or container used)

Spring-run Chinook Salmon transport will be performed pursuant to the SJRRP 2013 Adult and Juvenile Salmon Transport Protocol (see Appendix B). Both juvenile and adult salmon will be transported by insulated aluminum fish hauling tanks. The tanks will incorporate mechanical aeration and diffused gaseous oxygen. When feasible, fish will be transferred "in-water" in purse-style stretchers that hold both fish and water (e.g. water-to-water transfer). Direct netting of fish will be minimized to the greatest extent possible to reduce injury and fish stress. Eggs will be transported in coolers with equal volumes of eggs and river water.

5.3 Interim Facility

The small-scale Interim Facility (Figure 5.2) has been in operation since fall 2010, when the Conservation Program began rearing of fall-run Chinook Salmon to obtain practical experience rearing captive juvenile Chinook Salmon in the new facilities prior to working with FESA and CESA listed fish. The Conservation Program began annual collections of spring-run broodstock from the FRH in 2012, first spawning adults in fall 2015 when the 2012 brood year broodstock attained sexual maturity. Additional tanks and egg incubation equipment, as well as water recirculation and chiller equipment, were installed in 2014-2015 to help meet Conservation Program production targets. The Interim Facility will continue the Conservation Program's rearing of spring-run until the full-scale SCARF is operational.

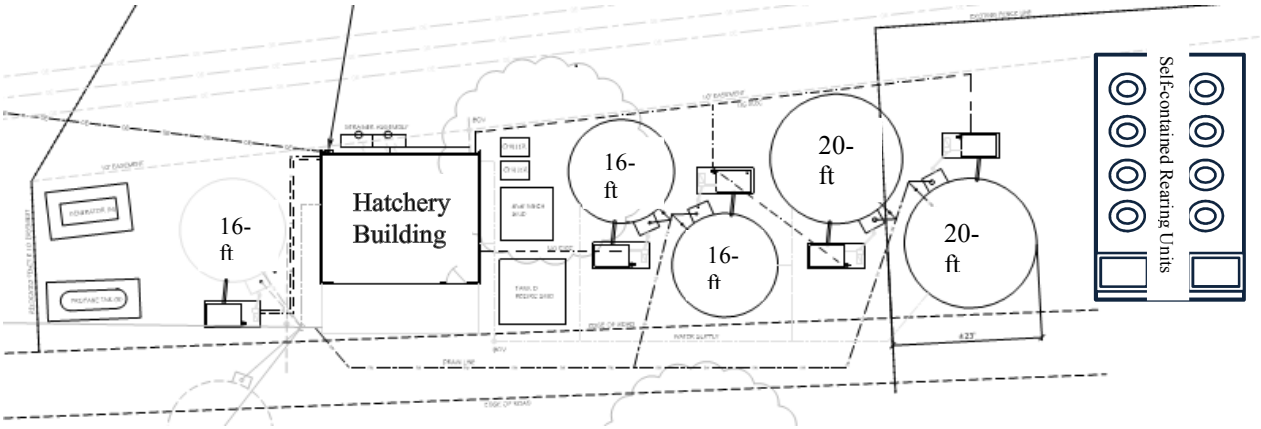

Figure 5.2: Interim Facility 2015 Design Drawing Showing Recent Improvements

5.3.1 Broodstock holding and spawning facilities (Interim Facility)

With recent upgrades to the Interim Facility, broodstock holding facilities are composed of four 3-ft circular tanks, eight 6-ft circular tanks, three 16-ft circular tanks and two 20-ft circular tanks. The Interim Facility improvements allow the capability to spawn a total of approximately 50-100 adult salmon annually and to rear their offspring to a size at which they can be coded wire tagged and released in the San Joaquin River. Smaller tanks (3-ft

to 6-ft) are covered by portable carports and each/every tank is individually screened to prevent fish from jumping out and predators from gaining access to broodstock. Gravity-fed water is delivered to each tank, but recirculation systems are being used to recirculate up to 95% of the incoming water supply.

After subsequent years of drought-related impacts to the water supply temperature, CDFW added chillers to the recirculation systems on all egg incubation, fry production, and early rearing facilities, as well as on all 6-to-16 ft. diameter tanks at the Interim Facility. The two 20-ft diameter tanks are capable of recirculating up to 70% of the incoming supply water but do not have associated chillers, because these tanks would be used during a time of year when water supply temperatures should not be a concern. Each of the three 16-ft circular tanks, each of two sets of four 6-ft circular tanks, and the four 3-ft circular tanks have chiller units installed. The chillers are components of 95% recirculation systems that include: drum filters to filter solid waste, fluidized bed filters to transform ammonia into less-harmful nitrogen compounds, carbon dioxide stripping/oxygenation towers, and ultraviolet (UV) treatment systems. The chillers themselves are capable of reducing water supply temperatures by up to 15°F. To accommodate the improvements made at the Interim Facility and mitigate the impacts of power outages, the facility's electrical system was upgraded to include an electrical panel, transformer, and a backup propane-powered electrical generator). The UV treatment systems have the ability of supplying no less than 150 mJ/cm2 for control of targeted pathogens. Different pathogens have varying sensitivities to UV light exposure, so the systems in place were designed to target those pathogens known to, or likely to occur in water supplied to the facility (see Table 5.1).

Table 5.1 UV Sensitivity of Selected Fish Pathogens

Pathogen	Minimum UV dose for 3 log reduction (mJ/cm2)	Source
Bacteria		
Aeromonas salmonicida	5.9+, 4.0, 2.7++	Liltved & Landfald, 1996; Yoshimuzu et al., 1990; Liltved et al., 1995
Yersinia ruckeri	2.7++	Liltved et al., 1995
Pseudomonas fluorescens	5.0	Yoshimizu et al., 1990
Protozoa		
Myxobolus cerbralis	40-, 40+	Hedrick et al., 2007; Hedrick et al., 2008
Fungi		
Saprolengia spp.	150# to 250#	Yoshimizu et al., 1990
Viruses		
Infectious hematopoietic necrosis virus	10, ≤3.0-, 3.0, 2.0, 1.0	Yoshimizu et al., 1991; Yoshimizu et al., 1986; Yoshimizu et al., 1990; Yoshimizu et al., 1990; Yoshimizu et al., 2005
Infectious pancreatic necrosis virus	337, 246, 150-, 122, 119, 100-	Yoshimizu et al., 2006; Yoshimizu et al., 1990; Yoshimizu et al., 1986; Liltved et al., 1995; Oye & Rimstad, 2001 Yoshimizu et al., 2005
++ = 5 log (99.999%); + = 4 log (99.999%); - = absence of microscopic lesions, , myxospores, and parasite DNA detected by qPRC; # = inhibited growth		

Modified from: Xyem Incorporated Rye Brook, NY (http://www.xylem.com/en-us/industries/aquaculture/Documents/protecting-fish-and-fish-farmers-from-infectious-diseases.pdf)

5.3.2 Incubation facilities (Interim Facility)

The Interim Facility has six 12-stack vertical tray incubators, two deep matrix incubators, and one moist air incubator (See details in Section 5.4.2). Each vertical flow incubator consists of 12 trays per stack, and will be operated at the manufacture's recommended flow rate of 3-6 GPM, depending on the loading density. Loading densities will not exceed 8,000 eggs per tray for green eggs and 10,000 eggs per tray for eyed-eggs. Individual family lots will be segregated into three or four sections per egg tray using segregation dividers. Opaque side panels will be added to the incubators to produce a darkened environment for incubation. An additional two 12-stack vertical tray incubators may be added later as production commitments increase. A 95% recirculation system with two 5-hp chillers was recently added for the indoor tanks and egg incubation facilities. The indoor building recirculation systems include: drum filters to filter solid waste, fluidized bed filters to transform ammonia into less-harmful nitrogen compounds, carbon dioxide stripping/oxygenation towers, and ultraviolet treatment systems to destroy pathogens. The chillers themselves are capable of reducing water supply temperatures by up to 15 °F.

5.3.3 Rearing facilities (Interim Facility)

Rearing facilities are organized into interior and exterior. Fry production occurs primarily in the hatchery building, with buttoned-up fry being placed in an aluminum rearing trough until they are large enough to be moved into one of four 3-ft diameter circular tanks. Further fry development, smolt production, and captive rearing occurs outside in the self-contained rearing units' eight 6-ft diameter circular tanks, the three 16-ft circular tanks, or the two 20-ft circular tanks.

Hatchery Building

Fry Production and Early Rearing: Fish will be reared from the unfed fry stage to approximately 3 grams each. Facilities within the hatchery building include:

- One aluminum rearing trough with screened dividers
- Four 3-ft diameter circular tanks
- Automatic 24 hour belt feeding system
- Natural lighting and available artificial lighting
- Roof ventilators
- Associated plumbing
- Work bench and storage shelves
- Chemical storage: built-in shelving
- Refrigerator
- Freezer

- Two recirculation/chiller units capable of 95% recirculation
- SCADA monitoring system control unit
- Oxygen tanks and distribution system

Exterior Hatchery Area

After early rearing, fry are moved to progressively larger circular tanks and then outside for juvenile rearing, smolt production, and captive rearing of Conservation Program broodstock. Exterior facilities include:

- Outdoor fry production: Two self-contained rearing units, each with four 6-ft diameter circular tanks and 95% recirculation system with chillers
- Outdoor smolt production: three 16-ft tanks and two 20-ft tanks with automatic feeders, netted or domed enclosures, used for smolt production from 3 grams to 7.5 grams and yearling production from 7.5 grams to 75 grams
- Captive rearing: the same tanks available for smolt production above (as fish are released to the river, space is made available in rearing tanks to hold growing broodstock), automatic feeders, solid roof bird enclosure and possible water reuse system, used for adult production from yearlings (75 grams) to adults (> 1 kilogram)
- Each of the 16-ft diameter tanks has an associated 95% recirculation system with chiller, drum filters, fluidized bed filters, carbon dioxide strippers, and oxygenation
- Ultraviolet water treatment used on a portion of water supply after exiting the aeration assembly

Effluent from the hatchery building and bottom drains from fish culture tanks is directed via gravity flow through a series of effluent treatment ponds, then to a common discharge point on the river. Existing settling ponds will be used for effluent treatment and monitored, as required by RWQCB NPDES General Order to minimize water quality impacts.

5.4 SCARF

The SCARF is currently in the 100% design phase, so the facilities to be constructed are well known (Figure 5.3). Major features of the SCARF include: a main hatchery building; outdoor broodstock and juvenile rearing tanks with volitional release channels; water aerator tower; and effluent drum filter, sludge-drying pit, and treatment systems. The hatchery building includes office space for up to five staff, a conference room and restrooms, water quality lab and research room, spawning, incubation and early rearing rooms, storage and workshop space, and public restrooms. Water recirculation/chiller systems will be installed in the research room and for egg incubation, and backup diesel-powered generators and diesel fuel storage tanks will be on the premises. The 100% working drawings are undergoing regulatory review by the State Architectural Committee and the State Fire Marshall. The full-scale SCARF should begin operations in late 2017, at which time the salmon being reared at the Interim Facility will be

integrated into the SCARF. The Interim Facility would remain in some capacity. Details of facilities for each life stage are provided below.

Figure 5.3: Conceptual design of the San Joaquin River Salmon Conservation and Research Facility in Friant California, adjacent to San Joaquin Fish Hatchery

5.4.2 Incubation facilities (SCARF)

The incubation room (15-ft x 34-ft) will be part of a common hatchery building containing an entrance from the outside and from the prep room, and an entrance into a fry production/early-rearing room. Each entrance will be fitted with a disinfection foot-bath and a hand sanitizing station. The room will provide low light conditions for incubation and will use multiple styles of incubators for egg development. Recirculation/chiller systems will be installed for egg incubation. These will be capable of 95% recirculation, which could reduce water supply temperatures by up to 15 °F if necessary. The incubation system will allow segregation of a total of 980 individual crosses.

- **16 Tray Vertical Flow Egg Incubators**
  - 31 units total, each with a 120,000 egg capacity (totaling a capacity of 3.72 million eggs)
  - Individual family lots will be segregated into three or four sections per tray using egg tray dividers, providing increased segregation for parental crosses, allowing up to 480 individual crosses
  - Opaque panels to provide dark conditions during incubation

- **Moist-Air/Fog Incubator**
  These may be used if deemed appropriate, but at a more limited production scale. Each unit would include the following:
  - 220 individual trays per unit to allow isolation and tracking of individual parental crosses, totaling the ability to hold 440 crosses simultaneously
  - Capacity for hatching 600,000 Chinook Salmon eggs
  - Ability to perform precise thermal marking of otoliths
  - Ability to control temperature and speed or slow egg development, or mimic in-river conditions
  - Provides a dark environment for incubation

- **Deep Matrix Full Immersion Incubator**
  These may also be used if deemed appropriate, although it would be at a much more limited production scale due to space limitations.
  - Hatches approximately 200,000 eggs
  - Provides a substrate for hatching to mimic in-river conditions by requiring "emergence"

5.4.3 Rearing facilities (SCARF)

Rearing facilities are organized into three main areas; fry production, smolt production, and captive rearing. The fry production facility is part of a larger common hatchery building that contains the following:

Hatchery Building

The hatchery building encompasses the fry production area, office area, and facilities described below:

- Fry Production Room: Fish will be reared from the unfed fry stage to approximately 3 grams each.
  - Culture tanks – 28 fiberglass rearing troughs
  - Trench drains (4)
  - Automatic 24 hour belt feeding system
  - Natural lighting and available artificial lighting
  - Space heaters
  - Roof ventilators
  - Work benches and storage cabinets
- Mud room / Lockers: gear lockers
- Freezer: built-in walk-in freezer
- Laboratory: built-in counters, HVAC and general lighting
- Research / Isolation: Recirculation/chiller units (4), built-in counters, HVAC and general lighting
- Office Space: manager's office and open office for four staff. HVAC and general lighting

- Conference/Break Room: sink and counter, HVAC and general lighting
- Storage room
- Restrooms: separate male and female restroom, HVAC and general lighting
- Covered Work Area: metal roof covering over the concrete slab, 24’ x 110’Utility Building: A utility (workshop/storage) building to provide the following:
- Dry feed storage: overhead doors
- Storage space and pump room

Exterior Hatchery Area

- Outdoor Smolt Production: four banks of culture tanks (three 16-ft tanks and one 30-ft tank in each bank), automatic feeders, netted or solid roof bird enclosure. Flow-through water system. Used for smolt production and yearling production.
- Captive Rearing: three banks of culture tanks (one 30-foot tank, three 16-foot tanks and two 8-ft tanks in each bank), automatic feeders, solid roof bird enclosure and possible water reuse system. Used for adult production from yearlings to adults.
- Volitional Release Channel: 18-inch wide, between fish culture tanks to be used for volitional release leading to either the San Joaquin River side-channel adjacent to the facility, or to a crowder box where the fish could be placed into a tank transport truck, in the event they need to be released to other reaches in the river.
- Ultraviolet water treatment will be used for fry production after exiting the aeration assembly.
- Effluent from hatchery building and bottom drains from fish culture tanks to be directed via gravity flow to micro-screen drum filters. Filtered water is directed through a series of effluent treatment ponds, then to a common discharge point on the river. Sludge from drum filters to be directed to drying pond for disposal. Existing settling ponds will be used for effluent treatment as required to minimize water quality impacts.

5.5 Satellite Incubation and Rearing Facility (SIRF)

The SIRF is a temporary satellite facility to the SCARF, located at the Reclamation maintenance facility immediately downstream of Friant Dam, 0.75 miles upstream of the Interim Facility and SCARF (Figure 1.1). The SIRF uses its own water supply line and allows for isolated incubation and the holding and/or quarantine of fish to all but eliminate the risk of disease transfer to SCARF broodstock.

Since 2012, the SIRF has been used for streamside spawning, egg incubation, and juvenile rearing of fall-run Chinook Salmon captured in the San Joaquin River. Beginning in 2016, the SIRF will be used to incubate spring-run eggs and rear juveniles from the FRH for translocation into the San Joaquin River. It is anticipated that as early as spring of 2018, the SIRF may also be used for the holding and spawning of adult spring-run returning to the river, and the incubation and rearing of their offspring.

5.5.1 Holding and Spawning Facilities (SIRF)

The SIRF includes four self-contained rearing units, each with five 6-ft diameter 500-gallon circular tanks (Figure 5.4). The systems are capable of operating on flow-through to 95% recirculation and include chillers and water filters (i.e., a biofilter and a rotary drum filter). These systems would be used to temporarily hold adult spring-run returning to the San Joaquin River until they are ready to be spawned.

5.5.2 Incubation Facilities (SIRF)

The incubation trailer at the SIRF includes two 7-tray vertical flow egg incubators and two Deep Matrix Incubators filled with either natural river substrate or artificial substrate (e.g., Bioballs®). Water supply can be flow-through or up to 95% recirculated water, and the trailer is equipped with a water chiller, filters (i.e., mechanical filter, fluidized bed filter, and UV sterilizer), and an aeration system. There is real-time monitoring of water temperature and dissolved oxygen, with an alarm system to notify staff if parameters are out of range. The capacity of the incubation trailer is approximately 140,000 juveniles per year.

5.5.3 Rearing Facilities (SIRF)

Rearing facilities are the same as would be used for adult holding. These include four self-contained rearing units, each with five 6-ft diameter 500-gallon circular tanks (Figure 5.5). The systems are capable of operating on flow-through to 95 % recirculation and include chillers and water filters. Capacity of the rearing tanks is approximately 220,000 juveniles per year.

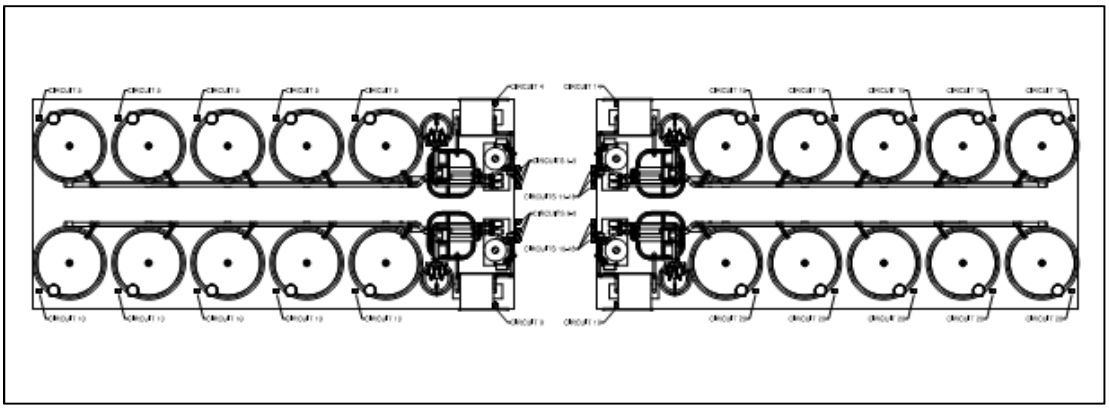

Figure 5.4: Rearing tanks and recirculation systems at the Satellite Incubation and Rearing Facility

5.6 Acclimation/release facilities

5.6.1 SCARF Smolt Production Volitional Release Channel

Smolt production facilities at the SCARF will consist of twelve 20-foot and four 30-foot diameter circular culture tanks. All tanks would have bottom drains to convey fish waste to the wastewater treatment system and side drains to permit volitional release of fish. A

series of concrete channels will be constructed and attached to the side drains of the tanks to provide drainage and volitional fish releases to the secondary channel of the San Joaquin River. Ventria (i.e., operable openings) on the side of the tanks would allow fish to voluntarily enter the release channel system during periods of fish outmigration. The volitional release channel would terminate at a concrete catch basin to be constructed in the secondary channel of the San Joaquin River from which outmigrating fish could enter the river. The volitional release channel will only be used when there is flow connectivity from the release point through the Restoration Area to allow outmigration of the released juveniles. Otherwise, juveniles will be collected at a crowder box along the VRC and loaded to a transport tank for transfer to a point within the Restoration Area where they could successfully outmigrate.

5.6.2 In-river Net Pens for Juvenile Acclimation/Release

Before release, all fish would be adipose fin-clipped and coded wire tagged. Juveniles may be placed in temporary holding pens for imprinting, acclimation, and juvenile growth before release into the San Joaquin River. Holding pens would consist of appropriately sized nets or aluminum mesh boxes suspended between pontoons and anchored to the bank or available structures by using rope or cable. Juveniles would be held at accepted densities for salmonids and fed daily using automated feeders. Release sites within the Restoration Area would be selected to provide appropriate water depth, velocity, temperature, substrate, and cover characteristics to promote juvenile growth and maximize survival. In the event of outmigration barriers or insufficient river flow, juveniles may be hauled to downstream locations suitable to allow outmigration to the ocean.

5.7 Describe operational difficulties or disasters that led to significant fish mortality

Water supply quantity and quality have been very reliable to the Interim Facility and adjacent SJH, which receive water from the same major supply line as the proposed SCARF. In the past 55 years, there was only one major interruption to water flow, which occurred in 1992 when a work crew accidentally ruptured the main line. Similarly, water quality from Millerton Lake has generally been very good, and mostly free from harmful pathogens. Temperature of water supplied to the SJH has historically been no higher than 60°F. However, with recent years of drought experienced by the State, water supplies have approached or exceeded 70°F during the months of September through November and into December.

Flooding occurred near the location of the SCARF in 1997, which caused the SJH raceways to become inundated with floodwater. At that time, many fish from the SJH escaped into the adjacent San Joaquin River. In the event of future flooding, it is possible that fish from both facilities will again be released to the river. Fish tanks will be designed to withstand full emersion during a flooding and tanks will be netted to prevent escape. CDFW has prepared an Emergency Action Plan that includes response to imminent flooding. Response is contingent upon prior notification by USBR that flood releases will occur.

5.8 Indicate available back-up systems, and risk aversion measures that will be applied, that minimize the likelihood for the take of listed natural fish that may result from equipment failure, water loss, flooding, disease transmission, or other events that could lead to injury or mortality

To address concerns about high water temperatures, the Interim Facility and SIRF may rely on recently installed water recirculation/chiller systems as described above. The 95% recirculation systems use 5% supply water coming into the system. If the supply is cut off for any reason, the main effluent drain could be closed and oxygen supplied artificially to the tanks until the water supply is restored. The chillers associated with the recirculation systems are able to lower water supply temperatures by up to 15°F during normal operation, as well as provide UV treatment to reduce or eliminate any potentially harmful pathogens. The systems rely on electrical power supply that runs water pumps and UV treatment systems and are therefore vulnerable to power outages. To address this concern, emergency backup generators have been installed that are capable of powering electricity for at least two days before refueling. The SIRF has similar recirculation, water quality, monitoring, and back-up power systems in place.

The SCARF fish culture system is designed to prevent fish loss due to system failure. Water for the fish culture system will be gravity fed, thereby reducing risk of interruption to flow by eliminating the use of electric pumps that are susceptible to failure by power outages. In addition, each tank will contain a water monitoring and alarm system that will alert staff of low dissolved oxygen levels, interruption to water flow, high or low water temperatures, or high or low water levels. The monitoring system will be integrated with a backup oxygen system that will trigger a solenoid for the supply of gaseous oxygen from compressed oxygen cylinders in the event of low oxygen conditions.

The SCARF was designed to be elevated above the 100-year flood plain. The hatchery building and rearing tanks will be built upon a 4-ft high elevated pad. The facility will be staffed with three fulltime personnel. The SCARF will be adjacent to the SJH housing and it is anticipated that personnel will be available to respond to emergencies, including flood alerts, and to improve security at the new hatchery. SCARF personnel will be trained on emergency procedures, conduct drills on response timing to alarms; and the development of a fish release plan.

SECTION 6 BROODSTOCK ORIGIN AND IDENTITY

Describe the origin and identity of broodstock used in the program, its ESA-listing status, annual collection goals, and relationship to wild fish of the same species/population.

This section describes the long-term strategy for sourcing broodstock for the Conservation Program and provides a phased approach to including each of the desired stocks into the reintroduced San Joaquin River population. For a more detailed review of potential broodstock and the broodstock identity decision, please see the Stock Selection Strategy: Spring-run Chinook Salmon (SJRRP 2010b).

6.1 Source

The Stock Selection Strategy (SJRRP 2010) recommends the founding population in the San Joaquin River consist of spring-run Chinook Salmon from Butte Creek, the Mill and Deer Creek Complex, and both wild and hatchery stocks from the Feather River. These source populations were chosen based on genetic signature, population status, and habitat similarities to the SJRRP Restoration Area. These evaluations and recommendations informed the National Environmental Policy Act (NEPA), California Environmental Quality Act (CEQA), FESA, and the CESA analyses for spring-run reintroduction under the SJRRP, which led to adoption of a multi-stock collection plan as the preferred alternative in the 10(j) Environmental Assessment for the experimental population designation. Under this alternative, collection of donor stocks would come, over time, from all of the identified source populations, including the potential for opportunistic collections of spring-run in other watersheds (e.g., Clear and Battle creeks).

In the interest of protecting source populations, the Conservation Program is implementing a phased approach to multi-stock collection. Collections would first occur first from larger more stable populations, and individuals from additional populations will be incorporated into broodstock as their populations recover and restoration projects on the San Joaquin River are completed. Between 2012 and 2017, broodstock would be collected solely from the FRH. Collections of individuals from Butte Creek and the San Joaquin River would begin in the spring of 2018, while FRH collections continued. Depending on population health and status, the Conservation Program would begin sourcing broodstock from Mill and/or Deer creeks, but this will not occur until 2023.

6.2 Supporting information

6.2.1 History and annual size

Please see Section 2 for information on run history and run size for the potential broodstock.

6.2.2 Past and proposed level of natural fish in broodstock

The Conservation Program will prioritize the collection of natural (non-hatchery) fish, but FRH fish may be utilized if non-hatchery fish are not available or collections are not permitted from wild populations. While the SCARF is under construction, the

Conservation Program will seek to annually collect enough juvenile fish and eggs to obtain a total 50-100 relatively unrelated females and 100-200 relatively unrelated males to breeding age. Between 2018 and 2022, the Conservation Program will include fish from at least two and up to three of the potential broodstock source populations. Beginning in 2023, the Conservation Program would like to add a fourth source population, natural origin fish from the Deer and Mill Creek Complex. Once the full-scale SCARF is in use, the Conservation Program will collect enough juvenile fish and eggs each year from three source populations to produce a total of 150-450 adult broodstock pairs. Returning naturalized adults from the San Joaquin River may be incorporated into the broodstock, although returns are not expected until 2018 or later.

The total number of broodstock collected from each source population over the course of the reintroduction will depend on the viability of those stocks and the effects of removal on the associated risk factors. While source population viability may limit the number of fish collected, collection goals are based on the number of fish necessary to capture the genetic diversity of the source stocks. Because all three potential source populations are distinct, they must be considered independently when setting collection goals. If large numbers of fish are available from all three source populations, broodstock collection could be undertaken at a higher rate to assist in meeting SJRRP escapement goals. All three populations should be used in roughly equal proportion as much as feasible; using one population at a much higher level than the others would overwhelm the genetic diversity in the other, smaller populations.

The benefits of protecting genetic diversity in Salmonid populations are well documented (Table 6.1). The total number of fish collected from each source population determines the effective population size of the founding population (Ne), which in turn determines the amount of genetic diversity from the source population that is initially represented in the new population. For salmon, if one assumes that N (adult census size) = N_e, N_e can be estimated as the number of breeders per year (N_b) summed over salmon's four year generation time (Waples 1990). While this assumption is generally not good, the Conservation Program can approximate the assumption by using broodstock composed of nearly equal proportions of males and females, with roughly equal family sizes. A four year generation time is appropriate here because, as noted in Section 2, the source populations for which data are available all have significant portions of the adult population returning at ages three and four. The assumption that $N = N_e$ depends on unrelated spawners, an equal sex ratio and equal family sizes, which can be approximated in a hatchery using factorial mating. Thus, for a hatchery that uses 50 adult fish per year ($N_b = 50$), generational N_e is approximately 200 fish, if hatchery conditions meet the assumptions.

Recommendations on the ideal number of fish to use for broodstock vary. Frankel and Soule (1981), Miller and Kapuscinski (2003), and Moyer et al. (2008) recommended 50 individual fish from each source population as the bare minimum. Kincaid (1983) recommended 50 breeding pairs, and Allendorf and Ryman (1987) recommended a minimum of 100 breeding pairs from each source population. These recommendations for the minimum number of fish all produce significantly less diversity in the broodstock than is found in the source population (Table 6.2). For example, if a hatchery uses 50 fish

per year for four years, the chance of losing a rare allele with a frequency of 0.5% in the source population is over 10%. Garza et al. (2008) examined 20 microsatellites in the Feather River spring-run population, and found 373 alleles for those microsatellites (Table 6.3). Of those 373 alleles, 55 (~15%) were present at a frequency of .005 or less, and a hatchery following the minimum collection numbers presented above would lose, on average, just over 7 alleles. More broadly, any effort to capture the genetic diversity of a source population inherently makes tradeoffs between capacity (and resilience of the source population to fish collection) and the genetic diversity represented in the broodstock population.

Table 6.1: Benefits of conserving genetic diversity in Salmonids (from Fraser et al. 2008)

Function of salmonid genetic diversity	References
Maximizes the potential for species to respond to environmental change	Utter (1981); Waples (1991, 1995); Ryman et al. (1995)
Protects the progenitors of future biodiversity (e.g., new species)	Bernatchez (1995); Taylor (1999); see also Bowen (1999)
Reduces the likelihood of extinction	Waples (1995); Dodson et al. (1998)
Long-term species persistence	Utter (1981); Waples (1991); Ryman et al. (1995); Taylor (1999)
Short-term population viability	Dodson et al. (1998)
Maintenance of natural evolutionary processes	Waples (1991, 1995); Dodson et al. (1998)
Protection of different habitats, and potentially ecosystem functioning	Waples (1991, 1995); Allendorf et al. (1997)
Maintenance of local adaptations	Waples (1991, 1995); Dodson et al. (1998)
Maintenance of ecosystem stability	Riddell (1993)
Permits humans to understand how salmonid biodiversity arises	Taylor (1999)
Development of proper restoration guidelines if some natural systems are conserved	Riddell (1993); Fraser and Bernatchez (2008)
Potential future resources for humans	Waples (1991); Fraser et al. (2006)
Potential future resources for aquaculture programs	O'Reilly and Doyle (2007)

Allele frequencies for very rare alleles are both extremely difficult to estimate accurately and are ephemeral, varying substantially every year and every generation. Moreover, even calculating the frequencies accurately at a single point in time requires very large sample sizes due to the rarity of the alleles. For example, an allele found only once in the Feather River population would have a frequency of 1/(276*2) = 0.0018, because the sample size for the Feather River was 276 fish and each fish has two alleles for each locus. The lowest calculable allelic frequencies for the other 3 source populations are higher, given their smaller sample sizes. Further, it is important to distinguish the genetic marker variation that is measured by relatively small sets of microsatellite and SNP markers from the quantitative genetic variation that is the actual material for natural selection and adaptation. Migration and mutation may introduce important genetic variation during the program period that would counteract the loss of diversity due to genetic drift/founder effects. In particular, outcrossing may provide combinations of alleles in the experimental population that are not found in the source populations. In the face of selective factors in the restored San Joaquin River, these novel combinations may

provide adaptive potential that is not adequately represented by measures such as heterozygosity and allelic richness of a small set of marker genes. Because the frequencies for very rare alleles cannot be accurately calculated, and because the frequencies of marker genes are only a proxy for the quantitative genetic variation, the goal N_e will have to be chosen largely based on the theoretical estimates in Table 6.2, with the aim of achieving as high an N_e in the hatchery as possible.

Larger broodstock populations will generally better capture genetic diversity in the source populations (Allendorf and Ryman 1987; Frankham et al. 2002), provided that there is minimal variance in family size/relatedness in the source population collections. Fraser et al. (2008) reviewed recommendations for the level of diversity that should be maintained in hatchery populations over time and found recommendations ranging from retention of 90% of genetic diversity (e.g. allelic richness, heterozygosity) over a 100-year period (Frankham et al. 2002) to a decrease in mean heterozygosity of 1% per generation (Franklin 1980, Frankel and Soule 1981). However, Fraser et al. (2008) concluded:

> "[T]here is currently no empirically or theoretically justifiable answer to the question 'how much genetic diversity is enough to conserve a species or population?' Additionally, a rate of loss of heterozygosity of 1% per generation might be acceptable in benign agricultural environments but has not been tested on captive reared salmonids or other fishes that will be released into the wild (Naish et al. 2008). In reality, the goal of any captive breeding program should be perhaps to conserve as much genetic diversity as possible [2008]."

Faced with this lack of concrete guidance, a breeding program should seek to capture a representative sample of the source population diversity, minimize founder events and the consequent loss of the natural populations' diversity through genetic drift, while also recognizing that natural selection and adaptation in the restored San Joaquin Rver may result in lower diversity due to the consequent variance in family size. Measures of marker genetic variation could be further affected by genetic hitchhiking effects. An N_b of 300 fish per year for 4 years, producing an N_e of 1200 fish, should capture the vast majority of the genetic diversity in a given source population. As seen in Table 6.3, an N_b of 300 fish has a less than 1% chance of not including alleles present at a frequency of only 0.002 in the source population and a less than 10% chance of not including alleles present at a frequency of 0.001 in the source population. An introduction using 300 fish per year for 4 years from each source population should produce a broodstock with marker genetic diversity very similar to the source populations, assuming a relatively unrelated broodstock, a 1:1 ratio of males to females, and similar family sizes. If the source populations are unable to support this level of extraction, a lower number of fish may be used, but the hatchery may need to continue importing natural fish from the source populations for a longer period (Moyer et al. 2009) to improve the odds that the variation in the source populations will be present in the experimental population. However, as naturalized fish begin to return and fish are outcrossed or outcross naturally, the frequencies of particular alleles will vary significantly from the source populations. Continued genetic monitoring can determine the degree to which the broodstock captures

the genetic diversity in the source population, and the extent to which returning adults reflect the diversity in the broodstock; the monitoring results should guide the Conservation Program's continuing broodstock collection.

Finally, taking a larger or smaller number of broodstock from one source population may reduce some of the benefits of using multiple sources, so broodstock should optimally be taken at the same level from all source populations. Taking a larger or smaller number from one population may reduce some of the benefits of using multiple sources for broodstock. If this is not possible because one of the three populations cannot support proposed collections, the SCARF may compensate by drawing smaller numbers of natural fish from that population for a longer period than from the other sources, which will increase the diversity captured from that population.

Table 6.2: Number of alleles found below 5 levels of low frequency in the source populations. Allele frequencies below .002 for Butte Creek and below .005 for Deer and Mill Creek cannot be calculated using available data. Based on data from Garza et al. (2008)

	Feather River	Butte Creek	Deer Creek	Mill Creek
Frequency of allele	373 total alleles	293 total alleles	296 total alleles	278 total alleles
Less than .005	55	32	NA	NA
Less than .004	42	20	NA	NA
Less than .003	34	0	NA	NA
Less than .002	2	NA	NA	NA
Less than .001	NA	NA	NA	NA

Table 6.3: Chance of not including an allele in the broodstock, given the size of the broodstock population and the alleles frequency in the source population.

	N_e	100	200	400	800	1200	1600	2000	2400
	N_b	25	50	100	200	300	400	500	600
Frequency of allele in population	0.01	13.40%	1.80%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%
	0.009	16.40%	2.69%	0.07%	0.00%	0.00%	0.00%	0.00%	0.00%
	0.008	20.06%	4.02%	0.16%	0.00%	0.00%	0.00%	0.00%	0.00%
	0.007	24.54%	6.02%	0.36%	0.00%	0.00%	0.00%	0.00%	0.00%
	0.006	30.01%	9.01%	0.81%	0.01%	0.00%	0.00%	0.00%	0.00%
	0.005	36.70%	13.47%	1.81%	0.03%	0.00%	0.00%	0.00%	0.00%
	0.004	44.86%	20.12%	4.05%	0.16%	0.01%	0.00%	0.00%	0.00%
	0.003	54.83%	30.07%	9.04%	0.82%	0.07%	0.01%	0.00%	0.00%
	0.002	67.01%	44.90%	20.16%	4.06%	0.82%	0.17%	0.03%	0.01%
	0.001	81.86%	67.02%	44.91%	20.17%	9.06%	4.07%	1.83%	0.82%

6.2.3 Genetic or ecological differences.

The potential source populations exhibit some genetic and ecological differences, and additional differences can be inferred based on their instream habitat use. Section 2 presents information on run timing and habitat preferences, whereas this section addresses genetics and temperature tolerances.

6.2.3.1 Genetic Differences

The potential source populations are genetically distinct, assuming that the Mill Creek and Deer Creek populations are treated as a single population for purposes of stock selection (Banks et al. 2000, Garza et al. 2008). While the Mill and Deer Creek populations are marginally genetically differentiated, it is not clear that the slight differences in observed allele frequencies are biologically significant and due to anything other than family structure. As such, Banks et al. (2000) and Garza et al. (2008) concluded that the two stocks should be treated as a single complex due to the high degree of gene flow and similar phenotypes. The degree of genetic differentiation found between the Feather River fall and spring-run fish is similarly slight; however, the phenotypic differences between the Feather River spring- and fall-runs warrant their treatment as two separate populations for reintroduction purposes.

Three studies have evaluated the relative genetic diversity of the three potential spring-run source populations. Banks et al. (2000) conducted a microsatellite study of the Mill and Deer Creek Complex and Butte Creek populations and found that the observed heterozygosity was essentially identical in the two populations (0.61 vs. 0.62). They found that the allelic diversity, as measured by the average number of alleles observed per locus, was about 6% higher in the Mill and Deer Creek Complex population than in the Butte Creek population (6.60 vs. 6.18, respectively), although the difference did not appear to be statistically significant.

Garza et al. (2008) supplied a second dataset, representing 20 microsatellite loci from Chinook Salmon collected from Mill Creek, Deer Creek, Butte Creek and Feather River stocks in 2002 and 2003. These data are discussed above in Section 6.2.3. To recap the salient results, the observed heterozygosities were 0.77, 0.77, 0.74 and 0.78 for Mill Creek, Deer Creek, Butte Creek and Feather River stocks, respectively. The mean allelic richness per locus of the Mill Creek, Deer Creek, Butte Creek and Feather River stocks were 11.09, 10.85, 9.76 and 11.25, respectively. The statistical significance of these differences was not reported, but all of the values appear to be relatively low and suggest a lack of diversity and the presence of past bottlenecks in these populations.

Finally, the third dataset consists of recent unpublished data from 169 single nucleotide polymorphism (SNP) loci developed by the Genetic Analysis of Pacific Salmonids (GAPS) consortium and by the Molecular Ecology and Genetic Analysis Team of the Southwest Fisheries Science Center (Garza unpublished). In this study, Deer and Mill creeks were considered as one population. Data were available for the Deer and Mill Creek Complex (N=71), Butte Creek (N=54) and Feather River (N=94) spring-run populations. The SNP dataset found the observed heterozygosity was 0.29, 0.26 and 0.31 in the Mill and Deer Creek Complex, Butte Creek and Feather River populations, respectively. The mean number of alleles was 1.91, 1.88 and 1.91 in the Mill and Deer Creek Complex, Butte Creek and Feather River populations, respectively. Again, the statistical significance of any differences in these means was not reported.

While the significance of the observed differences is not reported for these three studies, the measures of genetic diversity in all three of the datasets were the lowest for Butte

Creek, intermediate for Mill and Deer Creek Complex and the highest for Feather River spring-run fish. The biological significance of these data in terms of spring-run are unclear, given the known introgression of fall-run genes in the spring-run fish in the Feather River population. Tagging studies have found that some offspring from Feather River spring-run mating return as fall-run fish, and vice versa (CDFG 1998). The higher allele number and higher heterozygosity in the Feather River are likely due, at least in part, to this observed introgression. The higher diversity in the Mill and Deer Creek Complex is consistent with the small differentiation between those populations and the larger mean estimated census size in that combined population. Further, while the data do not allow strong conclusions about the relative risks of inbreeding depression in each population, all three populations have low genetic diversity and should not be used as a sole source for the reintroduction due to the high risk of inbreeding and reduced adaptive potential.

6.2.3.2 Temperature Tolerances

Appendix C provides instream temperature data from the source population watersheds (Figures C.1 and C.2) and the San Joaquin River Restoration Area (Figures C.3 through C.6) Figure C.6 presents modeled temperatures at varying distances from the dam under a Settlement hydrograph simulation for the period from 2000 to 2004,. Figure C.7. presents influent temperatures for 2001, 2008, and 2009 at the SJH, which uses the same water source as the Interim Facility and that will be used by the SCARF in the future.

Figure C.1 provides temperatures for the highest elevation locations in Butte, Deer, and Mill creeks for which consistent temperature data were available, and Figure C.2 provides temperatures for the lowest elevation locations in Butte, Deer, and Mill creeks for which consistent temperature data were available over the period of interest. Both figures include FRH water temperatures and temperatures from the bottom of the Low Flow Channel of the Feather River, where two-thirds of spring-run spawning takes place. Temperatures in the High Flow Channel of the Feather River are higher, up to 71-77°F, although most spring-run Chinook Salmon outmigrate from the Feather River as fry and do not experience those high temperatures. In contrast, many juveniles from Butte, Deer, and Mill creeks outmigrate as yearlings and are exposed to a wide range of water temperatures.

Water can be released from Oroville Dam through a multilevel outlet to provide appropriate water temperatures for the operation of the FRH and to protect downstream fisheries (NMFS 2009), which results in more consistent water temperatures for the Feather River than for the other populations. In the Low Flow Channel, peak temperatures range from 61°F upstream of the FRH to 69°F upstream of the Thermalito Afterbay Outlet (FERC 2007). Peak water temperatures in the High Flow Channel range from 71 to 77°F, and river cooling begins in late August, with minimum temperatures of 44 to 45°F reached by January or February.

The other three source streams all vary widely throughout the year, based on flow conditions and air temperatures. Generally, water temperatures in all three remain within roughly 5 degrees of one another (Figures C.1 and C.2), and at lower elevations, Butte

Creek is generally the warmest of the three.

Finally, as noted in the Stock Selection Strategy, disease outbreaks within the Butte Creek spring-run Chinook Salmon population have generally occurred during the summer holding period, ranging from a low in 2004 of 418 pre-spawn mortalities out of an estimated population of 10,639 to a high in 2003 of 11,231 pre-spawn mortalities out of an estimate population of 17,294 (Ward et al. 2007). In 2003, fish mortality was attributed to the high number of fish concentrated in limited holding pools with high water temperatures, and an outbreak of two diseases *Flavobacterium columnare* (Columnaris) and the protozoan *Ichthyophthirius multiphilis* (Ich) (Williams 2006). The mortalities during 2002 and 2003 coincided with significant daily average water temperatures above 19.5°C (67 °F). This population appears to experience strong ongoing selection for high water temperatures. Spring-running salmon in the Feather River that spend significant periods of time in the High Flow Channel may experience similar selection, as may the Deer and Mill Creek Complex populations.

6.2.4 Preferred Alternative and Reasons for Choosing

The TAC crafted recommendations to drive the stock selection process for the Conservation Program. The TAC recommended that the Conservation Program adopt a broodstock selection process aimed at identifying and using the source population(s) with the highest likelihood of establishing a self-sustaining naturally reproducing population in the San Joaquin River Restoration Area. The TAC developed seven criteria for considering the most appropriate source population(s) for reintroduction in the San Joaquin River (Meade 2007):

- The founding stock should be selected from currently existing stocks inhabiting the Central Valley to maximize the likely success of local adaptation to the San Joaquin River.

- The founding stock should have adequate genetic material (i.e., population abundance and genotypic/phenotypic diversity) to allow San Joaquin River specific pressures to eventually produce a locally adapted stock.

- Factors that should be considered when selecting the founding stock(s) include current trends in abundance of source spring-run Chinook Salmon populations (e.g., Butte Creek population), whether existing habitat conditions within a source watershed are fully used (e.g., are "surplus" fish available for relocation with minimal or potentially beneficial effects), logistic conditions affecting the ability to successfully collect and transport adults, eggs, or juveniles, and the genetic characteristics of the founding stock.

- A founding stock should be selected that has behavioral and life history characteristics most compatible with the anticipated conditions on the San Joaquin River.

- Wild stocks should be evaluated from various Central Valley rivers as a founding

stock with the goal of maximizing, to the extent possible, the genetic diversity of the founding stock to support the greatest degree of local adaptation to the San Joaquin River and to match the compatibility of life history characteristics with anticipated future environmental conditions.

Per the TAC Recommendations, the Genetics Subgroup of the FMWG developed the Stock Selection Strategy (SJRRP 2010b), which provides a detailed discussion of the stock selection process and the justification for the decision to pursue a multi-stock approach. Briefly, the Genetics Subgroup limited consideration of source populations to the largest three populations of spring-run Chinook Salmon in the Central Valley, the populations on Deer and Mill creeks, Butte Creek, and the Feather River. Other populations were considered and rejected as too small, too ephemeral, or not well characterized. The Genetics Subgroup focused on genetic considerations, current (census) population size, compatibility of life history characteristics to anticipated restored Restoration Area conditions, and availability of broodstock.

Genetic Considerations

Genetic considerations include effective population size (and risk of inbreeding), hatchery influence, and hybridization. As noted above, all three source populations have low genetic diversity, with minimal differences in diversity between the three populations. While the Feather River generally shows marginally higher diversity than the other two populations, many of the genetic markers used to study these populations are in linkage disequilibrium in the Feather River population, suggesting recent or ongoing hybridization with the fall-run salmon. This hybridization results in higher genetic diversity for the population. This higher diversity does not necessarily indicate a larger effective population size of pure spring-run fish. Using any single population would likely result in a reintroduced population with depauperate genetic diversity. No additional conclusions about which population should be used can be drawn based on their relative genetic diversity.

The Feather River has a strong hatchery influence. However, the Mill and Deer Creek Complex has no history of spring-run hatchery introductions, and the introductions of Feather River fish to Butte Creek does not appear to have had any appreciable genetic impact. Further, observed introgression between fall- and spring-run populations is only present in the Feather River population, and only the Feather River spring-run population is more genetically similar to fall-run populations than to other spring-run populations. Feather River fall-run fish may return during the spring-run, and some spring-run offspring return during the fall (J. Kindopp, pers. comm.). As noted in the Stock Selection Strategy, these factors have prompted the TAC to recommend against the use of the FRH stock or any other hatchery origin stock for use in reintroduction (Meade 2007). Nevertheless, the Genetic Sub-committee believes that several factors indicate that the Feather River should not be disqualified:

- Feather River stock may possess remnant alleles from the four presumably independent populations that once existed in the four Feather River tributaries above Oroville Dam.

- Lindley et al. (2004) indicated that of all 18 historic independent populations of spring-run Chinook Salmon in the Central Valley ESU, the historic environmental conditions in the Feather River most resembled historic conditions in the San Joaquin River.

- Presumed adaptations within the Feather River spring-running population to Oroville Dam (Bunn and Arthington 2002, Angilletta *et al*. 2008) could potentially benefit the San Joaquin River population, based on the Restoration Area being affected by Friant Dam

- Feather River spring-running fish will benefit from release into a location where they may be spatially distinct from fall-run fish.

- Feather River fish possess increased genetic diversity that, although likely a result of introgression with fall run fish, may nevertheless result in higher survival rates in a stochastic environment like the Restoration Area.

- Ease of accessing the Feather River stock in years of normal to high escapement.

Population Size

Population size data are reviewed in Section 3. Feather River and Butte Creek populations have been, on average, increasing during the last decade. Of the populations recommended in the Stock Selection Strategy (SJRRP 2010b), Butte Creek has the largest census size (GrandTab 2015). database. However, the Feather River population is the only population under active hatchery supplementation, and therefore taking fish from the Feather River population should have impacts that could be more easily mitigated through increased production at the FRH.Regardless of population trends, the collection of juvenile fish or eggs from the source populations to develop a broodstock should result in a *de minimus* impact on any one of the source populations. On average, 0.3% of eggs will survive to adulthood (Quinn 2005). Factoring in egg to adult mortality, the removal of the maximum number of juveniles or eggs discussed here, 2,820 individuals would not significantly affect the source population. For example, the proposed collection numbers within Butte Creek would represent just 0.01 – 5.3% of juveniles captured in the rotary screw trap and side diversion trap at the Parrot-Phelan Diversion Dam (based on Garman 2013, 2014, and 2015), and those trapped individuals represent only a small sub-set of the juvenile population .

Life History and Phenotypic Characteristics

Table 2.1 in Section 2 provides an overview of the life history characteristics of the three source populations. The extent to which these characteristics are caused by phenotypic plasticity driven by habitat characteristics in each source watershed as opposed genotypic characteristics of the population is unknown. Thus, drawing accurate conclusions about the populations' life histories in the restored San Joaquin River is not possible at this time. Nevertheless, potentially pertinent differences have been identified:

- Butte Creek spring-run fish experience selective pressures that may be similar to those of the restored upper San Joaquin River, including (1) low elevation of holding and spawning habitats, (2) highly regulated hydrology, (3) warmer water temperatures, and (4) high air temperatures during the summer months.

- Feather River fish have undergone selection to altered conditions below the Oroville Dam (Bunn and Arthington 2002, Angilleta et al. 2008) that may be similar to those within the Restoration. As a result, Feather River fish may exhibit similar life history strategies within the Restoration Area as is exhibited in the Feather River. Feather River fish possess increased genetic diversity that, although likely a result of introgression with fall run fish, may nevertheless give it increased life history flexibility that may allow it to achieve higher survival rates in a stochastic environment like the Restoration Area.

Preferred Alternative

After extensive consideration, the Genetic Subgroup members concurred that it would be nearly impossible to accurately predict the relative fitness of fish from the three potential spring-run source populations in the San Joaquin River Restoration Area. Even with additional data, unknown factors such as the restored conditions of the San Joaquin River, the straying rate of reintroduced fish, and the populations' ability to adapt to new conditions would prevent a confident selection of the best stock for reintroduction. After considering several alternatives discussed in the Stock Selection Strategies Document (SJRRP 2010b), the subgroup recommended reintroduction of spring-run Chinook Salmon from all three potential source populations: the Deer and Mill Creek Complex, Butte Creek, and Feather River as the preferred alternative.

A single stock introduction is likely to have a lower probability of success due to the low genetic diversity that can be captured and the limits on the number of fish that can be harvested for use in the Project. Moreover, the novel selective pressures placed on reintroduced fish in the upper San Joaquin River are likely to result in significant evolution in whatever stock or stocks are reintroduced, and introducing a population of fish with high genetic diversity must be a priority for success. The multiple stock reintroduction should be pursued following an adaptive management approach, with monitoring and evaluation used to evaluate the relative fitness and success of fish from the different stocks at various life stages following the reintroduction. The Genetics Subgroup noted several benefits and risks to this approach:

- Benefits:

    - Increased genetic diversity and reduction in inbreeding.
    - Increased program flexibility to accommodate changes in source population availability.
    - Availability of diverse reintroduction methods.
    - Availability of larger number of broodstock, speeding reintroduction.

- Risks:
    - Outbreeding depression
    - Lower fitness of Feather River population due to past hatchery selection
    - Monitoring independent success of each source population's establishment in the Restoration Area will require extensive monitoring and evaluation, including genetic analysis.

Further, use of the Feather River source population increases the risk of introgression with the fall-run fish due to past introgression in the FRH. As noted above, a portion of the Feather River spring-run progeny will return in the fall, which, left unchecked, could lead to increased mixing of the fall- and spring-run populations in the San Joaquin River. The FRH has adopted new practices to reduce hybridization between spring- and fall-running fish, and the Conservation Program will need to implement similar interventions to help preserve the spring-run phenotype. If the preferred alternative is selected as the final strategy, measures to reduce hybridization between the fall-run and spring-run fish should be a priority, and should consider the effectiveness of both use of an effective fish weir and adoption of long-term conservation hatchery practices that identify and exclude fall-run fish from spring-run matings.

6.3 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish that may occur as a result of broodstock selection practices

Several risks were identified above, and risk aversion measures will be adopted to address each of these risks:

- Selected broodstock(s) may not capture the genetic variation needed to promote a long-term naturally self-sustaining population in the Restoration Area.
    - Simultaneous multiple stock reintroduction will dramatically increase the diversity of the reintroduced population above the genetic diversity of any one of the introduced populations. Moreover, genetic monitoring of salmon collection and the broodstock will assist the Conservation Program in capturing as much genetic diversity as possible from the source populations. If collection efforts fail to capture a significant portion of the diversity in the source populations, additional years of collection (beyond the 4-8 years currently planned) may be required.
- An overlap in migration run-timing and lack of spatial separation between mature spring-run and fall-run Chinook Salmon in the Restoration Area may result in the genetic introgression of the two populations.
    - The use of the Feather River population exacerbates this risk. If the preferred alternative is selected as the final strategy, maintenance of the spring-run will require measures to reduce hybridization between the fall-run and spring-run fish,

including both use of an effective segregation protocol and adoption of hatchery practices that identify and exclude fall-run fish from spring-run matings at FRH.

- Removal of broodstock fishes from source population(s) may increase the risk of extirpation of the source population(s).
    - The NMFS, USFWS (as the permit holder) and CDFW will determine to what extent the Conservation Program is able to collect fish from the source populations. If determined that the risks to any of the source population(s) is too high, the Conservation Program may use only one or two source populations as broodstock, delay collections from one or more population, or collect fewer individuals from some populations. The increased risk to the source population(s) should be weighed against the benefits of representation and redundancy afforded by an additional spatially separated population of CV spring-run in the San Joaquin River. An additional population decreases the demographic and environmental risks inherent in an ESU consisting of one or a few small populations.
- Outbreeding depression may result from crossing distantly related populations of salmon. Monitoring independent success of each source population's establishment in the Restoration Area will require genetic analysis.
    - Genetic monitoring of the reintroduced population using parentage analysis should provide the Conservation Program with information on the frequency of outcrossed matings and their relative survival in the Restoration Area and whether to incorporate them into hatchery matings. If any cross type performs poorly, mating practices can be adjusted in the SCARF to reduce the proportion of these crosses. Over time, selection on the natural population should eliminate outbreeding depression as the reintroduced populations comingle.

SECTION 7 BROODSTOCK COLLECTION

Detailed information on Broodstock Collection is presented in the SJRRP's 10(a)1(A) permit application. The information below is summarized from that document.

7.1 Life-history stage to be collected (adults, eggs, or juveniles)

The life-history stage of broodstock collected will vary based on several factors, including the population status of each source population, potential impacts to the source population, the accessibility of each life-stage, disease status, stipulations of collection permits, and guidance from the adaptive management process. All fish or eggs entering SCARF will undergo an appropriate fish health inspection and, in general, no adults will be transferred to SCARF.

The life-history stage collected influences the degree of impact to the source population, and each life stage has its own associated risks and benefits (Table 7.1). Early life stages experience high mortality in the wild; therefore, those individuals have a lower probability of survival to reproduction and contributing to the population. It follows that removal of adults from a population has a greater per capita effect on the source population than removing eggs or juveniles. Juvenile collections have the benefit over eggs of allowing early selection pressure to occur naturally rather than under artificial conditions, thus reducing hatchery induced selection. However, egg collections have the benefit of reducing the risk of disease transfer to a facility since eggs are less likely to have contracted disease and can be more thoroughly disinfected than juveniles. Introduction of disease into a broodstock program can be highly problematic and affect the success of the program.

The Conservation Program will attempt to use multiple life stages to capture the desired genetic and phenotypic characteristics and to meet other specific objectives. Collection methods will be tested prior to use, evaluated for success, and refined over time. Genetic analysis will be used where needed in attempt to identify collection method biases in the relatedness of fish collected for broodstock and its effect on genetic diversity of the broodstock. Poor representation of genetic diversity will require changes to broodstock collection methods.

Hatchery personnel at the FRH will collect adults, from which eggs will be selected for the Conservation Program. Feather River Hatchery collections will include returning adults of both hatchery and natural origin. Beginning in 2018, adults may also be collected on the San Joaquin River for stream-side spawning or temporary holding at the Interim Facility and/or SIRF. Egg collections may also occur directly on the San Joaquin River through redd extraction. The Program does not anticipate collection of wild adults from the Butte Creek population due to the sensitivity of these populations and mortality concerns, although adults may be taken in salvage situations or if escapement greatly exceeds the carrying capacity of available holding, spawning, and rearing habitat.

Juvenile collections are planned to occur on Butte Creek and the San Joaquin River beginning in 2018, depending on the condition of those populations. Butte Creek juveniles will be collected using RSTs, while San Joaquin River collections will, where

permitted, use a combination of RSTs or weir traps, and emergence traps (Table 7.2).

Table 7.1: Influence of life-history stage on the risks and benefits of collecting hatchery broodstock

Relative Risks and Benefits Associated with Various Hatchery Broodstock Collection Methods	Redd Extraction	Juvenile Collection	Adult Collection
Risk of Mortality	Unknown	Moderate	High
Disease Transfer Risk	Low	Moderate	Moderate
Ease of Transport	High	Moderate	Low
Ability to control genetic diversity*	High	Moderate	Low
Risk of excessive relatedness	Low	Moderate	High
Hatchery-induced selection associated with early life-stage hatchery rearing	High	Low (High for FRH fish)	High
Ability to collect spatial diversity	High	Moderate (Low for FRH fish)	Low
Ability to control temporal diversity	High	Moderate	Low
Risk to source population	Unknown	Low	High

*Some designations are subjective and dependent on use of specific techniques. Designations assume that eggs are hatched and raised to provide broodstock, juveniles are grown to provide broodstock, and adults are mated and the eggs hatched and raised to provide broodstock.

Table 7.2: Collection methods planned and maximum collection methods by source populations

Population	Targeted Life Stage	Max Annual Collection[1]	Collection Methods
Feather River Hatchery[2]	Eggs or Juveniles	5,470	Hatchery Operations
San Joaquin River	Eggs, Juveniles, or Adults	2,980	Redd Extraction, Emergence Trap, Rotary Screw Trap, Fykes or Weirs, Seine, Dip nets
Butte Creek	Juveniles	2,910	Rotary Screw Trap

[1] Maximum numbers included in 10(a)1(A) permit application. Maximum collections from all source populations combined would be 5,400 eggs or juveniles per year, plus those required for pathology clearance (i.e, 70 per collection), based on SCARF capacity and Conservation Program needs.
[2] All broodstock collections prior to 2018 will occur from Feather River Hatchery.

7.2 Collection or sampling design

Collection methods will include eyed-egg collections through redd extraction, egg and juvenile collections from FRH, and juvenile collections through using screw traps or emergence traps, when appropriate. Adult collections and handling may also occur when by seining or fish trapping. Sampling design will occur as follows:

7.2.1 Redd Extraction

Some captive broodstock programs have insisted on redd extraction for broodstock collection due to better control of genetic variation and reduced risk of disease transfer (pers. comm. Barry Berejikian, NOAA Fisheries) which would have a detrimental effect on broodstock rearing programs. Many diseases are not transferred in the egg stage, and eggs can be more thoroughly disinfected than juveniles. Using individual redds provides a high likelihood of a single cross.

Redd extraction may be used on the San Joaquin River or where permits allow. Depending on the specific on-site conditions, either redd pumping or redd excavation may be used as the preferred extraction method, as described below. On-site decisions will be based on water clarity, water velocity, water depth, risk to non-target eggs and safety considerations of field staff.

Eggs would be collected approximately 20-30 days post-spawning, depending on water temperatures. Eggs are most resistant to disturbance after 200 accumulated temperature units (ATU's in °C), which occurs 20 days post-spawning at 10^{o} C. Eggs would be collected prior to 480 ATU's, which is when hatching can begin for Chinook eggs. Spawning surveys would be conducted roughly twice weekly during the spawning season and redds marked with the approximate date of spawning. Redds would be selected to provide spatial and temporal diversity by sampling multiple spawning locations during different times of the spawning season. Water temperatures will be monitored to assess the stage of egg development such that egg collection would occur during the stage of development to minimize egg mortality.

Eggs would be removed from each redd until the desired number reached (≤ 20 eggs). This equates to approximately < 0.5% of the eggs from an individual female, which should be sustainable as long as survival of the non-taken eggs can be maintained. Egg-to-fry survival rates in the Conservation Facility are anticipated to exceed 50%, with a target of 70% or greater. Egg to fry survival in naturally spawned eggs generally ranges between 25-50% (29% calculated for winter Chinook on average). Total eggs collected will depend on redd availability and permitting decisions by NMFS.

Following collection, eggs will be placed into coolers with equal volumes of eggs and river water. Ice will be placed in a separate compartment of the cooler such that it is in contact with the water but not with the eggs. The ideal temperature for transport is in the 5 – 10^{o} C range. Prior to entering the Conservation Facility, eggs and equipment will be disinfected with an iodophore at 100 parts per million (ppm) of free iodine for 30 minutes.

7.2.1.1 Redd Pumping

As described by Murdoch and Hopely (2005), eggs will be collected from redds using a small portable backpack mounted water pump (Figure 7.1) An aluminum probe is inserted into the redd. The probe is designed with an air intake, which

creates a Venturi effect that combines water and air. The mixture of air and water is used to float eggs to the surface. An aluminum frame basket covered with 3.2 mm wire mesh is on three sides and a 1.6 mm cloth net bag on the downstream side will be used to collect eggs. The basket will be placed over the portion of redd to be sampled. In an effort to minimize stress to the redd, hydraulic sampling will begin at the farthest most downstream point of the tail spill and progressed systematically upstream as necessary. This method ensures that disturbance to the redd is confined to the furthest downstream portion of the redd, decreasing the probability of impacts from personnel (i.e., stepping on egg pockets) or the sampling process (e.g., changing the hydraulics of the redd). Each redd will be sampled carefully until the first egg is collected and the developmental stage verified (i.e. eyed-egg stage). Eyed-eggs will be removed from the collection net by hand or with a small dip net and placed in small buckets. The eggs will be inventoried and buckets labeled with redd number and egg count. Buckets will then be placed in coolers on ice for transport to the Conservation Facility. Excess eggs will be re-injected into the redd using the hydraulic egg planter or carefully returned to the redd by hand.

Figure 7.1: Sample of Hydraulic Redd Pumping (From Venditti et al. 2002b)

7.2.1.2 Redd Excavation

This method will consist of carefully hand-digging into the tailspill of identified spring-run redds to obtain live fertilized eggs. The specific redds from which we will obtain eggs will be selected from areas of shallower water and gentle velocities to facilitate obtaining eggs without loss. Gravel will be carefully removed from the tailspill of the redd by hand until eggs are reached. The digging process will proceed slowly so that a clear view of the excavated area can be maintained throughout the process. Snorkel gear will be used to get a clear underwater view of the excavated area. A fine mesh dipnet will be used to retrieve the eggs. Eggs will be placed into a 5-gallon bucket of river water, maintained at or below the temperature of the river, as they are removed from the gravel. They will be counted as they are placed into the bucket until the desired number of eggs is reached (≤ 20 eggs). Once the eggs are obtained from the redd, gravel will be carefully replaced into the area from which it was removed until the pre-disturbance substrate contour is recreated.

7.2.2 Redd Emergence Traps

Once redds are detected, their location will be marked with a GPS unit and the date of detection will be recorded. Further, acoustic telemetry will be used to determine the female(s) associated with the redd, if possible. Daily water temperature data for each redd will be downloaded from the nearest California Data Exchange Center flow gauge station to estimate emergence timing through accumulated thermal units (ATUs; Beachum and Murray 1990). Emergence traps will be placed on each selected redd no more than two weeks prior to expected emergence to minimize the potential for the traps to influence sand deposition and hyporheic flow in the egg pocket.

The emergence trap will consist of nylon mesh covering a steel frame and a canvas skirt that will be buried straight down into the gravel to minimize lateral escapement of fish. Each emergence trap will be (approximately 2.4 m by 1.8 m) with a live-well at the narrower downstream end.

During installation, each emergence trap will be carried over to the selected redd and placed on top of the egg pocket(s). Subsequently, rebar will be installed around the frame and cinched down with washers and hose clamps to secure the trap to the riverbed. Caps will be installed on exposed rebar to minimize public safety hazards. Thereafter, the canvas skirt will be buried and the live-well will be attached to the narrow caudal end of the trap. Emergence traps will be checked and cleaned regularly (e.g., 2-4 times per week; daily during peak emergence) and emerged alevin or fry captured within the live-well of the trap will be counted, measured to the nearest millimeter fork length, identified by life-stage or level of development, assessed for physical abnormalities, and weighed. A subsample of the captured fish will be retained, transferred to a quarantine facility, and eventually incorporated into broodstock.

7.2.3 Feather River Hatchery Broodstock Collection

Spring-run Chinook broodstock collection protocols will be conducted according to methods described in the FRH HGMP (Cavallo et al. 2012, update in progress). Only fish entering the FRH between April 1 and June 30 and then reentering the FRH in September, as identified by Hallprint® tags, will be used for broodstock for the Conservation Facility. These may be crossed according to FRH protocols. Ovarian fluid samples from adults will be collected for analysis to determine presence of viruses and bacteria. After Fish Health Lab clearance, the preferred crosses can be segregated for the SJRRP. Selected broodstock eggs or juveniles will be transferred from FRH to the quarantine facility. Up to Seventy individuals will be sacrificed for pathology and then pending clearance, the remainder will be transferred to the Interim Facility/SCARF (Pathology Section 1.4). Individuals will only be collected that are in excess of what FRH needs to meet its production targets, so that SJRRP collections will not impact FRH production obligations.

7.2.4 Rotary Screw Traps, Fykes or Weirs

Rotary screw traps (RSTs) are the most common gear used to collect and monitor juvenile salmon abundance in tributaries in the California Central Valley. When placed properly and calibrated, RSTs provide reliable estimates of juvenile abundance. The RST consists of a funnel-shaped cone that is screened and suspended in the water column between floating pontoons. The cone rotates as water flows past the trap, guiding the fish moving downstream into a live box that is attached to the rear of the trap cone. The RSTs are usually installed at a fixed location and they can continuously sample for extended periods. Fish are confined to the live trap, which will be checked at least once daily to process fish and remove debris. When monitored at the appropriate time interval relative to the number of fish being collected, RSTs result in low mortality rates.

Juvenile spring-run salmon outmigration is monitored annually by RST on Butte Creek and the San Joaquin River. In some cases, capture locations may allow the capture of both fall- and spring-run Chinook Salmon. This is less of a concern on Butte Creek, where fall-run seldom spawn upstream of the sampling location. In these scenarios, larger yearling spring-run may be targeted on the San Joaquin River and/or Butte Creek, as they are most readily distinguished from fall-run Chinook. Collected fish will be genetically tested to verify spring-run origin.

On the San Joaquin River, fykes or weir-style traps may also be used for juvenile collection. Fish weirs are porous barriers built across streams to capture migrating fish in flowing waters and generally have much higher capture efficiency than RSTs. There are many different types of juvenile collection weirs and they can be constructed from a range of materials based on site conditions, but generally they function very similarly. Fykes or v-shaped weirs direct downstream migrating fish into a collection box. Similar to RSTs, these traps have very low mortality rates when checked and cleared of debris at least once daily.

7.2.5 Adult Capture

Adults returning to the San Joaquin River may be captured by fyke net, weir, dip net, or seine. A fyke net or picket weir may be used and multiple nets/weirs may be erected at each capture location, depending on site conditions. Fyke nets or weirs are placed in the river with wing walls extending towards each bank in a v-shaped pattern, designed to divert upstream migrating fish into a central collection net or box. Fyke nets and weirs should be checked daily and all fish removed. Dip nets may be used to capture stranded spring-run Chinook salmon found in connected irrigation canals, ditches, or areas of the San Joaquin River with very little flow. Salmon are collected by actively scooping the net underneath the fish and lifting the net from the water. Captured adult spring-run would either be tagged and released with access to suitable habitat to spawn naturally in the San Joaquin River, or they would be held, genetically tested, and artificially spawned at either the SIRF or, when the full-scale SCARF is operational, the current Interim Facility. If spawned artificially, the resulting juveniles may be

incorporated into the SCARF broodstock after receiving pathology clearance.

7.3 Identity

All broodstock will be genotyped before spawning by using single nucleotide polymorphism analysis or other appropriate genetic sampling method. Where fall- and spring-run Chinook Salmon juveniles coexist, larger juveniles will be presumed to be yearling spring-run, whose identity will be later verified by genotype analysis.

Feather River fish present a unique challenge due to their extensive introgression and the difficulty in assigning parentage to fall- or spring-run fish. All eggs or juveniles taken from the Feather River will be from parents who enter the hatchery in the spring, reenter in the fall and are of both hatchery and natural origin. Because the natural origin fish do not possess a coded wire tag to verify run identity, there is a small chance that they are offspring of fall-run parents. The level of risk associated with this scenario has been determined to be acceptable by the Conservation Program since escapement was verified to have occurred in the spring based on the presence of a Hallprint tag, and that the benefits associated with using fish of natural origin outweighs the risks associated with the small chance of using fish of fall-run origin.

Broodstock reared at the Conservation Facility also would be tagged with a PIT after reaching a minimum length of 55 mm. Sterilized tags would be injected into the peritoneum using an implant gun or syringe-style implanter. PIT tags would be used for monitoring individual fish throughout captivity. Prior to spawning, adult fish may be tagged intramuscularly with Petersen disc tags for easy visual identification (Harvey and Campbell 1989). The tag would consist of two plastic buttons which are held to the sides of the fish by a stainless steel pin passed through the muscle tissue beneath the dorsal fin. The discs would be colored or marked with letters or numbers. Adult fish would be anesthetized during all tagging activities using MS-222 or CO_2 or any other anesthetic that is approved for use on salmonids by the USFDA. The dosage of the anesthetics would be adjusted to avoid fish mortality.

All hatchery juveniles would be adipose fin clipped and coded wire tagged prior to release (Harvey and Campbell 1989). Coded wire tags are small (less than 1 mm) lengths of wire that are implanted into the snout of each juvenile using specialized tagging equipment. The tags (indicated by the removed adipose fin) would allow fish to be identified as belonging to a particular Conservation Program cohort when it is either captured as an adult in commercial or sport fisheries, or when it returns to the San Joaquin River to spawn and the carcass is recovered. Some adipose fin clips may be used for additional genetic analysis.

7.4 Proposed number to be collected

7.4.1 Program goal

Current collection allowances are described in the Program's Endangered Species Act Section 10(a)(1)(A) Permit for Direct Take of Listed Species for Scientific Research and Enhancement Purposes, which is valid through December 31, 2017.

Permit 14868 authorizes take of ESA-listed Central Valley spring-run Chinook Salmon from FRH during collection, transport and rearing of 560 FRH spring-run salmon eggs or juveniles during the first three years of the permit annually – and 2,760 eggs or juveniles in the fourth and fifth years, to establish broodstock in the Interim Facility and SCARF. In addition, the permit authorizes a low level of intentional mortality of 60 FRH surplus juvenile spring-run Chinook Salmon annually for pathogen analysis prior to transport to ensure that pathogens will not be transferred to either the Interim Facility or SCARF.

A new 10(a)(1)(A) permit application is currently under development and will request take of CV spring-run beyond 2017. When determining the number of broodstock to collect, the Program considers the viability and extinction risk of the source populations, as well as how collections would affect those factors. The goal of the Conservation Program is to collect sufficient eggs and juveniles to successfully re-establish a population of spring-run Chinook Salmon on the San Joaquin River.

The number of eggs or juveniles to collect annually is determined by permitting restrictions and the rearing capacity of facilities at the time of the collection. The target number for collection is described in the Program's annual Donor Stock Collection Plan. Additional considerations include the estimated survival rates based on previous results and production strategies from similar conservation programs. Egg to smolt survival rates in salmon hatcheries can be quite high, often averaging up to 80%. Between 1994-1998 smolt to adult survival rates at the Manchester Spring Chinook Broodstock Project averaged 71% for five consecutive brood years. During this period, adult survival increased over time resulting in an average of 85% during the final two years (McAuley et al. 1996).

The Conservation Program is being deployed in three phases, which allow for experimental rearing and preliminary reintroductions while full-scale SCARF is under construction. The three phases are: experimental production, interim production, and full-scale production. Interim Faclility operations are considered part of the interim production phase. As broodstock and production capacity increase, collections will be expanded beyond the current Feather River population, to additional source populations including Butte Creek and the San Joaquin River, and eventually Mill and Deer Creeks.

During the experimental phase, from October 2010 through October 2012, fall-run Chinook were used to test rearing systems and to fine tune conservation hatchery techniques. In year one of experimental production, 550 eyed-eggs were collected from Merced River Hatchery for rearing experimental captive broodstock. The fall-run broodstock were reared through adulthood and spawned, and their offspring were released to the San Joaquin River. This group provided a year-class of fish that preceded the rearing of spring-run Chinook, allowing the personnel practical experience with rearing captive Chinook Salmon broodstock.

October 2012 marked the beginning of the interim production phase and the beginning of spring-run Chinook collection and rearing for the Program. During

this period, collections were limited to 560 eggs per year from FRH.

During full-scale Conservation Facility production (beginning late fall, 2017), the Conservation Program aims to spawn a minimum of 75 pairs from each of the three source populations (i.e., FRH, SJR, and Butte Creek), and ideally 225 pairs from each of the three source populations, or a total of 150-450 spawning pairs (see Section 8 for details). A total of 900-5400 eggs/juveniles will be used to achieve this number. The actual number of fish per population per year will be limited by viability factors, such as annual escapement, but the duration of the Conservation Program's collections should provide enough fish to capture much of the diversity in the source populations and avoid founder effects, including excessive inbreeding or genetic bottlenecking.

7.4.2 Broodstock collection levels for the last twelve years (e.g. 1988-99), or for most recent years available

In the fall of 2012, 2013, and 2014, the Program collected a total of 560 eyed-eggs from FRH. In 2015, the Program collected 1,935 eyed-eggs from Feather River Hatchery in preparation for completion of the full-scale conservation Facility in fall of 2017. Between 2013 and 2015, an additional 80,000 eggs were annually collected at FRH, where they were hatched, reared to juveniles, and released to the San Joaquin River as smolts.

7.5 Disposition of hatchery-origin fish collected in surplus of broodstock needs

In order to produce adequate numbers of adult broodstock, an ample number of spring-run Chinook Salmon may be collected, which may result in surplus broodstock. Over the lifespan of the program, surplus fish will periodically be removed from the broodstock facility and preferably released to the San Joaquin River. Broodstock releases would depend on river conditions and suitability for spring-run Chinook Salmon. Surplus fish may be released for reintroduction, research purposes, or held in the Conservation Facility for other research purposes. Instream research goals will depend on the life stage at the time of release. Research fish will be monitored for false migration pathways, predation, spawning behavior, and other life history traits. In some instances, surplus fish may be and have been euthanized, depending on permit conditions.

7.6 Fish transportation and holding methods

Transportation and holding methods will vary depending on life stage and collection method. Eyed-eggs will be transported in a specialized Styrofoam container and kept cool and moist using ice (see Appendix D). Eyed-eggs will be disinfected with 10-minute bath treatment with 100 ppm of free iodine prior to entering any new facility. Transporting and disinfecting eyed-eggs just prior to hatching should be avoided.

Figure 7.2: Modified backpack and aerator for transporting live fish

If capturing salmon in remote locations, fish will be transported by backpack. Backpacks will be modified using heavy mil plastic bags or solid plastic containers and battery-powered aerators. At a staging location, fish will be transferred to an acceptable fish tank for transport (see Appendix B). The tank will be filled with stream water immediately prior to transport using a portable, screened pump. When necessary for isolating phenotypic characteristics (i.e. spawning location), individual groups of fish will be separated using small cages or similar devises suspended within the transport tank. The transport water will be oxygenated using compressed oxygen and impellor driven aerators. Dissolved oxygen levels will be monitored and maintained near saturation during transport. Transport water may be supplemented with sodium chloride to provide a physiologically isotonic concentration to minimize ionic disturbances. When possible, fish will be moved in and out of the transport truck using a water filled vessel (i.e. water to water transfer) and without netting to minimize stress and loss of slime. Transport times may be as long as 10 hours. Water will be tempered to 2°C of the facility receiving water before transferring fish.

7.7 Describe fish health maintenance and sanitation procedures applied

A biosecurity program will be instituted to (1) reduce the risk that pathogens will be introduced to the facility, (2) reduce the risk that pathogens will spread throughout the facility and (3) reduce conditions that can increase susceptibility to infection and disease. Overall fish health maintenance and sanitation procedures will include:

1. The water supplies will be treated with UV sterilization for egg incubation and where water is recirculated for fish production.

2. Transport tanks and equipment will be disinfected prior to use to prevent disease transmission. Similarly, all surgically related equipment (i.e., needles for egg harvest, and tissue collection utensils) used for broodstock spawning will be disinfected prior to use.

3. Feed will be stored and used according to manufacturer recommendations to avoid fish health problems related to mycotoxins and rancidity.

4. Captured juveniles brought to a quarantine facility (e.g., Interim Facility or SIRF) will be treated with at least an eight hour oxytetracycline bath @ 100 ppm followed by a three day course consisting of a one hour formalin drip at 1700

parts per million (or as prescribed by a veterinarian). During the quarantine period, the fish will be screened for the presence of specific pathogens, and they will be treated as directed by the pathologists. Following two-weeks of quarantine, the captured juveniles may be combined with other individuals from the same watershed group, or individually PIT tagged for identity if combined with other watershed groups. Fish will generally be quarantined for at least six weeks prior to transfer to SCARF.

5. Technology will be used to reduce human to fish contact to reduce stress and lower opportunity for disease transfer.

    a. Tank rotational water velocities to be maintained at speeds that allow self-cleaning to minimize need for brushing tanks.
    b. Use of automated feeders.
    c. Minimal traffic in fish rearing areas.
    d. Sufficient cover for shade and predator avoidance.
    e. Use open canals for moving fish to minimize handling.

6. All cleaning equipment and nets will be disinfected prior to use, and separate cleaning instruments are designated to each rearing tank.

7. Fish will be maintained under maximum densities of 0.15 lb/ft^3/in, and flushing rates will be maintained at a minimum of one turnover per hour to reduce stress and disease potential.

8. Feed will be carefully administered to avoid uneaten feed accumulating at the bottom of the rearing tanks.

9. Entryways will be minimized and a disinfectant foot bath will be deployed and maintained at each entryway.

10. Dead or moribund fish will be removed promptly from each rearing tank and sent to the Fish Health Lab for necropsy. Moribund fish will be humanely euthanized immediately after removal from rearing tank.

11. Fish will be monitored daily for behavior and physical abnormalities. Fish exhibiting abnormal behavior will be screened for pathogens. Sick fish will be promptly examined by the Fish Health Lab.

7.8 Disposition of carcasses

The Conservation Program will dispose of salmon carcasses in two ways. First, some carcasses arising from hatchery mortalities will be frozen and generally disposed of through the hatchery solid waste disposal system, which involves ultimate disposal at the municipal disposal facilities. Second, carcasses derived from mortalities that have undergone adequate depuration following chemical treatment may be used to provide nutrient loading in streams.

7.9 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the broodstock collection program

Techniques for egg, juvenile and adult collection, transportation methods and fish health maintenance procedures will be followed as described above and in this section and as prescribed in the 10(a)1(A) incidental take and enhancement of species permit that is to be issued by NMFS. Fishery techniques will be reviewed by the CFSG and NMFS prior to use by the Conservation Program. Newly approved techniques and procedures not described in this document will be detailed in the Annual Report. Juveniles and eggs from source populations will be collected and transported to one of the Conservation Program facilities using the following general guidelines (Carmichael et al. 2001):

1. Reduce the number of stressors
2. Reduce the severity of stressors
3. Minimize the duration of stressors
4. Minimize plasma ion disturbances
5. Minimize increases in metabolic rate

New methods will be tested within the Program using non-listed fall-run Chinook Salmon during the interim stage to determine stress and mortality rates associated with procedures. A quality control supervisor will be assigned during each egg and juvenile collection operation to supervise and document activities. Techniques will be modified appropriately if stressors are identified. Any technique observed to create undue stress on fish and eggs will be immediately aborted and reported to the quality control supervisor. During each fish and egg handling operation water quality will be monitored and dissolved oxygen levels will be maintain 80% saturation and water temperatures will not be allowed to exceed 70°F (21.1°C).

SECTION 8 MATING

8.1 Describe fish mating procedures that will be used, including those applied to meet performance indicators identified previously

Pollard and Flagg (2004) recommended the following operational standards for using broodstock propagation technology to recover populations of ESA-listed anadromous salmonids:

1. Spawn all available adults.
2. Retrieve all possible eggs from mature females.
3. Use spawning protocols that maximize the effective population size of hatchery-spawned fish:
    a. Factorial or (with greater numbers of parents) single-pair matings.
    b. Cryopreserved sperm (Benefits of using cryopreserved sperm should be weighed against potential for loss of viability, especially when the number of eggs is low. Additional straws from the same male may be used to counter low viability).
    c. Induced spawning with GnRHa implants or other methods.

The Conservation Program intends to follow the above guidelines with the exception of cryopreserving sperm for reasons described in Section 8.5.

The following mating protocol is from the Conservation Program's Standard Operating Procedure (SOP) which was used to spawn spring-run broodstock at the Interim Facility in 2015. The purpose of the SOP is to describe methods and techniques that will reduce negative impacts during spawning. The full spawning SOP is presented as Appendix E.

Procedures

8.1.1 Check for ripeness

All broodstock males and females will be examined weekly or biweekly (depending on temperatures and the number of fish that are close to spawning) during the spawning season to determine ripeness. All fish will be spawned when ripe. Ripeness for males is assessed by palpating the abdomen with an anterior to posterior motion in attempt to express milt. Expressed milt is placed on a glass slide and quickly viewed by microscope under 400-power magnification to assess motility. Approximately 10 µL of 0.09% saline solution is placed on the slide to activate the sperm. Sperm are generally active for only seconds after activation and when spawning occurs when air temperatures are elevated, the activation solution and microscope slide should be chilled to prevent reduced motility.

Female ripeness is assessed based on skin color, condition of the abdomen and vent, extent of ova development as assessed by ultrasound, and the status of ovulation. Females are considered ripe when the skin color has darkened, the vent/oviduct is protruded, the ova is hydrated, and finally, upon gentle palpitation, eggs are expressed from the vent, indicating that ovulation has occurred (i.e. eggs were released from the ovaries to the peritoneal cavity). Ova hydration is monitored using ultrasound and confirmed when the

ultrasound image has transitioned from a light color (hyperechoic) to a fully darkened color (hypoechoic or anechoic; See Figure 8.1). Fish are checked for ripeness once or twice per week during spawning.

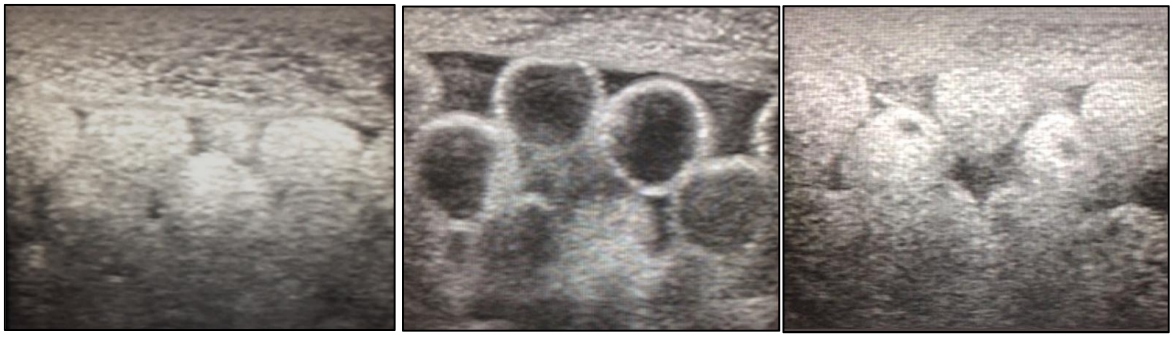

Figure 8.1. Ultrasound images of the progression of a maturing ova showing the increasing hydration of the ovum.

8.1.2 Sort fish

Sort males and females that are ready to spawn. If breeding matrix will be used, segregate and pair fish accordingly.

8.1.3 Kill and bleed female (and male if needed)

Use blunt force to the head, sever major artery in throat, sever artery in caudle peduncle, or overdose with MS-222.

8.1.4 Cut abdomen of female to expel eggs

Dry female and avoid blood and water in eggs. Expel eggs into a strainer to remove ovarian fluid sample for analysis of pathogens. Divide eggs into four equal sections and place eggs in four stainless steel or plastic pans. Add 0.09% saline solution to the pans and maintain saline solution with in 2°C of the rearing water temperature using a water bath if necessary.

8.1.5 Fertilize eggs

Squeeze milt from four males onto eggs for about 2-3 seconds to provide a sufficient volume of milt. Each of the four pans is to receive milt from a different male. Record parentage data and track crosses accordingly.

8.1.6 Wash eggs

Gently rinse eggs with 100 PPM buffered iodine to remove excess milt. Maintain iodine solution (i.e., Ovadine) with in 2°C of the rearing water temperature using a water bath if necessary.

8.1.7 Place eggs in 100 PPM Ovadine for 30 minutes for disinfection.

Place eggs in cheese cloth sac or similar device to keep eggs segregated while immersed in iodine.

8.1.8 Measure eggs

After disinfected, take 2 ounce egg count to determine the number of eggs per ounce. Measure the total volume of eggs from each quarter section of eggs using a graduated cylinder.

8.1.9 Incubate eggs

Place eggs into a vertical stack incubator egg tray that has been divided into four sections for an additional 1 ½ hours for water hardening. Record egg stack, tray, and tray section data and track crosses accordingly.

8.1.10 Egg Treatments

Treat each stack daily to reduce fungus levels by pouring 4 oz of Ovadine into the top tray. Do not disturb eggs until eyed.

8.2 Selection method

To allow the hatchery to identify close relatives and minimize mean kinship, all potential spawners will be genetically analyzed, generally prior to age-one. Thereafter, a relatedness estimate (e.g., Queller and Goodnight 1989; Blouin et al. 1996) will be developed for all pairs of broodstock fish (Kozfkay et al. 2008; Sturm et al. 2009) including potential breeding pairs to evaluate potential mates and same-sex pairings to detect full-siblings. Based on the molecular relatedness estimate, a spawning matrix will be constructed following Sturm et al. (2009). The spawning matrix will be organized by female, with all potential male mates listed below her in order of preference, based on their coefficient of relatedness (most desirable male is the least genetically-related).

All fish will be spawned when ripe. Actual pairings will attempt to involve the males highest on the list when the female is ripe, but no matings will involve fish related at the level of half-sibling or higher. Eggs from each female will be divided into four groups of roughly equal size and each will be fertilized by a different male. If fecundity is particularly low (i.e., < 1,000), eggs may be divided into fewer groups. A target ratio of 2 males for every female will increase genetic diversity across all broodstock mated. No male should be used with more than three females, assuming egg lots are split four ways, and no male should be used to fertilize more than the equivalent of 3/4 of a total egg lot. Eggs and fry from each cross should be kept separately until shortly after emergence, when the major period of in-hatchery mortality is passed, to allow for evaluation of the success of the cross.

If undertaken, matings between two different source populations will probably follow a different protocol because inbreeding is not a concern for these crosses. Fish will be selected for outcrossing based on their mean pairwise relatedness estimate compared to all other fish in their source population. The fish that are most highly related to the other fish in their populations are at the highest risk for causing inbreeding depression and are the least likely to have alleles otherwise not present within their populations. In the outcrossed fish protocol, females will be paired with four outgroup males randomly selected from the males chosen for outcrossing, and fertilization and rearing will proceed as described above for within population crosses.

Any returning naturalized adults in the San Joaquin River that are included in the broodstock should be evaluated using the same relatedness estimate approach identified above. Returning adults can be identified based on genetic or coded wire tags inserted before their initial release. Fish identified as strays may or may not be used as broodstock, depending on their origin. The natal origin for these fish can be determined based on otolith analysis (Barnett-Johnson et al. 2008) or genetic analysis. Eggs and/or juveniles resulting from these fish will be held separately until origin is determined. Use of these fish and of the returning adults generally will be governed by the recommendations of the GSG, the FMWG, and the HCT.

Table 8.1: Potential Mating Protocols, by Broodstock Scenarios

	Scenario 1 – One Broodstock (A)	Scenario 2 – Two Broodstock (A&B)	Scenario 3 – 3 Broodstock (A, B, &C)	Scenario 4 – One Broodstock (A) and Returning Adults (RA)[1]	Scenario 5 – Two Broodstock (A&B) and RA	Scenario 6 – Three Broodstock (A, B, C) & RA
Crosses[2]	1 Cross: AxA	3 Crosses: AxA, AxB, BxB	6 Crosses: AxA, AxB, AxC, BxB, BxC, CxC	2 Crosses: AxA, AxRA	5 Crosses: AxA, AxB, BxB, AxRA, BxRA	9 Crosses: AxA, AxB, AxC, AxRA, BxB, BxC, BxRA, CxC, CxRA
Division among crosses [3]	NA	Initially, 1/3 of A & B into each of the 3 crosses. May eventually vary based on returns from each cross.	Initially, 1/6 of A, B, & C into each of the crosses. May eventually vary based on returns from each cross.	Division will depend on the availability of RA. See notes below.	Division will depend on the availability of RA. See notes below.	Division will depend on the availability of RA. See notes below.
Mating Protocol[4]	Full or partial factorial mating	Partial factorial mating within each cross (1 female : 5 males)	Partial factorial mating within each cross (1:5)	Partial factorial mating within each cross (1:5)	Partial factorial mating within each cross (1:5)	Partial factorial mating within each cross (1:5)

[1] The RA stock will likely be the limiting factor in dividing broodstock among potential crosses. If they are not the limiting factor, spawners from available bloodstock should be divided evenly among the crosses in which they are involved (e.g. if A is used in 3 crosses, 1/3 of A should be used in each cross). Assuming RA availability is the limiting factor, broodstock division will depend on the sex of the RA spawners. RA females should be crossed with males from other available broodstock in a ratio of at least 1:4, although the ratio could be changed to 1:6 to allow an even contribution from each broodstock if more than one broodstock is available. The fraction of males used from each broodstock to cross with RA females should not exceed one over the number of crosses in which the broodstock is involved (e.g. if A is used in 3 crosses, a maximum of 1/3 of A males should be crossed with RA females.) RA males should be crossed with 5 or 6 females, depending on how many broodstock are available, and the fraction of females used from each broodstock to cross with RA males should not exceed one over the number of crosses in which the broodstock is involved (e.g. if A is used in 3 crosses, a maximum of 1/3 of A females should be crossed with RA males.). Assuming the RA spawners are the limiting factor, the excess broodstock from other sources should be evenly divided among the remaining crosses.

[2] Crosses between spring-run populations may be undertaken if hatchery capacity, broodstock availability, spawn timing, and other factors permit and if recommended by the Hatchery and Monitoring Technical Team.

[3] Fish with the highest mean relatedness within each broodstock population should be used for the crosses between broodstock populations.

[4] Individuals will be paired based on a spawning matrix.

8.3 Males

Some hatcheries faced with low male fertility use an approach where eggs are fertilized with a second male's milt (referred to as backup males) to ensure fertilization. Initially, backup males will not be used at the SCARF to avoid overrepresentation of some males due to advantages in sperm competition (Miller and Kapuscinski 2003, Campton 2004). Backup males may be required if infertility levels significantly reduce production below expected levels.

At the Interim Facility, the Conservation Program experienced high levels of precocious male maturation in both yearlings (age-1) and Jacks (age-2). In 2012, 84% of the experimental fall-run male Chinook Salmon matured as Jacks. In 2013, 33% of the spring-run males matured as yearlings. Fortunately, the SJRRP was able to reduce yearling maturation to 3% and Jacking to 7% of the male broodstock population during 2015 by managing growth rates during sensitive maturation decision periods. Because increased precocity in this program and others (Larsen et al. 2013), has been shown to be the result of hatchery practices, fish will most likely not pass the trait on to future generations. Therefore, the Conservation Program will allow contribution from precocious males when necessary to meet production goals. In general, Jacks will be used in a maximum of 20% of crosses to ensure representation of alternative life history strategies. Jack usage levels will be governed by the recommendations of the GSG, FMWG, and HCT, and will attempt to represent contributions of Jacks to reproduction at a rate similar to those of the source populations.

8.4 Fertilization

Fertilization will follow the protocols in Table 8.1. In order to maximize the hatchery effective population size, the targeted sex ratios (male:female) will be approximately 2:1. If high rates of infertility occur among males, backup males may be used. Except as noted above, gametes will not be pooled in order to allow the monitoring of pairwise breeding success and to avoid overrepresentation of some males due to sperm competition (Miller and Kapuscinski 2003, Campton 2004).

8.5 Cryopreserved gametes

Cryopreserved gametes may be used if there is an excess of males or to accommodate males maturing before females are available. Cryopreservation increases the pool of potential mating partners for each female and can increase effective population size and ensure that there are sufficient unrelated male gametes for use future generations.

8.6 Use of Ovulation Stimulating Hormones (Description of GnRH implant [Ovaplant] Usage and Evaluation)

Gonadotropin-releasing hormone (GnRH) may be used to stimulate ova release and sperm development. Ovaplant is the trade name of GnRH that is manufactured by Syndel International, Inc. and is used and described by CDFW Warm Springs Hatchery Coho Recovery Program in Geyserville, CA (White 2010, Unpublished Report).

A notice of claimed investigational exemption (FDA Form 3458) will be submitted to the Federal Drug Administration (FDA) for use of Ovaplant. All packages containing Ovaplant

cartridges will be labeled in accordance with Title 21 of the Code of Federal Regulations, Part 511.1B.

Ovaplant will be administered to broodstock during the course of ripeness sort activities occurring on a weekly or bi-weekly basis. Ovaplant would be administered to female broodstock to induce spawning only if they were deemed unlikely to complete final maturation. Generally, the female broodstock treated with Ovaplant may show signs of final maturation (e.g., coloration changes, abdominal softness, protrusion of the vent), but do not show signs of completing the final maturation process (egg hydration, ovulation). A portable ultrasound unit will be used to assist with monitoring gonadal development and sex identification. Ovaplant will be administered to male broodstock if needed to enhance milt production, facilitate milt extraction, and ensure adequate milt volume during spawning.

After receiving an implant, fish will be returned to their holding tank and tested 5-7 days later for ovulation or milt production. The date of the implant injection will be recorded for treated fish and the date of the first observed gamete release will be recorded for both treated and untreated fish. Implants will be administered as whole pellets, and will be delivered in a non-sterile fashion using a RalGun Pellet Injector, supplied by Syndel International, Inc. The site of the injection will be posterior to the dorsal fin, in the dorsal sinus or surrounding intramuscular tissue.\

On the day of spawning, total fecundity will be estimated for each female by determining the number of eggs in a 2 ounce sample. These data allow for a calculation of an ovulation rate for both treated and untreated females. Milt will be collected from males to be spawned with each female. Sperm motility will be examined at 40X magnification for each male selected for spawning following a subjective rating system (1-4):

1: 75-100% of sperm cells moving
2: 50-74% of sperm cells moving
3: 25-49% of sperm cells moving
4: 0-24% of sperm cells moving

After fertilization, egg survival to the eyed stage will be estimated by removing all dead eggs, and estimating the average and total weight of the remaining live eggs.

8.7 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the mating scheme

The mating protocols identified above seek to minimize the likelihood for adverse genetic or ecological effects to listed natural fish due to hatchery operations. The Conservation Program will use a combined broodstock and adult spawning approach described above to minimize both adverse genetic and ecological impacts to natural fish. Ideally, the Conservation Program would not change the genetic characteristics of the source population and would produce offspring for release that display the full range of genetic diversity found in the source population. However, hatchery operations carry genetic risks via inbreeding depression, domestication selection, and loss of genetic diversity through genetic drift. In general, the success in capturing and maintaining the source population's genetic diversity depends in part on adequate collection of broodstock fish and proper mating, respectively.

Genetic diversity decreases through genetic drift, which increases with decreasing effective population size. Factorial matings with all available adults to produce families of approximately equal size will maximize the effective population size (Fiumera et al. 2005, Frankham et al. 2000) and minimize loss of genetic diversity to random drift. While a full factorial scheme is most effective in increasing the effective population size, full factorial schemes can be prohibitively expensive in terms of time and labor. The use of partial factorial schemes as described above yields comparable effective population size with significantly less time and labor (Dupont-Nivet et al. 2006, Busack and Knudsen 2007). In general, there will likely be minimal gains in effective population size are made from increasing fish numbers in partial 1:4 factorial designs relative to 1:10 designs or a full factorial design given that the fish will be in the SCARF for only one generation (Busack and Knudsen 2007). Family sizes may be affected by differential fertilization or differential survival in the SCARF. If a small number of families have significantly higher survival, some individuals from those families may be withheld from broodstock use and instead used for the research identified in Section 12.

Inbreeding depression will be addressed directly by avoiding sibling breeding (Woodworth et al. 2002). Further, the Conservation Program will likely avoid inbreeding even when parentage is not known based on mating fish following allele-sharing relatedness estimates (Kozfkay et al. 2008). Cut-offs for related measures will be established once the broodstock has been genetically evaluated.

Outbreeding depression is also a risk. Even if fish from different source populations are not crossed in the hatchery, using multiple broodstock sources provides a high probability that natural outcrossing will occur in the reintroduced San Joaquin River population. Salmon, like most other vertebrates, use mate choice mechanisms to evaluate mates and modulate between inbreeding and outbreeding. Genetic evaluation of the frequency of such matings, and the subsequent performance of their offspring, may be used to guide crossing strategies in the SCARF. If there are clear indications of inbreeding depression in the broodstock, then experimental crosses between fish from different source populations can be incorporated into mating practices, since the risk of outbreeding depression from such crosses will be counterbalanced by the reduced risks from inbreeding. Experimental crosses would allow researchers to gather data on the performance of outbred crosses prior to release to the wild. The decision to cross broodstock from different source populations will be made on an annual basis by the GSG and FMWG.

Finally, domestication selection is reduced through the use of conservation hatchery practices described in Section 3 and by keeping the broodstock in the SCARF for only one generation.

The protocols presented in this section will be adaptively managed based on the results of monitoring and evaluation as described in Section 1.9 and Section 12. By implementing adaptive management, we will increase the likelihood in maximizing genetic diversity similar to that expressed in the source populations, increasing effective population size, and minimizing risk.

SECTION 9 INCUBATION AND REARING

Specify any management *goals* (e.g., "egg to smolt survival") that the hatchery is currently operating under for the hatchery stock in the appropriate sections below. Provide data on the success of meeting the desired hatchery goals.

9.1 Incubation:

9.1.1 Number of eggs taken and survival rates to eye-up and/or ponding

The number of eggs taken for the Program will increase over time, particularly when production is transferred from the Interim Facility to the SCARF. Current production targets are listed in Table 9.1 and reflect estimated production capacities of facilities rather than the carrying capacity of the San Joaquin River. The Conservation Program targets spawning between of 150-450 females annually at the SCARF beginning in 2018, resulting in collection range between 375,000-1,125,000 eggs, up to the maximum recommendations in Section 8. The number ultimately spawned in the SCARF will be controlled by NMFS permits and the ongoing adaptive management process.

The Interim Facility has developed data for egg survival based on its experimental production of 2010 brood year fall-run Chinook Salmon and the first generation of spring-run broodstock which were spawned in 2015. Juvenile survival of offspring produced at the facility has progressively improved over time and is expected to continue improve once construction is complete at the SCARF and the facilities are fully staffed.

The target survival from spawn to hatch is that experienced at FRH, which has been 85% in recent years (Cavallo et al. 2009). However, the Tucannon River spring-run Chinook Salmon program reported a seven-year average (2000-2006) for egg to smolt survival of 72.8% from the conventional hatchery program, but egg to smolt survival rates were only 37.6% in their captive broodstock program (Gallinat et al. 2009). Pollard and Flagg (2004) reported that egg-to-smolt survival rates for captive rearing programs are commonly greater that 75% and smolt to adult survival often exceed 50%.

The Conservation Program spawned the first broodstock at the Interim Facility in November 2012 as part of an experimental captive rearing study, in which ten precocious age-2 females were spawned to help refine spawning protocols and techniques. A spawning matrix was developed using genetic relatedness data provided by the UC Davis Genomic Variation Lab to ensure mating of least related individuals. Gamete development was monitored using ultrasonography. Spawning occurred during November 14-21, 2012, and corresponded to the peak of spawning at the Merced River Fish Facility and the peak of redd construction observed on the Merced River. This suggests that spawn timing was not significantly altered by captive rearing.

The precocious females were particularly small for spawning, averaging 680g, and therefore fecundity was particularly low (1,066 eggs per female), as body size of female salmon has been found to be correlated with fecundity (Kaufman et al. 2009). Egg size

Table 9.1: Schedule and Numbers of Juvenile Releases, Numbers of Collected Brood Stock Eggs Necessary to Achieve Commitments

Brood Year of Collected Donor Stock	Offspring Release Year	Expected Number of Juveniles Released	Number of Adults Needed for Production[1]	Estimated Female Fecundity (eggs/female)	Estimated Survival from Juvenile to Adult	Estimated Survival from Egg to Juvenile	Number of Eggs Needed To Collect as Brood Stock to Produce Necessary Number of Adults
2012	2016	120,000	240 (60 females)	2,500	0.8	0.8	375 (plus 60 for Pathology) = **435**
2013	2017	151,875	304 (76 females)	2,500	0.8	0.8	475 (plus 60 for Pathology) = **535**
2014	2018	200,000	400 (100 females)	2,500	0.8	0.8	625 (plus 60 for Pathology) = **685**
2015	2019	600,000	1200 (300 females)	2,500	0.8	0.8	1,875 (plus 60 for Pathology) = **1,935**
2016	2020	700,000	1400 (350 females)	2,500	0.8	0.8	2,188 (plus 60 for Pathology) = **2,248**
2017	2021	960,000	1,920 (480 females)	2,500	0.8	0.8	3,000 (plus 60 for Pathology) = **3,060**[2]

[1] Assumes 2:1 male to female ratio crosses to increase genetic diversity, and the uncertainty of sex of collected individuals but also assumes 50:50 chance of selected eggs being male or female.

[2] NMFS 10(a)1(A) Permit 14868 allows a maximum of 2760 eggs to be collected, so the number of eggs necessary for collection to produce the number of adults would need to be increased in the permit renewal, or the maximum number of eggs would be collected, but the 960,000 juveniles may not be produced for release.

was also small, averaging 185 eggs per fluid ounce. Comparatively, fecundity from wild CV fall-run Chinook Salmon typically averages 5,000 eggs with an egg size between 80-110 eggs per fluid once. Fertility and early survival of eggs was relatively high. Egg survival to the eyed-stage averaged 87%; however, survival was low during hatch and through swim-up. Many of the sac fry died while emerging from shells, resulting in a 28% survival to swim-up. The low survival likely reflected the small egg size and lower nutritional status of the embryos. Low egg survival to the eyed from age-2 female Chinook has been reported from wild Chinook Salmon returning to the Merced River Fish Facility, albeit higher than observed in this study.

During the fall of 2013, the same year-class of fall-run Chinook were spawned at age-3. Approximately 187,500 eggs were produced and survival to the eyed-stage was approximately 81%. Because of a larger body mass (average weight 1,987g), fecundity was higher at 2500 eggs per fish and egg size was 127 eggs per ounce (Table 9.2). However, egg to emergence was approximately 50%. The lower survival rate was attributed to the higher water temperatures that occurred during spawning, reaching 62 °F (16.7°), which accelerated fungus growth which reduced survival. Also, a high number of fry never successfully transferred to hatchery feed and as a result became emaciated and died. The high water temperatures were due to the ongoing regional drought, and, in response, the Conservation Program installed water chilling and water recirculation equipment to incubators and rearing tanks.

Spawning again occurred in the fall of 2015 with the first mature pairs of spring-run at the Interim Facility. Data from the spawn is summarized in Table 9.3. The Interim Facility entered the spawning season with an inventory of 100 females and 106 males and anticipated that the Program would be able to achieve its goal of spawning 60 females to produce approximately 120,000 juveniles. This was based on the data from the experimental fall-run Chinook where 90% of the females matured in year-3. However, only 51% of the spring-run females matured, which resulted in only 43 spawned females and a total of approximately 80,400 eggs. This may reflect the considerable variability observed in the age composition of adults returning to Feather River Hatchery (Table 9.4). The 80,400 eggs resulted in a survival to the eyed-stage of 77% and a survival from spawn to emergence of 63%. This was despite the ongoing drought conditions which resulted in influent water temperature reaching 67°F. Water recirculation equipment was used to successfully reduce temperatures to between 55-58°F.

Other differences were identified between the fall- and spring-run broodstock reared at the Interim Facility. The fecundity of the BY 2012 spring-run Chinook (1,953) was less than the BY 2010 fall-run Chinook (2,435), likely because of the lower body weight of the BY 2012 (1,654 g) compared to the BY 2010 fall-run Chinook broodstock (1,987 g). However, the eggs of the BY 2012 (123 eggs/ounce) were equivalent in size to the eggs from the BY 2010 (127 eggs/ounce) (Table 9.2). In the fall of 2016, the Interim Facility will spawn the first age-4 adults, and it is anticipated that average body weight will increase and, as a result, fecundity and egg survival will continue to improve.

Table 9.2: Comparison of spawning data from spawns that occurred in 2012, 2013, and 2015 at the Interim Facility

	BY 2010 age-2 Fall-run females	BY 2010 age-3 Fall-run females	BY 2012 age-3 Spring-run females
Average fecundity	1,066	2,435	1,937
Egg size (eggs/oz)	185	127	123
Survival to the eyed stage	87%	81%	79%
Survival from spawn to emergence	28%	50%	63%

Table 9.3: Summary of the spring-run Chinook Salmon spawn at the Interim Facility in the fall of 2015

Total Eggs Spawned	80,435
Total Eggs to eyed stage	61,833
Total Survival to Emergence	50,507
Percent Survival to eyed stage	77%
Percent Survival from Eyed to Emergence	82%
Percent Survival Spawn to Emergence	63%
Average Weight per Female (grams)	1,692
Average Length per Female (mm)	487
Average Fecundity	1,953
Egg Size (eggs per Ounce)	109
Egg Size 2015 FRH Spring-run Chinook (eggs/ounce)	106
Total Number of Females Spawned	43
Total Number of Males Spawned	65
Number of BY 2012 Males Spawned	56
Number of BY 2013 Males Spawned	10
Male to Female Ratio during Spawning	1.51
Percent 2013 BY Males of Total Males Spawned	15.4%
Average Number of Spawns per Male	3
Target Minimum Relatedness Value between Matings	-0.10
Average Relatedness Value between Matings (SD ±0.07)	-0.13
Highest/Lowest Relatedness Value between Matings	-0.01/-0.34

Table 9.4: Age composition at FRH based upon recovery of coded wire tags and the proportion of fish tagged in each brood year

Percent by Age of Spawning Run to Returning to Hatchery				
Year	Age2	Age 3	Age4	Age 5
2000	10.4	48.0	41.5	0.01
2001	3.1	70.3	26.3	0.03
2002	4.9	48.8	45.5	0.05
2003	5.9	17.7	76.0	0.04
2004	30.2	49.7	16.9	3.3

9.1.2 Cause for, and disposition of surplus egg takes

At the first indication that the SCARF may exceed egg take limits, NMFS will be notified via email and letter. The CFSG will discuss the possible alternatives and make a recommendation to NMFS regarding disposition of any excess eggs, fingerlings, or smolts beyond the current production goals. Surplus fish will be removed and preferably released to the San Joaquin River, depending on river conditions and suitability for spring-run Chinook Salmon, for reintroduction and research purposes, or held in the hatchery for other research purposes. Research may include temperature tolerance testing, with some mortality. Instream research will depend on the life stage at release; fish may be monitored for false migration pathways, predation, spawning behavior, and other life history traits.

9.1.3 Loading densities applied during incubation

The SCARF primarily intends to use vertical flow incubators (Marisource® – Fife, WA), however, deep matrix incubators and moist air or fog incubators (ARED – Wrangell, AK) may be used if determined appropriate. Each vertical flow incubator at the Interim Facility consists of 12 trays per stack, and will be operated at the manufacturer recommended flow rate of 3-6 GMP, depending on the loading density. Loading densities will not exceed 8,000 eggs per tray for green eggs and 10,000 eggs per tray for eyed-eggs. Individual family lots will be segregated into three or four sections per egg tray using segregation dividers. Opaque side panels will be added to the incubators to produce a darkened environment for incubation.

Deep matrix incubators are hatch boxes that simulate natural conditions by providing a substrate (plastic rings or gravel) where eggs hatch. The unit is a single pass flow through system and will be operated at the manufacture's recommended flow rate. Each unit has a recommended loading capacity of 200,000 salmon eggs.

Moist air incubation produces a fine mist for incubation to inhibit fungal growth and allow for accurate temperature control. Each incubator has 220 individual1.2-liter trays that each holds 2,700 eggs, with a total capacity of 600,000 eggs. The units recirculate 40 gallons of filtered water with 5 gallons of water, replaced daily. Filtration consists of 1 and 50 micron particle filters, a 10 micron carbon filter and ultraviolet sterilization. The

moist air units incubate green eggs through the eyed stage in a dark environment, after which the eggs are transferred to deep matrix or vertical tray incubators for hatching.

9.1.4 Incubation conditions

All egg incubation will occur in darkened conditions. The vertical tray incubators will use ambient water temperatures when temperatures are 55 °F (12.8 °C) or less. A water recirculation and chilling system will be used when temperatures exceed 55 °F. The system will consist of recirculation pump, micro-screen drum filter, UV sterilizer, fluidized bed sand filter, bubble wash bead filter, and a gas balancing column. The system will be continually monitored for dissolved oxygen, temperature, and flow. If conditions drop below acceptable levels, an audible alarm will be triggered and an automated dialing system will contact on-call staff and apprise them of the situation. Also, the system allows staff to call in by phone to receive information on current conditions.

Moist air incubators allow temperature control. Hatching temperatures will be based on the objectives of the Conservation Program and may include mimicking river temperatures, slowing or speeding development, or utilizing temperature to produce thermal marks on otoliths. Dissolved oxygen levels will be maintained near saturation. Eggs will be monitored twice daily, and dead eggs will be removed. Siltation is not anticipated to be a problem because of the water supply; the reservoir allows sediments to settle out before reaching the hatchery intake.

Egg incubation is anticipated to be similar to that found at the Feather River Hatchery, where spring-run Chinook Salmon green eggs develop into eyed eggs from 490-550 Daily Temperature Units (DTUs), averaging 513 DTUs. Eggs at FRH are typically well eyed at 513 DTUs, which is when they are usually addled (Cavallo et al. 2009).

9.1.5 Ponding

At the Interim Facility, hatchlings in the vertical tray incubators will be transferred into a 3- or 6-ft diameter circular fiberglass holding tank or small rectangular tanks for initial feeding, and monitored for early mortality. Hatchlings in deep matrix incubators (if used) will volitionally swim from the units into a circular fiberglass holding tank. After approximately 2-4 weeks, family groups will be combined in larger circular holding tanks (6-, 16- or 20-ft diameter).

At the SCARF, hatchlings in the vertical tray incubators will be transferred into 3-ft wide x 14-ft long rectangular fiberglass holding tanks for initial feeding, and monitored for early mortality. Hatchlings in deep matrix incubators (if used) will volitionally swim from the units into the rectangular holding tank. After 2-4 weeks, family groups will be combined in larger circular holding tanks (20-ft diameter).

9.1.6 Fish health maintenance and monitoring

Eyed eggs that are introduced to the SCARF will be disinfected with 10-minute bath treatment containing 100 ppm of free iodine. If necessary, eggs will be treated for fungus control with 120-180 ml of iodine per vertical incubator stack daily. At FRH, health inspection data for infectious hematopoietic necrosis virus (IHNV) and the bacteria *Renibacterium solmoninarum* [the causative agent for Bacterial Kidney Disease (BKD)] is collected from ovarian fluid of returning adult females annually during spawning (Cavallo et al. 2009). When eggs are properly disinfected, horizontal transfer of disease from IHNV infectious parents to juveniles can be prevented. As a preventative measure, eggs will be sourced from batches where testing of these pathogens is negative. Any adult females taken from other sources will be given the same analysis. All eggs that originate from IHNV or BKD positive parents will be discarded.

Fish health will be monitored by CDFW Fish Health Laboratory personnel. Diagnostic procedures for pathogen detection will follow American Fisheries Society professional standards as described in the American Fisheries Society Bluebook (AFS-FHS 2007). If disease is identified, appropriate treatments will be prescribed by a CDFW Fish Pathologist and follow-up examinations will be performed as necessary.

9.1.7 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish during incubation.

Eggs will be incubated using the same source water as the existing trout production hatchery, which has been successfully used for hatching trout and salmon eggs for over 50 years and has been shown to be free of highly virulent pathogens. Because the water originates from the end of a large reservoir (Lake Millerton), siltation has not been problematic. The Interim Facility will use the same non-filtered water. For precautionary measures, the SCARF will incorporate both solids filtration (microscreen drum filters) and UV sterilization during incubation and hatching. A water recirculation and chilling system will be used if temperatures exceed 55 °F. The water conditions will be continually monitored for dissolved oxygen, temperature, and flow. When condition drop below acceptable levels, an audible alarm will be triggered and an automated dialing system will alert on-call staff of the situation. Also, the monitoring system allows staff to call in by phone to receive information on current conditions.

9.2 Rearing

9.2.1 Provide survival rate data (*average program performance*) by hatchery life stage (fry to fingerling; fingerling to smolt) for the most recent twelve years

Information on survival rates varies considerably in the literature. Survival rates at the Idaho Department of Fish and Wildlife's Lyons Ferry Hatchery of captive reared Tucannon River spring-run Chinook Salmon from age 1 to age 5 varied from 3.2 to 16.9% (Gallinat et al., 2009). However, the same program observed significantly lower survival from the offspring of captive reared adults compared to the offspring of naturally reared and conventional hatchery reared adults. The Conservation Program anticipates

survival to be similar what is reported by Pollard and Flagg (2004), that egg-to-smolt survival rates for captive rearing programs are commonly greater that 75% and smolt to adult survival often exceed 50 percent.

During the fall of 2013, the BY 2010 of experimental fall-run Chinook Salmon were spawned at age-3. Egg to smolt survival was approximately 44%, lower than expected possibly attributed to the high water temperatures during spawning, which reached 62°F (16.7°). Some fry never successfully transferred to hatchery feed and, as a result, became emaciated and died. Currently, the BY 2015 Spring-run Chinook are pre-smolt and the survival rate is estimated to be 61%. In the fall of 2016, the Conservation Program will spawn the first age-4 adults, which are expected to have higher average body weight, fecundity, and egg survival.

9.2.2 Density and loading criteria (goals and actual levels).

During captivity, tank flushing rates will be no less than one turnover per hour and the maximum allowable density index will be 0.15 $lb/ft^3/in$, similar to that proposed by Banks (1994) and Ewing and Ewing (1995) for spring-run Chinook Salmon.

9.2.3 Fish rearing conditions

Dissolved oxygen levels will be maintained between 80-100% saturation and will not be allowed to drop below 70% saturation. Studies indicate the benefits of high dissolved oxygen levels in fish culture (Westers 2001). Both total suspended solids and carbon dioxide levels will be maintained at or below 10 mg/L (Piper et al. 1982, Timmons and Ebeling 2007). Human-fish contact will be minimized and culture tanks will be cleaned no more than twice per week, unless required by sanitary conditions.

The facility currently uses primarily circular rearing tanks, which have been shown to have several advantages over plug flow raceway designs and are the design of choice for many salmon captive rearing programs. The benefits of circular tanks include the following:

- The ability to adjust water velocities to target optimal swimming speeds for salmonids which has been shown in improve growth rates, feed efficiency, oxygen utilization, improved swimming performance and stamina and reduced aggression;
- The ability to self-clean, allowing improved water quality and minimized human to fish contact;
- Improve waste management characteristics;
- The ability to efficiently and evenly add supplemental oxygen; and
- Well adapted for water recirculation if needed.

Influent water temperatures historically have ranged between 45- 55°F at the existing trout hatchery. Some temperature control is possible by the adjustment of mixing valves associated with two water supply lines from the dam which draw water from two reservoir depths (high and low). During the summer months, water is drawn closer to the

base of the dam to supply cooler water. However, due to the ongoing regional drought the the past four years, water temperatures became a significant issue at the site. During the late-summer/fall period of 2014, temperatures began to exceed 60°F and it was determined water chillers were needed to protect the broodstock.

In early September 2014, the Department installed a single-pass 50-ton water chiller and two backup diesel generators. Within five days of installation, water temperatures dropped from 64° F to 60° F. The chiller remained in operation through mid-December, when influent water temperatures again to dropped below 60° F. By the end of December, temperatures fell below 56° F. The chiller unit proved to be effective in controlling water temperatures and reducing mortality under the conditions experienced at the Interim Facility. Because the drought continued into the following year, new water recirculation equipment was purchased and installed to reduce water temperatures. The equipment includes features that chills and aerates the water, filters and removes solids, removes CO_2 and ammonia, and disinfects pathogens. The equipment also includes a monitoring and alarm system which monitored water flow, temperature, and dissolved oxygen and was equipped with both an audible alarm and phone alert system. The equipment is also protected by a backup generator in the event of a power outage.

Installation of the new water recirculation equipment began during the summer of 2015 and was completed in February 2016. The equipment was successful in maintaining broodstock throughout the 2015 spawning season and will continue to be used to rear the broodstock on a limited water supply until the full-scale SCARF is completed.

9.2.4 Indicate fish growth information (*average program performance*), including length, weight, and condition factor data collected during rearing, if available

Preventing early maturation in broodstock has been an ongoing priority at the Interim Facility. Captive broodstock programs that rear Chinook Salmon often experience early sexual maturation of males. These “precocious” fish may be reduced or totally eliminated from breeding programs in order to avoid over-representing the trait in offspring; however, early maturing individuals may possess important genotypes or phenotypes that may prove beneficial under natural conditions.

Several factors are reported to trigger early maturation in Chinook Salmon including genetics, emergence timing (Larsen et al. 2013), photoperiod (Berrill et al. 2003), energy stores (Shearer et al. 2006) and size and/or growth rate at specific times of year (Larsen et al. 2004). The physiological decision to initiate maturation is reported to occur 8-12 months prior to spawning, and for yearlings, the decision is reported to occur shortly after emergence (Shearer et al. 2006). Reducing growth rates by restricting the amount of feed between September and January has been shown to lower the incidence of early male maturation (Larsen et al. 2013).

Central Valley Chinook Salmon apparently possess two “decision windows” that influence early maturation (i.e., prior to age-three) (Figure 9.1). The first decision window occurs shortly after swim-up and influences maturation the following September

at age-one. For this program, that initial decision window is believed to occur while the fish are in quarantine at Silverado Fisheries Base, prior to being transferred to the Interim Facility. The second decision window is reported to begin at age-one in September and lasts through January and influences maturation at age-2, when the males (in California) are referred to as “jacks”. However, our program has found that decision window has continued but decreasing influence on maturation into March.

The broodstock program has adopted a strategy to reduce early maturation by reducing growth rates during the first two maturation decision windows. For the first decision window, growth rates are reduced by lowering water temperatures and reducing feed rations (see section 9.2.6 for more detail). At Silverado Fisheries Base, temperatures are lowered to near 50° F during egg incubation and emergence (October - November) by using mechanical chiller units. To further reduce growth rates, fry are fed a reduced ration within two to three weeks of emergence, after they have successfully begun to ingest hatchery feed. The strategy for reducing precocity during the second decision window (the following September - March), has been to only reduce the feed ration. To implement this feeding strategy, juveniles are tissue-sampled and PIT tagged once they arrive at the Interim Facility and are 55 mm (fork length) or longer. Tissue samples are then used for both molecular-based sex identification and genotyping. Data for individual fish is then entered in a Microsoft Access database for recording the following parameters; PIT tag number, fish ID, length, weight, sex, tissue sample ID and condition factor.

Once the sex has been determined, typically by July or August, juveniles are separated by sex just prior to the onset of the second maturation decision window (i.e. September through March). Sexes are held in separate tanks when broodstock are 10 to19 months old during which time the males are placed on a restricted diet (i.e. 25% AGR) in effort to maintain a condition factor close to 1.0. Thereafter, the sexes are combined and fed a normal ration. Annual growth data for each brood year is listed Table 9.5. The table shows that initially, broodstock were reared at high growth rates in effort to match weights of wild salmon at the time of spawning. This approach ultimately resulted in high precocity rates. Over time, growth rates were decreased, particularly with males during September through March, in effort to reduce precocity. Moving forward, the program will attempt to maintain low levels of early maturation, but will continue to investigate techniques for maximizing body weights at the time of spawning in effort to improve egg quality and increase fecundity.

Table 9.5: Annual growth data for BY 2010 experimental fall-run broodstock and BY 2012-2014 spring-run broodstock. The table includes mid-winter growth data during the maturation decision window where condition factors appear to strongly influence early maturation at age-two.

	Brood Year	Weight		Length		Condition Factor		Precocious (%)	
		Male	Female	Male	Female	Male	Female	Male	Female
Yearling Data	2010	139	121	215	208	1.36	1.32	15	0
	2012	57	68	169	179	1.16	1.19	32	0
	2013	49	72	158	173	1.24	1.37	7	0
	2014	43	41	151	149	1.24	1.22	2	0
Maturation Decision for Age-2	2010	178	202	242	248	1.24	1.31	NA	NA
	2012	62.3	212	185	253	0.97	1.29	NA	NA
	2013	63	156	180	224	1.07	1.34	NA	NA
	2014	78	219	189	246	1.11	1.44	NA	NA
Age-2 Data	2010	365	541	302	338	1.31	1.36	84	11
	2012	297	340	396	554	1.45	1.38	22	0
	2013	421	670	306	355	1.43	1.47	13	0
Age-3 Data	2010	1,574	1,897	459	479	1.56	1.64	NA	NA
	2012	1,283	1,356	432	447	1.47	1.43	NA	NA

9.2.5 Indicate monthly fish growth rate and energy reserve data (*average program performance*), if available

Broodstock growth rates are modulated by the Program in effort to minimize precocity (see section 9.2.4 above and Figure 9.1 below). The Program's strategy essentially decreases energy reserves from male broodstock during the first two years to prevent early maturation (particularly from September through March). Female broodstock, which appear to be less sensitive to early maturation, are produced to maintain high energy reserves in effort to maintain high egg quality and high fecundity. Figure 9.1 shows how reducing male growth rates during the maturation decision windows results in lower precocity and further shows that much of the weight can be regained by increasing growth rates outside of the maturation decision window. Growth during smolt production will be modulated to meet Conservation Program goals for release size and release timing to avoid possible impacts to the wild population.

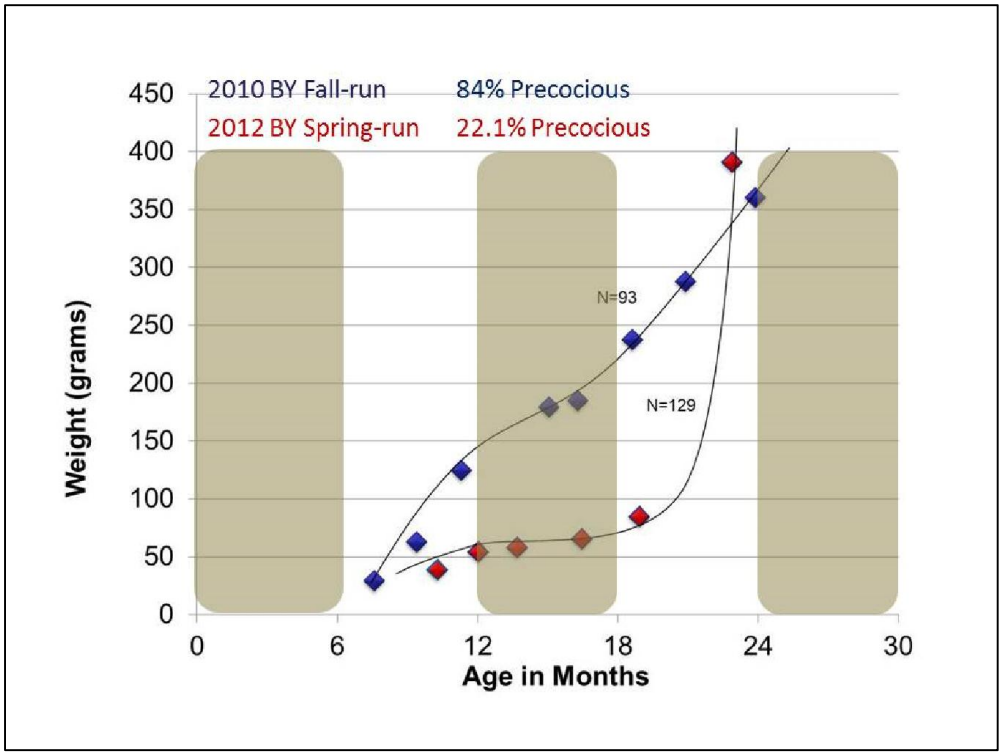

Figure 9.1 Comparison of the average weight of male 2010 BY fall-run and 2012 BY spring-run, showing the maturation "decision windows" in tan

9.2.6 Indicate food type used, daily application schedule, feeding rate range (e.g. % B.W./day and lbs/gpm inflow), and estimates of total food conversion efficiency during rearing (average program performance)

The Conservation Program will use high quality slow sinking salmon feed from a reputable fish feed manufacturer. A portion of the diet will also include frozen krill to help stimulate feed intake. Automated feeders will be used and feeding regimes and timing will attempt to mimic natural conditions, particularly for the smolt production program. The feed rate will be determined using a Microsoft Excel based program, GROW, developed for the Oregon Department of Fish and Wildlife. The program calculates the feed ration based on species, water temperature, body weight, feed conversion, and desired Allowable Growth Rate (AGR). The goal is to achieve and maintain a consistent condition factor ($K = (10^N W)/L^3$; where N = 5, W = weight in grams, and L = fork length in millimeters) during this period amongst changing water temperatures and associated metabolic requirements. Actual feed conversion ratios are calculated regularly and input into the program for accuracy. Maintaining a condition factor near 1.0 during the decision window appears to be adequate for reducing early maturation. To attain the targeted condition factor, males are offered a quarter ration (i.e., 25% of AGR) for a given weight and temperature during the maturation decision window. Females, which appear less sensitive to precocious maturation, are generally fed a full ration (i.e., 100 - 160% AGR).

9.2.7 Fish health monitoring, disease treatment, and sanitation procedures

All SCARF fish will be monitored by CDFW pathologists and certified prior to release. Treatment methods prescribed by fish pathologists for disease outbreaks and treatment protocols will be carried out by hatchery staff. Depending on the cause of an outbreak, treatment methods may vary. However, chemical treatments for external pathogens may include the use of salt, potassium permanganate, formalin or hydrogen peroxide as allowed by the hatchery discharge permit. Bacterial infections may warrant the use of oxytetracycline, florfenicol or other approved antibiotic. All treatment will follow veterinary guidance and will be used and monitored according to wastewater discharge requirements and regulations set forth by the U.S. Food and Drug Administration.

Sanitation procedures include:

- All cleaning equipment, lab equipment, transport tanks and nets will be disinfected in iodine-based disinfectant prior to use and separate cleaning instruments will be kept for each culture tank.
- Routine pathology health assessments will be carried out to maintain the health of all hatchery stocks. Fish will be monitored daily for behavior and physical abnormalities. Fish exhibiting abnormal behavior will be screened for pathogens. Sick fish will be promptly examined by the California Department of Fish and Game State Fish Health Lab.
- Feeding practices will be continuously monitored to avoid uneaten feed at the bottom of the rearing tanks and feed will be stored according to manufacturer recommendations to avoid fish health problems related to mycotoxins and rancidity, and feed will be used within the time recommended by the manufacturer.
- Water flushing rate will be maintained at a minimum of one turnover per hour and rotational water velocities will be elevated daily to improve water quality and tank sanitation.
- Sidewall viewing windows will be installed on all large tanks for increased fish health and tank sanitation monitoring.
- Dead or dying fish will be removed promptly from each rearing tank and necropsied. Dying fish will be humanely euthanized immediately after removal from rearing tank.

9.2.8 Smolt development indices (e.g. gill ATPase activity), if applicable

Smoltification timing will be monitored between the different groups within the SCARF to identify differences associated with origin. Indices used may include gill ATPase, skin reflectance, condition factor, scale loss and behavior.

9.2.9 Indicate the use of "natural" rearing methods as applied in the program

Section 3 of this HGMP provides a conceptual framework for conservation hatcheries that includes using methods for natural rearing. The methods to be employed include the following:

- Provide matrix substrates and darkened environments for egg incubation and alevin development.
- Promote development of body camouflage coloration in juvenile fish by creating more natural environments in hatchery rearing vessels, for example, overhead cover, and in-stream structures and substrates.
- Condition young fish to orient to the bottom rather than the surface of the rearing vessel by using appropriately positioned feed delivery systems.
- Exercise young fish by altering water-flow velocities in rearing vessels to enhance their ability to escape predators.

The use of natural rearing methods is a relatively new phenomenon, as no true conservation hatcheries were in existence prior to 1999 (Flagg and Nash 1999). The Conservation Program will institute the techniques that provide the most promise for increasing the reproductive fitness of fish for the Program, as developed and evaluated during rearing trials with fall-run Chinook Salmon. Any proposed natural rearing techniques will be reviewed by the CFSG and submitted to NMFS for approval prior to use on spring-run Chinook. Natural rearing techniques to be evaluated include provision of matrix substrates and darkened environments for proper egg and alevin development, use of overhead cover and in-stream structures and substrates to promote body camouflage coloration in juvenile fish, use feeding systems positions to supply food from the bottom of the rearing vessel, and periodic alteration of water-flow velocities to exercise young fish.

9.2.10 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish under propagation

After natural salmon are re-established in the San Joaquin River, consideration will be given to the size of hatchery fish at time of release and timing of release to minimize the risk of predation and competition with the natural fish. For precautionary measures, the SCARF will incorporate both solids filtration (sand filters) and UV sterilization and micro drum screen filters during incubation and hatching. The Conservation Program will strive to mimic natural rearing conditions in order to avoid, as much as possible, hatchery induced selection. Therefore, efforts will be made to incubate within a substrate (i.e. deep matrix) and in dark conditions. See additional details in Section 3.

SECTION 10 RELEASE

Describe fish release levels, and release practices applied through the hatchery program

10.1 Proposed fish release levels

The proposed fish release levels will be based on: (1) the success of the Conservation Program, (2) quantities of fish from the source populations and (3) the success of the captive rearing program. The projected releases in Table 10.1 reflect the anticipated production level of the Interim Facility and up to the maximum production capabilities for which the SCARF was designed. The actual carrying capacity of the river system is currently under investigation and will be based on available rearing, holding, and spawning habitat. However, channel improvement and habitat enhancement projects for the SJRRP are planned to continue until 2030 (SJRRP 2015), and these projects will increase the carrying capacity of the system as the reintroduced population grows. Release levels over time will be tailored to accommodate the identified carrying capacity.

Table 10.1. Projected juvenile releases and broodstock source population

Brood Year of Collected Donor Stock	Offspring Release Year	Target Number of Juveniles Released	Broodstock Source Population
2012	2016	48,350	FRH
2013	2017	151,875	FRH
2014	2018	200,000	FRH
2015	2019	600,000	FRH
2016	2020	700,000	FRH
2017	2021	960,000	FRH, Butte Creek, San Joaquin River
2018+	2022+	1,000,000	FRH, Butte Creek, San Joaquin River

10.2 Specific location(s) of proposed release(s)

Stream, river, or watercourse: San Joaquin River

Release point: The fish will be released directly from the hatchery whenever possible when there is adequate flow in the river side-channel, and connectivity with the lower San Joaquin River outside the Restoration Area. Additional release locations may be necessary based on the condition of the river and the results of the migration and predation studies outlined in Section 12. Additional potential release sites are presented in Table 10.2. To minimize straying, juveniles would be released as far upstream as feasible based on river connectivity and expected survival out of the Restoration Area.

Table 10.2. Potential release locations in the San Joaquin River

	Latitude (DMS)	Longitude (DMS)	River Mile
HWY 145 Bridge & SCARF	36°59'11.57"N	119°43'2.11"W	266-267
Lost Lake Park	36°58'14.16"N	119°44'21.19"W	264-265
Ball Ranch Access Point	36°56'38.09"N	119°44'18.74"W	262-263
Willow Ecological Reserve	36°55'48.92"N	119°45'2.27"W	260-261
Vulcan Access Point	36°54'33.52"N	119°46'20.93"W	257-259
Fort Washington Access Point	36°52'34.97"N	119°47'14.28"W	255-256
Sycamore Island	36°51'18.94"N	119°50'13.34"W	251-252
Scout Island	36°51'31.47"N	119°50'20.98"W	250-251
Millburn Unit	36°51'22.68"N	119°52'46.24"W	247-248
HWY 99 Bridge Crossing	36°50'35.05"N	119°55'55.42"W	243-244
Scagg's Bridge	36°82'27.89"N	120°55'69.19"W	235-234
Bifurcation Structure Access Point	36°46'26.48"N	120°17'4.08"W	215-217
Mendota Pool Access Point	36°47'34.23"N	120°22'18.88"W	204-205
Sacramento Dam	36°58'55.80"N	120°30'3.67"W	182-183
Firebaugh (bridge)	36°51'30.00"N	120°26'56.00"W	195-196
San Luis Wildlife Area	37°14'10.00"N	120°48'53.00"W	141-145
HWY 165 Bridge	37°17'43.31"N	120°51'4.25"W	132-133
HWY 140 Bridge	37°18'36.00"N	120°55'50.00"W	124-125
Hills Ferry Barrier	37°20'50.84"N	120°58'32.84"W	118-119

Major watershed: San Joaquin River
Basin or Region: Middle San Joaquin-Lower Chowchilla Watershed, USGS Unit: 18040001.

10.3 Actual numbers and sizes of fish released by age class through the program.

There have been no releases over the past 12 years.

10.4 Actual dates of release and description of release protocols.

The first release will occur in March 2016 with approximately 48,350 juveniles. Juveniles will generally be released to the Restoration Area between February and April. Fish will be transported following protocols developed by the Conservation Facility subgroup and placed into the Restoration Area. Selection of sites will need to be made based on environmental conditions given the water year type. Shaded sites or sites with suitable water temperatures (<18ºC), depths (>1.5 m), and water velocities (~.2 m^3/sec) will be selected. Temperature, depth, dissolved oxygen, and water velocity will be measured throughout the extent of the holding and release activities. At the Interim Facility or SCARF, all juvenile salmon will be weighed, measured, adipose fin clipped, and coded wire tagged (CWT) with 0.5 mm tags or standard length tags (depending upon fish size) prior to release. When fish cannot be released adjacent to the hatchery due to barriers to outmigration, fish will be released below the last barrier. If required, fish may be held for up to several days to encourage further imprinting and acclimation.

10.5 Fish transportation procedures, if applicable.

Transportation procedures for the purpose of fish releases will vary depending on life stage to be released. Eggs will be place in a specialized Styrofoam shipping container and will be cooled and kept moist using non-chlorinated ice and transported in a dark environment. Upon arrival at the release site, eggs will be rehydrated and tempered to the receiving water by increasing the egg temperature 1ºC per hour until matching the receiving water temperature. See Appendix D for Egg Transportation Protocol.

Juvenile and adult fish will transported to the release site using the following general guidelines (Carmichael et al. 2001):

1. Reduce the number of stressors
2. Reduce the severity of stressors
3. Minimize the duration of stressors
4. Minimize plasma ion disturbances
5. Minimize increases in metabolic rate

Fish will be released from the SCARF either directly to the San Joaquin River using a volitional-release channel or transported to a release site using a standard fish transport tank. The transport tank will be filled with raw hatchery water supply immediately prior to transport. The transport water will be oxygenated using compressed oxygen cylinders with oxygen stones and impellor driven aerators. Dissolved oxygen levels will be monitored and maintained near saturation during transport. Transport water may be supplemented with sodium chloride to provide a physiologically isotonic concentration to minimize ionic disturbances. When possible, fish will be moved in and out of the transport tank without netting using a shoot attached to the transport tank to minimize stress and loss of slime. When possible, the release site will be near the SCARF and predicted spawning ground. However, releases may occur much farther downstream within the Restoration Area to avoid migratory barriers and transport time may be as long as 2 hours if necessary. Water will be tempered to two degrees Celsius of the river location receiving the fish before transferring fish. When possible, releases will occur at night to minimize predation. For additional information, see Appendix B for the transportation protocol.

10.6 Acclimation procedures

The SJRRP's 10(a)1(A) permit (September 29, 2010 & December 2011) application reviews several methods for reintroducing eggs and juveniles to the San Joaquin River. For eggs, the document reviews streamside incubators, in-river incubation using an instream incubation box, and in-river incubation using egg injection into the gravel. Juveniles are expected to be available for release into the San Joaquin River at various ages and sizes from the FRFH and SCARF. Juveniles may be released within the same temporal window as collection, or as site availability allows; or they may be placed in temporary holding pens for imprinting and acclimation prior to release into the San Joaquin River. Release sites would be selected to provide appropriate water depth, velocity and temperature, substrate, and cover characteristics to promote juvenile growth and survival. The use of temporary holding pens would allow the juveniles to acclimate before release, and thereby reduce the risk of predation (Fisheries Foundation 2009). Juvenile salmon outmigrate in groups, which may reduce mortality due to predation. Temporarily holding

juveniles and releasing them in a series of groups may more closely resemble natural densities experienced during rearing and outmigration and increase their survivorship. Finally, if smolt-sized juveniles from the FRH are released in the Restoration Area, temporarily holding the fish within in-river pens may increase the likelihood that they imprint on the San Joaquin River and return to the Restoration Area to spawn as adults. Juvenile salmon experience odors associated with their home stream before seaward migration and use these olfactory cues for homing as adults (Dittman 1995). Numerous studies from the Pacific Northwest point to the value in developing olfactory cues for juvenile salmonids released outside of their natal streams, to improve homing to the river of release (Slatick et al. 1988). Fish that are produced at the Interim Facility and the SCARF will be reared on SJR water and therefore in general will not require placement in acclimation pens for the purposes of imprinting.

10.7 Marks applied, and proportions of the total hatchery population marked, to identify hatchery adults

All captive reared broodstock will be genotyped for PBT (See Section 12 for more details) and tagged using an intraperitoneal, passive integrated transponder (PIT) tag after reaching a minimum length of 55 mm. PIT tags will be used for monitoring individual fish throughout captivity. Immediately prior to spawning, fish will be disk tagged (intramuscularly) for easy visual identification. All Interim Facility and SCARF juveniles will be adipose fin clipped and CWT and may be PIT or acoustic tagged prior to release. Additional fin clips will be taken for genetic analysis as needed. Coded wire tags will be 0.5 mm tags or standard length tags (depending upon fish size). Half-length (0.5 mm) CWTs may be used to tag juvenile salmonids as small as 22 mm fork length (NMT 2005).

10.8 Disposition plans for fish identified at the time of release as surplus to programmed or approved levels

The number of fish collected from source populations may exceed the SCARF's carrying capacity if their survival is higher than anticipated. These excess fish will typically be released to the San Joaquin River as yearlings (age-1) to facilitate reintroduction and research. Depending on the life stage at release, research fish may be monitored for, among other things, false migration pathways, predation susceptibility, and spawning behavior. When excess fish are anticipated, the CFSG will coordinate with the FMWG regarding potential alternatives for using them, and make a recommendation to NMFS regarding final disposition of any excess eggs, fingerlings, or smolts.

10.9 Fish health certification procedures applied pre-release

Diagnostic procedures for pathogen detection will follow American Fisheries Society professional standards as described in the American Fisheries Society Bluebook (AFS-FHS 2007) and the California Department of Fish and Wildlife Fish Health Policy for Anadromous Fish Hatcheries (February 19, 2014). The goal of the Departments fish health strategy is as follows:

1. Strive to produce healthy fish for release or transfer.
2. Ensure that all production fish are raised under a specific fish health management

program.
3. Monitor and evaluate the health of wild and cultured fish populations.
4. Foster open and frequent communication among managers to jointly resolve fish health related issues.

If disease is identified, appropriate treatments will be prescribed by a CDFW Fish Pathologist as appropriate, and follow-up examinations will be performed as necessary. Fish health assessments will be conducted CDFW Fish Health Lab staff at critical points during fish husbandry in effort to prevent disease outbreaks. These include:

1. Analysis of ovarian fluid from female spawners
2. Analysis during quarantine and at least 30 days prior to transfer to SCARF
3. Analysis immediately prior to transfer to SCARF
4. Analysis prior to release to the wild
5. Analysis for diagnostic purposes during disease outbreaks

Pre-release health assessments include smolt index, fat index, plasma protein, blood hematocrit, etc., and are based on the work of Adams et al. (1993). Treatment methods prescribed by fish pathologists for disease outbreaks and treatment protocols will be carried out by hatchery staff. Depending on the cause of any outbreak, treatment methods may vary.

State statute and code provides authority to the CDFW to curtail or minimize the impact of diseases on fish within California. Implementation of this authority is achieved through: 1) inspecting wild fish and aquatic species captured for transport to a different location, 2) inspecting wild fish and aquatic species to acquire information, useful for fishery management decisions, on the geographical distribution of pathogens, and 3) recommending therapies and corrective measures, or stock destruction to minimize disease impacts. Regulations granting authority to protect the state's resources from fish diseases and parasites are contained in the Fish and Game Code, and the California Code of Regulations, Title 14 (Title 14). Title 14 states the procedures for aquaculture disease control. These regulations are applied to protect aquaculture and the watersheds or geographic areas the Department determines could be threatened. General conditions deal with procedural guidelines. These guidelines include:

- Inspections and examinations, and how they are to be conducted;
- Who is notified if a listed disease is identified;
- What to do upon confirmation of any listed disease;
- Methods of disposal, and disinfection of equipment and facilities;
- Certification, by a fish pathologist, prior to shipment from outside of the United States;
- Disease research and who is contacted prior to the causative agent being brought to the facility.

Disease categories are broken down into four groups by level of threat. These categories are: significant diseases, serious diseases, catastrophic diseases, and "Q" diseases (a disease for which there is so little information, permanent classification cannot be given). Each group has a list of diseases, and procedures to follow for each one. Also contained in the regulations is a list of aquatic diseases and their host organisms.

10.10 Emergency release procedures in response to flooding or water system failure

The Emergency Evacuation Plan for the Interim Facility is provided as Appendix F. The SCARF will be designed to minimize unintended releases to the San Joaquin River during flood events by installing screens on tanks. In the event that an emergency release is necessary due to flooding or other reasons, fish will be crowded into the volitional release channel for release to allow them to swim directly to the river from the facility, or be loaded into fish transport tanks, transported to the river at an appropriate location and released according to State and federal rules and requirements. Fish may also be transferred to a temporary holding location such as the SIRF located at Friant Dam, Friant, CA.

10.11 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish resulting from fish releases

As noted in Section 3, the spring-run Chinook Salmon in the experimental population will interact with listed fish during outmigration, rearing in the San Francisco Estuary, in the ocean, and by straying during spawning migration. The reintroduced fish are likely to interact with other listed salmonid populations, including the endangered winter-run Chinook Salmon and the threatened Central Valley Steelhead. Negative interactions may include induced behavioral changes in wild fish, competition for limited resources, depensatory predation, disease transfers, and interbreeding (Reisenbichler et al. 2004). The fish release methods can influence all of these potential interactions. Disease transfers were addressed under the certification procedures identified in Section 10.9.

Induced behavioral changes in wild fish, competition for limited resources, and depensatory predation are all aggravated by large releases of native fish. Initially, releases from the SCARF will be small and should present limited risk in these areas. As release sizes increase, allocation of reintroduced fish between the release of eggs and of juveniles should spread out the period over which juveniles are entering the system, reducing the risk to listed species. Further, with the juveniles raised in-hatchery, volitional release should allow for a gradual introduction of the juveniles into the system, further reducing the risk to listed species. Reintroductions will be adaptively managed to minimize impacts on other listed species.

SECTION 11 MONITORING AND EVALUATION OF PERFORMANCE INDICATORS

This section describes how "Performance Indicators" listed in Section 1.10 will be monitored. Results of "Performance Indicator" monitoring will be evaluated annually and used to adaptively manage the Conservation Program, as needed, to meet "Performance Standards".

11.1 Monitoring and evaluation of "Performance Indicators" presented in Section 1.10.

As noted in Section 1.9, some indicators are already measured and will continue to be measured as part of other ongoing programs. Where available, data from the ongoing monitoring efforts will be reviewed by the CFSG and GSG, with input from the HCT, to ensure donor stock collections and hatchery operations are consistent with all Conservation Program Objectives. This includes Performance Indicators:

1.A.i. – ii, 1.B.i – ii, 1.C.ii, 3.C.iv, 3.D.iv, 4.A.ii, 6.C.i

11.1.1 Describe plans and methods proposed to collect data necessary to respond to each "Performance Indicator" identified for the program

The Conservation Program will document the result of this monitoring effort and incorporate any necessary management actions to guide SCARF operations. The following monitoring activities will form the basis for Program guidance. These programs address specific indicators listed in Section 1.10; the particular indicators addressed are listed after each section. Some monitoring activities are already ongoing but are not managed by SCARF; these are also identified below.

11.1.1.1 SCARF Operations Monitoring

Monitoring: The Conservation Program will monitor and report on broodstock collection methods and results. Reporting will include estimates of impacts to source populations and any mortality or observed stress on fish.

Indicators: 1.D.i, 1.D.ii, 1.E.i, 1.F.i. – 1.F.v, 6.C.i. – iii

Monitoring: Release practices are documented, including location of releases, number of fish of each stage released, and physical marks applied to fish. Marking and genetic parental based tagging should allow differentiation of the reintroduced CV spring-run from other populations. Genetic analysis (e.g., parentage based tagging) will be used to examine success of different reintroduction methods. Experimental releases employing different release strategies are documented and results feed back into release decisions for future years. Adult returns are compared to release method and location. The effects of marking and tagging of fish on fish stress level will be investigated.

Indicators: 1.C.i, 1.C.iii, 2.B.i, 3.B.i, 3.C.ii – iv, 3.D.i – iv, 4.A.i, 4.A.iii, 6.A.i – ii

Monitoring: Public visits to the SCARF will be logged and total number of visitors will be reported annually. Public outreach activities at the SCARF and in other venues will be logged and reported annually. Recommendations for improving public outreach will be developed annually, and implementation of prior year's recommendations will be monitored and reported.

Indicators: 9.A.i – 9.B.ii

Monitoring: Fish health policy compliance will be monitored, and any observed disease outbreaks during inspections will be monitored and recorded. Rearing survival rates will be recorded for comparison to other hatcheries that rear spring-run Chinook Salmon. In-river population will be monitored for disease occurrence using both visualization and diagnostic assays. Fish carcass disposition procedures will be conducted in compliance with disease control regulations or guidelines.

Indicators: 5.A.i –5.B.ii

Monitoring: Rearing practices will be monitored and reported annually. Juvenile densities will be monitored and reported annually. Adherence of hatchery operations and conditions to recommended natural hatchery rearing practices (per Section 3) will be monitored, evaluated and integrated into SCARF operations as appropriate.

Indicators: 2.C.i

Monitoring: Water use and source will be reported annually. Water quality information, both for source and outflow, will be monitored and reported in compliance with water quality permits. Daily temperature of river water, SCARF tanks, and water supply will be monitored and recorded. Such data will be made available upon request.

Indicators: 8.C.i – 8.D.iii

Monitoring: SCARF permitting and compliance with the HGMP, including monitoring and reporting requirements, is evaluated annually. The CFSG and HCT meet biannually to review the SCARF operations, including any monitoring data collected, and make recommendations for changes to the hatchery practices or to the HGMP. Data and reports are publicly available and may be distributed to all participants.

Indicators: 8.A.i – B.ii, 8.E.i – iii

11.1.1.2 Genetics Monitoring

Monitoring: Any continued genetic monitoring of the selected source populations by other programs will be reported to the extent this information is available to the Conservation Program. This may be part of ongoing monitoring of those populations outside the Conservation Program for the Feather River, although additional genetic monitoring may need to be undertaken on the Butte, Deer, and Mill Creeks.

Monitoring: Genetic analysis of the broodstock population and the naturalizing experimental population from initial returns will be monitored through the end of the recovery program. This will document the matings used in the SCARF and the in-hatchery success of these matings. This will include analysis of all reintroduction methods employed to determine relative success of each method. This should include parentage analysis and an estimate of the success of each of the three source populations, both independently and based on percentage of the admixture in mixed offspring-run. If these studies reveal unexpected differentials in rates of establishment, either by differential survival of family-groups within sources or differential survival of broodstock source, recommendations should be made for changes in broodstock collection or mating practices. Introgression between spring-run and fall run populations in the San Joaquin River will also be monitored and reported, to the extent practicable given existing introgression in Feather River fish.

Indicators: 1.B.i, 2.A.i – iii, 2.B.i, 4.B.i – iii, 4.C.ii, 6.B.i, 7.A.i

11.1.1.3 Instream Monitoring

Monitoring: Escapement estimates will be developed for the returning adults beginning in 2016. Monitoring will include a counting station, snorkel surveys, redd surveys, and carcass surveys. The returning fish should be analyzed to determine their origin (strays vs. planted fish and spring-run vs. fall run). Spawner to recruitment ratios will be calculated for San Joaquin River fish. San Joaquin River escapement estimates will be the basis for SCARF production goals after the restoration period ends. Outmigrant monitoring will record number and origin of outmigrants.

Indicators: 3.A.i – v, 3.C.ii – iv, 3.D.iv, 4.A.iii, 4.B.ii, 4.C.i – ii, 6.A.i – 6.A.ii, 6.B.i, 7.A.i – ii, 7.B.i – 7.B.ii

Monitoring: Restoration of in-river habitat will be monitored and compared to baseline conditions. Estimates will be made of river carrying capacity, including spawning, freshwater rearing, and migration corridor in the San Joaquin River Restoration Area. Monitoring will include differentiation of spring-run and fall run habitat.

Indicators: 3.C.i – 3.C.iv

Long term monitoring of the natural population: Life history characteristics of the natural population are monitored for adaptation to the local environment. Includes monitoring over successive generations of:

- Juvenile dispersal/outmigration timing
- Juvenile size at smoltification and outmigration, and outmigration age composition
- Adult return timing
- Adult return age and sex composition
- Adult size at return
- Spawn timing and distribution
- Fry emergence timing

- Juvenile rearing densities, distribution, and behaviors
- Juvenile growth rate, condition factors, and survivals at several growth stages prior to final release
- Adult physical characteristics (length, weight, condition factors)
- Fecundity and egg size
- Spawning behavior and success
- Diet (food availability in natural environment)
- Incidence of disease in the natural environment

The Long-term Fisheries Monitoring Plan currently in development and will include static sites for collecting biological data and a genetic sample (e.g., fin clip) to allow genetic identification of individuals and their biological status (e.g.: growth, weight, condition factor) for both outmigrating juvenile and returning adult spring-run Chinook salmon.

Indicators: 4.B.i – 4.B.iii

11.1.2 Indicate whether funding, staffing, and other support logistics are available or committed to allow implementation of the monitoring and evaluation program

Funding for operations and maintenance at the SCARF, which includes monitoring of SCARF broodstock, is currently being provided to CDFW by Reclamation. Monitoring of the wild population is expected to be included in the SJRRP's Long-Term Monitoring Plan, which is in development.

11.2 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish resulting from monitoring and evaluation activities

Monitoring and evaluation activities will be conducted in close cooperation with the SJRRP's Technical teams and will be conducted in order to minimize stress and mortality to listed fish. In the event that activities are found to increase stress and mortality, findings will be presented to the HCT and CFSG, and appropriate measures will be taken to reduce the impacts of activities.

SECTION 12 RESEARCH

12.1 Objective or purpose

The Conservation Program includes several planned studies, and additional studies may be developed. The following list includes planned studies, although some of the studies may not be completed due to funding or time constraints. Any additional studies would be reviewed by the GSG, CFSG, FMWG, and NMFS before being added to an amended HGMP. Conservation needs will be given priority over research needs. The discussion below is divided by project for the planned studies.

12.1.1 Potential Natural Recolonization Study

Objective: This study will characterize the genetic makeup and life history diversity of the Chinook Salmon populations in the lower San Joaquin River and its tributaries.

Benefit: Information about potential natural recolonizers is vital to determining how best to integrate natural recolonization with hatchery-driven recolonization. This study will provide information about the origin, run-size, run-timing, and straying rate of natural populations located in close proximity to the Restoration Area and will make recommendations about how to include these fish in the reintroduction effort.

Broad Significance: This information will provide a better characterization of the Central Valley Chinook Salmon population as a whole and will provide additional demographic and genetic information about Chinook Salmon populations at the extreme southern end of their range.

Techniques: The analysis will center on single nucleotide polymorphisms (SNPs), which are used broadly in the characterization of Chinook Salmon populations. Initial analysis will rely on Chinook Salmon tissue from the tissue bank collected over the last several years, and additional analysis may include tissue from more targeted collections in the lower San Joaquin River and its tributaries. For example, PBT of the adult over summering Salmon on the San Joaquin River coupled with floy tagging and otolith studies of the same fish to determine their rivers of origin and subsequent genetic analysis of yearling outmigrants will allow assessment of hatchery vs. wild origin, river of origin, and the expression of the spring-run phenotype in these fish.

Alternative methods to achieve project objectives: None

Level of take of listed fish: Initially, no take is involved, because the study uses previously collected tissues. If targeted collection occurs, the level of take of listed fish is unknown, because the identity of the salmon in these areas is undetermined. However, NMFS does not recognize the presence of any spring-run population on the San Joaquin River in their ESA listing. Collection is non-lethal and involves fin clip, so even if fish are present, any take should be nonlethal.

***Risk aversion measures*:** For the initial phase, no risk aversion measures are needed. In the longer term, tissue sampling protocols will minimize risk to the sampled fish.

Initiation date and Principal Investigator: 2010, UC Davis, Reclamation

12.1.2 Broodstock Genetic Diversity Study

Objective: This study will examine the genetic diversity in the broodstock fish taken from each of the three potential source populations. Based on prior, ongoing, and, as needed, additional SNP work to characterize the source populations, the study will determine how well the diversity in the wild source population is reflected in the broodstock and will make recommendations for adaptively managing the broodstock collection to better capture the wild populations' diversity.

Benefit: The study will ensure adequate diversity in the broodstock to avoid bottlenecks and inbreeding in the experimental population.

Broad Significance: The study will provide empirical data on the population size necessary to adequately capture a wild population's genetic diversity, which should benefit reintroduction efforts for other salmonids.

Techniques: The analysis will center on single nucleotide polymorphisms (SNPs), which are used broadly in the characterization of Chinook Salmon populations. Initial analysis will rely on Chinook Salmon tissues collected ancillary to the PBT. Additional analysis, if needed, may include tissue from more targeted collections in the source populations.

Alternative methods to achieve project objectives: None.

Level of take of listed fish: None beyond normal hatchery operations for the broodstock. If necessary, some nonlethal take will result from the collection of additional fin clips from the source populations, although the level of collection is unknown at this time.

Risk aversion measures: None required.

***Initiation date and Principal Investigator*:** 2012 - UC Davis; NMFS Southwest Fisheries Science Center, BOR

12.1.3 Epigenetics Study: Comparison of Genetic Diversity and Methylation Diversity of spring-run broodstock

Objective: This study will evaluate spring-run Chinook Salmon broodstock for genetic diversity using neutral markers (microsatellites, SNPs, AFLPs) and compare observed variation to methylation diversity as detected using methylation-sensitive amplified fragment polymorphism (msAFLP) markers. In the Restoration Area, the relationship of

these two diversity indices, both independently and in combination, with survival and reproductive success will be assessed to determine if increased diversity is associated with higher fitness.

Benefit: Knowledge of the predictive power of genetic and epigenetic diversity for reintroduction success may enable more informed decision making regarding broodstock source selection in the future.

Broad Significance: Epigenetic diversity can accumulate from both natural selection and environmental change and is believed to be an important component of phenotypic plasticity. Recent research has suggested that natural populations with little genetic diversity can have large epigenetic diversity in different environments. The potential ability of some populations to adapt more quickly to the likely stochastic environment of the Restoration Area may lead to differential rates of survival and reproductive fitness. Although the overall genetic diversity of the source populations is low, an examination of source population epigenetic diversity will provide a more complete picture of overall diversity that can enable adaptation. This study may have broad implications towards increasing our understanding of how genetic and epigenetic factors interact in a natural stochastic system.

Techniques: Fin clip samples used for PBT will also be used for this study. Genomic DNA will be digested with methylation-specific restriction enzymes to detect individual differences in methylation patterns. Epigenetic and genetic population diversity indices will be compared and correlated to fitness using results from PBT.

Alternative methods to achieve project objectives: None

Level of take of listed fish: No additional take beyond normal hatchery operations for adults. For juveniles, sampling will opportunistic based on sampling for other studies, so there should be no additional incremental take.

Risk aversion measures: A minimal number of fish will be collected to adequately sample the genetic and epigenetic diversity of the populations. Collecting from multiple broodstock populations minimizes the impacts on any one population.

Initiation date and Principal Investigator: 2012, UC Davis or other

12.2 Cooperating and funding agencies

The cooperating and funding Agencies include CDFW, USFWS, USBR and NMFS.

12.3 Principal investigator or project supervisor and staff.

Principal investigators with be identified within the FMWG in cooperation with SCARF and CDFW personnel.

12.4 Status of stock, particularly the group affected by project, if different than the stock(s) described in Section 2

The stocks affected by the research will include those described in Section 2. In general, the spring-run populations in nearby rivers are not well characterized and appear to be ephemeral populations. Their status and identity are unknown. The Stock Selection Strategy discusses these small, ephemeral stocks in more detail, although additional research is necessary to better understand these stocks.

12.5 Techniques: include capture methods, drugs, samples collected, tags applied.

Techniques will vary by project. To the extent the techniques have been identified, they are discussed in Section 12.1.

12.6 Dates or time period in which research activity occurs.

Research with non-listed populations began in 2010. Any research impacting listed populations will not begin until permits are secured. Research will continue as allowed under those permits through the end of the SCARF program.

12.7 Care and maintenance of live fish or eggs, holding duration, transport methods.

See Sections 7 and 9.

12.8-10 Expected type and effects of take and potential for injury or mortality.

Expected type and effects of take and potential for injury or mortality will be described in detail as each of the research plans are developed. Each of the plans will be reviewed by the FMWG and will include review by CDFW, USFWS, BOR and NMFS. All research projects will be in compliance with State and federal permits and regulations.

All spring-run Chinook Salmon raised in the hatchery, and potentially some naturally-produced fish in the Restoration Area, as available, will be adipose fin clipped, both as an identifying mark (for hatchery fish) and to allow PBT. Fin clipping is generally not lethal, although a small number of fish may die during the process.

Outside of the Restoration Area, some additional tissue samples may be required from the San Joaquin tributaries and the potential source populations. If necessary, some nonlethal take will result from the collection of additional fin clips, although the level of collection is unknown at this time and will depend on data needs. For most of these fin clips, sampling will be opportunistically based on ongoing work in those systems, with little need for additional handling.

12.11 List species similar or related to the threatened species; provide number and causes of mortality related to this research project.

As available, information on take associated with each study is listed above. The number and causes of mortality related to projects will be described in detail as each research plan is

developed. Each plan will be reviewed by the FMWG and will include review by CDFW, USFWS, BOR and NMFS. All research projects will be in compliance with State and federal permits and regulations.

12.12 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse ecological effects, injury, or mortality to listed fish as a result of the proposed research activities.

As available, information on take associated with each study is listed above.

The following is a list of recommended hatchery studies for the revised HGMP:

- Continue research on the cause and control of precocious maturation.
- Conduct research associated with attempting to minimize the influence of hatchery induced selection. In particular, the female broodstock are currently significantly smaller than wild fish. Research could work to determine the causes of the smaller size of hatchery broodstock, and methods for producing broodstock that are of equivalent size of wild fish.
- Conduct research associated with the release of hatchery reared adults Spring-run Chinook to the SJR.

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SECTION 14 CERTIFICATION LANGUAGE AND SIGNATURE OF RESPONSIBLE PARTY

"I hereby certify that the information provided is complete, true and correct to the best of my knowledge and belief. I understand that the information provided in this HGMP is submitted for the purpose of receiving limits from take prohibitions specified under the Endangered Species Act of 1973 (16 U.S.C.1531-1543) and regulations promulgated thereafter for the proposed hatchery program, and that any false statement may subject me to the criminal penalties of 18 U.S.C. 1001, or penalties provided under the Endangered Species Act of 1973."

Name, Title, and Signature of Applicant:

Certified by_____ Date:_____

Kevin Shaffer, Acting Fisheries Branch Chief, CDFW

Certified by_____ Date:_____

Robert Clarke, Fisheries Program Supervisor, USFWS

Table 1. Estimated listed salmonid take levels for Broodstock Collections by location.

Listed species affected: Chinook Salmon	**ESU/Population: Central Valley Spring-Run**		**Activity: Broodstock Collections**	
Location of hatchery activity: Butte Creek	**Dates of activity: 1/1/2018 -12/31/2022**		**Hatchery program operator: CDFW**	
	Annual Take of Listed Fish By Life Stage *(Number of Fish)*			
Type of Take	Egg/Fry	Juvenile/Smolt	Adult	Carcass
Observe or harass a)				
Collect for transport b)				
Capture, handle, and release c)				
Capture, handle, tag/mark/tissue sample, and release d)				
Removal (e.g. broodstock) e) rotary screw trap		2910		
Intentional lethal take f)				
Unintentional lethal take g) loss during transport/holding		58		
Other Take (specify) h)				
Location of hatchery activity: Feather River Hatchery (FRH)	**Dates of activity: 1/1/2018 -12/31/2022**		**Hatchery program operator: CDFW**	
	Annual Take of Listed Fish By Life Stage *(Number of Fish)*			
Type of Take	Egg/Fry	Juvenile/Smolt	Adult	Carcass
Observe or harass a)				
Collect for transport b)				
Capture, handle, and release c)				
Capture, handle, tag/mark/tissue sample, and release d)				
Removal (e.g. broodstock) e) eggs from FRH	5470			
Intentional lethal take f)				
Unintentional lethal take g) loss during transport/holding	55			
Other Take (specify) h)				

Location of hatchery activity: San Joaquin River	Dates of activity: 1/1/2018 -12/31/2022	Hatchery program operator: CDFW		
Type of Take	**Annual Take of Listed Fish By Life Stage** ***(Number of Fish)***			
	Egg/Fry	Juvenile/Smolt	Adult	Carcass
Observe or harass a)				
Collect for transport b)				
Capture, handle, and release c)				
Capture, handle, tag/mark/tissue sample, and release d)				
Removal (e.g. broodstock) e) redd extraction[1]; emergence trap[2]; RST, weir, or seine[3]; and fyke net, weir, or dip net[4]	1000 [1] 400 [2]	2980 [3]	250 [4]	
Intentional lethal take f)				
Unintentional lethal take g) loss from collection/transport	154	60	13	
Other Take (specify) h)				

a. Contact with listed fish through stream surveys, carcass and mark recovery projects, or migrational delay at weirs.
b. Take associated with weir or trapping operations where listed fish are captured and transported for release.
c. Take associated with weir or trapping operations where listed fish are captured, handled and released upstream or downstream.
d. Take occurring due to tagging and/or bio-sampling of fish collected through trapping operations prior to upstream or downstream release, or through carcass recovery programs.
e. Listed fish removed from the wild and collected for use as broodstock.
f. Intentional mortality of listed fish, usually as a result of spawning as broodstock.
g. Unintentional mortality of listed fish, including loss of fish during transport or holding prior to spawning or prior to release into the wild, or, for integrated programs, mortalities during incubation and rearing.
h. Other takes not identified above as a category.

Table 2. Estimated listed salmonid take levels for Quarantine and Pathology of Broodstock.

Listed species affected: Chinook Salmon ESU/Population: Central Valley Spring-Run Activity: Quarantine and Pathology of Broodstock				
Location of hatchery activity: Silverado Fisheries Base Dates of activity: 1/1/2018 -12/31/2022 Hatchery program operator: CDFW				
	Annual Take of Listed Fish By Life Stage *(Number of Fish)*			
Type of Take	Egg/Fry	Juvenile/Smolt	Adult	Carcass
Observe or harass a)				
Collect for transport b)				
Capture, handle, and release c)				
Capture, handle, tag/mark/tissue sample, and release d) coded wire tagging broodstock		5400		
Removal (e.g. broodstock) e)				
Intentional lethal take f) pathology clearance for broodstock collected from FRH and Butte Cr. (70 per event)[1]; dying fish sacrificed for disease testing (6 per outbreak, as needed)[2]; and coded wire tagging[3]		280 [1] 115 [2] 40 [3]		
Unintentional lethal take g) loss during holding[4] and coded wire tagging[5]		1188 [4] 54 [5]		
Other Take (specify) h)				
Location of hatchery activity: SCARF/Interim Facility/SIRF Dates of activity: 1/1/2018 -12/31/2022 Hatchery program operator: CDFW				
	Annual Take of Listed Fish By Life Stage *(Number of Fish)*			
Type of Take	Egg/Fry	Juvenile/Smolt	Adult	Carcass
Observe or harass a)				
Collect for transport b)				
Capture, handle, and release c)				
Capture, handle, tag/mark/tissue sample, and release d) coded wire tagging		5400		
Removal (e.g. broodstock) e)				
Intentional lethal take f) pathology clearance for broodstock collected from SJR (70 per event)[6]; dying fish sacrificed for disease testing (6 per outbreak, as needed)[7]; and coded wire tagging[8]		280 [6] 115 [7] 20 [8]		
Unintentional lethal take g) loss during holding[9] and coded wire tagging[10]		1188 [9] 54 [10]		
Other Take (specify) h)				

Table 3. Estimated listed salmonid take levels for Broodstock Rearing.

Listed species affected: Chinook Salmon ESU/Population: Central Valley Spring-Run Activity: Broodstock Rearing				
Location of hatchery activity: SCARF/Interim Facility/SIRF Dates of activity: 1/1/2018 -12/31/2022 Hatchery program operator: CDFW				
	Annual Take of Listed Fish By Life Stage *(Number of Fish)*			
Type of Take	Egg/Fry	Juvenile/Smolt	Adult	Carcass
Observe or harass a)				
Collect for transport b) ancillary broodstock release to SJR		2,500	2,500	
Capture, handle, and release c)				
Capture, handle, tag/mark/tissue sample, and release d)				
Removal (e.g. broodstock) e)				
Intentional lethal take f)				
Unintentional lethal take g) rearing loss juvenile to adult[1] and capture/transport/release losses[2]		2,700 [1] 50 [2]	50 [2]	
Other Take (specify) h)				

Table 4. Estimated listed salmonid take levels for Spawning and Smolt Production.

Listed species affected: Chinook Salmon ESU/Population: Central Valley Spring-Run Activity: Spawning and Smolt Production				
Location of hatchery activity: SCARF/Interim Facility/SIRF Dates of activity: 1/1/2018 -12/31/2022 Hatchery program operator: CDFW				
	Annual Take of Listed Fish By Life Stage *(Number of Fish)*			
Type of Take	Egg/Fry	Juvenile/Smolt	Adult	Carcass
Observe or harass a)				
Collect for transport b)				
Capture, handle, and release c)				
Capture, handle, tag/mark/tissue sample, and release d) coded wire tagging and release to SJR		1,250,000		
Removal (e.g. broodstock) e)				
Intentional lethal take f) deformed or dying fish removed from production[1]; pre-release health assessment (20 per tank)[2]; coded wire tagging[3]; and broodstock spawning[4]	83,500 [1]	320 [2] 500 [3]	1,500 [4]	
Unintentional lethal take g) loss during incubation and rearing[5]; coded wire tagging[6]; and capture/transport/release[7]	667,000 [5]	12,500 [6] 25,000 [7]		
Other Take (specify) h)				

Table 5. Estimated listed salmonid take levels for San Joaquin River Population Monitoring.

Listed species affected: Chinook Salmon ESU/Population: Central Valley Spring-Run Activity: Population Monitoring				
Location of hatchery activity: San Joaquin River Dates of activity: 1/1/2018 -12/31/2022 Hatchery program operator: CDFW				
	Annual Take of Listed Fish By Life Stage *(Number of Fish)*			
Type of Take	Egg/Fry	Juvenile/Smolt	Adult	Carcass
Observe or harass a) weir with camera[1] and snorkel survey[2]			2,500 [1] 2,500 [2]	
Collect for transport b)				
Capture, handle, and release c) emergence trap	60,000 [3]			
Capture, handle, tag/mark/tissue sample, and release d) rotary screw trap[4]; weir (as needed if no river connectivity)[5]; fyke net[6]; carcass survey[7]		125,000 [4] 750,000 [5]	2,500 [6]	2,500 [7]
Removal (e.g. broodstock) e)				
Intentional lethal take f)				
Unintentional lethal take g) capture/holding/transport losses associated with emergence trap[3]; rotary screw trap[4]; weir[5]; and fyke net, weir, or dip net[6]	1,200 [3]	2,500 [4] 15,000 [5]	50 [6]	
Other Take (specify) h)				

Table 6. Estimated listed salmonid take levels for Translocation from Feather River Hatchery.

Listed species affected: Chinook Salmon ESU/Population: Central Valley Spring-Run Activity: Translocation				
Location of hatchery activity: FRH and SIRF Dates of activity: 1/1/2018 -12/31/2022 Hatchery program operator: CDFW				
	Annual Take of Listed Fish By Life Stage *(Number of Fish)*			
Type of Take	Egg/Fry	Juvenile/Smolt	Adult	Carcass
Observe or harass a)				
Collect for transport b)				
Capture, handle, and release c)				
Capture, handle, tag/mark/tissue sample, and release d) coded wire tagging and release to SJR		62,400		
Removal (e.g. broodstock) e) egg collection from FRH	80,000			
Intentional lethal take f) pre-release health assessment (10 per tank)[1]; dying fish sacrificed for disease testing (6 per outbreak, as needed)[2]; and coded wire tagging[3]		100 [1] 12 [2] 200 [3]		
Unintentional lethal take g) loss during collection and transport[4]; rearing[5]; and coded wire tagging[6]	1,600 [4]	17,600 [5] 624 [6]		
Other Take (specify) h)				