NACIMIENTO AND SAN ANTONIO DAMS STEELHEAD PASSAGE FEASIBILITY STUDY



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Contents

Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
amsl	above mean sea level
AF	acre-feet
basin	Salinas River basin
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
cm	centimeter
DO	dissolved oxygen
DPS	Distinct Population Segment
ESA	federal Endangered Species Act
FERC	Federal Energy Regulatory Commission
FSC	floating surface collector
FWC	floating weir collector
HCP	Habitat Conservation Plan
HLOW	high-level outlet works
LLOW	low-level outlet works
MCWRA	Monterey County Water Resources Agency
mg/L	milligrams per liter
mL	milliliter
NHC	National Hydrography Dataset
NWSC & CCSE	Nacitone Watersheds Steering Committee and Central Coast Salmon Enhancement
NMFS	National Marine Fisheries Service
NWPCC	Northwest Power and Conservation Council
RM	river mile
SCCC	South-Central California Coast
SRDF	Salinas River Diversion Facility
SVWP	Salinas Valley Water Project
TDS	total dissolved solids
USFS	U.S. Forest Service
USGS	U.S. Geological Survey

Chapter 1
Introduction

1.1 Background

The Salinas River is the longest river system along the central California coast. Fertile soils in the floodplain, a highly favorable climate, and the use of river flows for aquifer recharge and irrigation make the Salinas Valley one of the most productive agricultural regions in California, generating billions of dollars for the regional economy. However, given the intense agricultural demand in the basin and pervasive drought conditions, water allocation and management has been challenging. Specifically, stakeholders in the Salinas River basin (basin) have been faced with maintaining stream flows for agriculture and species habitat; controlling periodic flooding; managing invasive species; and addressing impaired water quality, loss of riparian vegetation, encroachment on the stream channel, and ad hoc bank stabilization.

Monterey County Water Resources Agency (MCWRA) is the primary local agency managing water and minimizing flood risks along the Salinas River and in Monterey County. MCWRA operates the San Antonio and Nacimiento Dams and a variety of other water management facilities along and near the Salinas River as part of the Salinas Valley Water Project (SVWP). In 2020, following development of the Salinas River Long-term Monitoring Plan (MCWRA and CSCC 2019), MCWRA began preparing a Habitat Conservation Plan (HCP) to cover non-federally funded or permitted activities associated with the MCWRA Salinas River water management system under the federal Endangered Species Act (ESA).

To support the development of the Salinas River Operations HCP, this study evaluates the feasibility of providing passage for adult and juvenile steelhead trout (*Oncorhynchus mykiss*) at Nacimiento and San Antonio Dams. Evaluation of fish passage alternatives has become a common requirement of ESA consultations for water infrastructure and dam projects where listed fish species are unable to access historic spawning and rearing habitats upstream of dams. The Salinas River HCP is intended to provide an effective framework to protect, enhance, and restore natural resources in specific areas of the basin. The purpose of the HCP is to restore the balance between natural resource conservation and water resources management by improving habitat conservation efforts in the Salinas River watershed.

A key component to habitat conservation as it relates to listed species is restoring and improving access to historical habitats, such as salmonid spawning and rearing habitat above impassable dams. On March 25, 2022, the National Marine Fisheries Service (NMFS) recommended MCWRA assess fish passage feasibility at Nacimiento and San Antonio Dams as it relates to ESA-listed South-Central California Coast (SCCC) Distinct Population Segment (DPS) steelhead trout (listed as *Threatened* in 2006; 71 FR 834). NMFS expects that addressing passage at both facilities is likely to meaningfully increase adult escapement (fish returning from the ocean) to the basin and juvenile production while improving population viability and moving the DPS closer to recovery. This study has been prepared in response to the NMFS recommendation and to ensure that all conservation strategies are considered while developing the HCP. The goal of this report is to evaluate the feasibility of multiple fish passage alternatives at the Nacimiento and San Antonio Dams for adult and juvenile steelhead trout and satisfy part of the preliminary design phase described in NMFS (2022). While this study does not provide specific design recommendations and cost estimates associated with each alternative, it does provide recommendations on the most feasible option given the species biological characteristics, facility information, and basin hydrologic characteristics.

1.2 Project Setting

The dam facilities impound the Nacimiento and San Antonio Rivers, both prominent tributaries to the Salinas River. For more detailed information on the Salinas basin as a whole, refer to the Long-Term Management Plan (MCWRA and CSCC 2019). The following sections provide information necessary to evaluate fish passage alternatives at Nacimiento and San Antonio Dams.

1.2.1 Salinas River Hydrology

The Salinas River watershed is the largest on the central California coast, draining approximately 4,240 square miles of land in Monterey and San Luis Obispo Counties (MCWRA 2014a). The headwaters of the Salinas River begin in the Santa Lucia and La Panza Mountain Ranges, in the Los Padres National Forest, and flow approximately 184 river miles north by northwest through the Salinas Valley and into the Monterey Bay near Castroville (MCWRA 2014a). The principal tributaries of the Salinas River floodplain within the plan area are the Nacimiento River, the San Antonio River, San Lorenzo Creek, and the Arroyo Seco River. Many of the tributaries to the Salinas River watershed are not gaged, meaning that streamflow, temperature, and water quality in these tributaries are not monitored. Only a handful of stream gages exist in the watershed and are shown on Figure 1-1.

1.2.2 Nacimiento and San Antonio Basins

The Nacimiento River is a major tributary of the Salinas River that originates from the Santa Lucia Mountains in the Los Padres National Forest at an elevation 3,350 feet above mean sea level (amsl). The Nacimiento basin drains approximately 362 square miles and is regulated at river mile (RM) 10 by Nacimiento Dam; Nacimiento Reservoir forms behind the dam. The river is approximately 55 miles long and flows southeast before joining the Salinas River. Much of the Nacimiento River remains dry during the summer months except for the headwaters in the Santa Lucia Mountains. The basin is typically divided into two areas: the lower basin that drains directly into the reservoir and the upper basin that drains into the Nacimiento River. Perennial conditions in the Nacimiento River exist in the uppermost reaches (NWSC and CCSE 2008).

The San Antonio River is another major tributary to the Salinas River that also originates in the Santa Lucia Mountains in the Los Padres National Forest at an elevation of 3,060 feet amsl (NWSC and CCSE 2008). The San Antonio basin drains approximately 344 square miles and is impounded by San Antonio Dam and Reservoir. The river is approximately 58 miles long, flowing southeast before joining the Salinas River. Much of the San Antonio basin is dry during the late summer and fall months; springs near the headwaters flow year-round (NWSC and CCSE 2008). However, the existence of perennial streams in the upper watershed have not been recently evaluated.

The two dams are jointly managed by MCWRA to control flood risk, recharge Salinas Valley aquifers to support irrigation and agriculture, enhance recreation, and provide flows for Salinas River steelhead (MCWRA and CSCC 2019). Water conservation is the agency’s highest priority and is accomplished primarily through groundwater recharge into Salinas Valley aquifers through targeted releases from Nacimiento and San Antonio Dams (MCWRA and CCSC 2019). Together the Nacimiento and San Antonio Rivers account for roughly 75% of the Salinas River flow (NWSC and CCSE 2008). Overall, about three times as much water flows into Nacimiento Reservoir compared to San Antonio Reservoir, due in part to differences in meteorological conditions and geologic characteristics (NWSC and CCSE 2008). Nacimiento and San Antonio Dams have year-round minimum release requirements of 60 cubic feet per second (cfs) and 3 cfs, respectively (Stillwater Sciences 2020). Flows in both systems have been significantly altered since the dams were built. In the Nacimiento River, winter and early spring flows downstream of the dam have decreased and late spring flows have increased, often exceeding 500 cfs (Stillwater Sciences 2020). In the San Antonio River several hundred cfs is released in the summer for agricultural purposes, depending on the water year type (Stillwater Sciences 2020).

1.2.3 South-Central California Coast Distinct Population Segment Steelhead

1.2.3.1 Life History

Oncorhynchus mykiss are known for having a particularly diverse set of life history strategies exhibiting resident, migratory, and anadromous forms. Anadromous variants, known as steelhead, migrate to the ocean as juveniles (known as smolts) to mature, whereas residents, known as rainbow trout, remain in fresh water for the entirety of their lives. Anadromous steelhead can produce resident offspring, just as resident rainbow trout can produce anadromous offspring, and the two life history variants are known to interbreed. Steelhead are generally classified as winter- or summer-run ecotypes depending on when they return to fresh water to spawn. Salinas River steelhead are winter run and generally migrate upstream between December and April and spawn shortly after (Table 1-1) (Stillwater Sciences 2020). Steelhead, unlike salmon of the same genus (*Oncorhynchus*), are iteroparous, meaning they can spawn more than once in their lifetime. Repeat spawning in the SCCC DPS has not been thoroughly investigated; therefore, it is unknown how many individuals exhibit repeat spawning and how this may affect population dynamics (NMFS 2013).

Within the SCCC DPS, a few watersheds support the expression a life history type termed "lagoon anadromous." In California, some river estuaries become cut off from the ocean during the summer by sandbars creating a seasonal lagoon (NMFS 2013). When this happens, some juveniles may migrate downstream and over-summer in the seasonal lagoons before migrating out to the ocean the following spring when the lagoon opens to the ocean. This life history strategy gives individuals an advantage as they can grow larger before entering the ocean environment, increasing their likelihood of survival and probability of returning as adults to spawn. However, if the lagoon remains closed off from the ocean during the adult migration period, adults are not able to access the river and reach spawning areas. Expression of a "lagoon-anadromous" life history has been observed in the Salinas River during years when the estuary is blocked by a sandbar. In this case, steelhead were observed migrating downstream to the lagoon, where they spent several months before migrating upstream to spawn (MCWRA and CSCC 2019).

After spawning, deposited eggs incubate within gravels from 3 to 8 weeks depending upon water temperatures (NMFS 2013) before emerging as alevins. Alevins emerge from gravels as fry between 2 and 6 weeks after hatching and move into the shallow and off-channel habitats that provide protection from predators and high flows. Juvenile steelhead remain in fresh water between 1 and 4 years, occupying a wide variety of habitat types including stream margins, main channel, and off-channel areas (e.g., backwaters, side channels). As individuals grow larger, ontogenetic shifts in behavior result in juveniles using more diverse habitat features. For example, foraging juveniles move to mid-channel habitat, commonly in or near riffles, rapids, and cascades, to establish territories and feed. They tend to choose territories in faster, shallower water as it is best suited to their style of feeding. Cover is an important habitat feature that helps juveniles avoid high temperatures and predation. Riparian vegetation, large woody debris, and large substrate (cobbles and boulders) provide cover for juveniles and are important for high-quality steelhead habitat. Juveniles undergo smoltification (a complex series of physiological changes where young salmonid fish adapt from living in fresh water to living in seawater) and migrate to the ocean in late winter and spring and spend between 1 and 4 years in the ocean maturing before returning to spawn in fresh water as adults (NMFS 2013).

1.2.3.2 Population Status

Steelhead populations across the SCCC DPS have declined dramatically from their estimated historical abundance. NMFS (2013) estimated that historically runs were often greater than 25,000 and have since declined to roughly 500 fish per year. Historically, steelhead were widely distributed throughout the Salinas basin, including the Arroyo Seco, Nacimiento, and San Antonio Rivers. Between 2010 and 2014 documented escapement to the Basin via upstream migrant trapping ranged from 0 to 43 adults (Cuthbert et al. 2014a) (Figure 1-2). Juvenile steelhead outmigration is also low, with fewer than 10 juvenile migrants captured annually in the upper Salinas basin between 2010 and 2014 (Cuthbert et al. 2014b). Sampling data suggests that the Arroyo Seco River in the lower Salinas basin is more productive, with substantially more juveniles sampled during outmigration monitoring relative to other locations (Figure 1-3).

1.2.4 Steelhead Habitat and Presence in the Study Area

MCWRA has conducted several years of stream surveys in the lower rivers to assess steelhead populations and conduct fisheries monitoring. An understanding of the habitat conditions required for the migratory fish species needing passage is critical to assessing alternatives and ultimately designing an effective passage system. Specific habitat characteristics important for steelhead to consider in the upper Salinas watershed as part of the feasibility assessment include streamflow, stream channel gradient, and water quality. The following subsections explore these habitat conditions in both the Nacimiento and San Antonio Rivers.

1.2.4.1 Nacimiento River

Hydrology

The Nacimiento River was historically capable of producing large flows, but after construction of Nacimiento Dam, the seasonal distribution and magnitude of flows entering the Salinas River has been significantly altered; in general, wet season flows have been reduced and dry season flows have increased (MCWRA and CSCC 2019). Since Nacimiento Dam was installed in 1956, peak flows in the lower river (downstream of the dam) have declined between 78 and 95% (Table 1-2 and Figure 1-4). The lower river is about 10 miles long to its confluence with the Salinas River.

The lower Nacimiento River is characterized by a low gradient and wide sections. Riparian vegetation is generally sparse but is present in some reaches. Typical substrate consists of gravel with some sand and cobble. Streamflow is a major limiting factor for steelhead habitat in the Nacimiento River below the dam because it is largely controlled by reservoir releases. Flows are typically low in the winter and high in the spring and summer to accommodate agricultural irrigation water supply downstream in the Salinas River basin (Stillwater Sciences 2020). Summer flow releases from the dam are primarily responsible for cool water temperatures, which likely provide a benefit to steelhead during peak summer temperatures. However, the value of cool water releases from the dam may be attenuated by the lack of velocity refuge in the reach downstream of the dam (Stillwater Sciences 2020). A consultation with NMFS by MCWRA determined that a minimum flow of 60 cfs as measured at the U.S. Geological Survey (USGS) streamflow gage along Nacimiento River below Nacimiento Dam near Bradley would provide adequate steelhead rearing habitat in the lower Nacimiento River. Until a conclusive study on steelhead rearing habitat is completed, the biological opinion has defined 60 cfs as the minimum rearing flow for the Nacimiento River below Nacimiento Dam (NMFS 2007; MCWRA 2018a).

Water Quality

Water quality is a measure of the physical, chemical, and biological characteristics of water and is influenced by factors both within the waterbody and by influences from stream runoff outside of the waterbody. The Salinas River watershed is in the jurisdiction of the Central Coast Regional Water Quality Control Board, which is responsible for adopting water quality control plans. Nacimiento Reservoir is a 303(d)-listed waterbody for the pollutant mercury and the Nacimiento River downstream of the reservoir is 303(d) listed for pH. In the Nacimiento River, the mean surface water quality objective for total dissolved solids (TDS) is 200 milligrams per liter (mg/L) (CCRWQCB 2019). MCWRA bi-annually monitors surface water conditions in Nacimiento Reservoir for dissolved oxygen (DO), temperature, nutrients, and general minerals, which includes TDS. Three of these water quality indicators—temperature, DO, and TDS—are important for steelhead. Generally, DO concentration should remain above 7.0 mg/L at any time. MCWRA recently analyzed water samples collected in September 2021 for TDS and found concentrations were slightly higher at the surface compared to a depth of 93 feet: 210 mg/L and 205 mg/L respectively. MCWRA has monitored temperature and DO in Nacimiento Reservoir since 2005. Generally, DO is less than 15 mg/L at the surface and quickly declines to near zero as depth increases (Figure 1-6). A similar trend was observed with reservoir water temperatures; temperatures were generally high at the surface and decreased with depth. Depending on the time of year surface temperatures exceeded 20 degrees Celsius (°C) and temperatures near the reservoir bottom were between 10 and 15°C.

Habitat conditions in the lower river contain some suitable habitat for steelhead and are characterized in general by low channel gradients, gravel substrate, sparse riparian vegetation, and warm water temperatures ranging from 11 to 23°C (Cuthbert et al. 2014b). Water temperatures are generally cooler closer to the dam where riparian vegetation is denser, and channel substrate is larger. Suitable spawning habitat exists along with many deep pools in the lower river, suggesting that area can support steelhead; recent captures of juvenile *O. mykiss* indicate that some natural production is occurring in the lower river (Cuthbert et al. 2014b).

Water temperatures above 20°C increase stress and disease susceptibility and cause individuals to lose their competitive edge with other fish (Reeves et al. 1987). Water temperature becomes lethal around 25°C (Brett 1952; McCullough et al. 2009). During water profile surveys conducted in spring 2022, temperatures at the reservoir surface were 19°C and DO fluctuated between 6 and 9 mg/L at depths less than 20 feet (Figure 1-6). Given that the 2022 surveys were completed in the spring, temperatures are likely to be cooler in the late winter and early spring when adult steelhead are actively moving upstream. DO was also low during the spring survey, but similarly may be more suitable during the cooler, wetter part of the year when inflows into the reservoir are likely higher. However, given the persistent drought conditions in Salinas Valley, temperature and DO may be poor during longer portions of the year, particularly during long periods without rainfall.

Steelhead Presence

Limited steelhead presence in the Nacimiento River below the dam has been documented (Stillwater Sciences 2020), although adults and juveniles have been observed infrequently and in very low abundances (Cuthbert et al. 2014a, 2014b). Dive count surveys along four monitoring sites (Sites 1–4) in the lower river in October 2014 resulted in positive observations of *O. mykiss* at three of the four sites surveyed, with the negative observation being the most downstream (MCWRA 2014b). Site 2 (about 3 kilometers downstream of Nacimiento Dam) had the highest density of *O. mykiss* with an estimate of 5.93 fish per 100 meters and contained beneficial habitat in the form of undercut banks and a boulder formation that created diverse flow conditions. A standardized average from the 2014 survey estimates that the total number of *O. mykiss* in the entire lower river is approximately 500 fish. On a subsequent survey in 2017, two young-of-the-year steelhead were observed at Site 2 (Cuthbert et al. 2018). The results from these surveys show that *O. mykiss* appear to associate with specific habitat that creates complex flow conditions, rather than with a specific position in the river (MCWRA 2014b).

1.2.4.2 San Antonio River

Hydrology

The San Antonio River watershed was historically capable of producing large flows to the Salinas River prior to the construction of San Antonio Dam. After its construction in 1967, the seasonal distribution and magnitude of flows entering the Salinas River significantly altered; in general, wet season flows reduced and dry season flows increased. The reservoir flows released during the dry season to maximize groundwater recharge adversely affect the riparian community, river hydrology, and steelhead habitat by changing the natural seasonal flow and dynamics of the river system (MCWRA and CSCC 2019). MCWRA maintains a minimum release flow of 10 cfs from San Antonio Reservoir until the surface elevation of San Antonio Reservoir is at or below the minimum pool elevation 666 feet amsl (MCWRA 2005). The minimum release flow into the lower river is not favorable to steelhead spawning or rearing habitat as this streamflow does not provide adequate habitat composition needed for steelhead (ENTRIX and EDAW 2002).

Water Quality

San Antonio Reservoir is a 303(d)-listed waterbody for the pollutant DDT and the San Antonio River downstream of the reservoir is 303(d) listed for E. coli and pH. MCWRA bi-annually monitors reservoir surface water at San Antonio Dam for DO, temperature, nutrients, and general minerals, which includes TDS. Three of these water quality indicators—temperature, DO, and TDS—are important for steelhead trout habitat requirements. For cold freshwater habitat, the criteria reference for DO concentration is to remain above 7.0 mg/L at any time. In the San Antonio River, the mean surface water quality objective for TDS is 250 mg/L (CCRWQCB 2019). MCWRA has monitored water temperatures and DO levels in San Antonio Reservoir since 2008. DO levels are highest at the surface and quickly decline to zero (Figure

1-8). Surface water temperatures often exceeded 20°C and declined to roughly 10°C near the reservoir bottom.

Thermal stratification may occur in the San Antonio Reservoir from spring through fall. During the stratification period (summer), surface water temperatures may range between 20 and 27°C, while at depths greater than about 30 feet water temperature is typically between 12 and 17°C (NWSC and CCSE 2008). Temperatures exceeding 20°C are generally unsuitable for steelhead migration and for other cold-water species (Bjornn and Reiser 1991). However, some studies have noted that California steelhead can tolerate temperatures in excess of 20°C when food resources are abundant, and temperatures cool at night (Casagrande 2010). Similarly, Thompson et al. (2012) observed no steelhead in Salinas River tributaries when maximum water temperatures exceeded 26°C and mean temperatures exceeded 21.5°C. Additionally, steelhead require relatively high DO concentrations (> 7 mg/L) for fish spawning and cold-water habitat (CCRWQCB 2019) and during the summer months, DO concentration drops below the thermocline, negating the possibility of trout habitat (NWSC and CCSE 2008).

Steelhead Presence

The San Antonio River is one of three tributaries in the Salinas River watershed considered to be a “principal steelhead spawning area;” however, monitoring on the river is not mandated by MCWRA’s Biological Opinion (NMFS 2007). Information related to habitat conditions of the San Antonio River downstream of San Antonio Dam indicates that steelhead spawning and rearing habitat is limited by substrate, channel form, temperature conditions, and streamflow (MCWRA 2005). Specifically, in the 2015 presence survey along 4.3 kilometers of the river, stream flows measured 5 cfs and water quality measurements showed water temperatures between 21.8°C (a.m. hours) and 26.8°C (p.m. hours) and DO concentrations between 2.8 mg/L and 7.9 mg/L. Given these water temperatures, it is likely that daily maximum temperatures at this site were approaching or exceeding the lethal threshold for steelhead. However, this was near the peak of the extended drought period that occurred between 2012 and 2016 throughout California, resulting in severely reduced flows throughout the Salinas Valley. Additionally, channel substrate was composed primarily of sand, silt, and fines, except for intermixed gravel in the pool immediately downstream from the dam. Therefore, the survey did not identify any locations that would provide suitable holding habitat for *O. mykiss* under existing streamflow, with the exception of the small pool directly below the dam. Adverse environmental conditions in the lower San Antonio River attributable to naturally occurring sulfur bacteria and compounded by low river flows has created unsuitable conditions for steelhead in most years.

The most recent steelhead presence surveys include a stranding survey in September 2013 and a presence/absence survey in August 2015, both below the dam. Results of both indicate that the Lower San Antonio River is unlikely to harbor many, if any, steelhead under typical conditions (Cuthbert et al. 2018). Although the lack of evidence of steelhead presence during this survey cannot confirm absence of the species in the survey reach, the survey concluded that steelhead presence was highly unlikely under measured environmental conditions (Cuthbert et al. 2018).

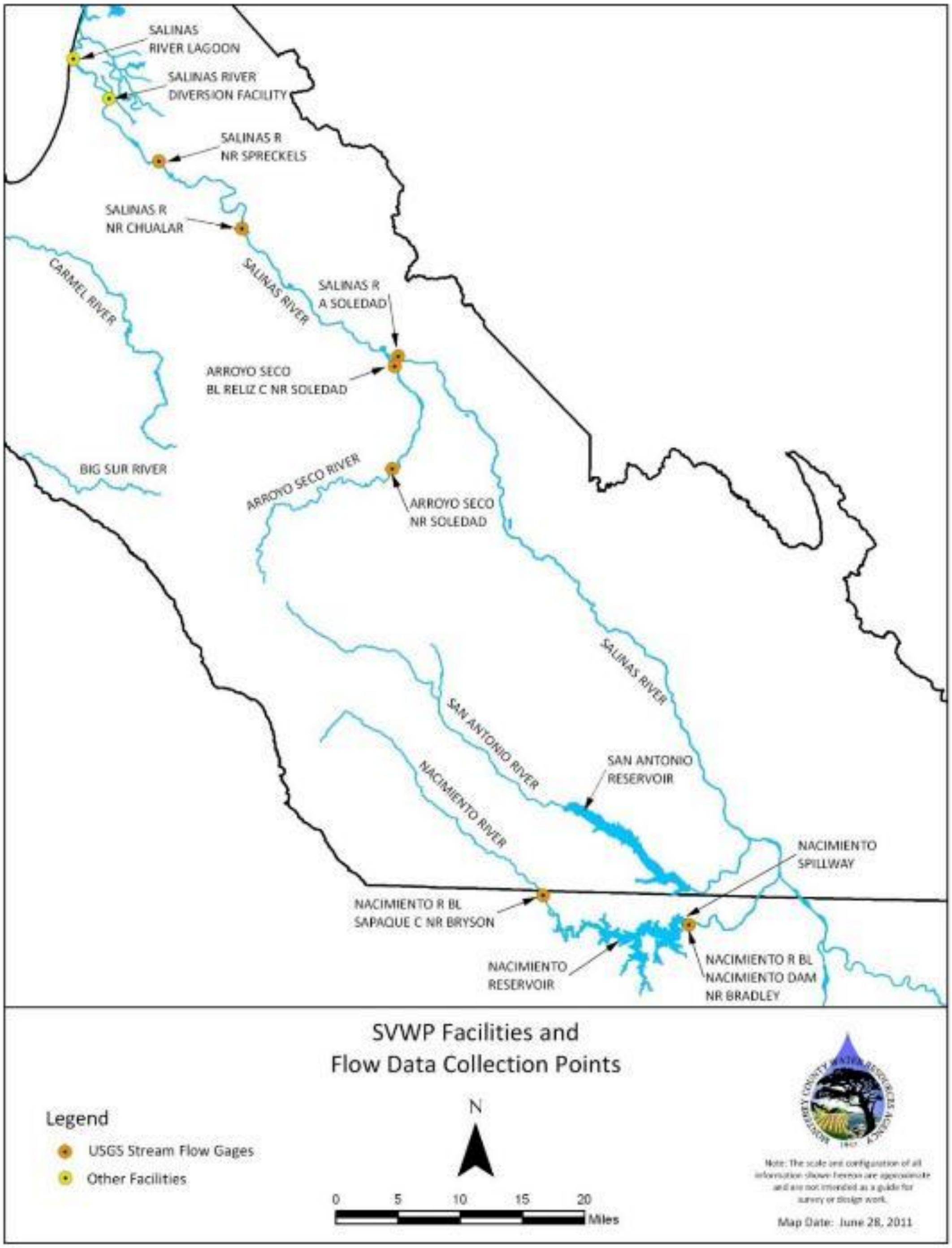
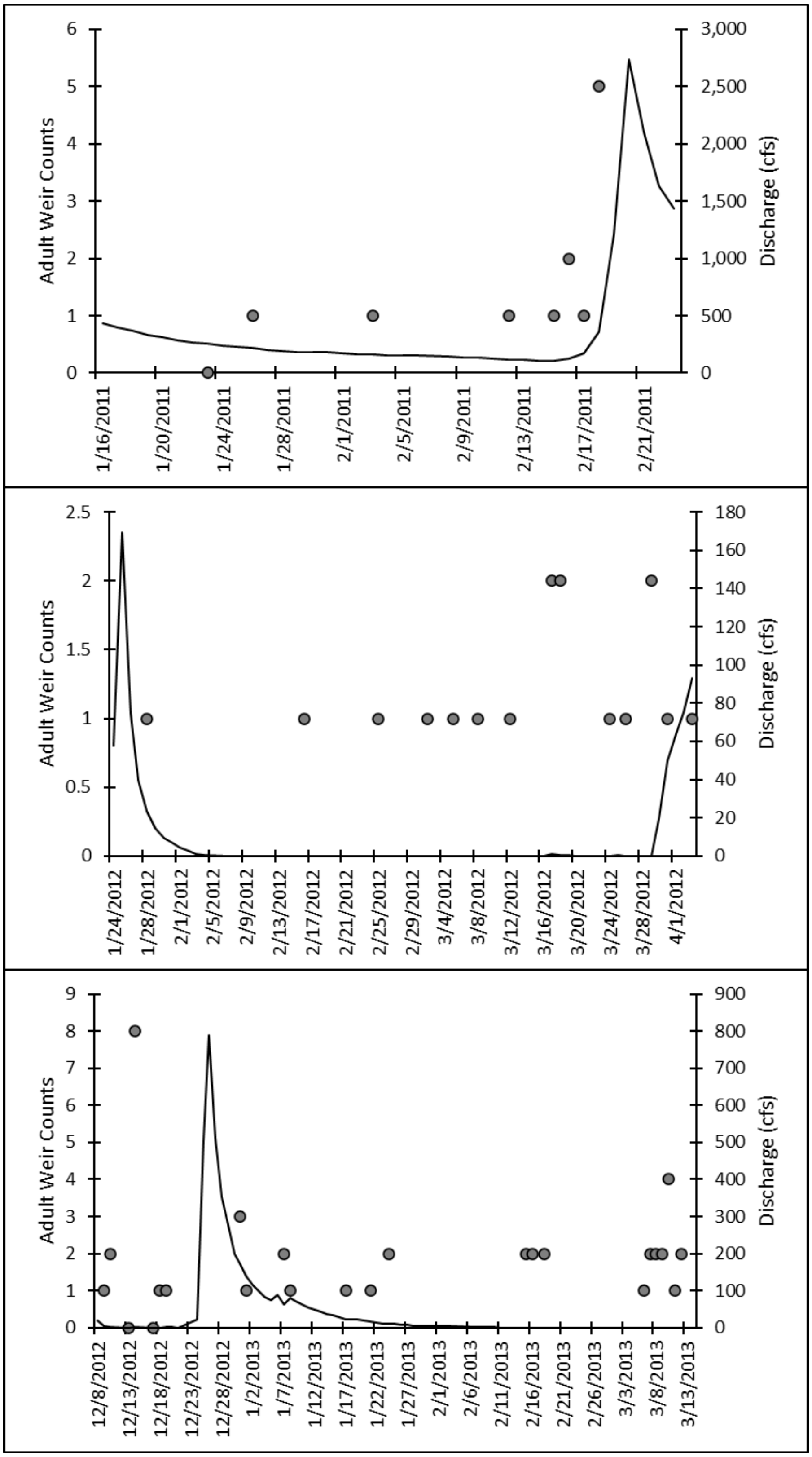


Figure 1-1. Salinas Valley Water Project Facilities and Data Collection Points

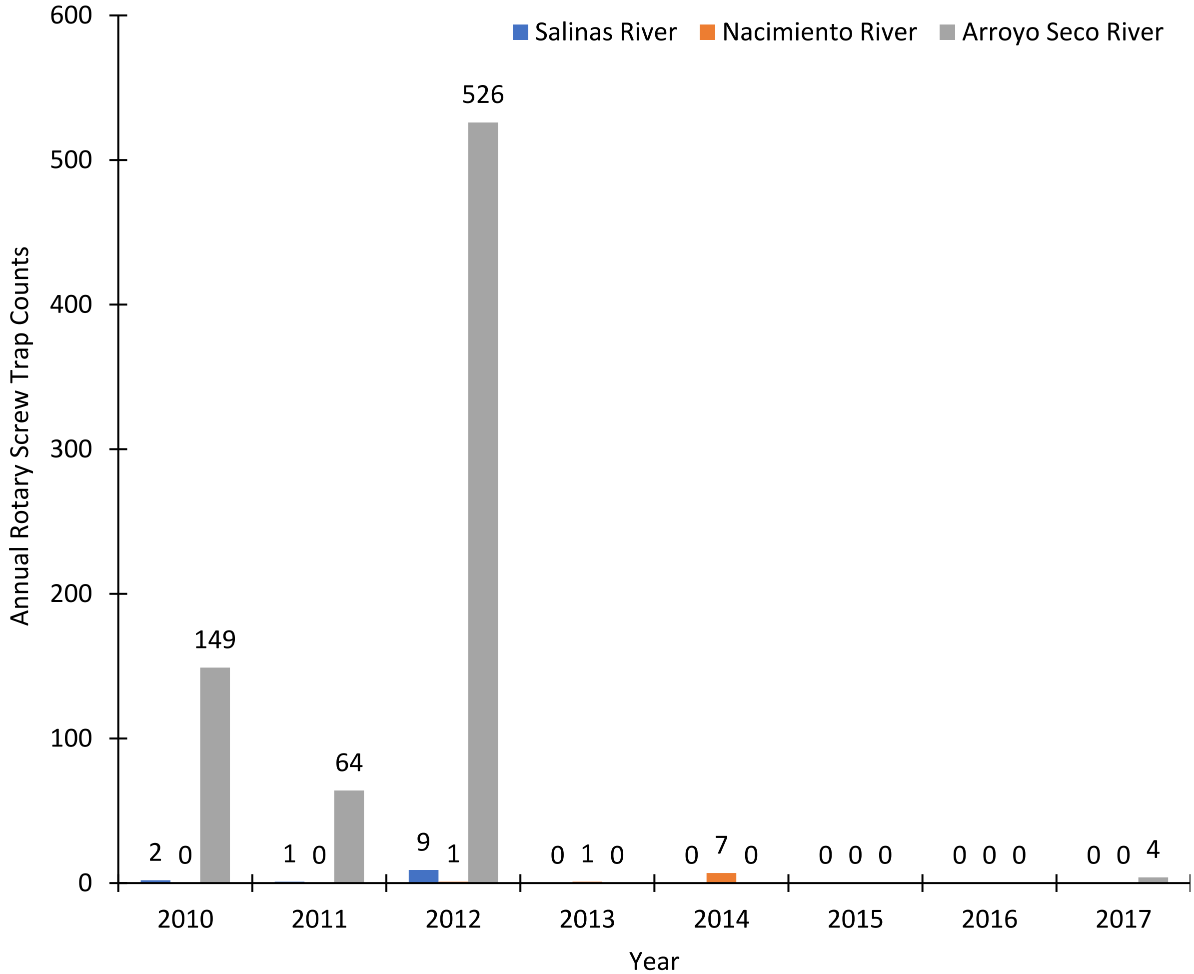
Table 1-1. Salinas River Steelhead Trout Life History Timing

Lifestage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Outmigration	■	■	■	■	■							
Adult Migration	■	■	■									■
Adult Outmigration (Kelts)			■	■	■							
Egg Incubation	■	■	■	■	■							■
Juvenile Rearing	■	■	■	■	■	■	■	■	■	■	■	■



Source: Cuthbert 2018

Figure 1-2. Salinas River Weir Adult Steelhead Upstream Counts



Source: Cuthbert 2018.

Figure 1-3. Annual Counts of Juvenile *O. mykiss* Sampled via Rotary Screw Traps on the Salinas, Nacimiento, and Arroyo Seco Rivers from 2010 to 2017

Table 1-2. Peak Flow Analyses for Stream Gages in the Upper Salinas River Basin

		Peak Flow (cubic feet per second)					
Gage	Years	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Nacimiento River near San Miguel[a]	1938–1956 (pre-dam)	20,000	37,000	51,000	69,000	83,000	98,000
Nacimiento River below Nacimiento Dam near Bradley[b]	1957–2018 (post-dam)	1,000 (-95%)	3,000 (-92%)	6,000 (-88%)	10,000 (-86%)	15,000 (-82%)	22,000 (-78%)
Salinas River near Bradley[c]	1957–2018	4,000	16,000	32,000	67,000	107,000	162,000

Sources: U.S. Geological Survey 2018; MCWRA and CSCC 2019

[a] USGS Gage 11149500 located near the San Luis Obispo/Monterey County border, approximately 7 river miles downstream of dam (Latitude 35°47'00", Longitude 120°47'24" NAD27).

[b] USGS Gage 11149400 located approximately 2 river miles downstream of dam (Latitude 35°45'41", Longitude 120°51'16" NAD27).

[c] USGS Gage 11150500 located approximately 6.5 river miles downstream of town of Bradley (Latitude 35°55'49", Longitude 120°52'04" NAD27).

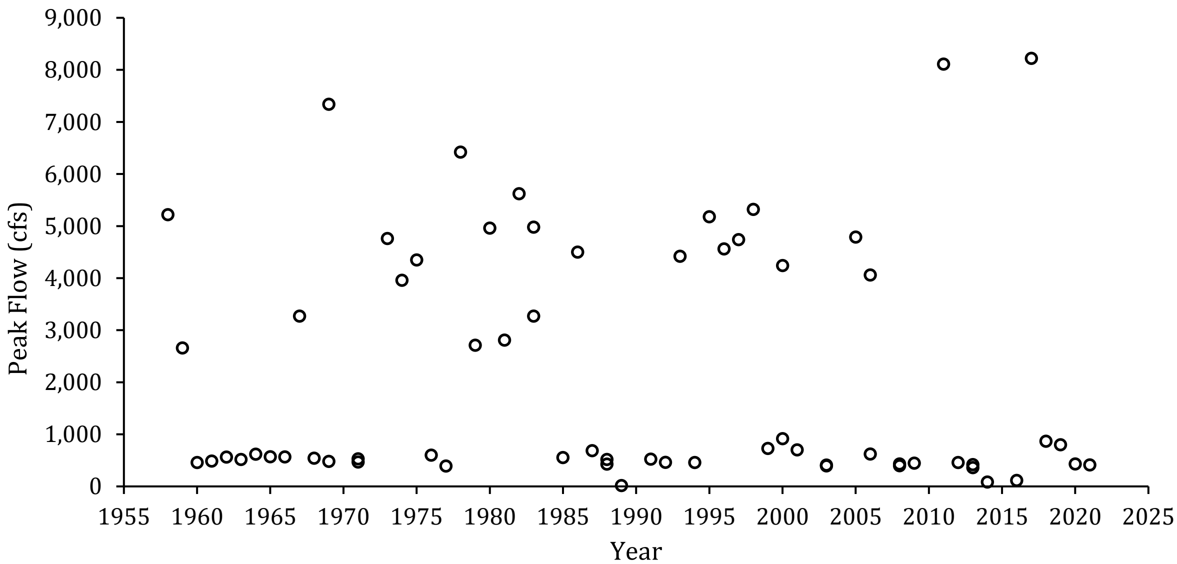


Figure 1-4. Annual Peak Flows (cubic feet per second) from 1958 to 2021 Recorded by USGS (gage 11149400) on the Nacimiento River below Nacimiento Dam near Bradley, California

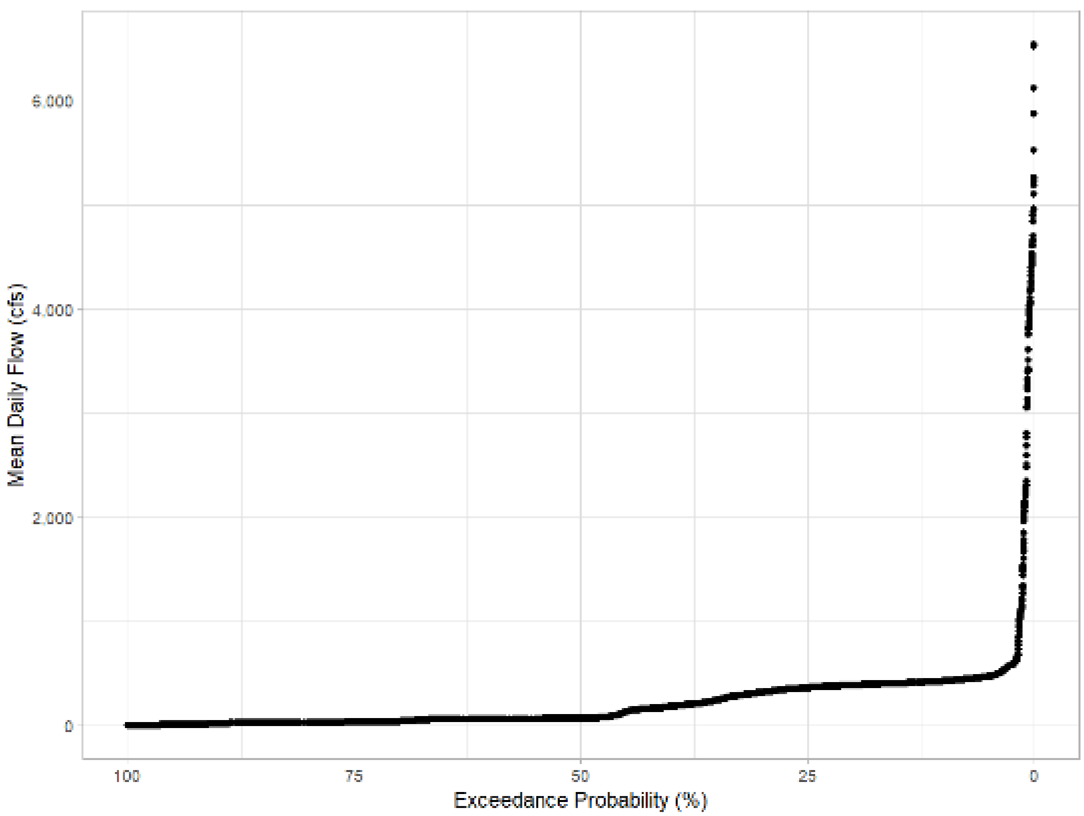


Figure 1-5. Mean Daily Flow Exceedance Probabilities Calculated for USGS gage 11149400 on the Nacimiento River below Nacimiento Dam near Bradley from October 1, 1988, to November 2, 2022

Table 1-3. Exceedance Probabilities and Recurrence Intervals for Nacimiento and San Antonio Rivers

Annual Exceedance Probability (%)	Recurrence Interval (n-year flood)	Nacimiento Discharge (cfs)[a]	San Antonio Discharge (cfs)[b]
96	1.5	0.10	0
50	2	116	7
43	2.33	185	10
20	5	401	100
10	10	478	225
4	25	591	370
2	50	1,630	550
1	100	3,120	736
0.5	200	4,240	1,080
0.02	500	6,290	2,500

[a] Calculated using data from the USGS gage (11194900) near Bradely, CA from 1958 to 2022.
[b] Streamflow is not measured downstream of the San Antonio Dam. Exceedances were calculated using dam release data from October 2, 1966, to August 30, 2021.

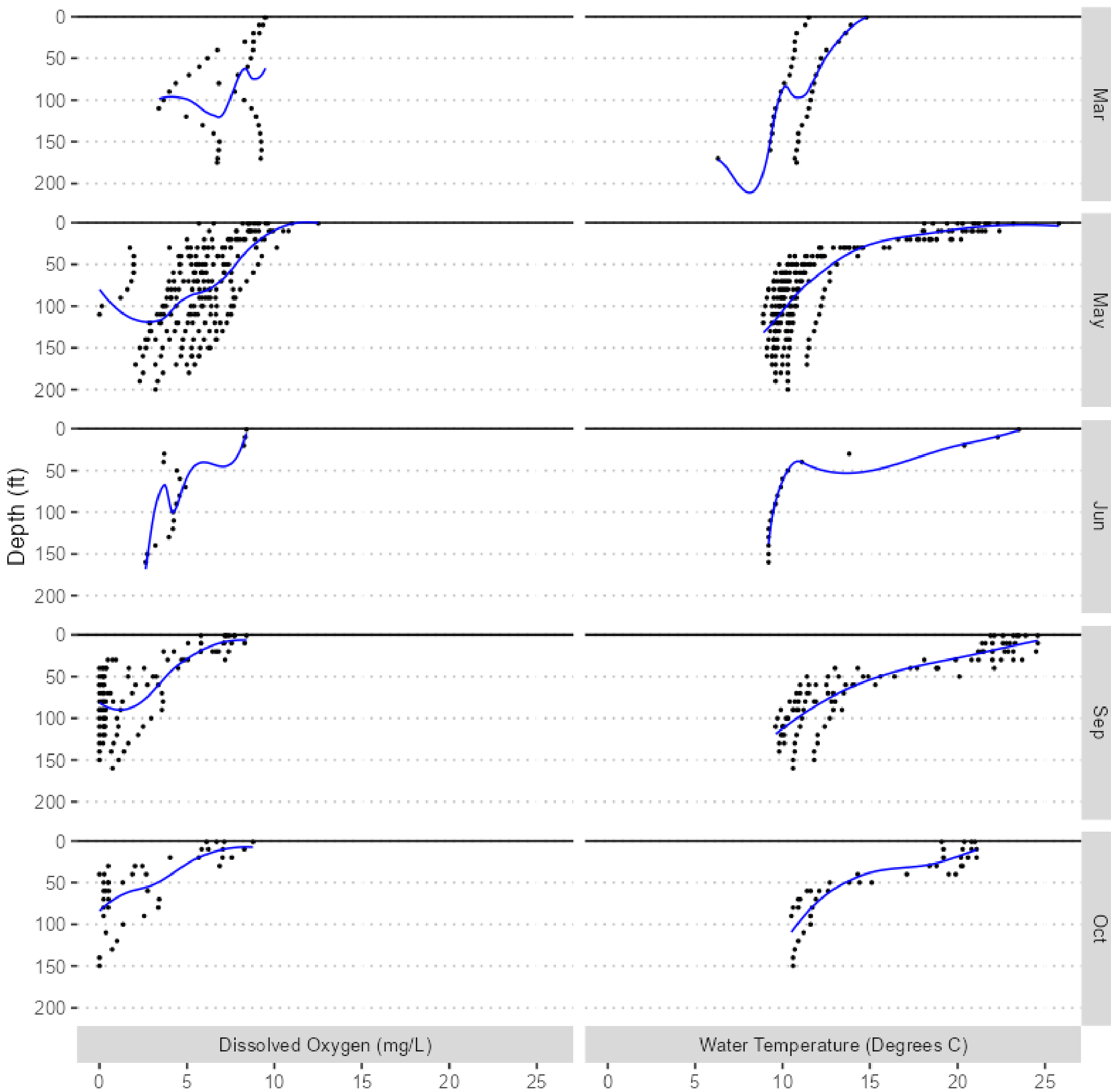
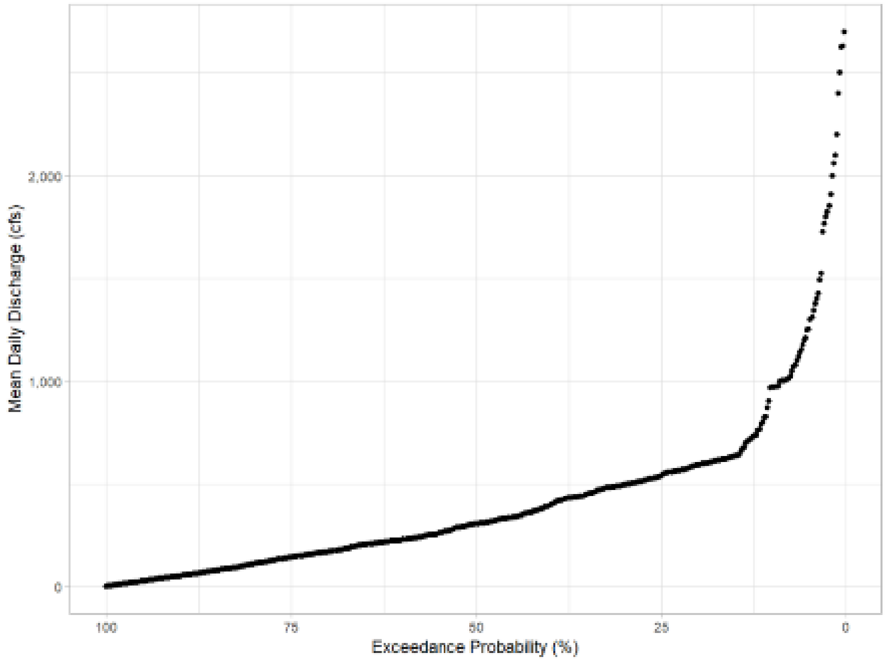


Figure 1-6. Water Quality Profiles Measured by MCWRA in Nacimiento Reservoir between 2005 and 2024.



Note: Daily streamflow measurements from an established USGS stream gage are not available on the San Antonio River below the dam.

Figure 1-7. Mean Daily Discharge Exceedance Probabilities Calculated using San Antonio Dam Discharge data from October 2, 1966, to August 30, 2021

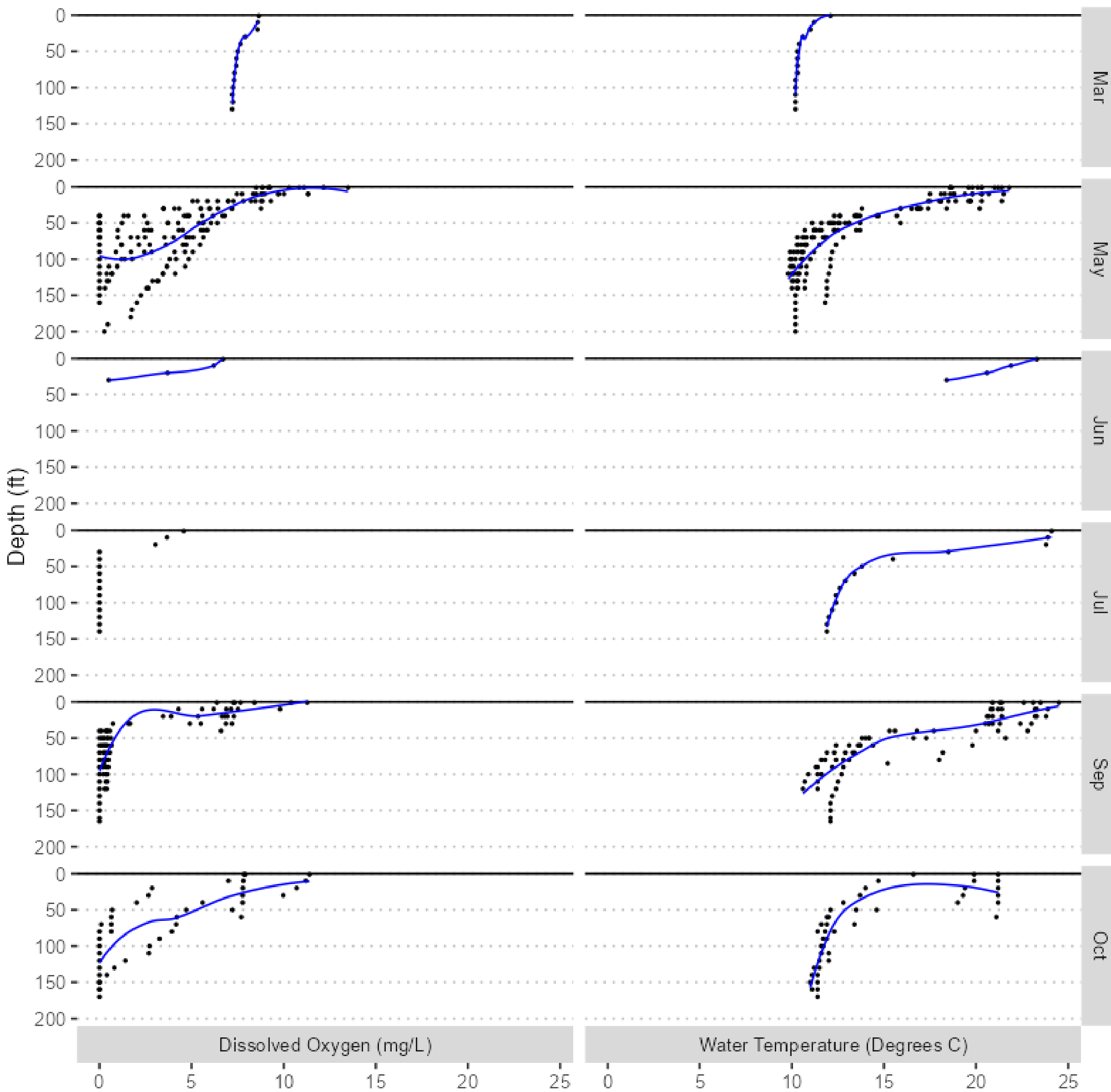


Figure 1-8. Water Quality Profiles Measured by MCWRA in San Antonio Reservoir between 2008 and 2024

Chapter 2
Review of Existing Information and Design Considerations

This assessment relies on the NMFS Anadromous Salmonid Design Manual (NMFS 2022) to evaluate the feasibility of passage alternatives at Nacimiento and San Antonio Dams. The manual "provides specific fish passage facility design criteria and technical assistance for [fish passage] actions within the WCR (West Coast Region)." For NMFS to provide technical assistance, they require the following information to be provided as part of a feasibility assessment.

- Functional relationship between the proposed fish passage facilities as related to project operations and stream flows.
- Site and physical information including basin hydrologic characteristics, project operations, stream or river morphology, and sediment and debris conditions.
- Biological information including salmonid biological characteristics, non-salmonids requiring passage, predation risk, fish behavior, additional research needs, streamflow requirements, poaching risks, and water quality.
- Operations and maintenance information such as plans, funding sources, and schedule of operations.

Based on these requirements, this preliminary evaluation of conceptual fish passage alternatives reviews existing conditions within each reservoir and the river channel immediately downstream of the dams as well as biological and life history characteristics of SCCC DPS steelhead in relation to NMFS requirements for specific fish passage alternatives. According to NMFS, "fish passage must be safe, timely, and effective. The risk of physical injury, stress, and passage delays must be minimal, and the system must be capable of passing sufficient numbers of adults upstream and juveniles downstream to support a viable population" (NMFS 2021). In general, NMFS requires fish passage be designed to allow volitional passage whenever feasibly possible (NMFS 2022).

This analysis also relies on fish passage feasibility studies completed in California and Oregon and two review documents to inform the study's analysis and conclusions. Specifically, this evaluation is informed by recent passage assessments completed by R2 Resource Consultants for Bowman Dam on the Crooked River in Oregon (R2 Resource Consultants Inc. 2020) and an evaluation at Santa Felica Dam on Piru Creek in the Santa Clara River watershed by the United Water Conservation District (Santa Felicia Dam Fish Passage Panel 2017) to develop passage alternatives and analyze feasibility. Similarly, information summarized by the California Department of Water Resources (DWR 2013) and the Northwest Power and Conservation Council concerning fish passage technologies at large dams in California and the Pacific Northwest (NPCC 2016) was also used to describe and evaluate passage alternatives. These studies and review documents provided valuable information on design, appropriate applications, costs, and examples where passage technologies have been successfully implemented.

2.1 Biological and Species Design Criteria

An understanding of the biological characteristics of the migratory fish species requiring passage is critical to assessing alternatives and ultimately designing an effective passage system. Migratory fish species for passage considerations in this study are adult and juvenile steelhead trout. Specific species characteristics important to consider as part of the feasibility assessment and design process include migration timing, jumping ability, swim speed, run abundances, and passage depths.

Potential run timing for upstream migrants is necessary to assess passage facility requirements at Nacimiento and San Antonio Dams. As noted in Section 1.2.3, *South-Central California Coast Distinct Population Segment Steelhead*, adult steelhead migrants typically enter the system between December and April (Table 1-1). Adult steelhead migration into the Salinas River is dependent on access and sufficient water in the Salinas River to accommodate upstream movement. It is common for a sandbar to form at the mouth of the Salinas River lagoon and block access to the river from the ocean. MCWRA manages connectivity to the ocean to prevent or alleviate flooding by grading or excavating a pilot channel across the sandbar to allow the river to reconnect to the ocean. The initial breach usually occurs in conjunction with winter storms between November and January but can occur any time between October and June (Hagar Environmental Science 2015). River flow may recede to low levels between storms and, depending on tide and wave conditions, the mouth may close again for periods of time (Hagar Environmental Science 2015). If the sandbar is not breached, then both adult and juvenile migrants are less likely to complete their respective migrations. Similarly, it is common for portions of the Salinas River to go dry at various points during the year, presenting another impediment to fish passage (Figure 2-1).

The potential ability of adult salmonids to migrate upstream is a function of streamflow velocity and water depth. Additionally, the ability of salmonids to pass over stream barriers depends on the swimming velocity of the fish, the horizontal and vertical distances to be jumped, and the angle to the top of the potential barrier (Bjornn and Reiser 1991). Established passage criteria over obstacles for adult *O. mykiss* requires a 1:1.25 height to pool depth ratio based on jumping ability and associated stream hydraulics, while studies suggest an outfall drop to pool depth ratio of 1:1 as conducive to leaping (Weigel et al. 2013; Pearson et al. 2005). A study by Reiser and Peacock (1985) computed maximum jumping heights of adult steelhead based on darting speeds and observed a maximum jumping height of 3.4 meters. Juvenile coho salmon (~100-millimeter hatchery fish) were capable, although at a very low percentage (3%), of overcoming a culvert-outlet outfall drop equivalent to approximately 2.5 body lengths. For the test conditions, the threshold for leaping success occurred at outfall drops between 2.5 and 3 body lengths (Pearson et al. 2005). For pool and weir fish ladders, the recommended head differential between pools is 1 foot for most salmon and trout, which can leap from pool to pool, and 0.75 foot for chum salmon (Fish Passage Technologies 1995). Exploring potential fish pool head differentials in subsequent sections is important when designing fish passage structures to enable the highest probability of steelhead upstream migration.

Adult migration can vary annually occurring early in December or towards the end of March (FISHBIO 2018). Adult migration often occurs after high flows when the lagoon is open to the ocean (FISHBIO 2018). For this study we assume that adult migrants would be entering the system and migrating upstream between December 1 and April 1. Recent monitoring efforts show the number of adult steelhead returning to the Salinas River has been low (Figure 1-2); between 2010 and 2017 fewer than 75 adults were observed passing the Salinas River weir at RM 2.75. Based on current conditions in the Salinas River watershed and recent adult monitoring efforts, we do not expect daily run size at either dam to be a limiting factor of fish passage designs. Moreover, historical data across the SCCC DPS is limited. In the 1960s estimates from the California Department of Fish and Game (CDFG) put the DPS at 17,750 adults with 500 annual spawners in the Pajaro, Salinas, Carmel, Little Sur, and Big Sur Rivers (NMFS 2007). Given the limited historical data we assume that the total number of adults returning to Nacimiento and San Antonio Rivers would not exceed 500 in any given year and that daily abundances would be limited to less than 50 adults.

All anadromous salmonids require adequate water depth to successfully complete freshwater migrations. Adequate depth varies between species and lifestages. For example, California Department of Fish and Wildlife (CDFW) (2017) considers 0.7 foot (8.4 inches) to be the minimum depth required for successful adult upstream passage. This depth requirement is important to consider when designing collection or passage facilities. If flows through a fishway do not provide sufficient water depth for fish to access and move through the facility it will be ineffective at providing passage to the intended species. Similarly, water releases from water storage or hydro facilities must provide sufficient depth within the river or stream channel for fish to reach the passage or collection facility.

2.2 Facilities and Operations

2.2.1 Nacimiento River and Reservoir

Nacimiento Dam and Reservoir has been in operation since 1957. The facility stores water in the winter and releases water in the spring and summer to support groundwater recharge and irrigation for agricultural purposes (Stillwater Sciences 2020). The facility is also operated to meet minimum flow requirements for upstream and downstream steelhead migrants and generates power via a small hydroelectric plant. Nacimiento Dam is 10 miles upstream from the Nacimiento and Salinas River confluence and is a complete barrier to steelhead spawning and rearing habitat in the upper Nacimiento basin (Cuthbert et al. 2014b).

2.2.1.1 Facilities

Nacimiento Dam crests at 825 feet amsl with a spillway elevation of 787.75 feet (Table 2-1 and Figure 2-2). The spillway can be extended to 800 feet using an inflatable Obermeyer spillway gate, which increases reservoir storage by 66,587 acre-feet (AF). Overall, Nacimiento Dam rises 215 feet above the streambed.

When the reservoir is full (elevation 800 feet) it has a maximum storage capacity of 377,900 AF, is 18 miles long, and has about 165 miles of shoreline. The maximum elevation during flood stage is 825 feet, with a maximum temporary capacity of 538,000 AF and a temporary surface area of 7,149 acres. The Nacimiento Reservoir was designed and constructed to meet specific purposes for water supply and flood control, and volumes of reservoir storage (typically referred to as pools or operational pools) were allocated for each purpose (Figure 2-2). A flood pool occupies the area between the top of the Obermeyer spillway gate when inflated (at an elevation of 800 feet amsl) down to the height of the concrete spillway (at an elevation of 787.75 feet amsl). The flood pool does not typically hold water; rather it is intended to provide winter flood protection by maintaining extra space in the reservoir to ensure the ability of the spillway to pass the probable maximum flood without overtopping the dam.

The conservation pool, which extends from the concrete spillway to the minimum pool, comprises most of the water in the reservoir and was designed to be managed for groundwater recharge in Monterey County. In general, this water is captured during the wet season and released during the dry season. The minimum pool retains water reserved for fish and wildlife habitat as well as a water entitlement belonging to the County of San Luis Obispo. The dead pool is the portion of the reservoir that cannot readily be released from the reservoir because it is below the elevation of the low-level outlet works (LLOW).

Spillway and Obermeyer Gates

The Nacimiento Dam spillway consists of a trapezoidal, unlined approach channel; an ungated concrete ogee crest weir with a crest elevation of 787.75 feet; and a 540-foot-long rectangular concrete chute that terminates in a flip bucket (a small bucket or lip at the bottom of the spillway designed to dissipate energy prior to releases entering the plunge pool). The highest point of the spillway is 787.75 feet amsl and the lowest point at the flip bucket is at about 630 feet amsl. The flip bucket is approximately 20 feet above the streambed. The spillway crest is a 150-foot-wide, ogee-shaped weir that is curved in plan with a 309.23-foot radius. Up to 60-foot-high retaining walls flank the ogee and the approach channel. The spillway chute tapers down to a 100-foot width and varies in slope from 0.15 foot/foot near the crest to 0.5 foot/foot near the flip bucket. The chute has sidewalls that vary in height from 13 to 25 feet. The flip bucket has a 50-foot vertical radius of curvature and directs the flow into the plunge pool.

The Obermeyer gate system is a patented bottom-hinged spillway gate that is supported entirely by an inflatable air bladder. This pneumatically actuated gate system is equipped with steel panels, a rubber bladder, and a simple steel frame. With accurate automatic pond level control, the spillway capacity is preserved as the low profile of the Obermeyer gate system allows efficient passage of flood flows without any significant increase in flood pond elevation. This prevents dangerous overtopping of dam embankments.

Hydroelectric Plant and Bypass Valves

The Nacimiento hydroelectric plant is a 4.351 megawatt/hour capacity hydroelectric power plant, which began operation downstream of the dam in 1987. The plant contains a large Francis turbine (Unit 1) capable of generating up to 4,418 kilovolt-amperes (kVA) and a smaller induction generator turbine (Unit 2) that are operated in the ranges of 150 cfs to 460 cfs, and 25 cfs, respectively. The hydroelectric plant requires a minimum reservoir elevation of 690 feet for the operation of Unit 1 and 728 feet for the operation of Unit 2. To maximize power production, two turbine runners have been provided for Unit 1. The high head runner is used for elevations above 735 feet. The low head runner is required for operation between elevations of 690 feet and 735 feet.

As a result of the installation and operation of the hydroelectric power generation facility in 1987, the dam is under the jurisdiction of the Federal Energy Regulatory Commission (FERC). To meet FERC requirements, MCWRA has adopted an Emergency Action Plan for the dam. The Emergency Action Plan contains a High Flow Operations Plan to ensure the dam is operated safely during flood events and that the appropriate agencies are notified of expected flood control releases.

Nacimiento Dam has two outlets: a high-level outlet works (HLOW) and a LLOW. The HLOW is composed of twin 8-foot by 8-foot square steel slide gates and cast concrete tunnels under the center of the spillway at an elevation of 755 feet. The HLOW has a maximum capacity of 5,500 cfs when the reservoir elevation is 800 feet. The LLOW is a 53-inch-diameter pipe near the southern side of the dam. The inlet to the LLOW consists of three 42-inch butterfly valves and a hydraulic operator set in a concrete structure at an elevation of 670 feet. Releases from the LLOW can be made from either a manifold of six 24-inch, manually operated valves or the hydroelectric power plant. The LLOW has a maximum capacity of 460 cfs when the reservoir elevation is 800 feet.

At the base of the spillway is a plunge pool that dissipates energy by slowing the velocity of releases before entering the Nacimiento River. The plunge pool is separated from the Nacimiento River by a causeway about 300 feet downstream of the bottom of the spillway. When the spillway is in operation, the plunge pool is connected via surface flow to the Nacimiento River.

2.2.1.2 Reservoir Operations

Nacimiento Reservoir is operated to meet irrigation, agricultural, groundwater, and fish passage needs throughout the Salinas River basin. To provide adequate spawning and rearing habitat in the Nacimiento River below Nacimiento Dam, 60 cfs is released from the reservoir throughout the year as long as surface elevation remains above the reservoir's minimum pool elevation of 678.8 (Figure 2-2) (MCWRA 2005). The reservoir is also operated during steelhead migration periods to provide passage opportunities for adults and juveniles from the Salinas River mouth to the Arroyo Seco, Nacimiento, and upper Salinas Rivers. More detailed descriptions of the fish passage flow prescriptions can be found in the 10-year flow evaluation report (MCWRA and ICF 2022) or the 2005 Flow Prescriptions (MCWRA 2005). For the purposes of this study, we rely on the minimum required flows for spawning and rearing habitat in the lower Nacimiento River. Reservoir elevations have fluctuated from 670 to 803 feet since the dam was operational (Figure 1-5) but exceed 730 feet most of the time (75% exceedance).

2.2.2 San Antonio River and Reservoir

The San Antonio Dam and Reservoir are in southern Monterey County, about 16 miles northwest of Paso Robles. San Antonio Dam is an earth-filled dam and was completed in 1967. Like Nacimiento, the conservation pool stores winter precipitation for later release to the Salinas River for groundwater recharge, fish passage, and the operation of the Salinas River Diversion Facility (SRDF). The San Antonio Dam is 5 miles upstream from the San Antonio River's confluence with the Salinas River and limits steelhead spawning and rearing habitat in the basin (NMFS 2007).

2.2.2.1 Facilities

San Antonio Dam crests at 802 feet amsl with a spillway elevation of 780 feet amsl (Figure 2-2 and Table 2-1). The spillway elevation and the maximum reservoir elevation are the same at 780 feet amsl. The reservoir does, however, contain a flood pool that extends from the spillway to the conservation pool at 774.5 feet asml, which increases reservoir storage by 30,000 AF. When the reservoir is full (elevation 780 feet) it has a maximum storage capacity of 335,000 AF, is 16 miles long, and has about 100 miles of shoreline. The maximum elevation during flood stage is 802 feet, with a maximum temporary storage capacity of 477,000 AF and a temporary surface area of 7,500 acres. The San Antonio Reservoir was designed and constructed to meet specific purposes for water supply and flood control, and volumes of reservoir storage (typically referred to as pools or operational pools) were allocated for each purpose. A flood pool occupies the area between the top of the spillway gate (at an elevation of 780 feet amsl) down to the top height of the conservation pool (at an elevation of 774.5 feet amsl). The flood pool does not typically hold water; it is intended to provide winter flood protection by maintaining extra space in the reservoir to enable the spillway to pass the probable maximum flood without overtopping the dam. The conservation pool, which extends from the minimum pool, comprises most of the water in the reservoir and was designed to be managed for groundwater recharge, fish passage, and the operation of the SVWP in Monterey County. In general, this water is captured during the wet season and released during the dry season. The minimum pool retains water reserved for fish and wildlife habitat. The dead pool is the portion of the reservoir that cannot readily be released from the reservoir as it is below the elevation of the LLOW.

2.2.2.2 Reservoir Operations

San Antonio Reservoir is operated to meet irrigation, agricultural, and groundwater needs in the Salinas River basin. Flow releases from San Antonio Dam range from 3 cfs to several thousand cfs and are managed to maintain the minimum flow requirements of 10 cfs from the reservoir (MCWRA 2005). Specifications for San Antonio Dam and Reservoir are provided in Table 2-1.

San Antonio Dam has an outlet works consisting of an 84-inch-diameter 1,085-foot steel conduit near the center of the dam. The conduit leads through the dam embankment from a small intake structure to an outlet structure, which contains a Howell-Bunger type valve and supports a concrete house. The outlet works have a maximum capacity of 2,200 cfs when the reservoir elevation is 780 feet.

Unlike Nacimiento, this dam does not have an inflatable gate, so the maximum reservoir elevation is the same as the spillway at an elevation of 780 feet amsl. MCWRA does, however, maintain a flood pool. The flood pool extends from the spillway to the conservation pool at 774.5 feet amsl. The maximum elevation during flood stage is 802 feet, with a maximum temporary capacity of about 477,000 AF and a temporary surface area of about 7,500 acres. The dead pool begins at an elevation of 645 feet and has 10,000 AF of storage.

2.2.3 Development of HCP Reoperation Protocols

MCWRA has operated the SVWP in accordance with the 2005 Flow Prescription (MCWRA 2005) and 2007 Biological Opinion (NMFS 2007) since 2010 to facilitate upstream and downstream steelhead passage. This is accomplished by providing water releases from Nacimiento and San Antonio Dams based on water year conditions, water availability, and established hydrologic triggers at various locations in the basin. Releases from Nacimiento and San Antonio Reservoirs are designed to occur when the likelihood of providing passage opportunities to the Arroyo Seco River are high. However, as part of the HCP development process the water management operations will be re-evaluated and restructured to minimize impacts on species covered by the HCP, including SCCC steelhead. At the end of this process operational releases from Nacimiento and San Antonio Dams may change from current (interim) operations. These evaluations will include assessment spawning, rearing, and migration habitat needs in the lower Nacimiento, lower San Antonio, and lower Salinas Rivers. This report evaluates fish passage alternatives based on historic and current SVWP operations. Further analyses will be needed once the SVWP operations are finalized as part of the HCP process.

Water year type is indicated at the top of each plot panel. Combined reservoir releases from Nacimiento and San Antonio Dams are shown in grey.

Figure 2-1. Flow Conditions in the Salinas River Basin at Various Monitoring Sites in the Salinas River and Arroyo Seco River

Table 2-1. Nacimiento and San Antonio Dam and Reservoir Key Facility Elevations and Statistics

Specifications	Nacimiento Reservoir	San Antonio Reservoir
Reservoir length (maximum capacity)	18 mi	16 mi
Shoreline (maximum capacity)	165 mi	100 mi
Dam crest length	1,650 ft	1,433 ft
Dam height above streambed	215 ft	201 ft
Dam crest elevation	825 ft amsl	802 ft amsl
Spillway elevation	800 ft amsl	780 ft amsl
Maximum storage capacity	377,900 AF	335,000 AF
Top of Dead pool elevation	670 ft amsl	645 ft amsl
Dead pool storage capacity	10,300 AF	10,000 AF
Top of Operational minimum pool elevation	687.8 ft amsl	666 ft amsl
Operational minimum pool storage capacity	12,000 AF	13,000 AF
Top of Conservation pool elevation	787.75 ft amsl	774.5 ft amsl
Conservation pool storage capacity	289,013 AF	282,000 AF
Top of Flood pool elevation	801 ft amsl	780 ft amsl
Flood pool storage capacity	66,587 AF	30,000 AF

Source: MCWRA 2018b, 2018c.
mi = mile; ft = feet; amsl = above mean sea level; AF = acre-feet

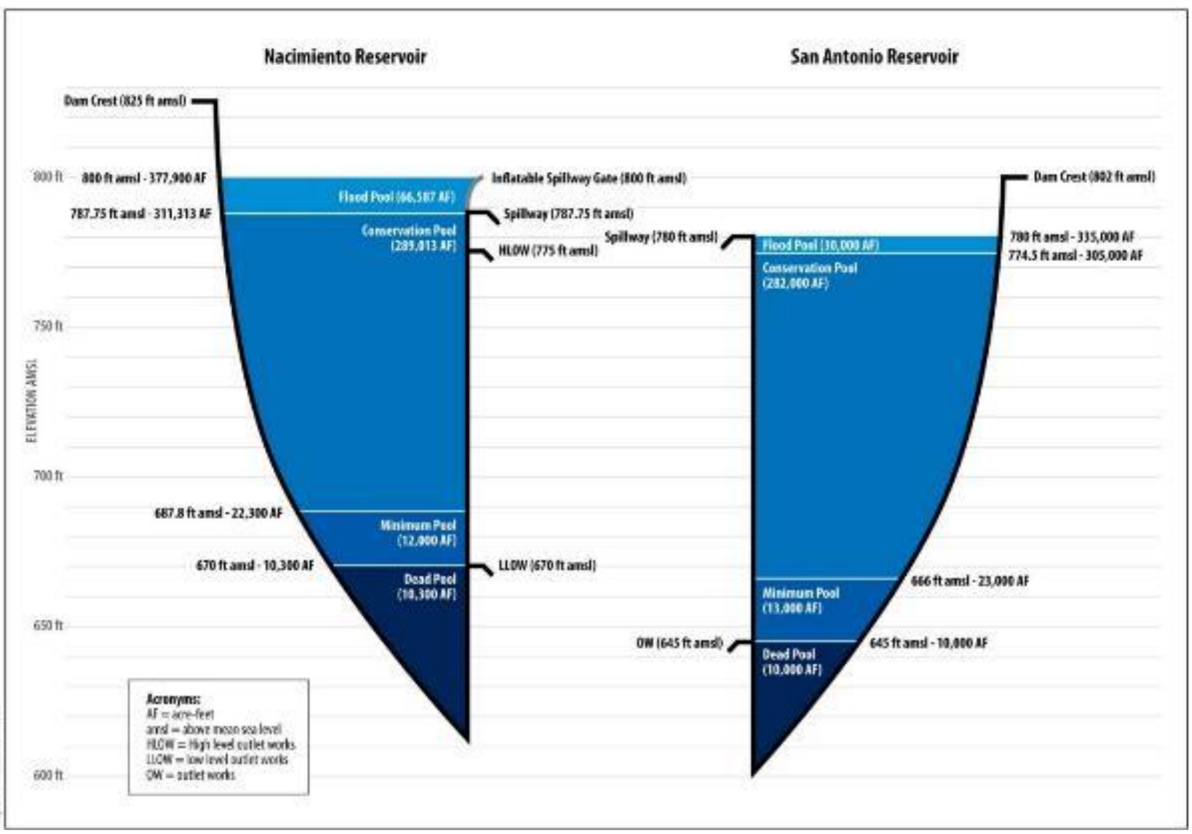


Figure 2-2. Nacimiento and San Antonio Reservoir Storage Levels and Key Operation Elevations

Figure 2-3. Location of Referenced Facility Components at Nacimiento Dam

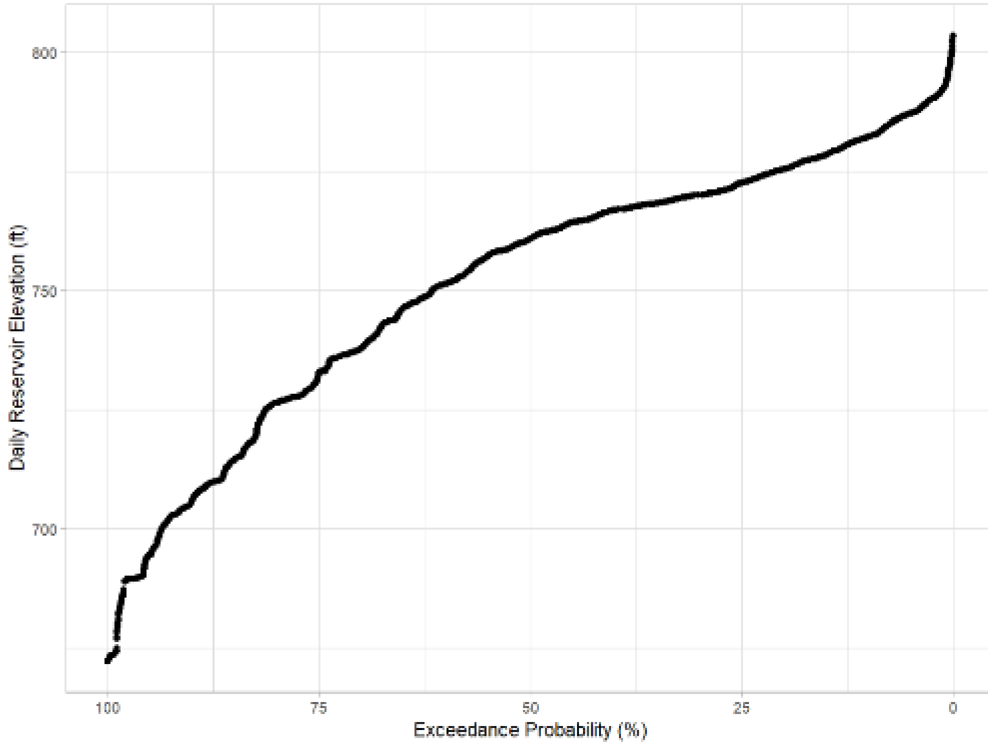


Figure 2-4. Nacimiento Reservoir Elevation Exceedance Probability from December 1, 1958, to February 28, 2022

Figure 2-5. Location of Referenced Facility Components at San Antonio Dam

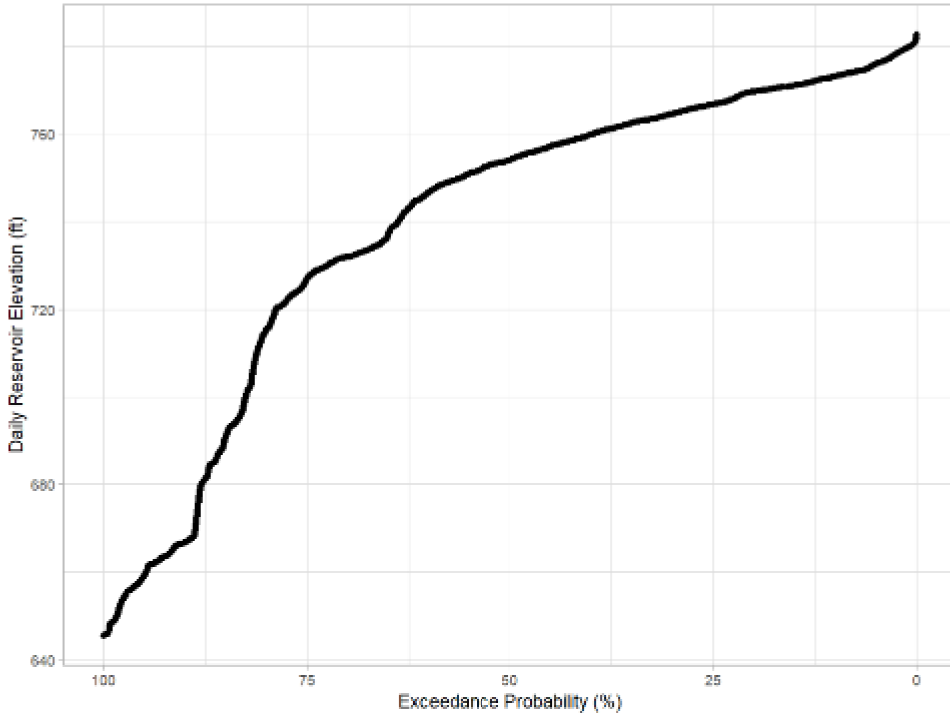


Figure 2-6. San Antonio Reservoir Elevation Exceedance Probabilities from October 1, 1966, to February 28, 2022

Chapter 3
Evaluation of Passage Alternatives

This chapter evaluates adult and juvenile salmonid passage technologies considered for the Nacimiento and San Antonio Dams. The scope of this study is to conceptually identify feasible passage alternatives based on the characteristics of the facility, species, and river. Construction and operation and maintenance costs incurred at other facilities in California, Oregon, and Washington are provided to give context for expected associated costs for each alternative.

3.1 Biological Constraints

Passage through Nacimiento and San Antonio Reservoirs present a variety of biological constraints for migrating steelhead. Passage through the reservoirs may expose juvenile and adult steelhead to poor water quality, low-flow and low-velocity conditions, and predation, all of which may reduce overall survival rates. Additionally, travel through each reservoir may be a lengthy process given the linear distance from the dam to the upper river and the extensive and complex shoreline. Similarly, the amount and quality of rearing and spawning habitat upstream of the reservoirs is critical in determining upper production potential. Based on review of available literature, no comprehensive field assessment of steelhead habitat has been conducted in these watersheds, though there have been numerous surveys for steelhead presence and general observations of habitat suitability. The great majority of these surveys and observations, documented by CDFG (now CDFW), U.S. Forest Service (USFS), NMFS, and environmental consultant staff, are older reports from the 1940s through the 1990s and likely do not reflect current conditions. The following sections discuss these factors in more detail. Also, each alternative evaluation expands on these factors as necessary.

3.1.1 Reservoir Conditions

Several of the evaluated passage alternatives would require adult and juvenile steelhead to travel through Nacimiento or San Antonio Reservoir to reach spawning habitat or to complete their outmigration, respectively. Nacimiento Reservoir is roughly 18 miles long with over 150 miles of shoreline (Table 2-1). San Antonio Reservoir is 16 miles long with 100 miles of shoreline. During a study of salmon and steelhead migration rates through Columbia and Snake River Reservoirs, Keefer et al. (2004) found that adult summer steelhead traveled, on average, between 13 and 25 miles per day. Based on this travel rate, travel through Nacimiento Reservoir could take adults more than a day to complete. The authors attributed long migration times with high water temperatures because fish sought out and held in tributaries with cold-water refugia. Given the lack of long-term monitoring data it is unclear if water temperatures in the reservoir during the adult migration period would cause migration delays.

Travel through Nacimiento Reservoir also presents a significant obstacle to smolts. Traveling through long reservoirs can result in prolonged migration rates and low survival as smolts can become disoriented due to low flows and low velocities. For example, Zabel et al. (2002) found that survival of smolts navigating the Columbia River and Snake River hydropower reservoirs declined as fish traveled longer distances. The authors estimated survival of steelhead and Chinook salmon from Lower Granite Dam to Little Goose Dam was 0.801 and 0.939, respectively (Zabel et al. 2002). However, survival from Lower Granite Reservoir to Bonneville

Dam was substantially lower, 0.038 and 0.264 for steelhead and Chinook salmon, respectively. Zabel et al. (2002) surmised that exceptionally low flows were a contributor to low survival rates and extended travel times. In general, higher flows through reservoirs result in better survival as smolts are less prone to becoming disoriented. This was demonstrated on the Yakima River by Courter et al. (2016), who found higher smolt survival over Roza Dam was positively correlated with increasing flow.

Poor water quality conditions in the reservoir may also negatively affect adult and juvenile survival. As described in Section 1.2.4.1, *Nacimiento River*, water quality, DO, and particularly temperature is impaired in Nacimiento Reservoir. Steelhead require diverse channel features and clean, cold water to survive. See Section 1.2.4.1 for more discussion on water quality conditions and impacts on steelhead. Like Nacimiento Reservoir, poor water quality conditions in San Antonio Reservoir may also negatively affect adult survival. As described in Section 1.2.4.2, *San Antonio River*, water quality, DO, and particularly temperature is impaired in San Antonio Reservoir. Additional investigations would be needed to fully evaluate the reservoir water quality and the associated effects on adult survival.

The Salinas River and its tributaries are known to supports populations of largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), white bass (*Morone chrysops*), striped bass (*Morone saxatilis*), channel catfish (*Ictalurus punctatus*), and white catfish (*Ictalurus catus*), all of which are known to feed on salmonids including steelhead (MCWRA and CSCC 2019). While there is limited data on the current presence and abundance of piscivorous fish in Nacimiento Reservoir, electrofishing surveys conducted by CDFW in 1995 as reported by ENTRIX and EDAW (2002) found that largemouth bass, smallmouth bass, white bass, white catfish, and channel catfish were all present in the reservoir. White bass has historically been of concern to CDFW in the reservoir since they were introduced in 1965 and appear to spawn in the headwaters of Nacimiento Reservoir and associated tributaries and have also been found in the Nacimiento River following flood control releases (ENTRIX and EDAW 2002). While there is limited data on the current presence and abundance of piscivorous fish in San Antonio Reservoir, electrofishing surveys conducted by CDFW as reported by ENTRIX and EDAW (2002) found that largemouth bass, smallmouth bass, striped bass, white catfish, and channel catfish were all present in the reservoir. Striped bass has been known to occur in the reservoir as this species was experimentally stocked beginning in 1971 and continuously stocked until the 1980s (; ENTRIX and EDAW 2002). Anecdotal reports of striped bass catch have also been reported in the reservoir as recently as 2014 and 2015. Additional investigation into the risk of piscivorous predation in the reservoir is needed to assess the impact of predation on smolt survival through the reservoir.

3.1.2 Salinas River Conditions

Nacimiento and San Antonio Dams have significantly altered the seasonal distribution and magnitude of streamflow in the Salinas River by reducing wet-season flows and increasing dry-season flows. It is not uncommon for flow in the mainstem Salinas River to cease completely during dry water years (Figure 2-1). When the riverbed becomes dry or flows intermittently for extended periods of time, adult and juvenile steelhead are unable to complete their migrations. During the adult migration period the Salinas River was dry during half of the time between 2010 and 2019 because of the extended drought period between 2012 and 2016 (MCWRA and ICF 2022). Similarly, during months when smolts typically migrate downstream the Salinas River was disconnected from the ocean for four of the years between 2010 and 2019. Historically, it also was not uncommon for the Salinas River to run dry.

3.2 Upstream Passage

Adult upstream fish passage technologies can be broadly grouped as volitional and non-volitional. Volitional passage technologies allow fish to pass continuously, allowing migrants to choose when they pass obstructions. Fish ladders, for example, provide a constant hydraulic connection from the reservoir upstream to the river downstream (DWR 2013). Volitional passage systems can be operated year-round and require less maintenance and fewer personnel to operate. Non-volitional technologies such as lifts, locks, and trap-and-haul operations rely on machines and people to collect, transport, and release fish upstream or downstream of the dam and reservoir. Trap-and-haul operations do not allow for year-round passage as personnel are required for operation. NMFS prefers volitional options as opposed to trap-and-haul methods to minimize handling and the risk of injury. However, volitional passage is not always possible due to facility constraints. The timing of trap operations can exclude early and late arriving fish, disproportionately affecting those fish by delaying or preventing migration altogether. This may, over time, cause adult return timing to be condensed and less diverse than natural or volitional passage systems.

NMFS (2022) sets general design criteria specific to all passage projects as well criteria for specific passage systems (e.g., trap and haul, fishways). General requirements include the following.

1. Design low flows: mean daily average streamflow that is exceeded 95% of the time when fish are actively migrating through the system. If possible, 25 years of daily stream measurements should be used.
2. Design high flow: mean daily average streamflow that is exceeded 5% of the time during periods when migrating fish are present at the site. If possible, 25 years of daily stream measurements should be used.
3. Design flood flows: fish passage systems should accommodate up to a 50-year flood event. A fish passage operation should not be inoperable due to high river flows for a period greater than 7 days during the migration period.
4. Attraction flow: attraction flows should be between 5 and 10% of the design high flow for streams with mean annual stream flows greater than 1,000 cfs.
5. Entrance hydraulic drop: entrance to the fishway must be maintained between 1 and 1.5 feet depending on the species present and designed to operate between 0.5 and 2 feet.
6. Entrance dimensions: the entrance to the fishway must be at least 4 feet wide and 6 feet deep.
7. Transport velocity: velocity between the fishway entrance and the first fishway weir, fishway channels, or over fishway weirs must be between 1.5 and 4.0 feet/second.

The following subsections discuss general features and characteristics and provide examples of upstream passage technologies.

3.2.1 Selection of Adult Passage Alternatives

Numerous technologies were initially considered for adult upstream passage at Nacimiento and San Antonio Dams. However, certain options were ruled out based on the physical characteristics and operations of the facilities and surrounding landscape (Table 3-1). After a preliminary review of upstream passage options, the following three alternatives were selected to be further evaluated at both facilities.

1. Volitional passage via a pool-style fish ladder.
2. Trap-and-haul program with collection at the base of the dams and transport via trucks upstream to release points within the reservoirs.
3. Trap-and-haul program with collection at a downstream location along the Salinas River and transport via trucks upstream to release points within the reservoirs.

Table 3-1. List of Adult Upstream Passage Concepts Deferred from Further Evaluation

Considered Alternative	Reason for Deferment
Roughened Bypass Channel	Impractical due to height of the dam and steep surrounding topography
Fish Locks	Limited documented success, impractical due to height of the dam and steep surrounding topography
Whooosh™ Fish Cannon	Unproven experimental technology
Fish Lift	Other alternative such as trap and haul are simpler, require less maintenance, and allow greater flexibility (i.e., different release points in the reservoir)

3.2.2 US Alternative 1: Volitional Passage via a Fish Ladder

Fishways and fish ladders are structures designed to facilitate fish passage over or around an obstacle, dam, or other migration barrier. Fish ladders and fishways are constantly hydraulically connected to the river and reservoir, providing volitional passage during migration periods. The behavior and swimming ability of the fish species requiring passage is a key factor in designing a fish ladder. Flow, velocity, turbulence, and drop height are also considered in the fish ladder design. If the conditions within the fish ladder preclude a fish's swimming ability the ladder is ineffective and acts as a barrier. Water quality is also important because fish, particularly salmonids, are sensitive to conditions such as dissolved gases and temperature. Attraction flow at the downstream entrance of the ladder is also a critical component of the design. Attraction flow guides adult salmonids to the ladder and ensures they can move upstream past the obstacle. For fish ladders at hydroelectric facilities, it is important that the entrance to a fish ladder is positioned outside of the influence of turbulent flows from spillways or powerhouses, which can hide the ladders attraction flow and disrupt or delay passage (NPCC 2016). Similarly, fish ladder exits need to be positioned in calm areas far enough above the dam so that fish are not entrained in the powerhouse or spillway discharge, causing what is known as "adult fallback."

NMFS groups fish ladders into two categories: (1) pool-style and (2) roughened chute-style. Pool-style ladders include vertical slot, pool and weir, weir and orifice, and pool and chute types. Roughened chute-style ladders are much less common but include Denil steeppass and Alaska steeppass types. Roughened chute-style ladders are not used where adult and juvenile salmonid migration occurs (NMFS 2022). The following evaluation focuses on the feasibility of constructing pool-style ladders at Nacimiento and San Antonio Dams. Key fish ladder design criteria are presented in Table 3-2.

Table 3-2. Fish Ladder Design Criteria

Ladder Feature	Design Criteria
Hydraulic Drop Between Ladder Pools	1 foot or less
Flow Depth	At least 1 foot
Pool Dimensions	Minimum of 8 feet long, 6 feet wide, and 5 feet deep; ladder pools should be designed so that there is no standing water in the pool when the system is dewatered.
Turning Pools	At least double the length of the standard fishway pool
Pool Volume	Volume should provide sufficient hydraulic capacity to absorb and dissipate the pool-to-pool energy and accommodate the maximum daily run of fish
Orifice Dimensions	Minimum dimensions of18 inches high by 15 inches wide

3.2.2.1 Nacimiento Dam

A fish ladder at Nacimiento Dam would provide volitional passage for adult steelhead from the main river channel below the dam (Figure 2-3) to the reservoir behind the dam. The entrance would need to be located far enough downstream of the dam outlets that the dam outlets would not falsely attract fish away from the entrance. The ladder entrance would also need to be far enough downstream to accommodate the linear distance necessary to traverse the 215 vertical feet to the top of the dam. To pass fish over the 215 vertical feet and maintain a slope of less than 10%,[1] a fish ladder at Nacimiento Dam would need to be at least 2,150 feet in length, classifying it as a high-head fish ladder, many of which have performance issues. Two possible ladder configurations are included in Figure 3-1. Configuration A would place the ladder along the north side of the river with the entrance approximately 2,200 feet downstream of the base of the spillway. Alternatively, under Configuration B the ladder would run along the south shore. These configurations could be altered by including more turning pools to reduce the overall linear distance from the base of the dam to the entrance, but this would increase total length of the ladder as turning pools are suggested to be at least double the length of the standard fishway pool (NMFS 2022) (Table 3-2).

The exit of the fish ladder would need to be designed to accommodate the 132 feet of potential reservoir elevation fluctuations (Table 3-3) and be located far enough away from the spillway to minimize risk of fallbacks during possible spill events. However, because water is rarely spilled at Nacimiento Dam risk of fallbacks would be low. The large fluctuations in reservoir elevation create a challenge in designing a safe and effective exit. While engineering solutions to this problem do exist, they are often complex and costly. One possible solution is adding a fish release pipe or slide at the end of the ladder that fish could utilize when water levels are below the ladder exit elevations. The location of both the ladder entrance and exit would require additional on-the-ground and engineering investigations.

Another concern is that the length of the ladder may cause water to warm during transit from the ladder exit downstream to the ladder entrance. This could act as a barrier, cause fish to delay, or turn around during their ascent. This presents a significant problem and would require that additional cold water be pumped into the ladder at various locations to ensure temperatures do not impede passage.

[1] NMFS (2022) generally recommends that fishways maintain a slope of less than 10%.

To provide volitional adult steelhead passage, the ladder would require continuous unimpeded flow during the adult upstream migration window (December 1 to March 31) (Table 3-3). Based on guidelines outlined by NMFS (2022), ladder attraction flows between 23.5 and 46.9 cfs (5–10% of 5% exceedance flows) during the adult migration period would be required (Table 3-3). According to NMFS (2022), the higher percentage of total river flows used to create attraction flow at the ladder entrance, the more effective the facility is likely to be. In this case, Nacimiento River minimum flows are required to be 60 cfs for the entire year as long as water supply is sufficient (MCWRA 2005). Considering the minimum flow requirements for the Nacimiento River (as defined in MCWRA 2005) and the attraction flows required for the ladder, 83.5 to 106.9 cfs flow may be necessary during the adult migration window. However, it may be possible to meet minimum flow requirements without additional releases from the dam by routing all 60 cfs through the ladder. Given the frequency of severe drought conditions since 2010, achieving those flow conditions during dry and dry-normal year types, or during periods of prolonged drought conditions, may prove difficult (MCWRA and ICF 2022).

Operation and maintenance of the facility would likely be minimal relative to other passage options but would require staff and resources in addition to those required for current dam operations. During migration periods it is likely that daily observation and periodic maintenance would be required to ensure the facility is functioning as intended. Maintenance may include periodic removal of debris, adjusting flow rates, and documenting fish movements.

Finally, the use of a fish ladder would require adults to travel the entire length (18 miles) of Nacimiento Reservoir to reach the upper basin to spawn. Similarly, kelts (repeat spawners) would have to navigate the reservoir during their migration back to the ocean and face the same obstacles. While conditions within the reservoir have not been well documented, adults may be exposed to degraded water quality conditions including high temperatures and low DO, disease, and parasites (Section 3.1, *Biological Constraints*). Moreover, low velocity and flow within the reservoir may disorient fish and slow migration rates.

In summary, a fish ladder may be feasible from a design perspective, but given the dam height, reservoir fluctuations, length of the reservoir, and expected conditions within the reservoir other designs are more feasible and likely to be more effective.

3.2.2.2 San Antonio Dam

A fish ladder at San Antonio Dam would provide volitional passage for adult steelhead from a suitable location near the dam outlet to the reservoir behind the dam. The entrance would need to be located far enough downstream of the dam outlet that the outlet would not falsely attract fish away from the ladder entrance. The ladder entrance would also need to be far enough downstream to accommodate the linear distance necessary to traverse the 201 vertical feet from the stream channel to the top of the dam. To pass fish over the 201 vertical feet and maintain a slope of less than 10%, a fish ladder at San Antonio Dam would need to be at least 2,000 feet long, classifying it as a high-head fish ladder, many of which have been shown to have significant performance issues. A possible ladder configuration is included in Figure 3-2. In this configuration the ladder would run along the north side of the dam opposite the spillway.

Due to the length of the ladder, it is likely that water would warm up during transit from the reservoir. This may act as a barrier and cause fish to delay or turn around during their ascent of the ladder. This presents a significant problem and would require additional cold water be pumped into the ladder at various locations to ensure temperatures do not impede passage.

The exit of the fish ladder would need to be designed to accommodate the nearly 138 feet of potential reservoir elevation fluctuations (Table 3-3) and be located far enough away from the spillway to minimize risk of fallbacks during spill events. The large fluctuations in reservoir elevation create a challenge in designing a safe and effective ladder exit. While engineering solutions to this problem do exist, they can be complex and costly. One possible solution is adding a fish release pipe or slide at the end of the ladder that fish could utilize when reservoir levels are lower than the ladder exit. The location of both the ladder entrance and exit would require additional on the ground and engineering investigations.

To provide volitional adult steelhead passage, the ladder would require continuous unimpeded flow during the adult upstream migration window (December 1 to March 31). Based on guidelines outlined by NMFS (2022), ladder attraction flows between 16.05 and 32.1 cfs (5–10% of 5% exceedance flows) would be required (Table 3-3). According to NMFS (2022), the higher percentage of total river flows used to create attraction flow at the ladder entrance the more effective the facility is likely to be. Given the frequency of severe drought conditions since 2010, achieving those flow conditions during dry and dry-normal year types, or during periods of prolonged drought conditions, may prove difficult (MCWRA and ICF 2022).

Operation and maintenance of the facility would likely be minimal relative to other passage options but would require staff and resources in addition to those required for current dam operations. During migration periods daily observation and periodic maintenance may be required to ensure the facility is functioning as intended. Maintenance may include periodic removal of debris, managing flow rates, and documenting fish movements.

Finally, the use of a fish ladder would require adults to travel the entire length (16 miles) of San Antonio Reservoir to reach the upper basin to spawn. Similarly, kelts (repeat spawners) would have to navigate the reservoir during their migration back to the ocean and face the same obstacles. While conditions within the reservoir have not been well documented, adults may be exposed to degraded water quality conditions including high temperatures and low DO, disease, and parasites (Section 3.1). Moreover, low velocity and flow within the reservoir may disorient fish and slow migration rates.

In summary, a fish ladder may be feasible from a design perspective, but given the dam height, reservoir fluctuations, length of the reservoir, and expected conditions within the reservoir other designs are more feasible and likely to be more effective.

3.2.2.3 Technical Considerations

The following advantages (pros) and risks (cons) were identified for US Alternative 1 at Nacimiento and San Antonio Dams.

Pros

- A fish ladder provides true volitional passage. Adult steelhead can decide when to enter and ascend the ladder.
- A ladder requires no handling and limited staffing.
- Fish can navigate to any tributary feeding into the reservoir.

Cons

- Fish ladders at high-head dams are rare and often perform poorly due to the length and height fish are required to traverse.
- Large reservoir fluctuations are complicated to accommodate and would require a complex engineered exit design.
- Given the length of the ladder water may warm during transit and create a barrier, causing fish to turn around or hold within the ladder.
- Water quality through the reservoir may be poor during the migration period and be detrimental to adult survival.
- Low flow and low velocity in the reservoirs along with the overall lengths and extensive shoreline may cause fish to become disoriented and prolong migration rates.
- Lack of water may make it difficult to achieve necessary attraction flows during drought conditions.

3.2.2.4 Estimate of Construction, Operation, and Maintenance Costs

Costs to build, operate, and maintain fish ladders can vary widely and depend largely on the dynamics of the river system. A few examples of construction costs for specific projects in the Pacific Northwest are provided below.

- A Half Ice Harbor pool and weir type ladder was built at River Mill Dam on the Clackamas River in 2006 for $16 million (equivalent to $23 million in 2022) (DWR 2013).
- A Half Ice Harbor pool and weir type ladder was built at Cougar Dam on the South Fork McKenzie River in 2010 for $11.3 million (equivalent to $16.6 million in 2022) (NPCC 2016).

Given the height of Nacimiento and San Antonio Dams and large reservoir fluctuations, it is likely that the engineering, design, and construction costs would be high to add a fish ladder at both facilities. While more investigations are needed to confirm designs and cost, it is expected that, based on review of the costs of other facilities, construction costs alone would exceed $25 million per facility (NPCC 2016; DWR 2013). Permitting, administrative, planning, and engineering costs would be in addition to construction costs. Operation and maintenance could exceed $100,000 annually.

Table 3-3. Nacimiento and San Antonio Rivers and Reservoirs Fish Passage Design Considerations

Design Considerations	Nacimiento	San Antonio
Design Flows		
Low Flows (95% exceedance) (cfs)[a]	80[d]	80[d]
High Flow (5% exceedance) (cfs)	566	325
Flood Flows (50-year) (cfs)[b]	1,630	550
Attraction flows (5-10% of 5 % Exceedance) (cfs)	28.3–56.6	16.25–32.5
Reservoir Characteristics		
Minimum Reservoir Elevation (ft)	672.25	645.5
Maximum Reservoir Elevation (ft)	803.4	782.65
Elevation Differential (ft)	131.15	137.15
Dam Height (ft)	215	201
Reservoir Length	18 mi	16
Ave. Annual Reservoir Fluctuation (ft)[c] (min–max)	8.5 (0.3–51.44)	4.03 (0.07–29.88)
Biological and Species Criteria		
Juvenile Outmigrant Timing	Mar 15–Jun 1	Mar 15–Jun 1
Juvenile Outmigrant Abundance	TBD	TBD
Adult Migrant Timing	Dec 1–Apr 1 (upstream); Mar 1–Jun 1 (kelts)	
Estimate Annul Adult Migrant Abundance	500	500
Reservoir Predation Risk	High	High

[a] Long-term flow data does not exist downstream of San Antonio Dam. Daily discharge data from the dam was used to approximate design flows. This may skew data high.
[b] Calculated from October 1, 1988, to November 2, 2022.
[c] Figure 3-6 provides a more detailed summary of reservoir fluctuations.
[d] Minimum design flows are based on NMFS 2023 guidance…"low flow design flow should be initially consistent with the lowest discharge at which fish are expected to be able to migrate upstream." Here that value is 80 cfs measured at Chualar on the Salinas River.

Figure 3-1. Example of fish ladder configurations A (blue line) and B (orange line) at Nacimiento Dam

Figure 3-2. Example of Fish Ladder Configuration at San Antonio Dam

3.2.3 US Alternative 2: Non-Volitional Passage via Trap and Haul

Trap-and-haul methodologies have been increasingly used to accommodate upstream passage for adult salmonids across the west coast. They are particularly effective for systems with long reservoirs, multiple reservoirs, or high-head dams where traditional fishways would be difficult to design and may not perform well. Additionally, trap-and-haul operations often require less water than fish ladders or other technologies, which can make them viable options for areas where water is scarce, and flows are frequently low (DWR 2013). However, trap-and-haul systems require a significant amount of handling and can have direct negative effects on fish health and behavior, including migration disruption, disease, and mortality. Fish traps or collection facilities can either be located at the base of the dam or downstream. Merwin Dam on the Lewis River, for example, was retrofitted with an adult fish trap/lift at the base of the dam that captures fish and lifts them to a fish collection and transfer facility from which fish are loaded into trucks and driven upstream around three large reservoirs—Merwin, Yale, and Swift. The Cowlitz River adult collection system uses an electrified barrier dam and fish ladder downstream of Mayfield Dam to collect migrating salmonids. Adults are then sampled, transferred to holding tanks, and then moved into transport trucks that carry and release fish into the upper Cowlitz Basin. The passage goal for trap-and-haul systems is to provide safe, efficient, and timely passage with no delay, strong attraction flows, high acceptance into the facility, and little to no injury or mortality (NPCC 2016). Trap and haul requires significant resources, including staff, equipment, maintenance, and time to operate effectively.

3.2.3.1 Nacimiento Dam

A trap-and-haul operation at Nacimiento Dam would consist of a fishway, collection facility, fish holding and processing facility, and truck loading facility. Fish would be collected at the base of Nacimiento Dam and driven by truck to one of two release sites along the reservoir shoreline.

Most trap-and-haul facilities use a fishway such as a fish ladder to attract and guide fish into a collection facility. A partial fish ladder like the type described in Alternative 1 would precede the collection facility but would likely be closer to the base of the dam than Alternative 1 because the fishway would not need to traverse the full height of the dam. Attraction flows to the fishway would be the same as those described for Alternative 1. Additionally, pool dimensions would be designed to meet NMFS requirements listed in Table 3-2. At the end of the fishway, a collection facility would be designed to trap and hold fish for a short period before they are counted, transferred into trucks, and transported to release locations.

The collection and holding facility would require a continuous flow of water to fill and maintain conditions in holding tanks where fish would be held until they are enumerated and prepped for transport. The holding tanks would be designed to accommodate the expected peak daily run size of fish returning to the basin. As described in Section 1.2.3, the current abundance of returning adult steelhead to the basin is exceptionally low, and for the purposes of this evaluation it is assumed that fewer than 500 adults would be collected at the facility. This means the facility could be a relatively simple manual system rather than a larger automated operation, representing significant cost savings.

Many trap-and-haul operations include a monitoring program that tracks abundance, identifies species, sex, and lifestage, evaluates fish condition (e.g., injuries, parasites, disease), and checks for tags (e.g., Passive Integrated Transponder (PIT) tag, anchor, coded wire). Depending on recovery goals of the passage and reintroduction programs, fish may be transported into different watersheds in the upper Nacimiento basin. This component of the program would largely depend on the program goals developed in coordination with NMFS. Given recent trends in annual adult returns, it is likely that all fish would be released near the upstream extent of Nacimiento Reservoir. During years when returns are higher, additional experimental releases to other reservoir tributaries could be considered.

Additional design requirements for the holding facility include the following (NMFS 2022).

- Provide 0.67 gallon of water per minute per adult.
- Hold fish for less than 24 hours.
- Maintain water temperatures below 50 degrees Fahrenheit (°F)
- Maintain DO between 6 and 7 parts per million.

From the holding facility fish would be moved to a transport truck via a transfer facility. Transfer facilities can be complex depending on the species requiring passage, the total numbers of individual fish, and the number of release locations. In this case, given the low numbers of expected adults, the truck transfer facility would also likely be relatively simple. One possible design is a hopper that could lift fish from the holding pool and transfer them directly into a transport truck. This would be considered a water-to-water transfer, which is preferable because it reduces injury risk.

Transport trucks would then drive fish from the collection facility above the dam and then into the reservoir. The advantage of a truck-and-haul operation is that fish can be released at essentially any location in the reservoir. Two potential release points include an existing boat launch near the dam on the northside of the reservoir (Figure 3-3) and one at the upper end of the reservoir near Ashbury Creek (Figure 3-4). Fish released at the northside boat launch would then need to travel the entire length of the reservoir to reach the upper Nacimiento River, potentially delaying migration timing and exposing fish to predation, warm temperatures, and disease. However, using the boat launch near the dam would allow fish to choose their migration route through the reservoir and enter any tributary in the reservoir basin to spawn. Further investigation is needed to assess habitat suitability in reservoir tributaries, including the upper Nacimiento. Releasing fish at the upper end of the reservoir may improve pre-spawn survival because travel time and distance would be reduced. Moreover, release at Ashbury Creek would reduce exposure to potentially detrimental conditions within the reservoir. The distance from the collection facility to the boat launch is approximately 30 miles and would likely result in approximately 1 hour of transit time.

Trap-and-haul operations, unlike volitional passage options, require that fish are handled multiple times, which may increase injury and mortality rates. However, trap-and-haul operations also allow for flexibility in where adults are released after collection in the facility. Similarly, the collection and holding facility would provide an opportunity to collect vital demographic, biological, and genetic information before adult steelhead are released upstream, which may improve the passage and reintroduction program over time. Trap-and-haul facilities may also require less water than the fish ladder described in Alternative 1, which is an important distinction given the pervasive drought conditions that afflict the Salinas Valley Groundwater Basin at times.

The Green Line Indicates the Fish Truck Route from the Collection Facility to the Release Site.

Figure 3-3. Trap-and-Haul Operational Configuration with the Fish Collection Facility at the Base of Nacimiento Dam and the Release Location Approximately 4,200 Feet Upstream at an Existing Boat Launch on the North Shore.

The roads leading to the Ashbury Creek boat launch and the launch itself would need be further inspected to ensure they are suitable.

Figure 3-4. Trap-and-Haul Operational Configuration with the Fish Collection Facility at the Base of Nacimiento Dam and the Release Location at the Upper End of the Reservoir at an Existing Boat Launch near Asbury Creek.

3.2.3.2 San Antonio Dam

A trap-and-haul operation at San Antonio Dam would resemble the operation described for Nacimiento Dam in that it would consist of a fishway, collection facility, fish holding facility, and truck loading facility. The requirements and designs described for Nacimiento Dam are applicable to San Antonio Dam.

The fishway, or fish ladder, would be located near the base of the dam and lead fish into a collection facility where they would be held for a short period of time before being enumerated, sorted, and loaded into trucks for transport above the reservoir. A partial fish ladder like the type described in Alternative 1 would precede the collection facility but would likely be closer to the base of the dam than under Alternative 1 because the fishway would not need to traverse the full height of the dam. Attraction flows to the fishway would be the same as those described for Alternative 1. Additionally, pool dimensions would be designed to meet NMFS requirements listed in Table 3-2. At the end of the fishway, a collection facility would be designed to trap and hold fish for a short period before they are enumerated and transferred into trucks and transported to release locations. The collection and holding facility would be constructed using specifications like those described for Nacimiento Dam.

Adult steelhead would be collected near the dam and trucked upstream to one of four established boat launches and released. San Antonio Reservoir is slightly smaller than Nacimiento, storing 335,000 AF compared to 377,000 AF, and is less complex in that it has fewer arms and substantially less shoreline. Due to its smaller size and the simpler shoreline adult steelhead may be able to more quickly navigate through San Antonio Reservoir compared to Nacimiento Reservoir. However, few tributaries enter the reservoir, which makes releasing fish lower in the reservoir less desirable (Figure 3-5). Using the boat launches at the upstream end of the reservoir near the upper San Antonio River would reduce exposure of adults to detrimental reservoir conditions and reduce migration time and distance to spawning habitats, potentially leading to higher survival rates.

Figure 3-5. Trap-and-Haul Operational Configuration with the Fish Collection Facility at the base of San Antonio Dam with Release Locations at Existing Boat Launches along the Reservoir and Upper San Antonio River

3.2.3.3 Technical Considerations

The following advantages (pros) and risks (cons) were identified for US Alternative 2 at Nacimiento and San Antonio Dams.

Pros

- Survival is generally high at trap-and-haul facilities after collection and hauling.
- Migration delay is less likely relative to Alternative 1 (fish ladder).
- A trap-and-haul operation provides flexibility to release fish upstream of the dam at any desired location, or to make releases at multiple locations.
- Trap-and-haul system is technically feasible at the dam.

Cons

- Does not provide volitional passage.
- Once in the trap fish may not volitionally exit.
- Daily staffing of the facility would be required during the migration window.
- Human handling is required, increasing potential for injury or death.
- Potential for vehicular accidents during transport which could result in loss of a load of fish.

3.2.3.4 Estimate of Construction, Operation, and Maintenance Costs

Example construction and operation and maintenance costs are provided for similar trap-and-haul facilities.

- Baker River trap-and-haul system on the Baker River in Washington was constructed in 2010 and cost roughly $25 million (equivalent to $34 million in 2022) (DWR 2013). Operation and maintenance costs vary annually, but range between $500,000 and $600,000 (NPCC 2016).
- South Fork McKenzie River trap-and-haul system with fish ladder was built in 2010 for $10.4 million (equivalent to $14.1 million in 2022) (DWR 2013).
- Merwin Dam trap-and-haul system on the Lewis River in Washington was constructed in 2014 and cost roughly $60 million (equivalent to $75.2 million in 2022) (NPCC 2016). Operation and maintenance costs exceed $200,000 annually.

3.2.4 US Alternative 3: Lower Salinas River Trap-and-Haul Facility

A trap-and-haul facility could also be built on the lower Salinas River. This option would be advantageous in several ways. First, from a cost standpoint building one facility would be cheaper than building a facility at each dam. Given the low annual abundance of adults returning to the Salinas River, a simple facility like those described under Alternative 2 would likely be sufficient to accommodate expected peak returns to the Salinas basin. Additionally, a facility located in the lower basin may facilitate adult passage during dry water years when long stretches of the Salinas River run dry. For this to happen, the facility would likely need to be within a few miles of the lagoon. Another advantage of this approach is that fish could be moved to other basins in addition to Nacimiento and San Antonio. NMFS' 2022 letter to MCWRA included a technical memo addressed to Bill Stevens, NMFS, from Mark H. Capelli, NMFS SCCC steelhead recovery coordinator, which described the role of the Salinas River and its tributaries in meeting NMFS' viability/recovery criteria. The memo explains that the Salinas River, given its size and complexity, contains five distinct steelhead habitat areas including Gabilan Creek, Arroyo Seco River, San Antonio River, Nacimiento River, and the upper Salinas River system, which includes numerous tributaries including the Santa Margarita River. An adult collection facility in the lower Salinas River could prove to be a vital tool for promoting recovery goals given the historically pervasive drought condition that may continue well into the future, exacerbating water scarcity throughout the basin. Additional genetic investigation would be required to develop a management plan that directs allocation of captured adults to each distinct habitat area. This strategy may result in a greater net benefit to steelhead in the basin than constructing separate passage facilities at Nacimiento and San Antonio Dams.

A facility in the lower river would need to be located near a water supply, which may prove difficult. Facilities at the dams have the advantage of being able to use water stored in the reservoirs for facility operations. Additional investigations would be required to determine if a location in the lower basin could provide the necessary amount of water to the facility during the adult migration period, particularly during drought years. One possible location is at or near SRDF (Figure 1-1). Locating the adult collection facility near the SRDF could prove advantageous from a design and construction perspective in that using portions of the existing infrastructure could reduce overall costs. The SRDF is also located low in the watershed, which could prove advantageous during drought conditions when much of the river upstream becomes dry or intermittent.

3.2.4.1 Technical Considerations

The following advantages (pros) and risks (cons) were identified for US Alternative 3 at Nacimiento and San Antonio Dams.

Pros

- May provide for adult upstream passage during drought years when flows in the lower Salinas River preclude natural passage.
- Facilitate recovery efforts in the five distinct steelhead habitat areas within the greater Salinas River basin.
- Need for one collection facility rather than two, resulting in lower construction and operational costs.

Cons

- Does not provide volitional passage.
- Genetic analysis is needed to appropriately distribute captured adults to natal subbasins.
- Daily staffing of the facility would be required during migration window.
- Human handling is required, increasing potential for injury or death.
- Potential for vehicular accidents during transport which could result in loss of a load of fish.
- Uncertain availability of water during dry years to consistently operate a trap in the lower river.
- When sufficient flow is available to maintain a lagoon opening and attract steelhead, upstream passage to the Arroyo Seco and other tributaries may already be possible without the need to trap and haul.

3.2.4.2 Estimate of Construction, Operation, and Maintenance Costs

Construction and operation and maintenance costs for similar trap-and-haul facilities are described in Section 3.2.3.4, *Estimate of Construction, Operation, and Maintenance Costs*.

3.3 Downstream Passage

Downstream passage for juvenile salmonids can be particularly challenging at high-head dams due to costs and engineering complexity. Passage for juvenile salmonids at high-head dams, such as Nacimiento and San Antonio, can occur through various volitional and non-volitional methods. Volitional passage methods include unmodified dam outlets, turbines, spillways, screened bypasses, bypass channels, and other water conveyance systems. Non-volitional passage most commonly occurs via trap-and-haul systems, such as floating surface collectors (FSCs). In systems that support iteroparous salmonids such as *O. mykiss* downstream passage systems must also support post spawning adults known as kelts.

3.3.1 Selection of Juvenile Passage Alternatives

Numerous technologies were considered for juvenile downstream passage at Nacimiento and San Antonio Dams. However, certain options were ruled out based on the physical characteristics of the facilities and surrounding landscape (Table 3-4). After a preliminary review of upstream passage options, six alternatives were included to be further evaluated.

1. Volitional passage through unmodified dam outlet works.
2. Volitional passage through dam spillways.
3. Volitional passage through screened intake and bypass system.
4. Truck-and-haul system using FSCs in reservoir forebays.
5. Floating weir collector (FWC) using a bypass or trap-and-haul collection facility.
6. Trap-and-haul system using an in-river collector in the river upstream of the reservoir pool.

Table 3-4. Deferred Juvenile Passage Alternatives

Considered Alternative	Reason for Deferment
Roughened Bypass Channel/Nature-like fishway	Impractical due to height of the dam and steep surrounding topography
Floating Bypass Channel	Significant elevation changes in reservoir
Fish Locks	Difficult to design due to height of dam and rugged topography

3.3.2 Existing Condition: DS Volitional Passage through Existing Dam Outlets

Juvenile salmonids can use existing dam outlets as passage routes. However, depending on the configuration of the facility this may be ineffective and may result in high rates of injury and mortality. Injury and mortality rates are dependent on which route juveniles take, either through the dam outlet or over the spillway (DWR 2013). Survival of fish passing through hydroelectric turbines depends on the size, type, and operation of the turbines and the species, size, lifestage, and condition of fish (DWR 2013). Passage through turbines has become less common as the understanding of risks has become better documented and designs move fish through different routes.

3.3.2.1 Nacimiento Dam

As described in Section 2.2.1.1, Nacimiento Dam has two outlets, the HLOW and the LLOW (Figure 2-2), that steelhead smolts could volitionally use during their downstream migration. However, both outlets would expose steelhead smolts to a variety of potentially lethal mechanisms. Mortality and injury related to passage through turbines is well documented and results from extreme pressure changes, blade strikes, shear stress, and cavitation (Keefer et al. 2013; DWR 2013). Passage through the HLOW presents risks because fish would travel approximately 508 feet down the concrete spillway to the plunge pool and may experience abrasion and shear stress.

Passage through the LLOW also presents challenges. For fish to move through the LLOW to the Nacimiento River, they would first need to pass through the hydroelectric plant turbines before exiting to the low-level outlet channel and the main river. Migrating juvenile salmonids are generally surface oriented and may have difficulty locating the LLOW when reservoir elevations are greater than 670 feet amsl (location of the LLOW), which may delay migrants and increase exposure to piscivorous predators. Survival through turbines can vary depending upon the type of turbine, volume of flow, species, and fish size. For example, Muir et al. (2001) found that yearling Chinook salmon survival through the turbines at Little Goose Dam ranged from 86.5 to 92.7% and was approximately 93% for steelhead. Perry et al. (2003) found that yearling Chinook salmon (87%) survived passage through turbines at McNary Dam on the Columbia River at higher rates than subyearling Chinook salmon (77%).

3.3.2.2 San Antonio Dam

Steelhead smolts passing San Antonio Dam via the outlet works would face similar obstacles as described for Nacimiento Dam. However, San Antonio Dam is not equipped with a hydropower system and is used exclusively for water storage and flood control. Water is released via the outlet works (645 feet amsl) to the outlet channel and the lower San Antonio River. Migrating juvenile salmonids are generally surface oriented and may have difficulty locating the outlet works when reservoir elevations are greater than 645 feet amsl, which may delay migrants and increase exposure to predators. While fish could pass through the outlet works it is unclear how well fish would survive. Migration through the 16-mile San Antonio Reservoir poses similar risks as those described for Nacimiento Reservoir and in Section 3.1. Poor water quality, predation, and low flow and velocity conditions may result in poor smolt survival rates through the reservoir.

3.3.2.3 Technical Considerations

While juveniles could pass through the existing outlets at Nacimiento and San Antonio Dams, studies have not been completed to evaluate survival or passage efficiency through the outlets, but they are expected to be low. Additional investigations would be needed to fully evaluate the effectiveness of this approach. The following advantages (pros) and risks (cons) were identified for DS Volitional Passage through Existing Dam Outlets at Nacimiento and San Antonio Dams.

Pros

- No modifications to the current dam configurations are needed.

Cons

- Passage rates are likely to be low as fish are unlikely to be attracted to the outlet gates at either facility.
- Fish injury or mortality could be high, particularly at Nacimiento Dam due to the presence of hydroelectric turbines.

3.3.3 DS Alternative 1: Passage via Spillway

A more common approach is to pass migrating juvenile salmonids over spillways during spill events or intentionally spill water during the outmigration period. This practice is commonly used at run-of-the-river dams such as the mainstem Columbia or Lower Snake River dams that have very little storage capacity. Spillways are rarely used at facilities designed for water storage and flood control.

3.3.3.1 Nacimiento Dam

Smolts could also pass over the spillway when reservoir levels exceed flood pool elevations and water is passed over the spillway. Passage over a spillway is generally safer for juvenile outmigrants than passage through turbines. Mortality and injury rates associated with spillway passage can be lower than through turbines but is dependent on the spillway configuration and plunge pool depth.

Given the recent and prolonged drought conditions throughout California, spilling at Nacimiento Dam is unlikely to occur at frequent intervals in the future.[2] Moreover, passage via spill would also likely result in high injury and mortality rates given the length (540 feet long) and steep gradient (0.15 ft/ft to 0.5 ft/ft) of the spillway chute. Additionally, the chute is concrete, which could cause abrasive damage to smolts plummeting down the spillway.

3.3.3.2 San Antonio Dam

Like Nacimiento Dam, the spillway at San Antonio Dam is used when reservoir elevations exceed the flood pool elevation (780 feet amsl). Given recent drought conditions it is unlikely the spillway would be used in the future or that enough stored water would be available to provide spill specifically for smolt passage. Additionally, the San Antonio spillway is a passive design, meaning that when water reaches certain elevation it spills over the dam down the spillway.

3.3.3.3 Technical Considerations

Based on the spillway and spilling basin design some survival of smolts passed via spill is possible. However, neither dam regularly spills water due to water storage needs. The following advantages (pros) and risks (cons) were identified for DS Alternative 1 at Nacimiento and San Antonio Dams.

Pros

- No modifications to the current dam configurations are needed.

Cons

- Spill events have occurred infrequently in the past and given recent drought conditions intentionally spilling water to pass smolts is not feasible at either facility without severely affecting facility operations, flood management, and agency water allocation requirements.

[2] Future investigations could examine the frequency of water that is released via the various spillway components (e.g., high-level gates, Obermeyer spillway gates).

- Dam operations would need to be modified to provide enough spill during the migration period to pass juveniles.
- Injury and mortality rates are likely to be high given the height and structure of each spillway.

3.3.4 DS Alternative 2: Passage through a Screened Intake and Bypass

Volitional passage can also be achieved through a combination of fish screens and a bypass system. Fish screens are designed to prevent fish, primarily juveniles, from being entrained into water diversions including hydroelectric facilities, municipal, irrigation, or other water withdrawal projects (NMFS 2022). Screened bypass systems allow migrating fish around a dam without passing through the powerhouse or over the spillway (DWR 2013). Bypass systems are commonly used in the Pacific Northwest and California and utilize angled, louver, Eicher, modular inclined screens, angled rotary drum screens, plane screens, or submerged traveling screens. Additionally, screened bypasses are designed to prevent fish impingement and avoid predation above background levels (NMFS 2022). Screens generally require periodic maintenance to remove debris and ensure they are functioning properly. All new fish screens are required to include active cleaning systems that remove accumulated debris and ensures the screens are clean and free of impinged materials. Cleaning systems are physical, hydraulic, or pneumatic. NMFS (2022) recommends physical cleaning systems for most applications, which use a brush or other device to physically remove debris.

A juvenile bypass system can either move fish directly into the river below the dam or into a collection and transport facility from which they can be trucked further downstream and released. Physical guidance structures such as nets direct fish into the bypass system and away from the water diversion. A screened bypass system should convey 100% of the diverted water through the screening system to ensure all fish are removed before the water enters the water diversion facility. A portion of the diverted water would be routed to the bypass to transport fish around the dam. Flow into the fish screens needs to be strong enough to attract fish but within suitable velocity ranges (<0.4 foot per second) (NMFS 2022). Bypass entrances should be located at the downstream end of the fish screens and allow downstream migrants to easily locate and enter the bypass pipe or conduit and naturally funnel fish and flow to the bypass entrance (NMFS 2022).

An example of a screened juvenile bypass system is operated on Rocky Reach Dam on the mainstem Columbia River. The juvenile bypass system at Rocky Reach Dam includes a collector system comprised of two channels in the dam forebay. The channels include stainless steel screens and submerged pumps that create attraction flows. Once in the channel, fish move into a steel tube that transports fish through the dam and then across the face of the spillway before returning fish back to the Columbia River about a third of a mile downstream of the dam. While this system is substantially larger it provides an example of a highly effective screened bypass system that could be modified and applied to Nacimiento and San Antonio Dams.

3.3.4.1 Nacimiento Dam and San Antonio Dam

A screened juvenile bypass system at Nacimiento and San Antonio Dams would need to accommodate the large annual fluctuations in reservoir elevations (Figure 3-6). One possible approach to accounting for reservoir fluctuations is a floating or adjustable intake attached to a tower structure that could track changing reservoir levels. Designing this type of facility would be complex and costly. A variety of screen types could be effective including V-screens, rotary drum screens, or cylindrical screens (NMFS 2022). However, screen elevations would need to be manually or automatically adjusted based on reservoir levels. NMFS (2022) criteria require that screens be fully or partially submerged depending on screen type. Further engineering investigations would be needed to determine the most appropriate and effective screen type and would depend largely on the amount of water available to operate the screens and bypass systems. Conceptually, a small proportion of operational flow would be diverted through the facility to transport fish through a bypass pipe. The remainder of the flow would be used for normal dam operational purposes.

Given the small releases at San Antonio Dam (Figure 3-7) there may not be sufficient water to accommodate a bypass facility as it would require continuous attraction flow and flow through the bypass pipe for the duration of the migration window. Operations at Nacimiento would likely accommodate a bypass system as releases during the migration period are generally higher and could accommodate the additional water demands of the passage system. However, both reservoirs experience periods when flows are exceptionally low, which may inhibit screen operation and reduce passage of smolts and kelts. Minimum flows from Nacimiento Reservoir are currently managed at 60 cfs, while flows at San Antonio are managed at 3 cfs. These values will likely change once hydrologic modeling is completed as part of the HCP process.

Like Alternative 1, screened bypass systems at the dams require that fish travel through the entire reservoir before entering the bypass system, exposing fish to predation, poor water quality, and low flow and velocity, all of which can reduce smolt survival (Section 3.1).

Fish would either be released directly into the outlet channels below the dams or into a collection facility to be sorted and transferred into trucks and driven downstream to be released in the lower Salinas River. If released into the outlet channel careful consideration of the outfall location is needed. Birds or warm-water fish may be attracted to and congregate near the fish return outfall and feed on migrating smolts. NMFS requires bypass outfalls to be located in areas with sufficient depth and velocity to reduce avian predation and deter predatory fish from congregating at the release location (NPCC 2016).

A collection facility could be located at the end of the outfall in the outlet channel to allow for sorting, enumeration, and monitoring of migrating fish. This facility would also ensure that nonnative fish (e.g., smallmouth bass, striped bass) remain in the reservoir and do not infiltrate the lower Salinas River. Without the sorting facility all fish would be allowed to move through the bypass to the lower Nacimiento, San Antonio, and Salinas Rivers. Pending further investigation, it may be important to prevent the passage of nonnatives from the reservoirs to the lower rivers. Similarly, the collection facility would also allow for collected fish to be trucked downstream should low water or poor water quality in the lower Nacimiento or San Antonio Rivers impede downstream migration to the lower Salinas River and the ocean.

3.3.4.2 Technical Considerations

The following advantages (pros) and risks (cons) were identified for DS Alternative 2 at Nacimiento and San Antonio Dams.

Pros

- Fish can access the entire reservoir for rearing due to the location of the collection facility.
- Provides volitional passage for smolts and kelts.
- Fish would be expected to survive at high rates through the bypass to the tailrace.
- A collection facility would allow for more detailed monitoring and separating of species.

Cons

- Fish would be susceptible to high temperatures and predators while migrating through the reservoirs.
- Operation of multiple gates/intake facilities would require close monitoring and automation to ensure the facility remains functional across the range of reservoir elevations.
- Large and costly facility to design, construct, and operate.

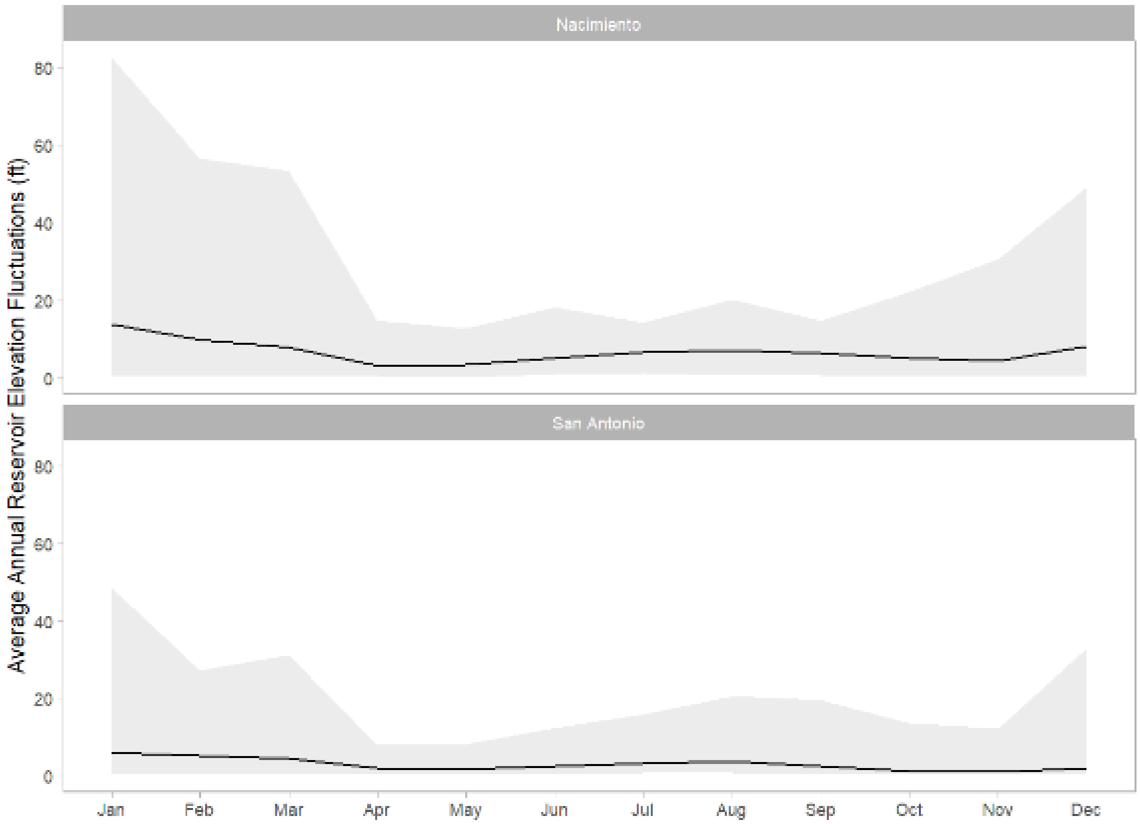
3.3.4.3 Estimate of Construction, Operation, and Maintenance Costs

Screened juvenile bypass systems are generally expensive to construct, operate, and maintain and can vary widely depending on the characteristics of the river, reservoir, and facility. A few examples of construction costs for specific projects in the Pacific Northwest are provided.

- Rocky Reach Dam on the Columbia River screened juvenile bypass was built in 2002 for approximately $107 million[3] (equivalent to $176 million in 2022).
- Construction is currently underway for a novel helix bypass and tunnel at Cle Elum Dam on the Cle Elum River. The project is estimated to cost significantly more than $100 million.

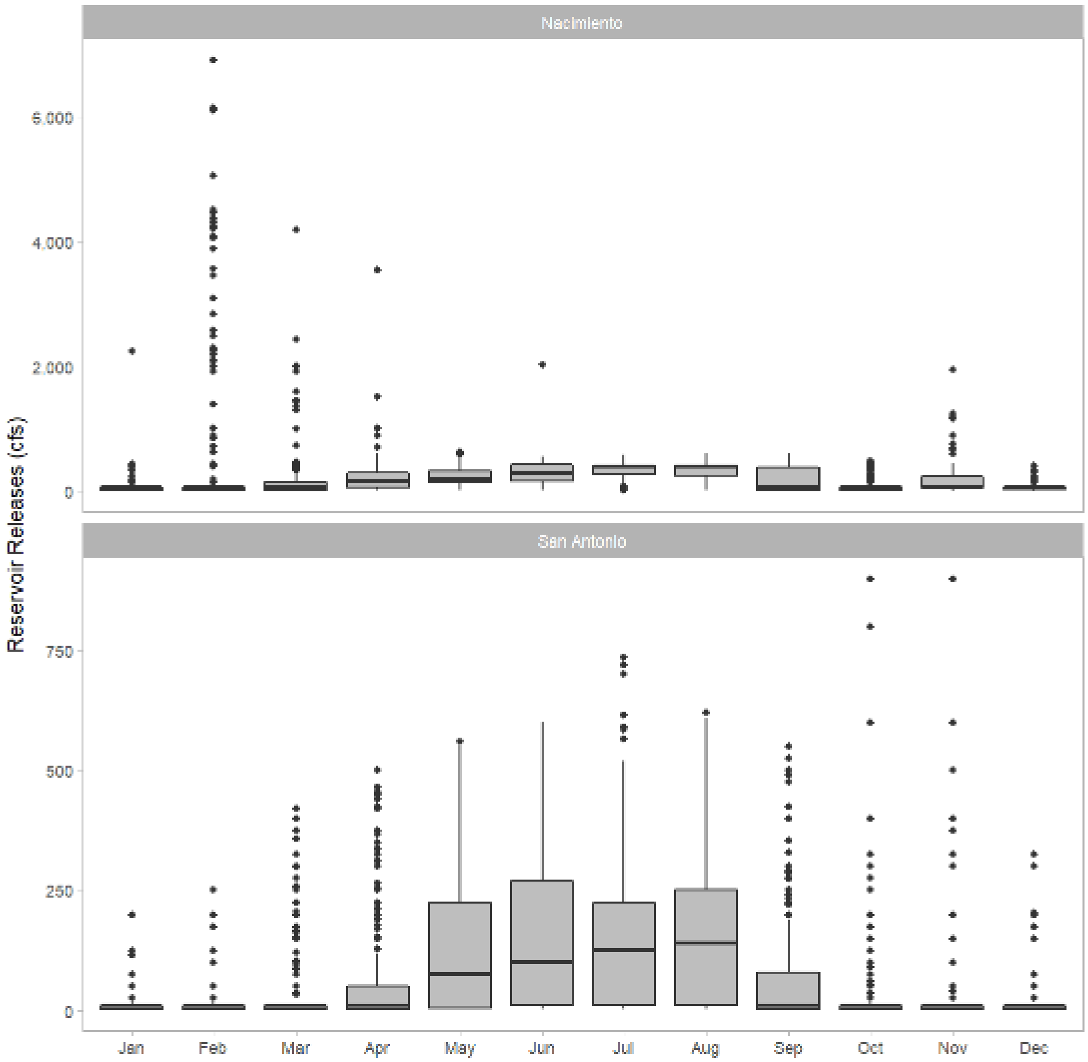
Permitting, design, administrative, and operation and maintenance would be additional costs.

[3] Juvenile Fish Bypass (chelanpud.org)



The shaded grey area represents the minimum and maximum observed monthly fluctuations in surface elevation.

Figure 3-6. Average Annual Reservoir Surface Elevation Fluctuations (feet) observed Monthly at Nacimiento (1958–2022) and San Antonio (1966–2022) Reservoirs



Median values are indicated by the horizontal black line in each box, the lower and upper hinges are the 25th and 75th percentile values, each whisker extends 1.5 times the interquartile range, and the points represent outliers.

Figure 3-7. Reservoir Releases from Nacimiento (top) and San Antonio (bottom) Dams, January 1, 2000, to August 30, 2021

3.3.5 DS Alternative 3: Floating Surface Collector in Reservoir Forebay

Trap-and-haul programs have become increasingly popular in systems where juvenile salmonids must pass through multiple reservoirs to complete their seaward migration. Trap-and-haul operations can include FSCs, in-river collectors, or bypass channels or pipes leading to a collection facility (Section 3.3.4, *DS Alternative 2: Passage through a Screened Intake and Bypass*). Captured fish are then transferred to trucks and transported downstream and released back in the river to complete their migration.

FSCs are facilities built to take advantage of juvenile salmonids near-surface orientation during downstream migration. These facilities float in the reservoir forebay and create attraction flows using a series of pumps that draw juvenile salmonids into the collection facility and prevent them from entering the powerhouse or outlet works. FSCs have become increasingly popular in the Pacific Northwest at hydroelectric facilities with large storage reservoirs. Large FSCs are currently operated on Swift Reservoir on the Lewis River, Washington and in Upper and Lower Baker Lakes in the Skagit River basin, Washington. The Baker Lake projects have been extremely successful at passing large numbers of juvenile salmonids and have become well known as successful case studies for juvenile salmonid passage at a high-head dam with numerous reservoirs (NPCC 2016). FSCs are generally built away from the dam face to improve collection efficiency and prevent entrainment into the powerhouse or dam outlet. It is common for FSCs to be built with structural guidance systems such as guide nets to prevent fish from entering turbine intakes, diversions, or spillways and guiding them into the FSC (DWR 2013). Once collected in the facility, fish are held in tanks until they are transferred into trucks and driven downstream to complete their migration to the ocean.

An FSC was recently installed at Los Padres Dam on the Carmel River and has had varying success (Ohms and Boughton 2021). The surface collector at Los Padres is an FWC. FWCs require attraction flow to draw fish into the collection system. The FWC at Los Padres uses 5 cfs inflow at the inlet with increasing velocity further into the facility, maxing out at 7 feet per second. The FWC system on the Carmel River connects to a bypass pipe that transports fish 1,200 feet around the dam and releases them approximately 200 feet below the spillway.

3.3.5.1 Nacimiento Dam

Given that FSCs are designed to float on the water surface, a key consideration is the magnitude of surface water elevation fluctuations. Extreme fluctuation in water elevation may complicate the design and operation of an FSC facility. Water surface elevation at Nacimiento Reservoir has been monitored since 1958. Substantial fluctuations in surface elevation have been recorded during the juvenile outmigration period (Figure 3-6). In some months, reservoir elevation varies nearly 80 feet, which may pose significant engineering challenges particularly for the behavioral or physical guidance system directing migrants into the facility. Physical guidance systems, such as guide nets, can be challenging and expensive to install, maintain, and operate and require significant configuration testing to ensure that a high proportion of smolts are directed into the FSC. In systems that transport large amounts of wood and other debris frequent maintenance is required for the system to remain effective. This is not likely to be an issue in Nacimiento Reservoir given the surrounding vegetation and landscape.

Another concern related to the fluctuation in reservoir elevation is the amount of water required for attraction flows to draw smolts into the facility. Like fish ladders for upstream migration, smolt passage systems, particularly in reservoirs where flow and velocity are often low, require sufficient attraction flow to function properly. If the FSC attraction flows are too similar to the background reservoir flow, smolts may have difficulty locating the facility. Additional investigations would be required to determine appropriate attraction flows for a FSC at Nacimiento Dam. However, based on information from similar facilities, attraction flows would likely range from 200 to 500 cfs to effectively draw and retain smolts in the facility. Attraction flows at the FSC installed at Swift Reservoir on the Lewis River are approximately 600 cfs during normal operations and 500 cfs is used at the FSC on Baker Lake (NPCC 2016). These projects are likely larger than what would be required at Nacimiento Dam but provide context on the expected range of attraction flows required to ensure high capture efficiency at the facility. Providing sufficient water to produce that amount of attraction may not be feasible at Nacimiento if reservoir levels are low.

At Nacimiento Dam the FWC described above would be a more feasible approach compared to the FSC. FWCs are typically smaller and require less infrastructure relative to an FSC such as the ones described in Washington. A design similar to the FWC at Los Padres Dam may perform well at Nacimiento Dam because it could accommodate the fluctuating reservoir levels with significantly less attraction flow relative to an FSC. The current minimum monthly flow requirements at Nacimiento (60 cfs) would likely be sufficient FWC attraction flows. Similarly, the FWC would be simpler to operate. However, low reservoir levels may impair FWC function, and a pumping system may be required to move fish from the collector to the bypass or into the collection facility. At higher reservoir elevations a gravity-fed system may be sufficient to move fish from the collection facility. The FWC could be designed to move fish to a bypass pipe with an outfall in the outlet channel or fish could be moved into a holding facility to be sorted before being moved to trucks and transported downstream. The benefits of a collection facility are described as part of DS Alternative 2. A physical guidance system would be needed for an FWC at Nacimiento Dam to function efficiently. Relative to Los Padres Dam and Reservoir, the Nacimiento forebay is wider and longer, which may cause fish to have difficulty locating the FWC entrance. A guide net would be important to ensure that a high proportion of fish locate the facility.

A downstream passage at Los Padres Dam occurs via the FWC and over the spillway. As described in DS Alternative 1, providing downstream passage via the spillway at Nacimiento Dam is not feasible given the low frequency of spill events. Because of this an FWC at Nacimiento would be the only passage route for downstream migrants. Monitoring of outmigrant movements at Los Padres Dam found that fish were more likely to utilize the spillway than the FWC, but passage over the spillway was depth limited (Ohms et al. 2022).

The effects of traveling through Nacimiento Reservoir as described previously in Alternatives 1 and 2 are also applicable here.

3.3.5.2 San Antonio Dam

Designing an FSC in San Antonio Reservoir presents similar challenges as those described in the previous section for Nacimiento Dam and Reservoir. Surface elevations in San Antonio Reservoir are generally more stable than Nacimiento Reservoir (Figure 3-6). However, over the course of the monitoring period at the reservoir (1966–2022) surface elevations vary substantially, more than 130 feet in some months. Effectively maintaining and operating an FSC in San Antonio Reservoir would be challenging given the large fluctuations in surface elevation, potentially poor reservoir water quality conditions during the outmigration period and expected necessary high attraction flows.

The effects of traveling through San Antonio Reservoir described previously under DS Alternatives 1 and 2 are also applicable here.

3.3.5.3 Technical Considerations

Constructing an FSC at Nacimiento and San Antonio Reservoirs is largely infeasible due to the extreme fluctuations in reservoir elevation. An FWC may be more feasible and could accommodate large fluctuations in reservoir elevations. However, it is unclear how successful this system would be without supplementing passage via the dam spillways. The following advantages (pros) and risks (cons) were identified for DS Alternative 3 at Nacimiento and San Antonio Dams.

Pros

- Access to the entire reservoir for rearing, foraging, and growth.
- Guide net would prevent fish from entering the dam intakes.
- Collection facility would ensure nonnative species are contained in the reservoir.

Cons

- Adequate attraction flows may be difficult to attain at both facilities.
- Guide nets are not 100% effective, and some fish may pass through the net to the turbines (Nacimiento), or outlet works (Nacimiento and San Antonio).
- Costs for design, construction, and operation would be very high.

3.3.5.4 Estimate of Construction, Operation, and Maintenance Costs

Costs to design, construct, operate, and maintain an FSC are high.

Examples of construction and operation and maintenance costs for other projects with high-functioning FSCs are provided below.

- Floating surface collector at Upper Baker Lake was operational in 2008 and cost $53 million (equivalent to $73 million in 2022) to construct and costs between $500,000 and $600,000 to operate and maintain (NPCC 2016).
- Floating surface collector was installed on Swift Reservoir in 2012 and cost roughly $64 million (equivalent to $82.7 million in 2022) and costs nearly $300,000 annually to operate and maintain (NPCC 2016).

Figure 3-8. Example of Possible FSC Configuration at Nacimiento Dam

Figure 3-9 Example of Possible FSC Configuration at San Antonio Dam

3.3.6 DS Alternative 4: In-River Collector Upstream of Reservoir

Another trap-and-haul design uses an in-river collector upstream of the reservoir. This alternative could be accomplish using a temporary trap system such as a screw trap or a permanent in-river guidance system such as an inflatable rubber dam or a weir that directs fish and water through a screened off-channel bypass and collection facility. Temporary trapping systems could be employed to ramp up passage efforts and preliminarily evaluate the effectiveness of collecting smolts in the upper river basins. For a long-term passage operation, the inflatable rubber dam or weir may be more appropriate and effective. Most of the diverted screened water would be returned to the river and a small portion would be used to move fish into holding tanks until they could be transported in trucks downstream of the dams. This design could be operated across a wide range of flow conditions during the migration window as well as allow for unimpeded flows outside of the migration window. This type of facility could accommodate outmigrating smolts and kelts. Additionally, this type of design would require a fishway built on the opposite bank to accommodate upstream passage while the dam is inflated. An in-river collector upstream of the reservoir eliminates exposure to poor water quality, reduces predation risk, and decreases migration time and distance.

3.3.6.1 Nacimiento Reservoir

DS Alternative 4 at Nacimiento Reservoir considers a permanent in-river guidance system including a rubber inflatable Obermeyer-style dam, screened bypass facility, collection and holding facility, truck loading apparatus, and adult upstream fishway. This alternative would require backing up water within the river to create a pool deep enough for a bypass system to function effectively. Field surveys would be needed to identify a suitable location and determine the dimensions of the dam, but aerial imagery suggests that the dam would need to be roughly 200 feet wide if constructed near Grizzley Bend (Figure 3-10). The height of the dam would likely need to be between 5 and 10 feet depending on site characteristics. The river stage height further upstream near Bryson can range from 3 to 10 feet during the smolt migration period. Additional engineering investigations would be required to determine the dimensions of the dam, the size of the backwater pool formed behind the dam, and the total area of surrounding landscape that would be inundated as a result. Predation is another concern with forming a deep water pool behind a dam constructed at the upstream end of the reservoir as this would likely create habitat for warm water piscivorous fish such as white bass.

A pool and weir fish ladder may be necessary depending on upstream passage opportunities. If a ladder was deemed necessary, it would be designed per NMFS (2022) passage criteria for adults and juveniles and located opposite of the bypass facility. An adult trap-and-haul system would eliminate the need for a fish ladder as adults could be released upstream of the in-river collection system. Flow through the fish ladder would likely be less than 10 cfs to minimize the number of juveniles that utilize this pathway while providing sufficient conditions for adults to swim upstream through the ladder. However, some downstream migrants would avoid the bypass and collection facility and migrate through the fishway to the reservoir. Without passage facilities at the dam these fish would be trapped within the reservoir unable to complete their downstream migration.

High spring flows observed in the upper Nacimiento basin may make operating this type of facility difficult (Figure 3-11). The rubber bladder would need to be deflated when the river stage exceeds the dam height, which would allow downstream migrants to bypass the facility. Spilling water over the dam is not operationally feasible as this would significantly reduce the number of downstream migrants captured in the bypass and collection facility (Manning et al. 2005). However, given the magnitude of recent discharge conditions in the upper river (Figure 3-12) it may be difficult to design a facility capable of accommodating the expected volume of water. Conversely, given recent drought conditions flows during the winter and spring may be too low to continuously operate this type of facility.

An additional challenge associated with this alternative is the remoteness of the area upstream of Nacimiento Reservoir. The river within approximately 5 miles of the reservoir is largely inaccessible by road. Construction of an in-river collector near Grizzley Bend (roughly 2 miles from the edge of Nacimiento Reservoir) would require construction of new roads to support construction and operation of the facility. This presents significant permitting challenges. Moreover, this type of facility would have a significant impact on the terrestrial and aquatic environments, modifying sediment transport dynamics, altering the surrounding landscape by increasing inundation elevations, and possibly affecting riparian or upland species. Impacts on terrestrial and aquatic state- and federally listed species would also be a concern from a permitting, cost, and feasibility perspective.

A temporary system with screw traps could be used to preliminarily evaluate effectiveness of an in-river collector. A screw trap could be located near existing roads upstream of Grizzley Bend. This type of operation would require daily operation and maintenance to ensure high collection efficiency and low injury and mortality rates. A physical guidance device such as a net may also be needed to ensure a high proportion of outmigrants are captured. Following collection, smolts would be removed from the trap and transported downstream in trucks to the lower Nacimiento River below the dam or another release location in the lower Salinas River. This approach could also provide valuable information on current anadromous *O. mykiss* production in the upper basin and potential feasibility and effectiveness of a larger-scale in-river collection operation.

3.3.6.2 San Antonio Reservoir

The San Antonio River in the first 6 miles upstream from the reservoir may be less suitable for Alternative 4 given the lower volume of water and complex, braided, and wide alluvial channel (Figure 3-13). An in-river collector would likely be most effective near where Interlake Road (SR G-14) crosses the San Antonio River (Figure 3-13). A similar system as described above for Nacimiento River would be designed for the San Antonio River. The inflatable rubber dam would need to create a backwater deep enough to divert water to the screened-off channel bypass and collection facility. The San Antonio River upstream of the complex braided reach is between 60 and 180 feet wide and the river stage can vary up to 10 feet. Additional engineering investigations would be required to determine the dimensions of the dam, the size of the backwater pool formed behind the dam, and the total area of surrounding landscape that would be inundated as a result.

A pool and weir fish ladder may be necessary depending on upstream passage opportunities. If a ladder were deemed necessary, it would be designed per NMFS (2022) passage criteria for adults and juveniles and located opposite the bypass facility. An adult trap-and-haul system would eliminate the need for a fish ladder as adults could be released upstream of the in-river collection system. Flow through the fish ladder would likely be less than 10 cfs to minimize the number of juveniles that use this pathway while providing sufficient conditions for adults to swim upstream through the ladder. However, some downstream migrants would avoid the bypass and collection facility and migrate through the fishway to the reservoir. Without passage facilities at the dam these fish would be trapped within the reservoir, unable to complete their downstream migration.

High spring flows observed in the upper San Antonio basin may make operating this type of facility difficult (Figure 3-14). The rubber bladder would need to be deflated when river stage exceeds the dam height which would prevent capture of downstream migrants. Spilling water over the dam is not operationally feasible as this would significantly reduce the number of downstream migrants captured in the bypass and collection facility (Manning et al. 2005). However, given the magnitude of recent discharge conditions in the upper river (Figure 3-15) it may be difficult to design a facility capable of accommodating the expected volume of water. Conversely, given recent drought conditions flows may be too low to continuously operate this type of facility.

The proposed construction area is accessible via existing roads, which would minimize the construction and permitting required. However, Alternative 4 on the San Antonio would have an impact on terrestrial and aquatic environments. The inflatable rubber dam would modify sediment transport dynamics, the backwater behind the dam would alter the surrounding landscape by increasing inundation elevations and could affect riparian or upland species. Impacts on terrestrial and aquatic state- and federally listed species would also be a concern from a permitting, cost, and feasibility perspective.

The temporary system described for Nacimiento could be preliminarily used in the upper San Antonio River to evaluate the effectiveness of an in-river collector system. Smolts collected in a screw trap could then be trucked downstream to the lower San Antonio River or the Salinas River.

3.3.6.3 Technical Considerations

The following advantages (pros) and risks (cons) were identified for DS Alternative 4 at Nacimiento and San Antonio Dams.

Pros

- Eliminates risk of low survival through reservoir.
- Does not require modification to dam structures.
- Could be implemented in phases with a screw trap or other temporary trapping systems initially.

Cons

- Risk of failure at high flows.
- Areas upstream of the reservoirs are remote and largely inaccessible. Additional reconnaissance would be needed to determine accessibility.
- Some outmigrants may avoid the facility and end up in the reservoir.
- Sediment, bedload, and debris accumulation may periodically impede operations.
- Backwater created by the dam may impact upland and riparian species.

- Complex environmental permitting.
- Human handling is required increasing potential for injury or death.
- Potential for vehicular accidents during transport, which could result in loss of a load of fish.

3.3.6.4 Estimate of Construction, Operation, and Maintenance

Example costs from other projects are not available because this type of passage approach has not been widely applied. A screw trapping program would include equipment, personnel, construction, permitting, and administrative costs. Installing a rubber dam with a bypass facility presents numerous permitting, design, and construction challenges. United Water estimated the cost of an in-creek collector of $3–5 million with annual operating costs ranging from $30,000 to $50,000 (Santa Felicia Dam Fish Passage Panel 2017). The cost of in-river collectors on Nacimiento and San Antonio Rivers may be greater compared to Piru Creek because they are larger systems and may require a more complex design.

Figure 3-10. Conceptual Example of an In-River Collection System Configuration in the Upper Nacimiento River near Nacimiento Reservoir

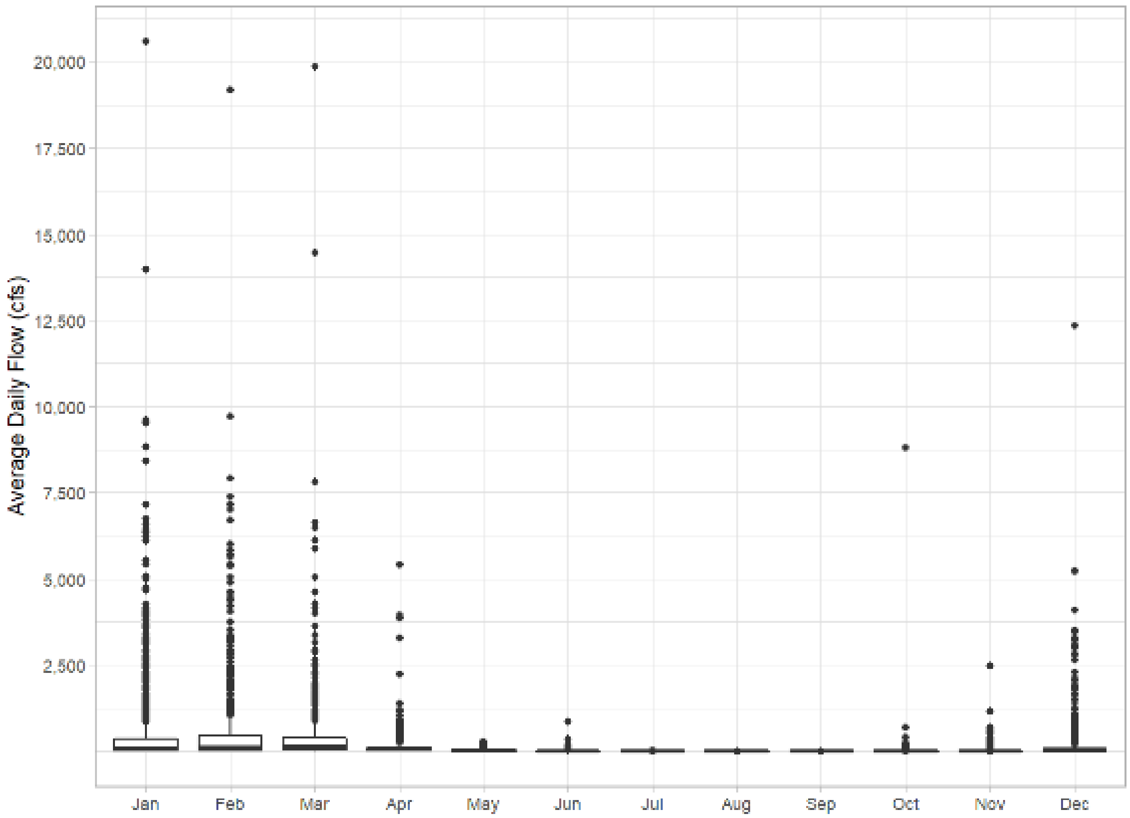


Figure 3-11. Mean Daily Flows on the Nacimiento River Recorded at USGS Stream Gage 11148900 near Bryson, California between 1958 and 2022

Drought conditions were present from 2012 through 2016 and in 2018, 2020, 2021, and 2022.

Figure 3-12. Mean Daily Flows on the Nacimiento River Recorded at USGS Stream Gage 11148900 near Bryson, California between 2011 and 2022.

Figure 3-13. Conceptual Example of an In-River Collection System Configuration in the Upper San Antonio River near San Antonio Reservoir

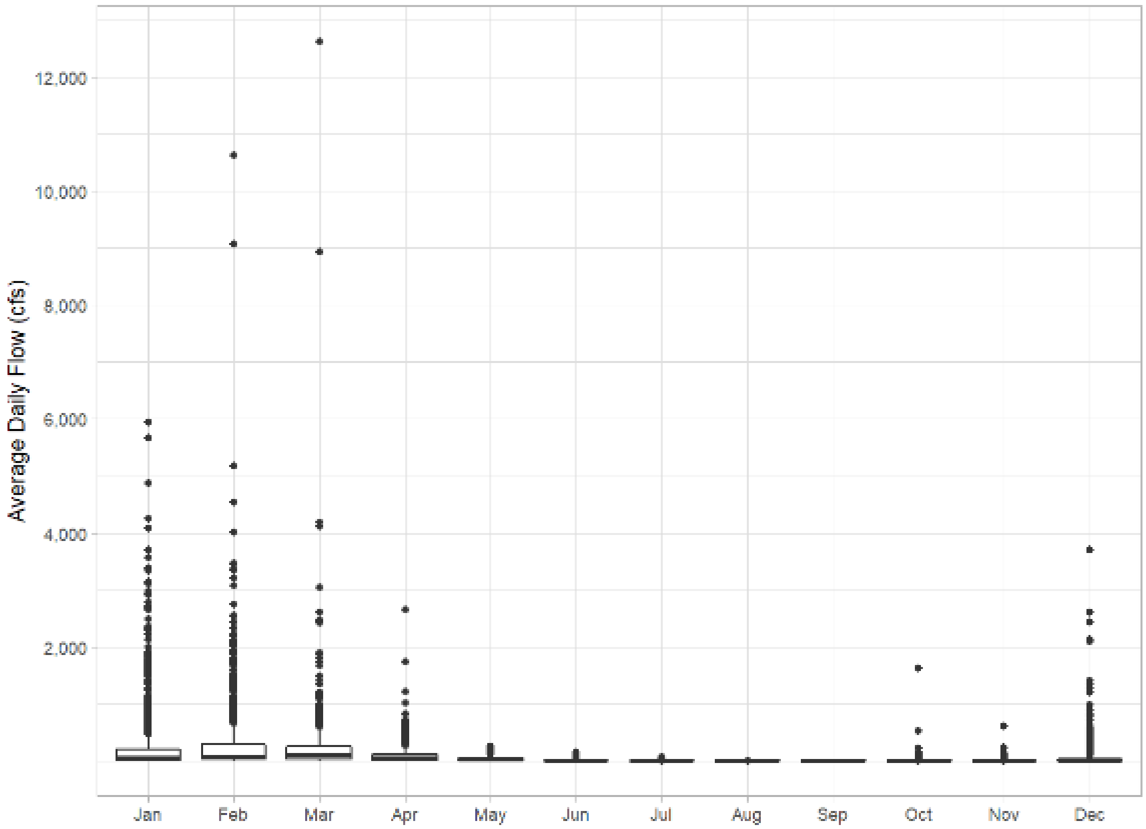


Figure 3-14. Mean Daily Flows on the San Antonio River Recorded at USGS Stream Gage 11149900 near Lockwood, California

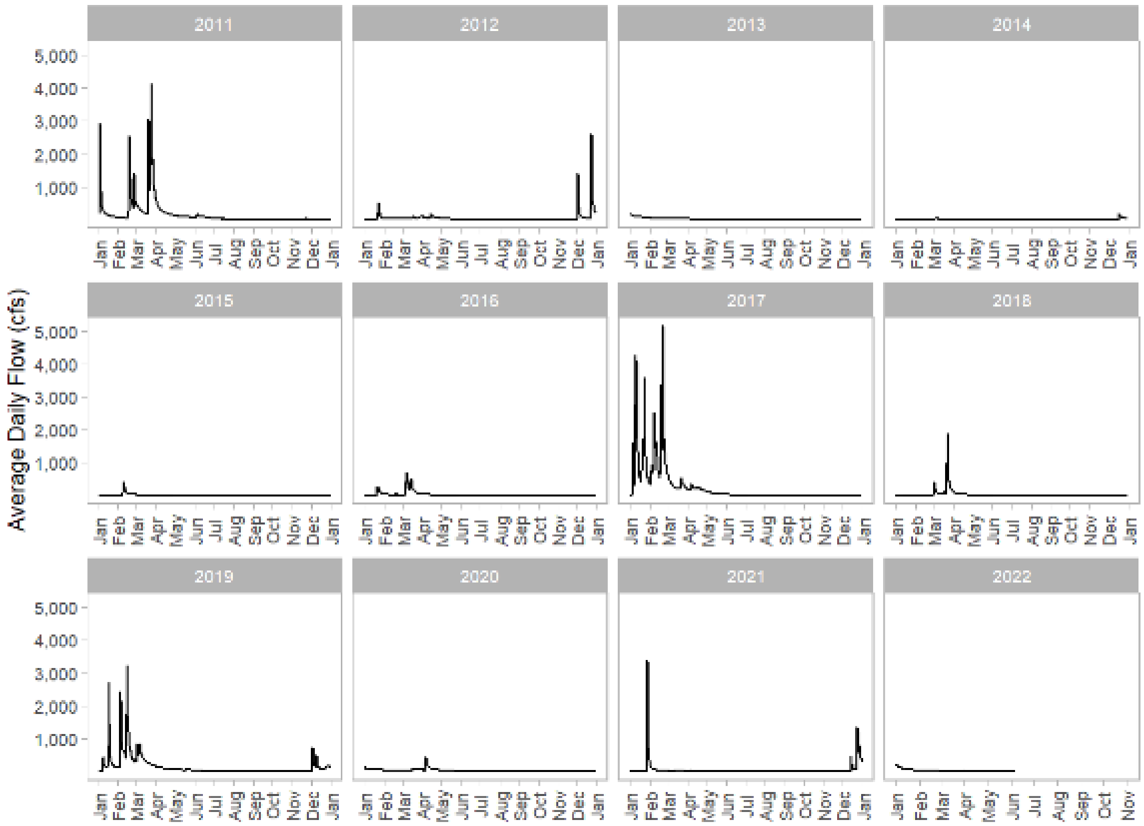


Figure 3-15. Mean Daily Flows on the San Antonio River Recorded at USGS Stream Gage 11149900 near Lockwood, California between 2010 and 2022

3.4 Passage Enhancements

Facility enhancements could be added to the alternatives described in Section 3.3, *Downstream Passage*, to improve downstream fish passage efficiency. One such example is an acclimation or release pond. A release or acclimation pond holds transported juveniles, adults, or kelts temporarily for a short period to allow them to recover from handling stress and acclimate to the conditions of the water at the release site. An acclimation facility typically includes a fish unloading facility, water supply from the receiving waterbody, holding pond, predator protection and deterrent devices, and a release gate. Locations of acclimation/release ponds would be determined once final passage strategies are selected, however at least three release sites would be needed: (1) upper Nacimiento River, (2) upper San Antonio River, and (3) lower Salinas River.

Another possible enhancement is a monitoring facility. A monitoring facility was described as part of DS Alternatives 2, 3, and 4. The goal of a monitoring facility is to collect demographic and biological data on migrating juveniles and kelts. The monitoring facility would allow accurate counts of migrants and as deemed necessary, allow direct sampling or tagging of individual fish. The addition of a monitoring facility would improve the understanding of population dynamics in the basin and inform recovery efforts. Juvenile and adult monitoring facilities could also be combined depending on the selected passage strategies.

Chapter 4
Steelhead Trout Production Potential in the Upper Nacimiento and San Antonio Watersheds

This chapter supplements the dam fish passage feasibility analysis by examining the potential of the Nacimiento and San Antonio basins upstream of the reservoirs to support and produce steelhead trout. This evaluation quantifies steelhead production upstream of the dams using readily available public data and on-the-ground habitat surveys in selected stream reaches. Evaluating steelhead production potential in the upper basin through habitat characterization is a critical component of the passage feasibility study. If the quantity of high-quality suitable habitat in the areas upstream of the dams is low, modifying the dams with passage facilities is unlikely to result in meaningful increases in steelhead production. However, if habitat quality in the upper basins is high and abundant, then steelhead production could be greatly improved if access is restored.

First, the following subsections describe conditions in the upper basins based on historical reports and data. Then conditions in the upper basin are examined to assess migration and rearing opportunity for steelhead trout using topographical, hydrologic, and channel geomorphological information derived from GIS and field data.

4.1 Historical Conditions

Historically, areas above Nacimiento and San Antonio Dams comprised some of the best steelhead trout spawning and rearing habitats in the Salinas River valley (MCWRA and SWRCB 2008) (Figure 4-1 and Figure 4-2). Roughly 286 miles of habitat (66%) in the upper basins is no longer accessible to adult steelhead due to the presence of Nacimiento and San Antonio Dams (NMFS 2007). The following sections describe historical habitat conditions and trout abundance, density, and distributions within the upper Nacimiento and San Antonio watersheds based largely on information in Titus et al. (2002), The Watershed Institute (2002), and Becker and Reining (2008). More recent information on habitat and fish populations in the upper basins is largely lacking.

4.1.1 Nacimiento Basin

Prior to construction of Nacimiento Dam the upper Nacimiento River provided some of the most important spawning and rearing habitat for Salinas River steelhead (Titus et al. in prep; MCWRA 2008) (Figure 4-1). Surveys in the early 1900s documented juvenile *O. mykiss* in the foothills and mountainous headwater regions of the basin (Snyder 1913 in Titus et al. in prep). Snyder (1913) also observed numerous steelhead carcasses and noted that juvenile production was good in the upper portions of the river.

Surveys completed by USFS in September 1981 along the upper Nacimiento River in the Los Padres National Forest (Titus et al. in prep) observed intermittent stream flows and rainbow trout concentrated in the remaining perennial pools. Densities, based on visual abundance estimates, ranged from 20 to 40 trout per 100 meters and fish averaged between 5 and 10 centimeters (cm) in length (2.5 to 20 cm range). The observed sizes suggested these fish were young-of-the-year and that natural reproduction was occurring.

In 1992, CDFW (at that time the California Department of Fish and Game) surveyed 5 miles of the Nacimiento River upstream of the reservoir and reported a rainbow trout density of 1,036 fish per mile, or roughly 64 fish per 100 meters, and characterized the habitat quality as poor with low trout density largely due to the lack of instream cover and shelter (Becker and Reining 2008). However, CDFW indicated that the areas upstream from the Nacimiento-Ferguson Road bridge showed much greater production potential for wild trout (Becker and Reining 2008).

A 2002 survey conducted by The Watershed Institute (Earth Systems Science and Policy California State University Monterey Bay) found rainbow trout were abundant in the upper Nacimiento River. A few of the larger pools contained approximately 40 young-of-the-year per pool. Significant trout densities were observed in both reaches studied. Their densities were 38 and 33.4 trout per 100 meters. These estimates were similar to the USFS estimates described above. Only two trout larger than 15 cm were observed in the Nacimiento River and most were less than 8 cm (The Watershed Institute 2003).

Upstream in tributaries of the Nacimiento, historic surveys noted several upper basin tributaries with relatively high trout abundance and high-quality habitat. Las Tablas Creek was surveyed by CDFW in its entirety (approximately 40 kilometers) on March 25, 1966 (Becker and Reining 2008) and was documented to contain spawning gravels and rearing habitat including pools and instream cover (e.g., undercut banks). Overall, CDFW rated the habitat quality in Las Tablas Creek as high and no barriers or diversions were observed. However, at the time of the survey, the lower half of Las Tablas Creek had been polluted with heavy metals by Buena Vista Mining Company mines (Titus et al. in prep). CDFW also noted that *O. mykiss* in Nacimiento Reservoir have been observed moving into Las Tablas Creek in the spring, presumably to spawn (Becker and Reining 2008).

Surveys by CDFW in 1992 in the Negro Fork Nacimiento River indicated that trout density was high relative to other streams surveyed in the basin (CDFG 1993 in Becker and Reining 2008). CDFW postulated that due to low summer flows pool habitats and riparian vegetation were particularly important to maintaining resident trout populations.

Other tributaries to the Nacimiento River identified as potentially high production streams include the following.

- Dip Creek—Identified by CDFW in 1969 as having spawning and rearing habitats (SWRCB 1969 in Becker and Reining 2008)
- Stony Creek—Identified by CDFW in 1969 as having spawning and rearing habitats (SWRCB 1969 in Becker and Reining 2008)
- San Miguel Creek—Identified by CDFW in 1979 as supporting rainbow trout (CDFG 1979 in Becker and Reining 2008)

The Nacimiento River above the reservoir has also been historically stocked with both rainbow and brown trout (*Salmo trutta*) since the 1960s (Titus et al. in prep). Beginning in the early 1980s stocking was focused on the Arroyo Seco and Nacimiento Rivers (Table 4-1).

Table 4-1. Historic Rainbow Trout Stocking Efforts by CDFG and Monterey Bay Salmon and Trout Project

Date	Agency	Stock of Origin	Rearing Location	Number Released	Release Location
1981	CDFG	Silverado Hatchery (Napa)	-	17,095	Nacimiento River (Below Dam)
1984	CDFG	Silverado Hatchery (Napa)	-	16,145	Nacimiento River (Below Dam)
March 1984	MBSSP	Carmel River	-	5,700	Arroyo Seco River (Government Camp)
1985	CDFG	Silverado Hatchery (Napa)	-	17,570	Nacimiento River (Below Dam)
March 7, 1985	MBSSP	Russian River	-	5,635	Arroyo Seco River (Government Camp)
1986	CDFG	Silverado Hatchery (Napa)	-	18,550	Nacimiento River (Below Dam)
March 18, 1986	MBSSP	San Lorenzo River	Big Creek	12,500	Arroyo Seco River (Government Camp)
1987	CDFG	Silverado Hatchery (Napa)	-	17,290	Nacimiento River (Below Dam)
March 11, 1987	MBSSP	San Lorenzo	Big Creek	5,200	Arroyo Seco River (Government Camp)
1988	CDFG	Silverado Hatchery (Napa)	-	12,520	Nacimiento River (Below Dam)
March 9, 1988	MBSSP	San Lorenzo	Big Creek	4,500	Salinas River at Slide Gate
1989	CDFG	Silverado Hatchery (Napa)	-	16,050	Nacimiento River (Below Dam)
1991	CDFG	Silverado Hatchery (Napa)	-	8,600	Nacimiento River (Below Dam)
March 22, 1991	MBSSP	San Lorenzo River	Big Creek	7,425	Salinas River at Old Highway 1
March 26,1991	MBSSP	San Lorenzo River	Big Creek	7,920	Salinas River at Old Highway 1
1992	CDFG	Silverado Hatchery (Napa)	-	10,560	Nacimiento River (Below Dam)
April 14, 1992	MBSSP	San Lorenzo River	Salinas Pond	6,510	Salinas River/Lagoon at Twin Bridges
April 17, 1992	MBSSP	San Lorenzo River	Salinas Pond	3,580	Salinas River/Lagoon at Twin Bridges
1993	CDFG	Silverado Hatchery (Napa)	-	18,020	Nacimiento River (Below Dam)
February 20, 1993	MBSSP	San Lorenzo River	Salinas Pond	8,028	Arroyo Seco
1994	CDFG	Silverado Hatchery (Napa)	-	11,500	Nacimiento River (Below Dam)
March 15, 1994	MBSSP	San Lorenzo River	Salinas Pond	4,080	Salinas River at Davis Road
1995	MBSSP	San Lorenzo River	Big Creek	6,175	Lower Salinas River
April 3, 1996	MBSSP	San Lorenzo River	Big Creek	3,980	Salinas River at Twin Bridges
Total				228,038	Salinas Watershed

Source: The Watershed Institute 2003.

4.1.2 San Antonio Basin

The San Antonio River basin was historically an important spawning and rearing area for Salinas River steelhead (Titus et al. in prep; MCWRA 2008) (Figure 4-1). Snyder (1913) found juvenile *O. mykiss* at two sampling stations along the San Antonio River. They also noted that fishing for juvenile *O. mykiss* was especially good in the upper reaches of the San Antonio River. Rainbow trout were present in the upper San Antonio River when surveyed by CDFW during the mid-1930s. Spawning grounds were scattered in distribution, and the presence of migration barriers was noted.

Prior to the construction of San Antonio Dam and impoundment of the river, CDFW conducted a detailed survey of a large portion of the San Antonio drainage between July and September 1965 (Titus et al. in prep). The survey identified the following areas of the basins as *lacking* suitable spawning and rearing habitats for *O. mykiss*.

- Mainstem San Antonio from the Salinas confluence to Merle Ranch
- Jolon Creek
- Mission Creek
- Coleman Creek

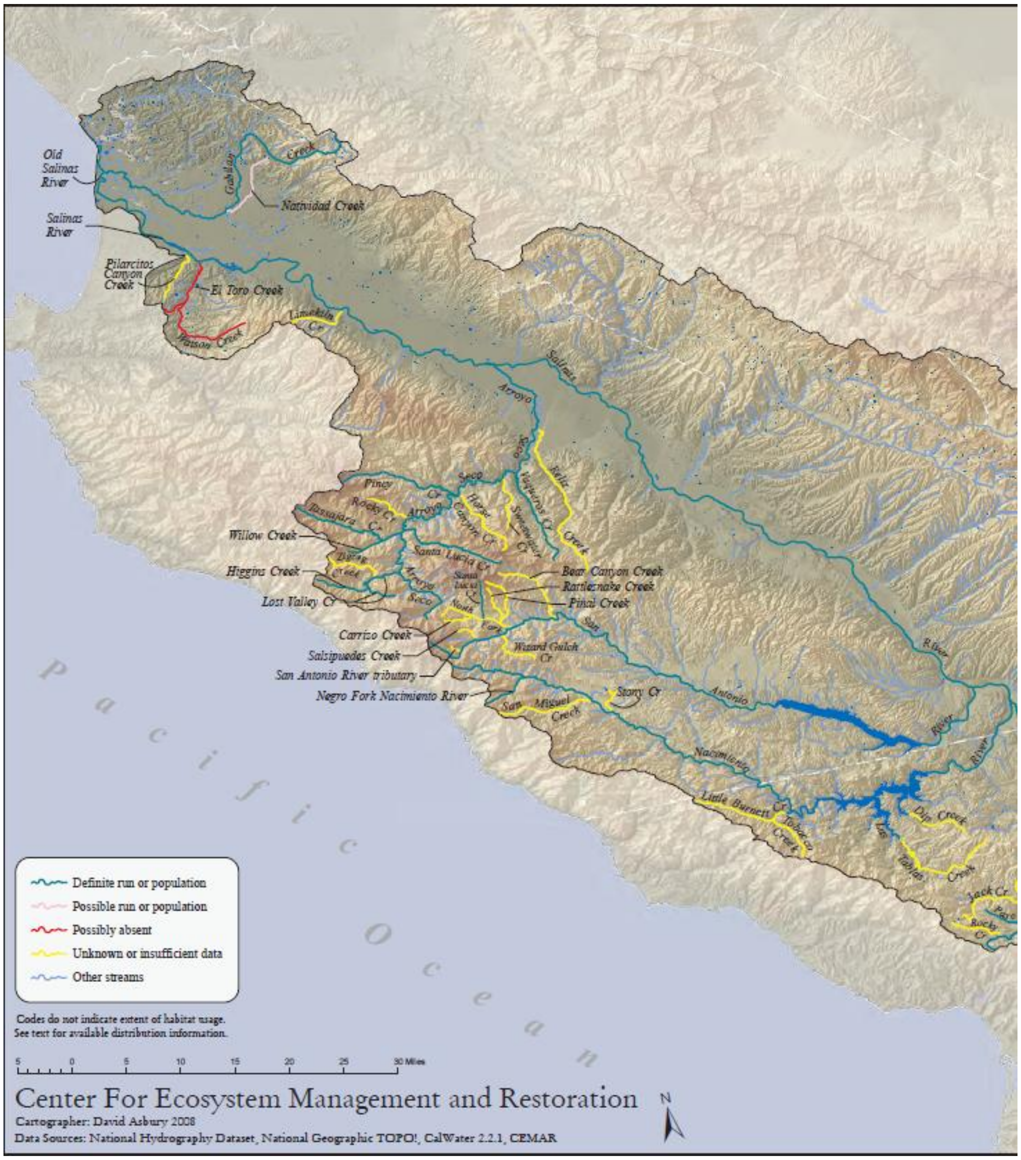
Bear Canyon Creek in the upper basin was found to contain approximately 10 trout per 100 meters of stream, significantly less than Nacimiento densities, with fish ranging from 2.5 to 12.5 cm in length (Titus et al. in prep). The mainstem San Antonio River upstream of Merle Ranch contained roughly 82 trout per 100 meters, Salispuedes Creek 13 trout per 100 meters, and the North Fork San Antonio River 13 to 16 trout per 100 meters. Several small tributaries to the North Fork were also reported to support small numbers of trout including Rattlesnake, Pinal, Sycamore, Carrizo, and an unnamed tributary.

A 1994 survey performed by CDFW concluded that an 8.5-mile stretch of the San Antonio River, upstream of the reservoir, does not provide a significant amount of summer and rearing habitat for medium (6–12 inches) to large (> 12 inches) trout (Becker and Reining 2008). Gradient was considered steep in the headwaters decreasing to moderate in the lower areas. The average stream width was 8.5 feet and ranged from 4 to 110 feet wide. A flashboard dam located on the Merle Ranch created a pool 100 feet long and 110 feet wide. The average depth of the stream was 1.5 feet with a range of 0.2 to 9.0 feet. Flow was estimated at 1.0 cfs. Boulders, silt, and sand dominated the upper and lower reaches, with gravel most abundant in the middle reach of the study area. Overhead cover for trout was rated as good in the upper reaches with complexity coming from woody debris, boulders, undercut banks, and overhanging vegetation. Cover for fish is considered poor in the lower portions of the study area and consisted mainly of boulders and some overhanging vegetation. Water temperatures ranged from 55 to 74°F. The warmer temperatures were measured in the lower reaches where riparian cover was lacking. Numerous barriers were present in the lower reaches and these barriers were mostly cascades created by boulder jams. All were definite summer barriers at the measured flow rate with many considered winter barriers as well. The streamflow was around 1.0 cfs, although significantly more than measured in nearby drainages. The average stream depth was 1.5 feet, although some pool units were over 8 feet deep. Although instream habitat appeared to be good in the middle and upper portions of the stream spawning areas were most abundant in the middle reach. Numerous barriers were also identified that prevented the movement of fish through the stream to access and use the available habitat. The low stream flows could have been reducing the rearing habitat to a level capable of supporting only a small number of adult fish.

Stocking of rainbow trout has also occurred periodically in the San Antonio basin; however, it is unclear how often or the quantity of fish stocked.

Source: Becker and Reining (2008)

Figure 4-1. Historical Status of *O. mykiss* in the Salinas River Basin



Source: Becker and Reining (2008)

Figure 4-2. Status of *O. mykiss* in the Salinas River Basin as of 2008

4.1.3 Summary

Historical accounts and data collected before and after the construction of San Antonio and Nacimiento Dams indicates that suitable habitat for steelhead life history expression is limited to headwater tributaries in the upper watersheds in the Santa Lucia Mountains. The mainstem rivers above the dams are largely lacking high-quality rearing habitat and high quality spawning gravels are also limited. Similarly, historic accounts and data suggest that summer temperatures and flow conditions in mainstem portions of the upper rivers are not conducive to rearing juvenile *O. mykiss* and may impede seasonal migrations of juveniles and adults. Based on the historical data the following streams are most likely to support populations of *O. mykiss*.

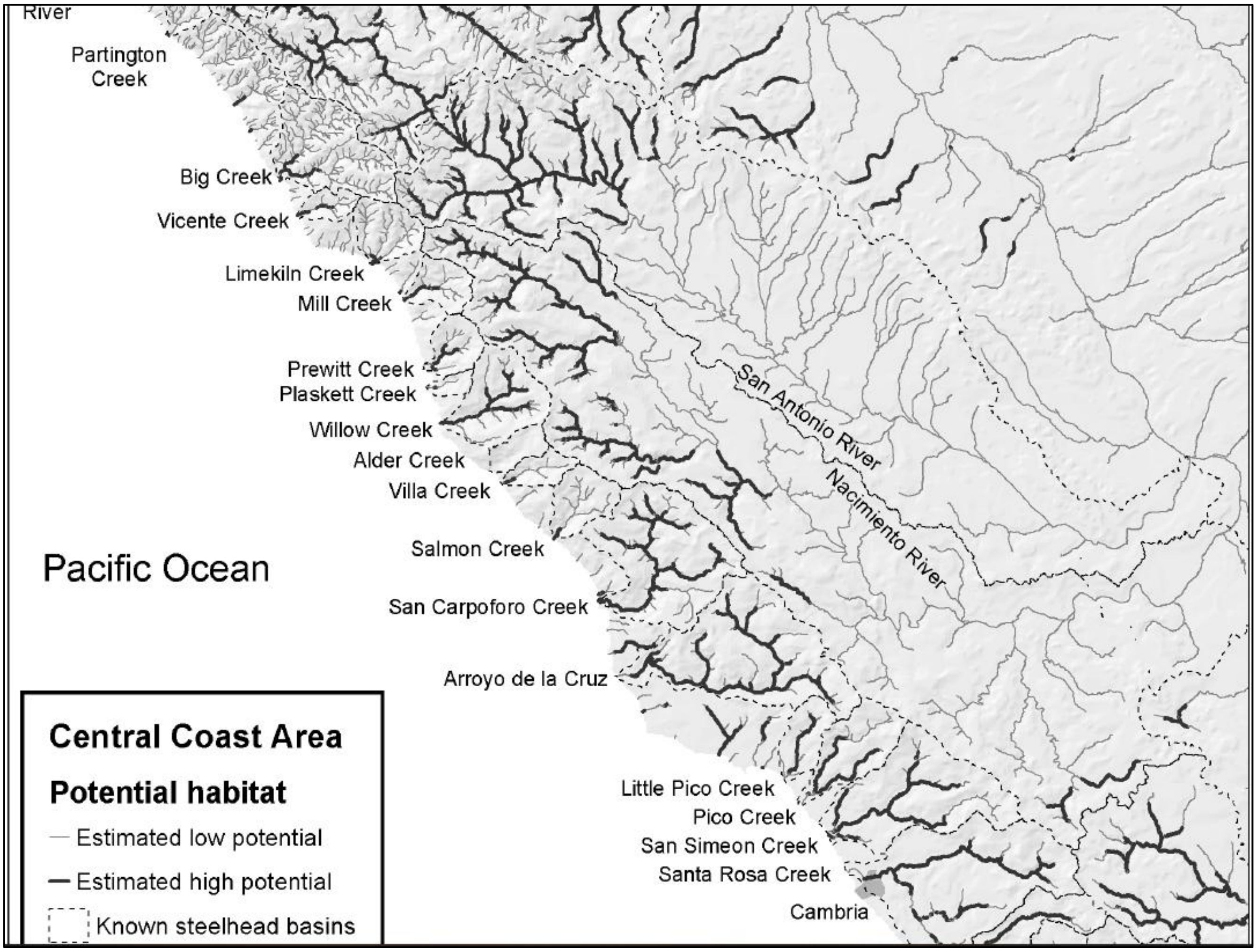
- Nacimiento Basin
    - Las Tablas Creek

  - Old Negro Fork
  - Dip Creek
  - Stony Creek
  - Nacimiento River upstream of the Nacimiento-Ferguson Road Bridge
  - Nacimiento River within the Los Padres National Forest
- San Antonio River upstream of Merle Ranch

4.2 Characterizing Upper Basin Over-Summer Intrinsic Potential

The NMFS Southwest Fisheries Science Center completed an evaluation of over-summering habitat for steelhead trout occupying the South-Central/Southern California Coast recovery domains (Boughton and Goslin 2006). Over-summering habitat is largely considered to be a key limiting factor for California steelhead due to the arid Mediterranean climate. Summers are often very dry and hot, causing smaller streams to run dry until the winter and spring rainy season. Because steelhead rear in fresh water between 1 and 3 years before migrating to the ocean as smolts, summer freshwater habitat is a requirement for population success.

Boughton and Goslin (2006) relied on GIS systems to employ an environmental envelope method that predicts habitat occupancy based on known occurrences of steelhead in other streams. This method relies on geomorphic, hydrologic, and climate parameters that are known to control the broad-scale suitability of stream reaches under natural conditions. Specifically, the 2006 analysis leveraged stream gradient, summer mean discharge, summer temperature, valley width relative to mean discharge, and whether the reach occurred in alluvial soils. Using the envelope method and the described landscape features, NMFS ranked stream reaches as having high or low potential of over-summering habitats for juvenile steelhead (Figure 4-3). Findings from the Boughton and Goslin (2006) analysis revealed that the upper Nacimiento and San Antonio River basins contained high potential summer rearing habitat for juvenile steelhead in high-up headwater streams. These streams are a substantial distance upstream from the most upstream extent of the reservoirs.



Source: Boughton and Goslin 2006

Figure 4-3. Intrinsic Potential Ratings for the Salinas Valley

4.3 Evaluation of Hydrologic Conditions

Hydrologic conditions in the upper Nacimiento and San Antonio Basins were evaluated by analyzing existing hydrologic data recorded by the USGS and examining stream typing designations in the USGS's National Hydrography Dataset (NHD) (USGS 2023). USGS maintains two long-term stream gages in the upper basin. One gage is located near Bryson on the Nacimiento River upstream of the reservoir. The other gage is located near Lockwood on the San Antonio River upstream of the reservoir. Stream discharge data collection on the Nacimiento and San Antonio Rivers began on October 1, 1988, and December 14, 1986, respectively, and both gages are still recording data.

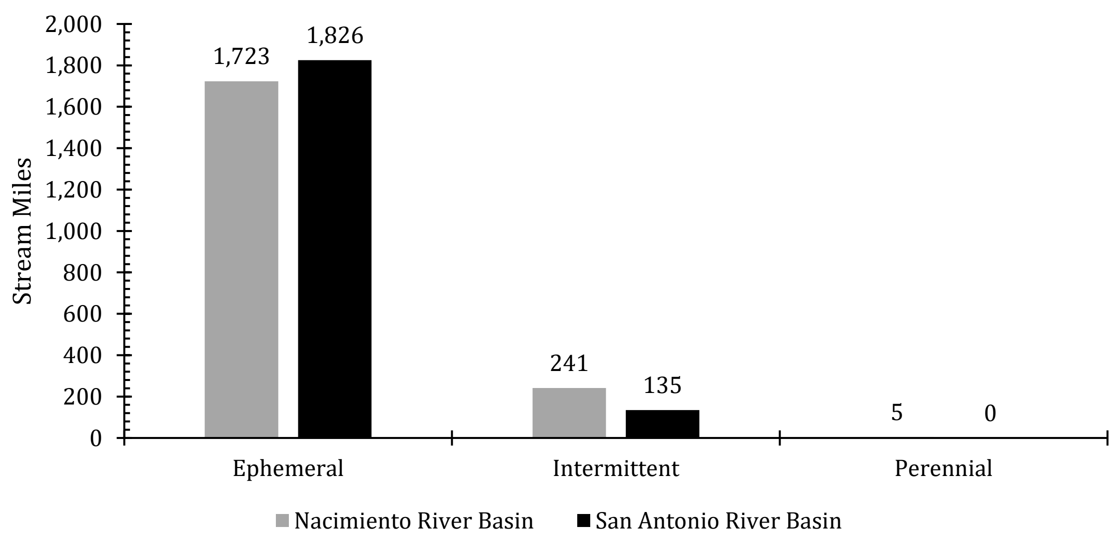
The USGS NHD dataset is a comprehensive hydrography dataset for the entire United States. This spatial dataset includes rivers, streams, canals, lakes, ponds, reservoirs, coastlines, and dams. The NHD dataset also provides an indication of stream types including ephemeral, intermittent, and perennial designations. Ephemeral streams are defined as streams or portions of a stream that flow briefly in direct response to precipitation in the immediate vicinity, and whose channel is at all times above the groundwater reservoir (Levick et al. 2008). Intermittent streams are those that flow continuously only at certain times of the year, for example when receiving water from a spring, groundwater source, or surface source, such as melting snow (seasonal) (Levick et al. 2008). At low flow there may be dry segments alternating with flowing segments. Perennial streams are those that flow year-round and are considered permanent features, and for which baseflow is maintained by groundwater discharge to the streambed due to the groundwater elevation adjacent to the stream typically being higher than the elevation of the streambed (Levick et al. 2008). Throughout the arid regions of North America many perennial streams are separated by ephemeral or intermittent segments of flow due to variable geology along the river. This is often referred to as interrupted or spatially intermittent (Levick et al. 2008). The occurrence of intermittent or ephemeral reaches within perennial reaches can create migration barriers for adult and juvenile steelhead as well as strand resident adults or rearing juveniles in disconnected stream reaches. This is most likely to occur during dry periods when flows are low, precipitation is infrequent, and snowmelt has ended.

Within the upper Nacimiento and San Antonio River basins nearly 90% of streams within the NHD dataset are classified as ephemeral (Figure 4-4), meaning they flow only during precipitation events or following snowmelt. Only 5 miles of the entire stream network in the upper basin is classified as perennial (Figure 4-4). Perennial stream reaches are limited to a short stretch of river upstream of Nacimiento Reservoir (Figure 4-5). Around 8.5% of the stream network is classified as intermittent and likely only supports flowing water during the spring and winter months when precipitation is more frequent, and the landscape is saturated. Accuracy of the NHD dataset has been quantitatively evaluated. For example, Hafen et al. (2020) examined how the accuracy of perennial and non-perennial stream classifications was influenced by climate conditions on an annual basis and found that classifications varied depending on precipitation and temperature anomalies specific to regions and years. In another study Jaeger et al. (2020) evaluated field observations of flow permanence and compared them to NHD classifications. The study determined the NHD dataset had a high rate of false positives in which non-perennial streams were classified as perennial and a low rate of false negatives in which perennial streams were classified as non-perennial. These studies highlight that there is uncertainty associated with NHD classifications and the NHD may not be fully representative of on-the-ground conditions.

Flows recorded by USGS near Bryson and Lockwood, California reveal that mean flows during late spring, summer, fall, and early winter are often zero, meaning the channel is dry and no water is flowing into the reservoir (Figure 4-6). During the adult steelhead migration period flows on the Nacimiento River exceed roughly 40 cfs 50% of the time but are more often less than 2 cfs (75% exceedance) (Table 4-2). On the San Antonio River mean daily flows exceed 25 cfs 50% of the time but are more commonly zero. Annual peak flows in both basins have declined since records began in the late 1980s (Figure 4-7). Peak flows on the upper Nacimiento River reached an all-time high in 1993, exceeding 50,000 cfs. Flows peaked twice in 2021, reaching 10,000 and nearly 25,000 cfs. Flow magnitude in the upper San Antonio basin is lower than the Nacimiento, with the largest peak flows occurring in 1998 around 25,000 cfs (Figure 4-7). Flow peaked twice on the San Antonio River in 2021, reaching nearly 2,500 and 6,000 cfs.

Flows on the upper Nacimiento River are generally low during the late spring, summer, and fall with a high frequency of zero flow days (Figure 4-6). During the winter and spring, flows are more widely distributed but generally less than 500 cfs. The timing of low or zero flow conditions does coincide with portions of adult and smolt migration periods. However, flows appear to be generally high enough during peak migration periods to support adult and smolt upstream and downstream movement, respectively. However, given that the Nacimiento River monitoring gage is located at the lower end of the system, it is unclear how far upstream suitable flow conditions extend. The NHD dataset indicates that perennial flow extends roughly 5 miles upstream from the uppermost extent of the Nacimiento Reservoir (Figure 4-5). Therefore, it is unclear whether adult steelhead could migrate from the reservoir to the high Intrinsic Potential (IP) streams located in the headwater reaches of the basin (Figure 4-3). Even during wet water years, the distribution of flows during the beginning (December) and end (March/April) of the adult migration period are low and could impede migration into the upper basin. During wet water years flows during peak adult migration periods (January to March) are likely to facilitate movement of adult fish to the high IP streams. However, based on flows during dry and normal water years adult migration may be impeded. Similarly, downstream migration of kelts may also be affected by low flows, particularly towards the end of the downstream migration season (May/June) during low water years. Smolt downstream migration from high IP streams may also be affected by low-flow conditions along the mainstem upper Nacimiento River, particularly during dry water years in May and early June. Steelhead smolts require less water to successfully migrate downstream than adults do to move upstream; therefore, successful smolt migration may be possible under lower-flow conditions.

The trends for the upper Nacimiento River basin are also present in the upper San Antonio River basin suggesting that adult, smolt, and kelt migration may be impeded as a result of hydrologic conditions present in the basin.



Stream types are designated in the USGS National Hydrography Dataset.

Figure 4-4. Total Miles of Stream Types in both the San Antonio and Nacimiento River Basins Upstream of the Reservoirs

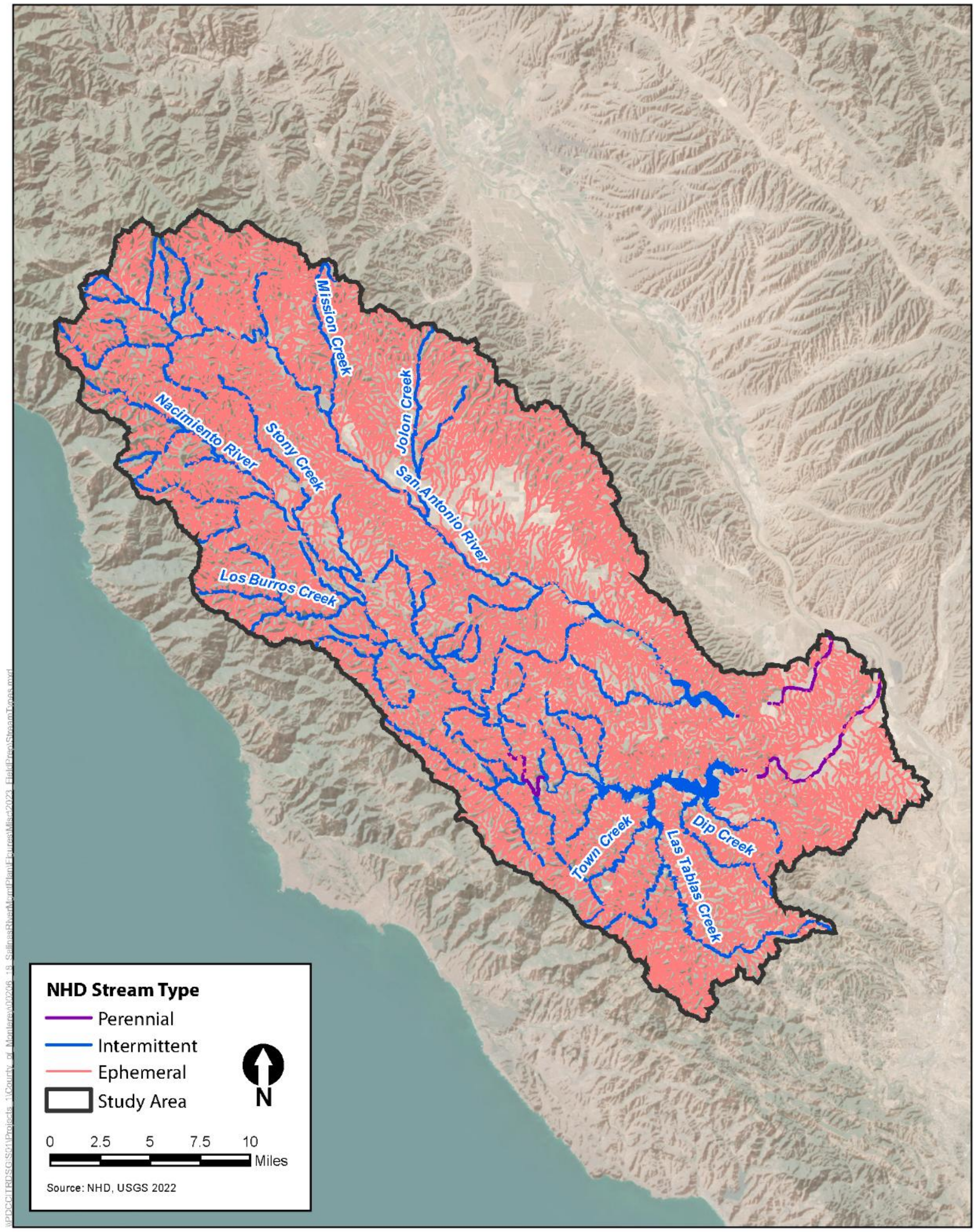
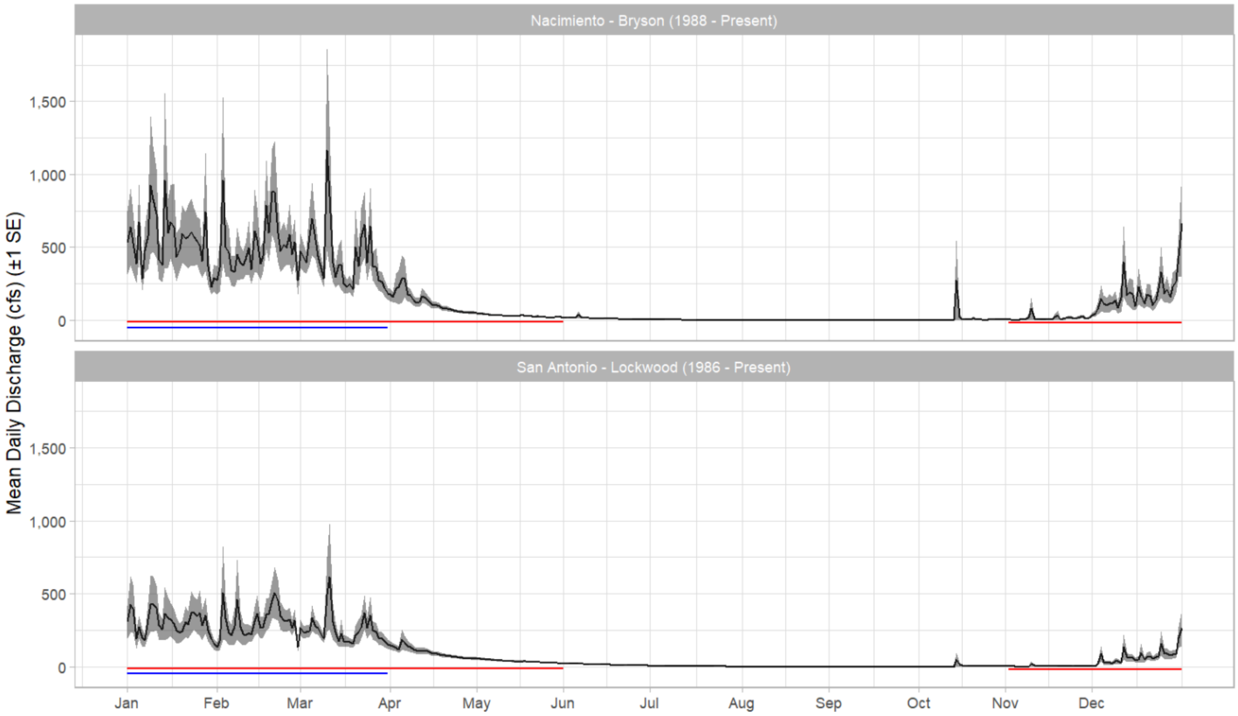


Figure 4-5. Stream Type Designations in the Upper Nacimiento and San Antonio River Basin



Adult migration timing is indicated by the horizontal redline and smolt migration timing is indicated by the blue line.

Figure 4-6. Mean Daily Discharges Recorded at Bryson along the Nacimiento River 1988–2023 and at Lockwood along the San Antonio River 1986–2023.

Table 4-2. Extracted Exceedance Probability Values for Nacimiento and San Antonio River Split by Adult Migration Months (November–March) and Smolt Migration Months (January–May)

Annual Exceedance Probability (%)	Nacimiento[a]		San Antonio[b]	
	Smolt Migration Discharge (cfs)	Adult Migration Discharge (cfs)	Smolt Migration Discharge (cfs)	Adult Migration Discharge(cfs)
95	5.4	0	0	0
75	25.7	1.6	22	0
50	85.5	38.5	67.1	25
25	295	215	212	142
5	1,873	1604	1031	887
0.5	6,738	6,524	3,454	3,347

[a] Calculated using data from the USGS gage (11148900) near Bryson, CA from 1988 to 2023.

[b] Calculated using data from the USGS gage (11149900) near Lockwood, CA from 1986 to 2023.

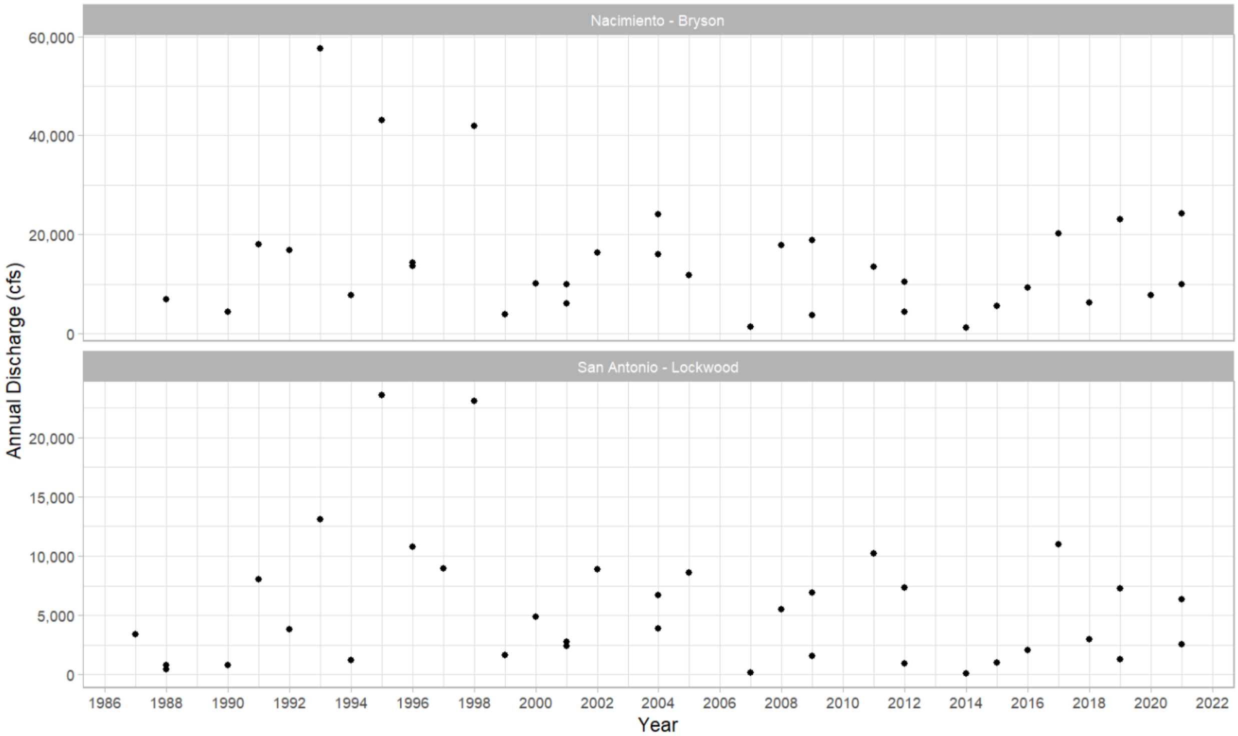


Figure 4-7. Annual Peak Flows Calculated by USGS on the Nacimiento River near Bryson, California and on the San Antonio River near Lockwood, California

4.4 Evaluation of Passage Impediments

For steelhead passage at Nacimiento and San Antonio Dams to result in population improvements, adult steelhead must be able to reach spawning habitats in the streams upstream of dams and reservoirs. To evaluate access to high-quality habitat in the upper basin, natural and artificial passage impediments were assessed. LiDAR and topographic data were used to identify areas within the mainstem Nacimiento and San Antonio Rivers that may preclude access to upper basin tributaries due to exceptionally steep gradients or other natural barriers (i.e., waterfalls). Artificial barriers identified by CDFW were mapped based on degree of passage (e.g., impassable, partially passable). Artificial barriers include hydroelectric dams, water storage projects, irrigation diversions, water withdrawals, and improperly fitted or functioning road culverts.

Adult Salinas River steelhead complete their upstream migration during the winter and spring periods when flows are typically high, and barriers may not pose significant passage risk relative to low-flow periods. Studies have evaluated what constitutes a passage barrier by examining the ability of steelhead and other salmonids to jump or leap over instream obstructions. A study by Reiser and Peacock (1985) computed maximum jumping heights of adult steelhead of 3.4 meters based on darting speeds (Bjornn and Reiser 1991). Typically, passage criteria over obstacles for adult *O. mykiss* requires a 1:1.25 height to pool depth ratio based on jumping ability and associated stream hydraulics while other studies suggest an outfall drop to pool depth ratio of 1:1 as conducive to leaping (Weigel et al. 2013; Pearson et al. 2005).

The following sections describe potential topographic and known artificial and natural barriers in the upper watersheds and how they may affect the extent of anadromy should passage facilities be added to the dams.

4.4.1 Topographic Impediments

Topographic conditions are often used to estimate the upper extent of anadromy. For example, CDFW determined via literature review that a sustained slope of 8% precludes anadromy (CDFG 1998). Additionally, based on literature reviews of stream gradient and upstream habitat limits of steelhead, R2 Resource Consultants (2007) reported that a sustained slope of approximately 12% over 330 feet would likely limit upstream passage of steelhead (and coho salmon) in Northern California coastal streams. Lindley et al (2006) also identifies 12% as the upper end for steelhead suitability. This criterion corresponds to the limiting value used to define intrinsic habitat potential for steelhead in Northern California streams by NMFS (Agrawal et al. 2005 in R2 Resource Consultants 2007). In Oregon, the Department of Forestry characterizes natural falls and chutes greater than 8 feet high as barriers to salmon and steelhead. Natural falls or chutes less than 8 feet may act as a barrier if there is insufficient pool depth below the falls (<1.25 times deeper than the jump height). Furthermore, ODF considers reaches with gradients greater than 20% for more than 30 feet to be barriers to upstream salmon and steelhead migration. Similarly, the Washington Department of Fish and Wildlife considers a 12% slope for more than 525 feet to be a gradient barrier. Based on these criteria, stream gradients were evaluated using a 10-meter digital elevation model from USGS to identify areas that may preclude anadromy. Stream gradients were grouped into the following bins: < 8%, 8–12%, and >12%.

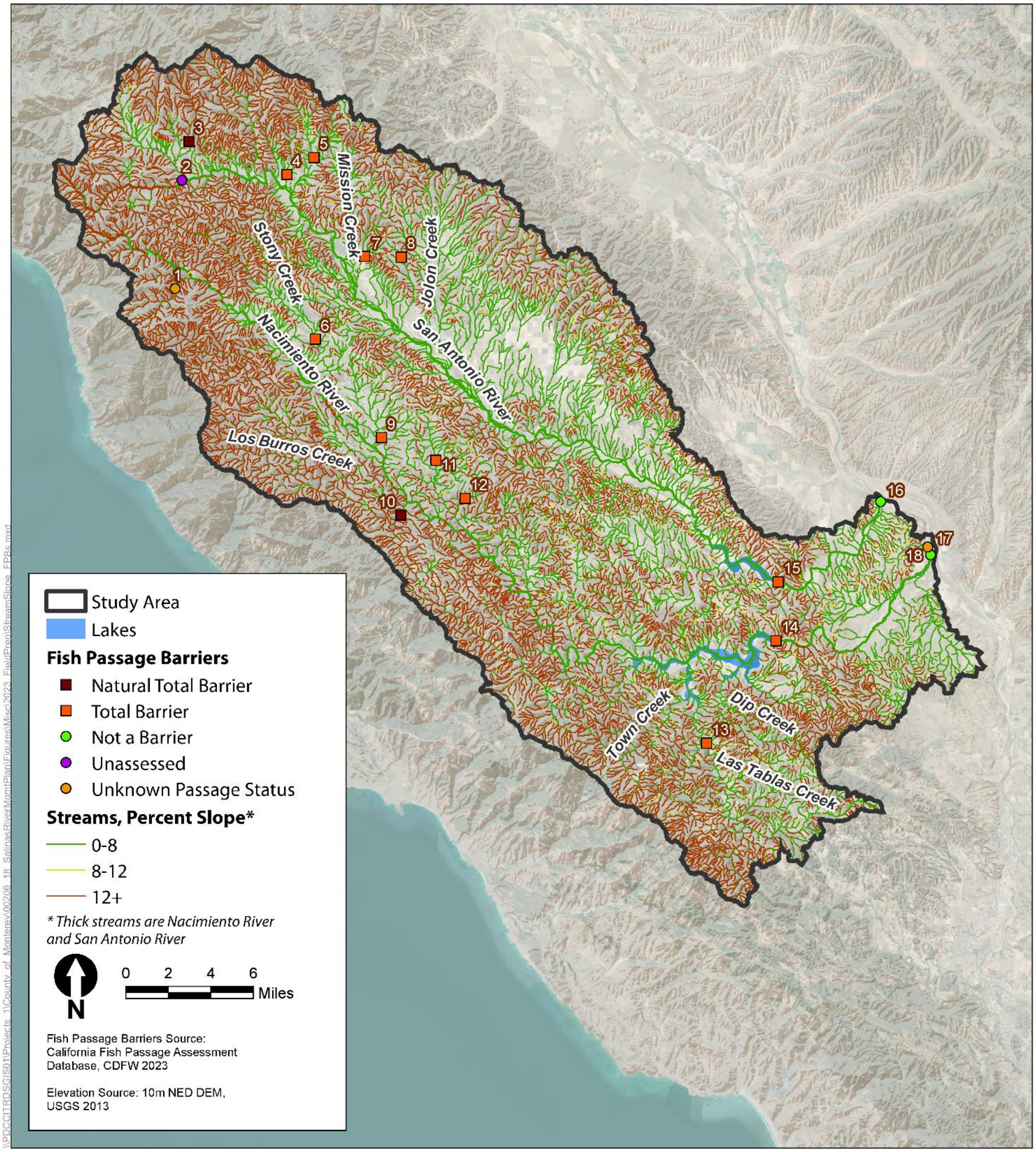
Nearly 60% of the stream network in the upper Nacimiento River basin was classified as having gradients greater than 8% (Table 4-3). Furthermore, 45% of the stream network was classified with gradients greater than 12%. These areas represent possible passage impediments to upstream migrating adult steelhead. Numerous reaches of the mainstem Nacimiento River were categorized with slopes greater than 12% (Figure 4-8), although further field surveys would be necessary these results. These areas are downstream of the sub watersheds identified by NMFS as having high intrinsic potential for juvenile steelhead over summer rearing habitats. Field verification of these areas is needed to confirm that passage may be impeded.

Stream gradients along the majority of the mainstem San Antonio River were less than 8% and therefore unlikely to present upstream migration impediments to adult steelhead. Additionally, tributaries in the far northern reaches of the upper San Antonio also appear to accessible based on stream gradient estimates (Figure 4-8). Gradients in the uppermost reaches of the mainstem San Antonio River are estimated to be greater than 12% and may be difficult for adult steelhead to reach. These areas likely contain higher-quality habitats relative to downstream reaches.

Findings from Boughton and Goslin (2006) suggest that streams with a high potential for containing over-summer rearing habitat for juvenile *O. mykiss* are located in the far northern reaches of each subbasin (Figure 4-3) where much of the stream network is estimated to have slopes that exceed 8% representing potential passage impediments.

Table 4-3. Total Miles of Stream within Slope Categories in the Upper Nacimiento and San Antonio Basins. Percentages are Included in Parentheses.

Basin	Miles of Stream			
	0–8%	**8–12%**	**>12%**	**Total**
Nacimiento	824 (41%)	293 (15%)	906 (45%)	2,024
San Antonio	1,002.94 (51%)	253.56 (13%)	724.91 (37%)	1,981
Total	**1,827**	**547**	**1,631**	**4,006**



Data was provided by the California LiDAR Status database.

Figure 4-8. Stream Slope of the Upper Nacimiento and San Antonio River Basin

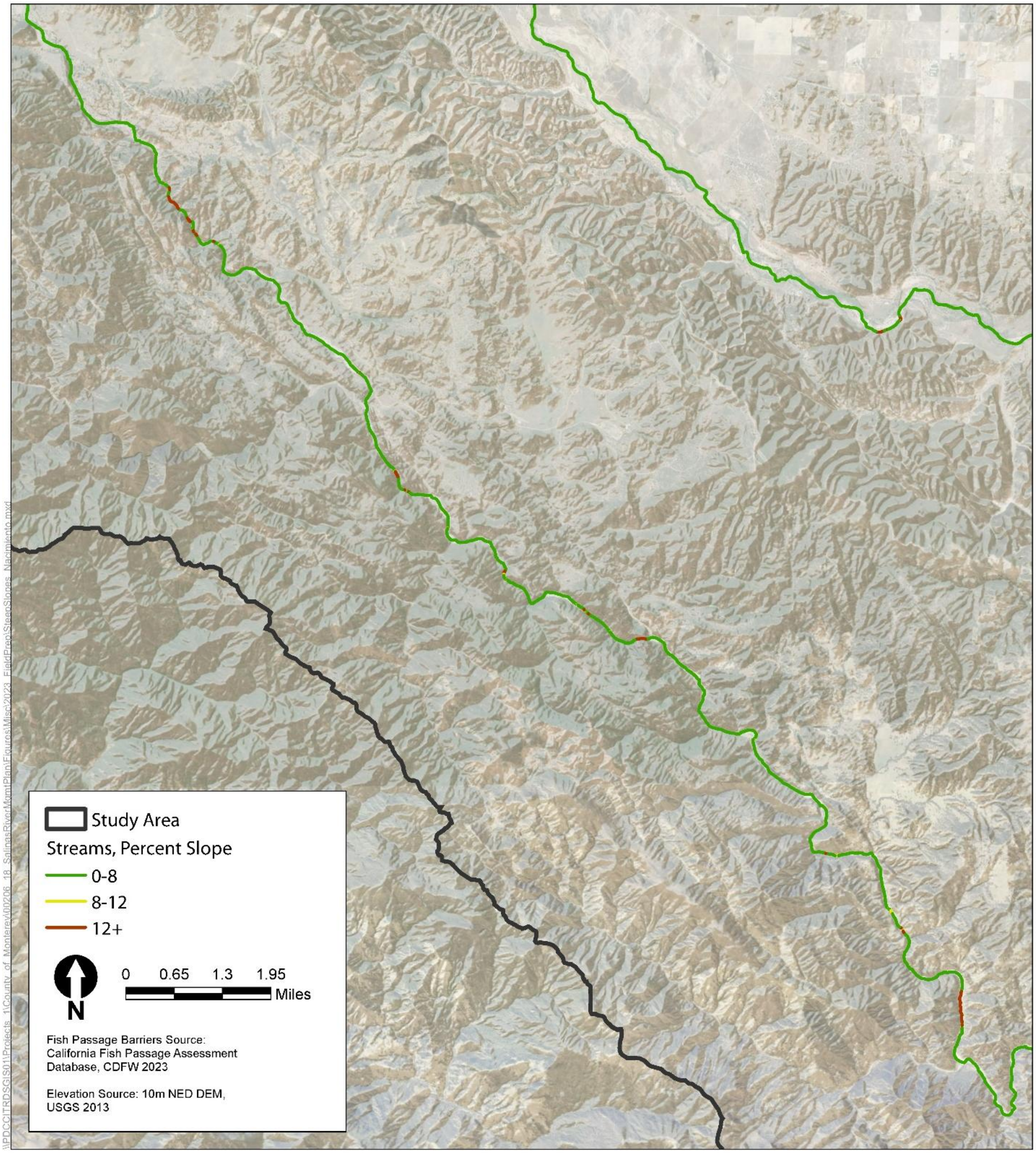


Figure 4-9. Locations of Potential Gradient Barriers in the Upper Mainstem Nacimiento River

4.4.2 Artificial and Natural Barriers

Artificial passage barriers were mapped using data from California's Passage Assessment Database which contains a map-based inventory of known and potential barriers to anadromous fish throughout California (CalFish 2024). Artificial and natural barriers in the upper Nacimiento and San Antonio watersheds were mapped based on passage status (Figure 4-8). There are 13 impassable, or total, barriers in both watersheds not including Nacimiento and San Antonio Dams. Total barriers are those that are deemed completely impassable by anadromous fish.

4.4.2.1 Nacimiento Basin

Within the upper Nacimiento River total passage barriers exist on Stony, Las Tablas, El Piojo, Aqua Fria, Salmon, and Sycamore Creeks (Table 4-4). Intrinsic potential modeling and historical accounts from CDFW suggest that Las Tablas Creek and Stony Creek contain high rearing and spawning habitat potential. The total barrier to anadromous fish on Stony Creek is a 27-foot dam near the creek's confluence with the mainstem Nacimiento River. Based on IP modeling (Boughton and Goslin 2006) and CDFW historical surveys, it is likely that suitable habitat exists upstream of the dam, although the extent is unclear. Based on aerial imagery, very little riparian vegetation exists along the creek suggesting that water temperatures during the dry season may be limiting *O. mykiss* rearing potential.

A 37-foot dam without a fish passage structure also exists on Las Tablas Creek approximately 1 mile upstream from the Franklin/Las Tablas Creek arm of Nacimiento Reservoir. The upper tributaries of Las Tablas Creek were ranked as high IP streams by Boughton and Goslin (2006); however, these areas would be inaccessible to migrating adult steelhead due to the presence of the dam. Surveys by CDFW in 1966 identified high-quality spawning and rearing habitat in the upper portions of the creek above the current location of the dam, but also indicated that flows in the summer were intermittent and contributed to resident trout summer mortality (Titus et al. in prep).

A natural bedrock barrier was identified on the Negro Fork Nacimiento River and its barrier status is considered unknown. Without field verification it is unclear if this barrier is passable under certain conditions. Bedrock chutes often act as barriers under high-flow conditions due to the velocity of water running through the chute. It is possible that the bedrock barrier identified on the Negro Fork Nacimiento River is passable during lower-flow conditions and impassable at high flows when velocities may exceed the swimming ability of steelhead.

A nearly 100-foot natural waterfall was identified in 2002 on Salmon Creek approximately 1 mile upstream from the creek's confluence with the Nacimiento River (Table 4-4 and Figure 4-8). No historical data exist on trout abundance or habitat quality or quantity for Salmon Creek. However, based on aerial imagery and proximity to the Los Padres National Forest, the riparian areas along Salmon Creek appear to be intact for the extent of stream below the waterfall barrier as well as upstream of the barrier. Intact riparian areas suggest that important ecological processes such as large wood recruitment are functioning, indicative of high-quality rearing habitat potential. Aerial imagery also indicates that the stream below the waterfall barrier is dominated by large boulder substrates indicative of poor spawning conditions; however, field surveys would be required to confirm habitat conditions.

Dams also exist on Sycamore, El Piojo, and Agua Fria Creeks on the east side of the upper Nacimiento River basin. However, none of these three streams were identified as high IP streams by Boughton and Goslin (2006). Additionally, surveys have not been completed on these streams to assess habitat conditions or trout production.

4.4.2.2 San Antonio Basin

Within the upper San Antonio basin five artificial dams are identified in the Passage Assessment Database as total barriers to anadromous fish passage (CalFish 2024). One natural waterfall and one unassessed dam were also identified.

A 25-foot-high earthen dam is located on Coleman Canyon Creek forming Coleman Reservoir (Table 4-4). Coleman Canyon Creek is a tributary to Mission Creek, eventually flowing into the San Antonio River. Given Coleman Canyon Creek's location high in the watershed, approximately 6.5 miles from the mainstem upper San Antonio River, it is unlikely that suitable rearing or spawning habitat exists above the dam.

Milpitas Reservoir is located on an unnamed tributary to the San Antonio River high in the watershed (Figure 4-8). Milpitas Reservoir is owned by the U.S. Army and is located on Fort Hunter Liggett Army Base. Aerial imagery suggests a defined stream channel exists upstream of the reservoir; however, it is relatively small and lacks riparian vegetation. Field investigations would be necessary to fully assess habitat conditions above Milpitas Reservoir.

A 30-foot earthen dam that forms Oat Hill Reservoir on Ruby Canyon Creek is owned by Fort Hunter Liggett Army Base and is located approximately 4 miles upstream from the Ruby Canyon Creek San Antonio River confluence (Figure 4-8). Aerial imagery depicts a poorly formed stream channel below the reservoir and IP modeling indicates low potential for over-summer rearing habitat in Ruby Canyon Creek.

A 20-foot earthen dam on Sulphur Spring Canyon is owned by Fort Hunter Liggett Army Base and is approximately 2.5 miles upstream from the San Antonio River confluence (Figure 4-8). Aerial imagery depicts a poorly formed and exposed channel upstream and downstream of the reservoir.

A natural waterfall exists on Pinal Creek in the headwater reaches of the North Fork San Antonio River (Figure 4-8). The North Fork San Antonio River is part of the headwater areas of the upper San Antonio River basin rated as high IP for over-summer rearing habitat for steelhead. The areas upstream of Pinal Creek falls have a high likelihood of containing suitable rearing habitat for *O. mykiss*. While the Passage Assessment Database does not include information on the height of the waterfall it is ranked as a total barrier to upstream migration and therefore likely exceeds the jumping ability of steelhead. Aside from Pinal Creek falls, there are no documented artificial or naturally occurring barriers that would prevent adults or juveniles from accessing the uppermost reaches of the mainstem San Antonio or North Fork San Antonio Rivers.

Table 4-4. Natural and Artificial Barriers Identified in the Upper Nacimiento and San Antonio River Basins

Basin	ID	Stream Name	Tributary To	Site Name	Type	Barrier Status	Survey Date	Owner	Blocked Stream Miles
Nacimiento	1	Negro Fork	Nacimiento River	Bedrock barrier	Unknown	Unknown	2002	N/A	22.38
	10	Salmon Creek	Nacimiento River	End of anadromy	100’ high waterfall	Total	2002	N/A	56.94
	12	Sycamore Creek	El Piojo Creek	Sycamore Reservoir	26’ Dam	Total	Unknown	U.S. Army	4.05
	6	Stony Creek	Nacimiento River	Lower Stoney Valley	Dam	Total	2002	Fort Hunter Liggett	71.30
	13	Las Tablas Creek	Nacimiento River	Las Tablas Creek	37’ Dam	Total	2002	Security Pacific National Bank	202.66
	11	El Piojo Creek	Nacimiento River	El Piojo	Dam	Total	2002	Fort Hunter Liggett	14.35
	9	Agua Fria Creek	Nacimiento River	Hughes Reservoir	Dam	Total	2002	Fort Hunter Liggett	6.85
	17	unnamed	Nacimiento River	Hwy 101 Xing	4.5’ diameter Culvert Pipe	Unknown	1905	CDOT	0
San Antonio	2	San Antonio River	Salinas River	Flashboard Dam	Dam	Unassessed	Unknown	USFS	120.26
	3	Pinal Creek	North Fork San Antonio River	Pinal Creek Falls	Natural waterfall	Total	2008	Unknown	20.48
	5	Coleman Canyon	Mission Creek	Coleman Reservoir	25’ high Earth Dam	Total	1999	U.S. Army	38.69
	4	unnamed	San Antonio River	Milpitas Reservoir	20’ high Earth Dam	Total	1999	U.S. Army	13.43
	8	Ruby Canyon	San Antonio River	Oat Hill Reservoir	30’ Earth Dam	Total	2002	Fort Hunter Liggett	2.40
	7	Sulphur Spring Canyon	San Antonio River	Engineer	20’ Dam	Total	2002	Fort Hunter Liggett	36.60

Barrier locations can be referenced on Figure 4-8 using the ID column.

4.5 Water Quality Conditions

Stream temperature directly influences aquatic organisms' physiology, metabolic rates, and life history behaviors and as well as aspects of important habitat processes for fish and aquatic species such as nutrient cycling and productivity (Allen 1995). Stream temperature is a function of multiple factors that can be expressed in terms of a *heat budget*. In general, sources of heat input include direct solar radiation and convection. Heat is lost through long-wave radiation, conduction, and evaporation. However, of all these factors, direct solar radiation is the primary contributor to increases in daily maximum stream temperature (Brown and Krygier 1970; Johnson 2004).

Water temperature also affects DO solubility, declining with increasing water temperature. Low DO can raise stress levels and ultimately result in mortality of fish and other aquatic species if exposure is prolonged. Temperature also governs many biochemical and physiological processes in cold-blooded aquatic organisms. For example, increased water temperature generally increases metabolic rates throughout the food chain, resulting in higher rates of food consumption for both salmonids and any predators of salmonids.

Water temperatures are affected by meteorological conditions, shade, the temperature of tributaries, hyporheic flow, and groundwater sources. Heavily shaded reaches or those with significant groundwater and, to a lesser extent, hyporheic inputs, are normally cooler than those without these elements. Shade may come from vegetation or topography, with midday shading being most beneficial at limiting input from solar radiation. When topographic or vegetative shading is substantial, river orientation can affect the length of time in a day when the channel is exposed to solar radiation. An east-west orientation can reduce exposure compared to a north-south orientation of a channel that is otherwise similar in size and condition. Additionally, higher discharge results in higher water velocity, decreasing the time water resides within the channel. If water is generally warming and approaching equilibrium values as it is moving downstream, higher velocities mean that equilibrium temperatures will be reached farther downstream compared to lower velocities.

Salmonids tolerate a range of temperatures (USEPA 2003), and thresholds are species and life-stage specific. As summarized in McCullough et al. (2001), water temperatures around 10°C are ideal for steelhead egg incubation and hatching and optimal water temperatures are between 11 and 12°C. Some studies found an effect on alevin size at warmer temperatures with a significant reduction in size as water temperatures approached 15°C.

Much of the literature reviewed in McCullough et al. (2001) reported juvenile steelhead preferred water temperatures as a daily average of at or below 14.0°C (Table 4-5). Hahn (1977), as cited in McCullough et al. (2001), reported steelhead fry and older juveniles seemed to do well when temperatures fluctuated between 8 and 19°C with a mean of 13.5°C. Rearing juveniles are more resilient to high water temperatures and can survive unsuitable and often extreme conditions for short periods of time. However, survival is lower when temperatures exceed 20°C because most or all energy is used for metabolic maintenance. Temperatures that have been reported in the literature as impairing smoltification range from approximately 12 to 15°C or more (McCullough et al. 2001). Steelhead appear to be most sensitive during this stage, as opposed to their greater resistance to high temperatures during other juvenile stages (e.g., parr).

Water quality data in the upper Nacimiento and San Antonio River basins is limited. However, USGS has collected instantaneous temperature samples in each basin from the 1960s through the 2010s. These data demonstrate that water temperatures consistently exceed thermal thresholds for steelhead trout throughout the year (Figure 4-10). In the Nacimiento basin, USGS has measured water temperatures opportunistically on the upper Nacimiento River below Sapaque Creek near Bryson, California. There is a pool at the gage location that receives a small amount of return flow from the channel and remains relatively cool even when disconnected from surface flow making it one of the cooler low-flow areas in that section of river (Demers pers. comm.). Since USGS began collecting water temperatures at Sapaque Creek temperatures in the winter have been historically cool, generally less than 15°C. Temperatures in the spring are much more variable ranging from less than 10°C to nearly 30°C in some years. Summer temperatures were greater than 20°C in all year's samples were collected. Fall temperatures were between 10 and 20°C**.**

Water temperatures in the San Antonio basin were generally higher than in the Nacimiento basin (Figure 4-10). Conditions in the winter ranged from 5°C to approximately 16°C. Spring temperatures were much more variable, ranging from 11°C to nearly 30°C. Summer temperature conditions were generally high, exceeding 20°C in all but 2 years. Fall temperatures were typically below 18°C.

Instantaneous temperature readings are snapshots and do not fully represent the variability in diel temperature fluctuations. However, these provide some insight into how thermal conditions in the upper basins may affect steelhead life history expression. Table 4-5 includes temperature thresholds for steelhead trout based on relevant literature. When comparing instantaneous temperature readings to the thermal criteria present in Table 4-5 water temperatures recorded on the mainstem San Antonio and Nacimiento Rivers are often much higher than the preferred ranges for steelhead. For example, adult steelhead migrate upstream during the winter months to the upper Salinas basin and tributaries such as the Nacimiento and San Antonio Rivers (Table 1-1). Given that these rivers are located roughly 100 miles upstream from the Salinas River lagoon it is likely that adults would be migrating up the Nacimiento and San Antonio Rivers later in the migration window, during February and March. Depending on water year designations (dry, normal, or wet) conditions upstream of the reservoirs may exceed adult migration and pre-spawning holding preferences. In some years, water temperatures exceeded 20°C in both basins, which could cause adults to avoid or delay migrating until temperatures become suitable. In extreme cases when water temperatures exceed 24°C mortality could occur. Similarly, steelhead smolts are more sensitive to high temperatures than rearing juveniles (parr) and have been observed delaying migration when temperatures exceed 14°C. Temperatures in the spring have frequently exceeded 14°C in both basins and could cause smolts to delay downstream migrations.

Rearing juvenile steelhead are much more resilient to high water temperatures compared to smolts, mainly because they are not undergoing physiological changes in anticipation of entry to the ocean. However, temperatures greater than 19°C are poor for rearing juvenile steelhead. Temperatures greater than 22°C have been shown to result in stress and disease; 24°C is considered lethal to juveniles. Because temperature conditions in the lower rivers near the head of the reservoirs frequently exceed 20°C in the spring and summer these areas are unlikely to support rearing juvenile steelhead through the summer months.

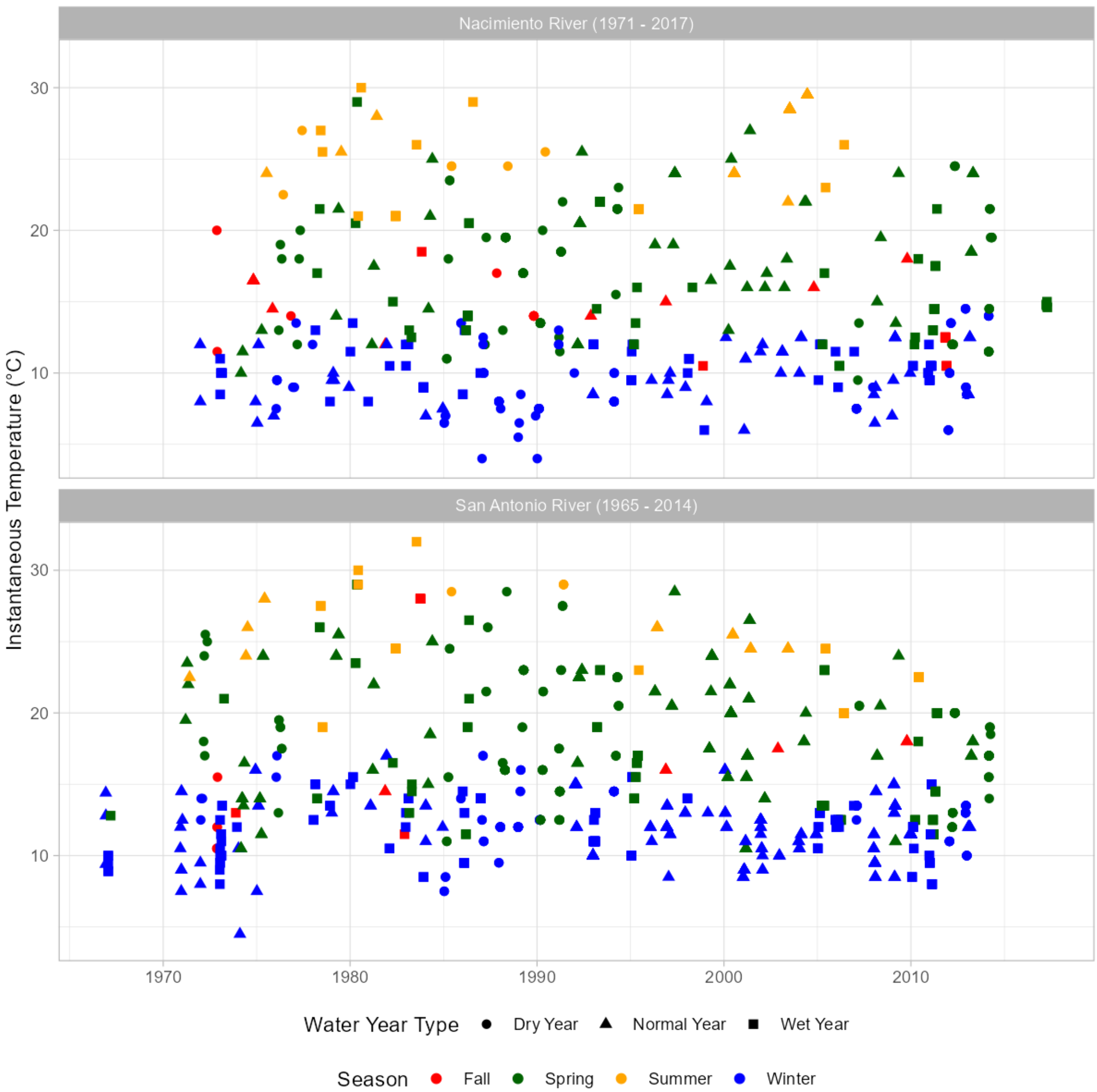
Historical and future temperature conditions were also examined from the NorWeST temperature database to further characterize conditions in the upper basins. The NorWeST database is a useful tool for evaluating water temperatures in areas without a robust temperature monitoring network. Modeled mean August water temperatures from the NorWeST database were used to characterize expected temperature conditions throughout the upper Nacimiento and San Antonio Rivers (Figure 4-11). Modeled mean historical August water temperatures (1993–2011) in coastal California are based on actual water temperature measurements, stream slope, and northing coordinates. Mean August modeled temperature conditions suggest that cool water conducive to rearing juveniles is concentrated in headwater reaches of both basins (Figure 4-11). More than 50 and 60% of the modeled historical August stream temperatures in the upper Nacimiento and San Antonio basins, respectively, are greater than 17°C, which is generally considered suboptimal for most steelhead lifestages (Table 4-5).

Furthermore, projections of temperature conditions in 2040 are expected to increase as a result of changing climate patterns. In the Nacimiento basin, mean August temperatures are projected to exceed 17°C in all streams and more than 70% of streams are projected to exceed 20°C (Table 4-7). Similarly, in the San Antonio basin, the nearly 80% of streams are expected to exceed 20°C by 2040. Less than 5% are projected to remain below 18°C. By 2040, based on NorWeST temperature modeling, conditions within the mainstem rivers and mainstem tributaries may become too hot to support rearing juvenile *O. mykiss*. Temperature projections suggest that suitable habitat may be limited to headwater reaches in both basins in the next 15 to 20 years.

Table 4-5. Temperature Thresholds for Steelhead Trout

Lifestage	Categories	Criteria	Period
Adult Migration & Pre-spawn Holding	Preference	≤13.0	December–March
	Suboptimal	>13.0 & ≤14.0	
	Avoidance	>14.0 & ≤21.0	
	Delay	>21.0 & ≤24.0	
	Lethal	>24.0	
Spawning	Preference	≤12.0	March–April
	Suboptimal	>12.0 & ≤21.0	
	Lethal	>21.0	
Egg Incubation	Preference	≤12.0	December–May
	Suboptimal	>12.0 & ≤15.0	
	Stress/Disease	>15.0	
Summer Juvenile Rearing	Preference	≤14.0 (daily average with maximum of 19.0)	Year-round
	Suboptimal	>14.0 & ≤19.0 (daily average)	
	Avoidance	>19.0 & ≤22.0	
	Stress/Disease	>22.0 & ≤24.0	
	Lethal	>24.0	
Smolt Outmigration	Preference	≤14.0	January–May
	Delay	>14.0	

Sources: Based on McCullough et al. 2001; Carter 2005; Richter and Kolmes 2005.



Sources: USGS 2023b

Figure 4-10. Instantaneous Water Temperatures in the Nacimiento and San Antonio Rivers Measured near the Upstream Extent of the Reservoirs

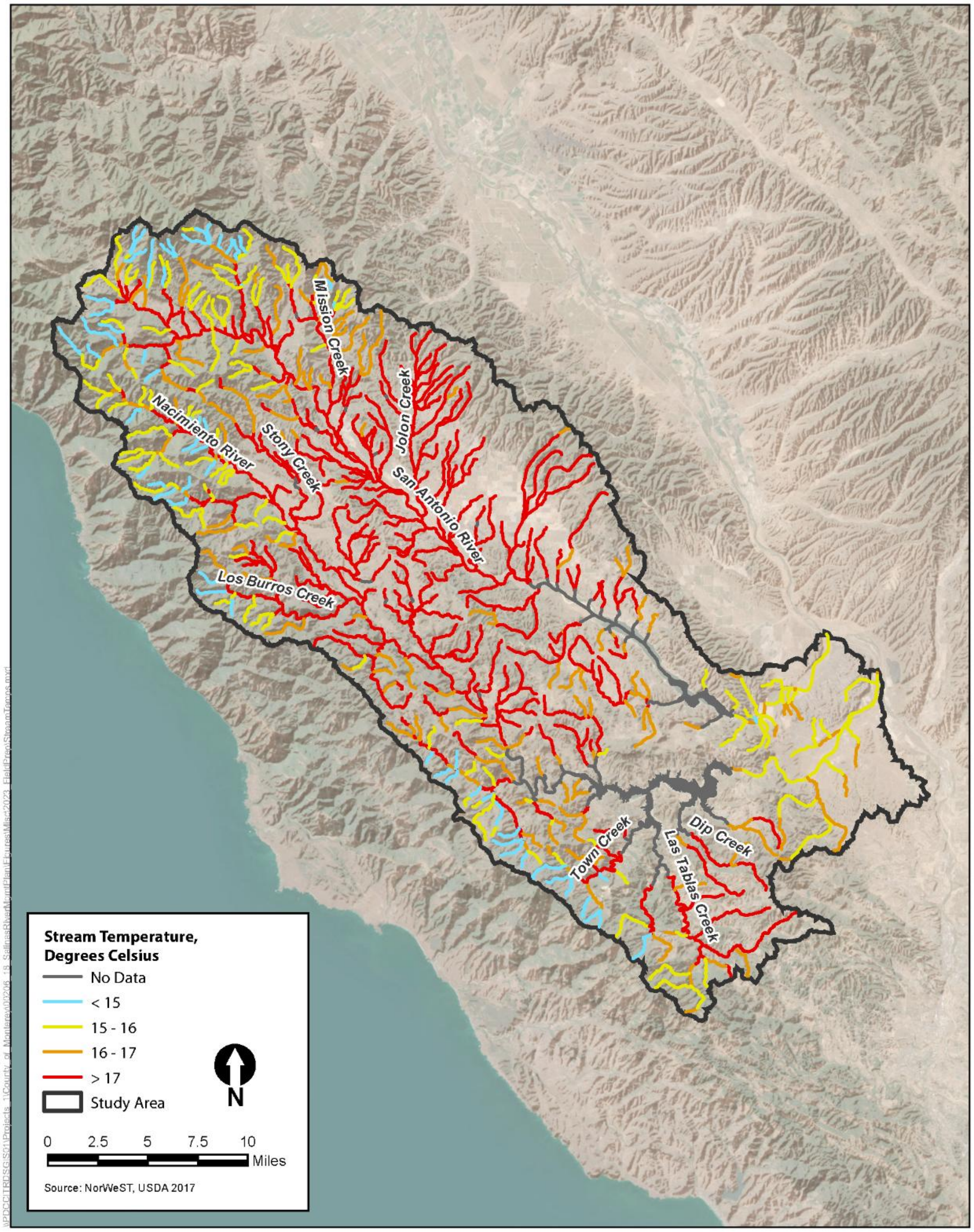


Figure 4-11. Modeled Mean August Stream Temperatures (°C), 1993–2011

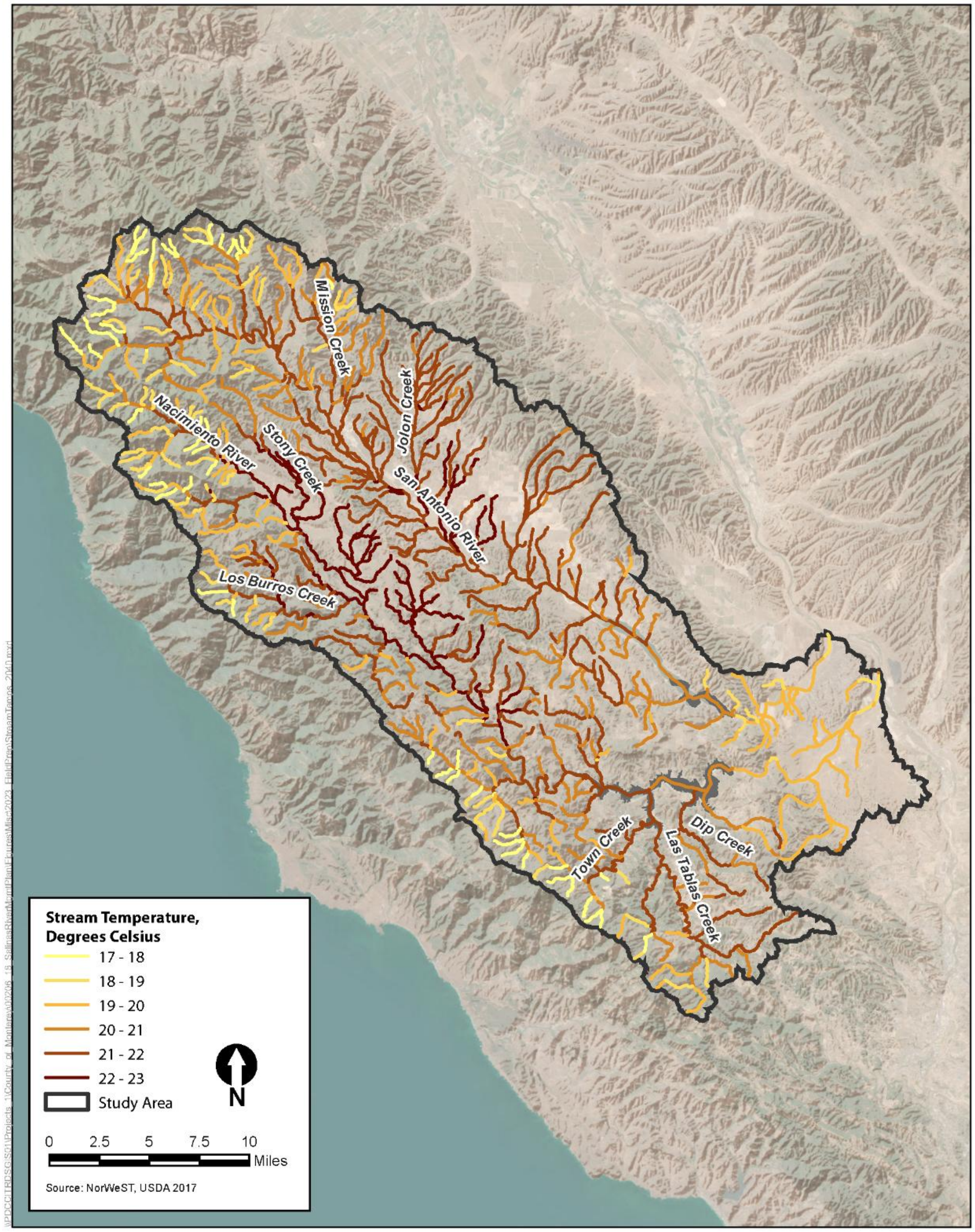


Figure 4-12. Projected Mean August Temperatures (°C) in 2040

Table 4-6. Total Stream Miles of Modeled Mean August Stream Temperatures (°C) from 1993–2011 in the Nacimiento and San Antonio River Basins

Historic August Mean Temperatures (°C)	Stream Miles	
	Nacimiento Basin	San Antonio Basin
< 15	37.4 (8%)	30.0 (6%)
15–16	69.9 (15%)	56.8 (12%)
16–17	88.9 (19%)	79.0 (16%)
> 17	235.3 (50%)	300.2 (61%)
No Data	41.4 (9%)	26.2 (5%)

Source: Isaak et al. (2013)

Table 4-7. Total Stream Miles of Projected Mean August Temperatures (°C) in 2040 in the Nacimiento and San Antonio River Basins

2040 August Mean Temperature Projections (°C)	Stream Miles	
	Nacimiento Basin	San Antonio Basin
17–18	30.4 (6%)	25.7 (5%)
18–19	41.7 (9%)	25.8 (5%)
19–20	55.5 (12%)	50.2 (10%)
20–21	99.4 (21%)	107.9 (22%)
21–22	154.5 (33%)	256.5 (52%)
22–23	91.4 (19%)	26.1 (5%)

Source: Isaak et al. (2013)

4.6 Current Habitat Conditions

Habitat conditions were also evaluated in a subset of high intrinsic potential streams deemed to be accessible via the passage impediments analysis. The purpose of this effort was to supplement the previously described desktop analysis with actual data collected on the ground in the basins. Surveys were designed to allow crews to cover as many streams as possible with the focus on assessing rearing habitat potential and passage conditions. Rearing surveys were focused along streams identified by Boughton and Goslin (2006) as high intrinsic potential streams. Surveys were also conducted along the mainstem Nacimiento River in areas where the slope analysis identified stream gradients exceeded steelhead passage criteria (8–12%).

4.6.1 Methods

4.6.1.1 Habitat Surveys

Information on habitat quality, habitat quantity, and *O. mykiss* abundance and distribution in the upper Nacimiento and San Antonio basins is extremely limited. The data that does exist is severely outdated, making it difficult to assess current conditions in the basins. To fill this data gap field surveys were completed to document habitat conditions in selected streams in both upper watersheds. This effort focused on mapping connected surface flow and documenting water temperature conditions. Sampling reaches were identified using the compiled information analyzed in the preceding sections. Specifically, intrinsic potential ratings from Boughton and Goslin (2006) were used as a starting point for randomly selecting survey locations in each basin. GIS software was used to randomly select locations within each basin along high intrinsic potential streams to complete field surveys. Once survey sites were identified, access to each location was evaluated and sites deemed inaccessible were removed from the survey sample.

At each survey location field crews mapped and measured the linear distance of surface water connectivity, recorded water depths along the channel thalweg, and periodically recorded water temperatures within each reach of connected surface water flow. This was completed 1 mile upstream of each randomly selected site location. GPS locations were recorded for each connected section of water. Any observations of fish were also recorded and to the extent possible species and sizes were recorded.

4.6.1.2 Fish Passage Surveys

Following the slope analysis described in Section 4.4.1, *Topographic Impediments*, multiple reaches in the mainstem Nacimiento River proximate to the reservoir were identified as possibly impeding adult upstream movement due to stream gradients greater than 12%. Because this represents a significant passage impediment and has implications for accessing habitat upstream it was deemed necessary to evaluate these areas to determine if channel conditions do in fact preclude passage. These areas were identified using GIS software and crews used this information to navigate to those locations in the field. Once in the field fish biologists evaluated stream gradients using clinometers and identified any naturally occurring barriers such as waterfalls. These areas were marked using GPS, gradients were recorded, and detailed photos were taken. Surface water connectivity was also recorded along with water temperature if water was present.

4.6.1.3 Species Composition

Species composition was evaluated by sampling environmental DNA (eDNA) in strategic locations throughout the upper watershed. In total 14 eDNA samples were collected using single use kits from Jonah Ventures (Boulder, Colorado), which employ a 60-milliliter (mL) syringe, a 5-micrometer filter disc contained within a plastic cartridge, and Longmire's solution for stabilization of DNA during transport to the laboratory. The volume of collected samples ranged from 90 to 240 mL (average = 142.14 mL), as sites with higher turbidity resulted in more rapid clogging of the filter disc. Following extraction of DNA in the laboratory, analysis of collected samples was performed using the MiFish primers, which target the 12S region of the mitochondrial genome and which are known to provide good taxonomic resolution for fish species.

4.6.2 Results

4.6.2.1 Habitat Surveys

Sixteen stream reaches were surveyed for *O. mykiss* rearing and spawning habitats in September 2023 (Table 4-8). The following sections describe the conditions at the time of the surveys at each surveyed reach.

Table 4-8. Rearing Habitat Survey Locations in Upper Nacimiento and San Antonio Basins

Basin	Stream	Site Name	Length Surveyed (m)
Nacimiento	Nacimiento River	#1	1,866
	Salmon Creek	#2	1,201
	Town Creek	#3	1,191
	Las Tablas Creek	#4	797
	Franklin Creek	#5	893
	San Miguel Creek	#6	1,263
	Los Burros Creek	#16	221
San Antonio	San Antonio River	#7	1,327
	Pinalito Creek	#8	963
	Forest Creek	#9	852
	San Antonio River	#10	674
	Mission Creek	#11	1,774
	NF San Antonio River	#12	776
	Pinal Creek	#13	774
	Rattlesnake Creek	#14	832
	Santa Lucia Creek	#15	1,166

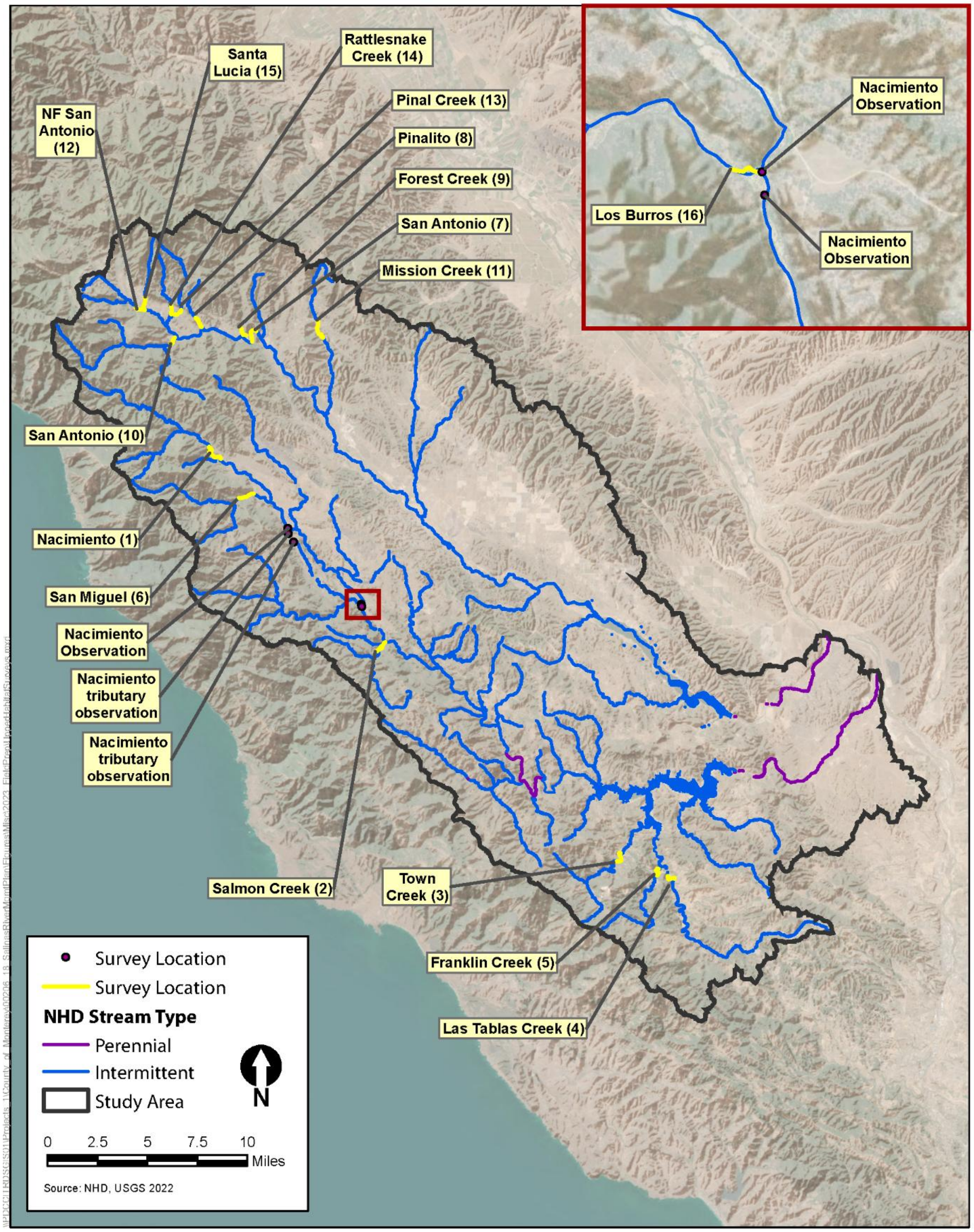


Figure 4-13. Locations of Habitat Surveys in the Upper Nacimiento and San Antonio Basins

Nacimiento Basin

Franklin Creek (#5)

Franklin Creek flows into the southernmost arm of Nacimiento Reservoir (Figure 4-13). A total of 893 meters were surveyed (Table 4-8), in which no connected flow was observed. The channel was dominated by disconnected standing pools (Figure 4-14). Bankfull channel width ranged from 34 to 57 meters and no spawning habitat was observed. Depth of the isolated pools ranged from 0.03 to 1.68 meters. Water temperatures were high ranging from 17 to 24.5°C (Figure 4-15). The presence of riparian vegetation was low, ranging from 0 to 15% with an average of 12% (Figure 4-16). Little to no instream shelter was observed.

Figure 4-14. Photos of Stream Habitat Conditions in Franklin Creek from Habitat Surveys Conducted on September 11, 2023

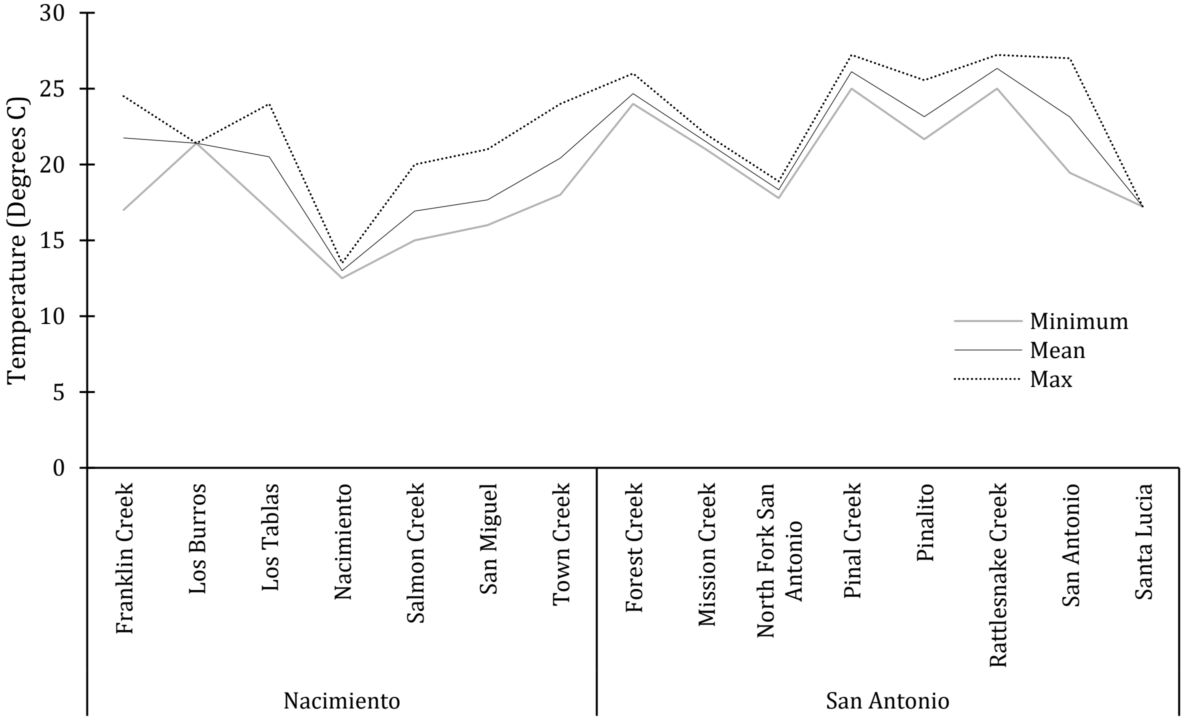


Figure 4-15. Minimum, Mean, and Maximum Water Temperatures Measured in the Upper Nacimiento and San Antonio River Basins Between September 11 and 13, 2023.

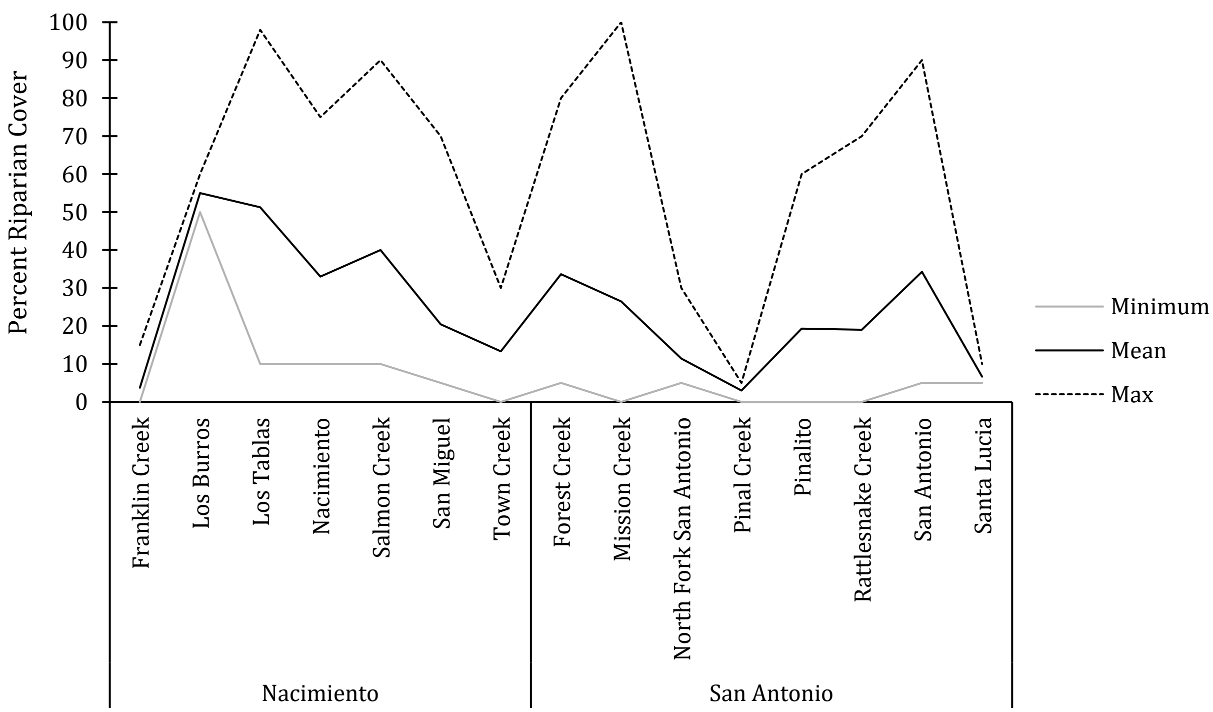


Figure 4-16. Minimum, Mean, and Maximum Percent Riparian Cover Measured in the Upper Nacimiento and San Antonio River Basins Between September 11 and 13, 2023.

Los Burros Creek (#16)

Los Burros Creek is a large tributary to the mainstem Nacimiento River located near the midpoint of the watershed upstream of the reservoir (Figure 4-13). A total of 221 meters were surveyed (Table 4-8) and the channel was dry except for small, isolated pools (Figure 4-17). Upstream of the isolated pools the channel is wide (bankfull width was roughly 87 meters) with high-quality diverse gravel possibly suitable for *O. mykiss* spawning. Observations also suggest that during high flows water depth exceeds 10 feet. Water temperatures measured in isolated pools were between 20.5 and 24°C (Figure 4-15). Riparian cover was relatively high, ranging from 50 to 60% (Figure 4-16). Instream shelter was limited.

Las Tablas Creek (#4)

Las Tablas Creek combines with Franklin Creek and flows into the southernmost arm of Nacimiento Reservoir (Figure 4-13). A total of 797 meters were surveyed (Table 4-8) and the channel was intermittently connected, but flow was generally low (Figure 4-17). Substrate and banks were highly disturbed by wild hogs at the time of the surveys. Water temperatures were generally high, ranging from 17 to 24°C (Figure 4-15). Riparian cover was heavy in some areas covering almost 100% of the channel banks but averaging about 50% (Figure 4-16). Roughly 3,700 square feet of suitable spawning habitat was recorded and was further distributed throughout the surveyed area.

Figure 4-17. Photos of Stream Conditions in Las Tablas Creek from Habitat Surveys Conducted on September 11, 2023.

Nacimiento River

Site #1

The uppermost reaches of the Nacimiento River were surveyed (Figure 4-13), roughly 1,866 meters (Table 4-8), and found to have flowing water (Figure 4-18), although depth was relatively shallow, ranging from less than 0.1 to 1.08 meters. Throughout the surveyed reach a large alluvial floodplain roughly 25 meters wide, with cobble and gravel suitable for spawning was observed. Portions of the substrate were heavily embedded. Water temperatures were generally cool, less than 13.5°C (Figure 4-15). Riparian cover averaged 33%, ranging from 15 to 75% (Figure 4-16). Numerous wood ducks were observed at the time of the survey.

Additional Observations

Additional sections of the Nacimiento River were opportunistically investigated but empirical data was not recorded (Figure 4-13). No passage barriers were observed in the sections of the Nacimiento River upstream of the reservoir (Figure 4-19). That stretch of river consists of large, isolated pools. Some of the bigger pools are up to 150 meters long and some are very deep (>4 meters) and surrounded by large rock outcroppings. Some pools were tested for water quality and water temperatures ranged from 17.2 to 24.5°C.

Figure 4-18. Photos of Stream Habitat Conditions in Nacimiento River from Habitat Surveys Conducted on September 12, 2023

Figure 4-19. Observations from the Mainstem Nacimiento River Near the Upstream Extent of the Reservoir

Salmon Creek (#2)

Field crews surveyed 1,201 meters of Salmon Creek (Table 4-8) downstream of Warmuth Bridge (Figure 4-13) on September 13, 2023, and flow was intermittent with lots of dry channel and exposed substrate (Figure 4-20). Near the bottom of the surveyed area the channel was wide and consisted of wide gravelly alluvial; bankfull width ranged from 14 to 38 meters. Upstream substrate changes to cobble/boulder composition with intermittent pools. Inundated pool depths ranged from less than 0.1 meter to nearly 1.5 meters. Small amounts of spawning habitat were observed throughout the surveyed reaches, although these areas were mostly dry. Conditions suggest hyporheic flow among pools. Water temperatures were moderate, ranging from 15 to 20°C (Figure 4-15). Riparian cover was 40% on average, ranging from 10 to 90% (Figure 4-16). Instream shelter was ranked relatively high given the quantity of large boulders.

Figure 4-20. Photos of Stream Habitat Conditions in Salmon Creek from Habitat Surveys Conducted on September 13, 2023

San Miguel Creek (#6)

San Miguel Creek is located high in the Upper Nacimiento River basin (Figure 4-13). Field crews surveyed 1,263 meters of San Miguel Creek on September 12, 2023 (Table 4-8). Flow in San Miguel Creek was disconnected and intermittent with stagnant pools (Figure 4-21). Suitable spawning substrate was observed but was too embedded to be considered high quality or useable. Water temperatures in the intermittent flow areas were generally cool, ranging between 16 and 21°C (Figure 4-15). Riparian cover was generally low, less than 25% (Figure 4-16).

Figure 4-21. Photos of Stream Habitat Conditions in San Miguel Creek from Habitat Surveys Conducted on September 12, 2023

Town Creek (#3)

Town Creek is a small tributary flowing into the south end of Nacimiento Reservoir (Figure 4-13). Field crews surveyed 1,191 meters of stream on September 11, 2023 (Table 4-8), during which flows were mostly connected but were too low, less than 0.5 meter, to be passable by anadromous fish (Figure 4-22). No viable steelhead spawning habitat was observed. Riparian cover was generally low, less than 30% (Figure 4-16) and water temperatures were high, 18 to 24°C (Figure 4-15).

Figure 4-22. Photos of Stream Habitat Conditions in Town Creek from Habitat Surveys Conducted on September 11, 2023

San Antonio Basin

Forest Creek (#9)

Forest Creek is a small tributary to the San Antonio River located on the north side of the river well upstream of the reservoir (Figure 4-13). Field crews surveyed 852 meters of stream on September 11, 2023 (Table 4-8), during which flows were connected (Figure 4-23). The channel is relatively narrow with a maximum bankfull width of roughly 31 meters. Water temperatures were high, between 24 and 26°C (Figure 4-15). Riparian cover was variable, ranging from 5 to 80% along the surveyed areas (Figure 4-16).

Figure 4-23. Photos of Stream Habitat Conditions in Forest Creek from Habitat Surveys Conducted on September 11, 2023

Mission Creek (#11)

Mission Creek is a notable tributary to the upper San Antonio River from the north (Figure 4-13). Field crews surveyed 1,774 meters on September 11, 2023 (Table 4-8), during which the channel was nearly completely dry (Figure 4-24). No spawning habitat was observed as most of the channel was dominated by sand and fines. One wetted pool was observed about 1 meter deep and about 22°C (Figure 4-15). Riparian vegetation was dense in some areas, covering 100% of the channel along the creek banks (Figure 4-16).

Figure 4-24. Photos of Stream Habitat Conditions in Mission Creek from Habitat Surveys Conducted on September 12, 2023

North Fork San Antonio (#12)

The North Fork San Antonio River was the uppermost reach surveyed in the San Antonio basin (Figure 4-13). Approximately 776 meters of stream was surveyed along the North Fork on September 12, 2023 (Table 4-8). The channel was fully connected with frequent deep areas, up to 0.85 meters. Water temperatures were generally cool, less than 19°C (Figure 4-15). However, riparian cover along the surveyed channel was generally low, less than 30% (Figure 4-16). The substrate was a combination of cobble, boulder, bedrock, and gravel. No spawning habitat was observed.

Figure 4-25. North Fork San Antonio River, September 12, 2023.

Pinal Creek (#13)

Pinal Creek is located high in the upper San Antonio basin. Approximately 774 meters of stream were surveyed on September 12, 2023 (Table 4-8). Flow was connected but low with less than 0.5 meter of water (Figure 4-26). Water temperature was high, exceeding 25°C at all measured locations (Figure 4-15). Riparian cover was low, less than 5% in the surveyed areas (Figure 4-16). No spawning habitat was identified during surveys.

Figure 4-26. Photos of Stream Habitat Conditions in Pinal Creek from Habitat Surveys Conducted on September 12, 2023

Pinalito Creek (#8)

Pinalito Creek is located in the uppermost reaches of the upper San Antonio River basin and is the adjacent drainage to Pinal Creek to the west (Figure 4-13). Roughly 963 meters were surveyed on September 11, 2023 (Table 4-8), and nearly the entire area was devoid of water (Figure 4-27). The channel is generally very narrow with a mean bankfull width of 8 meters. Water temperature in the few areas where water coalesced were high, above 21°C (Figure 4-15). Riparian cover was variable, reaching 60% in some locations and absent in others (Figure 4-16). No spawning habitat was observed during surveys.

Figure 4-27. Photos of Stream Habitat Conditions in Pinalito Creek from Habitat Surveys Conducted on September 11, 2023

Rattlesnake Creek (#14)

Rattlesnake Creek joins Pinal Creek before joining with the San Antonio River in the uppermost portion of the basin (Figure 4-13). Roughly 832 meters were surveyed on September 12, 2023 (Table 4-8); nearly the entire reach was flowing and connected. The channel was relatively narrow, and the water depth was shallow, less than 0.5 meter. Water temperatures were high, greater than 26°C (Figure 4-15). Riparian vegetation was sparse, covering on average 20% of the stream banks (Figure 4-16).

Figure 4-28. Photos of Stream Habitat Conditions in Rattlesnake Creek from Habitat Surveys Conducted on September 12, 2023

Santa Lucia Creek (#15)

Santa Lucia Creek is a tributary to the North Fork San Antonio (Figure 4-13). Roughly 1,166 meters of Santa Lucia Creek were surveyed on September 12, 2023 (Table 4-8). The channel had flowing water at the time of the survey but is relatively steep, with a prominent cascade feature located at the bottom end of the surveyed reach that may present passage issues for resident and migratory *O. mykiss* (Figure 4-29). Water temperatures were quite cool relative to other areas, around 17°C (Figure 4-15). Riparian cover was low, less than 10% (Figure 4-16). Some suitable spawning areas were noted in the surveyed reach.

Figure 4-29. Photos of Stream Habitat Conditions in Santa Lucia Creek from Habitat Surveys Conducted on September 12, 2023

San Antonio River (#10)

Roughly 2,001 meters of the mainstem San Antonio River was surveyed on September 11 and 12, 2023 (Table 4-8), just upstream of the confluence of the North Fork San Antonio River (Figure 4-13). Flows in this section of the river were fully connected at the time of the surveys with water depths ranging from 0.1 to 0.9 meter. The channel was relatively wide with a maximum observed bankfull width of 46 meters. Water temperatures were high, above 19°C

(Figure 4-15). Riparian conditions were highly variable, ranging from 5 to 90% coverage (Figure 4-16). The instream shelter was high, consisting mostly of large boulders.

Figure 4-30. Photos of Stream Habitat Conditions in the San Antonio River from Habitat Surveys Conducted on September 12, 2023

4.6.2.2 Fish Passage

Several potential fish passage barriers were observed during habitat surveys, including a natural cascade in Santa Lucia Creek and an old flashboard dam on the San Antonio River. Field verification of the areas identified in Figure 4-9 as potential gradient barriers were determined not to present passage issues based on channel gradient.

4.6.2.3 Species Composition

In total, 56 sequences were detected across the 14 samples, and 50 of these were assigned to class *Actinopterygii* (i.e., fish). Of the other six sequences, a single sequence was assigned to a bird species (common starling [*Sturnus vulgaris*]) and the remaining five could not be assigned based on available reference libraries.

Among the detected sequences belonging to fish species, 21 were assigned to the family level. All of these family-level assignments fell within the families *Catostomidae* and *Leuciscidae*, which are represented by only a few species in the study area, and therefore can be inferred to have derived from Sacramento sucker (*Catostomus occidentalis*), speckled dace (*Rhinichthys* *osculus*), and hitch (*Lavinia exilicauda*), all species that were physically observed by the field crew during sampling. Another 10 sequences were assigned to the genus level, and represented the genera *Catostomidae*, *Oncorhynchus*, and *Rhinichthys*. A single sequence was assigned to the genus *Gila* in the family *Leuciscidae*, but the lower percent match (98.9% rather than 100%) suggests this may be a misassignment of DNA belonging to either hitch or speckled dace, which are members of the same family. Once again, the detection of sequences in the *Catostomidae* and *Rhinichthys* genera can be inferred to have derived from Sacramento sucker and speckled dace, whereas the sequence assigned to genus *Oncorhynchus* likely represents the DNA signal of a rainbow trout (*Oncorhynchus mykiss*). Finally, a total of 18 sequences were assigned to the species level, 16 of which were speckled dace and 2 of which were hitch.

A summary of eDNA detection data is presented below (Table 4-9). The single detection of DNA derived from rainbow trout suggests that assessed habitat in the mainstem San Antonio River harbored this species during the surveys. The lack of rainbow trout detections at other locations should not be taken as definitive evidence that the species was not present. This is particularly true given high water temperatures in sites in both the Nacimiento (12.5–24.5°C; average = 18.7°C) and the San Antonio (17.2–27.2°C; average = 22.8°C), which, along with high ultraviolet exposure, may contribute to rapid degradation of any DNA shed into the environment, reducing the temporal extent of the eDNA signal. Further, the presence of very large numbers of Sacramento suckers and Cyprinids observed in many of the field sites would suggest that their DNA signal would be very strong, which may have led to their DNA outcompeting that of rarer species during sequencing.

Direct observations of fish include the species identified in the eDNA detections.

- Nacimiento Basin
  - *Franklin Creek*: American shad
  - *Los Burros Creek*: Juvenile black bass
  - *Las Tablas*: Black bass, bluegill, sucker spp., and snails
  - *Nacimiento River*: Juvenile suckers, pikeminnows, and adult and juvenile black bass
  - *Salmon Creek*: Sacramento sucker, juvenile smallmouth bass, and juvenile sucker spp.
  - *San Miguel Creek*: young of the year suckers
  - *Town Creek*: speckled dace, black bass, sucker spp., and shiner spp.
- San Antonio
  - *San Antonio River*: adult sucker spp. and juvenile pikeminnow
  - *Pinalito Creek*: sucker spp.
  - *North Fork San Antonio*: sucker spp., pikeminnow, speckled dace
  - *Pinal Creek*: pikeminnow
  - *Rattlesnake Creek*: juvenile sucker spp. and roach
  - *Forest Creek*: sucker spp. and pikeminnow

Table 4-9. Summary of eDNA Detections by Site

Basin	Stream	Site	Date	Volume (mL)	Detections
Nacimiento	Nacimiento (mainstem)	1	Sep. 12	240	Sacramento Sucker Speckled Dace
	Town Creek	3	Sep. 11	240	No sequences detected
	Las Tablas Creek	4	Sep. 11	90	Sacramento Sucker
	Franklin Creek	5	Sep. 11	180	No sequences detected
	San Miguel Creek	6	Sep. 12	120	No sequences detected
	Nacimiento (mainstem)	16	Sep. 11	180	No sequences detected
San Antonio	San Antonio (mainstem)	7	Sep. 11	120	No sequences detected
	Forest Creek	9	Sep. 11	120	No sequences detected
	San Antonio (mainstem)	10	Sep. 12	120	Hitch Sacramento Sucker Speckled Dace Rainbow Trout
	Mission Creek	11	Sep. 11	100	Sacramento Sucker
	North Fork San Antonio	12	Sep. 12	120	Hitch Sacramento Sucker Speckled Dace
	Pinal Creek	13	Sep. 12	120	Hitch or Speckled Dace Sacramento Sucker
	Rattlesnake Creek	14	Sep. 12	120	Sacramento Sucker Speckled Dace
	Santa Lucia Creek	15	Sep. 12	120	No sequences detected

Species listed in the Detections column are based on the highest level of taxonomic resolution available, and in some cases inferred from family- or genus-level assignments of detected sequences. This results in the listing of hitch “or” speckled dace in cases where assignments were not resolved below the family *Leuciscidae* level. Note that site numbers correspond to those depicted on the map in Figure 4-31.

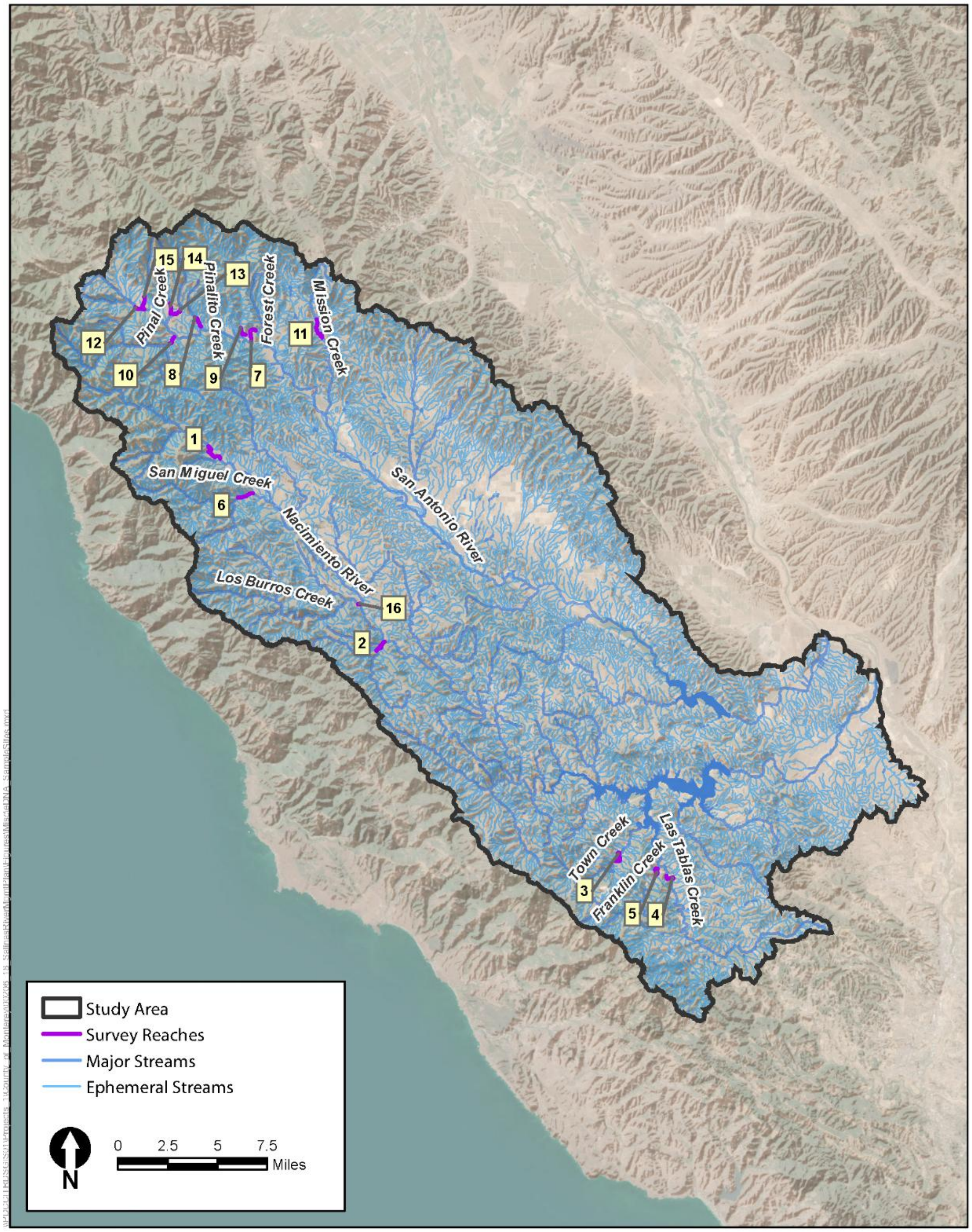


Figure 4-31. Map of eDNA Sampling Locations in the Nacimiento and San Antonio Watersheds

4.6.3 Discussion

Habitat surveys in the upper watershed revealed that summer habitat conditions are generally poor with warm water temperatures, intermittent flow or dry channels, isolated pools, and limited suitable substrates. Observations of spawning habitats were most concentrated in Las

Tablas Creek and limited or absent in the other reaches surveyed. Findings from the surveys suggest that habitats necessary for rearing juveniles in the summer are limited to the uppermost reaches of the San Antonio and Nacimiento River basins and that opportunities for spawning are limited.

4.7 Upper Basin *O. Mykiss* Production Potential

Based on the preceding analysis and field investigation, production potential for anadromous steelhead in the upper Nacimiento and San Antonio basins overall is low and limited to a few areas in the upper reaches of each basin. The system appears to be limited by high water temperatures, lack of spawning areas, low flows, and a significant population of black bass, a known predator of *O. mykiss*. Additionally, the distance that migratory steelhead lifestages need to travel to reach these areas is substantial and due to the frequency of occurrence of low flows it may be difficult or impossible for migrants to traverse the migratory corridor during low water years. The findings from this analysis suggest that reconnection of the upper and lower basins in both the Nacimiento and San Antonio River basins via fish passage facilities would not result in substantial increases in Salinas River steelhead production.

Chapter 5
Conclusion and Recommendations

5.1 Nacimiento Dam

As a result of this evaluation a trap-and-haul operation (US Alternative 2 and 3) was identified to be the most feasible option for moving adult steelhead above Nacimiento Dam to the upper Nacimiento River basin. Volitional passage at the dam is not feasible given the height of the dam and the large fluctuations in reservoir elevation. Alternatives 2 and 3 would use a short fish ladder, adult collection and holding facility, truck transfer facility, and fish transport trucks to safely transport adults upstream to various release locations. Given water quality conditions and the length of Nacimiento Reservoir, release of adults near the head of the reservoir would likely result in lower pre-spawn mortality than releasing fish into the reservoir forebay. Further investigation is needed to determine whether a facility at Nacimiento Dam or in the lower Salinas River would be more effective. Each option has its advantages and disadvantages, which are discussed in more detail in Section 4.3, *Evaluation of Hydrologic Conditions*.

The most feasible juvenile downstream passage option at Nacimiento Dam is less clear. However, based on this preliminary evaluation DS Alternatives 2 and 4 are likely to be the most effective. DS Alternative 2 is likely to be cost prohibitive given the costs of similar projects (>$100 million for construction). DS Alternative 4 is likely to be more affordable and can be preliminarily evaluated using a temporary trapping system such as a screw trap. However, this alternative would also require significant permitting and land acquisition costs. DS Alternative 3 (FWC) is also viable; however, additional investigation is needed to ensure this type of system will operate efficiently. For example, the FWC on Los Padres Dam passed roughly 35% of juveniles while 65% passed via the spillway (Ohms and Boughton 2021). Additional investigations would be needed to estimate passage efficiency of an FWC system without the option of spillway passage. DS Alternative 4 is a compelling option as it does not require modifications to the dam itself and it eliminates travel through the 18-mile-long reservoir where water quality conditions and predatory fish may substantially reduce survival rates.

5.2 San Antonio Dam

A trap-and-haul system is likely to be the most effective for passing adult steelhead above San Antonio Dam and Reservoir to the upper San Antonio River to spawn. Adults should be released upstream of the reservoir closer to spawning habitat to reduce the likelihood of pre-spawn mortality. The facility would be designed similar to the system described for Nacimiento Dam. Further investigation is needed to determine whether a facility at San Antonio Dam or in the lower Salinas River would be more effective. Each option has its advantages and disadvantages, which are discussed in more detail in Section 4.3. Operational changes would likely be required to provide sufficient attraction flows and operational flows for a trap-and-haul system at San Antonio Dam. Currently, minimum releases at the dam are maintained at 10 cfs. This may not provide sufficient depth or attraction flows for adult steelhead to reach and enter the adult collection facility. Until the HCP hydraulic modeling is completed to define the SVWP reoperations it is unclear if operations can provide the flows necessary to support this type of facility.

Juvenile passage at San Antonio Dam is feasible. DS Alternatives 2 and 4 are most likely to be successful given the significant fluctuations in reservoir elevation. Alternative 4 may be more effective because it eliminates the need for smolts and kelts to navigate the length of San Antonio Reservoir. Additionally, DS Alternative 2 may be cost prohibitive; similar projects in the northwest have exceeded $100 million in design and construction costs. DS Alternative 4 is likely to be more affordable and can be preliminarily evaluated using a temporary trapping system such as a screw trap. However, this alternative would also likely require significant permitting and land acquisition costs.

5.3 Additional Considerations

Additional studies and investigations would be required to fully evaluate feasibility, design specifics, and costs associated with reconnecting resident and anadromous *O. mykiss* populations within the Salinas Basin. For example, further consideration should be given to US Alternative 3. This option could result in significant cost savings and provide additional flexibility for managing steelhead populations in the entire Salinas basin. Specifically, during dry water years when releases from Nacimiento and San Antonio Dams fail to create continuous connected flow through the Salinas River during the adult migration period, an adult collection facility in the lower river would allow managers to collect fish and move them past the dry portions of river into the upper Nacimiento and San Antonio Rivers. Moreover, fish could be transported to the other distinct steelhead habitat areas identified by NMFS. Adults could be strategically released into streams with flowing water, increasing the likelihood of successful spawning. If trap-and-haul programs are established at each dam it is possible that during dry years very few or no adults will reach the collection facilities due to the Salinas River being dry. Given the frequency of drought conditions during the last 10 years (Figure 2-1) it very likely that drought conditions in the future will impede adult steelhead migration to the upper basin.

Additionally, a lagoon breaching strategy would need to be developed that promotes migration of adult steelhead through the lagoon during years when natural flows and reservoir releases are not enough to breach the sandbar. If the lagoon is closed off to the ocean it is likely that very few to no adults would reach the trap-and-haul facilities. As part of the development of SVWP reoperations it will be important to develop a lagoon management strategy that promotes adult steelhead access to the Salinas River.

Further assessments are required to fully determine the effects of habitat on passage success. For example, additional targeted monitoring of reservoir conditions should be conducted to inform adult release and juvenile collection strategies. Data available to evaluate reservoir conditions during both juvenile and adult migration periods is limited for both reservoirs. The data that is available suggests that temperatures and DO levels may reduce survival through the reservoir for both adult and juvenile steelhead. Similarly, the prevalence of parasites, predators, and disease is not well documented and could significantly reduce reservoir survival, particularly for smolts. Another factor that should be considered is the assemblage of fish in the reservoir. In some cases, reservoirs contain warmwater species that do not reside in the rivers below and adding passage at the dam may allow nonnative species to colonize the lower river.

Habitat conditions were evaluated within the upper Nacimiento and San Antonio River basins to determine the likelihood of successfully reintroducing anadromous steelhead to these areas via fish passage facilities at both dams. While the upper basins are assumed to support populations of resident rainbow trout habitat is limited by warm waters, low flows, and lack of spawning habitats. Based on habitat surveys production potential is likely low, although a formal study was not completed to quantify steelhead production potential or carrying capacity. Because habitat conditions in the upper basin appear to be poor, adding passage to the dams may not be the most viable option to improve population viability and move the SCCC DPS closer to recovery. While habitat in the upper basin is poor additional investigations should be completed to evaluate the extent of anadromy and whether resident populations are contributing to anadromous populations. This could be accomplished through genetic and smolt monitoring studies such as monitoring for smolting juveniles in the upper basin using screw traps located upstream of the reservoir. Collection of scale samples from smolting individuals could shed light into the genetic make-up of the upper basin *O. mykiss* populations.

An additional concern is creating passage systems at either facility that allow for an ecological trap to develop. An ecological trap occurs when organisms choose habitats based on cues that may have indicated habitat quality or suitability prior to anthropogenic alterations (Ohms et al. 2022). A recent study completed on the Carmel River evaluated if a fish passage system created an ecological trap by luring adults (steelhead) to spawn above the dam but "failing to successfully pass migrating juveniles and adults [kelts] downstream" (Ohms et al. 2022). The authors found that despite facilitating adult upstream passage at Los Padres Dam downstream passage was hindered for both migrating juveniles and kelts. Furthermore, the study found that juveniles passed the reservoir and dam at very low rates, around 20%; passage of kelts was even lower. This study highlights the importance of designing passage systems that function at high levels to ensure the adults passed upstream trigger the intended response in population abundance, viability, and recovery. In the case of the Salinas basin juvenile downstream passage through the Nacimiento and San Antonio Reservoirs and around the dams should be prioritized to connect resident produced anadromous *O. mykiss* to the estuary and marine environments.

Finally, a more in-depth and formal cost and economic analysis could be completed for each of the evaluated alternatives. This analysis should include permitting, design, construction, and operation and maintenance costs.

Chapter 6
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