Appendix G

San Joaquin Juvenile Chinook Salmon Trap and Haul Analysis Report

March 17, 2014

SAN JOAQUIN RIVER
RESTORATION PROGRAM

June 2017

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Executive Summary

One of the primary goals of the San Joaquin River Restoration Program (SJRRP) (http://www.restoresjr.net/) is to restore populations of spring Chinook and fall Chinook to the San Joaquin River from Friant Dam to the confluence with the Merced River.

A major concern of the on-going restoration effort is the effect low (i.e., critical low and critical high) water years may have on the survival and migration success of juvenile Chinook salmon. Under low flow conditions, there may be a very low probability of juvenile Chinook successfully migrating from spawning grounds to the ocean. This, in turn, would result in few, if any, adults returning to the system in subsequent years. A loss of a single or multiple brood years could seriously threaten the success of the reintroduction effort.

One action that may increase juvenile survival in low flow years is implementation of a juvenile trap-and-haul program. The program would be designed to collect juvenile migrants at one or multiple locations in the San Joaquin River Restoration Area and transport them for release in a downstream location with suitable flow and stream temperatures.

This report describes the actions and facilities required to implement a successful juvenile Chinook trap-and-haul program in the San Joaquin River. Based on a review of both portable and stationary screening systems, seven alternatives were reviewed:

- Alternative A- Donny Bridge V-Screen (1,000 cfs)
- Alternative B- Emmert Pump Station V-Screen (1,000 cfs)
- Alternative C- Chowchilla Bifurcation V-Screen (1,000 cfs)
- Alternative D- San Mateo Crossing V-Screen (1,000 cfs)
- Alternative E- 500 CFS V-Screen
- Alternative F- Inclined Plane Screen
- Alternative G- Portable Traps

The alternatives were evaluated based on their ability to achieve three juvenile Chinook production targets, which if met, would produce the range of adult returns described in the Fish Management Plan for the San Joaquin River Restoration Program. The three juvenile production targets are:

1. Target 1 (107,000) – the number of juveniles needed to produce 500 spring-run and 500 fall-run adult Chinook

2. Target 2 (321,000) – the number of juvenile Chinook needed to produce 2,500 spring-run and 2,500 fall-run adult Chinook

3. Target 3 (2.33 million) - the number of juvenile Chinook needed to produce 30,000 spring-run and 10,000 fall-run adult Chinook.

The results of the analysis indicate the 500 cfs and 1,000 cfs screening systems would likely achieve each of the three juvenile production targets during low flow years (i.e., Critical-Low, Critical-High and Dry) at a cost ranging from $20 to $33 million.

The 300 cfs inclined plane screen alternative would only be able to achieve the juvenile targets in Critical-Low and High years, although at a greatly reduced cost ($14 to $21 million).

In contrast, the portable trap alternative would only achieve target 1 for the same water year types as described for Alternatives A-G (Table E-1). The capital cost of the system would be approximately $117,000 (estimated high range) with monthly operations and maintenance costs estimated at about $203,000.

Table E-1. Summary of alternative performance (by water year type) and range of cost.

Juvenile Collection Target/Water Year Type	Alternatives A-D 1,000 CFS	Alternative E 500 CFS	Alternative F 300 CFS (Inclined Plane)	Alternative G- Portable Traps
Target 1 (107,000)				
Critical-Low	Yes	Yes	Yes	Yes
Critical-High	Yes	Yes	Yes	Yes
Dry	Yes	Yes	Yes	Yes
Normal-Dry	Yes	Yes	Yes	No
Normal-Wet	Yes	Yes	No	No
Target 2 (321,000)				
Critical-Low	Yes	Yes	Yes	Yes
Critical-High	Yes	Yes	Yes	No
Dry	Yes	Yes	Yes	No
Normal-Dry	Yes	Yes	No	No
Normal-Wet	Yes	No	No	No
Target 3 (2.33 million)				
Critical-Low	Yes	Yes	Yes	No
Critical-High	Yes	Yes	Yes	No
Dry	Yes	Yes	No	No
Normal-Dry	Yes	No	No	No
Normal-Wet	No	No	No	No
Cost	$20-33 million	$14 to	$0.8 to 1.3	$0.077 to 0.117

		$21million	million	million

Because site-specific juvenile Chinook run-timing data were not available for the San Joaquin River Restoration Area, the analysis was based on the assumption that screening system fish collection efficiency (Alternatives A-F) and river flow are proportional. In short, if the system screened 100 percent of the flow, then it collected 100 percent of the fish. For the portable trap alternative, fish collection efficiency was set at 30 percent.

Under the assumption that managers will elect to develop a trap-and-haul system for the program, the following steps are required:

- Confirm biological objectives (abundance, life history diversity, fish size)
- Confirm operational assumptions (dates of operation and water year type)
- Complete a site selection analysis
- Complete a 30 percent engineering design report

As these steps are being completed, other recommended steps include:

- Developing trap efficiency estimates of screw traps currently operating in the restoration area
- Testing an inclined plane screen at Chowchilla Bifurcation Structure
- Developing juvenile run-timing and size by month
- Estimating juvenile survival rates from rearing areas to collection sites
- Estimating juvenile survival rates for reaches below collection sites
- Estimating juvenile survival rates for fish collected, transported and released at the Highway 165 Bridge.

1.0 Juvenile Trapping Background and Purpose

One of the primary goals of the San Joaquin River Restoration Program (SJRRP) (http://www.restoresjr.net/) is to restore populations of spring Chinook and fall Chinook (Chinook) salmon to the San Joaquin River from Friant Dam to the confluence with the Merced River. To succeed, the restoration effort will require a combination of actions including habitat improvement, modification of the stream channel and existing structures, establishment of river flows sufficient to protect Chinook freshwater life stages, and fish passage.

A major concern of the on-going restoration effort is the effect that low (i.e., critical low and critical high) water years may have on the survival and migration success of juvenile Chinook prior to completion of channel and flow restoration measures. Under low flow conditions, there may be a very low probability of juvenile Chinook successfully migrating from spawning grounds to the ocean. This would result in few, if any, adults returning to the system in subsequent years. A loss of a single or multiple brood years could seriously threaten the success of the reintroduction effort.

One action that could be undertaken to increase juvenile survival in low flow years is to implement a juvenile trap-and-haul program. The program would be designed to collect juvenile migrants in one or multiple locations in the San Joaquin River and transport them for release in a downstream location with suitable flow and stream temperatures.

This report describes actions and facilities that could be implemented to achieve a successful juvenile trap and haul program in the San Joaquin River.

1.1 Project Area

The project area consists of the San Joaquin River from Friant Dam to the river's confluence with the Merced River (Figure 1).

The analysis area for potential juvenile trap and haul facilities is restricted to the reach of river extending from Friant Dam to the Mendota Pool. Locations within or downstream of the pool were not considered based on the USFWS assessment that preventing juvenile losses above Mendota Pool would be the most efficient means to address mortality associated with low flows in the short term. Over the long term, it is expected that Mendota Pool will be bypassed and fish losses associated with juvenile migration through the pool will not be an issue.

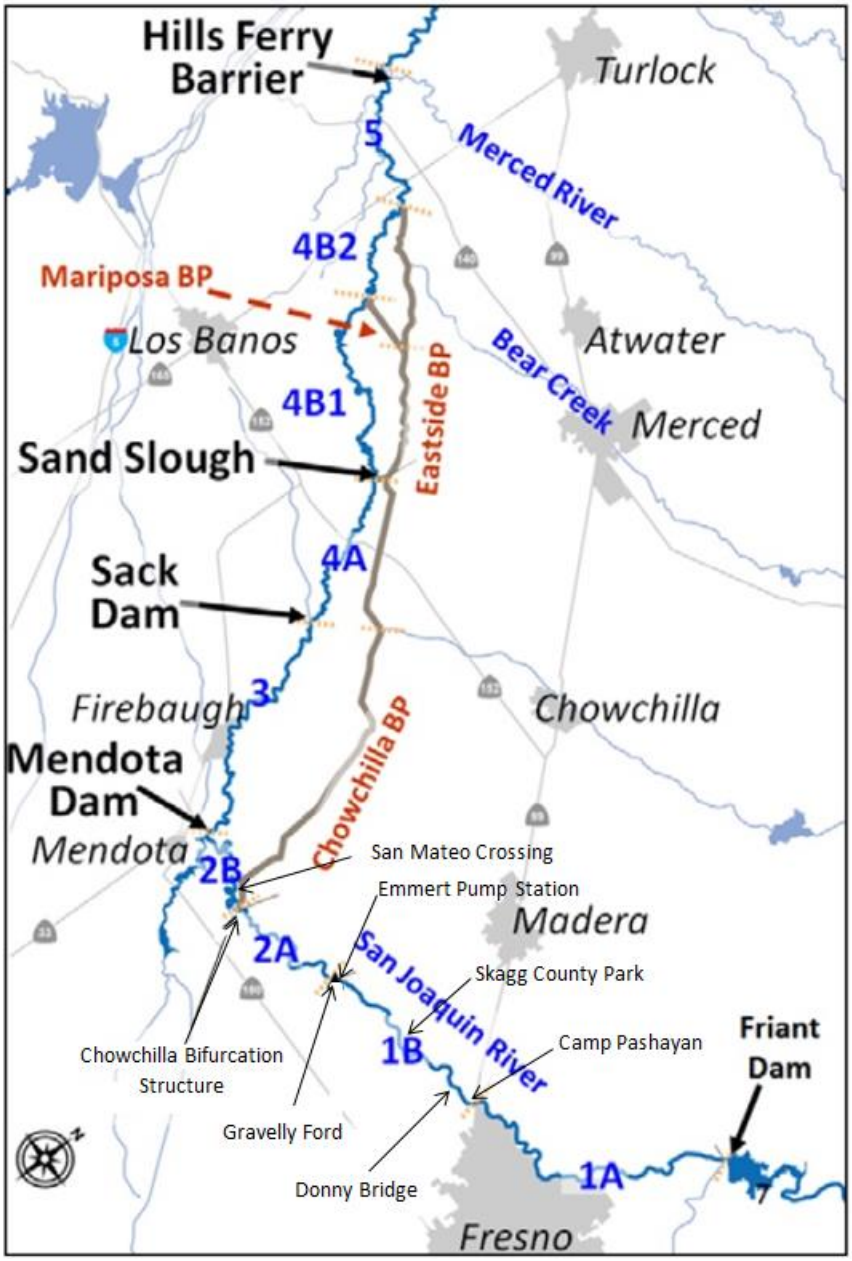

Figure 1. Project area and potential Chinook salmon smolt trapping sites.

1.2 Project Authorization

This project was initiated by the United States Fish and Wildlife Service to assist and support the San Joaquin River Restoration Program with a review of alternatives for juvenile Chinook trapping and hauling.

2.0 Juvenile Chinook Trapping Goals

The goal of a juvenile trapping program is to help achieve adult Chinook salmon production goals for the SJRRP. According to the Fisheries Management Plan (FMP), the short-term and average adult production goals for the program are as follows (SJRRP 2010)[1]:

- Achieve a minimum of 500 naturally produced adult spring Chinook and 500 naturally produced fall-run Chinook
- Achieve a 5-year running average target of 2,500 naturally produced adult spring-run Chinook and 2,500 fall-run Chinook

The long-term goal of the program is to achieve a spawning population target of 30,000 and 10,000 naturally produced spring-run and fall-run Chinook, respectively (SJRRP 2010).

To achieve the minimum adult production target (500 of each run), managers indicate that 44,000 spring-run and 63,000 fall-run Chinook subyearling (> 70 mm in length) smolts must successfully migrate out of the system each year[2]. In contrast, achieving the long-term population target will require 1.575 million and 750,000 spring-run and fall-run Chinook subyearlings, respectively[3].

Based on these adult and juvenile production targets, this analysis evaluates the ability of different trapping systems to achieve short-term, average and long-term adult production goals (Table 1).

A key assumption in the juvenile abundance target values for each category is that the survival rate to adult for captured juveniles will range from 1.3 percent (fall-run) to 1.89 percent (spring-run). This may be the case in average or higher water years, but is not expected in critical water years. In the critical water years, river temperatures will be higher, resulting in greater natural mortality (predation, etc.) and mortality due to stress associated with collection, transport and release. For example, research on Chinook salmon smolts migrating through the Sacramento-San Joaquin River Delta indicated that as stream temperatures increase, mortality rates increased (Baker et al. 1994).

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[1] The near-term goals are measured as fish on the spawning grounds.

[2] The FMP states that juvenile production includes fry, parr, subyearlings and age 1+ migrants, which implies that any combination of these life stages would achieve the juvenile production target. However, the analysis assumes that the targets are based on subyearlings (> 70 mm in length) as described in Section 3.2.2 of the FMP.

[3] The FMP analysis calculated the value based on 833 spawners. Therefore, this equates to a subyearling to adult survival rate of 1.89% for spring-run and 1.3% for fall-run. The FMP did not provide an expected survival rate for yearling smolts migrating from the system.

Table 1. Minimum number of subyearling spring-run and fall-run Chinook required to achieve short-term, average and long-term adult production goals.

Category	Adult Production Target	No. of Spring-run Subyearlings	No. of Fall-run Subyearlings	Total
Short Term	500 spring-run and 500-fall run*	44,000	63,000	107,000
Average	2,500 spring-run and 2,500 fall-run	132,000	189,000	321,000
Long Term	30,000 spring-run and 10,000 fall-run	1.575 million	750,000	2.325 million

* The number of juveniles required is based on an analysis in the FMP that assumed 833 spawners.

3.0 Biological and Environmental Assumptions

Key biological and environmental parameters used to develop and operate trap-and-haul systems are provided below.

3.1 Juvenile Chinook Migration Timing and Size

The trapping systems will operate over the time period when juvenile fish are emigrating from the San Joaquin River system. The expected out-migration timing for juvenile spring-run and fall-run Chinook is shown in Tables 2 and 3, respectively.

Because juvenile run-timing data were not available for the restoration area, run-timing information was compiled from the Feather River (Bilski and Kindrop 2009), Stanislaus River (Pyper and Justice 2006), Butte Creek (McReynolds et al. 2007) and the San Joaquin Restoration Program (SJRRP 2007). Although this run-timing information is not specific to the restoration area, it is sufficient to describe the timing and likely size of fish that may be collected as part of the trap-and-haul program.

Table 2. Juvenile run-timing for spring-run Chinook.

Life Stage	Fish Length (mm)	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Emergent fry	< 40	▨									▨	▨	▨
Fry Migration	< 60	▨	▨										▨
Smolt Migration	> 60 < 120	▨	▨	▨	▨	▨	▨						
Yearling Migration	> 120	▨	▨	▨	▨	▨	▨			▨	▨	▨	▨

Table 3. Juvenile run-timing for fall-run Chinook

Life Stage	Fish Length (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Emergent Fry	< 40	▨	▨									▨	▨
Fry Migration	< 60	▨	▨	▨									▨
Smolt Migration	> 60 < 120*			▨	▨	▨	▨						

*Some fish may be larger than 120 mm.

The data in the run-timing tables indicate the trap-and-haul system may collect fish ranging in size from less than 40 mm to over 120 mm, depending on when the system is operated.

Because of concerns about mortality associated with trapping and hauling emergent fry, the trapping sites examined in this report are located many miles downstream of spawning areas (Pers. Comm., Michelle Workman, USFWS. 2013)[4].

3.2 Total Juvenile Production

The number of juvenile fish available for capture in a given year will depend upon adult spawning escapement and egg-to-juvenile migrant survival rate(s). Because the program is just

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[4] Emergent fry will be less than 40 mm in length and many will still maintain their yolk-sack. Their size makes them more vulnerable to increased mortality due to contact with screening structures, sorting facilities and transport.

starting, this analysis assumes total annual juvenile production will range from 107,000 to 2.33 million (Table 1).

3.3 Predator Abundance at Capture and Release Sites

The abundance, size and species of fish and other predators present at both capture and release sites can substantially reduce the number of Chinook collected and their survival rate after release (Buell 2003, Zamen et al. 2013, Dawley et al. 1992).

Properly designed juvenile fish collection facilities should be equipped with sorting facilities that remove larger predacious fish from the system as soon as possible to reduce predation mortality and stress on the target species. In addition, if collection facilities concentrate predators or increase their habitat (e.g., form pools), then control measures should be implemented as needed.

To reduce predation mortality, transported fish should be released in areas that are free of predators, exhibit protective river temperatures, and have water velocities greater than 4.0 ft/sec if possible (NMFS 2011).

3.4 Adult Straying

A major issue with juvenile trap-and-haul systems is that the returning adults may stray to spawning areas outside of their basin of origin due to a decreased homing ability. Adult straying reduces the number of fish returning to the basin and may have negative genetic impacts to other populations (CA HSRG 2012) (Keefer and Caudill 2012)[5]. The California Hatchery Scientific Review Group concluded adult stray rates should not exceed those exhibited by natural populations, which are typically less than 5 percent (CA HSRG 2012).

Kormos et al. (2012) evaluated adult stray rates for Central Valley hatchery Chinook transported and released outside the basin of origin or released in-basin. The authors found that the out-of-basin releases had stray rates ranging from approximately 5 to 90 percent compared to less than 10 percent for most in-basin releases.

In a literature review of salmon and steelhead straying, Keefer and Caudill (2012) found transported fish had higher stray rates than non-transported fish. Stray rates varied by species, environmental conditions, transport distance and whether the fish were acclimated prior to release. In general, adult stray rates increased as transport distance increased; however, this rate may decrease if fish are acclimated prior to release.

3.5 Acclimation

For supplementation and other hatchery programs, fish may be transferred to release sites and held there for a period of time to “acclimate” to the conditions present in the release stream. Acclimating fish before release is theorized to increase juvenile survival rates and decrease adult stray rates[6]. In a review of acclimation, Keefer and Caudill (2012) concluded that results

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[5] http://www.dfw.state.or.us/fish/OHRC/docs/2013/pubs/steelhead_and_salmon_straying.pdf

[6] Much of the work on acclimation was conducted on hatchery fish. The San Joaquin program will be collecting and transporting wild fish (and some hatchery fish) that have spent considerable time rearing in the river; therefore, acclimation prior to release may not be an effective action to improve homing.

depended on the species, location, timing duration of exposure, fish condition and migration readiness.

The Hatchery Scientific Review Group reviewed literature addressing acclimation effects on hatchery fish survival and adult straying. They concluded acclimation increased homing fidelity but results were mixed for increased survival (HSRG 2004).

A major acclimation issue for the SJRRP will be stream temperature at any acclimation site. During critical flow years, stream temperatures will likely exceed 20° C, which would result in relatively high mortality on fish held for any substantial length of time. For example, Baker et al. 1994 found that as temperatures exceed this level, juvenile mortality exceeded 50 percent. The U.S. Army Corps of Engineers (Corps) uses 20° C as the temperature that triggers special handling protocols to reduce stress levels on fish collected and transported on the Columbia River (USACE 2011).

For this analysis, it is assumed an acclimation facility will not be required for the program. Fish captured at the collection points are expected to have spent sufficient time in river to imprint to the system and therefore exhibit high homing fidelity. If a trap-and-haul system is built in the future, studies quantifying stray rates can be used to determine the need for acclimation facilities.

3.6 Stream Flow

Stream flow by date and water year type is shown in Table 4. The data indicate flows in the San Joaquin River will be less than 1,000 cfs when juveniles are expected to migrate from the system (i.e., October to May). Flows may exceed 1,000 cfs in March for non-wet water years[7]. In Normal-Wet and Wet water years, flows can exceed 1,500 cfs from February 16th to June 30th.

The largest screening systems presented in this report have been designed to handle a flow of 1,000 cfs. It is assumed that at flows higher than 1,000 cfs, river conditions are adequate for juvenile migration and a trap-and-haul system would not be required.

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[7] For Critical (High and Low) and Dry water years, river flow in March is set at 1,500 cfs. This flow is designed to attract upstream migrating adults and stimulate juvenile migration. If a trap-and-haul system is implemented, peak flow may need to be reduced to 1,000 cfs to maximize juvenile collection.

Table 4. San Joaquin River flow (cfs) by date and water year type.

Date	Water Year Type[8] and Discharge (cfs)					
	Critical Low	Critical High	Dry	Normal Dry	Normal Wet	Wet
10/1-10/31	160	160	350	350	350	350
11/1-11/6	130	400	700	700	700	700
11/7-11/10	120	120	700	700	700	700
11/11-12/31	120	120	350	350	350	350
1/1-2/28	100	110	350	350	350	350
3/1-3/15	130	500	500	500	500	500
3/16-3/31	130	1500	1500	1500	1500	1500
4/1-4/15	150	200	350	2500	2500	2500
4/16-4/30	150	200	350	350	4000	4000
5/1-6/30	190	215	350	350	350	2000
7/1-8/31	230	255	350	350	350	350
9/1-9/30	210	260	350	350	350	350

Source: FMP 2010- Appendix E

3.7 Stream Temperature

3.7.1 Temperature Criteria

Optimal, critical and lethal stream temperatures for spring-run and fall-run Chinook salmon are presented in Figure 2 for the Central Valley (SJRRP 2011). Optimal migration conditions for juvenile Chinook have stream temperatures less than 15.6°C. As stream temperatures increase into the critical range (18-21°C), juvenile survival decreases because of multiple inter-related factors (Baker et al. 1994). Temperatures above 23.9°C are lethal to juvenile Chinook exposed to this temperature for prolonged periods (i.e., days).

Mortality associated with collecting, handling and transporting juvenile Chinook when temperatures reach critical levels will reduce the survival rates for these fish. From a survival standpoint, the trap-and-haul program ideally would cease operations when stream temperatures reach the upper end of the critical range (21.1°C).

The decision to cease trapping operations due to temperature concerns would depend on the expected survival rates for the two migration routes: transport versus in-river. If at higher stream temperatures in-river migrants have lower survival rates than transported fish, then the trapping program could be maintained as it provides a survival benefit to the population.

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[8] The wettest 20% of the 83-year period of record is classified as “Wet.” In order of descending wetness, the next 30% of years are classified as “Normal-Wet,” the next 30% of years are classified as “Normal-Dry,” and the next 15% of years are classified as “Dry.” The remaining 5% of years are classified as “critical.” A subset of the critical years, those with less than 400,000 acre-feet (TAF) of unimpaired runoff, are classified as “Critical-Low”; the remaining critical years are classified as “Critical-High.”

3.7.2 San Joaquin River Temperatures

Stream temperatures in the San Joaquin River will vary over time and influence by river reach, month, river flow, ambient air temperature and the effectiveness of future habitat actions in the restoration area. Stream temperature data collected for various reaches since 2009 is available on the San Joaquin River Restoration Program web site.

(http://restoresjr.net/flows/Water%20Quality/index.html)

These data and results of stream temperature modeling (SJRRP 2008) indicate water temperatures near the areas where fish collection facilities are proposed (see Section 5) would be classified as optimal (i.e., < 15.6°C or 60°F) for juvenile migration from mid-November to early April in most years. Stream temperatures classified as critical (18-21°C or 64.4-70°F) for juvenile migrants may occur starting in late April and may reach lethal levels as early as May/June. Temperatures in the fall drop back to the critical range sometime in October, depending on river flow, ambient air temperature, etc.

A comparison of the juvenile migration timing and stream temperature data shows there is substantial overlap in the two parameters. Thus, both the biology of the species and river environmental conditions indicate an effective trap-and-haul system may be possible in the San Joaquin River.

3.8 Fish Sorting and Marking

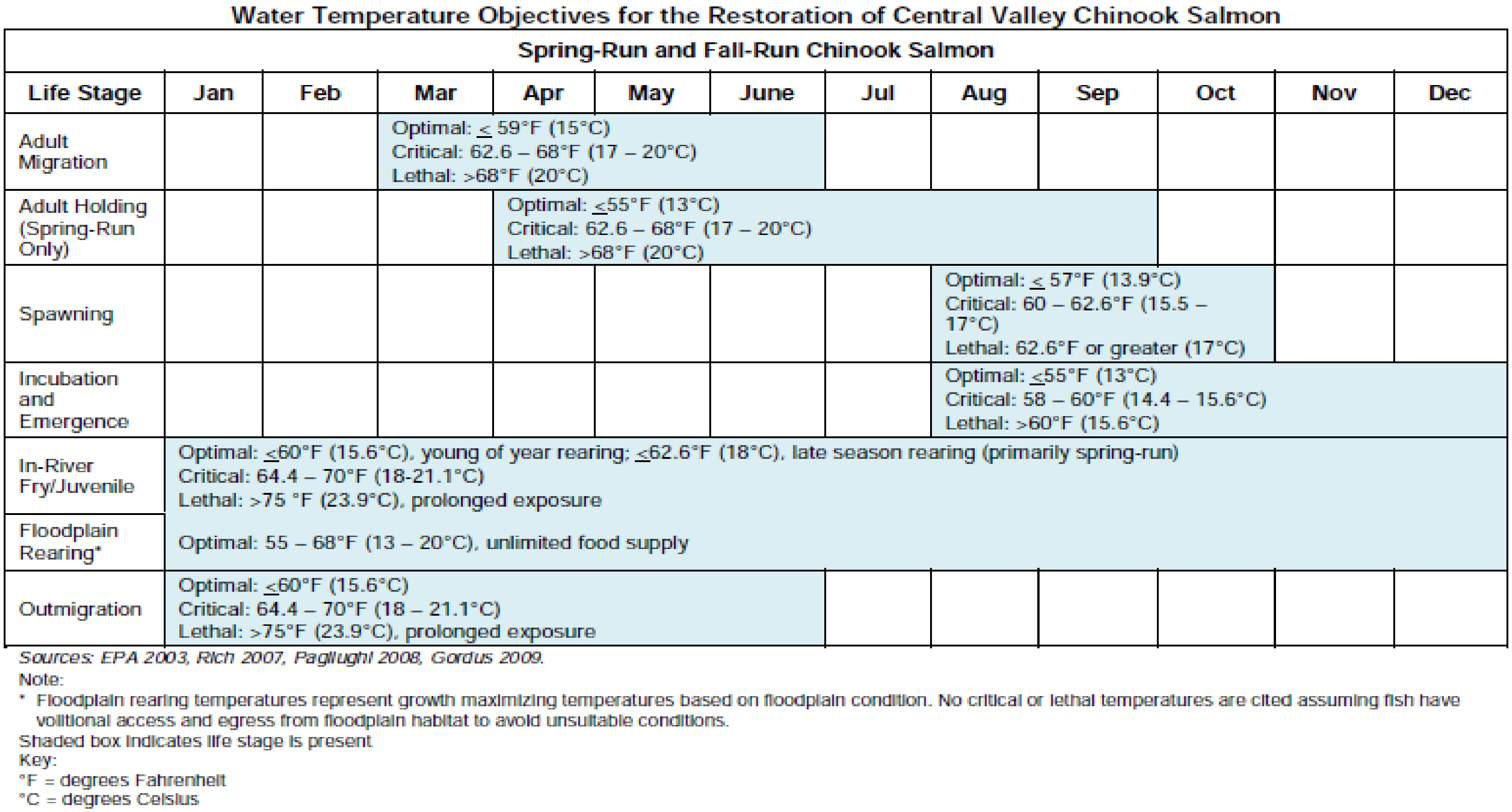
In designing a trap-and-haul system, consideration should be given to whether the facility must:

- Separate smaller from larger fish:
  Mixing large and small fish into the transport system may result in predation loss and increased stress levels.

- Remove non-target species from the system:
  Non-target species such as bass may be captured along with the juvenile Chinook. Bass may prey on the Chinook juveniles and also increase their stress levels which will reduce the effectiveness of the system. In addition, a decision is needed about the fate of captured fish by species (i.e., transport, return to the river, etc.)

- Provide facilities to sample and mark fish:
  Juvenile sampling facilities provide the ability to conduct biological evaluations on survival, abundance, stray rates and contribution to harvest, etc.

For the larger screening system alternatives described in Section 5, it is assumed that fish will need to be sorted by size. A full-scale juvenile sorting facility is not proposed under the assumption that fish handling increases stress and mortality rates on the collected population; especially during low flow years when stream temperatures will be within or above the critical range. However, costs for a full-scale juvenile sorting facility are provided in the report should fish sampling and marking be required.



Water Temperature Objectives for the Restoration of Central Valley Chinook Salmon

<table>
<tr><th colspan="13">Spring-Run and Fall-Run Chinook Salmon</th></tr>
<tr><th>Life Stage</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>June</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td>Adult Migration</td><td></td><td></td><td colspan="4">Optimal: ≤ 59°F (15°C)
Critical: 62.6 – 68°F (17 – 20°C)
Lethal: >68°F (20°C)</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Adult Holding (Spring-Run Only)</td><td></td><td></td><td></td><td colspan="6">Optimal: ≤55°F (13°C)
Critical: 62.6 – 68°F (17 – 20°C)
Lethal: >68°F (20°C)</td><td></td><td></td><td></td></tr>
<tr><td>Spawning</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Optimal: ≤ 57°F (13.9°C)
Critical: 60 – 62.6°F (15.5 – 17°C)
Lethal: 62.6°F or greater (17°C)</td><td></td><td></td></tr>
<tr><td>Incubation and Emergence</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="5">Optimal: ≤55°F (13°C)
Critical: 58 – 60°F (14.4 – 15.6°C)
Lethal: >60°F (15.6°C)</td></tr>
<tr><td>In-River Fry/Juvenile</td><td colspan="12">Optimal: ≤60°F (15.6°C), young of year rearing; ≤62.6°F (18°C), late season rearing (primarily spring-run)
Critical: 64.4 – 70°F (18-21.1°C)
Lethal: >75 °F (23.9°C), prolonged exposure</td></tr>
<tr><td>Floodplain Rearing*</td><td colspan="12">Optimal: 55 – 68°F (13 – 20°C), unlimited food supply</td></tr>
<tr><td>Outmigration</td><td colspan="6">Optimal: ≤60°F (15.6°C)
Critical: 64.4 – 70°F (18 – 21.1°C)
Lethal: >75°F (23.9°C), prolonged exposure</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Sources: EPA 2003, Rich 2007, Pagliughi 2008, Gordus 2009.

Note:

* Floodplain rearing temperatures represent growth maximizing temperatures based on floodplain condition. No critical or lethal temperatures are cited assuming fish have volitional access and egress from floodplain habitat to avoid unsuitable conditions.

Shaded box indicates life stage is present

Key:

°F = degrees Fahrenheit

°C = degrees Celsius

Source: SJRRP 2011

Figure 2. Optimal, critical and lethal temperature values for Central Valley spring-run and fall-run Chinook

3.9 Adult Passage

It is assumed adult passage facilities or bypass would be required for all screening alternatives that completely block the river. Based on this assumption, cost estimates for a facility are provided to assist managers in decision making.

The decision to construct adult passage facilities will depend on the environmental conditions in which the screening systems will operate. If the systems are only operated during low flow years, adults could be trapped at sites downstream of the screen and transported to spawning areas near Friant Dam[9]. This action would alleviate the need to provide adult passage at the screen site.

3.10 Biological Design Criteria

Biological design criteria and rationale for the trap-and-haul system are provided in Table 5 and are based on the data described above.

4.0 Review of Existing Technology and Programs

This section describes portable and stationary collection systems that have been used by others to collect juvenile salmonids.

4.1 Portable Systems

Researchers have used a variety of small portable traps to collect juvenile salmonids to achieve a range of research and management objectives. Such trapping systems include screw traps, Merwin traps, self-cleaning scoop or inclined screen traps, and migrant dippers. These traps have all been used to collect juvenile salmonids in free-flowing rivers and impoundments with varying success (Raymond and Collins 1975). (http://www.fao.org/docrep/003/AA043B/AA043B10.htm).

Protocols for operating juvenile traps can be found in Volkhardt et al. (2008), Conlin and Tutty (1979) and Magnus et al. (2006).

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[9] Adults could be trapped and hauled above the screen site in any year; however it would be inconsistent with the objectives of the Settlement. An exception for low flow years could be a reasonable compromise in regards to construction costs.

Table 5. Biological design criteria for the trap-and-haul system for the San Joaquin River.

Parameter	Criteria	Rationale
Juvenile Collection Targets		
Target 1	44,000 spring-run and 63,000 fall-run juveniles	The minimum number of juveniles required to produce 500 adults of each run
Target 2	132,000 spring-run and 189,000 fall-run juveniles	The minimum number of juveniles required to produce 2,500 adults of each Chinook run
Target 3	1.575 million spring-run and 0.750 million fall-run juveniles	The minimum number of juveniles required to produce 30,000 spring-run and 10,000 fall-run Chinook adults
Location	Downstream of known Chinook spawning habitat; Upstream of the Mendota Pool	Locating facilities downstream of spawning areas ensures: 1) the entire juvenile population may be collected, and 2) reduces the probability of encountering large numbers of emergent fry. Juvenile fish survival rate through Mendota Pool is expected to be low.
Period of Operation	October 15 -May 15 (peak period January-May)	Likely time period for juvenile spring-run and fall-run Chinook migration; with the majority of fish migrating from January to May.
Temperature Restriction	Operations cease when stream temperatures exceed 21° C	Temperatures above this level are likely to result in substantial mortality to collected fish (Baker et al. 1994).
Sorting Requirements	Sort by size only (< 60 mm, and > 60 mm)	Reduces stress and predation rates on juvenile Chinook. Assume marking facilities will not be required because they increase stress and mortality rates on juvenile Chinook, especially when operated under high stream temperatures. Screens would be used to sort Chinook into two size classes, fry (< 60 mm) and subyearlings/yearlings (> 60 mm) to reduce predation and stress levels during holding and transport. Screens/bars would also be provided to remove fish greater than 200 mm.

Parameter	Criteria	Rationale
Juvenile Collection Targets		
Collection and Transport Survival Rate	Stationary Systems- 98% Portable Systems- > 90%	Stationary systems will be designed to achieve NMFS fry or yearling criteria; therefore, survival rates are expected to be high (NMFS 2011). Portable systems will incur more mortality as a result of violation of NMFS design criteria and handling required to transfer fish from the collectors to the transport truck.
Release Location	Highway 165 Bridge	Current release site for SJRRP juveniles
Acclimation	None	May be added in the future
Adult Straying to Other Basins	<5 percent	Stray rates above this level may result in detrimental genetic impacts to other Chinook populations in the Central Valley (California HSRG 2012).
Adult Passage	Yes	Adult passage facilities will be required to allow spring Chinook adults to volitionally migrate through the system.

According to United States Army Corps of Engineers (USACE 2010):

> *"The major advantages of using small traps for fish sampling is their low cost, portability, ability to collect fish in free-flowing and slack water environments and simple mechanics which do not require highly trained field crews and costly support facilities to operate. The disadvantage of these traps has generally been low juvenile fish collection efficiency, inability to operate during high flows when the majority of migrants may be present and high risk of trap damage due to debris entering the trap."*

Descriptions of these portable traps and their effectiveness in collecting juvenile salmonids are presented below.

4.1.1 Screw Traps

Screw traps are rotating collection systems used in monitoring programs to catch juvenile fish in a riverine environment (http://fishbio.com/rotary-screw-trap-2). They are used extensively in the United States to sample juvenile salmonids migrating from rearing areas to the ocean (Figure 3). Screw traps require a water velocity greater than 1.5 foot/sec to turn the screw (or cone) that collects fish from the river (Figure 3).

A literature review of screw trap operations and fish trapping efficiency in primarily California rivers was completed in 2003 (SWRI 2003). The authors of this report summarized the trapping efficiency for a single screw trap, multiple screw traps and screw traps combined with some sort of guidance device (see Table 1 in SWRI 2003). In general, fish trap efficiency for these systems was less than 5 percent but with some traps showing up to 48 percent collection efficiency. The authors suggested higher trapping efficiencies may have been due to how efficiency was estimated, operational flow levels, or as a result of using guidance devices to lead fish to the trap entrance. Guidance devices were effective at increasing trapping efficiency, although could exhibit problems such as impingement of fish and debris on the devices, which likely increased fish mortality and system maintenance.

Another example of high trapping efficiency for a screw trap was documented in western Washington. The Lewis River screw trap operated during low summer flows (<1,000 cfs) and was able to capture between 10 and 40 percent of juvenile coho, Chinook and steelhead entering Swift Reservoir (PacifiCorp 2005). The length of the fish collected ranged from 30-190 mm; however, during higher flows, the trap was susceptible to debris problems that made it inoperable during peak juvenile migration periods. Therefore, the ability of such a system to collect a substantial portion of the entire juvenile migration was lower than what was estimated through mark recapture studies.

As flows increase, trapping efficiency for screw traps generally decreases (Pyper and Justice 2006). Other variables that may affect the screw trap efficiency include trap size, fish species, fish size, stream width, stream depth, water turbidity, water velocity and noise.

Data collected in the Okanogan River (in northeastern Washington) indicated fish mortality from screw trap operation ranged from 0.5 to 4.43 percent for juvenile summer/fall Chinook. The average mortality rate for Chinook smolts captured with the 8-foot and 5-foot screw traps was 4.43 and 0.54 percent, respectively (Colville Tribes 2008). The mortality rate observed in this study for the 5-foot trap was similar to that described for salmonids captured in Upper Redwood Creek from 2000-2012 (Sparkman 2013).

Source: Taylor 2010

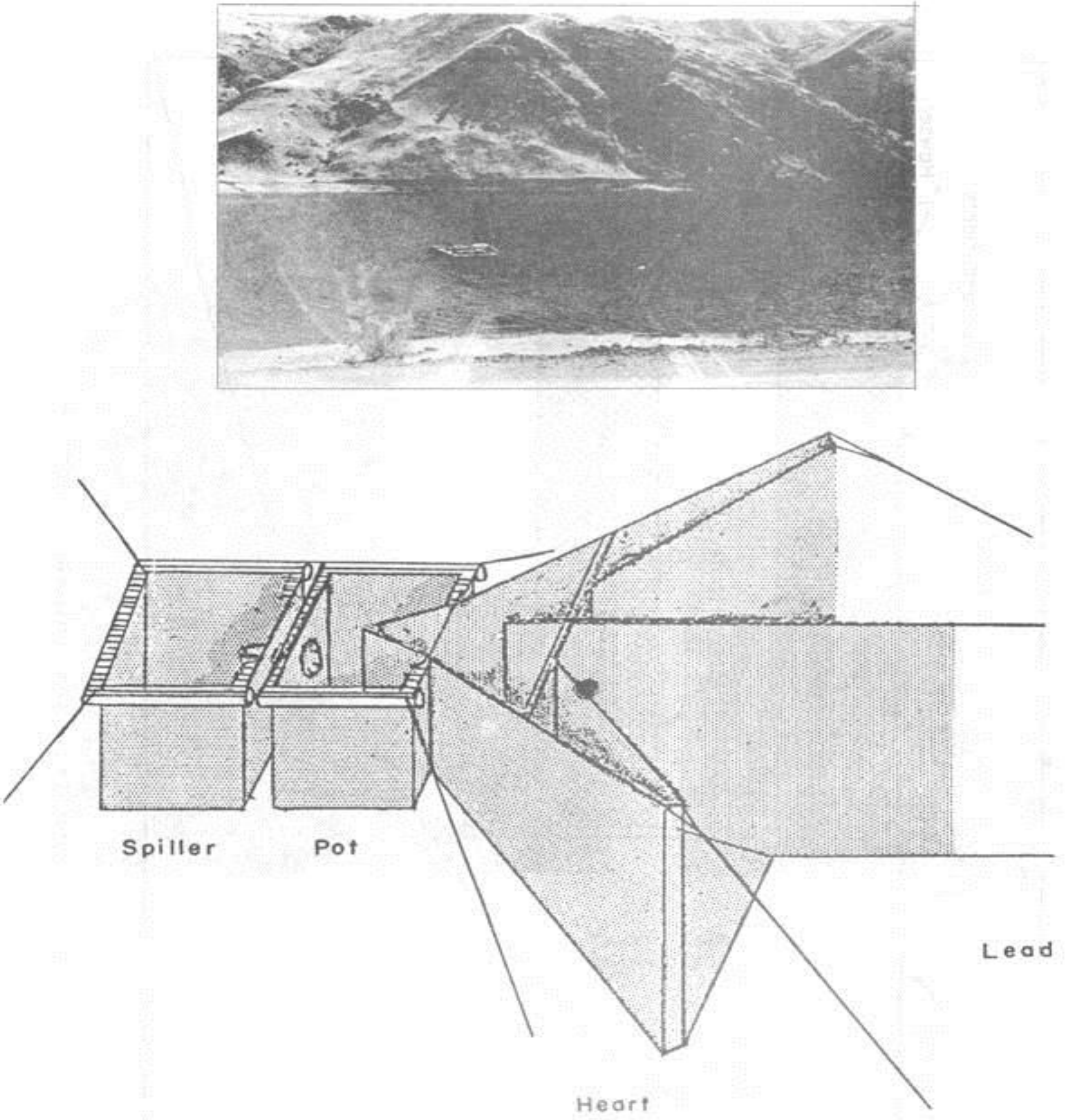
Figure 3. Screw trap being fished below Lookout Point Dam in 2009.

4.1.2 Merwin Traps

A Merwin trap is a floating system that uses long net leads to guide fish to the trap (Figure 4). It is generally used in low water velocity (< 0.5 ft/sec) areas such as reservoirs and lakes to collect fish migrating near the shore.

Merwin traps were used at Mossyrock Reservoir (Riffe Lake) in the late 1960s and early 1970s to collect juvenile fish for transport and release below Mayfield Dam on the Cowlitz River in Washington (Hager and DeCew 1970). Merwin traps placed at the head of the reservoir and near the dam were used to collect subyearling and yearling Chinook, steelhead and coho, respectively. From 1968 through 1973, yearly catches ranged from 11,000 to 321,000 juvenile salmonids, with the vast majority being coho. No direct estimates of fish collection efficiency were made for the traps at this project. The system was abandoned as the resource agency did not feel sufficient numbers of fish were collected to maintain the run over time.

At Merwin Dam on the Lewis River, researchers tested a Merwin trap with leads and a gulper (water attraction) in Lake Merwin. Collection efficiency of the system was estimated at 74 percent for yearling coho (Allen and Rothfus 1976). The system was abandoned when mitigation for project impacts was changed to hatchery production.



Source: Reproduced from Raymond and Collins 1975.

Figure 4. Example of Merwin Trap.

4.1.3 Scoop Traps

Self-cleaning scoop traps can be used in riverine environments where water velocity is higher than 3 feet/sec and depth greater than 5 feet (Figure 5). A set of traveling screens are used to remove debris entering the trap. Net leads (or louvers) can be used to guide fish to the scoop, thereby increasing fish capture efficiency. According to Raymond and Collins (1975), fish trapping efficiency has ranged from 3 to 15 percent.

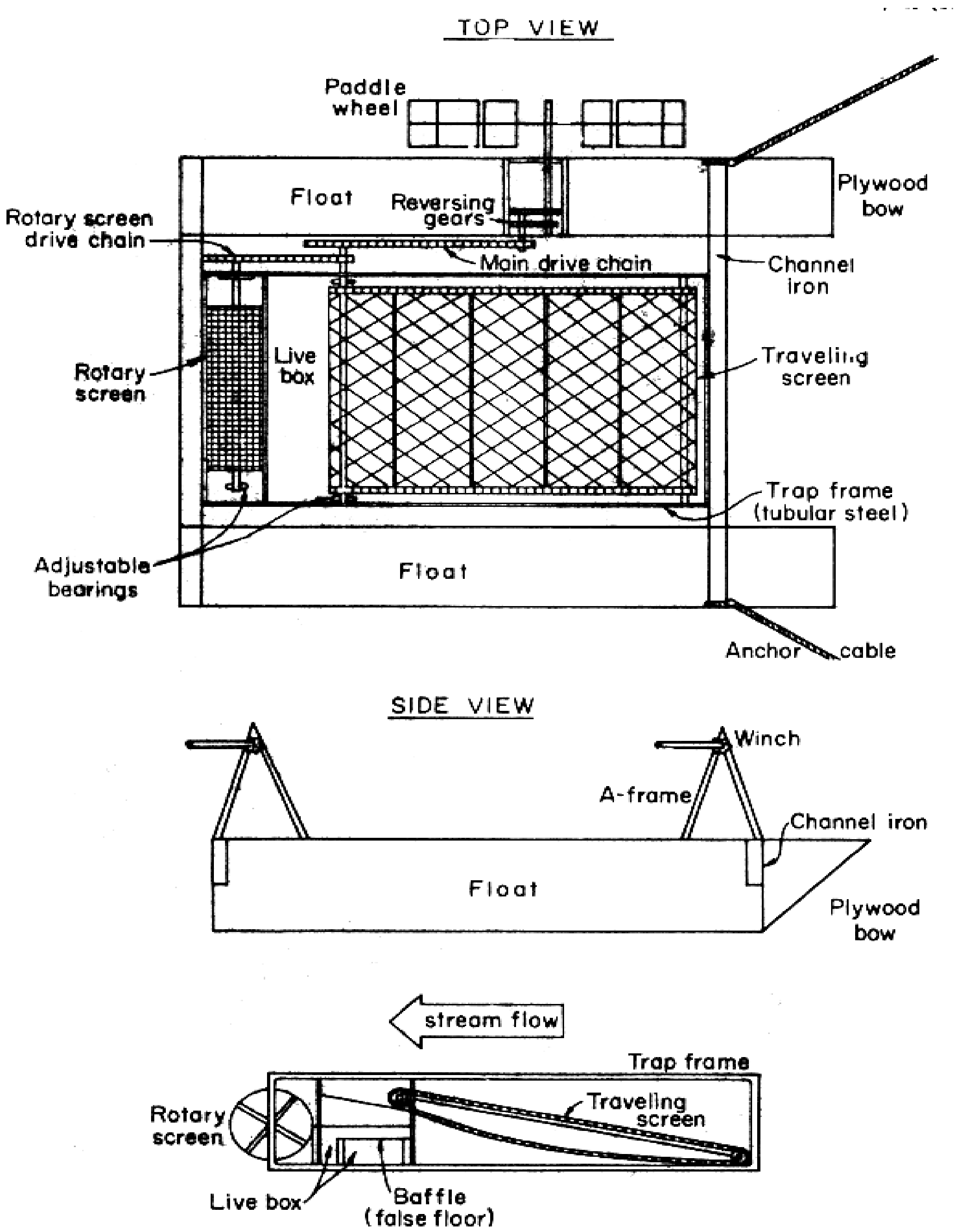
4.1.4 Dippers

A dipper trap is similar to a screw trap, as it uses a continuously rotating scoop to remove fish from the water and transfer them to a trough. The trap works best in riverine environments where flows are less than 3 feet/sec (Figure 6). Debris can be an issue for the trap and for that reason, some dippers incorporate traveling screens to move accumulated debris to the downstream end of the trap where it is removed.

Data collected on Eagle Creek in Idaho on a dipper trap equipped with a louver system (Figure 7) showed 14 to 91 percent of marked fish were recaptured in the system. Average collection efficiency was greater than 50 percent, and appeared to be higher in the fall when flows were lower. Louver angle affected the size of fish actually collected in the trap, with a 10-15 degree angle working the best for all size classes (mostly greater than 53 mm) (Krcma and Raleigh 1970).

4.1.5 Inclined Screen Traps

An inclined-screen trap is similar to a scoop trap. The trap consists of an inclined structure that extends into the water and leads fish to a live box(es) trap. The system can be fished in shallow or deep water; depending on the size (length) of the inclined ramp. Todd (1994) reported trapping efficiencies up to 12 percent for sockeye juveniles.



Source: Reproduced from Raymond and Collins 1975

Figure 5. Self-cleaning scoop trap.

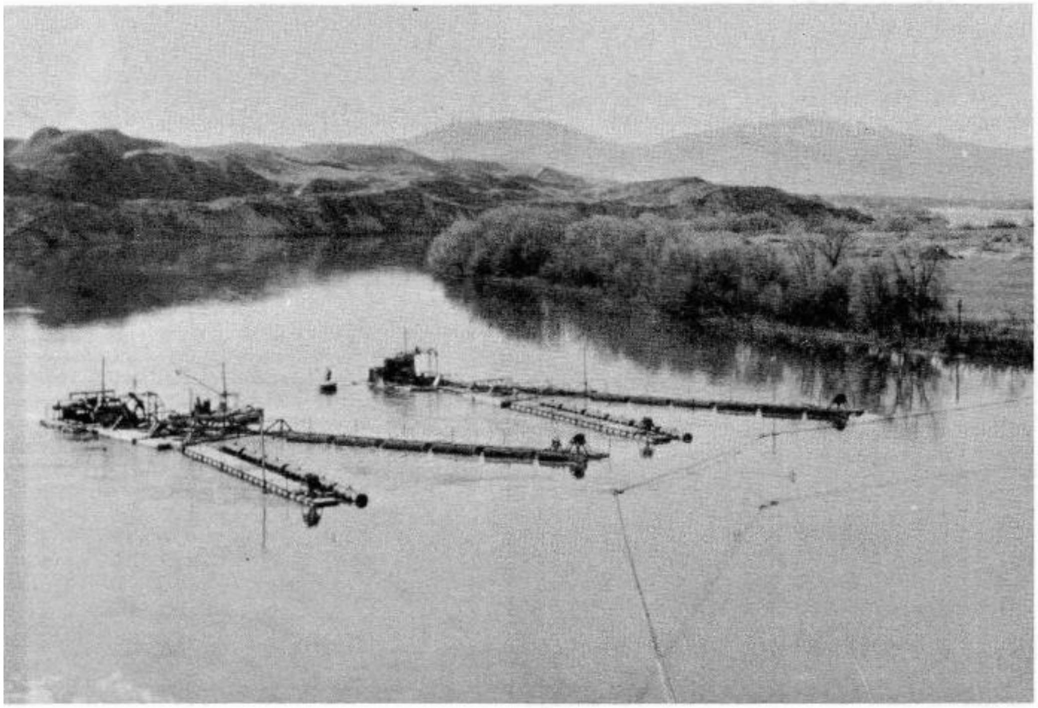


Figure 6. Migrant dipper traps being operated in the Snake River (reproduced from Krcma and Raleigh 1970).

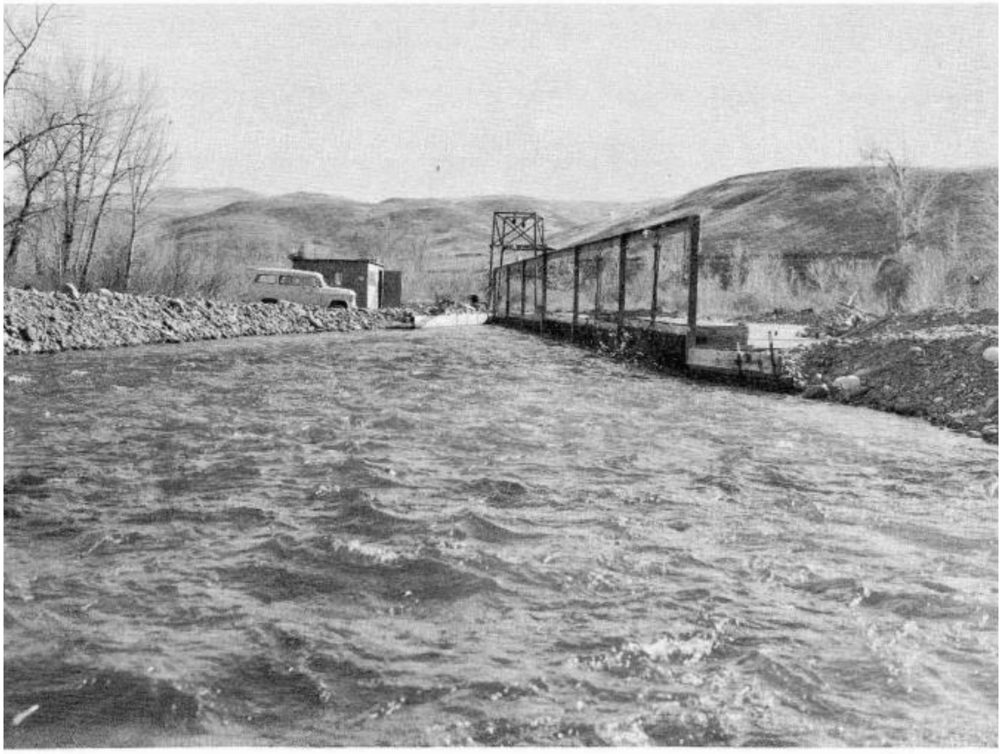


Figure 7. Stationary louver array used at Eagle Creek, Idaho (reproduced from Krcma and Raleigh 1970).

4.1.6 Beach Seining

Beach seines are used on the Hanford Reach of the Columbia River to collect wild fish for tagging (Fryer 2013). The program collects up to 200,000 juvenile fall Chinook each year. Fish are collected from the river using a 36.6-meter-long and 3.0-meter-deep beach seine (mesh size of 4.8 mm). The collected fish are transported to a marking site, marked and then released back to the river. Sampling generally occurs over a two week period in May and June.

Fish mortality from seining operations from 1987-2013 was generally less than 5 percent. However, mortality rates have been as high as 20 percent due to high stream temperatures, use of inexperienced crews and primitive facilities.

Flows during tagging generally exceeded 100,000 cfs; therefore, stream depth was sufficient to operate large jet sleds for moving fish, people and gear. For the shallow San Joaquin River, shallow-draft Alaskan style airboats would likely be required to move collected fish to pick up and transport points.

(http://www.diamondbackairboats.com/airboats/alaskan.htm).

4.2 Stationary Systems

Permanently installed systems require engineered infrastructure and more technically trained operations staff than portable systems. Both in-line and off-line trapping systems are described below. Stationary fish screening devices are non-moveable systems that generally require substantial infrastructure to build and operate. These types of screening systems are referred to as positive barrier screens and include:

- Flat Plate
- Drum Screens
- Cylindrical Screens
- Travelling Screens

The systems may also include ancillary devices (inflatable rubber dams, weirs, etc.) that divert fish and/or flow from the river channel to the stationary screening system. These types of devices allow the screening facility to be built outside of the natural river channel.

A thorough review of typical stationary screening systems was completed by the Bureau of Reclamation (BOR) in 2006 (BOR 2006). The BOR report provides detailed information on:

- Design
- Siting Options
- Debris and Sediment Loading
- Fish Predation
- Operation and Maintenance

- Capital Cost
- Advantages/Disadvantages
- Selection of a Preferred System

For this analysis we use the data provided by the BOR and others to briefly describe some of the systems that could be used on the San Joaquin River.

4.2.1 Flat Plate Screens

These types of systems use flat plate screening material to separate fish from flow. The screens are placed in either a diagonal or V-shape configuration in the river channel or off-channel canal (Figure 8). Fish are guided into a bypass system where they may be sampled, placed into trucks and barges for transport or returned to the river. Flat plate screens designed to achieve NMFS design criteria have been built for flows ranging from less than a 100 cfs to approximately 3,000 cfs (BOR 2006).

The effectiveness of the flat plate system to collect and safely remove fish from the water is very high (upwards of 98 percent survival) (NMFS 2011). Fish mortality generally results from fish being impinged on screening surfaces, descaled from debris build up that alters screen hydraulics, handling due to fish sampling/transport and predation near the point where fish are returned to the river (NMFS 2012).

Fish collection efficiency depends on the total amount of river flow that can be screened. The system is generally designed to effectively operate over the mean daily average flow corresponding to the 5 percent (high flow design) and 95 percent (low flow design) of the time when fish are present (NMFS 2011).

Source: BOR 2006

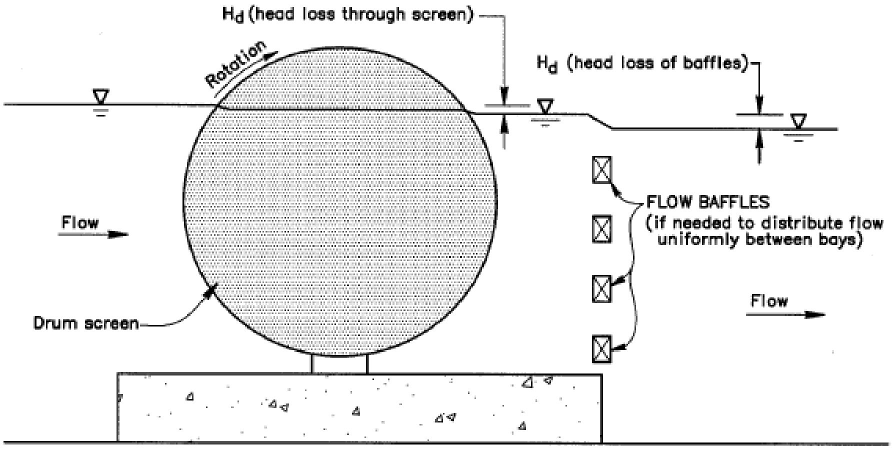
Figure 8. Flat plate V-screen with terminal fish bypass at Red Bluff, California.

4.2.2 Drum Screens

As the name implies, drum screens are cylindrical-shaped structures covered with a fine mesh screen (Figure 9). The screens are cleaned by turning the drum slowly over time, an approach that is very effective at keeping screens clean and thus ensuring they operate as designed.

Like flat plate screening systems, the drums are angled across the river flow to provide sufficient sweeping velocity to achieve NMFS design criteria. According to the BOR (2006), drum screen systems have been effective at screening flows from a few cfs to over 3,000 cfs. A review of the hydraulic performance of this type of system can be found in Vucelick et al. (2004).

Fish mortality and descaling rates for drum screens have both generally averaged less than 5 percent (Neitzel et al. 1985). Fish collection efficiency has been shown to be greater than 90 percent for juvenile salmonids (Neitzel et al. 1990a and 1990b). Collection efficiency for salmonid fry is lower, but generally greater than 85 percent.



Source: BOR 2006

Figure 9. Drum screen sectional view.

4.2.3 Cylindrical Screens

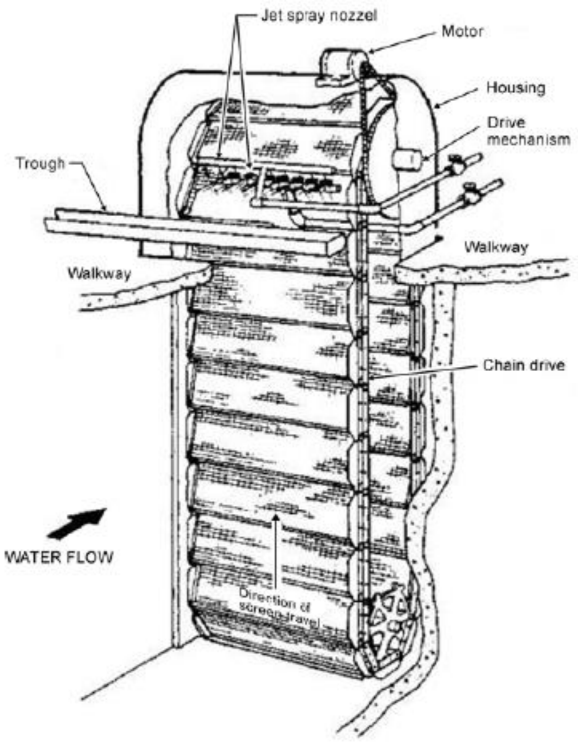
Cylindrical screens are generally used to prevent entrainment of juvenile and adult fish into irrigation pumping systems. They are attached to the submerged pump intake and can be constructed to be self-cleaning. Because fish are excluded from entering the screen structure, they cannot be used to collect fish and are not applicable to this analysis.

4.2.4 Travelling Screens

Travelling screens are submerged systems sited vertically or angled into the flow entering a turbine or water inlet of some type (Figure 10). They are also used as a secondary dewatering system to remove the fish from the flow entering a larger screening system.

Because the screens "travel" (i.e., move), they have excellent debris handling capability. They have been used extensively for irrigation diversions (BOR 2006) and at mainstem dams on the Columbia River (Ledgerwood et al. 1988).

The fish collection efficiency of travelling screen systems depends primarily on the percent of the total flow entering the water intake that is being screened, with a higher percentage equating to higher fish collection efficiency. Fish descaling rates have generally been less than 5 percent but can vary by species and fish size (Ledgerwood et al. 1988).



Source: BOR 2006, EPRI 1986

Figure 10. Vertical Travelling Screen

4.3 On-going Trap-and-Haul Programs

The world's largest juvenile salmon trap-and-haul program is operated on the Columbia River. Millions of juvenile Chinook, sockeye and steelhead are collected at mainstem dams and transported by barge (or truck) and released (without acclimation) hundreds of miles downstream below Bonneville Dam (www.fpc.org). In addition, smaller trap-and-haul systems are operated in the Deschutes River (Oregon), Cowlitz Falls (Washington) and Baker River (Washington).

The Columbia River trap-and-haul system has been intensively studied for over 40 years (www.fpc.org). In general, the system has been shown to produce equal or better survival rates compared to in-river migration for most species in the majority of water years. In low water years, with higher stream temperatures, transported fish generally survive at much higher rates than in-river migrants.

Based on Columbia River transport studies, researchers have identified the following problems with a trap-and-haul system:

- Adults transported as juveniles have higher stray rates than fish that migrated in river.
- There appears to be delayed mortality associated with transported fish.
- Riverine conditions have a large effect on the success of the transportation program.
- The act of transportation may be placing selective pressures on the species that are not well understood.

To reduce concerns about selective pressures on the species due to transport, a spread-the-risk policy is in place in the Columbia River wherein a large portion of the juvenile migrants are allowed to migrate in-river. Detailed reviews of the transportation program can be found in Tuomikoski et al. 2013 and at the following web sites:

www.nwcouncil.org/fw/isab
www.FPC.org

Finally, a major lesson learned from the Columbia River system is that a substantial amount of time and resources is required to optimize a trap-and-haul program. The effectiveness of the system can vary by month, river discharge, temperature, fish condition and species.

5.0 Application to San Joaquin River

This section provides design criteria, describes site visit observations at potential San Joaquin River trapping sites, potential screening methods, and provides conceptual designs and an estimated range of magnitude costs for future capital construction and monthly operations and maintenance (see Table 8 below). Sections 5.5 through 5.10 summarize assessments of fixed structures; Section 5.11 summarizes potential applications of portable systems.

5.1 Design and Site Selection Criteria

As noted in Section 3, the trapping facility will be operated during the juvenile out-migration period, which generally corresponds to the spring run-off period. Flows during this period are illustrated in Table 4 above. The trapping facility will be located at a selected site, downstream of the primary spawning habitat. This reach of the river is low gradient and is expected to have relatively moderate debris and sedimentation issues. In addition to the biological criteria discussed above, hydraulic, hydrologic and site selection criteria have been developed.

5.1.1 Hydrologic and Hydraulic Design Criteria

This section presents the general hydrologic and hydraulic design criteria used to define the overall scope of the conceptual alternatives and associated facility components. The biological criteria are presented in Section 3.3. Table 6 illustrates the general hydrologic and hydraulic criteria.

Table 6. General hydrologic and hydraulic criteria.

Criteria	Unit	Value	Comment
Design flow range for juvenile collection	cfs	150-1,000	See Table 4
Trap Efficiency	percent	100	Target per USFWS
Approach velocity	fps	0.4	Fry criterion for screens with cleaning system (CDFW[1]).
Sweeping velocity	fps	>0.4	Greater than approach velocity.
Screen opening size	inches	0.069	Slotted openings shall not exceed 1.75 mm in the narrow direction, or 3/32-inch for round and square openings per CDFW [1]
Minimum screen porosity	percent	27	The percent open for any screen material must be at least 27%, per NMFS 2011, 11.7.1.6
Floodplain impacts	-	-	No net rise in the 100-year flood profile when building in the floodplain per Executive Order 11988.

[1] http://www.dfg.ca.gov/fish/Resources/Projects/Engin/Engin_ScreenCriteria.asp

5.1.2 Site Selection Criteria

Prior to the evaluations provided in this document, USFWS developed a list of seven potential sites for juvenile fish collection facilities. This pre-screening effort selected sites downstream of the primary spawning habitat (downstream end of restoration reach 1A) and upstream of Mendota Pool (in restoration reach 2B), which is thought to be a major source of delay for downstream migrants (Pers Comm., Michelle Workman, USFWS). Additional site selection criteria were developed to evaluate the potential sites and advance the highest ranking sites most suitable for short-term and long-term trap-and-haul solutions. Other criteria, such as the biological criteria and the hydrology and hydraulic criteria, for the trapping facility to be successful are presented in Tables 5 and 6, respectively. The site selection criteria list includes:

- Access and ownership: Ease of access for operational staff and fish transport vehicles, land use (zoning), and public or private ownership
- Power availability: The proximity of primary power for running bypass pumps and debris management equipment.
- Sediment and debris potential: A rough assessment of potential debris and sediment management issues at each site.
- Boat passage/public safety: Identification of needs for recreational boat passage or portage facilities and public access with related safety and vandalism concerns.
- Disturbance to riparian habitat: Informal assessment of the quality of the existing riparian zone at each potential site.
- Disturbance to river geomorphology: The degree to which the stream channel would need to be altered to accommodate a permanent trapping facility
- Available water depth and velocity
- Flooding potential: Rough assessment of carrying capacity of existing channel for the identified range of flows for trapping facility operations (150 to 1,000 cfs).
- Existing structures: Presence of existing structures that may enhance or detract from site opportunities.
- Other: Distance from spawning habitat, etc.

The results of the site selection analysis are shown in Table 7.

5.2 Site Visits – Existing Conditions

Site visits were conducted on November 14, 2013, by representatives of the USFWS, DJ Warren Associates and McMillen LLC. Seven potential juvenile trapping sites were included in the site visit evaluations as shown on Figure 1. As directed by USFWS, all sites are downstream of the spawning grounds, providing the highest juvenile collection potential and reducing effects on emergent fry. The potential juvenile trapping sites visited were:

- Camp Pashayan (River Mile (RM) 243.2)
- Donny Bridge (RM 240.7)
- Skagg County Park (RM 233.8)
- Emmert Pump Station (RM 229.3)
- Gravelly Ford (RM 229.0)
- Chowchilla Bifurcation Structure (RM 216.0)
- San Mateo Crossing (RM 211.7)

All sites are located in a reach of river that generally flows east to west, with land on the north bank in Madera County (online Assessors information not available) and land on the south bank in Fresno County (online Assessors information available). Each of the sites is briefly discussed below.

5.2.1 Camp Pashayan

This site is in a 31-acre park owned by the San Joaquin River Conservancy and operated by the non-profit River Parkway Trust. It is located just north of Fresno, at the boundary of restoration reach 1a and 1b (RM 243.3). The site is the only adult release location presently used as part of the SJRRP and a screw trap is operated here (Figure 11). It is at the downstream end of the spawning habitat reach and is 22 miles downstream of Friant Dam. The park includes a public boat launch and walking trails along the left bank of the river.

Figure 11. Camp Pashayan – looking upstream at the screw trap site.

Through the park, much of the river is 120 to 140 feet wide, at a very low gradient, with a low bank on the left and higher bank on the right. The screw trap is seasonally placed in a higher velocity reach at the downstream end of the park where the river channel narrows to less than 30 feet, and has a depth of 3 to 4 feet at the 300 cfs flow rate observed during the site visit.

5.2.2 Donny Bridge

This site is on a 140-acre parcel of private land, zoned AE20-Exclusive Agriculture, and was accessed from the south, via dirt roads through private orchards off of Herndon Avenue. The site features an existing 50-foot-long, 15-foot-wide precast concrete bridge deck spanning the San Joaquin River (see Figure 12). The bridge deck is supported by steel pipe columns at 15-foot on center and steel trusses. It appears that fill was placed in the river channel to shorten the bridge span during original construction. Road approaches to the bridge are not maintained and presently are passable only by high clearance off-road vehicles. A BOR low flow and water temperature gaging station located on the bridge reported a flow of 240 cfs at the time of the site visit. The wetted channel of the river was roughly 32 feet wide, with depth of two to three feet on the upstream side, deepening to 4 to 5 feet on the downstream side of the bridge. Flow velocities were 3 to 4 feet per second, with the thalweg transitioning from the left bank to right bank as it passed under the bridge. The stream bottom is generally small cobbles and rounded gravels. A short distance upstream and downstream of the bridge, the river widens to over 150 feet. Velocities correspondingly decline to barely perceptible.

Figure 12. Donny Bridge from left bank

5.2.3 Skaggs Bridge County Park

This site is a large riverfront park owned by Fresno County and is accessed via paved roads on the left bank of the river. Highway 145 crosses the river at a high, 800-foot-long bridge near the upstream end of the park (Figure 13). The left bank is in Mendota County; ownership could not be determined. Vehicle access to the park is prohibited in the winter, but the site is completely accessible to pedestrians year-round. The park is situated at the downstream end of restoration reach 1b, and upstream end of reach 2a.

The stream banks are low with gravel bars at least 200 feet wide throughout the park reach (Figure 13). Flows were approximately 240 cfs in Figure 13. Much of the gravel bar appeared to have been inundated during the 1,200 cfs pulsed release conducted in late October 2013. Stream depths and velocities vary widely, with shallow gravelly riffles, and deeper slow pools.

Figure 13. Skaggs Bridge County Park from left bank at Highway 145

5.2.4 Gravelly Ford/Emmert Pump Station

This location features two potential trapping sites about 1/3 mile apart. The Gravelly Ford site is accessed from the south, via 1.5 miles of dirt road through private orchards off of the paved West Ashlan Road. The left bank of the river through this reach is part of a 525 acre parcel of private land zoned AE20 Exclusive Agricultural. The stream channel at Gravelly Ford is a relatively narrow section of the river (Figure 14). There are passive integrated transponder (PIT) antennae on both banks for detecting migrating fish. It also has a BOR gaging station that is a key monitoring point for maintaining instream flows related to Friant Dam releases. The left bank rises quickly above the floodplain, and there is a 400-foot-wide brushy floodplain along the right bank. A side channel in the right bank floodway conveys approximately 50 cfs when river flows reach 1,060 cfs (Pers. Comm., M. Workman, USFWS). There is a shallow, 30-foot-wide riffle section just downstream of the PIT arrays identified as a potential trapping site by USFWS (Figure 14).

Figure 14. Gravelly Ford riffle from left bank

Five hundred yards upstream of Gravelly Ford is concrete pump station on the right bank that is owned by Gravelly Ford West Ranch and operated by a cooperating land owner, Steve Emmert. Vehicle access is available only from the right bank, via dirt roads through the Emmert ranch. At this location, the right bank is high and there is a 400-foot-wide, brushy floodplain along the left bank. At the pump station, the stream channel is approximately 100 feet wide and 3 to 5 feet deep at the right bank thalweg. The stream velocity is very low. The land owner suggests that the existing pump station could provide an anchor point for a potential trapping facility with vehicle access through private orchards from the north. Significant road improvements across the floodplain would be required to reach this site from the south.

Figure 15. Emmert Pump Station from the left bank

5.2.5 Chowchilla Bifurcation Structures

The Chowchilla facility is owned and operated by the Bureau of Reclamation and consists of two nearly identical dams designed to work in tandem to divert flood flows from the San Joaquin River channel into a 22-mile-long bypass channel. Each dam is approximately 80 feet wide, with 18-foot-wide gates that can be raised or lowered as needed to control flood events. Normally the gates on the main river structure are open and the bypass channel gates are closed. Vehicle access to the site is controlled by fencing, barriers, and locked gates.

The dam on the main river has been identified as a likely trapping site. The upstream face of the dam is protected by a trash rack with vertical steel bars. There is a flared concrete apron with tapering wing walls on the downstream side (see Figure 16). A 95-foot-long fixed concrete weir on the downstream apron equalizes flow through the dam gate and trash rack openings. The pool upstream of the dam is dredged annually to remove accumulated sediment. A rudimentary boat ramp on the left bank below the dam is used by USFWS staff to access monitoring equipment installed a short distance downstream.

A small maintenance facility is located between the two dams to the north of the river channel. It includes back-up power and related fuel storage and sediment removal equipment.

Figure 16. On-river portion of the Chowchilla Bifurcation Structure from the left bank

5.2.6 San Mateo Crossing

San Mateo Road crosses the San Joaquin River at this location (Figure 1). The crossing is a poorly maintained gravel road spanning the 300-foot-wide river channel, with the river routed under the road through an 8-foot-diameter steel pipe culvert (see Figure 17). The site is fully accessible to the public via San Mateo Road. Although the road is rough, it provides the only crossing point for many miles and is used regularly by local traffic. Land on the left bank is part of a 263-acre parcel of private land, zoned AE20 Exclusive Agricultural. The road is inundated at moderate flows when the hydraulic capacity of the culvert is exceeded. During the October 2013 pulsed flow event, releases of 1,200 cfs made the road impassable; it was in the process of being re-opened to traffic at the time of the site visit.

The river channel is shallow and braided on the upstream side of the crossing, featuring small islands and trees in the middle of the stream. There is a deep, 80-foot-wide pool on the downstream side of the crossing, with a high velocity zone at the road culvert outfall. Overhead power is available approximately 800 feet to the north.

Figure 17. San Mateo Crossing from the left bank

5.3 Site Selection

Each of the potential sites was evaluated using the selection criteria in Section 5.1.2. Table 7 presents the site evaluation.

Table 7. Site evaluation matrix

	Camp Pashayan (RM 243.2)	Donny Bridge (RM 240.7)	Skagg County Park (RM 233.8)	Emmert Pump Station (RM 229.3)	Gravelly Ford (RM 229.0)	Chowchilla Bifurcation Structure (RM 216.0)	San Mateo Crossing (RM 211.7)
Access and Ownership	Rough access road. Owned by Conservation Group	Dirt road access from Herndon Avenue. Privately owned.	Paved access from Hwy 145, but major road construction in floodplain would be required for new facility. County ownership.	Access via dirt road. Private agriculture land	Access via 1.5 miles of dirt road. Private agriculture land	Controlled vehicle access via gravel road. Federal ownership Adjoining parcels private agricultural.	Public right-of-way access via gravel road. Adjoining parcels private agricultural
Power	Power at Hwy. 99 crossing short distance downstream.	No power at the site but available in close proximity.	Overhead power north of site.	Some power at the pump station but would require upsize.	No power at the site but available in close proximity.	Power on site	Overhead power 800 feet north of the site.
Sediment and Debris Potential	Low sediment potential.	Low sediment potential.	River meandering with high potential for sediment and debris.	Low sediment potential.	Low sediment potential.	High sediment potential but with existing annual dredging maintenance.	Some sediment potential.
Public Boat Passage/Public Safety	Public park with a boat launch area just upstream.	No public access, boat passage required, portage feasible.	Public park, boat passage required.	No public access, boat passage required.	No public access, boat passage required.	No public access; boat passage not required now. Portage feasible.	Accessible by public, boat portage feasible.
Disturbance to Riparian Habitat	High potential to disturb riparian habitat.	Some disturbance of riparian habitat in previously affected areas.	Would require significant disturbance of riparian floodplain habitat.	The site has potential for some riparian habitat disturbance.	Would require significant disturbance of riparian floodplain habitat	Limited riparian disturbance in previously affected area required.	Would require significant disturbance of riparian habitat.
Disturbance to River Geomorphology	High	Likely low.	Meandering river reach with high potential for change in geomorphology.	Likely low.	High. Need to address side channel bypass condition at high flows.	Low. Control structure in place.	High due to meandering/braided river channel.
Available Water Depth and Velocity	3 to 4 feet of water depth at 300 cfs. Moderate velocity	About 5 feet of water depth downstream of bridge at 240 cfs. Moderate velocity	Mostly shallow – variable depths and velocities	Deep, very low velocity	3 to 4 feet of depth at 300 cfs. Moderate velocity	Controllable. Deep downstream of apron. Low velocity	Deep pool downstream of culvert. Moderate velocity
Flooding Potential – No Rise Potential	Low right bank. Meeting no-rise criteria may be difficult	Well confined. Meeting no rise criteria may be difficult	Much of the gravel bar gets inundated at high flow. No-rise would be difficult to meet	Low left bank with 400-foot-wide brushy floodplain, possible side channel flow. No rise criteria may be difficult to meet.	Low right bank, 400-foot-wide brushy floodplain and side channel flow at moderate flows. No rise criteria difficult to meet.	Flood control with existing diversion control. No rise controllable	Road bed in floodplain, inundated at high flows. No rise possible if road fill removed and replace by new bridge.
Existing Structure	There is no existing structure at this site.	50’-foot- long by 15-foot-wide bridge and road bed fill at this site.	Bridge for Hwy 145. Likely cannot tie to.	Pump station on right bank.	PIT array and gaging station nearby	Two diversion structures that could be modified	Road fill across channel with 8-foot-diameter culvert under road.
Other	This site is immediately below the spawning habitat (i.e., closer to the Friant Dam) which may result in the capture of emergent fry. Emergent fry are difficult to effectively trap, handle and transport.	This site is immediately below the spawning habitat (i.e., closer to the Friant Dam) which may result in the capture of emergent fry. Emergent fry are difficult to effectively trap, handle and transport.	Wide river channel.			The diversion structures have trash racks and 4 independently adjustable flow control gates.	New bridge to replace culvert possible. Trap facility could be incorporated in new bridge.

5.3.1 Sites to be Eliminated

Based on the selection criteria and the site evaluation summary in Table 7, three sites can be eliminated from consideration:

Camp Pashyan – This site should be eliminated because it is too close to the spawning habitat, would require significant road improvements and result in significant riparian habitat impacts. The need to accommodate the public and the boat launch would create design complexity, increased cost, permitting, and safety issues.

Skagg County Park – This site should be eliminated because of the wide river channel that would likely require a large and costly structure in the floodway. Access by the public would create vandalism risk, design complexity, increased cost, and safety issues.

Gravelly Ford - This site is recommended for elimination due to the low right bank, potential for flooding, and side channel bypass during high flow conditions. These factors would require a large and costly structure because there is no existing large structure to tie to.

5.3.2 Sites to Evaluate Further

The following four sites are recommended for evaluation of trapping capabilities:

Donny Bridge – This site, even though close to the spawning habitat, is recommended due to access, water depth, and low risk during flood event. This is a well-confined section of river that would likely require a smaller structure. There is also potential to tie into the existing bridge structure. The access road would need to be upgraded and power brought to the site.

Emmert Pump Station - This site is recommended due to the wide and deep river section where a trapping facility could be located in-channel, minimizing earthwork costs and impact on riparian habitat. This site also has a cooperative land owner, an existing structure and low sediment potential. The wide floodplain on the left bank will help to bypass high flows (exceeding the trapping range) around the proposed trap structure; this could help meet the no net rise standard in the 100-year flood water surface elevation.

Chowchilla Bifurcation Structure – This site is recommended due to controlled vehicular access to the site (i.e., not opened to public); the previously disturbed riparian zone; an existing structure that can control floods, water depth, and water velocity; the presence of a maintenance facility, power, and existing debris and sediment management provisions.

San Mateo Crossing – This site is recommended due to the water depth available at the site, road access, and power. While this site presently is inundated during high flows, the river channel is more defined than some of the eliminated sites, therefore minimizing the size of the facility. There is also potential to raise the road above the floodplain and add a new bridge, which would likely ensure support from public. There are concerns with vandalism and public safety at this site that would need to be addressed as part of the design process.

5.4 Design Constraints

Each of the recommended sites has general design constraints applicable to all. Constraints include, but are not limited to:

- Stream gradient is low.
- Due to the low gradient, the fish bypass pipe would be below the river water surface elevation, which would necessitate a very long pipe to return large fish (i.e., non-juvenile Chinook, bass, etc.) to the river. Large fish may need to be collected, held, and returned to the river through other means.
- The need to collect 100 percent of the fish at 1,000 cfs means that all the flow would need to be screened. Regardless of the screening technology selected (i.e., V-screen, drum screen, etc.), the same approach velocity and surface area criteria apply and a similar facility footprint would be required. An option to trap fish only up to a 500 cfs flow rate has also been included in the cost analysis.
- The water surface elevation likely cannot be raised beyond the 1,000 cfs elevation to create a backwater pool and additional gradient. To do so could raise groundwater levels, which may impact adjacent agricultural fields. Potential backwater pool elevations and the effects of raising them will need further site specific evaluation.

5.5 Alternative A: Donny Bridge

5.5.1 Recommended Trapping Method

An in-channel trapping method is recommended to pass flood flows without creating any increase in river water surface elevation. It is assumed the in-channel trapping method would use vertical plate V-screens as described in Section 4. The surface area of the screens would be the same for each screening technology. The V-screen would provide the smallest trapping facility footprint. Technology like the traveling belt would be appropriate if there was greater water depth (about 15 to 20 feet). The bar screens would be linear and create about 440 feet of screen along the river bank, exceeding the fish travel time criteria in front of the screen. In addition, the bar screen would require a long trashrack or a long mechanical cleaning system that would not provide any protection against debris impact on the screen. The drum screen would have a large footprint and it would be difficult to direct juvenile fish into a fish bypass pipe.

5.5.2 Design Description and Range of Costs

Figure 18 illustrates the Donny Bridge alternative, components of which are described below.

Diversion Weir – An inflatable diversion weir would divert flow to the trapping facility without increasing the river depth. During the downstream fish migration period, the diversion weir would be inflated. The rest of the time, or during flow events in excess of 1,000 cfs, the weir would be deflated to facilitate fish migration, passage of flood flows, and to allow movement of bedload and debris. An inflatable Obermeyer weir is proposed. When operated, it would create no net rise to the 100-year flood profile at the site. For this evaluation, it is assumed that the water depth, and consequently the diversion weir height, would be 6 feet at 1,000 cfs. This assumption will need to be verified during subsequent design phases, when detailed topographic and bathymetric survey information is available. The diversion weir would have four sections, each about 15 feet in length, and would be located under a new Donny Bridge. The new bridge would be designed to pass the maximum flood or pulse flow with two feet of freeboard. The new bridge would replace the existing Donny Bridge.

Intake – The intake is designed to protect the fish screen from large debris. The intake structure would be located on the right bank of the river, upstream of the fish screen. It would have a one-foot-high sill to limit bedload movement through the screen and a water depth of approximately 5 feet. The approach velocity would be approximately 3 fps. Consequently, the intake width would be approximately 70 feet to accommodate a flow of 1,000 cfs. The river bank just upstream of the intake would need to be excavated to provide the required depth. A slanted trashrack, required to protect the fish screen, would have 2-inch-thick bars, 10 inches on center, to allow large fish to pass. A trashrack cleaning mechanism would be required, as would a maintenance bridge. Bulkhead gates would be needed not to dewater the canal but to protect the fish screen and force flow to travel within the main channel during high flood event.

Fish Screen – The fish screen would be a double V-screen designed to meet criteria listed in Table 6. Each V-screen would be sized for 500 cfs and would be about 105 feet long by 6 feet deep and have primary and secondary screens. Each V-screen entrance would be about 30 feet wide. The length of the V-screen is directly related to the water depth available in the river. The fish screens would be designed so the velocity does not drop within the V-screen but continues to increase as the fish reaches the V-screen's throat. The throat would be a nominal 24-inch transition to a bypass pipe. A ramp with variable slope would be used in the secondary screen to adapt to the change in water surface elevation.

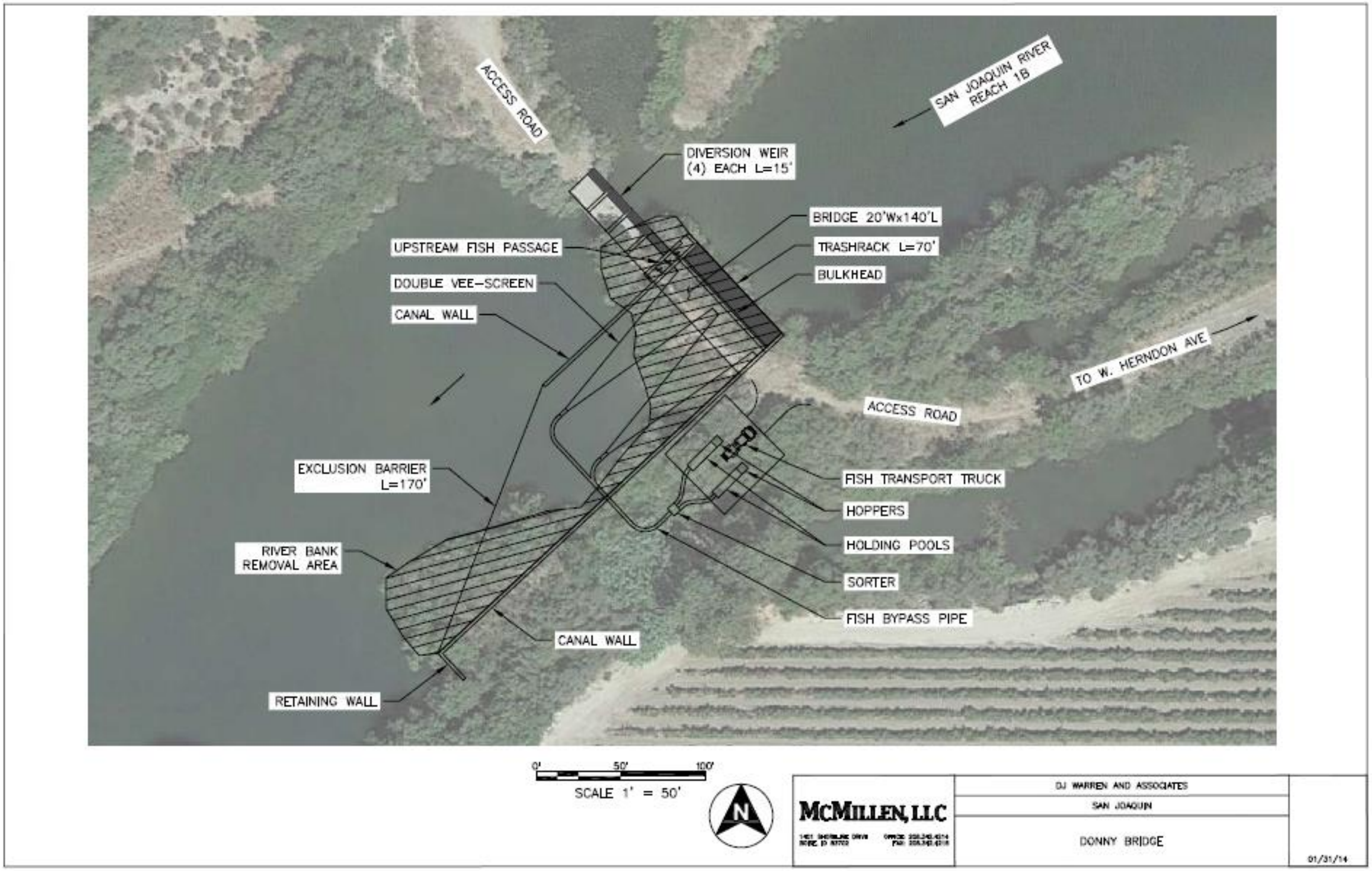


Figure 18. Alternative A: Conceptual design of Donny Bridge juvenile collection facility.

Upstream Fishway – A vertical slot fishway between the diversion weir and the fish screen would provide upstream fish passage during the juvenile collection period. Once the juvenile trapping season is complete, the diversion weirs would be lowered and fish would migrate through the main river body. The upstream fishway would be design for flows ranging from 10 to 40 cfs. Additional attraction flow could be added through a wall diffuser between the fish screen canal and the entrance pool of the fishway to further increase upstream migrant fish attraction without decreasing juvenile collection potential. The fishway exit (i.e., exit for upstream migrants) would parallel the river flow to minimize collection of juvenile fish. By locating it close to a diversion weir, lowering a weir would flush debris accumulating in front of the exit pool.

Fish Bypass and Fish Transfer Facility –The transfer facility would be sized to accommodate the peak day of fry migration, using flow and fish-density indexes. A 24-inch-diameter fish bypass pipe would convey about 10 cfs to the fish transfer facility while flowing half-full; velocity would be maintained at about 7 fps. The bypass, designed to meet NMFS criteria, would be equipped with sorter bars through which small fish would drop and be directed to a below grade holding pool. Due to the site constraints, large fish could not be returned directly to the river. They would be directed to a separate holding pool at the fish transfer facility. A crowder and hopper or fish lock would be used to collect and return non-target fish to the river. Juvenile Chinook would be placed in a truck using a crowder and hopper or a fish pump. Stakeholders will need to determine the need for additional sorting, in which case the fish transfer facility would require additional sorting capability beyond fish size and post-sort holding pools. Holding pools would be designed using typical fish flow and density indexes.

Order-of-magnitude cost estimates were developed to facilitate relative comparisons between the different alternatives. Capital costs for the Donny Bridge alternative would range between $21.5 million and $32.8 million, assuming an accuracy of +30% and -15%. The monthly O&M would be about $97,000.

These costs do not include a juvenile sampling facility. A juvenile sorting and sampling facility would have provisions to sample, anesthetize, interrogate, recover, sort and hold fish. This would add significant cost. Figure 19 illustrates a recently constructed, more elaborate juvenile sampling facility operated by Portland General Electric on the Clackamas River, Oregon. If stakeholders decide a juvenile sorting facility is necessary, the construction cost would increase by $3 to 5 million and the annual O&M cost would increase significantly. These sampling facility costs would be nearly identical for any of the potential sites.

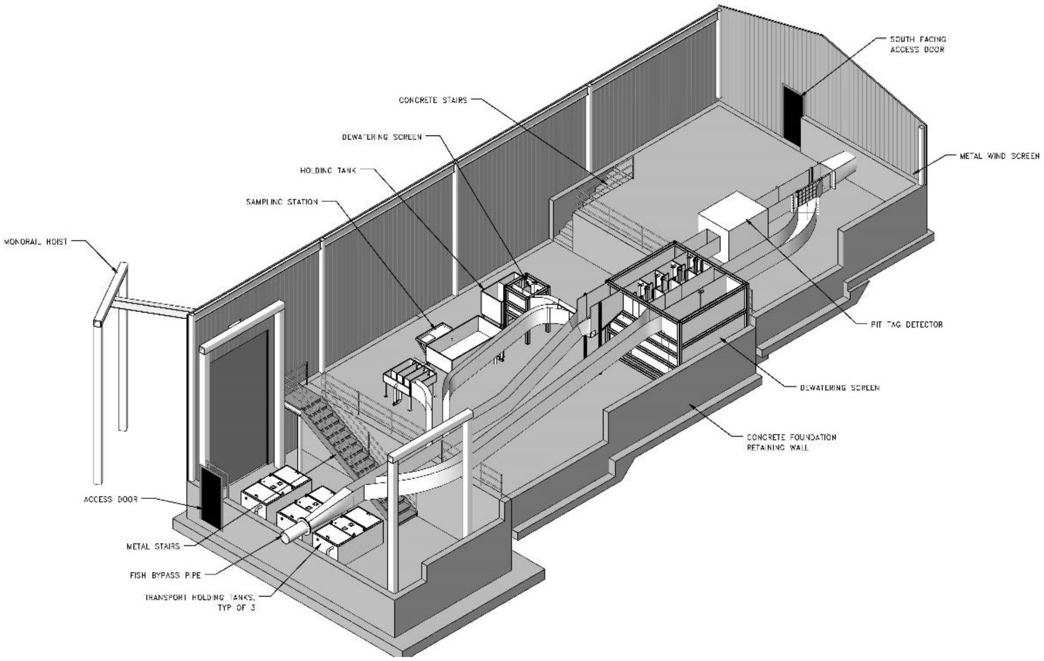


Figure 19. **Juvenile sampling facility illustration**

5.5.3 Expected Performance Criteria

This trapping facility would have a 99 percent fish collection potential at the high design flow of 1,000 cfs, declining to about 93 percent at the low design flow of 150 cfs. This is due to the upstream fish passage, assuming that juvenile fish are using the stream cross-section uniformly. The fishway flow is assumed to be 10 cfs. Collection potential could increase to 100 percent at flows up to 1,000 cfs if the upstream fishway was not being operated. The facility could operate above 1,000 cfs by lowering one of the inflatable weirs and bypassing the additional flow. This would incrementally decrease the trapping potential. It is assumed that above a given high flow of approximately 1,050 cfs, the diversion weirs would be lowered, the bulkhead at the intake would also be lowered and the entire river flow would bypass the trapping facility. At that point, the facility would be shut down and no trapping would occur.

The expected collection performance for alternatives A, B, C, and D would be equal and is therefore not a differentiating factor.

5.6 Alternative B: Emmert Pump Station

5.6.1 Recommended Trapping Method

It is assumed this in-channel trapping method would use a V-screen as described in Section 4 and under Alternative A above.

5.6.2 Design Description and Range of Costs

Figure 20 illustrates the components of Alternative B described below.

Diversion Weir – The diversion weir would be similar to Alternative A; however, at this site, the maintenance bridge needed to maintain trapping facility equipment would not need to span the river. The left bank is prone to flooding, and the flood zone is about 400 feet wide. Since no bridge would pass over the diversion weir, the intermediate piers are not required. The diversion weir would also have four inflatable Obermeyer sections, each about 15 feet long and about 6 feet high.

The fish screen, canal, exclusion barrier, upstream fishway, fish bypass, fish transfer facility and performance objectives would be similar in design to Alternative A.

Order-of-magnitude cost estimates were developed to provide relative comparisons between the different alternatives. Capital costs for the Emmert Pump Station facility would range between $20.1 million and $30.8 million, assuming an accuracy of +30% and -15%. The monthly O&M would be approximately $101,000.

5.6.3 Expected Performance Criteria

Performance would be similar to Alternative A.

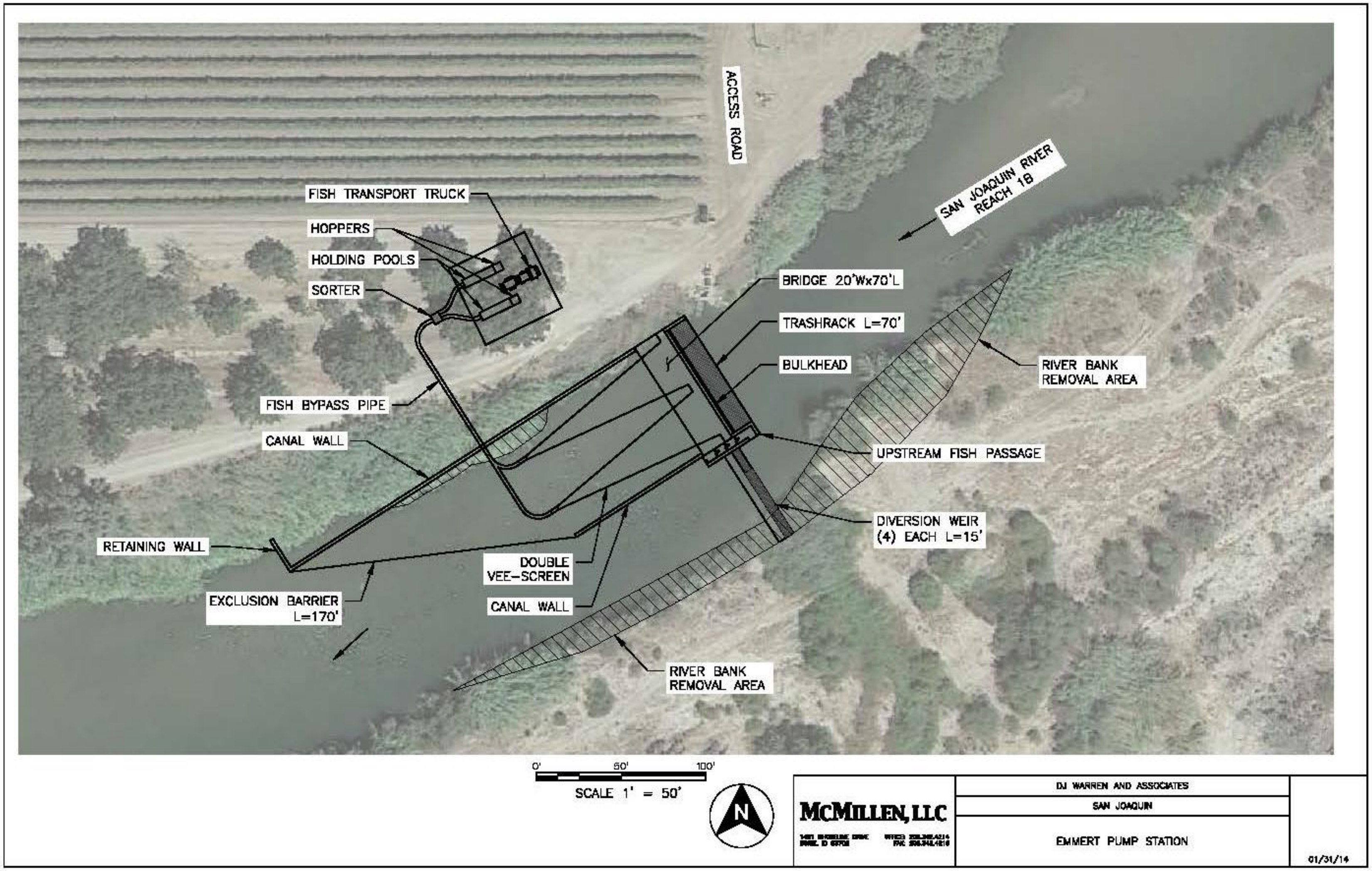


Figure 20. **Alternative B: Conceptual design of Emmert Pump Station fish collection facility**

5.7 Alternative C: Chowchilla Bifurcation Structure

5.7.1 Recommended Trapping Method

The trapping method proposed at Chowchilla is similar to Alternative A and would make use of the existing diversion dam. The proposed trapping facility could be placed on either side of the existing diversion dam, creating a hybrid facility that would not be fully in-channel or off-channel.

5.7.2 Design Description and Range of Costs

Figure 21 illustrates Alternative C and each of its components are described below.

Diversion Weir – The trapping facility would be incorporated into the existing Chowchilla diversion weir. The existing maintenance bridge for the trashrack would need to be extended over the new intake. The existing right wingwall would be removed and the right abutment would be tied into the proposed trapping facility.

Canal and Exclusion Barrier – A small canal would need to be established adjacent to the diversion structure. A new right canal wall would function as a retaining wall and flow direction wall. The left canal wall would protect the V-screen during flood events when the diversion gates are lowered. The canal would be 70 feet wide and rectangular in section. The top of the canal would match the existing bridge and access road elevation. The water depth would be approximately 6 feet minus any head losses associated with the trashrack and fish screen. A 170-foot-long exclusion barrier would be installed at the downstream end of the canal to ensure the approach velocity does not exceed 1 fps and create false attraction to the fish screen. Upstream migrants would pass along the exclusion barrier to the entrance of the upstream fishway.

The intake, fish screen, upstream fishway, fish bypass and fish transfer facility would be similar to Alternative A. Order-of-magnitude cost estimates were developed to facilitate relative comparisons between the different alternatives. Capital costs of a new facility at the Chowchilla Bifurcation Structure would range between $21 million and $32 million, assuming an accuracy of +30% and -15%. The monthly O&M would be approximately $100,000.

5.7.3 Expected Performance Criteria

Performance would be similar to Alternative A.

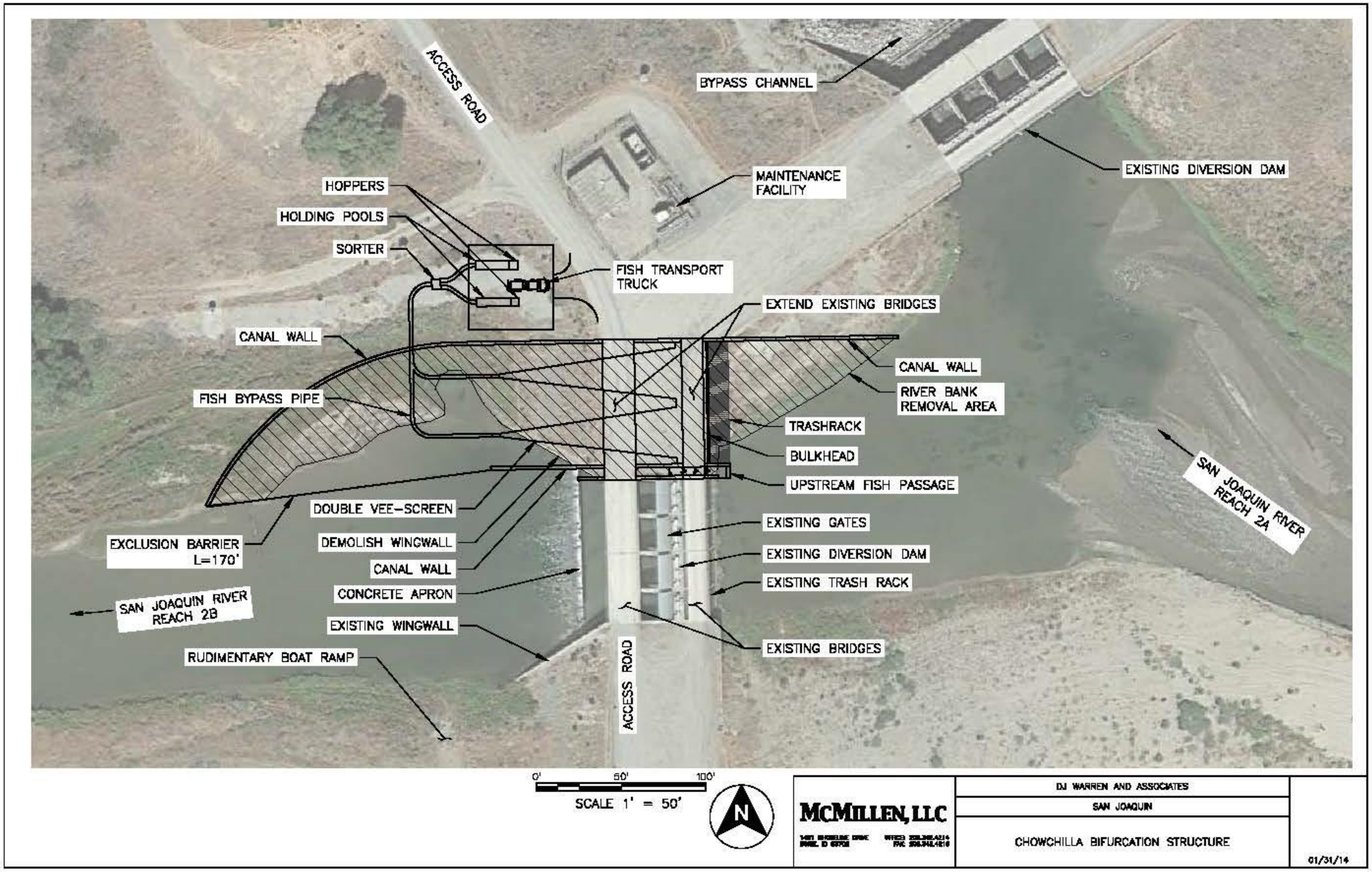


Figure 21. **Alternative C: Conceptual design of Chowchilla Bifurcation Structure collection facility.**

5.8 Alternative D: San Mateo Crossing

5.8.1 Recommended Trapping Method

The trapping method at San Mateo Crossing would use a V-screen as described in Section 4.

5.8.2 Design Description and Range of Costs

Figure 22 presents Alternative D and the juvenile trap-and-haul components are described below.

Diversion Weir – The diversion weir would be similar to Alternative A, using four inflatable Obermeyer weir sections, each about 15 feet long, installed under a new San Mateo Bridge. The new bridge would be designed to pass the maximum flood flow with at least two feet of freeboard. This bridge would replace the existing 8-foot culvert to provide year round crossing for the public.

The intake, fish screen, canal, exclusion barrier, upstream fishway, fish bypass, fish transfer facility, and performance objectives would be similar to Alternative A. Additional site security measures would need to be incorporated to accommodate public use. Costs include a 20-foot wide bridge to allow two-way traffic over the bridge.

Order-of-magnitude costs estimates were developed to facilitate relative comparisons between the different alternatives. The capital cost would range between $21.5 million and $33 million, assuming an accuracy of +30% and -15%. The monthly O&M would be approximately $100,000.

5.8.3 Expected Performance Criteria

Performance would be similar to Alternative A.

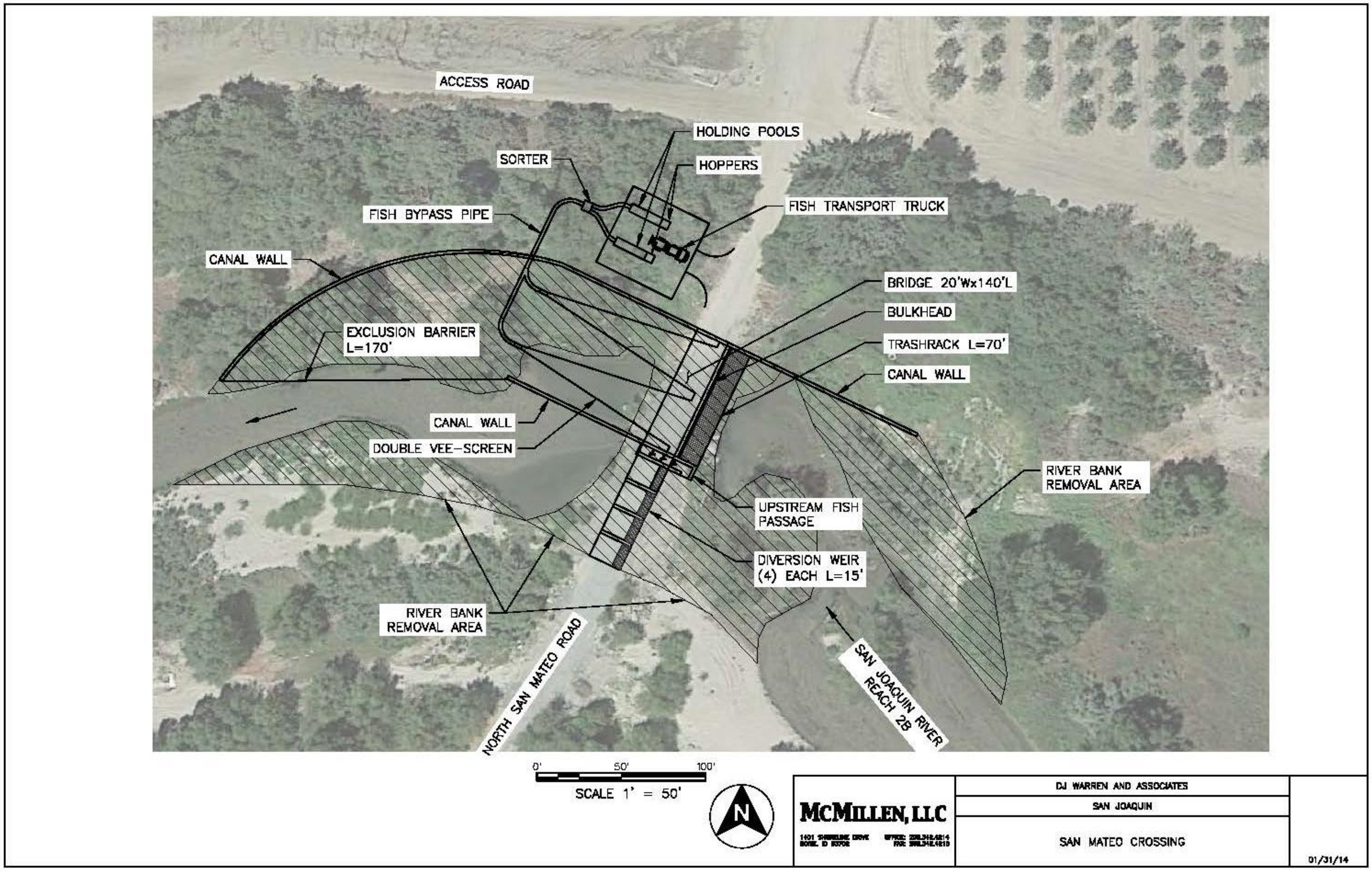


Figure 22 Alternative D: Conceptual design of San Mateo Crossing collection facility.

5.9 Alternative E: 500 cfs V-Screen

5.9.1 Recommended Trapping Method

This alternative is presented to discuss the potential for a V-screen trapping method at any of the locations discussed above but with a lower design maximum flow of 500 cfs to reduce overall project costs while still capturing downstream juvenile migrants during critical flow periods.

5.9.2 Design Description and Range of Costs

The reduced juvenile trap-and-haul facility would be similar to Alternative A presented above, with the exception of the following components:

Diversion Weir – The inflatable diversion weir would be lowered for flood event in excess of 500 cfs. To create no net rise to the 100-year flood profile at the site, the diversion weir would have the same overall dimensions as illustrated in the examples above.

Intake – The length of the intake would be reduced from 70 feet to 35 feet to accommodate 500 cfs and an approach velocity of 3 fps.

Fish Screen – The fish screen would be a single V-screen designed to meet fry criteria listed in Table 6. The V-screen would be sized for 500 cfs, be about 105 feet long by 6 feet deep, and would have primary and secondary screens. The V-screen entrance would be about 30 feet wide.

Canal and Exclusion Barrier – The 35-foot-wide canal section would be rectangular with a water depth of approximately 6 feet minus any head losses associated with the trashrack and fish screen. The top of the canal walls would be above the 100-year flood elevation. The canal would be equipped with an exclusion barrier about 85 feet long.

Upstream Fishway – The upstream fishway would be similar to the one presented in Alternative A.

Fish Bypass and Fish Transfer Facility – The fish bypass and the fish transfer facility would be similar to Alternative A.

Order-of-magnitude cost estimates were developed to facilitate relative comparisons between the different alternatives. The capital cost would range between $14 million and $21 million, assuming an accuracy of +30% and -15%. The monthly O&M would be about $90,000. These costs do not include a juvenile sorting facility.

5.9.3 Expected Performance Criteria

This trapping facility would have a lower collection potential than Alternatives A, B, C, and D since the design flow is only 500 cfs. The estimated fish collection efficiency for Alternative E is provided in Table 9.

5.10 Alternative F: Inclined Plane Screen

5.10.1 Recommended Trapping Method

An inclined plane screen could be installed in one of the bays at the Chowchilla Bifurcation. The screen would be operated downstream of the gates (Figure 23) and would be attached to a floating pontoon system similar to that described for the scoop trap in Section 4.0.

5.10.2 Design Description and Range of Costs

The screen structure would be floated into place at its sample location, tight against the downstream sill. To increase sampling depth, temporary removable walls would be constructed between the bays, the sill raised by 2 feet and gates in 3 of the 4 bays would be closed to increase the water depth within the remaining open bay. A notch would be cut into the new sill to create a depth of 2 to 3 feet over the inclined screen, which would fit snugly into the slot. The screen would be sized for smolts (>60 mm) and therefore an approach velocity of 0.8 fps could be used. It is likely there would be no emergent fry at this location as it is far downstream of Reach 1A where the spawning habitat is located. The screen would be about 18 feet wide by 20 feet long.

Fish would be trapped in a collection box at the downstream end of the screen. Fish transfer from the collection box to the transport truck would be performed by a small crane that would lift the box to the bridge deck. The system will be designed to allow water-to-water transfer of the collected fish to the truck.

This alternative would be capable of collecting all the fish moving downstream but would be limited to flow below 300 cfs. Above this flow, the inclined plane screen structure would need to be removed to protect the structure and all radial gates opened to pass flood flows.

Order-of-magnitude cost estimates were developed to facilitate relative comparisons between the different alternatives. The capital cost of this installation at Chowchilla would range between $800,000 and $1.3 million, assuming an accuracy of +30% and -15%. The monthly O&M would be about $63,000. These costs do not include a juvenile sorting facility

5.10.3 Expected Performance Criteria

The inclined plane screen system is assumed to have 100 percent collection efficiency for flows lower than 300 cfs. Trapping with the inclined plane screen would not occur above 300 cfs.

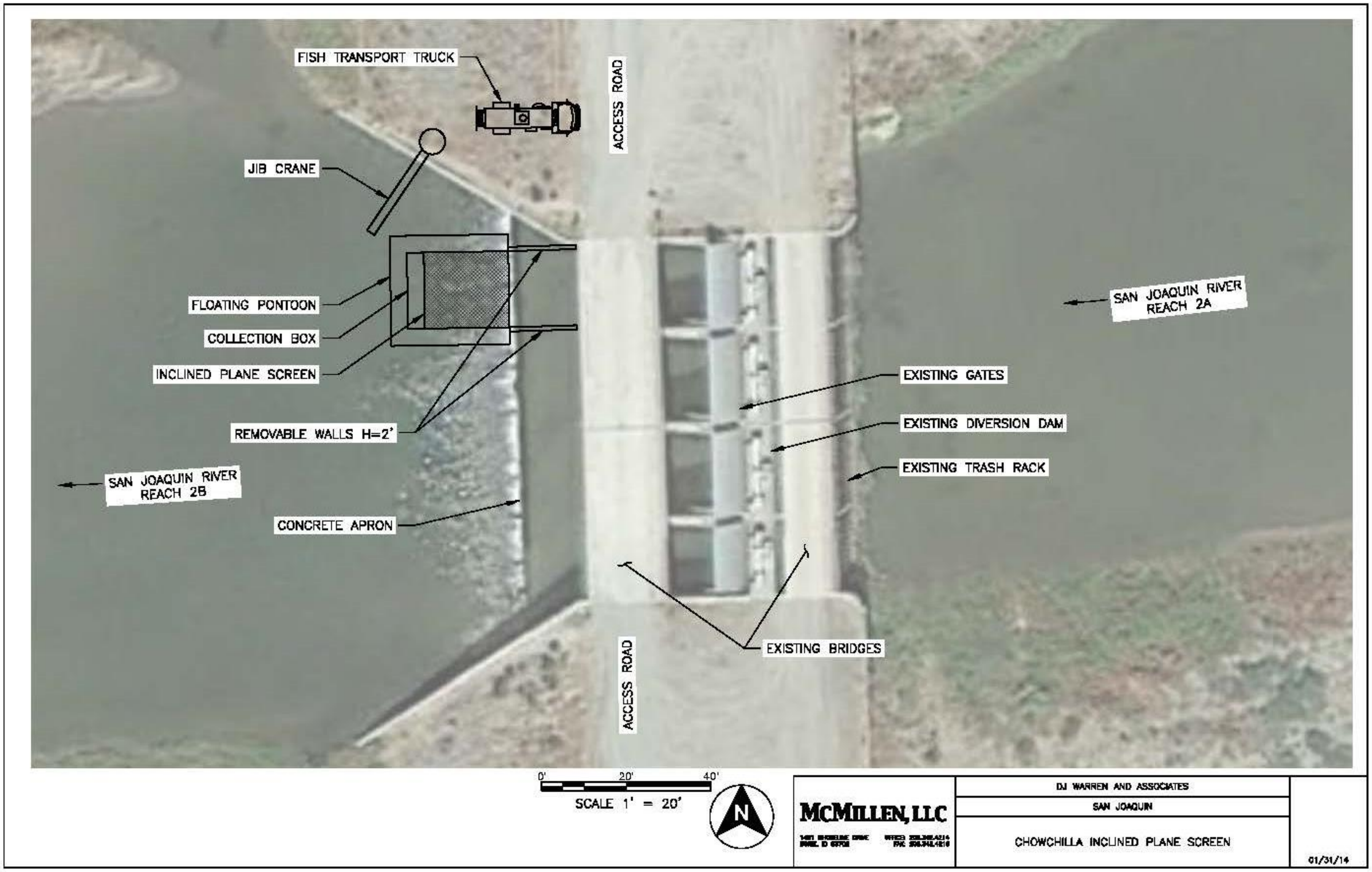


Figure 23. **Alternative F: Chowchilla inclined plane screen**

5.11 Alternative G: Series of Portable Traps

The large screening systems with their high collection efficiency would provide an effective means to achieve all three juvenile capture target levels. The effectiveness, however, comes at estimated costs that could exceed $33 million.

A less expensive approach using portable systems may be a feasible alternative to the large screening systems. However, because of the lower collection efficiency of these types of systems, it is less likely that juvenile production Targets 2 and 3 could be readily achieved.

A description of the portable trapping system is described below.

5.11.1 Recommended Trapping Method

A portable technology is recommended for this application. While various systems could accomplish the program objectives, screw traps are a portable technology currently in use in the San Joaquin system. Portable traps could be operated at the following locations:

- Donny Bridge (screw trap)
- San Mateo Crossing (screw trap)
- Emmert Pump Station (screw trap)

Additional trapping sites may be included if tests at these three locations show capture rates of 10 percent or less (i.e., collect 10 percent of the total number of juveniles migrating past each location).

5.11.2 Design Description and Range of Costs

Screw traps (5 to 8 feet in diameter) could be operated at Donny Bridge, San Mateo Crossing and the Emmert Pump Station.

The screw trap at Donny Bridge would be located downstream of the bridge. The trap would be anchored to the bridge or the shoreline. Depending on debris loads, 4-foot-high nets or screens may be used to guide fish to the entrance of the trap. A second screw trap may be used at this site if collection efficiency for a single trap is less than 10 percent.

The San Mateo Crossing screw trap would be located downstream of the culvert. The trap would be anchored to the shoreline. Four-foot-high portable screens may be placed upstream of the culvert to divert fish to the culvert if flows exceed its capacity [10]. A second screw trap may be used at this site if collection efficiency for a single trap is less than 10 percent.

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[10] Adding a second culvert to the road crossing may be another option that could be explored. Screw traps would be placed downstream of each culvert. The culvert provides an excellent means of concentrating fish. If this action was implemented, then consideration would be given to building a screening system (inclined screen etc., at the outlet of the culvert).

The third screw trap would be located just downstream of the Emmert Pump Station. Wing-nets or screens would be placed in a V-shape just upstream of the screw trap to funnel fish to the entrance of the trap.

Depending on how close the screw traps can be located to the shore or bridge, fish transfer may occur by boat, through the use of fish pumps, or via a small crane.

Order-of-magnitude costs estimates were developed to facilitate relative comparisons between the different alternatives. The capital costs of these installations would range between $77,000 and $117,000, assuming an accuracy of +30% and -15%. The monthly O&M would be about $203,000 and it is assumed operations would last about two months.

5.11.3 Expected Performance Criteria

Each portable trap is expected to have a capture efficiency of 5-10 percent. All traps combined are expected to capture 30 percent of the total juvenile production. Additional traps would be added if the efficiency of a single trap at a single location does not achieve the 10 percent criterion.

A 30 percent trapping efficiency is deemed likely to achieve juvenile production Target 1 (~100,000 juveniles). This could result in the production of up to 500 spring-run and 500 fall-run adult Chinook given current juvenile to adult survival assumptions[11].

5.12 Release Locations

Fish would be collected and trucked to release points near the Highway 165 Bridge on the San Joaquin River. Standard protocols for the loading, transport and release of juvenile salmonids would be followed.

5.13 Cost Summary

Range of magnitude construction and operating costs were developed for each of the trapping alternatives described above as summarized in Table 8. Additional cost information is included in Appendix A – Cost Details. The construction costs for a permanent, high efficiency trap (Alternatives A through D) are in a similar range. Monthly operations costs vary primarily based on the transportation distance between the trap site and release location.

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[11] The juvenile to adult survival rate must be 1 percent or higher to achieve a return of 500 adults for each run.

Table 8. Cost Summary of Alternatives A-G

Alternative	Capital Cost ($)		Monthly O&M Cost
	High Range	Low Range	
Alternative A - Donny Bridge	$32,816,000	$21,457,000	$97,368
Alternative B - Emmert Pump Station	$30,807,000	$20,144,000	$100,913
Alternative C - Chowchilla Bifurcation Structure	$31,934,000	$20,880,000	$93,320
Alternative D - San Mateo Crossing	$32,907,000	$21,516,000	$92,973
Alternative E - 500 cfs V-Screen	$21,031,000	$13,751,000	$85,584
Alternative F - Inclined Plane Screen	$1,255,000	$821,000	$62,641
Alternative G – Portable Traps	$117,000	$77,000	$203,391

6.0 River Flow Effects on the Performance of the Alternatives

The effectiveness of the alternatives will depend on juvenile Chinook run timing and the proportion of the total river flow each is capable of screening. Because juvenile run timing (abundance by month) has yet to be determined for the San Joaquin River Restoration area, flow data for key periods for each of six water year types is used as a surrogate indicator of likely system fish collection efficiency. The analysis assumes fish collection efficiency is proportional to the percentage of the water screened. In short, if 100 percent of the water is screened, then the system has a fish collection efficiency of 100 percent.

The results of the analysis are provided in color-coded tables (Tables 8-10). The colors represent three levels of fish collection efficiency:

1. Green = 100%
2. Blue = >50%-99%
3. Red = 50% or less

Data in each table are summarized into three juvenile migration periods:

1. October 1-December 31 (fall migration)
2. January 1-June 30 (winter/spring migration)
3. March 16- April 30 (peak spring migration)

Examining results over the three migration periods depicts the effect the systems may have on population life history diversity. Juvenile fish size, age and run-type may be different for each period. Additionally, the juvenile-to-adult survival rate for each period may vary due to differences in riverine and ocean conditions. It is assumed trapping systems that effectively catch fish over all three time periods are preferred over those that do not.

The flow data for each month and year is shown in Table 8. The fish collection efficiency values for each timeframe are based on simple averages. As data on juvenile run timing are developed, the weighting can be adjusted accordingly. The results of this analysis are provided for each alternative below.

6.1 Alternatives A-D (1,000 cfs V-Screen)

The expected fish collection efficiency for alternatives using a 1,000 cfs V-screen is provided in Table 8. Results of the analysis are as follows:

1. Fish collection efficiency ranges from 89 to 100 percent in all three migration time periods for Critical-Low, Critical-High and Dry water years.
2. Fish collection efficiency ranges from 69 to 100 percent in all three migration time periods in Normal-Dry years and 44 to 100 percent in Normal-Wet and Wet water years.
3. For the peak spring migration period, fish collection efficiency drops to 44 percent in the Normal Wet and Wet water years.

Data indicate the 1,000 cfs V-screen will have excellent fish collection efficiency for each migration period and water year. Although fish collection efficiency drops to 44 percent for the peak spring migration period in better water years, river flows (1,500-4,000 cfs) during this period should be sufficient to protect juvenile migrants (see yellow cells in Table 8).

6.2 Alternative E (500 cfs V-Screen)

Estimated fish collection efficiency for Alternative E (500 cfs V-screen) is provided in Table 9. Results of the analysis are as follows:

- Fish collection efficiency ranges from 78 to 100 percent in the three migration time periods for Critical-Low, Critical-High and Dry water years.
- Fish collection efficiency ranges from 51 to 86 percent in all three migration time periods for Normal-Dry and 22 to 86 percent in Normal-Wet and Wet water years.
- For the peak spring migration period, fish collection efficiency is 22 percent in the Normal Wet and Wet water years.

The analysis shows fish collection efficiency of the 500 cfs V-screen is identical to the 1,000 cfs system for Critical-Low water years. For all other water years, fish collection efficiency of the 500 cfs V-Screen is 10-22 percent lower than the 1,000 cfs system.

It should also be noted that river flow from March 16 to March 31 is 1,500 cfs for all water years other than a Critical-Low water year. Therefore, the 33 percent fish collection efficiency value for this period may not be a concern as in-river juvenile migration survival rates may be high (see yellow cells in Table 9).

In addition, if a juvenile collection system was available, some consideration could be given to maintaining flows at 500 cfs or less. This action would ensure collection efficiency was always 100 percent during the likely peak of the juvenile migration during Critical-High and Dry water years. This action would have to be weighed against the impacts lower flows may have on water temperature and upstream migrating adult spring Chinook salmon.

6.3 Alternative F- Inclined Plane Traps

The inclined plane screen system is assumed to have 100 percent collection efficiency for flows lower than 300 cfs. Trapping with the inclined plane screen would not occur above 300 cfs.

Estimated fish collection efficiency for Alternative F is provided in Table 10. Results of the analysis are as follows:

- Fish collection efficiency ranges from 64 to 100 percent in the three migration time periods for Critical-Low, Critical-High and Dry water years.
- Fish collection efficiency ranges from 39 to 71 percent in all three migration time periods for Normal-Dry and 13 to 71 percent in Normal-Wet and Wet water years.
- For the peak spring migration period, fish collection efficiency is 13 percent in the Normal Wet and Wet water years.

The inclined plane screen has similar performance to Alternatives A-E for Critical-Low and Critical High water years. As river flows increase above 300 cfs system performance also decreases.

6.4 Alternative G (Portable Traps)

A flow analysis was not conducted for the Portable Trap alternative. The screw trap system is assumed to have a 30 percent collection efficiency value regardless of flow. Additional screw traps would be added as needed to achieve the 30 percent value. Trapping would not occur once flows exceed 1,000 cfs.

Table 9. Fish collection efficiency of Alternatives A-D (1,000 cfs V-screen) by date and water year type.

	Date	Fish Collection Efficiency by Water Year Type						Flow in CFS by Water Year Type					
		Critical Low	Critical High	Dry	Normal Dry	Normal Wet	Wet	Critical Low	Critical High	Dry	Normal Dry	Normal Wet	Wet
	10/1-10/31	100%	100%	100%	100%	100%	100%	160	160	350	350	350	350
	11/1-11/6	100%	100%	100%	100%	100%	100%	130	400	700	700	700	700
	11/7-11/10	100%	100%	100%	100%	100%	100%	120	120	700	700	700	700
	11/11-12/31	100%	100%	100%	100%	100%	100%	120	120	350	350	350	350
	1/1-2/28	100%	100%	100%	100%	100%	100%	100	110	350	350	350	350
	3/1-3/15	100%	100%	100%	100%	100%	100%	130	500	500	500	500	500
	3/16-3/31	100%	67%	67%	67%	67%	67%	130	1500	1500	1500	1500	1500
	4/1-4/15	100%	100%	100%	40%	40%	40%	150	200	350	2500	2500	2500
	4/16-4/30	100%	100%	100%	100%	25%	25%	150	200	350	350	4000	4000
	5/1-6/30	100%	100%	100%	100%	100%	50%	190	215	350	350	350	2000
	7/1-8/31	100%	100%	100%	100%	100%	100%	230	255	350	350	350	350
	9/1-9/30	100%	100%	100%	100%	100%	100%	210	260	350	350	350	350
Migration Period	**Yearly Average**	100%	97%	97%	92%	86%	82%						
Fall Migration	October 1-Dec 31	100%	100%	100%	100%	100%	100%						
Winter/Spring	January 1-June 30	100%	97%	97%	91%	83%	78%						
Peak Spring	March 16-April 30	100%	89%	89%	69%	44%	44%						

🟩 100% 🟦 > 50%-99% 🟥 50% or less 🟨 Fish Collection May Not Be Needed

Table 10. Fish collection efficiency of Alternative E (500 cfs V-screen) by date and water year type.

	Date	Fish Collection Efficiency by Water Year Type						Flow in CFS by Water Year					
		Critical Low	Critical High	Dry	Normal Dry	Normal Wet	Wet	Critical Low	Critical High	Dry	Normal Dry	Normal Wet	Wet
	10/1-10/31	100%	100%	100%	100%	100%	100%	160	160	350	350	350	350
	11/1-11/6	100%	100%	71%	71%	71%	71%	130	400	700	700	700	700
	11/7-11/10	100%	100%	71%	71%	71%	71%	120	120	700	700	700	700
	11/11-12/31	100%	100%	100%	100%	100%	100%	120	120	350	350	350	350
	1/1-2/28	100%	100%	100%	100%	100%	100%	100	110	350	350	350	350
	3/1-3/15	100%	100%	100%	100%	100%	100%	130	500	500	500	500	500
	3/16-3/31	100%	33%	33%	33%	33%	33%	130	1500	1500	1500	1500	1500
	4/1-4/15	100%	100%	100%	20%	20%	20%	150	200	350	2500	2500	2500
	4/16-4/30	100%	100%	100%	100%	12.50%	12.50%	150	200	350	350	4000	4000
	5/1-6/30	100%	100%	100%	100%	100%	25%	190	215	350	350	350	2000
	7/1-8/31	100%	100%	100%	100%	100%	100%	230	255	350	350	350	350
	9/1-9/30	100%	100%	100%	100%	100%	100%	210	260	350	350	350	350
Migration Season	**Yearly Average**	100%	94%	90%	83%	76%	69%						
Fall Migration	October 1-Dec 31	100%	100%	86%	86%	86%	86%						
Winter/Spring	January 1-June 30	100%	93%	88%	80%	71%	63%						
Peak Spring	March 16-April 30	100%	78%	78%	51%	22%	22%						

🟩 100% 🟦 > 50%-99% 🟥 50% or less 🟨 Fish Collection May Not Be Needed

Table 11. Fish collection efficiency of Alternative F (300 cfs inclined plane screen) by date and water year type.

	Date	Fish Collection Efficiency by Water Year Type						Flow in CFS by Water Year					
		Critical Low	Critical High	Dry	Normal Dry	Normal Wet	Wet	Critical Low	Critical High	Dry	Normal Dry	Normal Wet	Wet
	10/1-10/31	100%	100%	85.7%	85.7%	85.7%	85.7%	160	160	350	350	350	350
	11/1-11/6	100%	75%	57.1%	57.1%	57.1%	57.1%	130	400	700	700	700	700
	11/7-11/10	100%	100%	57.1%	57.1%	57.1%	57.1%	120	120	700	700	700	700
	11/11-12/31	100%	100%	85.7%	85.7%	85.7%	85.7%	120	120	350	350	350	350
	1/1-2/28	100%	100%	85.7%	85.7%	85.7%	85.7%	100	110	350	350	350	350
	3/1-3/15	100%	60%	60%	60%	60%	60%	130	500	500	500	500	500
	3/16-3/31	100%	20%	20%	20%	20%	20%	130	1500	1500	1500	1500	1500
	4/1-4/15	100%	100%	85.7%	12%	12%	12%	150	200	350	2500	2500	2500
	4/16-4/30	100%	100%	85.7%	85.7%	7.5%	7.5%	150	200	350	350	4000	4000
	5/1-6/30	100%	100%	85.7%	85.7%	85.7%	15%	190	215	350	350	350	2000
	7/1-8/31	100%	100%	85.7%	85.7%	85.7%	85.7%	230	255	350	350	350	350
	9/1-9/30	100%	100%	85.7%	85.7%	85.7%	85.7%	210	260	350	350	350	350
Migration Season	**Yearly Average**	100%	88%	73%	67%	61%	55%						
Fall Migration	October 1-Dec 31	100%	94%	71%	71%	71%	71%						
Winter/Spring	January 1-June 30	100%	86%	71%	63%	56%	49%						
Peak Spring	March 16-April 30	100%	73%	64%	39%	13%	13%						
🟩	100%	🟦	> 50%-99%	🟥	50% or less			🟨	Fish Collection May Not Be Needed				

6.5. Summary of Alternative Performance and Cost

The results of the analysis indicate the 500 cfs and 1,000 cfs screening systems would likely achieve each of the three juvenile production targets during low flow years (i.e., Critical-Low, Critical-High and Dry) at a cost ranging from $20 to $33 million.

The 300 cfs inclined plane screen alternative would only be able to achieve the targets in Critical-Low and High years; however, at greatly reduced cost ($ 0.8-1.3 million).

In contrast, the portable trap alternative would only achieve target 1 for the same water year types as described for Alternatives A-G (Table E-1). The capital cost of the system would be approximately $117,000 (estimated high range with monthly operations and maintenance costs estimated at about $203,000.

Table 12. Summary of alternative performance (by water year type) and range of cost.

Juvenile Collection Target/Water Year Type	Alternatives A-D 1,000 CFS	Alternative E 500 CFS	Alternative F 300 CFS (Inclined Plane)	Alternative G-Portable Traps
Target 1 (107,000)				
Critical-Low	Yes	Yes	Yes	Yes
Critical-High	Yes	Yes	Yes	Yes
Dry	Yes	Yes	Yes	Yes
Normal-Dry	Yes	Yes	Yes	No
Normal-Wet	Yes	Yes	No	No
Target 2 (321,000)				
Critical-Low	Yes	Yes	Yes	Yes
Critical-High	Yes	Yes	Yes	No
Dry	Yes	Yes	Yes	No
Normal-Dry	Yes	Yes	No	No
Normal-Wet	Yes	No	No	No
Target 3 (2.33 million)				
Critical-Low	Yes	Yes	Yes	No
Critical-High	Yes	Yes	Yes	No
Dry	Yes	Yes	No	No
Normal-Dry	Yes	No	No	No
Normal-Wet	No	No	No	No
Cost	$20-33 million	$14-21 million	$0.8-1.3 million	$0.077 to $0.117 million

The cost estimate for each alternative does not include a full scale juvenile sorting and marking facility. The inclusion of this type of facility would increase costs from $3 to 5 million.

7.0 Next Steps

The results of this analysis provide information on the size, location, costs and capability of five trap-and-haul system alternatives to achieve juvenile and adult Chinook production targets identified in the Fish Management Plan. Under the assumption managers will elect to develop a trap-and-haul system for the program, the following steps are required:

- Confirm biological objectives (abundance, life history diversity, fish size)
- Confirm operation assumptions (dates of operation and water year type)
- Complete a site selection analysis
- Complete a 30 percent engineering design report.

As these steps are being completed, the following data collection activities should be conducted:

- Develop trap efficiency estimates of screw traps currently being operated in the restoration area.
- Test an inclined plane screen at Chowchilla Bifurcation Structure
- Develop juvenile run-timing and size by month
- Estimate juvenile survival rates from rearing areas to collection sites
- Estimate juvenile survival rates for reaches below collection sites
- Estimate juvenile survival rates for fish collected, transported and released at Highway 165 Bridge.

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APPENDIX A
COST DETAILS

San Joaquin Juvenile Chinook Trap and Haul Analysis
Project Cost Estimate
Summary of Range of Magnitude Costs by Alternative

Date: 1/27/2014
By: V. Autier
Checked By: M. Reiser

	Capital Cost ($)		Monthly O&M Cost
Alternative	**High Range**	**Low Range**	
Alternative A - Donny Bridge	$32,816,000.00	$21,457,000.00	$97,368.10
Alternative B - Emmert Pump Station	$30,807,000.00	$20,144,000.00	$100,912.65
Alternative C - Chowchilla Bifurcation Structure	$31,934,000.00	$20,880,000.00	$93,319.52
Alternative D - San Mateo Crossing	$32,907,000.00	$21,516,000.00	$92,972.62
Alternative E - 500 cfs V-Screen	$21,031,000.00	$13,751,000.00	$85,583.60
Alternative F - Inclined Plane Screen	$1,255,000.00	$821,000.00	$62,640.50
Alternative G - Portable Traps	$117,000.00	$77,000.00	$203,391.07

Notes and Assumptions:

All costs are order-of-magnitude costs for comparative purposes only.

All costs are estimated in 2014 Dollars

San Joaquin Juvenile Chinook Trap and Haul Analysis
Project Cost Estimate
Alternative A - Donny Bridge

Date: 1/27/2014
By: V. Autier
Checked By: M. Reiser

Capital Construction Costs

No.	Item Description	Quantity	Unit	Unit Cost (2014)	Total Cost	Notes
1	Site Clearing and Grubbing	0.24	Acre	$4,000	$960	
2	Excavation	3,717	CY	$20	$75,000	
3	Cofferdams and Dewatering	15,900	SF	$35	$ 557,000	
4	2- 500cfs V-screens (1,000cfs)	1	LS	$16,495,000	$16,495,000	Per USBR Klamath A-Canal (Escalated from 2003). Includes trashrack and bulkhead.
5	Canal	1	LS	$640,000	$640,000	Cast-in-place concrete.
6	Exclusion Barrier	1	LS	$1,224,000	$1,224,000	
7	Diversion weir (Obermeyer gates)	1	LS	$950,580	$950,580	
8	Upstream Fishway	1	LS	$600,000	$600,000	$150,000/pool
9	Bridge 20'(W)*140'(L)	1	LS	$2,800,000	$2,800,000	
10	Sorting Facility	1	LS	$1,500,000	$1,500,000	
11	Fish Transport Truck	1	EA	$250,000	$ 250,000	
12	Demolition	1	LS	$150,000	$150,000	

Subtotal: $25,242,540

Range of Magnitude Costs	
High Contingency (+30%)	$32,816,000
Low Contingency (-15%)	$21,457,000

Monthly Operations and Maintenance Costs

No.	Item Description	Quantity	Unit	Unit Cost (2014)	Total Cost
1	Truck Transport Distance	5,280	Miles	$1.45	$7,656
2	Facility Labor	720	Hrs	$50	$36,000
3	Truck Transport labor	120	Hrs	$50	$6,000
4	Maintenance	1	LS	$25,243	$25,243
				Subtotal:	$74,899
				Contingency (30%)	$22,470
				Total Monthly O&M:	**$97,368**

Notes
2-way trip, 88 miles per trip
2 persons, 12 hrs per day
1 person, 4 hrs per day
0.1% of construction cost

Notes and Assumptions:

All costs are estimated in 2014 Dollars

San Joaquin Juvenile Chinook Trap and Haul Analysis

Project Cost Estimate

Alternative B - Emmert Pump Station

Date: 1/27/2014
By: V. Autier
Checked By: M. Reiser

Capital Construction Costs

No.	Item Description	Quantity	Unit	Unit Cost (2014)	Total Cost	Notes
1	Site Clearing and Grubbing	0.14	Acre	$4,000	$551	
2	Excavation	6,400	CY	$ 20	$ 128,000	
3	Cofferdams and Dewatering	16,650	SF	$35	$583,000	
4	2- 500cfs V-screens (1,000cfs)	1	LS	$16,495,000	$16,495,000	Per USBR Klamath A-Canal (Escalated from 2003). Includes trashrack and bulkhead.
5	Canal	1	LS	$640,000	$640,000	Cast-in-place concrete.
6	Exclusion Barrier	1	LS	$1,224,000	$1,224,000	
7	Diversion weir (Obermeyer gates)	1	LS	$877,140	$877,140	
8	Upstream Fishway	1	LS	$600,000	$600,000	$150,000/pool
9	Bridge 20'(W)*7'(L)	1	LS	$1,400,000	$1,400,000	
10	Sorting Facility	1	LS	$1,500,000	$1,500,000	
11	Fish Transport Truck	1	EA	$250,000	$250,000	
				Subtotal:	$23,697,691	
	Range of Magnitude Costs					
	High Contingency (+30%)				$30,807,000	
	Low Contingency (-15%)				$20,144,000	

Monthly Operations and Maintenance Costs

No.	Item Description	Quantity	Unit	Unit Cost (2014)	Total Cost	Notes
1	Truck Transport Distance	4,140	Miles	$1.45	$6,003	2-way trip, 69 miles per trip
2	Facility Labor	720	Hrs	$50	$36,000	2 persons, 12 hrs per day
3	Truck Transport labor	120	Hrs	$50	$6,000	1 person, 4 hrs per day
4	Maintenance	1	LS	$29,622	$29,622	0.1% of construction cost
				Subtotal:	$77,625	
				Contingency (30%)	$23,288	
				Total Monthly O&M:	**$100,913**	

Notes and Assumptions:
All costs are estimated in 2014 Dollars

San Joaquin Juvenile Chinook Trap and Haul Analysis
Project Cost Estimate
Alternative C - Chowchilla Bifurcation Structure

Date: 1/27/2014
By: V. Autier
Checked By: M. Reiser

Capital Construction Costs

No.	Item Description	Quantity	Unit	Unit Cost (2014)	Total Cost	Notes
1	Site Clearing and Grubbing	0.56	Acre	$4,000	$2,250	
2	Excavation	13,067	CY	$15	$196,000	
3	Cofferdams and Dewatering	14,400	SF	$35	$504,000	
4	2- 500cfs V-screens (1,000cfs)	1	LS	$16,495,000	$16,495,000	Per USBR Klamath A-Canal (Escalated from 2003). Includes trashrack and bulkhead.
5	Canal	1	LS	$693,000	$693,000	Cast-in-place concrete.
6	Exclusion Barrier	1	LS	$1,224,000	$1,224,000	
7	Demolition	1	LS	$300,000	$300,000	
8	Upstream Fishway	1	LS	$600,000	$600,000	$150,000/pool
9	2 Bridges 20'(W)*70'(L)	1	LS	$2,800,000	$2,800,000	
10	Sorting Facility	1	LS	$1,500,000	$1,500,000	
11	Fish Transport Truck	1	EA	$250,000	$250,000	
				Subtotal:	$24,564,250	

Range of Magnitude Costs	
High Contingency (+30%)	$31,934,000
Low Contingency (-15%)	$20,880,000

Monthly Operations and Maintenance Costs

No.	Item Description	Quantity	Unit	Unit Cost (2014)	Total Cost	Notes
1	Truck Transport Distance	3,600	Miles	$1.45	$5,220	2-way trip, 60 miles per trip
2	Facility Labor	720	Hrs	$50	$36,000	2 persons, 12 hrs per day
3	Truck Transport labor	120	Hrs	$50	$6,000	1 person, 4 hrs per day
4	Maintenance	1	LS	$24,564	$24,564	0.1% of construction cost
				Subtotal:	$71,784	
				Contingency (30%)	$21,535	
				Total Monthly O&M:	**$93,320**	

Notes and Assumptions:

All costs are estimated in 2014 Dollars

San Joaquin Juvenile Chinook Trap and Haul Analysis
Project Cost Estimate
Alternative D - San Mateo Crossing

Date: 1/27/2014
By: V. Autier
Checked By: M. Reiser

Capital Construction Costs

No.	Item Description	Quantity	Unit	Unit Cost (2014)	Total Cost	Notes
1	Site Clearing and Grubbing	0.70	Acre	$4,000	$2,819	
2	Excavation	10,916	CY	$20	$219,000	
3	Cofferdams and Dewatering	16,500	SF	$35	$578,000	
4	2- 500cfs V-screens (1,000cfs)	1	LS	$16,495,000	$16,495,000	Per USBR Klamath A-Canal (Escalated from 2003). Includes trashrack and bulkhead.
5	Canal	1	LS	$693,000	$693,000	Cast-in-place concrete.
6	Exclusion Barrier	1	LS	$1,224,000	$1,224,000	
7	Diversion weir (Obermeyer gates)	1	LS	$950,580	$950,580	
8	Upstream Fishway	1	LS	$600,000	$600,000	$150,000/pool
9	Bridge 20'(W)*140'(L)	1	LS	$2,800,000	$2,800,000	
10	Sorting Facility	1	LS	$1,500,000	$1,500,000	
11	Fish Transport Truck	1	EA	$250,000	$250,000	
				Subtotal:	$25,312,399	

Range of Magnitude Costs	
High Contingency (+30%)	$32,907,000
Low Contingency (-15%)	$21,516,000

Monthly Operations and Maintenance Costs

No.	Item Description	Quantity	Unit	Unit Cost (2014)	Total Cost	Notes
1	Truck Transport Distance	2,900	Miles	$1.45	$4,205	2-way trip, 58 miles per trip
2	Facility Labor	720	Hrs	$50	$36,000	2 persons, 12 hrs per day
3	Truck Transport labor	120	Hrs	$50	$6,000	1 person, 4 hrs per day
4	Maintenance	1	LS	$25,312	$25,312	0.1% of construction cost
				Subtotal:	$71,517	
				Contingency (30%)	$21,455	
				Total Monthly O&M:	**$92,973**	

Notes and Assumptions:

All costs are estimated in 2014 Dollars

San Joaquin Juvenile Chinook Trap and Haul Analysis
Project Cost Estimate
Alternative E - 500 cfs V-Screen

Date: 1/27/2014
By: V. Autier
Checked By: M. Reiser

Capital Construction Costs

No.	Item Description	Quantity	Unit	Unit Cost (2014)	Total Cost	Notes
1	Site Clearing and Grubbing	0.24	Acre	$4,000	$960	
2	Excavation	2,478	CY	$20	$50,000	
3	Cofferdams and Dewatering	15,900	SF	$35	$557,000	
4	500cfs V-screen	1	LS	$8,247,000	$8,247,000	Per USBR Klamath A-Canal (Escalated from 2003). Includes trashrack and bulkhead.
5	Canal	1	LS	$460,000	$460,000	Cast-in-place concrete.
6	Exclusion Barrier	1	LS	$612,000	$612,000	
7	Diversion weir (Obermeyer gates)	1	LS	$950,580	$950,580	
8	Upstream Fishway	1	LS	$600,000	$600,000	$150,000/pool
9	Bridge 20'(W)*140'(L)	1	LS	$2,800,000	$2,800,000	
10	Sorting Facility	1	LS	$1,500,000	$1,500,000	
11	Fish Transport Truck	1	EA	$250,000	$250,000	
12	Demolition	1	LS	$150,000	$150,000	
				Subtotal:	$16,177,540	

Range of Magnitude Costs	
High Contingency (+30%)	$21,031,000
Low Contingency (-15%)	$13,751,000

Monthly Operations and Maintenance Costs

No.	Item Description	Quantity	Unit	Unit Cost (2014)	Total Cost
1	Truck Transport Distance	5,280	Miles	$1.45	$7,656
2	Facility Labor	720	Hrs	$50	$36,000
3	Truck Transport labor	120	Hrs	$50	$6,000
4	Maintenance	1	LS	$16,178	$16,178

Notes
2-way trip, 88 miles per trip
2 persons, 12 hrs per day
1 person, 4 hrs per day
0.1% of construction cost

Subtotal: $65,834

Contingency (30%) $19,750

Total Monthly O&M: **$85,584**

Notes and Assumptions:

All costs are estimated in 2014 Dollars

San Joaquin Juvenile Chinook Trap and Haul Analysis

Project Cost Estimate

Alternative F - Inclined Plane Screen

Date: 1/27/2014
By: V. Autier
Checked By: M. Reiser

Capital Construction Costs

No.	Item Description	Quantity	Unit	Unit Cost (2014)	Total Cost	Notes
1	Cofferdams and Dewatering	1	LS	$50,000	$50,000	
2	Inclined Plane Screen, pontoon, and Collection Box	1	LS	$600,000	$600,000	
3	Jib Crane	1	LS	$15,000	$15,000	
4	Fish Transport Truck	1	EA	$250,000	$250,000	
5	Demolition	1	LS	$50,000	$50,000	2- tons Caldwell Base mounted
				Subtotal:	$965,000	

Range of Magnitude Costs	
High Contingency (+30%)	$1,255,000
Low Contingency (-15%)	$821,000

Monthly Operations and Maintenance Costs

No.	Item Description	Quantity	Unit	Unit Cost (2014)	Total Cost
1	Truck Transport Distance	3,600	Miles	$1.45	$5,220
2	Facility Labor	720	Hrs	$50	$36,000
3	Truck Transport labor	120	Hrs	$50	$6,000
4	Maintenance	1	LS	$965	$965
				Subtotal:	$48,185
				Contingency (30%)	$14,456
				Total Monthly O&M:	**$62,641**

Notes
2-way trip, 60 miles per trip
2 persons, 12 hrs per day
1 person, 4 hrs per day
0.1% of construction cost

Notes and Assumptions:

All costs are estimated in 2014 Dollars

San Joaquin Juvenile Chinook Trap and Haul Analysis

Project Cost Estimate

Alternative G - Portable Traps

Date: 2/11/2014
By: Warren, Malone
Checked By: Warren

Capital Construction Costs

No.	Item Description	Quantity	Unit	Unit Cost (2014)	Total Cost
1	Smolt Traps and installation materials	3	1	$30,000	$90,000
				Subtotal:	$90,000

Notes
Estimated cost for a smolt trap with trailer, rigging and other installation materials

Range of Magnitude Costs	
High Contingency (+30%)	$117,000
Low Contingency (-15%)	$77,000

Monthly Operations and Maintenance Costs

No.	Item Description	Quantity	Unit	Unit Cost (2014)	Total Cost	Notes
1	Truck Transport Distance	4,107	Miles	$1.45	$5,955	Average total miles (Donny Bridge, Emmert, San Mateo)
2	Facility Labor	2880	Hrs	$50	$144,000	2 people / 3 traps/ 16 hours/ day (duration is 60 days)
3	Truck Transport labor	120	Hrs	$50	$6,000	
4	Maintenance	1	LS	$500	$500	
				Subtotal:	$156,455	
				Contingency (30%)	$46,936	
				Total Monthly O&M:	**$203,391**	

Notes and Assumptions:
All costs are estimated in 2014 Dollars