UNITED WATER CONSERVATION DISTRICT

"Conserving Water Since 1927"

Fish Passage Monitoring and Studies
Freeman Diversion Facility
Santa Clara River, Ventura County, California

Annual Report
2012 Monitoring Season

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Annual Report
2012 Monitoring Season

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2012

Cover Photos (by Steve Howard): clockwise from top*:* Freeman Diversion Structure, 2012 Steelhead adult, 2012 steelhead adult passing false weir in Freeman fish ladder

Page

LIST OF TABLES

Page

Page

LIST OF PHOTOGRAPHS

Page

The water year of 2012 was considered a moderately dry year. Rainfall in wet years can exceed 40 inches in the lower coastal plain and even more in the mountain areas. Rainfall in dry years can range from close to zero to a few inches. A total of 9.95 inches of rain was measured at the Santa Paula Wilson Ranch gauge (Station 245B) located in Santa Paula during the 2012 season. The highest monthly rain total was 2.83 inches in March.

The sandbar at the Santa Clara River Estuary (SCRE) was open to the ocean from March 20 to April 20. The estuary was closed the remainder of the steelhead migration season (January through June). Smolt trapping at the Freeman Diversion started on January 18 and ended on June 29, 2012. Steelhead smolts were first observed in the fish trap on March 13 and last observed on June 16, 2011. A total of 31 smolts, 59 young-of-the-year, 5 resident rainbow trout, and 1 adult kelt steelhead (see section 2.3.3 for description) were captured in the fish trap. A total of two adult steelhead passed through the fish ladder during the migration season. The two adult steelhead passed through the ladder from April 15 to 16. The fish ladder was in operation from March 26-28 and from April 14-24, 2012.

No Pacific lamprey were observed during the 2012 migration season. However, adult lamprey could traverse the fish ladder without being detected except when the ladder is drained. Table 1, Appendix A summarizes the daily fish ladder operations as well as the *O. mykiss* and physical data collected during monitoring activities in 2012.

Water temperature monitoring in 2012 occurred in the mainstem Santa Clara River, Santa Paula Creek, and Sespe Creek. Temperature loggers deployed in the estuary cannot be accessed until the estuary breaches in the 2013 water year and no temperature data was collected for Piru Creek due to land access issues.

1.1 FREEMAN DIVERSION FACILITY

The Freeman Diversion Facility was constructed in 1991 and is located approximately 10.7 miles upstream from the Pacific Ocean. The main purpose of the facility is to divert surface water from the Santa Clara River to conserve groundwater resources in the Oxnard plain through percolation to the groundwater aquifer. The facility is comprised of a concrete structure, a Denil fishway (fish ladder), a fish screen bay, a downstream migrant trap, and various canals and spreading grounds (Figure 1, Appendix A). The concrete structure is a complete barrier to steelhead and potential barrier to Pacific lamprey upstream migration. The structure is only a potential barrier to lamprey because this species can traverse vertical obstructions if water is flowing over the surface and there are no sharp angles. The fish ladder was constructed to facilitate anadromous migration over the Freeman Diversion Structure. The fish screen bay is located directly downstream of where flow enters the facility and its function is to keep fish out of the canals and spreading grounds and to direct fish to the downstream migrant trap. A fish bypass pipe is located at the end of the fish screen bay that can be used to direct fish back to the river when there is sufficient flow to allow for volitional migration to the estuary.

1.2 FISH SPECIES COMPOSITION

The Santa Clara River is home to two native, anadromous fish species, the southern steelhead trout (*Oncorhynchus mykiss irideus*) and the Pacific lamprey (*Entosphenus tridentatus*). Steelhead and resident rainbow trout are known collectively as coastal rainbow trout. Steelhead is the common name for anadromous coastal rainbow trout. The term “anadromy” describes a life cycle or life history trait where species live as adults in the ocean and return to freshwater to spawn. Resident coastal rainbow trout live their entire lives in freshwater. Both resident as well as anadromous coastal rainbow trout exist in the Santa Clara River. Evidence from data collected at the Freeman Diversion suggests that resident rainbow trout can produce progeny that will migrate to the ocean. A steelhead that migrates from freshwater where it was born to the ocean between the ages of 1 to 3 years is referred to as a smolt. The term smolt reflects the physical and physiological changes coastal rainbow trout experience when preparing for life in saltwater. A kelt is an adult steelhead that enters freshwater to spawn and later the same year (or the following year) returns to the ocean. Southern steelhead are federally listed as endangered.

Pacific lamprey are strictly anadromous and cannot persist in freshwater alone. Juvenile lamprey, which live in freshwater for up to seven years before migrating to the ocean, are referred to as ammocoetes. A downstream migrant Pacific lamprey is referred to as a macropthalmia. The term macropthalmia, similar to smolt, reflects the physical and physiological changes juvenile Pacific lamprey experience when preparing for life in saltwater. Pacific lamprey currently have no federal protection, but lamprey numbers have dropped precipitously since the early 2000's in the Santa Clara River and in many drainages on the west coast of the United States (Swift and Howard 2009).

There are two additional native fish species in the Santa Clara River, the federally-endangered tidewater goby (*Eucyclogobius newberryi*), which lives in the estuary and the threespine stickleback (*Gasterosteus aculeatus*). The threespine stickleback is comprised of two sub-species in the Santa Clara River, the partially-armored (*Gasterosteus aculeatus microcephalus*) and unarmored threespine stickleback (*Gasterosteus aculeatus williamsoni*). The partially-armored stickleback, which is plentiful, exists in the Ventura county reach and the unarmored threespine stickleback exists in the Los Angeles county reach of the Santa Clara River. The unarmored threespine stickleback sub-species is a federal and California endangered species and a California fully-protected species. Currently, the unarmored sub-species is not known to occur in Ventura County. Additional fish species known to occur in the Santa Clara River include: Arroyo chub (*Gila orcutti*), Santa Ana sucker (*Catostomus santaanae*), Owens sucker (*Catostomus fumeiventris*), Santa Ana-Owens sucker hybrids (*C. santaanae x fumeiventris*), largemouth bass (*Micropterus salmoides*), green sunfish (*Lepomis cyanellus*), bluegill (*Lepomis macrochirus*), brown bullhead (*Ameiurus nebulosus*), black bullhead (*Ameiurus melas*), prickly sculpin (*Cottus asper*), fathead minnow (*Pimephales promelas*), Mississippi (inland) silverside (*Menidia audens*), threadfin shad (*Dorosoma petenense*), common carp

(*Cyprinus carpio*), goldfish (*Carassius auratus*) crappie (*Pomoxis spp*.) and mosquitofish (*Gambusia affinis*). See Table 2, Appendix A.

1.3 Environmental Setting

The Santa Clara River is the largest watershed in southern California south of Point Conception and drains an area of approximately 1600 square miles. Its headwaters originate on the north slope of the San Gabriel Mountains near Acton, California in Los Angeles County and the river flows approximately 116 miles from east to west to its estuary in the City of Ventura. The Santa Clara River and its tributaries have high annual flow variability, from extreme flood events to multi-year droughts.

1.3.1 Rainfall

During the 2012 rain season (10/1/2011-9/30/2012), Santa Paula had 57.3% of normal rainfall totaling 9.95 inches (Ventura Watershed Protection District website, Santa Paula-Wilson Ranch 245B). The most rainfall in a 24 hour period was 1.33 inches on March 26, 2012 and the second highest was 0.96 inches on October 6, 2011. The highest monthly rainfall was 2.83 inches in March. (Figure 2, Appendix A). Southern California can have cold or warm winters depending on ocean currents and other factors. Cold winters, like the one this year tend to produce moderate storms and snow on local mountains. Warm winters, such as 2005, produce storms that produce large amounts of rain in a short period of time, typically resulting in flood conditions. Cold winters can be beneficial to *O. mykiss* because of sustained flows from snow melt and sustained cold water into the summer months. Warm winters can have negative effects on *O.mykiss* due to redd scouring but can also be beneficial when high flows remove excess vegetation (both exotic and native), scour and transport fine sediments, deposit clean gravels, and provide extended migration opportunities.

Tributaries

The major tributaries of the Santa Clara River include Santa Paula Creek, Sespe Creek, and Piru Creek. Santa Paula Creek has two fish passage facilities located within the first four miles of the lower creek (USACE and Canyon Irrigation fish ladders). These facilities have numerous physical and operational problems that result in restricted upstream passage either intermittently or completely depending on maintenance or damage in any given year. Sespe Creek is free-flowing, but illegal road crossings within the lower river potentially block both upstream and downstream passage at certain flows. Piru Creek has two major dams (Santa Felicia Dam and Pyramid Dam) that do not include fish passage facilities and are complete barriers to upstream fish passage and intermittent barriers to downstream passage (fish can move downstream during spills over dams).

Santa Paula and Sespe Creeks are considered to be the primary steelhead-bearing drainages in the Santa Clara River watershed and are the closest major tributaries to the ocean. These tributaries were flowing during the entire 2012 migration season. It is unknown when steelhead smolts emigrate from the tributaries to the mainstem Santa Clara River. Currently, it is assumed that smolts emigrate from the tributaries following storm pulses based on data collected in the Santa Ynez River (Tim Robinson, Cachuma Operations and Maintenance Board, pers. comm.). Steelhead smolts are observed at the Freeman Diversion from January to June but the majority of these fish are observed in March, April, and May. In 2012, smolts were observed at the Freeman Diversion through June.

1.4 REGULATORY STATUS (STEELHEAD)

NOAA Fisheries, otherwise known as the National Marine Fisheries Service (NMFS), listed the southern California steelhead, *Oncorhynchus mykiss irideus*, as endangered in 1997 (NMFS 1997) under the Endangered Species Act (ESA) of 1973. Steelhead were organized into stocks (i.e., groups) of evolutionary significant units (ESU) that represented groupings considered to be substantially reproductively isolated from other steelhead stocks and an important part of the evolutionary legacy of the species. Currently, the southern California steelhead ESU includes populations from the Santa Maria River in San Luis Obispo County south to the US/Mexican border in San Diego County (NMFS 2003). NOAA Fisheries later recognized the anadromous life history form of *O. mykiss* as a distinct population segment (DPS) under the ESA (NMFS 2006). The DPS policy differs from the ESU by delineating a group of organisms by “marked separation” rather than “substantial reproductive isolation”. In the case of *O. mykiss* of the southern California steelhead ESU, this marked separation between the two life history forms was considered valid because of physical, physiological, ecological, and behavioral factors related to its anadromous life history characteristics. Both resident and anadromous *O. mykiss*, where the two forms co-occur and are not reproductively isolated and exist below complete barriers, are still part of the ESU; however, the anadromous *O. mykiss* (steelhead) are now part of a smaller subset identified as the southern California steelhead DPS (CMWD 2008).

The remainder of this report summarizes the monitoring study methods and results at the United Water Conservation District (hereafter, District) Freeman Diversion Fish Passage Facility on the Santa Clara River in 2012.

2.1 INTRODUCTION

In southern California, steelhead and Pacific lamprey migrate downstream from their natal streams to the Pacific Ocean in the spring. Data collected from 1991 to 2012 at the Freeman Diversion indicate that the majority of downstream migration occurs in March, April, and May, although migration can occur from January through June and during 2009 migration was observed into July. Migration typically occurs when flows in the Santa Clara River are rapidly receding. When this occurs, it is necessary to trap all downstream migrant steelhead and Pacific lamprey and relocate them to the estuary or other appropriate habitats (based on individual life stages) to prevent fish stranding in dewatered sections of the river below the Freeman Diversion.

The primary objective for trapping and transporting downstream migrants is to avoid impacts to steelhead smolts, kelts, and lamprey macropthalmia during their downstream migration to the Pacific Ocean when there is not sufficient flow in the lower river. This reduction in flow could be natural and/or the result of diversions at the Freeman Diversion and by other water users in the watershed. Another important objective is to gather data regarding anadromous downstream migration in the Santa Clara River. Since there is a lack of knowledge regarding steelhead in southern California, these data can be useful during the steelhead recovery planning process and for managers of anadromous fishes in the Santa Clara River as well as the region as a whole. Additionally, trapping activities aid in monitoring fish movement and assemblages within the Santa Clara River and can potentially prevent stranding and predation when conditions are not favorable in the lower river due to natural conditions as well as diversions occurring at the Freeman Diversion and elsewhere in the watershed.

2.2 METHODS

2.2.1 DOWNSTREAM MIGRANT TRAP CHECKS

Trapping occurred from January 18 to June 29, 2012. Fish relocation was triggered when there was not sufficient flow in the lower river based on depth criteria at critical riffles. The current smolt target flow is 120 cfs measured approximately 5.5 mi downstream of the Freeman Diversion within a sandy glide habitat unit in the lower Santa Clara River. This target flow threshold was developed from the analysis of depth, velocity and wetted width taken at a range of flows within long, sandy glides. These results were used to develop a smolt target flow (120 cfs) where more than 50% of the wetted stream channel was greater than 0.5 feet deep. Trapping and transporting commenced when flow receded to 80 cfs at the sandy glide flow measurement site. A trapping trigger or critical passage flow of 80 cfs was developed because only a narrow width (10 % or less of the wetted stream channel) was equal to or greater than 0.5 feet deep during the depth, velocity and wetted width study. A smolt radio telemetry study is in development to address uncertainties regarding smolt migration behavior and rate of migration in the lower Santa Clara River. This study is planned to be implemented in United's Multi-Species Habitat Conservation Plan (MSHCP). The primary objective of this study will be to evaluate smolt migration rates and success at various flows to inform and potentially modify the smolt target flows and trapping operations.

Downstream migrant steelhead smolts, kelts, Pacific lamprey macropthalmia, and other fish entering the fish screen bay within the diversion facility were prevented from entering the diversion canal by a self-cleaning, 1.75 mm (0.07 inch) mesh wedge wire screen which directs the fish to a downstream migrant fish trap. From January 18 to June 29, 2012, fish were collected in the downstream migrant trap. Steelhead smolts and kelts trapped at the facility were transported in aerated coolers by truck to the Santa Clara River Estuary when flows were less than 80 cfs at the critical riffle, or released in the Santa Clara River below the Freeman Diversion when migration flows were being released. The steelhead kelt trapped in 2012 was transported upstream to the Santa Clara River near Santa Paula because it was not clear at the time that this fish was a kelt. Scale analysis later confirmed it was a kelt. No lamprey macropthalmia were observed or trapped. Resident coastal rainbow trout not exhibiting smolting characteristics were transported, depending on flow conditions, to the Santa Clara River, Santa Paula Creek, or Sespe Creek. No lamprey ammocoetes were observed or trapped. Currently, the Santa Clara River above Santa Paula is the preferred relocation site for resident coastal rainbow trout and lamprey ammocoetes. All other native aquatic species were returned to the river upstream of the diversion. Non-native and exotic aquatic species were removed from the river unless they were considered special status species in neighboring watersheds (e.g., Santa Ana sucker).

The downstream migrant trap consists of 3/16-inch mesh metal screens. Flow enters through a weir gate with an opening that directs fish and other aquatic species into the trap from the fish screen bay. The trap is situated to keep all intercepted fish immersed in at least two feet of flowing water.

The trap was checked daily in the morning and downstream migrants were removed from the trap with a dip net, counted and measured. Other trapped aquatic species were counted and documented during each trap check. All fisheries personnel were trained in species identification and handling. A species identification handbook drafted by Steve Howard (senior fisheries biologist) was also available.

Data Collection – Steelhead smolts were measured (fork length) to the nearest millimeter on a wet fish measuring board. Measurements typically took no more than 10 seconds per individual. Lamprey ammocoetes and macropthalmia, when observed, are measured to total length from head to tail. Smolt condition factor (Wedemeyer 1996) will be quantified in the future by weighing and measuring each fish. Water temperature was measured in the fish trap prior to handling fish and monitored in the transport cooler during transport. Fish were not transported at temperatures above 20°C and transport activities were performed early in the morning to minimize stress to the fish. General fish condition was assessed as well as degree of smoltification or smolt condition. Smolt condition or level of smoltification will be quantified in the future based on methods in Haner et al. (1995). Water temperature, dissolved oxygen, pH, conductivity, salinity and turbidity were measured at the relocation sites with a multi-parameter water quality meter. When possible, photos of collected and transported steelhead and lamprey were taken with a digital camera. All data were documented on standardized datasheets and transferred daily to an electronic database.

Fish Transportation – Fish were collected from the fish trap with 1/8th inch or smaller mesh dip nets, data were collected and compiled on datasheets and the fish were typically placed in 100 quart aerated coolers. No more than 25 smolts, ammocoetes or macropthalmia were placed in an individual cooler. No more than one adult steelhead or kelt was placed in individual coolers. If a low number of smolts or macropthalmia were collected, these fish were placed in aerated buckets to minimize handling during release. Fish handling and transport time was generally no more than one hour.

2.2.2 Fish Transport Locations

Anadromous Fish

All anadromous downstream migrant fish (steelhead smolts and kelts, Pacific lamprey macropthalmia) were transported from the Freeman Diversion to the Santa Clara River Estuary (Photo 1 Appendix B) when discharge in the Santa Clara was less than 80 cfs. When flows were greater than 80 cfs, fish were released in the Santa Clara downstream of the Freeman Diversion. The specific relocation site depended on the condition of the estuary. The estuary was monitored daily during the migration season to inform relocation activities. Generally fish were released to fresh water in the estuary that had at least 1 foot of depth and instream cover nearby. Areas of the estuary that were known to be low in oxygen were avoided.

Acclimation Schedule - Fish were acclimated to the receiving water using the schedule in Table 3.

Table 3 – Fish acclimation schedule.

Degree Differential (between cooler and receiving water)	Acclimation Minutes
0-2	10
3-5	20
6-7	30
8 and over*	40

* Fish transportation should not occur when the water temperature is too high (>20°C). If this occurs the fish transport time schedule will be modified. If the estuary water temperature is over 23°C the lead fisheries biologist will be contacted before acclimating.

Non-Anadromous Fish

Non-anadromous fish (resident coastal rainbow trout and Pacific lamprey ammocoetes) were transported via aerated coolers to either the mainstem Santa Clara River, Sespe Creek, or Santa Paula Creek (Photo 13, 17, and 15, Appendix B). If conditions are not suitable for trout in the mainstem Santa Clara River, resident rainbow trout might be transported to Santa Paula Creek upstream of Steckel Park or Sespe Creek at Grand Avenue. All other native, non-anadromous fish and aquatic species were transported and released upstream of the Freeman Diversion Structure.

2.2.3 Smolt Length Measurements

Trapped smolts were measured to fork length (Photo 2, Appendix B). Lengths were measured by placing the fish in a fish measurement cradle for no more than 10 seconds. The fish were not sedated. If an individual fish could not be measured in less than 10 seconds, the fish was placed back in an aerated cooler and not measured again.

2.3 Results

2.3.1 Downstream Migrant Trap Checks

The downstream migrant trap was in operation from January 18 to June 29, 2012, with occasional periods where the trap was not used due to excess flows or other limiting factors (3 days). Smolts entered the trap from March 22 to June 16, 2011 (Figure 3, Appendix A). Smolt surveys occurred during operational flushes and fish screen bay checks through the end of June. A total of 31 steelhead smolts (Photo 2 and 3, Appendix B), 1 steelhead kelt (Photo 18, Appendix B, 59 young-of-the-year (YOY) coastal rainbow trout, and 5 resident coastal rainbow trout (Photo 4, Appendix B) were trapped and relocated during the 2012 migration season. Smolt length frequencies and length by dates can be found in Figures 4 and 5 (Appendix A) respectively. One dead YOY coastal rainbow trout was found in the trap on June 29, 2012 and the mortality appeared to be caused by unsuccessful predation by a bird. The number of steelhead smolts trapped in 2012 may be lower than the actual annual total number because smolts may have used the fish ladder and bypass flows released over the crest of the diversion or through the roller gate bypassing the diversion intake and avoiding capture in the fish trap. Two resident coastal rainbow trout (370 mm and 234 mm fork length) were captured in the fish screen bay on April 18, two (195 mm, 305 mm) were captured in the downstream trap April 3-April 4, and one (95 mm) was captured in the fish screen bay on January 4. Most of the steelhead smolts trapped at the Freeman Diversion were transported to the Santa Clara River Estuary due to low flows (below 80 cfs in the Santa Clara River), but six smolts were released below the Freeman Diversion during periods of adequate bypass flows. No lamprey ammocoetes or macropthalmia were observed or collected at the Freeman Diversion Facility in 2012.

Additional fish collected in the Freeman downstream migrant trap included: partially armored threespine stickleback (N=1694), Arroyo chub (N=4686), Santa Ana sucker (N=2920), Owens sucker (N=126), Santa Ana/Owens sucker hybrids (N=128), crappie spp. (N=1), fathead minnow (N=1735), common carp (N=536), largemouth bass (N=0), green sunfish (N=13), brown bullhead (N=8), prickly sculpin (N=261) and mosquitofish (N=37) (Table 4, Appendix A). Sucker species were identified based on lip morphology to the extent possible, but the validity of this method is questionable. Red swamp crayfish were regularly captured in the trap (N=1525).

Amphibians and reptiles collected in the Freeman downstream migrant fish trap included: Western toad (N=24), bullfrog (N=1516, mostly larvae), African clawed frog (N=101), tree or Pacific chorus frog (N=28) and Western pond turtle (N=24) (Table 4, Appendix A). The regional and regulatory status of amphibians and reptiles collected at the Freeman Diversion can be found in Table 5 (Appendix A). A healthy pond turtle population exists directly above and below the Freeman Diversion Structure.

2.3.2 Smolt Length Measurements

A total of 31 smolts were measured. The average length of the 2012 smolts was 176.5 mm (standard deviation 34.5 mm). Smolt length distribution is available in Figure 4, Appendix A.

2.3.3 Steelhead Kelt

A single steelhead kelt was collected in the downstream migrant trap on April 3rd. The fish length was 470 mm (FL), color was fairly silvery and it did not have the typical signs of weight loss from a same-year kelt (Photo 18, Appendix B). This fish appears to have spawned in 2011 and returned to the ocean in 2012, gaining weight in freshwater over the summer, fall and winter months. Biologists from CDFW, NMFS, San Jose State University (SJSU), and COMB reviewed the scales and submitted valuable input regarding the age of the fish. Most of the reviewers considered the fish to be age 3+ or 4 and one reviewer thought it might be 2+. All reviewers agreed that this fish had an ocean phase in its life cycle based on extended growth after leaving freshwater. Our interpretation is that this fish appears to have been born in 2008 and lived in freshwater for two years, left its natal tributary in the winter of 2010 and reared in the mainstem for a few months, entered the ocean as a two year old smolt in the spring of 2010, lived in the ocean for one year and returned to the Santa Clara River to spawn at age 3 in 2011, hopefully spawned in a tributary, oversummered in freshwater for a year and then returned to the ocean as a kelt at age 4. Our interpretation of the scale can be viewed in Photo 19, Appendix B. The graphic in the photo was generated by Scott Volan (COMB). The scale is comparable to some scales taken from steelhead of similar size in the Santa Ynez River.

This interpretation fits well with the hydrology and access conditions (estuary sandberm open) for 2010 and 2011. In 2010, a total of 72 steelhead smolts were trapped at the Freeman Diversion and many were relocated below the structure. In 2010, bypass flows occurred from January 18 to March 19 and from April 6 to April 28, and the sand berm was open from January 18 to March 29 and from April 8 to May 11. Consequently, in 2010 there were plenty of opportunities for smolts to migrate to the estuary of their own volition and exit the estuary to the ocean. In 2011, the fish ladder was in operation from approximately January 19 to February 19, March 1 to March 11 and from April 4 to June 8. There were excellent access opportunities in 2011 for adult steelhead to enter the river from the ocean and ample time for adult steelhead to migrate to spawning tributaries. Unfortunately the migration monitoring system did not detect this fish in 2011 when it assumedly passed the Freeman Diversion. United upgraded the video monitoring system in 2012 to further reduce the chances of missed detection of adults (see section 3.2.2).

3.1 INTRODUCTION

The Freeman Diversion Facility is equipped with a Denil fish ladder (fishway) that was constructed to facilitate steelhead and Pacific lamprey upstream migration over the concrete diversion structure. Although Denil fishways are not ideal for lamprey passage, the fish ladder did pass hundreds of lamprey in the 1990's (Chase 2001, Swift and Howard 2009). There is some uncertainty regarding how many steelhead have passed the diversion structure because of a previously inconsistent and inefficient monitoring program, as well as regulatory and extreme environmental constraints (flashy flows, high turbidity). Despite uncertainties in the data, a minimum of 11 wild adult steelhead have been observed at the diversion structure since it was constructed in 1991 including two hatchery origin adults steelhead observed in 2008.

3.2 METHODS

In years with sufficient rainfall, upstream migrant monitoring is conducted to determine if adult steelhead use and effectively navigate the fish ladder. Currently, there is no active fish trap deployed within the fish ladder to monitor steelhead and lamprey upstream migration. In order to monitor steelhead upstream migration, the District installed a passive monitoring device that counts upstream migrants when they jump over a false weir and through an infrared (IR) scanning device while then being documented by an integrated video monitoring system. Lamprey likely migrate under a grated section of the passive monitoring device, where it is unlikely that they will be observed. The only other option for monitoring steelhead or lamprey upstream migration within the diversion facility is during fish ladder shutdowns or when flow is reduced within the fish ladder. Monitoring during hour-long shutdowns of the fish ladder only allows for intermittent observations during the migration season. It would benefit steelhead recovery efforts and increase knowledge regarding steelhead and Pacific lamprey migration if an active trap was installed within the fish ladder. A trap would temporarily capture all upstream migrants so that information could be gathered regarding ladder efficiency, migration timing, fish condition, water quality at migration, as well as other parameters of interest.

3.2.1 Bypass Flow Monitoring and Ladder Operation

The current flow threshold for sufficient upstream migration is 160 cfs, measured at critical riffles in the lower Santa Clara River. This threshold was developed from the results of a steelhead migration instream flow study conducted by Thomas R. Payne and Associates (now Normandeau Associates) in the lower Santa Clara River (TRPA 2005). This study evaluated surface water depths at various flows to understand what minimum flows would be required for steelhead to successfully migrate from the ocean to the Freeman Diversion Fish Ladder.

During fish ladder operations, bypass flows were monitored at two sites between the Freeman Diversion and Highway 101 to ensure that a minimum of 160 cfs was maintained at the most downstream monitoring site located approximately 0.6 miles upstream of the Highway 101 Bridge. The two monitoring sites were located approximately 0.14 miles below the Freeman Diversion Structure and 5.5 miles downstream of the Freeman Diversion or 0.6 miles upstream of the 101 Bridge (Figure 6, Appendix A). The most downstream monitoring site was located near the end of the losing reach of the river where the highest percolation rates of surface water are believed to occur.

Flow was measured with a YSI/SonTek FlowTracker Acoustic Doppler Velocimeter. Flow measurements were conducted using USGS standards for measuring flow using acoustic Doppler technology in open channels (Rehmel 2007). The measurement site (critical riffle area) was located within a long and wide sandy glide. The numerous shallow glides found in the Santa Clara River potentially result in migration bottlenecks and delay for steelhead migration (S. Howard, personal observations of physical habitat). The actual critical riffles (typical area to measure shallow conditions) have narrower active channels (wetted width) than glide habitats resulting in deeper, more suitable migration conditions compared to the wide, sandy glides.

The Freeman Diversion Fish Ladder operations are based on negotiations between NMFS biologists and the District hydrologist and biologists. These operating criteria were revised in the United States Bureau of Reclamation's

Biological Assessment of the Operation of the Vern Freeman Diversion Dam and Fish Ladder, Santa Clara River, Ventura County, California, and later revised in the Proposed 2009 Interim Operations Plan and 2010 Smolt Bypass Flow Plan.

The operating criteria are as follows:

When United starts diverting water after a storm (turn-in), diversion rates are limited when total river flow is less than or equal to 750 cfs. When turning in at total river flow greater than 635 cfs and less than or equal to 750 cfs, only 30% of the remaining river can be diverted providing that the required bypass flows for steelhead are met. When turning in at total river flow less than or equal to 635 cfs, only 20% of the remaining river can be diverted providing that the required bypass flows for steelhead are met. These diversion restrictions apply only to turning-in procedures undertaken during the principal steelhead migration season (January through May) when total river discharge is less than or equal to 750 cfs.

January 1 – March 14 Bypass Flows

After a storm event triggers migration flows, the fish ladder and auxiliary flows will be operated on the following schedule: From January 1 to March 14 (adult bypass flows), bypass flows with a target of 160 cfs including a ramp-down schedule (Table 1) will be maintained for 18 days. If total river flow drops below 160 cfs at the critical riffle without diversions during the 18 day flow window, the total amount of flow released will be reduced by 1/3 each day for three days and reduced to 20 cfs on the fourth day. If an adult steelhead is detected in the fish ladder during ramp down, flows will be maintained at the current release discharge for 24 hours and then ramp down will proceed if no adult steelhead are detected. During the ramp down period, United may divert water not being released downstream.

March 15 – May 31 bypass flows

From March 15 to May 31, United may continuously maintain critical diversions of 40 cfs during bypass flow releases. From March 15 to May 31, following a storm, a bypass flow of 160 cfs will be maintained for 11 days then reduced to 120 cfs until this flow cannot be maintained (Table 2). The smolt target flow of 120 cfs was developed from water depth surveys focused on providing downstream migrating smolts with safe, volitional passage through the lower river. However, when flows at the critical riffle are predicted to reach a low critical flow of 80 cfs within 5 days, smolts will be trapped and transported. After flows reach 80 cfs, bypass flow will be reduced by 1/3 each day for three days and reduced to 20 cfs on the fourth day. For all ramp down operations, if natural flows decline faster than the specified ramping rates and it is impossible to maintain the prescribed 1/3 daily reduction in flow, then natural flows will be used for that 24 hour period.

Smolts may migrate downstream regardless of storm events, so United will provide bypass flows of 120 cfs for smolt migration from March 15 to May 31 while maintaining critical diversions of 40 cfs. If there is not sufficient water to provide smolt bypass flows of 120 cfs and maintain the critical diversion of 40 cfs, smolts will be trapped and transported when river flows are predicted to recede to 80 cfs with 40 cfs diverted within five days. When adult bypass flows are not in effect and smolts are captured in the fish trap outside of the smolt bypass flow period, they will be transported to the estuary.

The bypass flow schedules for 2012 are presented in Tables 6 and 7, Appendix A. A detailed operations flow chart that includes the bypass flow release decision matrix will be included in the MSHCP that is currently in development.

3.2.2 Video Migration Monitoring

Upstream migration monitoring was conducted using a false weir, infrared scanners, and a computer-based surveillance system. (Photo 5, 6, and 7, Appendix B). The false weir creates a barrier within the ladder that forces upstream migrant steelhead to jump out of the water approximately six inches to get over a small “fall or plunge” to continue upstream. Consequently, the migrating steelhead jump through the infrared scanners that detect the migration event, 3 cameras film each fish that negotiates the weir and the surveillance system records video of the events on a computer hard drive. The weir was designed with a bar screen at the bottom of the structure to allow Pacific lamprey to pass under the false weir. It is unclear if Pacific lamprey are able to pass through the bar screen due to a lack of data regarding approach water velocities at the screen. Approach velocities at the bar screen and potential monitoring alternatives will be evaluated during the next several years of operations.

Prior to the deployment of the current computer surveillance system in 2010, a

DVR system with a single low resolution camera was used to monitor steelhead migration through the fish ladder. The new computer based system provides substantially greater resolution and multiple functions to detect movement. During 2012, IR scanners were used to detect movement over the false weir. Although the surveillance software can detect movement, it is difficult to isolate detection of fish from the water moving in the background. When steelhead traverse the fish ladder and jump over the false weir, the computer based monitoring system documents the event with a flashing alarm on computer screen. Alarms and associated video footage are reviewed daily. The computer system records continuously and there is sufficient hard disk storage to save video for up to 7 days, depending on the number of cameras in use. Once the hard drive is full, new data is saved over old data, starting at the beginning of the old file. Migration events are saved as short video files on the computer hard drive. The surveillance system receives digital video from two low-light, high resolution, above-water cameras placed upstream and downstream of the false weir, as well as an underwater camera placed downstream focused on the false weir. Three twenty-five watt fluorescent lights were used to illuminate the false weir at night.

The IR scanner device is equipped with sensors on both sides of the false weir with multiple closely-spaced infrared beams. When the beams are broken by a fish jumping over the weir, the IR scanner signals the surveillance system to record the event.

To evaluate the efficiency of the IR scanner device, the video monitoring system was checked daily to ensure proper function. Triggered alarms were reviewed and any necessary adjustments were made to the water levels, scanning devices, or recording equipment. Additional cameras were placed at the weir after the 2012 monitoring season to provide views conducive to using motion detection in the surveillance software. Motion detection as well as infrared detection will be used in the future to increase the efficiency of the detection system.

3.2.3 PIT Tag Monitoring

During past monitoring seasons, a Biomark FS2001 PIT tag scanner along with a 24” x 24” antenna was deployed in the fish ladder with the objective of detecting any steelhead that were tagged in 2008 or any tagged out-of-basin steelhead that might stray into the Santa Clara River. PIT tags (Passive Integrated Transponder) use RFID (radio frequency identification) and have no battery so the microchip remains inactive until read with a scanner. The scanner sends a low frequency signal to the microchip within the tag providing the power needed to send its unique code back to the scanner and positively identifying the individual fish. Passive tags are designed to last the life of the fish, providing a reliable, long term identification method.

The PIT Tag monitoring system was deployed just above the most upstream Denil plate in the fish ladder. There was some concern regarding head differential upstream and downstream of the antenna which was over 1 foot. The water velocities through the antennae as well as the head differential created a possible barrier within the fish ladder. To address this concern, the antenna was removed from the ladder in 2011. We will research options for future deployment in the future, particularly in combination with planned upcoming PIT tagging efforts for smolts in the upper Santa Clara watershed.

3.2.4 Ladder Shutdowns

A thorough examination of the entire fish ladder was conducted to check for the presence of any fish species during shutdown or dewatering of the ladder. The ladder was shut down for operational or maintenance reasons such as high storms flows, channel flushes, and/or removal of debris from the weir.

3.2.5 DIDSON Migration Monitoring

The DIDSON camera was deployed in the river below the Freeman Diversion focusing on a cross section perpendicular to the direction of flow. This site was chosen directly upstream of a riffle crest where the wetted width of the river was the narrowest and where the channel bed cross section had the least obstructions such as boulders or an uneven bottom. The DIDSON camera was placed on a portable mount that can also be used as a trailer attached to an ATV (Photo 8, Appendix B). The mount was placed in the river and a weir was deployed from the bank to the DIDSON mount to ensure fish pass the sonar beams. The objective of this monitoring scheme was to detect both upstream and downstream migrating steelhead as they approach or exit the Freeman Diversion

Facility. The original objective was to monitor adult steelhead as they approached and entered the entrance gates to the Freeman Diversion Fish Ladder. There are several challenges to placing the DIDSON at the base of the diversion including frequent changes to the area directly below the structure due to scour or sediment aggradations, as well as turbulence and bubbles in the area where water exits the fish ladder. The sonar beams do not travel through air bubbles, excessive turbulence and extremely high suspended solids and so sonar imaging is limited in periods where these conditions are present. During 2012, the streambed was highly mobile, with substantial sand deposition and scour occurring during migration flows, which at times buried the DIDSON and ultimately prevented successful DIDSON monitoring below the Freeman Diversion.

3.3 RESULTS

3.3.1 BYPASS FLOW MONITORING AND LADDER OPERATION

The fish ladder was in operation from March 26-28th and April 14-24th, 2012. Two adult steelhead were observed traversing the fish ladder in 2012, the first on April 15 at 17:21 and second on April 16th at 13:28. Bypass flow monitoring results can be found in Table 6, Appendix A.

3.3.2 VIDEO MIGRATION OBSERVATION

The surveillance system was operated continually from March 26-28th and April 14-24th, 2012 during the operation of the fish ladder. Throughout this period the alarm trigger system was monitored and checked daily.

In 2012, numerous triggered alarms were determined to be “false hits” (i.e., triggered by something other than steelhead). These false triggers were due to increased sensitivity of the scanners following calibration.

3.3.3 LADDER SHUTDOWNS

The fish ladder was shut down a total of two times in 2012. Shut down events occurred on April 1 and April 25 when bypass flows were terminated due to insufficient flow in the river.

3.3.4 DIDSON Migration Monitoring

The DIDSON was deployed and quickly removed from the river in 2012 due to adverse stream conditions (e.g., shifting sands and unstable bed).

4.1 INTRODUCTION

During high flow events when the river is highly turbid from elevated concentrations of total suspended solids (over 3000 ntu's), District operations staff "turn-out" all river flows from the facility resulting in the impound upstream of the diversion structure becoming dewatered or extremely shallow. When the water is turned out of the facility, head gates are closed to retain sufficient depth in the fish screen bay to avoid potential predation of fish by birds until fisheries staff can survey for stranded fish. During all "turn-out" events when the fish ladder is in operation, the fish ladder must be shut down and inspected for potential stranded fish. When the fish ladder is shut down it slowly dewaters and this can result in fish becoming stranded in the fish ladder.

Additional operations and maintenance activities include "flushes" where District operations staff temporarily "turn-out" all river flows from the facility to maintain the active channel toward the facility headworks or to conduct maintenance of the canal gates and screens. During a flush, the river will pass through the flushing channel, carrying away material deposited upstream of the intake. As the flush continues, the river continues to scour sediment or headcut for a distance back from the intake, up to several hundred feet. Flushing is necessary to keep both the diversion and the fish ladder in operation. When flushes occur, head gates are closed to retain sufficient depth in the fish screen bay to avoid potential predation of fish by birds until fisheries staff can survey for stranded fish.

The primary objective of fish stranding surveys is to rescue any fish that become stranded when diversion operations cause river flow to rapidly diminish downstream of the Freeman Diversion in the Santa Clara River and within the fish screen bay and fish ladder during dewatering operations.

4.2 METHODS

4.2.1 FISH SCREEN BAY STRANDING SURVEYS

During turn-out and flushing events, the fish screen bay was thoroughly examined for the presence of steelhead, Pacific lamprey and other aquatic species. Two or more biologists surveyed the fish screen bay as it dewatered. These surveys were conducted by seining the entire area with either 1/8 or 1/4 inch mesh brailed seines, 4 feet deep and 10 to 20 ft long (Photo 9, Appendix B). The primary objective of these surveys was to capture and relocate steelhead and Pacific lamprey stranded during dewatering of the fish screen bay to appropriate habitats either in the estuary (smolts, kelts, macropthalmia) or the Santa Clara River and associated tributaries (resident coastal rainbow trout and Pacific lamprey ammocoetes). Also, the fish screen bay was periodically dewatered opportunistically to look for steelhead and Pacific lamprey migrants that could potentially be delayed in the fish screen bay. All fish were transported via aerated coolers and non-native aquatic species were removed from the river. All data collected during stranding surveys were documented on standardized datasheets. Fish were transported utilizing methods described in Section 2.2 of this report.

4.2.2 LOWER SANTA CLARA RIVER STRANDING SURVEYS

Stranding surveys were conducted in the Santa Clara River below the Freeman Diversion when bypass flows were significantly reduced or when releases were stopped all together, due to turn-out or flushing events. These surveys were conducted by entering the non-wetted area of the floodplain via a Polaris Ranger all-terrain vehicle that was stocked with equipment necessary to collect, hold and transport stranded fish. Stranded fish were captured either with dip nets or 1/8 inch to 1/4 inch mesh brailed seines and placed in aerated coolers. In 2012, no surveys were required. In years when upstream migrant steelhead and Pacific lamprey are collected during these surveys they will be relocated upstream of the Freeman Diversion Structure. Downstream migrant steelhead (smolts) will be relocated to the Santa Clara River Estuary. In years when downstream migrant Pacific lamprey (macropthalmia) are collected during stranding surveys they will be relocated to the estuary.

4.2.3 Fish Ladder Stranding Surveys

Stranding surveys were conducted in the fish ladder during turn-out events. When the fish ladder is in operation and one of these events occurs, the fish ladder becomes dewatered and the potential exists for steelhead and Pacific lamprey to become stranded either between the Denil plates or in resting pools of the fish ladder. A biologist was present and conducted surveys when these operations occurred by walking the length of the ladder searching for any stranded fish as the ladder dewatered. Dip nets and buckets were used to rescue any stranded fish.

Fish ladder stranding surveys were also conducted during maintenance activities to visually survey for steelhead and Pacific lamprey that that might become stranded in the fish ladder during these activities. If a fish was observed in the Denil sections of the ladder it was captured with a dip net, placed in a bucket and relocated to an appropriate location based on its life stage.

4.3 Results

4.3.1 Fish Screen Bay Stranding Surveys

A total of 5 turn-out and 2 flush events occurred during the 2012 water year. The turn-out events were due to high turbidity levels from the suspended sediment load, while the flush was performed for channel maintenance and personnel training. Four fish screen bay stranding surveys were conducted; surveys were not performed for two events because the durations were short enough (<1 day) to maintain water levels in the fish bay. Three stranding surveys yielded a total of six steelhead smolts, 1 young-of-the-year, and two resident trout (Table 7, Appendix A), one survey did not observe any *O. mykiss*. All six smolts were released at the Santa Clara River Estuary, resident trout and young-of-the-year were released in the mainstem Santa Clara River at the Ventura County Watershed Protection District project near Santa Paula. These fish were included in the total trapping results section (see section 2.3.1).

4.3.2 Lower Santa Clara River Stranding Surveys

No visual stranding surveys were required below the Freeman Diversion Structure following turn-out events because bypass flows were released following the turn-out events which maintained surface flow in the river or flushes occurred outside the smolt migration season.

4.3.3 Fish Ladder Stranding Surveys

There were a total of 6 turn-out events but only 1 occurred when the fish ladder was in operation, requiring a ladder check. A biologist walked the length of the fish ladder during each event as the ladder dewatered. No *O. mykiss* were observed stranded in the fish ladder during these surveys.

5.1 INTRODUCTION

Water quality monitoring for 2012 was conducted to monitor water quality conditions that steelhead and Pacific lamprey are exposed to in various areas within the watershed. Water quality parameters such as dissolved oxygen, pH, conductivity, salinity, and turbidity were collected *in situ* at some sites. Water temperature monitoring was conducted in various locations in the watershed and water quality measurements were focused primarily in the Santa Clara River Estuary, Santa Paula Creek, Sespe Creek, and the main stem Santa Clara River where coastal rainbow trout were relocated during the 2012 monitoring season. Only water temperature measurement results are included in this report because other parameters were only measured during intermittent fish transport activities.

5.2 METHODS

Water quality monitoring in 2012 consisted of water temperature measurements utilizing Onset Hobo® temperature loggers at various sites within the Santa Clara River watershed and in-situ water quality measurements taken during fish relocation activities using a Hach Quanta multi-parameter water quality meter. The majority of the temperature loggers were placed in pool habitats at mid-depth and programmed to take measurements every hour. The standardized data collection dates were October 1, 2011 through September 31, 2012.

Water temperature monitoring occurred at the following sites:

- Site 2: Freeman Fish Trap Bay
- Site 3: Freeman Fish Screen Bay
- Site 4: Santa Clara River at the Ventura County bank stabilization project
- Site 4A: Santa Clara River side channel at the Ventura County bank stabilization project
- Site 6B: Santa Paula Creek upstream of Harvey Diversion
- Site 7: Santa Paula Creek at Steckel Park

- Site 8: Santa Paula Creek directly downstream of Sisar Creek confluence
- Site 9B: Sespe Creek at Grand Avenue

Some of the other site numbers are not presented here because the loggers were either lost due to high flows or conditions were such that access to the sites was not feasible. A map identifying each monitoring site can be found in Figure 7, Appendix A. Graphs depicting data at these eight sites are in Figures 8-15, Appendix A. Specific information regarding each site can be found in Table 8, Appendix A. An additional temperature logger was installed in the Santa Clara River Estuary, but cannot be retrieved until the first future breaching of the estuary occurs.

5.3 RESULTS

5.1.1 FREEMAN FISH TRAP BAY

The Santa Clara River Freeman Fish Trap Bay water temperature monitoring site was located within the fish trap bay at the Freeman Diversion in Saticoy. The logger was attached to a rung of a permanent ladder structure within the fish trap bay. The logger was attached with zip ties approximately 1.0 feet from the bottom of the bay (Photo 10, Appendix B). The objective at this location was to monitor water temperatures in the fish trap bay where the downstream migrant fish trap is located. Steelhead smolts and several other aquatic species were trapped at this location during the migration season (typically January-June). Temperature monitoring is critical at this location as this is where the fish remain until the daily trap check occurs. Occasionally resident and young-of-the-year coastal rainbow trout as well as steelhead kelts may also be found in the trap. The minimum water temperature collected at this site was 7.4 ºC and the maximum temperature was 27.6 ºC (Table 9, Appendix A).

5.1.2 FREEMAN FISH SCREEN BAY

The Santa Clara River Freeman Fish Screen Bay water temperature monitoring site was located within the fish screen bay. The fish screen bay consists of a concrete channel where downstream migrants enter the diversion and migrate to the downstream migrant fish trap. The logger was located approximately 50 feet downstream from the intake to the fish screen bay and attached to an eye hook

0.5 feet from the bottom along a concrete wall (Photo 11, Appendix B). The objective at this location was to monitor water temperatures in the main stem as river flow enters the Freeman Facility. Downstream migrant steelhead, Pacific lamprey and other aquatic species temporarily rear in the fish screen bay prior to entering the trap. The downstream migrant fish trap is typically taken out of operation between June and December and all fish that enter the facility rear in the fish screen bay until trapping operations commence in January. The minimum water temperature collected at this site was 1.85 ºC and the maximum temperature was 27.63 ºC (Table 9, Appendix A).

5.1.3 Santa Clara River at VCWPD Project

The Santa Clara River at the Ventura County Watershed Protection District (VCWPD) Project water temperature monitoring site was located approximately 100 feet downstream from the most downstream groin at the county bank stabilization project site off South Mountain Road in Santa Paula. The logger was attached to a fence post with zip ties 0.9 feet from the bottom (Photo 12, Appendix B) in a pool about 3.5 ft deep. The objective at this location was to monitor water temperatures in the main stem Santa Clara River between Sespe Creek and the Freeman Diversion. In the future we will be adding more temperature monitoring sites throughout the Santa Clara River to closely monitor temperatures during the steelhead and Pacific lamprey migration season. The minimum water temperature collected at this site was 9.44 ºC and the maximum temperature was 23.6 ºC (Table 9, Appendix A).

5.1.4 Santa Clara River at VCWPD Project side channel

The Santa Clara River at the Ventura County Watershed Protection District (VCWPD) Project side channel water temperature monitoring site was located in near the middle groin at the county bank stabilization project site off South Mountain Road in Santa Paula. The logger was wired to rocks on the bank and is resting on the bottom (Photo 13, Appendix B) in a pool about 3.5 ft deep. The objective at this location was to monitor water temperatures in the side channel of the Santa Clara River between Sespe Creek and the Freeman Diversion where resident trout captured in the downstream migrant trap are released during the trapping season. In the future we will be adding more temperature monitoring sites throughout the Santa Clara River to closely monitor temperatures during the steelhead and Pacific lamprey migration season. The minimum water temperature collected at this site was 16.27 ºC and the maximum temperature was 18.91 ºC (Table 9, Appendix A).

5.1.5 Santa Paula Creek upstream of Harvey Diversion

The Santa Paula Creek upstream of Harvey Diversion water temperature monitoring site was located in a low gradient riffle habitat type approximately 500 feet upstream from Harvey Diversion along Highway 150 in Santa Paula. The logger was attached to a fence post with zip ties under a boulder 0.4 inches from the bottom (Photo 14, Appendix B). The objective at this location was to monitor water temperatures in Santa Paula Creek. The minimum water temperature collected at this site was 7.19 ºC and the maximum temperature was 30.4 ºC (Table 9, Appendix A).

5.1.6 Santa Paula Creek at Steckel Park

The Santa Paula Creek at Steckel Park water temperature monitoring site was located in a pool habitat type ~50 feet upstream of the Steckel Park Bridge. The logger was attached 0.2 feet from the bottom with zip ties to a fence post. The fence post was located under a boulder and was secured to an alder tree via cable along the bank (Photo 15, Appendix B). This location was ideal for monitoring temperatures for due to adequate flows, areas of scour and in-stream cover. The temperature logger was buried under sediment during a storm on March 18, 2011, but continued logging. The minimum water temperature collected at this site was 7.16 ºC and the maximum temperature was 24.65 ºC (Table 9, Appendix A).

5.1.7 Santa Paula Creek Directly Downstream of Sisar Creek Confluence

The Santa Paula Creek directly downstream of Sisar Creek confluence water temperature monitoring site was located in a pool habitat type approximately 35 feet downstream of the Sisar Creek confluence. The logger is attached 7.25 inches from the bottom with zip ties to a fence post (Photo 16, Appendix B). This habitat was ideal for water temperature monitoring because of the scoured pool and direct observation of resident *O. mykiss* at this site. The pool habitat filled in during the winter and the logger was moved to a pool downstream. The objective at this location was to monitor ambient water temperatures in Santa Paula Creek.

The minimum water temperature collected at this site was 8.54 ºC and the maximum temperature was 21.68 ºC (Table 9, Appendix A).

5.1.8 Sespe Creek at Grand Avenue

The Sespe Creek at Grand Avenue water temperature monitoring site was located in a pool habitat type approximately 150 ft downstream of the USGS Gauge along Grand Avenue. The logger was attached to a fence post between two boulders, 0.5 feet from the bottom along the bank (Photo 17, Appendix B). The objective at this location was to monitor water temperatures at the resident and young-of-the-year coastal rainbow trout release location in Sespe Creek. This was an easily accessible pool with sufficient flow creating areas of scour and abundant in-stream cover, primarily riparian vegetation and boulder substrate. The minimum water temperature collected at this site was 6.61 ºC and the maximum temperature was 31.38 ºC (Table 9, Appendix A).

5.4 Discussion

The maximum water temperatures at most sites extends above what many believe to be the chronic or incipient upper lethal temperature limit of 25 ºC for many anadromous salmonids, although higher temperatures reaching 29 ºC can be tolerated for a short period of time (Myrick and Cech 2001) if water quality conditions are favorable and food is available. The maximum water temperature of 33.9 ºC occurred in Santa Paula Creek upstream of Harvey Diversion during the summer. However, this logger was placed in a shallow riffle which represents typical riffle habitat in Santa Paula Creek. These extreme water temperatures are not uncommon in small streams of southern California. Southern California coastal rainbow trout have adapted to a wide variation in water temperatures by seeking out thermal refuges when available. Other behavioral responses to upper thermal extremes include increase feeding when food is available to offset the cost of an elevated metabolic rate although feeding does decline after about 19 ºC but growth can still occur up to 25 ºC (Myrick and Cech 2000). The duration of exposure is important because these fish will experience upper thermal limits over a period of a few hours during any given day but can maintain body weight at 25 ºC for 30 days (Myrick and Cech 2000). In drainages where thermal refuge is limited or absent and low food production occurs, thermal stress alone can cause mortalities.

Next year, additional temperature monitoring sites will be located throughout the watershed. Once we acquire enough temperature loggers, we plan to also conduct temperature monitoring at reference pools that contain areas of thermal refuge.

Behler, J. L. and F. W. King. 1996. National Audubon Society Field Guide to North American Reptiles and Amphibians. Alfred A. Knopf, Inc. New York.

California Department of Fish and Game. 2009. California Natural Diversity Database, Special Animals (883 taxa). The Natural Resources Agency, Biogeographic Data Branch.

Chase, S. 2001. Contributions to the life history of adult Pacific lamprey (*Lampetra tridentata*) in the Santa Clara River of southern California. Bulletin of the Southern California Academy of Sciences 100(2):74–85.

CMWD. 2008. 2008 Annual progress report for the Robles Diversion Fish Passage Facility. Casitas Municipal Water District, Oak View, CA.

Haner, Philip V., J.C. Faler, R.M. Shrock, D.W. Rondorf, and A. G. Maule. 1995. Skin reflectance as a nonlethal measure of smoltification for juvenile salmonids. North American Journal of Fisheries Management 15: 814 - 822.

Myrick, C. A., and J. J. Cech, Jr. 2000. Temperature influences on California rainbow trout physiological performance. Fish Physiology and Biochemistry 22(3):245–254.

Myrick, C. A. and J. J. Cech, Jr. 2001. Bay-Delta Modeling Forum. Technical publication 01-1. Temperature effects on Chinook salmon and steelhead: a review focusing on California's Central Valley populations.

National Marine Fisheries Service. 1997. Endangered and Threatened Species: Listing of Several Evolutionary Significant Units (ESUs) of West Coast Steelhead. Federal Register, 50 CFR Parts 222 and 227 [Docket No. 960730210–7193–02; I.D. 050294D] RIN 0648–XX65. Vol. 62, page 43937.

National Marine Fisheries Service. 2003. Endangered and Threatened Species: Range Extension for Endangered Steelhead in Southern California. Federal Register, 50 CFR Part 224 [Docket No. 001025296-2079-02; I.D. 072600A] RIN 0648-AO05. Vol. 67 page 21586.

National Marine Fisheries Service. 2006. Endangered and Threatened Species: Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead. Federal

Register, 50 CFR Part 223 and 224 [Docket No. 051216341–5341–01; I.D. No. 052104F] RIN 0648–AR93. Vol. 71 page 834-862.

Rehmel, M. 2007. Application of Acoustic Doppler Velocimeters for Streamflow Measurements. Journal of Hydraulic Engineering. DOI: 10.1061/(ASCE)0733-9429(2007)133:12(1433)

Swift, C. C., and S. R. Howard. 2009. Current Status and Distribution of the Pacific Lamprey South of Point Conception, Coastal Southern California, USA. American Fisheries Society Symposium 72:269-278.

Thomas R. Payne and Associates (TRPA). 2005. Assessing passage of steelhead over riffles in the lower Santa Clara River. Draft Final Report. 31 pp.

Wedemeyer, G.A. 1996. Physiology of Fish in Intensive Culture Systems. Chapman and Hall, New York, New York.

Appendix A

Tables and Figures

Table 1 - Freeman Diversion Operations and Steelhead Monitoring Data

January

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Ladder Operation																															
Smolt Trapping																															
Smolts																															
Adult Steelhead																															
Steelhead Kelt																															
Turbidity (ntu)																		14.4	12.5	89	603	93.5	579	71.4	50.9	45.9	52.4	82	50.4	43	36.6
Estuary	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed

February

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Ladder Operation																													
Smolt Trapping																													
Smolts																													
Adult Steelhead																													
Steelhead Kelt																													
Turbidity (ntu)	37.1	36.2	34.3	25.9	32	29.6	41.4	32	28.1	22.2	21.3	17.5	20.9	23.1	23.3	22.8	17.8	17.3	15.9	15.1	12.3	13.2	9.63	9.38	7.17	7.57	11.1	8.74	8.14
Estuary	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed

March

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Ladder Operation																															
Smolt Trapping																															
Smolts																						1		1			1	1		1	
Adult Steelhead																															
Steelhead Kelt																															
Turbidity (ntu)	6.92	7.66	5.97	3.43	4.83	4.35	4.03	4.98	3.95	3.93	3.87	3.94	23.8	24.7	8.27	82.9	5.18	14.1	73.8	50.7	38.2	31.6	31	55.3	340	288	80	52	51.7	51.7	51.7
Estuary	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open

April

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ladder Operation																														
Smolt Trapping																														
Smolts	1	2											7						1			1	2	3	1		3			2
Adult Steelhead															1	1														
Steelhead Kelt					1																									
Turbidity (ntu)	51.7	51.7	51.7	51.7	51.7	37.6	8.79	8.2	6.85	83.1	215	211	753	272	104	57.5	39.7	33.2	25.9	20.2	16.4	13.2	13.1	10.9	9.71	16.5	9.69	8.55	8.47	8.97
Estuary	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed

May

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Ladder Operation																															
Smolt Trapping																															
Smolts			1																												
Adult Steelhead																															
Steelhead Kelt																															
Turbidity (ntu)	11.8	12.3	10.5	9.72	10.7	9.44	8.86	8.08	7.24	6.21	5.93	5.57	7.16	6.96	5.64	8.57	89.7	12.2	6.99	9.14	19.4	15	13.6	9.08	12.1	14.2	9.68	11.2	6	7.39	11.6
Estuary	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed

*Blank cells mean no activity or no data collected on that day

Table 1 Continued - Freeman Diversion Operations and Steelhead Monitoring Data

June

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ladder Operation																														
Smolt Trapping																														
Smolts												1				1														
Adult Steelhead																														
Steelhead Kelt																														
Turbidity (ntu)	5.1	5.82	4.78	4.63	4.04	4.3	4.4	4.55	3.85	4.22	3.93	5.23	3.81	3.84	3.81	7.69	3.58	2.64	3.36	5.37	4.52	4.01	3.67	3.35	4.88	4.33	3.67			
Estuary	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed

July

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Ladder Operation																															
Other Monitoring																															
Smolts																															
Adult Steelhead																															
Steelhead Kelt																															
Turbidity (ntu)																															
Estuary	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed

August

	1	2	3	4	5–31
Ladder Operation					End Of Monitoring Season
Other Monitoring					
Smolts					
Adult Steelhead					
Turbidity (ntu)					
Estuary	Closed	Closed	Closed	Closed	

*Blank cells mean no activity or no data collected on that day

Table 2 - Santa Clara River Fish Species

Common Name	Scientific Name	Status	Resident - Anadromous	Regulatory Status
Tidewater Goby	*Eucyclogobius newberryi*	Native	Resident	FE, DFG: SSC
Partially Armored Stickleback	*G. a. microcephalus*	Native	Resident	--
Unarmored Stickleback	*G.a. williamsoni*	Native	Resident	FE, SE, DFG: FP
Arroyo Chub	*Gila orcuttii*	Native	Resident	DFG: SSC
Pacific Lamprey	*Entosphenus tridentatus*	Native	Anadromous	--
Rainbow Trout	*Oncorhynchus mykiss*	Native	Resident	--
Steelhead Trout	*Oncorhynchus mykiss irideus*	Native	Anadromous	FE, DFG: SSC
Black Bullhead	*Ameiurus melas*	Introduced	Resident	--
Brown Bullhead	*Ameiurus nebulosus*	Introduced	Resident	--
Santa Ana Sucker	*Catostomus santaanae*	Introduced*	Resident	*FT, DFG: SSC
Owens Sucker	*Catostomus fumeiventris*	Introduced	Resident	**DFG: SSC
Hybrid Sucker	*C.santaanae x C. fumeiventris*	Introduced	Resident	--
Prickly Sculpin	*Cottus asper*	Introduced	Resident	--
Common Carp	*Cyprinus carpio*	Introduced	Resident	--
Goldfish	*Carassius auratus*	Introduced	Resident	--
Threadfin Shad	*Dorosoma petenense*	Introduced	Resident	--
Mosquitofish	*Gambusia affinis*	Introduced	Resident	--
Channel Catfish	*Ictalurus punctatus*	Introduced	Resident	--
Green Sunfish	*Lepomis cyanellus*	Introduced	Resident	--
Bluegill	*Lepomis macrochirus*	Introduced	Resident	--
Mississippi Silverside	*Menidia audens*	Introduced	Resident	--
Largemouth Bass	*Micropterus salmoides*	Introduced	Resident	--
Fathead Minnow	*Pimephales promelas*	Introduced	Resident	--
Black Crappie	*Pomoxis nigromaculatus*	Introduced	Resident	--
White Crappie	*Pomoxis annularis*	Introduced	Resident	--
Brown Trout	*Salmo trutta trutta*	Introduced	Resident	--

FE = Federally Endangered Species; FT = Federally Threatened Species; SE = State Endangered Species; DFG: FP = California Department of Fish and Game - Fully Protected Species; DFG: SSC = California Department of Fish and Game - Species of Special Concern.

*Santa Ana Sucker is listed as FT and DFG:SSC in its native drainage; this does not include the Santa Clara River.

**Owens Sucker is listed as DFG: SSC in its native drainage; this does not include the Santa Clara River.

Table 4 - Freeman Diversion Fish Monitoring Species Totals 2012

Fish Species: **STK** = Steelhead Adult Kelt, **ST =** Steelhead Adult**, RS =** Smolt**, RT =** Resident Rainbow**, YOY** = Young of the Year *O. mykiss* , **PL (Adult) =** Lamprey Adult**, PL (Am) =** Lamprey Ammocoete**, TS =** Stickleback**, AC =** Arroyo Chub**, SS =** Santa Ana Sucker**, OS =** Owens Sucker**, SSxOS =** Sucker Hybrid**, FM =** Fathead Minnow**, LB =** Largemouth Bass**, GS =** Green Sunfish**, BB=** Brown Bullhead**, BC =** Black Bullhead**, PS =** Prickly Sculpin**, MF =** Mosquitofish

Amphibian & Reptile Species: WT = Western Toad, **AT** = Arroyo Toad, **SFT** = Spadefoot Toad, **BF** = Bullfrog, **CRLF** = Red-legged Frog, **PT** = Pond Turtle, **AF** = African Clawed Frog, **TF** = Tree Frog

	Native Fishes									Non-native Fishes									
	STK	ST	RS	RT	YOY	PL (Adult)	PL (Am)	TS	AC	SS	OS	SS x OS	FM	LB	GS	BB	CC	PS	MF
Total	1	2	31	5	59	0	0	1694	4686	2920	126	128	1735	0	13	8	536	261	37

	Amphibians and Reptiles							
	WT	AT	SFT	CRLF	BF	AF	TF	PT
Total	24	0	0	0	1516	101	28	6

Biologists: Mike Booth, Steve Howard **Fish Technicians:** Chris In, Monica Jacinto, Dan Pankau, Stephen Pfeiler, Dave Wilson

Table 5 - Santa Clara River Reptile and Amphibian Species

Common Name	Scientific Name	Status	Regulatory Status
Two-striped Garter Snake	*Thamnophis couchi hammondi*	Native	DFG: SSC
Southwestern Pond Turtle	*Clemmys marmorata pallida*	Native	DFG: SSC
Red-earred Slider	*Chrysemys scripta elegans*	Introduced	--
California Treefrog	*Hyla cadaverina*	Native	--
Pacific Treefrog	*Hyla regilla*	Native	--
Western Toad	*Bufo boreas*	Native	--
Bullfrog	*Rana catesbeiana*	Introduced	--
African Clawed Frog	*Xenopus laevis*	Introduced	--
DFG: SSC = California Department of Fish & Game - Species of Special Concern			

Table 6. Steelhead Bypass Flow Monitoring

Date	Daily Average Diversions	*Total River Flow Below the Freeman (cfs) "this equals all flow measured below the diversion dam"*	*Critical Riffle Flow (cfs) (~5.0 miles downstream of Freeman)*	Surface Water Loss to Groundwater (Between Freeman at Critical Riffle Site)	Crit Rif Target	Notes
3/17/2012	0	**ND**	**ND**	ND	160	Storm resulted in turn-out. Adult flows triggered
3/18/2012	0	**ND**	**205.0**	ND	160	Can't maintain adult flows tomorrow. Flows receding rapidly. Ladder not operated to direct smolts to trap.
3/19/2012	21	**179.3**	**98.2**	81.1	80-120	Turned in 40 cfs at ~11:00AM. Remaining flow to river
3/20/2012	54	**70.1**	**13.4**	56.8	1/3rd ramp down	Turn in 20 additional cfs
3/21/2012	63	**63.2**	**ND**	ND	1/3rd ramp down	Closed the aux gate 50 % following flow measurement.
3/22/2012	71	**18.2**	**ND**	ND	1/3rd ramp down	
3/23/2012	68	**20.0**	**0.0**	ND	20	Bridge gap between storms w/ 20 cfs
3/24/2012	67	**20.0**	**0.0**	ND	20	Bridge gap between storms w/ 20 cfs
3/25/2012	67	**ND**	**ND**	ND	160	New storm resulted in turn-out
3/26/2012	51	**ND**	**ND**	ND	160	Turned in at 7:30 AM
3/27/2012	60	**188.1**	**108.7**	79.4	80-120	Reduced diversion (from 70 to 40 cfs). Can't maintain 160 cfs downstream even with no diversions.
3/28/2012	41	**162.2**	**63.3**	98.9	80-120	
3/29/2012	43*	**105.3**	**33.3**	72.0	1/3rd ramp down	
3/30/2012	78*	**77.8**	**ND**	ND	1/3rd ramp down	
3/31/2012	102*	**37.5**	**ND**	ND	1/3rd ramp down	
4/1/2012	124*	**12.9**	**ND**	ND	20	
4/2/2012	106*	**ND**	**ND**	ND	0	End of bypass flows for this storm
4/13/2012	58.65	**ND**	**ND**	ND	160	
4/14/2012	220.74	**ND**	**ND**	ND	160	
4/15/2012	128.95	**174.7**	**105.1**	69.7	160	
4/16/2012	40.05	**219.6**	**143.9**	75.7	160	Flow receding rapidly
4/17/2012	41.39	**193.4**	**115.9**	77.5	80-120	Can't maintain 160 cfs even with no diversions. Flow receding rapidly
4/18/2012	46.40	**189.9**	**ND**	ND	80-120	
4/19/2012	44.36	**201.3**	**99.8**	101.5	80-120	
4/20/2012	63.99	**167.1**	**73.6**	93.5	80-120	Starting 1/3rd bypass flow ramp-down
4/21/2012	97.20	**65.5**	**ND**	ND		1/3rd bypass flow ramp down
4/22/2012	93.82	**33.3**	**ND**	ND		1/3rd bypass flow ramp down
4/23/2012	91.49	**30.0**	**ND**	ND		~20 cfs bypass. We will bridge storm gap with 20 cfs.
4/24/2012	93.35	**20.0**	**ND**	ND		
4/25/2012	97.49	**20.0**	**ND**	ND		
4/26/2012	107.56	**0.0**	**ND**	ND		New storm did not trigger bypass flows. 20 cfs "bridge the gap" flow now diverted

* Instantaneous measurements in morning. SCADA system malfunctioned eliminating continuous flow data collection.

Table 7 - Fish stranding survey results

Stranding Survey Location	Adult Steelhead	Smolts	Resident *O. mykiss*	Young-of-the-year (YOY)	Total
Freeman Fish Screen Bay	0	6	3	1	10
Fish Ladder	0	0	0	0	0

Table 8. Temperature monitoring sites

Location	Logger #	Date deployed	Max Depth	Logger depth (ft from bottom)	Habitat Type	Photo
Freeman Fish Trap Bay	1269160	5/16/2008	3.0	1.0	pool	10
Freeman Fish Screen Bay	1269166	12/8/2008	2.5	0.5	pool	11
Santa Clara River at VCWPD Project	2270563	1/11/12	3.5	2.0	pool	12
Santa Clara River at VCWPD Project side channel	9947131	8/01/12	3.5	0.6	pool	13
Santa Paula Creek upstream of Harvey Diversion	2270574	1/13/12	0.9	0.3	riffle	14
Santa Paula Creek at Steckel Park	1269161	3/27/08	1.8	0.2	pool	15
Santa Paula Creek directly downstream of Sisar Creek confluence	2250248	1/16/2009	2.25	0.7	pool	16
Sespe Creek at Grand Avenue	2270588	1/11/12	1.5	0.5	pool	17

Table 9. Water temperature statistics by monitoring site.

Location	Max Temp (°C)	Date Max Temp	Min Temp (°C)	Date Min Temp	Mean Temp (°C)
Freeman Fish Trap Bay	27.6	5/23/12	7.4	3/19/12	16.1
Freeman Fish Screen Bay	28.5	4/4/12	1.9	3/19/12	16.7
Santa Clara River at VCWPD Project	23.6	5/23/12	9.4	4/14/12	16.1
Santa Clara River at VCWPD Project side channel	18.9	8/11/12	16.3	8/2/12	17.6
Santa Paula Creek upstream of Harvey Diversion	30.5	8/11/12	7.2	1/19/12	16.4
Santa Paula Creek at Steckel Park	24.7	8/13/12	7.2	12/23/11	15.4
Santa Paula Creek directly downstream of Sisar Creek confluence	21.7	7/25/11	8.5	12/23/11	15.2
Sespe Creek at Grand Avenue	31.4	8/11/12	6.6	1/19/12	18.0

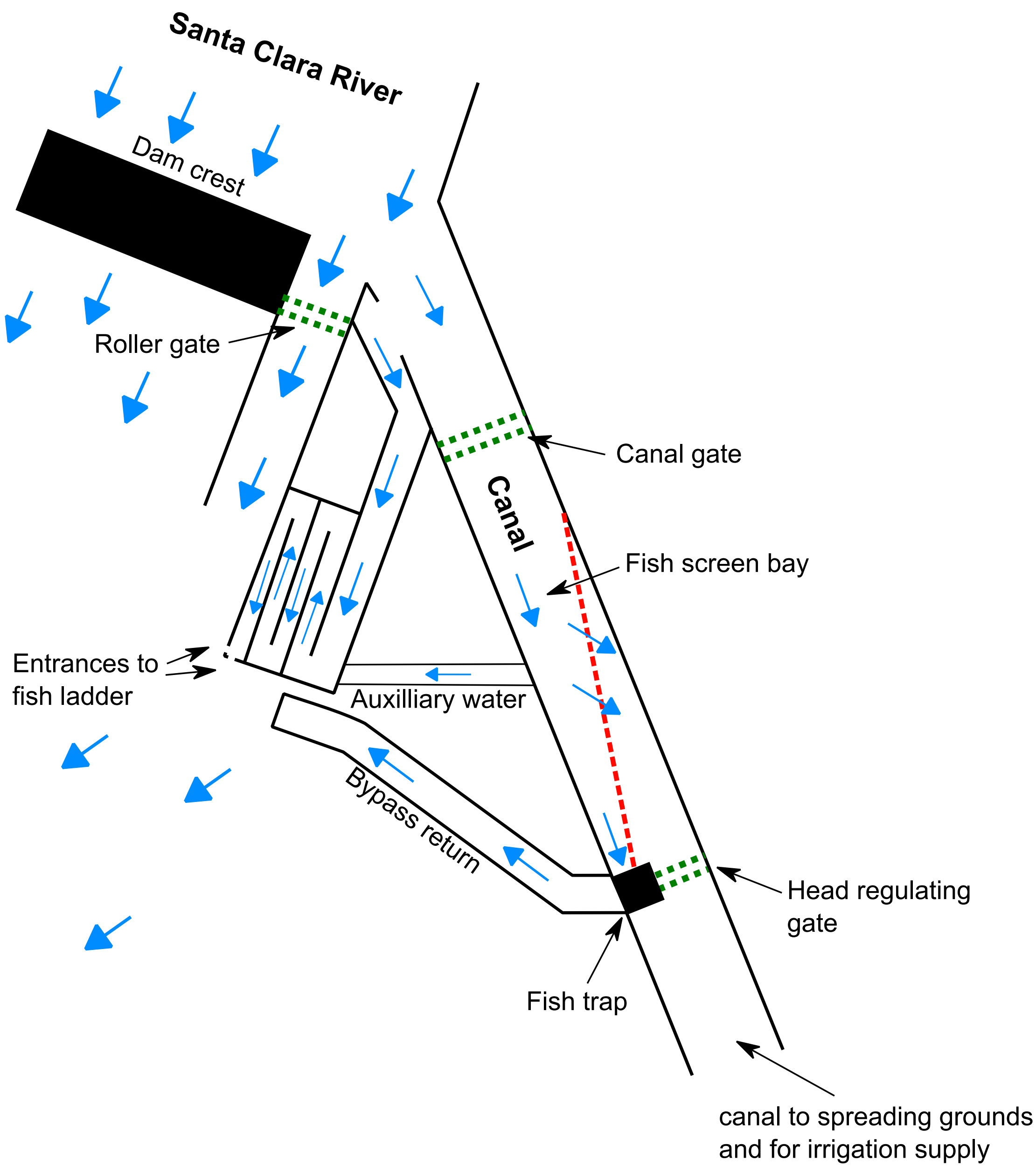


Figure 1. Schematic of Freeman Diversion Facility

Figure 2 - Daily Rainfall Totals in Santa Paula, CA

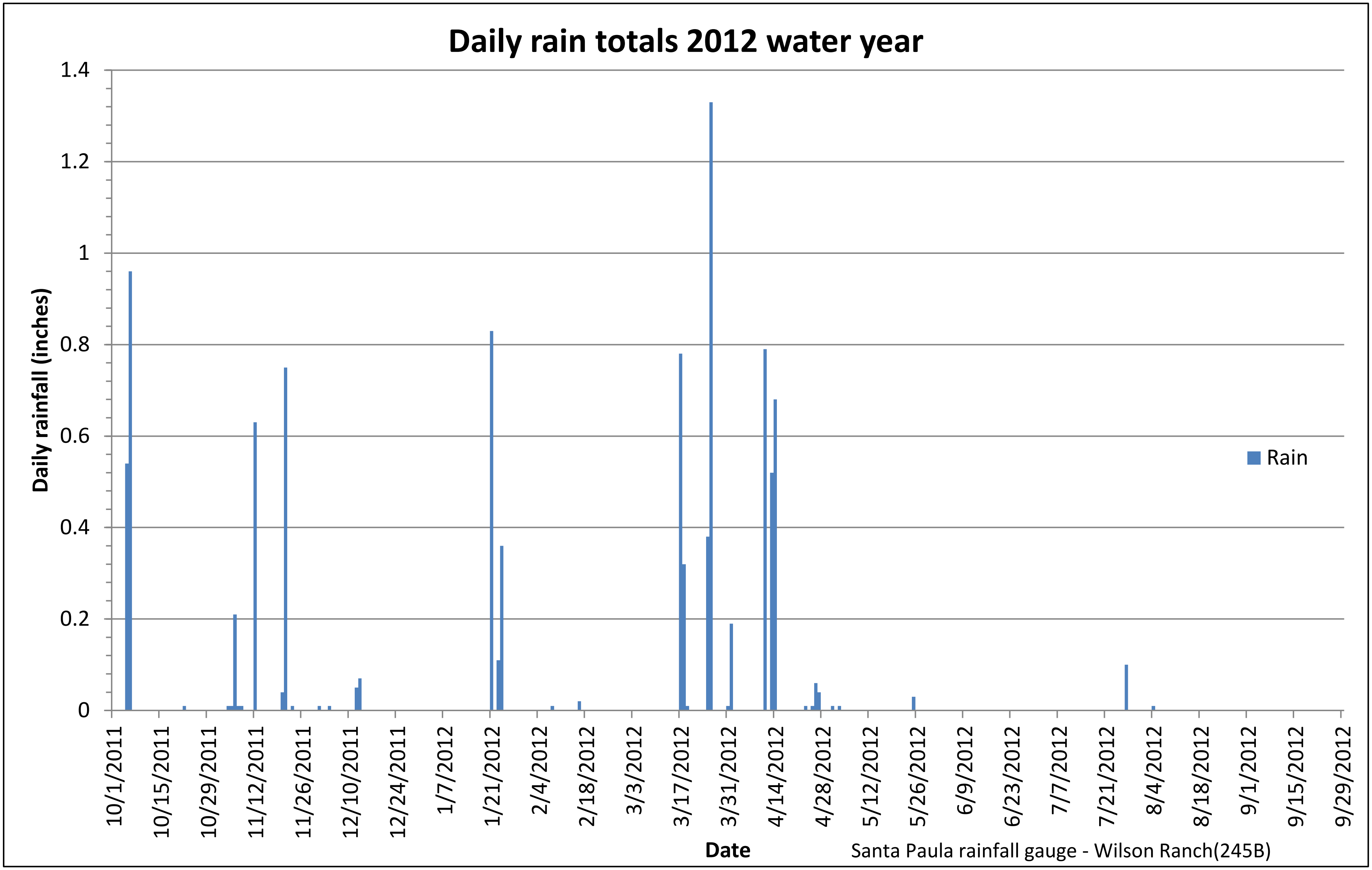


Figure 3 - Steelhead monitoring results

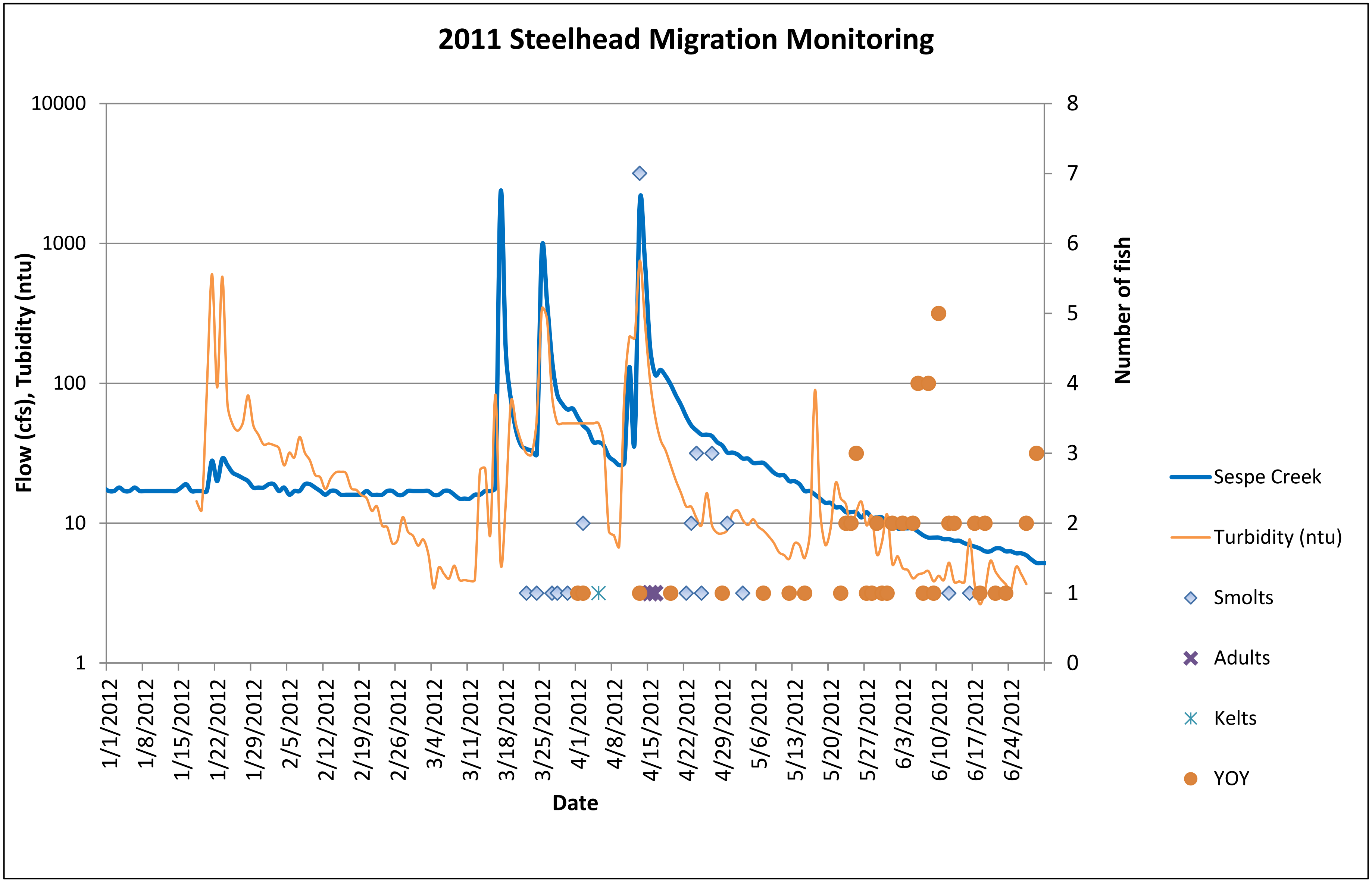


Figure 4 - Steelhead Length Frequency Histogram

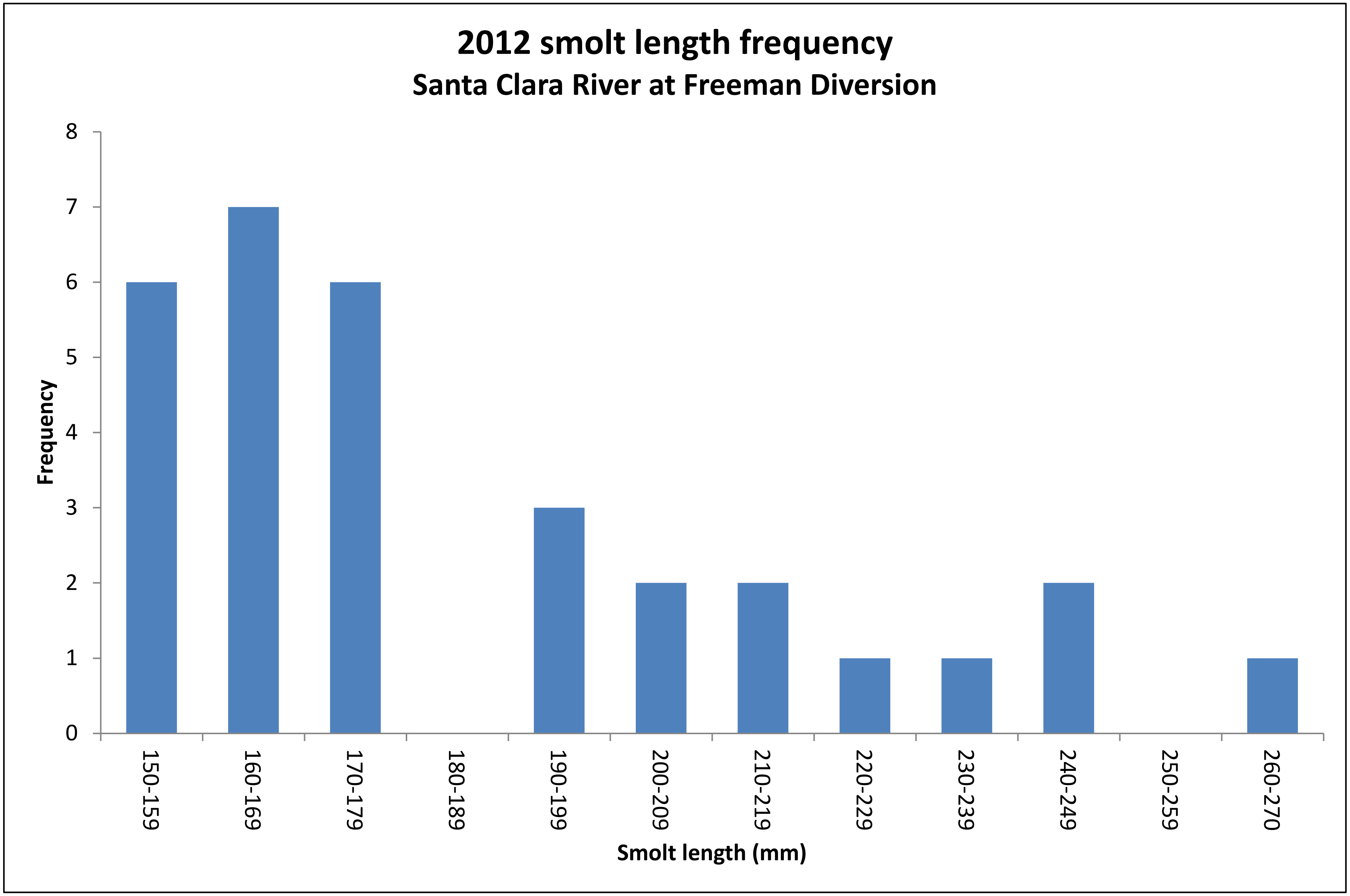
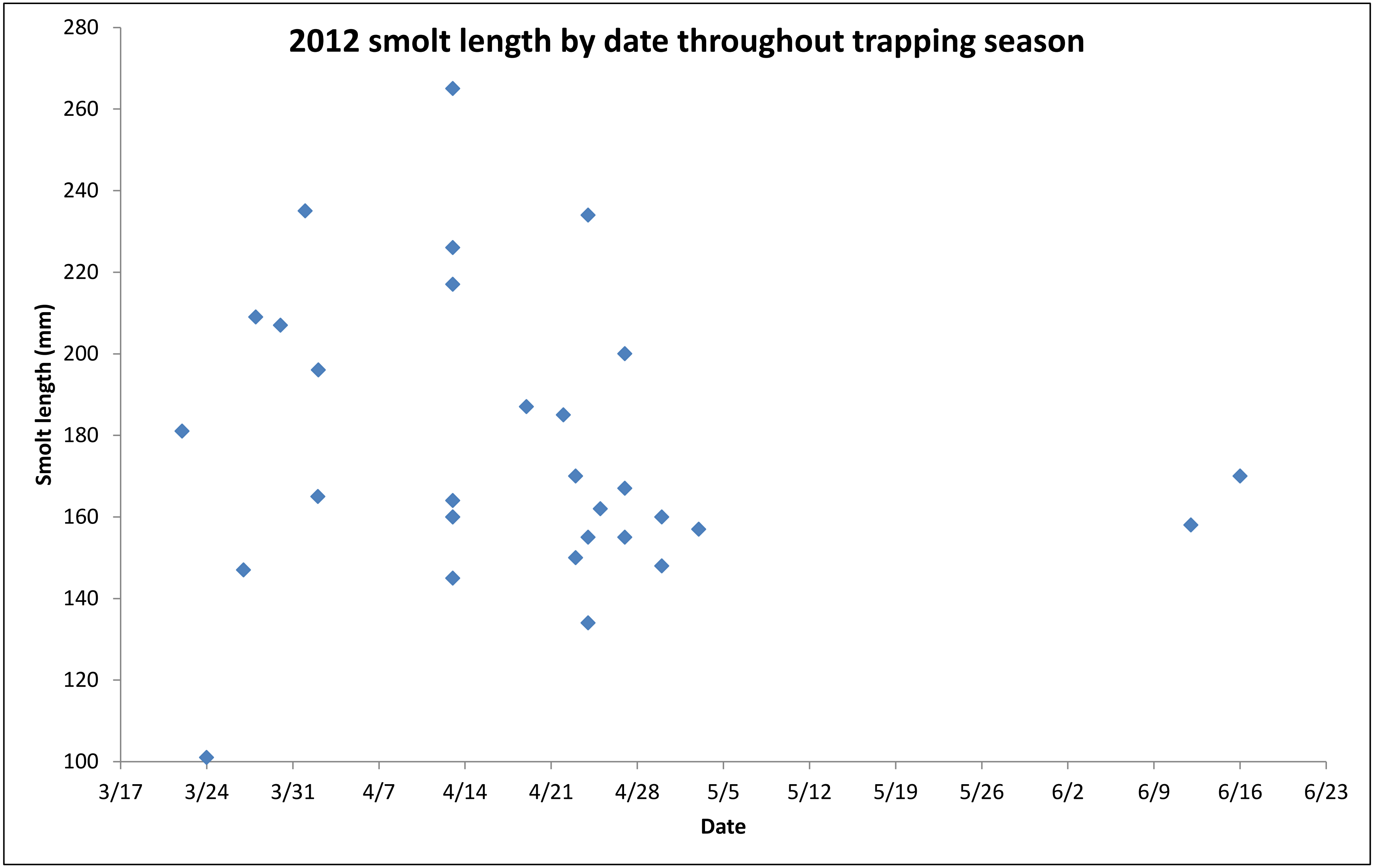


Figure 5 - Steelhead Lengths by Date



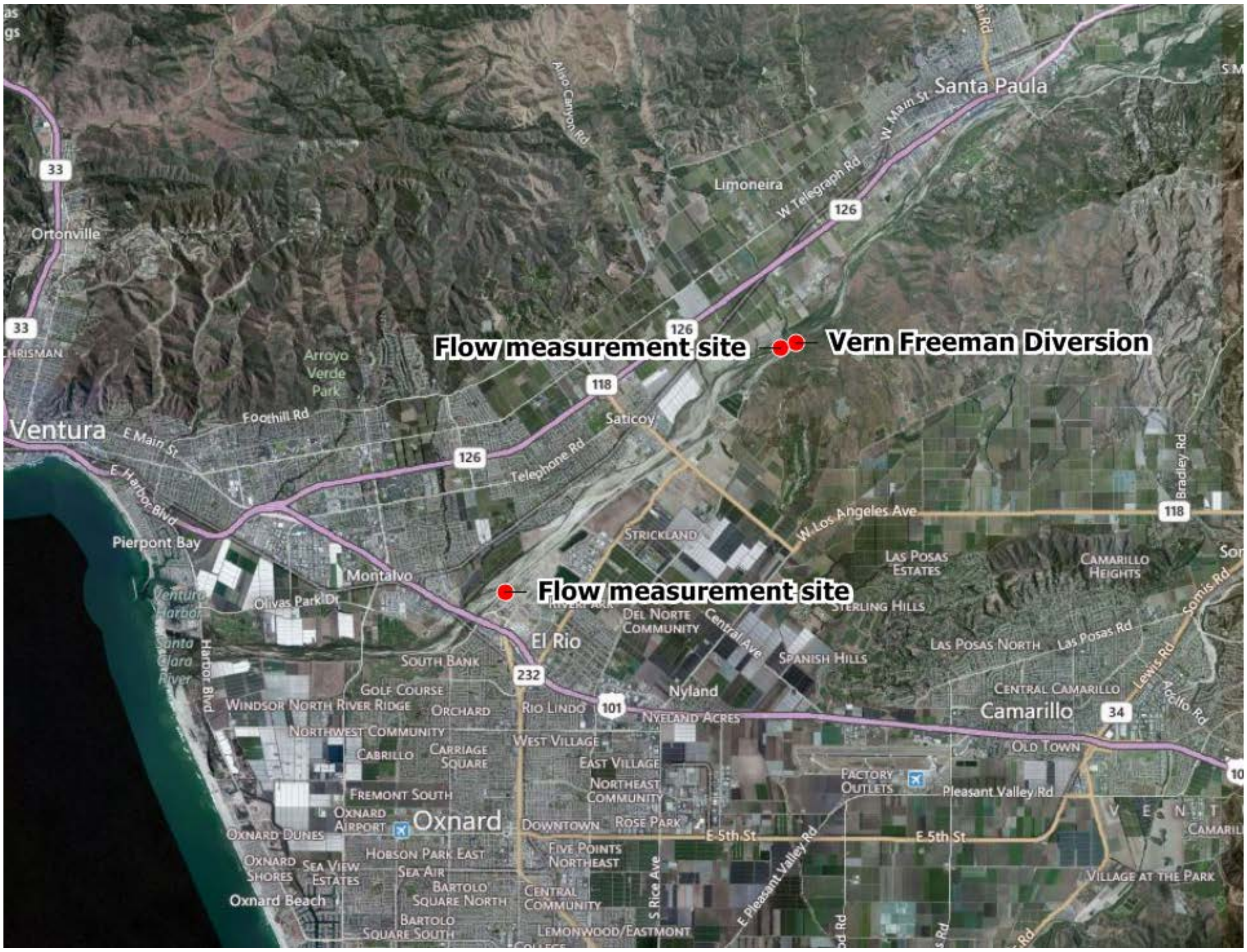


Figure 6. Freeman bypass flow monitoring sites below the Freeman Diversion

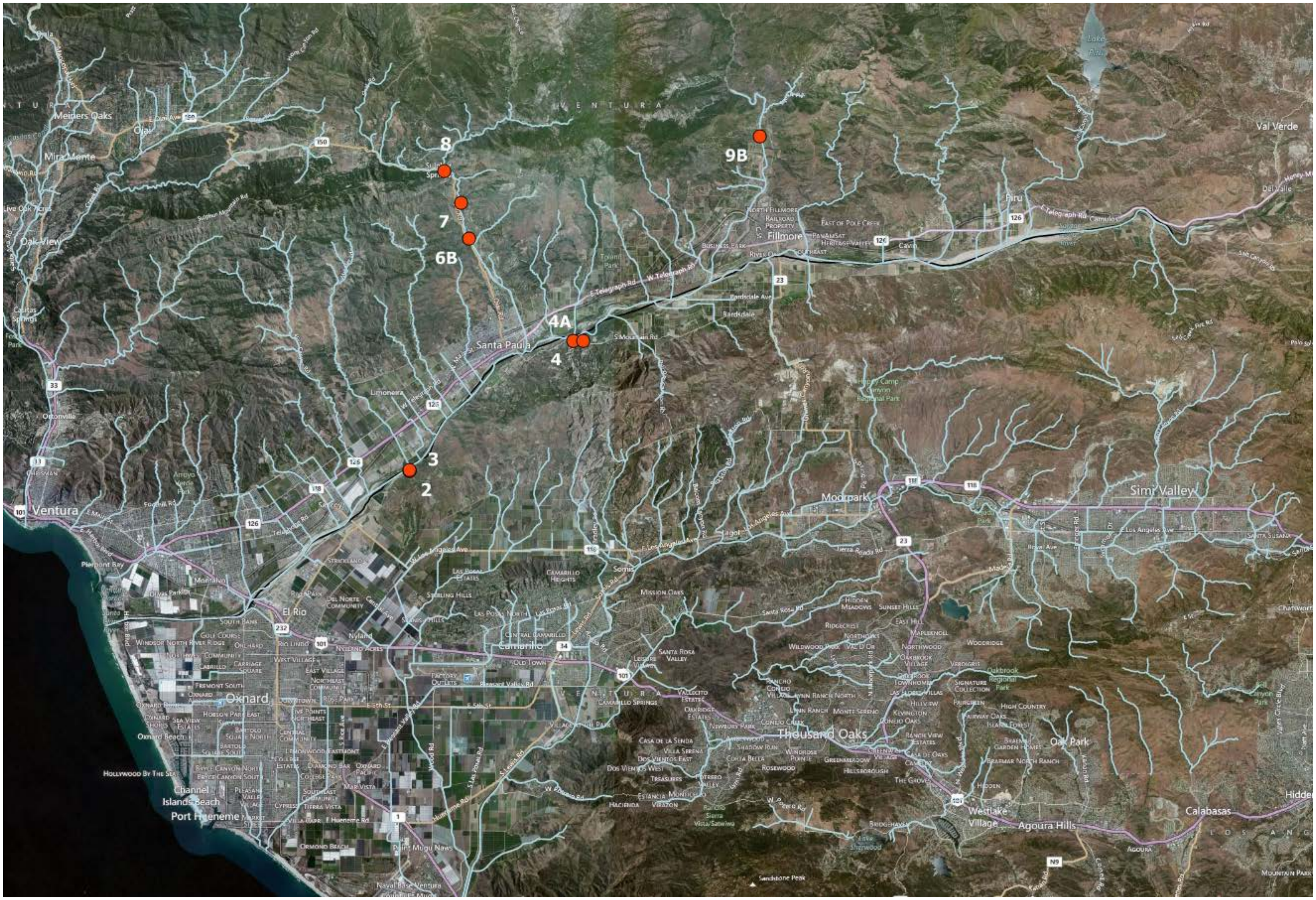


Figure 7. Water temperature monitoring sites within the Santa Clara River watershed.

Figure 8. Freeman fish trap bay water temperature

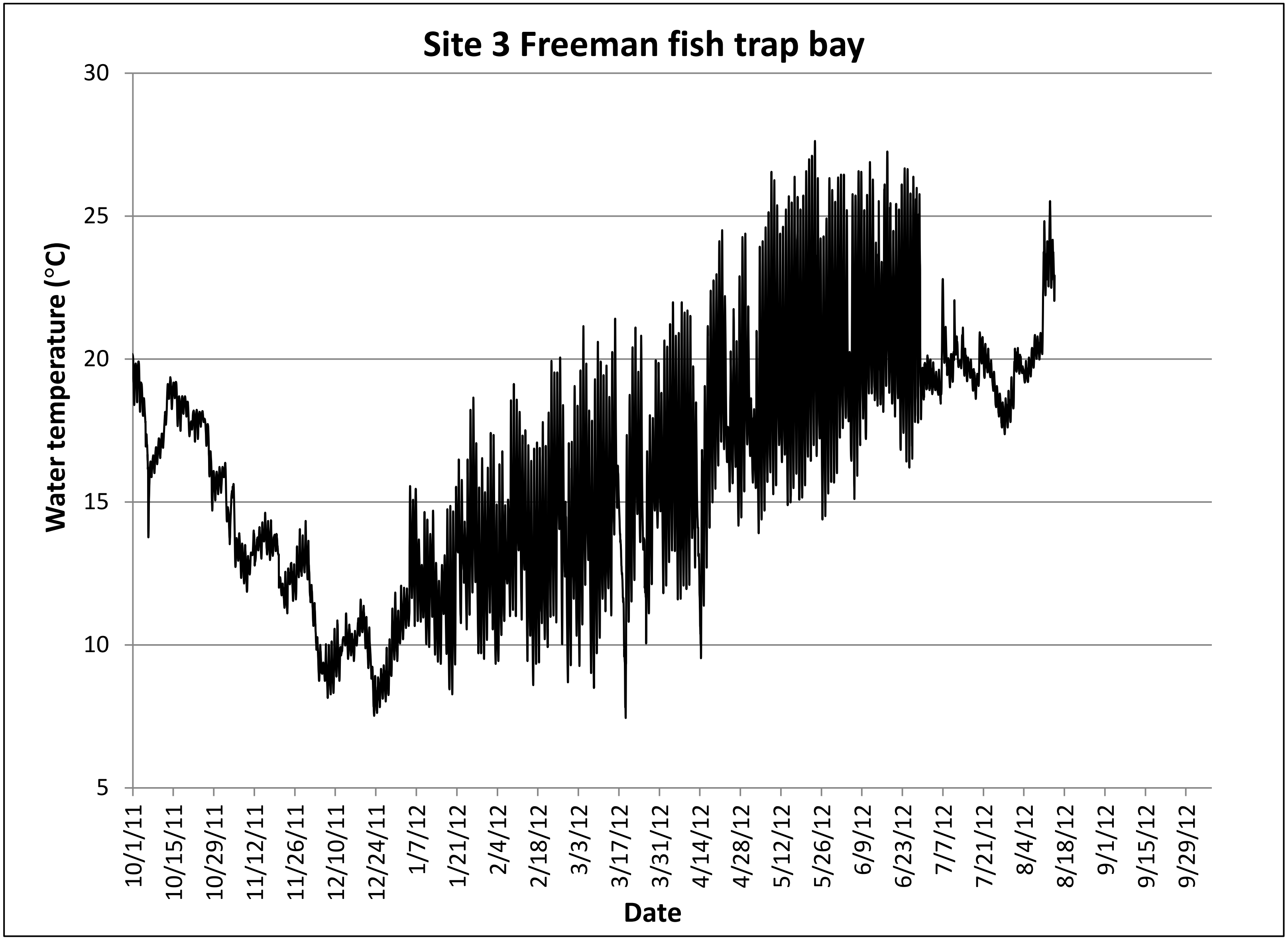


Figure 9. Freeman fish screen bay water temperature

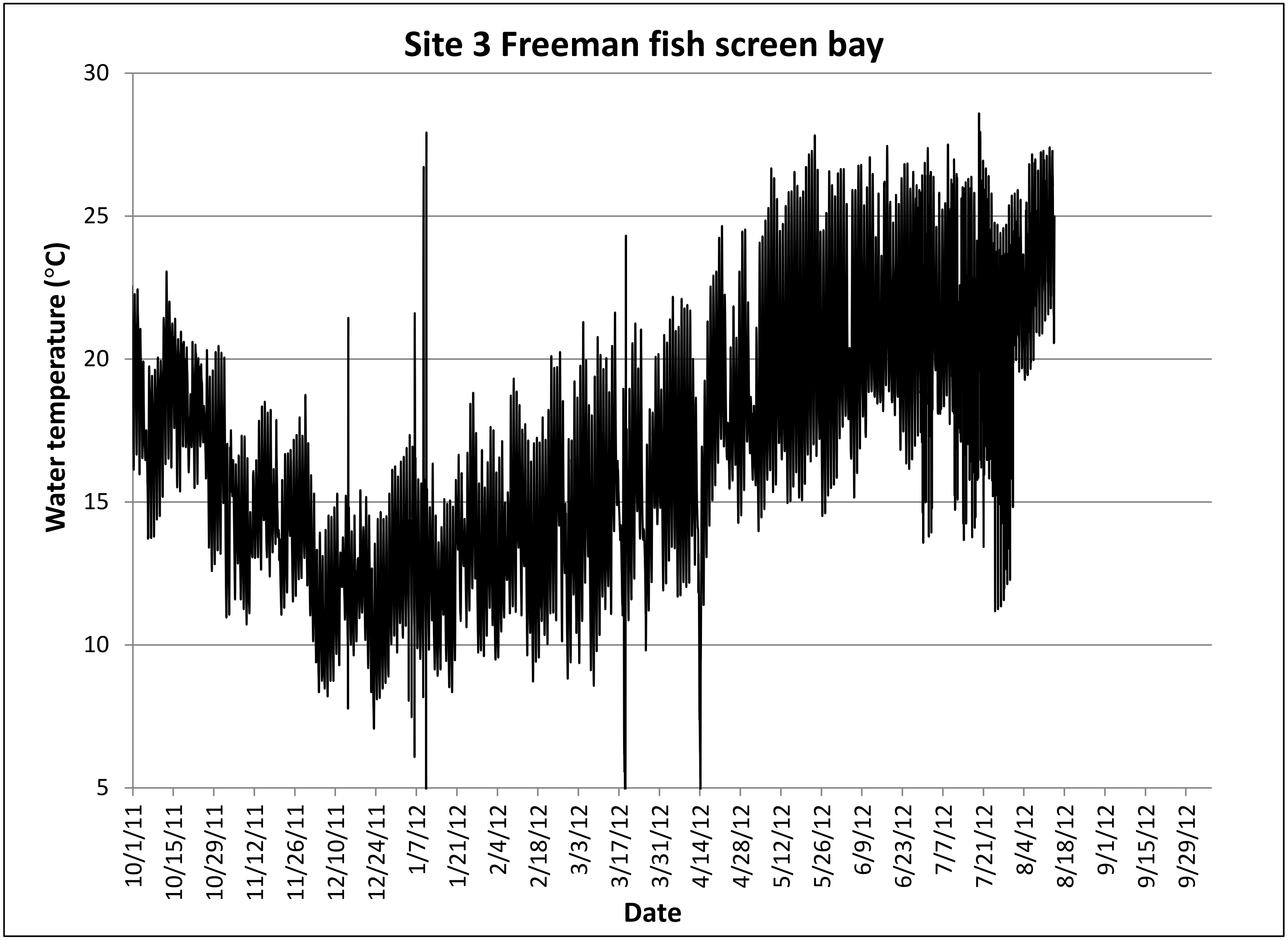


Figure 10. Santa Clara River at Ventura county bank stabilization project

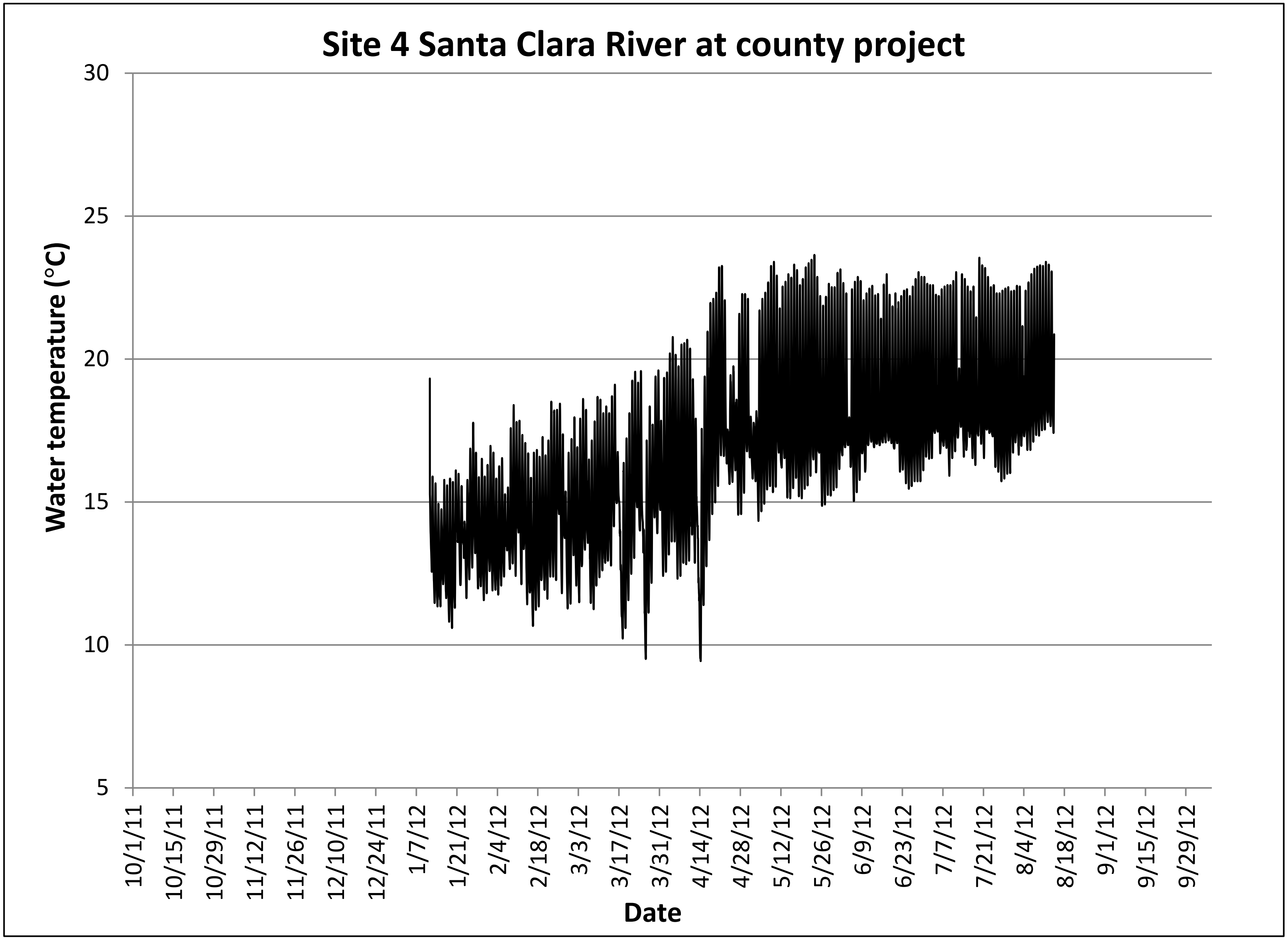


Figure 11. Santa Clara River side channel at Ventura county bank stabilization project

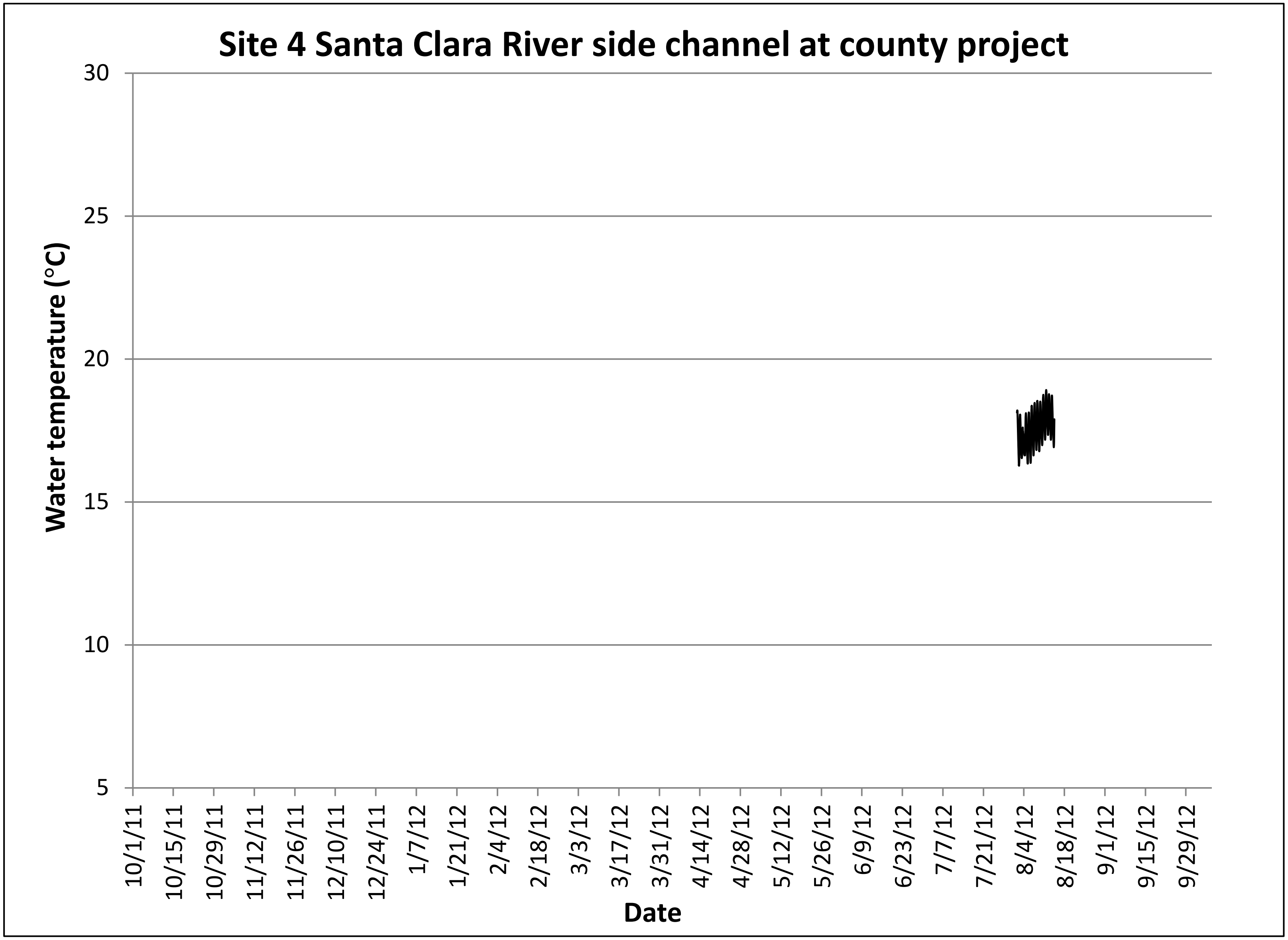


Figure 12. Santa Paula Creek upstream of Harvey diversion

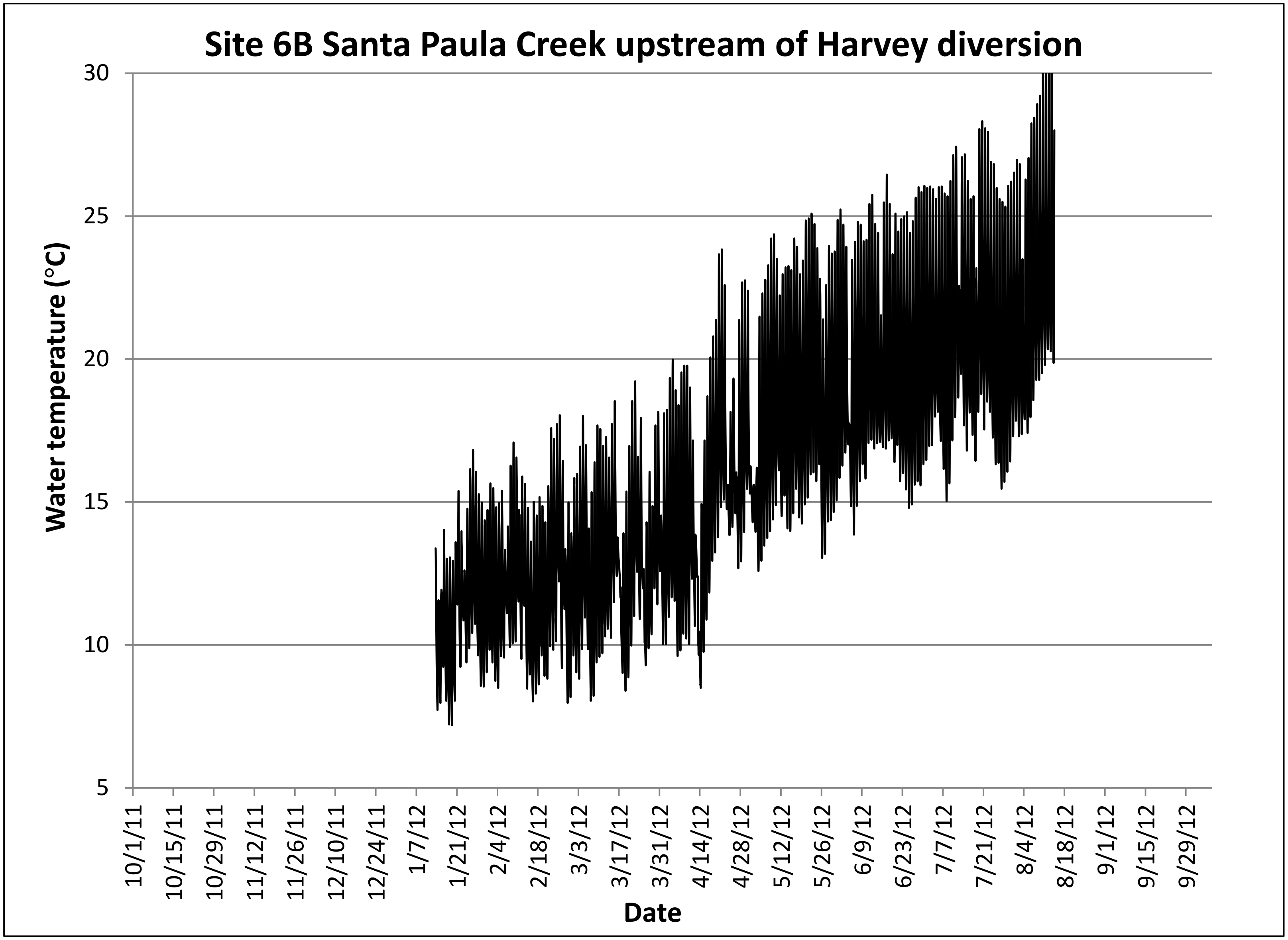


Figure 13. Santa Paula Creek at Steckel Park

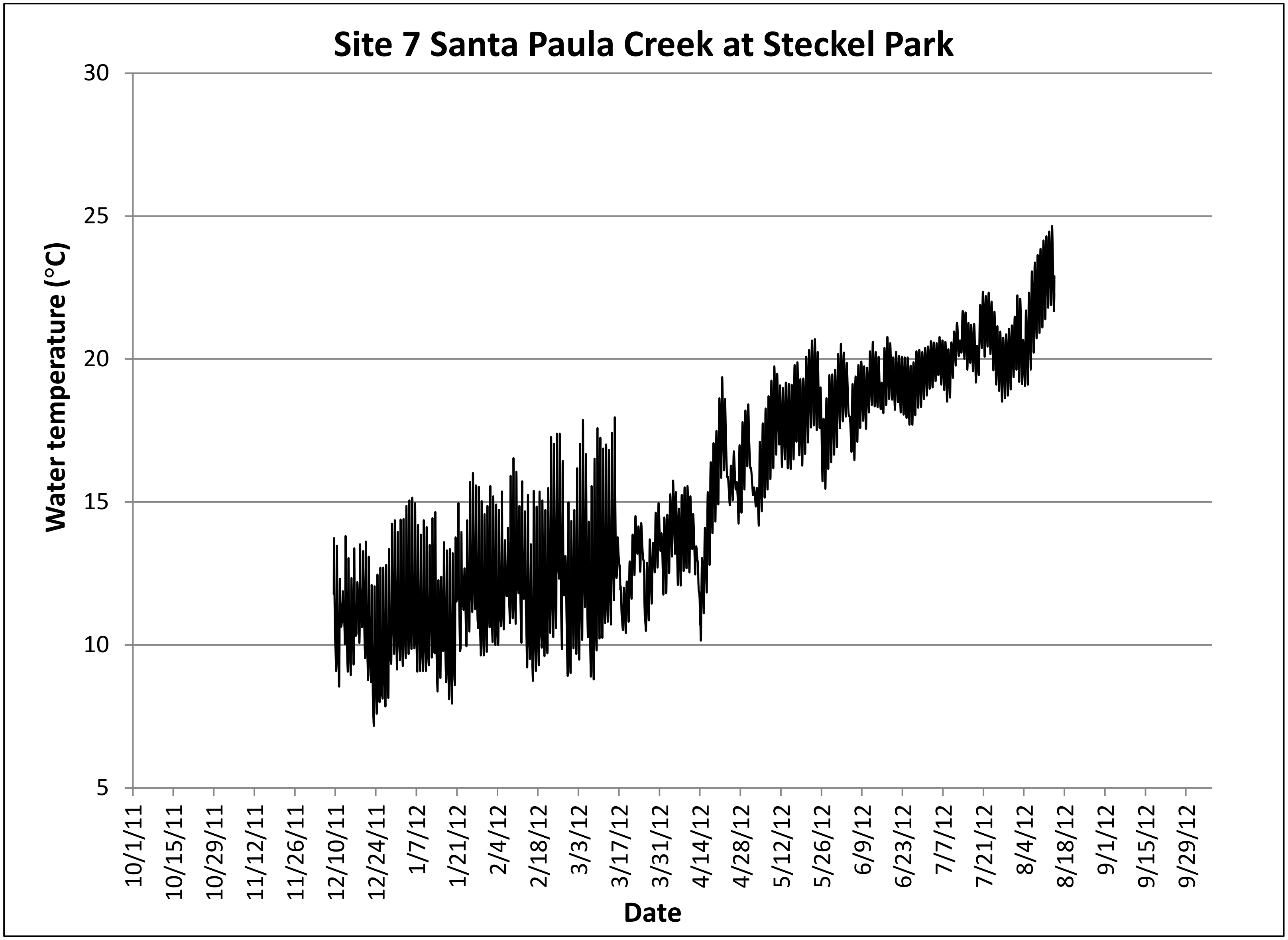


Figure 14. Santa Paula Creek at confluence with Sisar Creek

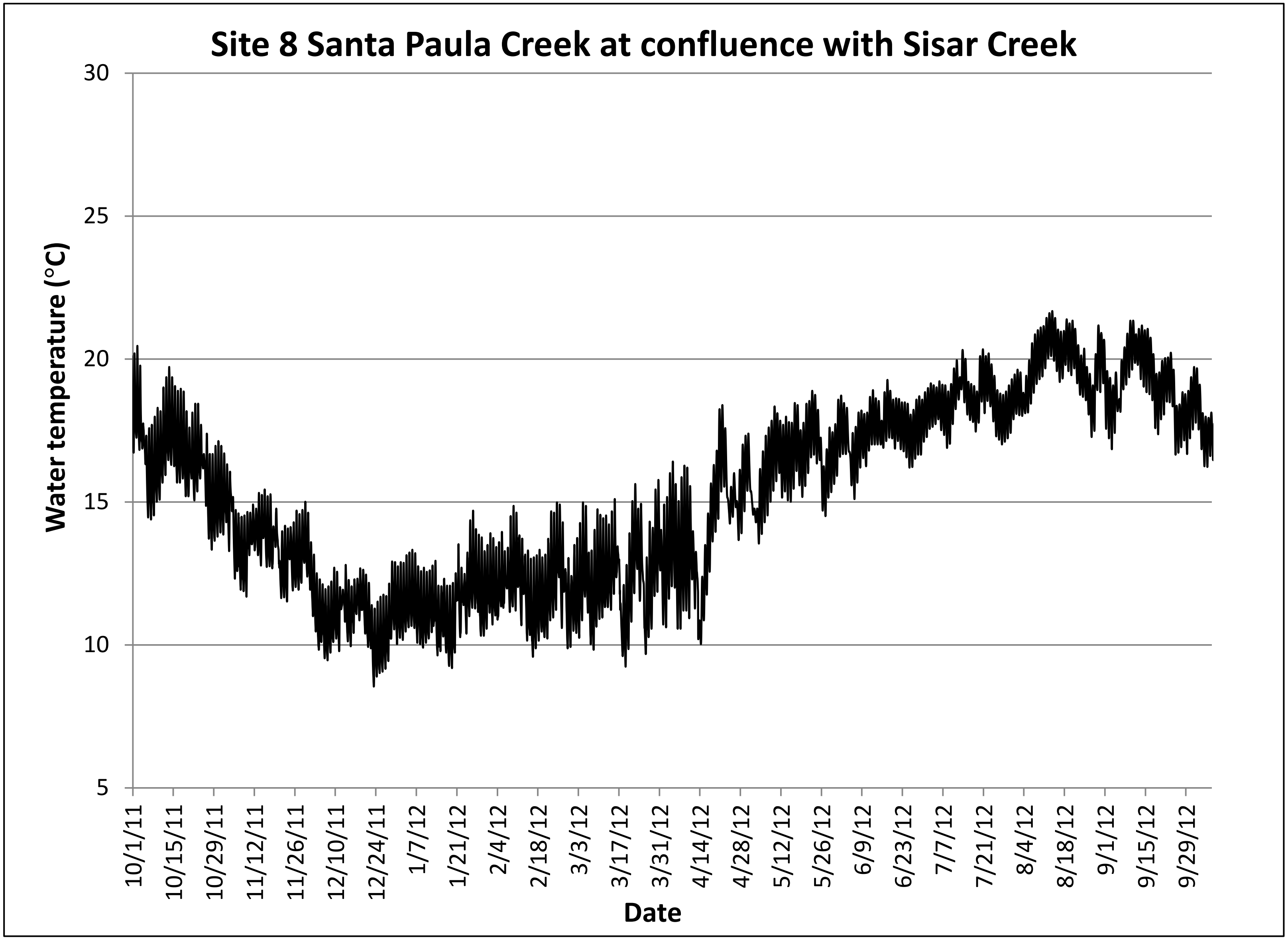
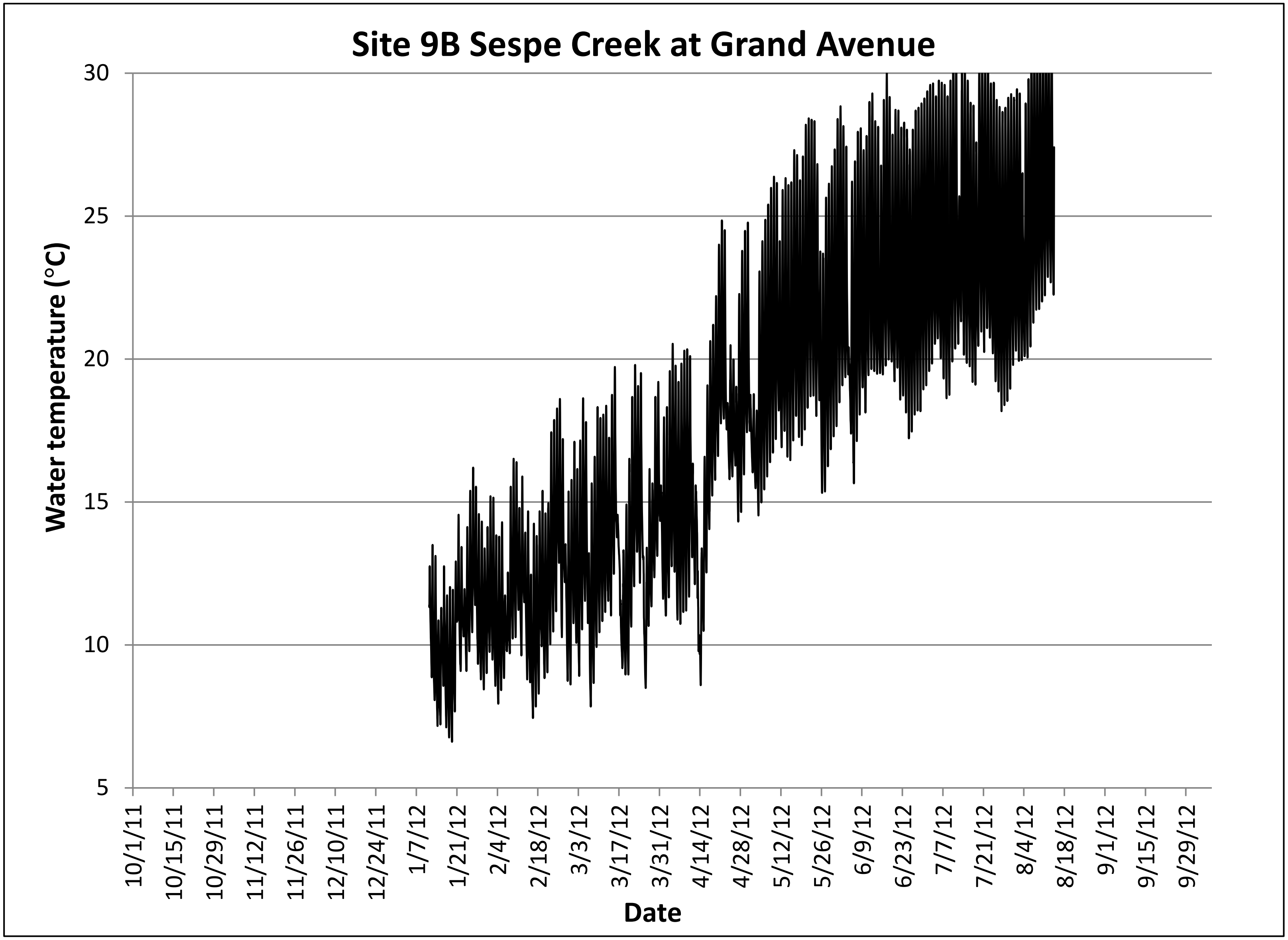


Figure 15. Sespe Creek at Grand Avenue



Appendix B

Photos

Photo 1. Santa Clara River estuary release site open

Photo 2. Santa Clara River steelhead smolt length measurement

Photo 3. Santa Clara River steelhead smolt

Photo 4. Resident rainbow trout.

Photo 5. Adult steelhead passing the false weir April 15, 2012

Photo 6. Upstream migration monitoring infrared scanners

Photo 7. Upstream migration monitoring surveillance system.

Photo 8. Polaris UTV and DIDSON trailer mount

Photo 9. Fish screen bay stranding survey

Photo 10. Fish trap bay water temperature monitoring site

Photo 11. Fish screen bay water temperature monitoring site

Photo 12. VCWPD project water temperature monitoring site

Photo 13. VCWPD project side channel water temperature monitoring site

Photo 14. Santa Paula Creek upstream of Harvey Diversion water temperature monitoring site

Photo 15. Santa Paula Creek at Steckel Park water temperature monitoring site

Photo 16. Santa Paula Creek directly downstream of Sisar Creek confluence water temperature monitoring site

Photo 17. Sespe Creek at Grand Avenue water temperature monitoring site

Photo 18. Steelhead kelt captured in the downstream migrant trap at the Freeman Diversion on 4/5/2012

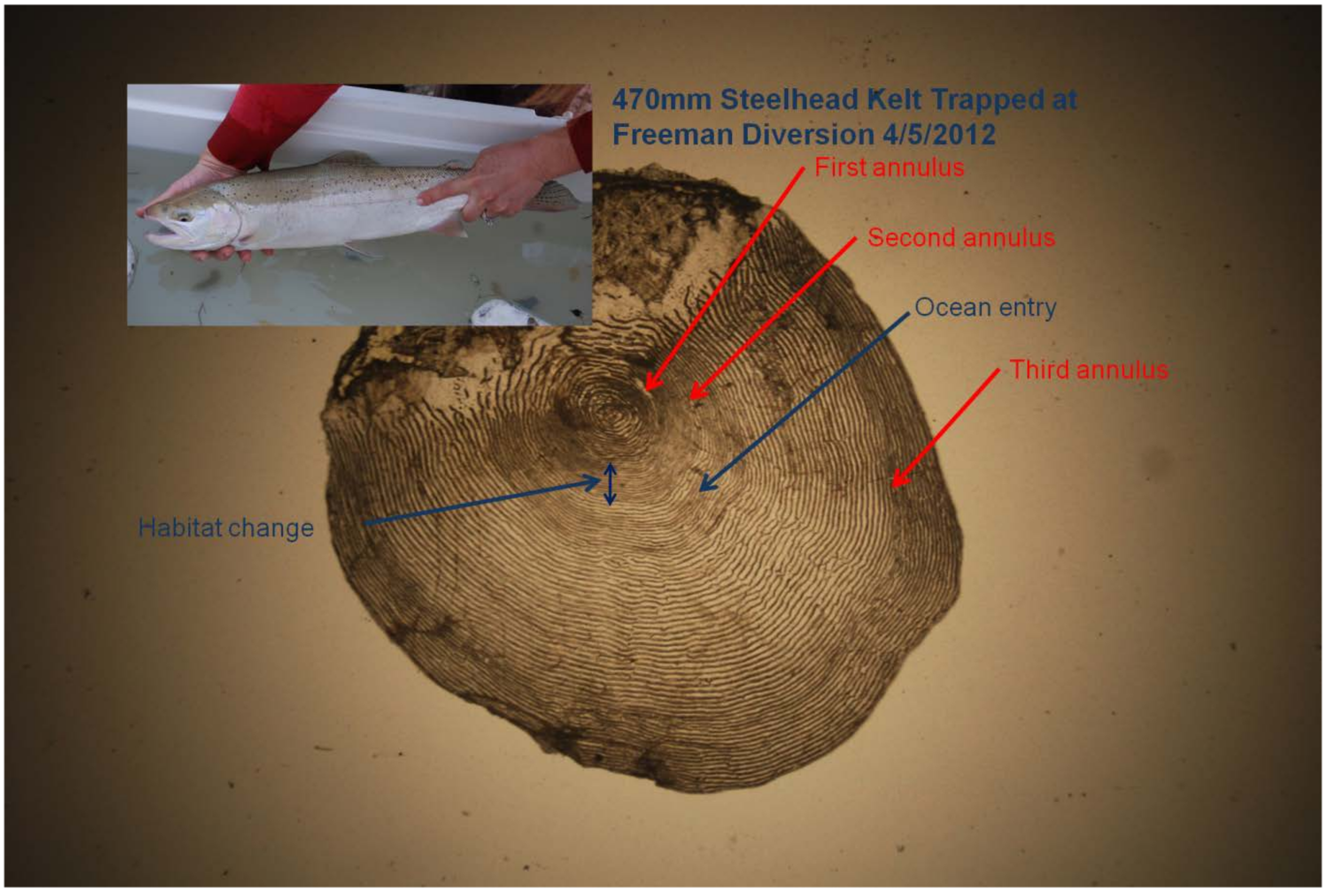


Photo 19. Scale analysis from steelhead kelt captured in the downstream migrant trap on 4/5/2012

Freeman Diversion panoramic photos

1/19/12

1/20/12

1/21/12

1/22/12

1/23/12

1/24/12

1/25/12

1/26/12

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3/17/12 – 9:30 AM

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4/8/12

4/10/12

4/11/12 - 9:30 AM

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