UNITED WATER CONSERVATION DISTRICT
"Conserving Water Since 1927"

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

Annual Report
2011 Monitoring Season

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Vern Freeman Diversion Facility
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Annual Report
2011 Monitoring Season

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2011

Cover Photos (by Steve Howard): clockwise from top*:* Freeman Diversion Dam, 2011 Steelhead smolt, 2011 Flow monitoring site

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The water year of 2011 was considered a moderately "wet 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 31.82 inches of rain was measured at the Santa Paula Wilson Ranch gauge (Station 245B) located in Santa Paula during the 2011 season. The highest monthly rain total was 9.49 inches in January.

The sandbar at the Santa Clara River Estuary (SCRE) was open to the ocean from January 12-13, 25-27, and February 19 to June 30. The estuary was closed the remainder of the steelhead migration season (January through June). Smolt trapping at the Freeman Diversion started on January 12 and ended on June 30, 2011. Steelhead smolts were first observed in the fish trap on February 11 and last observed on June 17, 2011. A low number of smolts were trapped during the new, extended bypass flow releases. Consequently, it appears that during fish ladder and bypass flow operations the majority of smolts bypassed the fish screen bay and fish trap by swimming over the dam or through the fish ladder. The fish ladder was in operation from February 19 to March 19 and from April 4 to June 8, 2011.

No adult steelhead traversed the fish ladder in 2011. A total of 19 steelhead smolts, 4 resident coastal rainbow trout, and 0 young-of-the-year coastal rainbow trout were trapped at the Freeman Diversion Fish Trap. No Pacific lamprey were observed during the 2011 migration season. However, a small number of adult lamprey could have traversed the fish ladder because there is currently no way to detect them 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 2011.

Water temperature monitoring in 2011 occurred in the mainstem Santa Clara River, Santa Paula Creek, and Piru Creek. Temperature loggers deployed in the estuary, mainstem Santa Clara River near Santa Paula, Sespe Creek and a few sites in Santa Paula Creek were lost following a large storm that occurred on March 19, 2011.

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 dam, 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 dam is a complete barrier to steelhead and Pacific lamprey upstream migration. The fish ladder was constructed to facilitate anadromous migration over the Freeman Diversion Dam. 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. Anadromous or anadromy is a life cycle or life history trait that refers to fish species that live 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. An adult steelhead that has entered freshwater to spawn and later the same year, or the following year, returns back to the ocean is referred to as a kelt.

Pacific lamprey are strictly anadromous and do not persist in freshwater alone. 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. Juvenile lamprey, which live in freshwater for up to seven years before migrating to the ocean, are referred to as ammocoetes. Southern steelhead are federally listed as endangered, while Pacific lamprey currently have no federal protection. Pacific 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.

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. The unarmored sub-species are currently 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 in various forms of cross breeding (*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*) and mosquitofish (*Gambusia affinis*). See Table 2, Appendix A.

1.3 ENVIRONMENTAL SETTING

The Santa Clara River is comprised of 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.

Rainfall

During the 2011 rain season (10/1/2010-9/30/2011), Santa Paula had 183.4% of normal rainfall totaling 31.82 inches (Ventura Watershed Protection District website, Santa Paula-Wilson Ranch 245B). The most rainfall in a 24 hour period was 2.35 inches on October 15, 2009 and the second highest was 1.58 inches on January 21, 2010. The highest monthly rainfall was 9.49 inches in December. (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 amount 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 and deposit clean gravels.

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 blocking upstream passage either intermittently or completely depending on maintenance or damage in any given year. Sespe Creek is free-flowing but currently has some issues regarding illegal crossings within the lower river that apparently could 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.

The tributaries in the Santa Clara River that are considered to be the primary steelhead-bearing drainages are Santa Paula and Sespe Creeks. These tributaries were flowing during the entire 2011 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 pers.com.). 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 2011, smolts were observed at the Freeman Diversion through June. On average, smolts tend to be shorter early in the season and longer and more robust toward the end of the migration season, but we did not have a large enough sample size to assess this trend in 2011. There is the potential that smolts rearing or migrating through the mainstem later in the season are feeding on the spring larvae of Santa Ana and Owens sucker and arroyo chub, although there are no known data or published research documenting this. Consequently, increased biomass from the spring spawn of non-native fishes could provide an ample food supply and could affect smolt migration behavior by delaying or even stopping migration due to the increased food resource. The effects on native fishes by the presence of non-native and exotic species could be far reaching beyond predation and competition for space.

1.4 REGULATORY STATUS (STEELHEAD)

NOAA Fisheries, otherwise known as the National Marine Fisheries Service (NMFS), listed the southern California steelhead, *Oncorhynchus mykiss*, 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) and represented groupings that were considered to be substantially isolated from other steelhead stocks reproductively and were 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 and study methods and results at the United Water Conservation District (hereafter, District) Vern Freeman Diversion Fish Passage Facility on the Santa Clara River in 2011.

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 2011 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 in 2009 was observed into July. This migration can occur 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.

The primary objective for trapping 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. Another important objective is to gather data regarding anadromous downstream migration in the Santa Clara River. Since there is a lack of specific 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 mitigate for stranding and predation when conditions are not favorable in the lower river due to natural conditions or to diversions occurring at the Freeman Diversion.

2.2 METHODS

2.2.1 DOWNSTREAM MIGRANT TRAP CHECKS

Trapping was triggered when there was not sufficient flow in the lower river based on depth criteria at critical riffles. The current minimum flow threshold for downstream migration (smolt target flow) is 120 cfs measured within a sandy glide habitat unit near a critical riffle site in the lower Santa Clara River. This threshold was developed from the results of depth, velocity and wetted width study where measurements were 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 commenced when flow receded to 80 cfs at the sandy glide flow measurement site. The trapping trigger of 80 cfs was chosen 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 2012. The primary objective of this study will be to evaluate smolt migration rates and success at various flows to inform a future smolt bypass flow plan.

Downstream migrant steelhead smolts, kelts, 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 mesh wedge wire screen which directs the fish to a downstream migrant fish trap. If there was sufficient flow in the lower river for downstream migration, the downstream migrant trap was lifted from the fish trap bay and all downstream migrants had the opportunity to enter a fish bypass pipe and exit to the river downstream of the diversion. When flow between the diversion and the ocean was not contiguous and greater than 80 cfs, fish were collected in the downstream migrant trap. Steelhead smolts, kelts and lamprey macropthalmia trapped at the facility were transported in aerated coolers by truck to the Santa Clara River Estuary. Resident coastal rainbow trout that were not exhibiting phenotypic smolting characteristics and lamprey ammocoetes were transported, depending on flow conditions, to the Santa Clara River, Santa Paula Creek, or Sespe Creek. Currently, Sespe Creek 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 are considered special status species in neighboring watersheds such as, but not limited to, the 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.

<u>Data Collection –</u> 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 these 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). Haner et al. (1995) found that mean skin reflectance of steelhead and spring Chinook salmon was significantly correlated with mean gill ATPase activity and mean skin guanine concentration. 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 were taken with a digital camera of steelhead and lamprey collected and transported. All data were documented on standardized datasheets and transferred daily to an electronic database.

<u>Fish Transportation –</u> 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 are collected, these fish might be placed in aerated buckets to minimize handling during release. Fish handling and transport time was generally no more than one hour.

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 and 2, Appendix B). The specific relocation site in the estuary depended on the condition of the dynamic estuary. The estuary was monitored daily during the migration season to inform relocation activities. Generally fish were released to freshwater in the estuary that has 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 are 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 we will need to change our fish transport time schedule. 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 rainbow trout and Pacific lamprey ammocoetes) were transported via aerated coolers to either the mainstem Santa Clara River, in Sespe Creek, or Santa Paula Creek (Photo 3, 4 and 5, Appendix B). Depending on conditions in Sespe Creek and access problems, resident rainbow trout might be transported to Santa Paula Creek upstream of Steckel Park or the Santa Clara River near Santa Paula. All other native, non-anadromous fish and aquatic species were transported and released upstream of the Freeman Diversion Dam.

2.2.2 SMOLT LENGTH MEASUREMENTS

Trapped smolts were measured to fork length (Photo 6, Appendix A). Lengths were measured by placing the fish in a fish measurement cradle for no more that 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 12 to June 30, 2011, with occasional periods where the trap was not used due to excess flows or other limiting factors (19 days). Smolts entered the trap from March 11 to June 17, 2011 (Figure 3, Appendix A). Smolt surveys continued during operational flushes and fish screen bay checks through the end of July. A total of 19 steelhead smolts (Photo 7, Appendix B), 0 steelhead kelt and 4 resident coastal rainbow trout (Photo 8, Appendix B) were trapped and relocated during the 2011 migration season. Smolt length frequencies and length by dates can be found in Figures 4 and 5 (Appendix A) respectively. Two dead smolts were found in the trap, one on April 18 and one on April 19. The low number of steelhead smolts trapped in 2011 is potentially a result of extended bypass flows that occurred within the migration season. The majority of smolts likely either migrated over the dam or through the fish ladder when bypass flows were released, but there currently is no way to assess fish passage through these pathways. The 4 resident coastal rainbow trout arrived on February 24, March 3 and 11, and April 25, 2011. One of the 19 steelhead smolts trapped at the

Freeman Diversion was transported to the Santa Clara River Estuary, the remainder were released below the Freeman Diversion. No lamprey ammocoetes or macropthalmia were observed or collected at the Freeman Diversion Facility in 2011.

Additional fish collected in the Freeman downstream migrant trap included: partially armored threespine stickleback (N=198), Arroyo chub (N=1297), Santa Ana sucker (N=138), Owens sucker (N=35), Santa Ana/Owens sucker hybrids (N=43), fathead minnow (N=253), largemouth bass (N=0), green sunfish (N=8), brown bullhead (N=1), black bullhead (N=2), prickly sculpin (N=590) and mosquitofish (N=33) (Table 4, Appendix A). Sucker species were identified based on lip morphology but the validity of this method is questionable.

Amphibians and reptiles collected in the Freeman downstream migrant fish trap included: Western toad (N=11), bullfrog (N=150, mostly larvae), African clawed frog (N=60), tree frog (N=12) and Western pond turtle (N=12) (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 Dam.

2.3.2 Smolt Length Measurements

A total of 19 smolts were measured. The average length of the 2011 smolts was 189.3 mm (standard deviation 27.5 mm).

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 dam. 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 dam because of a previously inefficient monitoring program due to antiquated technology, as well as regulatory and extreme environmental constraints (flashy flows, high turbidity). Even with the uncertainties in the data, a low number of native adult steelhead (N=9) have been observed at the diversion dam since it was constructed in 1991. Two additional adult steelhead of hatchery origin were observed in the fish ladder 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. Data were collected using standardized data sheets that include: date and time, number of adult upstream migrants observed and/or relocated, numbers of other aquatic species observed, flow and water quality parameters, and photos. Fork length measurements were taken when possible to the nearest millimeter on a wet measuring board. Water quality data were collected using a Hydrolab multi-parameter Quanta meter. Currently, there is no active fish trap deployed within the fish ladder to monitor 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. The IR scanning device was checked daily by running an object through the beams. The results of these checks were documented on data sheets. To date, no fish have been documented by the counter. The only other option for monitoring upstream migration through 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 Pacific lamprey migration if an active trap was installed within the fish ladder. An active trap would temporarily trap 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.

The remainder of the section describes each upstream migration monitoring method in detail.

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 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 Dam 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 surface water percolates sub-surface to groundwater.

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-wide sandy glide. The existence of numerous shallow glides appears (S. Howard personal observations) to be the critical habitat type (migration bottlenecks and delay) regarding velocity and depth for steelhead migration in the Santa Clara River. The actual critical riffles (typical area to measure shallow conditions) have narrower active channels (wetted width) than glide habitats resulting in deeper conditions compared to the wide, sandy glides.

The Freeman Diversion Fish Ladder was operated based on results from negotiations between NMFS biologists and the District hydrologist and biologist. These new 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 current bypass flow 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 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. 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 2011 are presented in Tables 6 and 7, Appendix A.

3.2.2 Video Migration Monitoring

Upstream migration monitoring was conducted using a false weir, infrared scanners and a computer based surveillance system. (Photo 9, 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 scanner that detects the migration event, 3 cameras film each fish that negotiates the weir and the surveillance system records 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 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.

A computer-based surveillance system was used to detect and monitor steelhead traversing the fish ladder (Photo 10, Appendix B). 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 2011 we only used the IR scanners to detect movement over the false weir. Although the surveillance software can detect movement, it is difficult to tease out 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 by saving a 20 second video on the computer hard drive. When an event is detected a flashing alarm shows up on computer screen. The event is saved as a file that can be reviewed. The computer system also records continuously and there is enough storage on the 1 TB hard drive to save video for close to a week 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. Passage events that are detected can first be reviewed from the 20 second file and later reviewed from the continuous file if needed. 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 was 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. Any recorded images saved on the computer were reviewed by staff during these checks.

3.2.3 PIT Tag Monitoring

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 mid way through the migration season. We will research options for future deployment in 2012.

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. Also, the ladder was periodically shut down opportunistically to survey the facility for steelhead and/or Pacific lamprey migrants.

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 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 11, 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 (Photo 12, Appendix B). 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 dam 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 suspended solids based on experiments conducted in 2010.

3.3 RESULTS

3.3.1 BYPASS FLOW MONITORING AND LADDER OPERATION

The fish ladder was in operation nearly continuously from February 19 to June 8, 2011. No steelhead or Pacific lamprey were observed traversing the fish ladder in 2011. Bypass flow monitoring results can be found in Table 8, Appendix A.

3.3.2 VIDEO MIGRATION OBSERVATION

The surveillance system was operated continually from February 19 to June 8 during the operation of the fish ladder except during the turn-outs listed in section 3.3.3 below. Throughout this period the alarm trigger system and video recordings were monitored and checked daily.

In 2011, all triggered alarms were determined to be “false hits” (i.e., triggered by something other than steelhead).

3.3.3 Ladder Shutdowns

The fish ladder was shut down a total of nine times in 2011. Shut down events occurred on February 29, March 11, 24, and 29, April 11 and 24, and May 24 and June 6 due to flow turned out to the river during turn-outs results from storms or flushing events.

3.3.4 DIDSON Migration Monitoring

The DIDSON camera detected both upstream and downstream movement of fish at the monitoring site located directly below the Freeman Diversion Dam (Figure 7, Appendix A). Fish species identification is difficult with this technology and was not possible (upstream migrants) from data collected during the first year of monitoring. Large fish (>300 mm) observed in DIDSON video were either steelhead or common carp. We observed large schools of carp in isolated pools directly downstream of the dam and in the lower river following the end of the bypass flow releases. There are large numbers of common carp in the Santa Clara River Estuary and these fish potentially could have migrated up river during the extended bypass flow releases in 2011. At this time, we cannot distinguish between these species in the DIDSON images. Smolts were identified by their downstream swimming behavior while still pointing upstream. Size estimates were computed using the DIDSON software and appear to be repeatable within 50 mm.

Between April 1 and May 16, 2011, we detected a total of 23 fish with the DIDSON camera. Of these fish, 10 individuals were moving upstream (416 ± 94 mm, mean + standard deviation, range 222-553 mm) and 13 were moving downstream (401 ± 120 mm, range 144-620 mm). All but two individuals were detected during the night between 19:00 and 04:00. The two individuals detected during the day were moving downstream. We are planning to test alternative installation locations in 2012 to focus on habitats where steelhead and carp would behave differently. Additionally, a beam concentrating lens will be used during 2012, which should increase image quality and provide better discrimination between species.

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 and the fish screen bay section of the diversion structure can become 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 from birds. Additional operations and maintenance activities include "flushes" where District operations staff "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 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.

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 that are 4 feet deep and from 10 to 20 feet long (Photo 13, 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 or 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 held up in the fish screen bay. All fish were transported via aerated coolers. Non-native aquatic species were removed from the river. All data collected during stranding surveys were documented on standardized datasheets. Fish were transported utilizing materials and 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 2011, no upstream migrant steelhead or Pacific lamprey were collected during these surveys. In years when upstream migrant steelhead and Pacific lamprey are collected during these surveys they will be relocated upstream of the Freeman Diversion Dam. Downstream migrant steelhead (smolts) were relocated to the Santa Clara River Estuary. In 2011, no downstream migrant Pacific lamprey were collected. In years when downstream migrant Pacific lamprey (macropthalmia) are collected during these 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 and flushing 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 in 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 turn-out and 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. If a fish was observed in one of the resting pools of the ladder and appeared to not be in immediate danger, flow was turned back in the ladder to allow the fish to continue migrating upstream on its own.

4.3 RESULTS

4.3.1 FISH SCREEN BAY STRANDING SURVEYS

A total of 6 turn-out events occurred during the 2011 water year. Two of these events were during gate maintenance that also resulted in flushing sediment from behind the dam. The remaining turn-out events were due to high turbidity levels from high sediment loads. Four fish screen bay stranding surveys were conducted. Three stranding surveys yielded a total of 3 steelhead smolts (Table 9, Appendix A). All 3 smolts were released below the Freeman Diversion. These smolts (n=3) were included in the total smolt trapping results (n=19) section (see section 2.3.1).

4.3.2 LOWER SANTA CLARA RIVER STRANDING SURVEYS

No visual stranding surveys were conducted below the Freeman Diversion Dam following turn-out events.

4.3.3 FISH LADDER STRANDING SURVEYS

There were a total of 6 turn-out events but only 2 occurred when the fish ladder was in operation, requiring ladder checks. A biologist walked the length of the fish ladder during each event as the ladder dewatered. One *O. mykiss* was observed stranded in the fish ladder during these surveys.

5.1 INTRODUCTION

Water quality monitoring for 2011 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. 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 2011 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 for 2011 included 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 Horiba U-10 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, 2010 through September 31, 2011. In situ water quality measurements were collected when steelhead were relocated to the Santa Clara River Estuary, main stem Santa Clara River or Sespe Creek.

Water temperature monitoring occurred at the following eleven sites:

- Site 2: Freeman Fish Trap Bay
- Site 3: Freeman Fish Screen Bay
- Site 7: Santa Paula Creek at Steckel Park
- Site 8: Santa Paula Creek directly downstream of Sisar Creek confluence
- Site 10B: Piru Creek upstream of Temescal property line
- Site 11: Piru Creek downstream of the Old USGS gauge Site

- Site 12B: Piru Creek at the old USGS gauge Site
- Site 13: Piru Creek at second bridge
- Site 14: Piru Creek downstream of spill and release channel confluence #1
- Site 15: Piru Creek downstream of spill and release channel confluence #2
- Site 16: Piru Creek at the USGS Gauge directly downstream of Santa Felicia Dam

A map identifying each monitoring site can be found in Figure 8, Appendix A. Graphs depicting data at these eleven sites are in Figures 9-19, Appendix A. Specific information regarding each site can be found in Table 10, Appendix A. Additional temperature loggers were installed in the Santa Clara River Estuary, Santa Clara River at the VCWPD project, and Santa Paula Creek upstream of the Harvey Diversion, but these loggers were lost during high flow events. Loggers will be replaced during 2012.

5.3 RESULTS

5.3.1 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 14, 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 6.4 ºC and the maximum temperature was 25.6 ºC (Table 11, Appendix A).

5.3.2 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 fish screen bay and attached to an eye hook 0.5 feet from the bottom along a concrete wall (Photo 15, 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 5.3 ºC and the maximum temperature was 28.5 ºC (Table 11, Appendix A).

5.3.3 SANTA PAULA CREEK AT STECKEL PARK

The Santa Paula Creek at Steckel Park water temperature monitoring site was located in a glide 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 16, 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 6.8 ºC and the maximum temperature was 20.7 ºC (Table 11, Appendix A).

5.3.4 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 17, 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 objective at this location was to monitor ambient water temperatures in Santa Paula Creek. The minimum water temperature collected at this site was 6.8 ºC and the maximum temperature was 20.5 ºC (Table 11, Appendix A).

5.3.5 Piru Creek Upstream of Temescal's Property Line

The Piru Creek upstream of Temescal's property line water temperature monitoring site is located in a pool habitat type approximately 1.5 miles upstream of the confluence with the Santa Clara River. The logger was attached 0.35 ft from the bottom with zip ties to a fencepost near cattails (Photo 18, Appendix B). The objective at this location was to monitor ambient water temperatures in lower Piru Creek. The minimum water temperature collected at this site was 6.0 ºC and the maximum temperature was 27.7 ºC (Table 11, Appendix A).

5.3.6 Piru Creek Downstream of the Old USGS Gauge

The Piru Creek downstream of the old USGS Gauge water temperature monitoring site was located in pool habitat type approximately 3 miles upstream from the confluence with the Santa Clara River. The logger was attached 1.1 FT from the bottom with zip ties to a small fencepost (Photo 19, Appendix B). The objective at this location was to monitor ambient water temperatures in lower Piru Creek. The minimum water temperature collected at this site was 5.9 ºC and the maximum temperature was 26.1 ºC (Table 11, Appendix A).

5.3.7 Piru Creek at the Old USGS Gauge

The Piru Creek at the old USGS Gauge water temperature monitoring site was located in low gradient riffle habitat type approximately 3 miles upstream from the confluence with the Santa Clara River. The logger was attached 0.6 inches from the bottom with zip ties to a pre-existing pipe (Photo 20, Appendix B). The objective at this location was to monitor water temperatures in lower Piru Creek. The minimum water temperature collected at this site was 5.4 ºC and the maximum temperature was 28.7 ºC (Table 11, Appendix A).

5.1.1 5.3.8 Piru Creek at the Second Bridge

The Piru Creek at the second bridge (most upstream bridge) water temperature monitoring site was located in riffle habitat type approximately 1.5 miles downstream from Santa Felicia dam. The logger was attached 0.2 ft from the bottom with zip ties to small fencepost cabled to a boulder in mid-channel (Photo

21, Appendix B). The objective at this location was to monitor ambient water temperatures in lower Piru Creek. The minimum water temperature collected at this site was 5.6 ºC and the maximum temperature was 25.2 ºC (Table 11, Appendix A).

5.3.9 Piru Creek Downstream of Spill and Release Channel Confluence #1

The Piru Creek at the old USGS gauge water temperature monitoring site was located in low gradient riffle habitat type approximately 0.75 miles downstream from Santa Felicia Dam. The logger was attached 0.7 ft from the bottom with zip ties to large fencepost in cattails near the right bank adjacent to Temescal's pump site. (Photo 22, Appendix B). The objective at this location was to monitor water temperatures in lower Piru Creek. The minimum water temperature collected at this site was 7.0 ºC and the maximum temperature was 19.3 ºC (Table 11, Appendix A).

5.3.10 Piru Creek Downstream of Spill and Release Channel Confluence #2

The Piru Creek downstream of the spill and release channel confluence water temperature monitoring site was located in low gradient riffle habitat type approximately 0.75 miles downstream from Santa Felicia Dam. The logger was attached 0.13 ft from the bottom with zip ties to small fencepost near a bedrock slab along the left bank (Photo 23, Appendix B). The objective at this location was to monitor water temperatures in lower Piru Creek. The minimum water temperature collected at this site was 7.0 ºC and the maximum temperature was 19.9 ºC (Table 11, Appendix A).

5.3.11 Piru Creek at the USGS Gauge Directly Downstream of Santa Felicia Dam

The Piru Creek at USGS Gauge directly downstream of Santa Felicia Dam water temperature monitoring site was located in a pool habitat type approximately 700 feet downstream of Santa Felicia Dam. The logger was attached 0.3 inches from the bottom with zip ties to a permanent staff gauge (Photo 24, Appendix B). The objective at this location was to monitor water temperatures in lower Piru Creek. The minimum water temperature collected at this site was 8.0 ºC and the maximum temperature was 18.9 ºC (Table 11, Appendix A).

5.4 DISCUSSION

The maximum water temperatures at most sites extend 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. 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). Also, the duration of exposure is important since these fish will experience upper thermal limits over a period of a few hours during any given day and only seasonally and these fish 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 will conduct temperature monitoring at reference pools that contain areas of thermal refuge.

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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)												95	23		840	25	30	24		25	28	27	29	28	28	27	24	27	20	16	18
Estuary	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	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
Ladder Operation																												
Smolt Trapping																												
Smolts																												
Adult Steelhead																												
Steelhead Kelt																												
Turbidity (ntu)	11	13	14	25	17	18	12	17	15	26	23	7	17	10	15	185	86	79	2600		82	45	41	56	78			136
Estuary	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

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																				
Adult Steelhead																															
Steelhead Kelt																															
Turbidity (ntu)	>1000	82	136	76	53	60	84																								
Estuary	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	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	1						3	2	1		1	
Adult Steelhead																														
Steelhead Kelt																														
Turbidity (ntu)	10	9	9	8	11	11	8	11	8	18	10	9	29	14	9	15	9	17	7	6	8	16	8	4	20	9	26	11		8
Estuary	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open

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					1									1							2							
Adult Steelhead																															
Steelhead Kelt																															
Turbidity (ntu)		8	8	10	13	10	6	5	7		8		24	6	6	4	4	8	5	11	6										
Estuary	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open

*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)																														
Estuary	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open

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					
Other Monitoring					
Smolts					
Adult Steelhead					End Of Monitoring Season
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 2011

<u>Fish Species:</u> 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

<u>Amphibian & Reptile Species</u>: 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	BC	PS	MF
Total	0	0	19	4	0	0	0	198	1297	138	35	43	253	0	8	1	2	590	33

	Amphibians and Reptiles							
	WT	AT	SFT	CRLF	BF	AF	TF	PT
Total	11	0	0	0	150	60	12	12

Biologists: Steve Howard, Sara Gray, **Fish Technicians:** Chris In, Amanda Goldstein

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 - Bypass Flow Schedule from January 1st to March 31st.

Day of Fish Ladder Operation	Designated Minimum Flows at Critical Riffle (cfs)
1	160
2	160
3	160
4	160
5	160
6	160
7	150
8	140
9	130
10	120
11	110
12	100
13	90
14	80
15	2/3 of previous day*
16	2/3 of previous day*
17	2/3 of previous day*
18	20*

*Ramping down flow measured at the Freeman Diversion

Table 7 - Bypass Flow Schedule from April 1st to May 31st.

Day of Fish Ladder Operation	Designated Minimum Flows at Critical Riffle (cfs)
1	160
2	160
3	160
4	160
5	160
6	160
7	160
8	160
9	160
10	160
11	160
12	160
13	160
14	160
15	160
16	160
17	160
18	160
19	150
20	140
21	130
22	120
23	110
24	100
25	90
26	80
27	2/3 of previous day*
28	2/3 of previous day*
29	2/3 of previous day*
30	20*

*Ramping down flow measured at the Freeman Diversion

Table 8 - Freeman Diversion Steelhead Bypass Flow Monitoring Results

Date	Fish Ladder Flow(cfs)	Auxiliary Gate Flow (cfs)	*Total River Flow Below the Freeman (cfs)*	*Critical Riffle Flow (cfs) (~5.5 miles downstream of Freeman)*	Surface Water Loss to Groundwater (Between Freeman at Critical Riffle Site)[#]	Critical Riffle Target
2/19/2011	40	80	ND	ND	**ND**	160
2/20/2011	40	80	249.648	173.126	76.522	160
2/21/2011	40	80	178.239	118.922	59.317	160
2/22/2011	40	80	187.378	119.63	67.748	160
2/23/2011	40	80	224.89	178.054	46.836	160
2/24/2011	40	80	182.877	130.054	52.823	160
2/25/2011	40	80	ND	170.257	ND	150
New Storm						
2/26/2011	40	80	ND	ND	ND	160
2/27/2011	40	80	ND	ND	ND	160
2/28/2011	40	80	243.386	197.075	46.311	160
3/1/2011	40	80	205.601	170.968	34.633	160
3/2/2011	40	80	191.987	160.588	31.399	160
3/3/2011	40	80	224.950	204.409	20.541	160
3/4/2011	40	80	233.148	207.329	25.819	150
3/5/2011	40	80	139.027	115.090	23.937	140
3/6/2011	40	80	181.012	140.675	40.337	130
3/7/2011	40	80	205.106	182.022	23.084	120
3/8/2011	40	80	170.902	146.987	23.915	120
3/9/2011	40	80	128.189	91.414	36.775	120
3/10/2011	40	80	137.517	118.388	19.129	120
3/11/2011	40	80	132.530	ND	ND	120
3/12/2011	40	80	139.656	118.291	21.365	120
3/13/2011	40	80	139.163	ND	ND	120
3/14/2011	40	80	144.718	117.534	27.184	120
3/15/2011	40	80	153.502	127.360	26.142	120
3/16/2011	40	80	148.828	127.726	21.102	120
3/21/2011	**Turn-out**					160
3/22/2011	40	80	ND	ND	ND	160
3/23/2011	40	80	ND	ND	ND	160
3/24/2011	40	80	ND	ND	ND	160
3/25/2011	40	80	ND	ND	ND	160
3/26/2011	40	80	ND	ND	ND	150
3/28/2011	40	80	ND	ND	ND	130
3/30/2011	40	80	ND	ND	ND	120
3/31/2011	40	80	ND	ND	ND	120
4/1/2011	40	80	ND	ND	ND	120

Table 8 - Freeman Diversion Steelhead Bypass Flow Monitoring Results (cont.)

Date	Fish Ladder Flow(cfs)	Auxiliary Gate Flow (cfs)	*Total River Flow Below the Freeman (cfs)*	*Critical Riffle Flow (cfs) (~5.5 miles downstream of Freeman)*	Surface Water Loss to Groundwater (Between Freeman at Critical Riffle Site)[#]	Critical Riffle Target
4/3/2011	40	80	ND	ND	ND	120
4/4/2011	40	80	ND	ND	ND	120
4/5/2011	40	80	ND	ND	ND	120
4/6/2011	40	80	ND	ND	ND	120
4/7/2011	40	80	ND	328.362	ND	120
4/8/2011	40	80	ND	ND	ND	120
4/9/2011	40	80	ND	292.331	ND	120
4/10/2011	40	80	ND	192.184	ND	120
4/11/2011	40	80	ND	ND	ND	120
4/12/2011	40	80	174.773	208.861	-34	120
4/13/2011	40	80	124.708	166.081	-41	120
4/14/2011	40	80	120.127	160.600	-40	120
4/15/2011	40	80	114.889	196.942	-82	120
4/16/2011	40	80	115.680	166.168	-50	120
4/17/2011	40	80	108.729	162.723	-54	120
4/18/2011	40	80	105.290	163.814	-59	120
4/19/2011	40	80	95.754	168.977	-73	120
4/20/2011	**Turn-out**					120
4/21/2011	40	80	120.805	199.359	-79	120
4/22/2011	40	80	114.647	151.505	-37	120
4/23/2011	30	60	109.465	147.096	-38	120
4/24/2011	30	60	110.749	145.288	-35	120
4/25/2011	30	60	80.385	135.983	-56	120
4/26/2011	30	60	85.994	155.076	-69	120
4/27/2011	30	60	115.149	164.446	-49	120
4/28/2011	30	60	117.936	143.364	-25	120
4/29/2011	30	60	112.626	140.311	-28	120
5/4/2011	30	60	105.858	135.503	-30	120
5/5/2011	30	60	102.390	115.283	-13	120
5/6/2011	30	60	ND	146.562	ND	120
5/7/2011	30	60	107.864	132.096	-24	120
5/9/2011	30	60	112.252	132.806	-21	120
5/10/2011	30	60	112.471	131.380	-19	120
5/11/2011	30	60	105.910	139.310	-33	120
5/12/2011	30	60	113.474	134.566	-21	120
5/13/2011	30	60	110.952	134.264	-23	120
5/14/2011	30	60	104.102	134.945	-31	120

Table 8 - Freeman Diversion Steelhead Bypass Flow Monitoring Results (cont.)

Date	Fish Ladder Flow(cfs)	Auxiliary Gate Flow (cfs)	*Total River Flow Below the Freeman (cfs)*	*Critical Riffle Flow (cfs) (~5.5 miles downstream of Freeman)*	Surface Water Loss to Groundwater (Between Freeman at Critical Riffle Site)#	Critical Riffle Target
5/16/2011	30	60	108.155	124.693	-17	120
5/17/2011	30	60	ND	ND	ND	120
5/18/2011	30	60	106.231	130.998	-25	120
5/19/2011	30	60	101.926	106.073	-4	120
5/20/2011	30	60	97.097	114.948	-18	120
5/21/2011	30	60	107.270	124.488	-17	120
5/22/2011	30	60	102.673	115.237	-13	120
5/23/2011	30	60	105.327	109.770	-4	120
5/24/2011	**Turn-out (~5 hours)**					120
5/25/2011	30	60	135.865	137.913	-2	120
5/26/2011	30	60	122.363	134.291	-12	120
5/27/2011	30	60	118.579	126.858	-8	120
5/28/2011	30	60	100.512	109.381	-9	120
5/29/2011	30	60	113.481	107.571	6	120
5/30/2011	30	60	117.286	104.088	13	120
5/31/2011	30	60	117.392	112.955	4	80-120*
6/1/2011	30	60	86.031	91.045	-5	80-120
6/2/2011	**Turn-out (2 hours)**					80-120
6/3/2011	30	60	108.401	88.158	20	80-120
6/4/2011	30	60	90.720	67.008	24	80-120
6/5/2011	30	60	84.985	62.088	23	80-120
6/6/2011	30	60	96.233	84.712	12	80-120
6/7/2011	30	60	88.761	69.703	19	80-120
6/8/2011	0	60	62.270	ND		Ramp down
6/9/2011	0	30	33.043	ND		Ramp down
6/10/2011	**Shut down (10:40)**					Shut down

* when can't maintain 80 cfs projected 5-days out, start ramp-down in 5 days
# A negative value = surface water gain from groundwater

TABLE 9 - FISH STRANDING SURVEY RESULTS

Stranding Survey Location	Adult Steelhead	Smolts	Resident *O. mykiss*	Total
Freeman Fish Screen Bay	0	3	1	4
Fish Ladder	0	1	0	0

Table 10. 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	14
Freeman Fish Screen Bay	1269166	12/8/2008	2.5	0.5	pool	15
Santa Paula Creek at Steckel Park	1269161	3/27/08	1.8	0.2	glide	16
Santa Paula Creek directly downstream of Sisar Creek confluence	2250248	1/16/2009	2.25	0.7	pool	17
Piru Creek upstream of Temescal property line	1269167	8/26/10	1.25	0.35	pool	18
Piru Creek downstream of the Old USGS gauge Site	2267173	2/4/11	2.3	1.1	pool	19
Piru Creek at the old USGS gauge Site	2270569	8/17/11			run	20
Piru Creek at second bridge	2250243	8/26/10	0.6	0.2	run	21
Piru Creek downstream of spill and release channel confluence #1	2267158	8/31/10	1.3	0.7	pool	22
Piru Creek downstream of spill and release channel confluence #2	2270581	8/31/11	0.45	0.13	low gradient	23
Piru Creek at the USGS Gauge directly downstream of Santa Felicia Dam	1269164	8/27/08	0.4	0.2	run	24

Table 11. 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	25.6	6/15/11	6.3	2/27/11	15.5
Freeman Fish Screen Bay	28.5	8/24/10	5.3	3/22/11	16.0
Santa Paula Creek at Steckel Park	20.7	8/29/11	6.8	2/27/11	14.7
Santa Paula Creek directly downstream of Sisar Creek confluence	20.5	6/23/11	6.8	2/27/11	12.9
Piru Creek upstream of Temescal property line	27.7	7/4/11	6.0	2/3/11	16.1
Piru Creek downstream of the Old USGS gauge Site	26.1	5/3/11	5.9	2/27/11	16.3
Piru Creek at the old USGS gauge Site	28.7	8/26/10	5.4	2/3/11	16.0
Piru Creek at second bridge	25.2	7/6/11	5.6	2/3/11	14.5
Piru Creek downstream of spill and release channel confluence #1	19.3	4/17/11	7.0	2/2/11	12.7
Piru Creek downstream of spill and release channel confluence #2	19.9	10/28/11	7.0	2/2/11	13.2
Piru Creek at the USGS Gauge directly downstream of Santa Felicia Dam	18.9	10/24/11	8.0	2/2/11	12.8

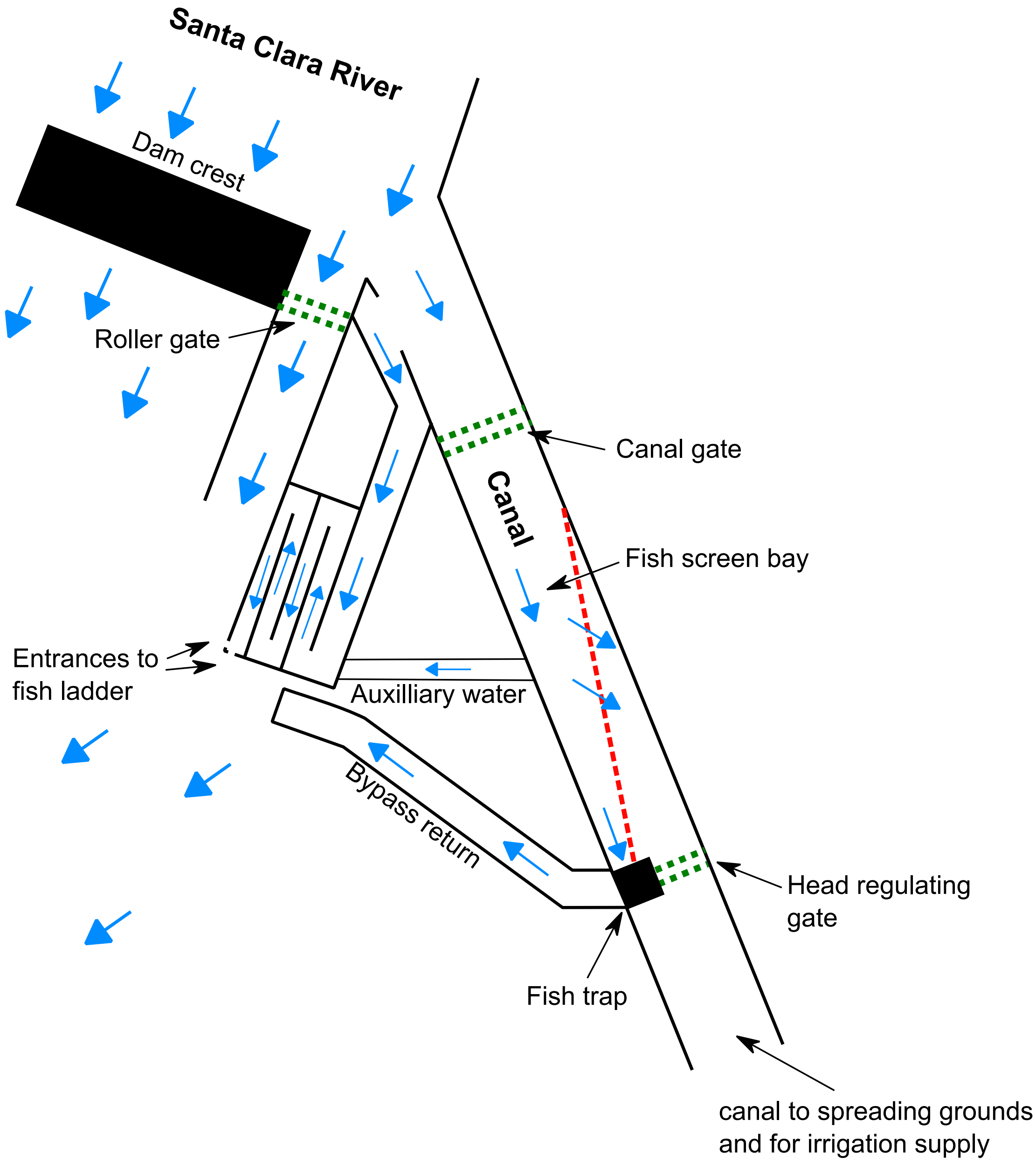


Figure 1. Schematic of Freeman Diversion Facility

Figure 2 - Daily Rainfall Totals in Santa Paula, CA

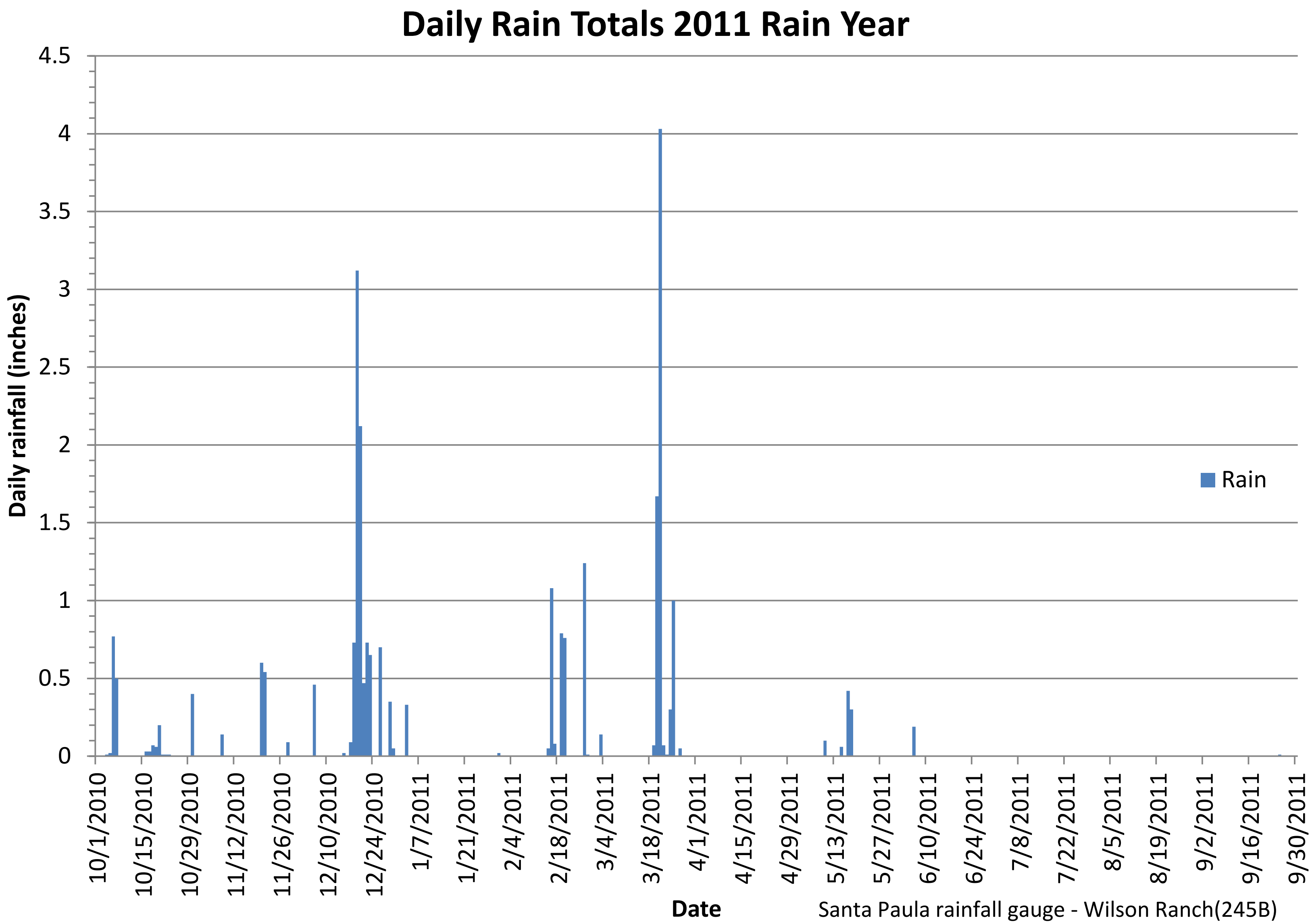


Figure 3 - Steelhead monitoring results

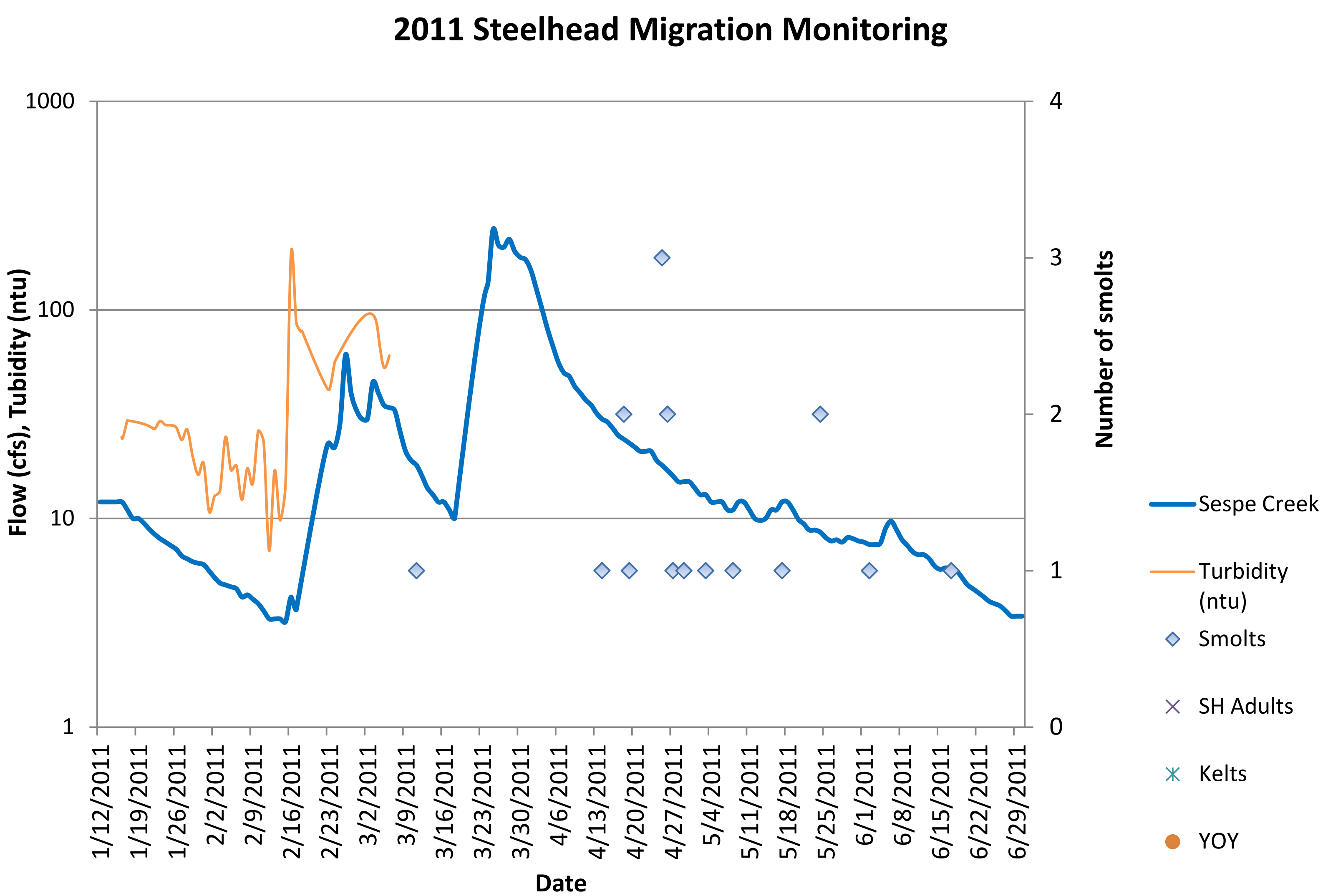


Figure 4 - Steelhead Length Frequency Histogram

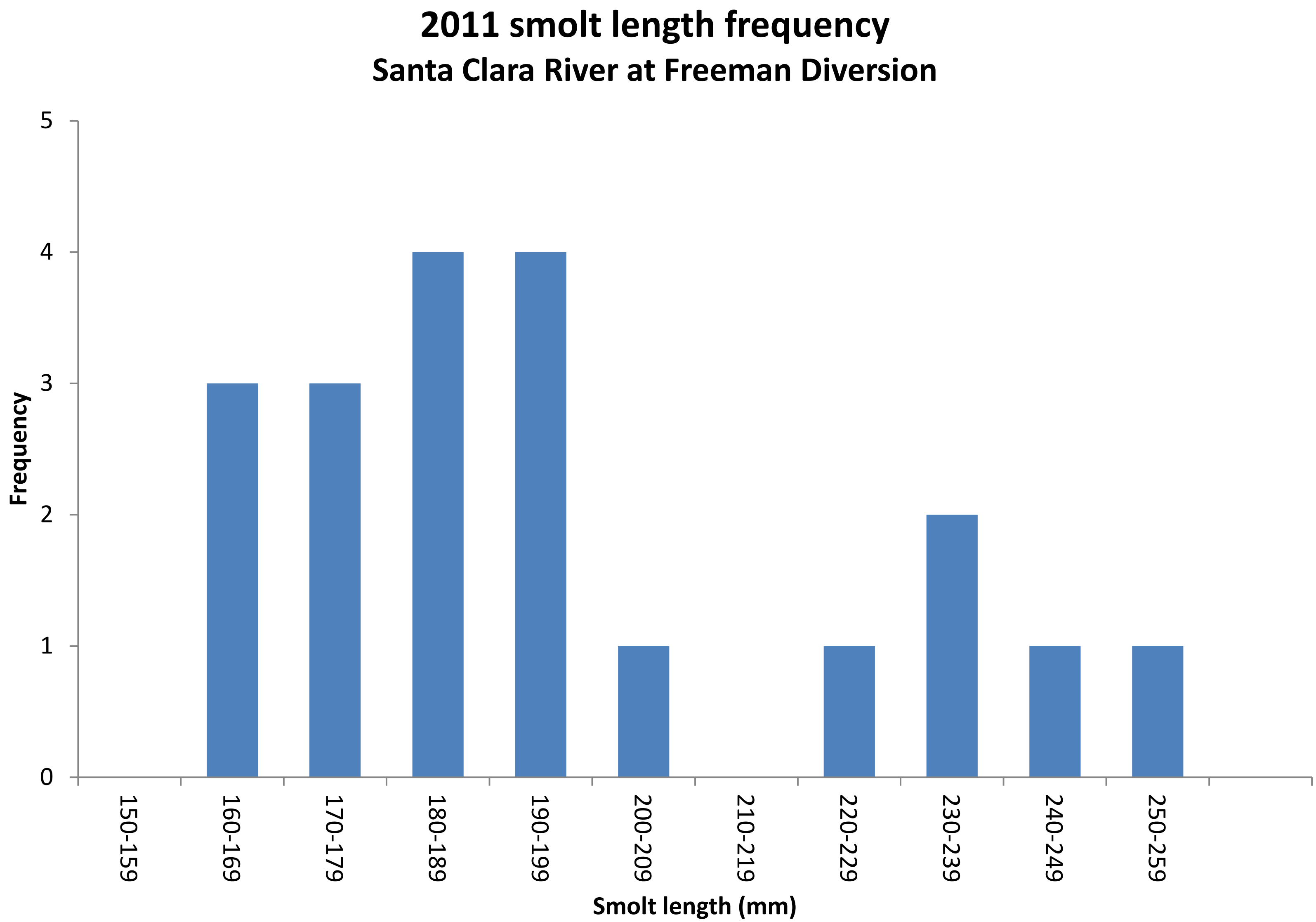


Figure 5 - Steelhead Lengths by Date

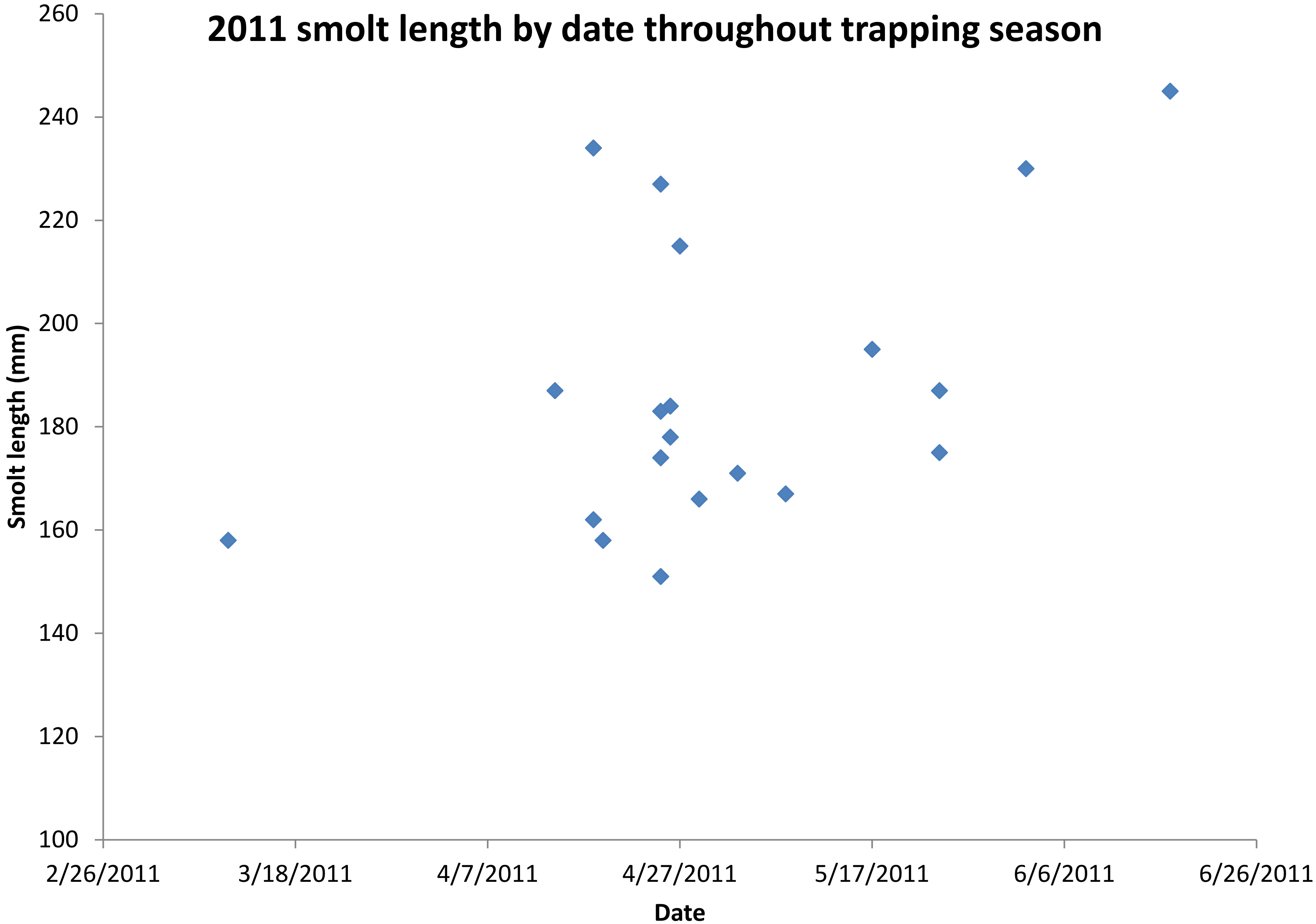


Figure 6. Freeman bypass flow monitoring sites below the Freeman Diversion

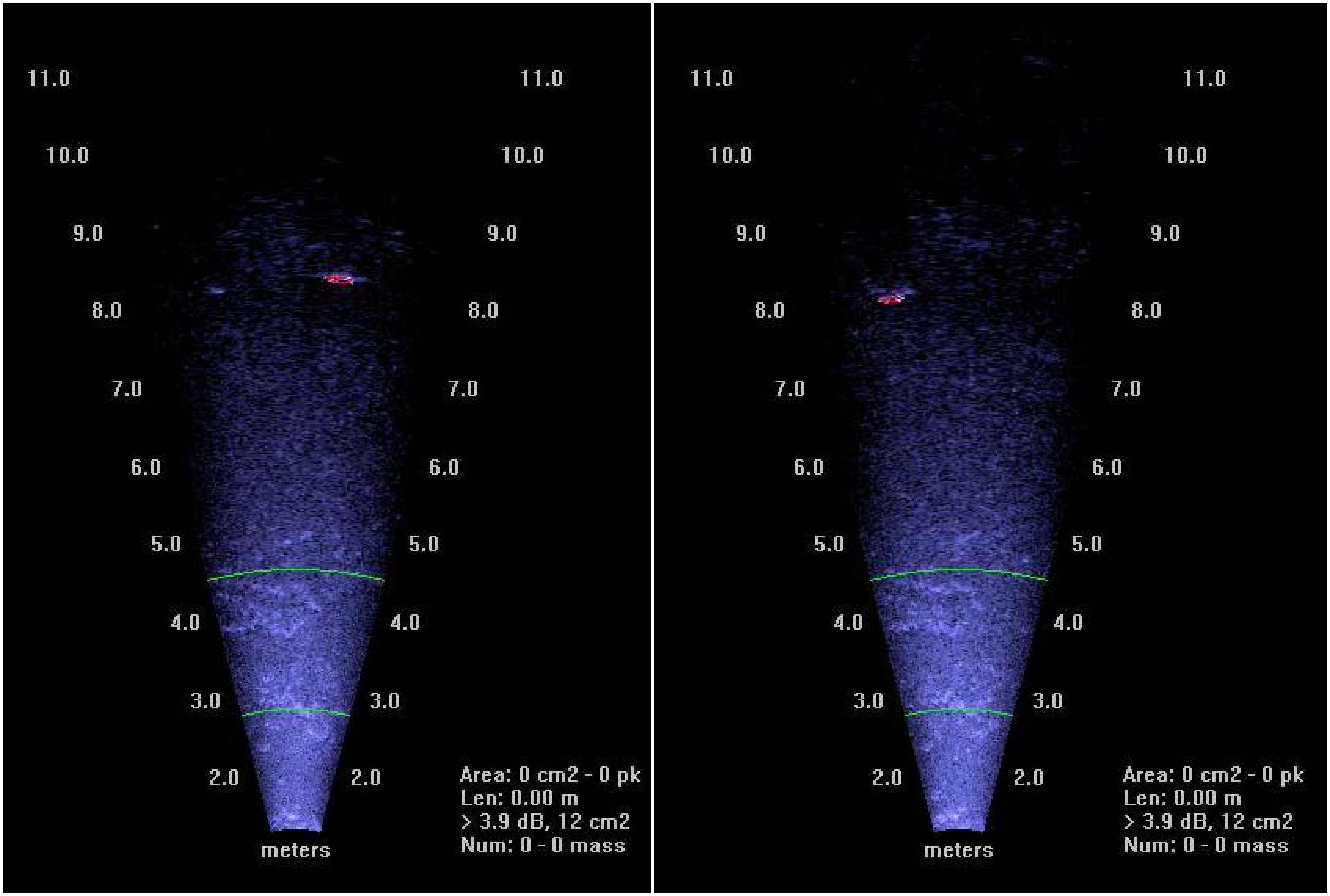


Figure 7. DIDSON images from April 28 (left) depicting a 426 mm fish moving upstream and May 13 (right), a 548 mm fish moving downstream. The body of the fish is indicated in red.

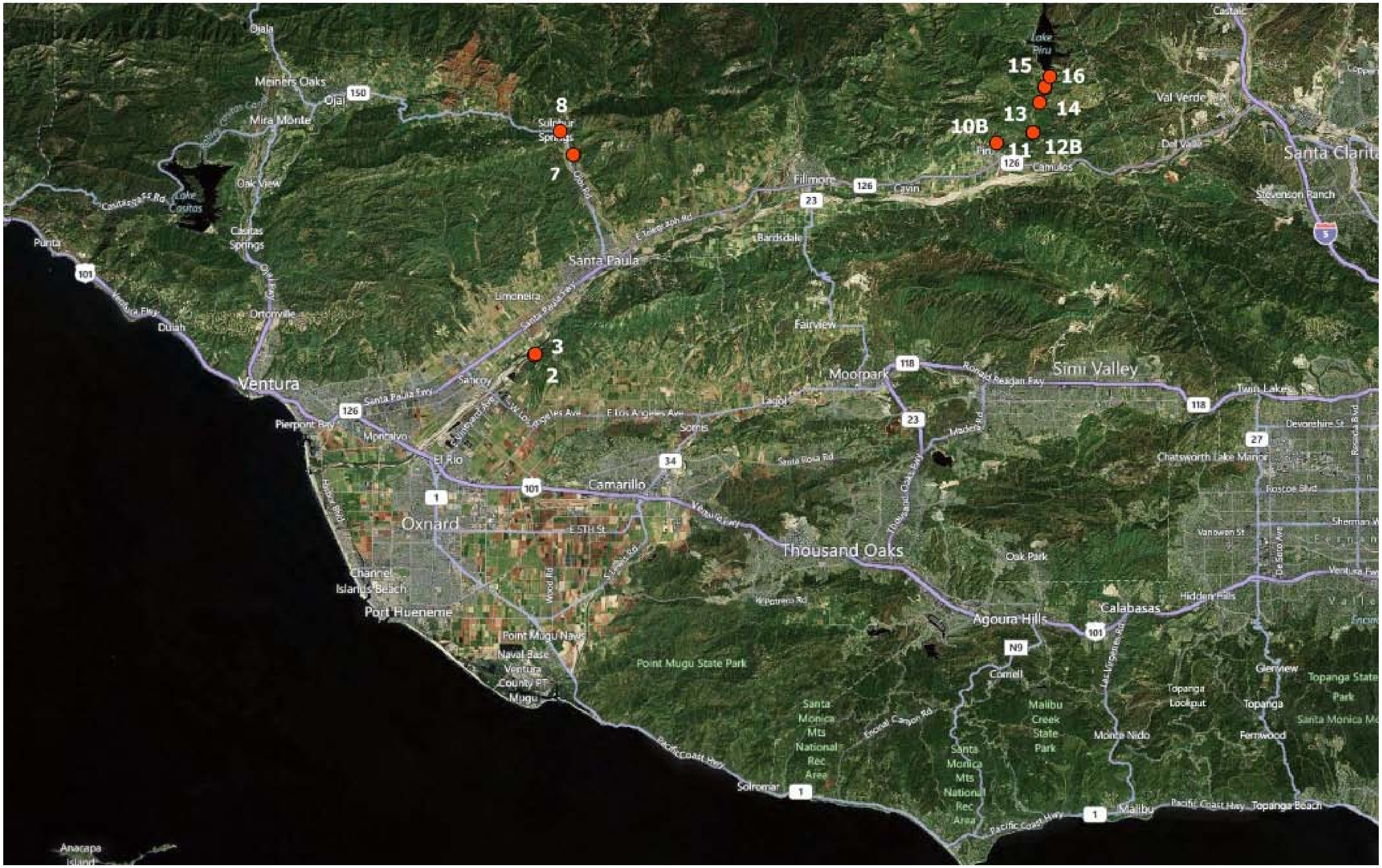


Figure 8. Water temperature monitoring sites within the Santa Clara River watershed.

Figure 9. Freeman fish trap bay water temperature

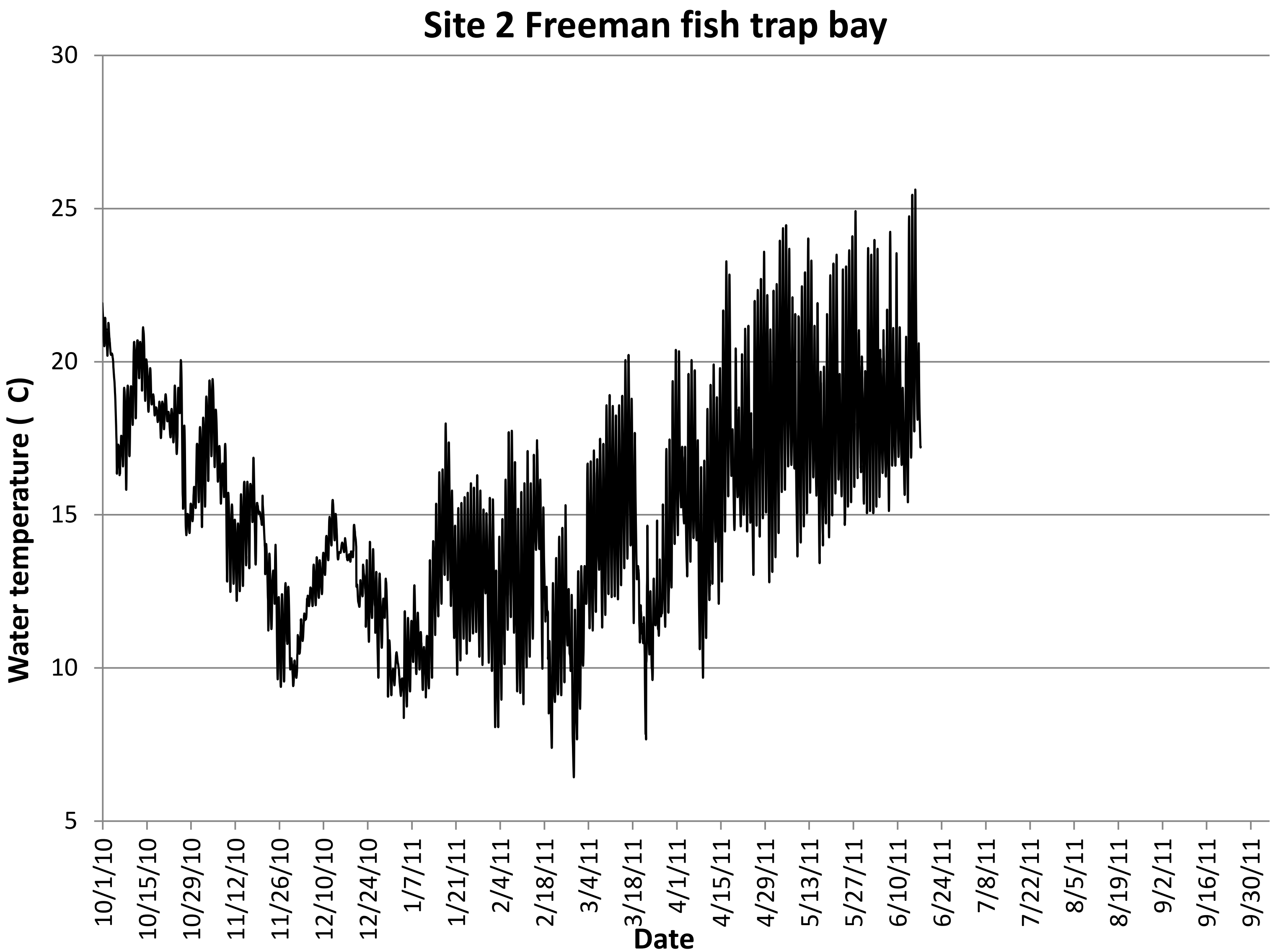


Figure 10. Freeman fish screen bay water temperature

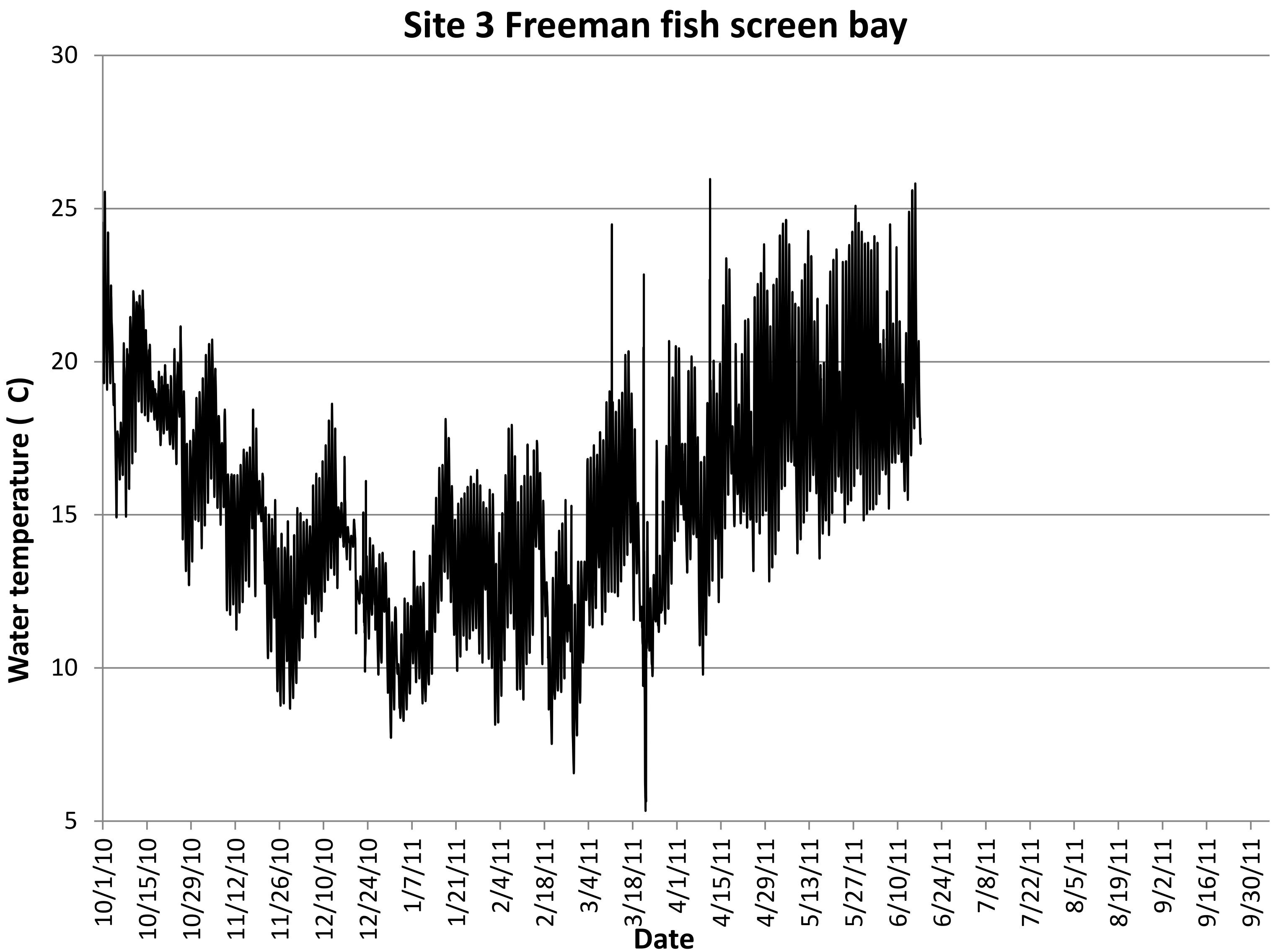


Figure 11. Santa Paula Creek at Steckel Park water temperature

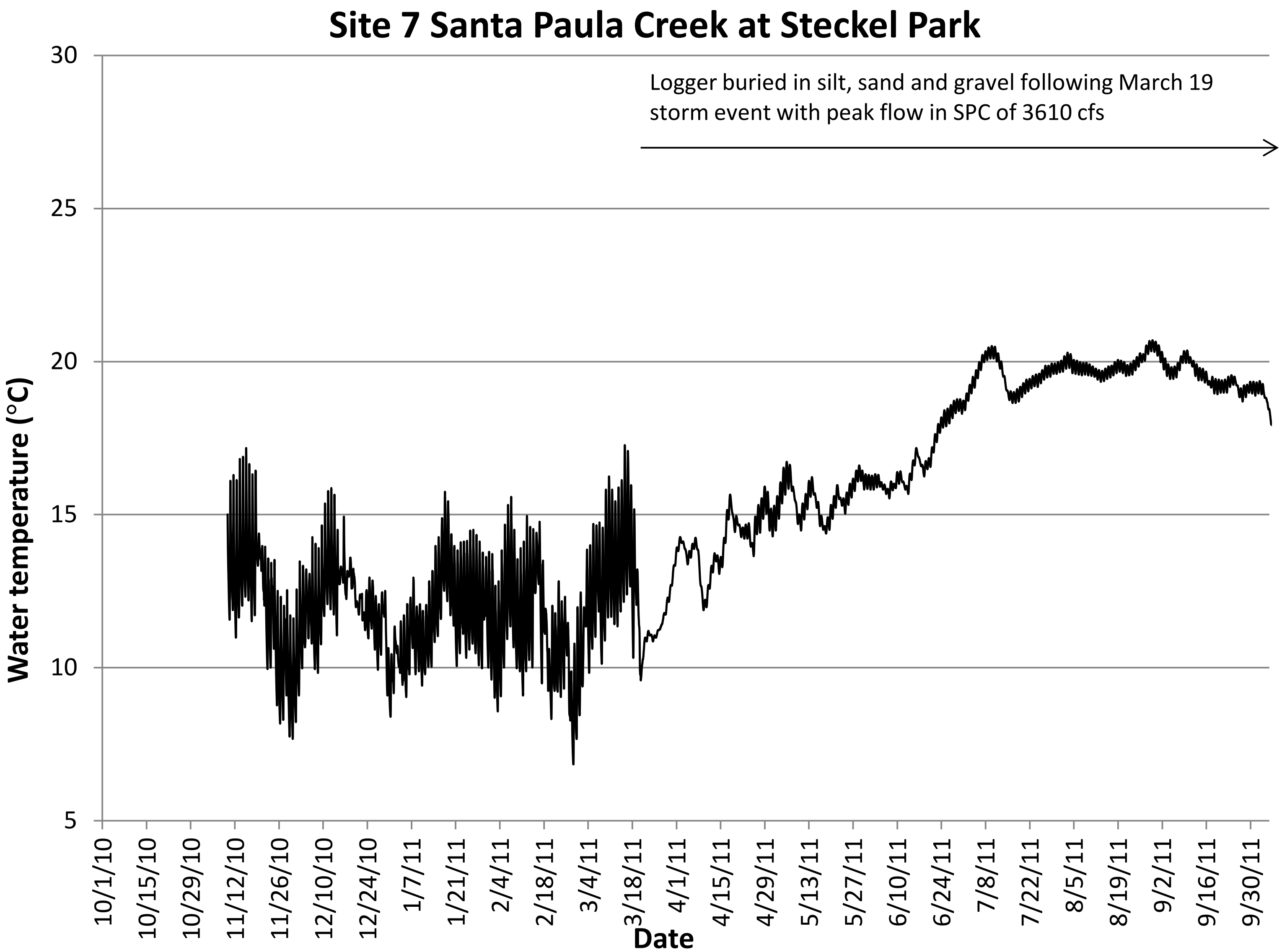


Figure 12. Santa Paula Creek downstream of Sisar Creek confluence water temperature

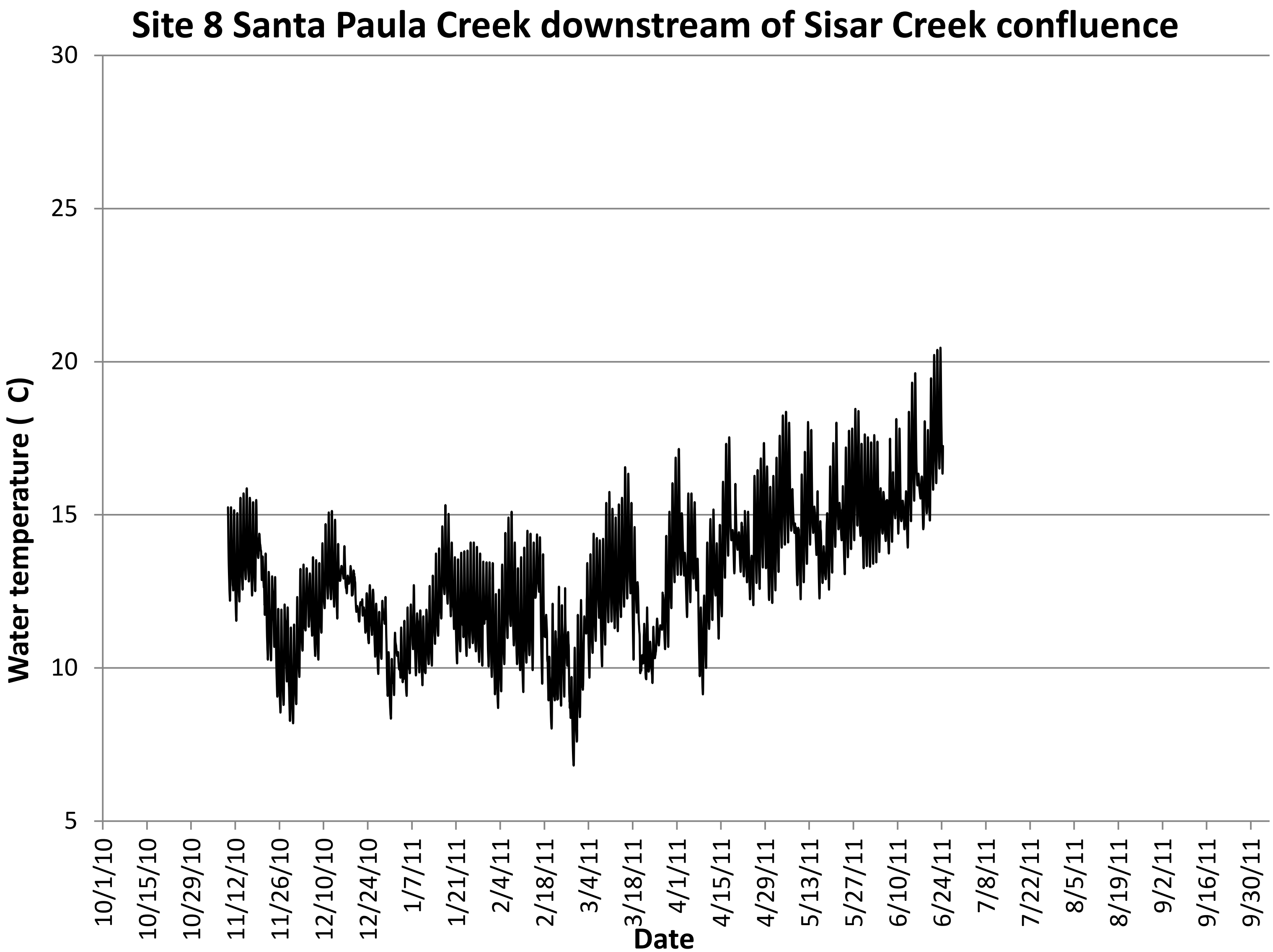


Figure 13. Piru Creek upstream of Temescal property line water temperature

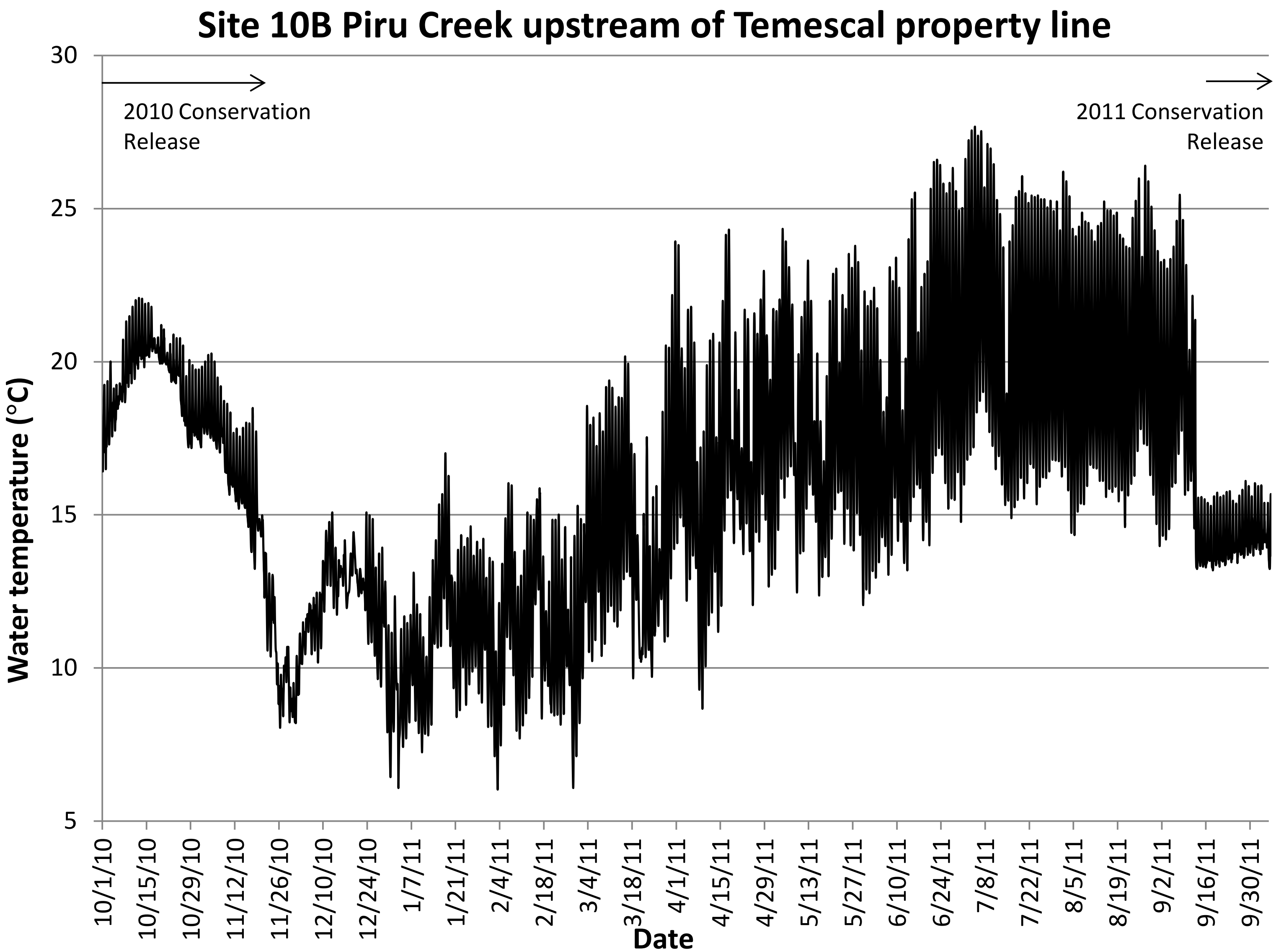


Figure 14. Piru Creek downstream of old USGS gauge water temperature

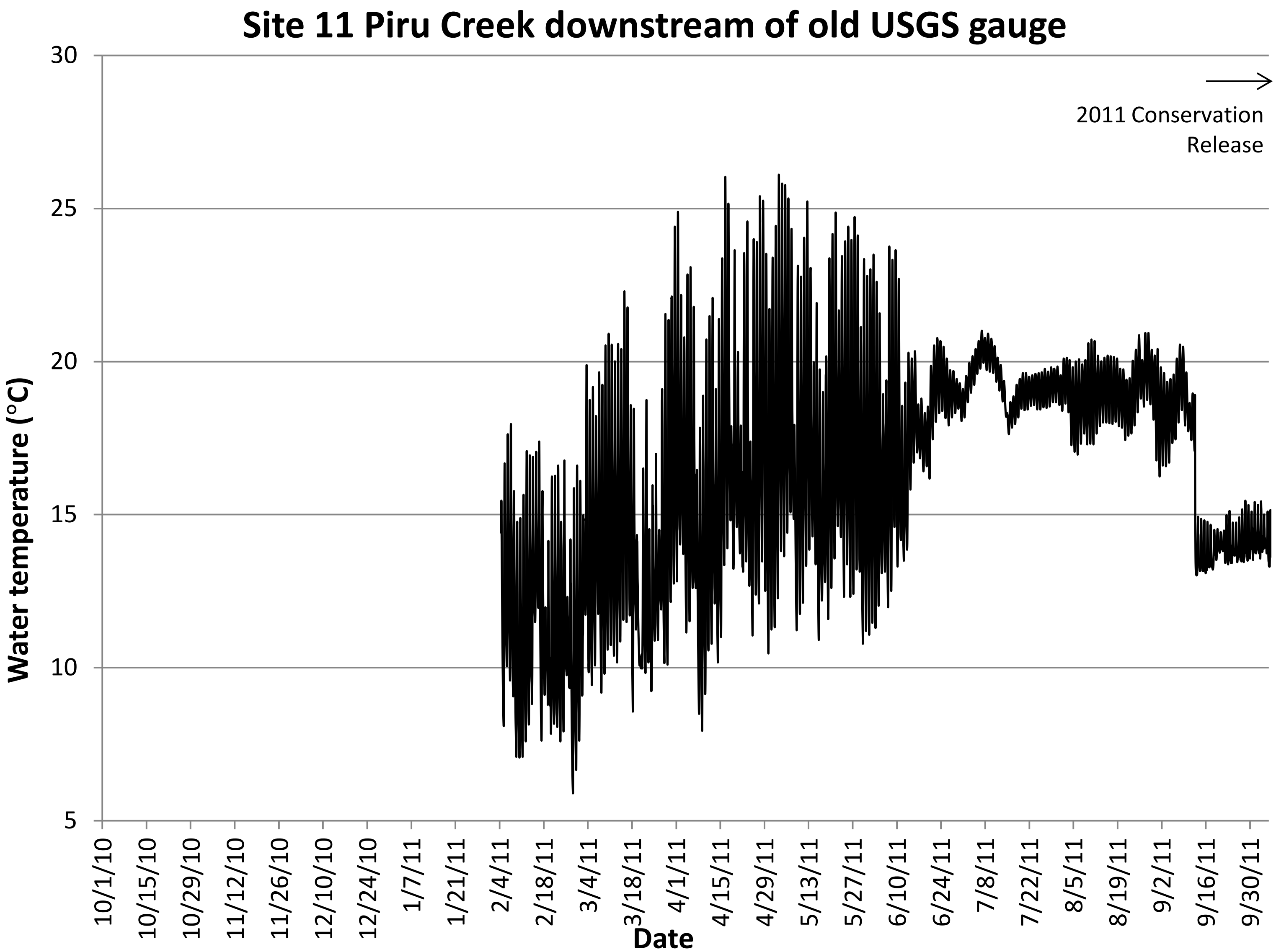


Figure 15. Piru Creek at old USGS gauge water temperature

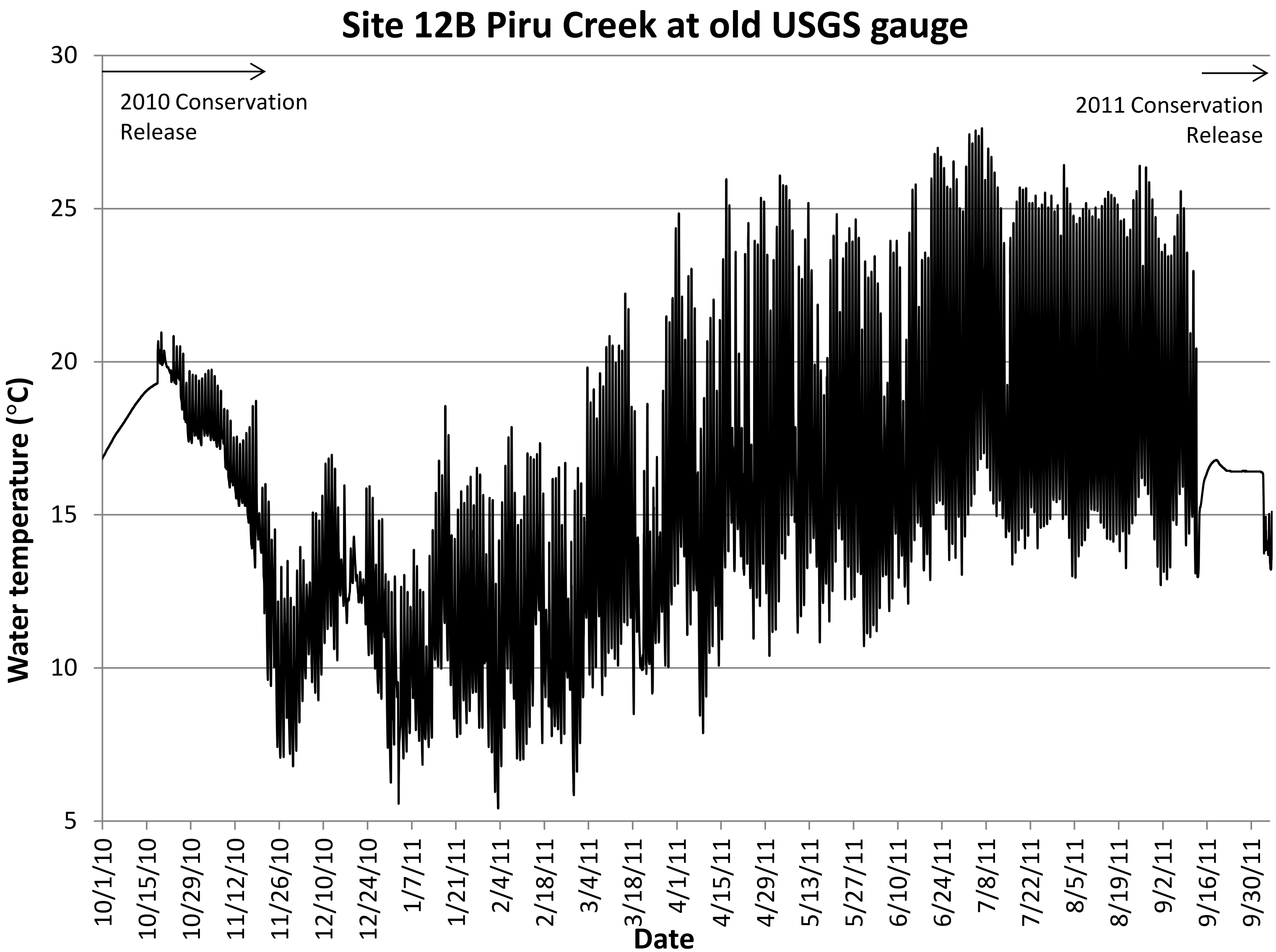


Figure 16. Piru Creek upstream of second bridge water temperature

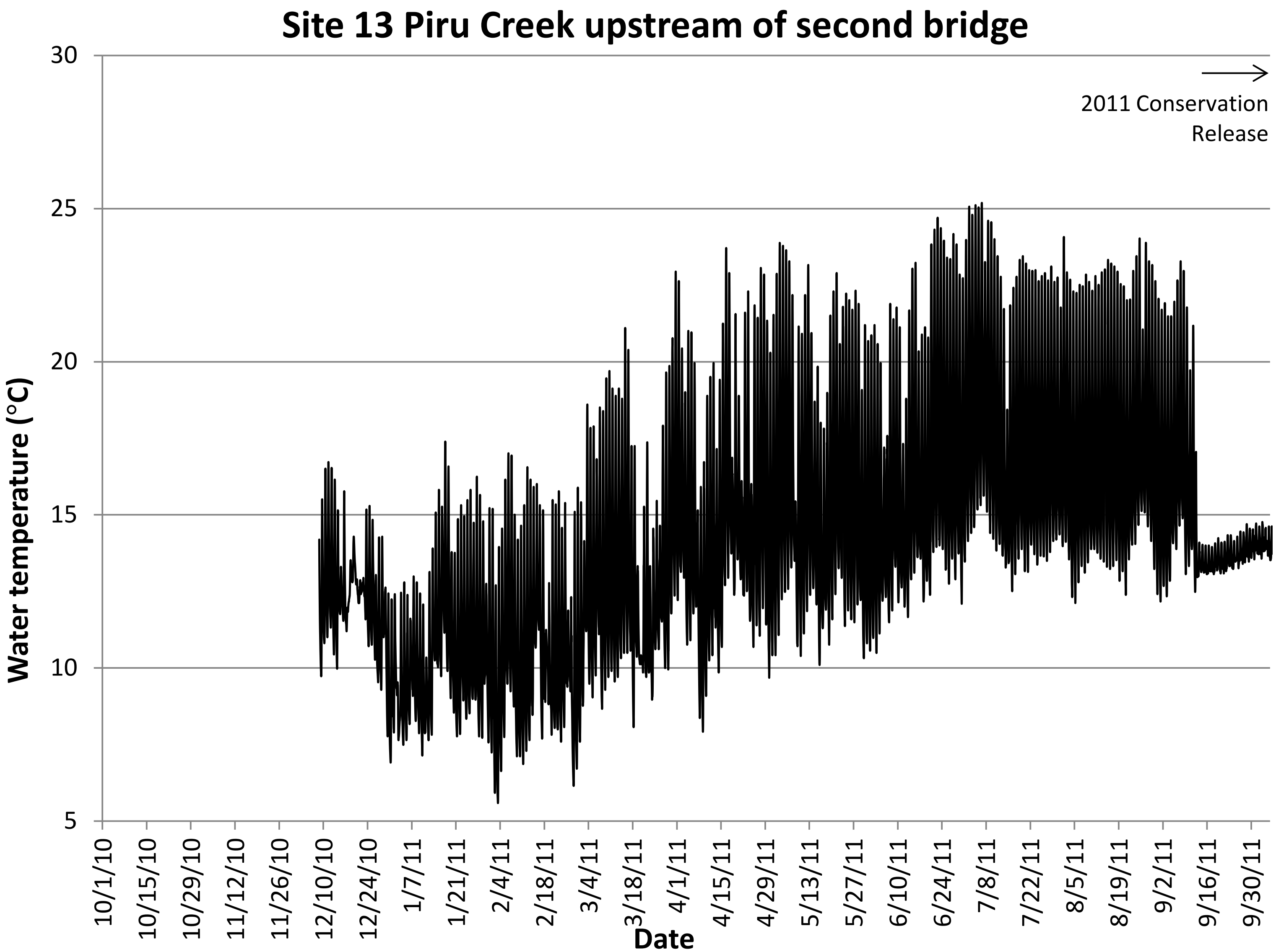


Figure 17. Piru Creek downstream of spill and release channel confluence #1 water temperature

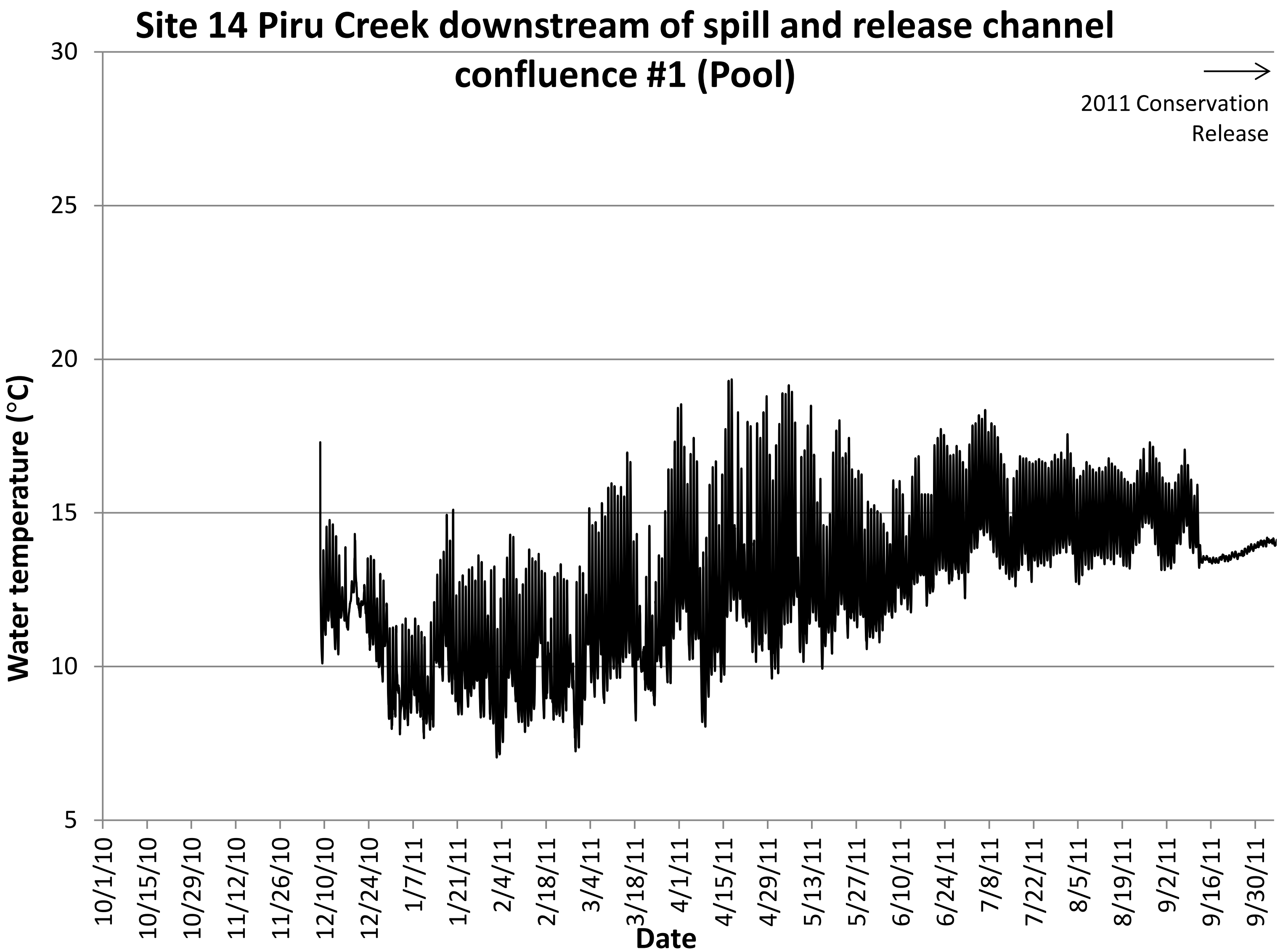


Figure 18. Piru Creek downstream of spill and release channel confluence #2 water temperature

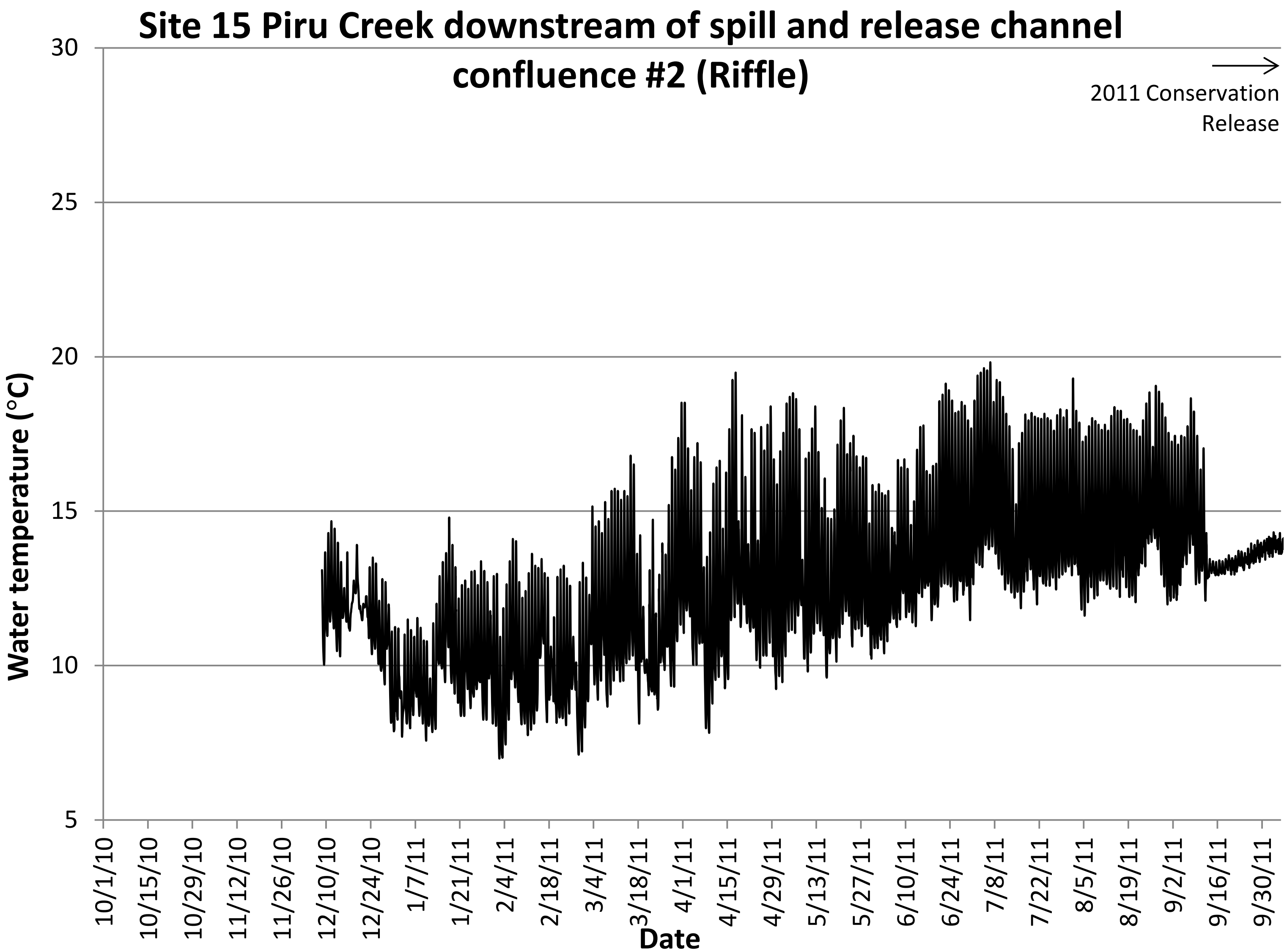
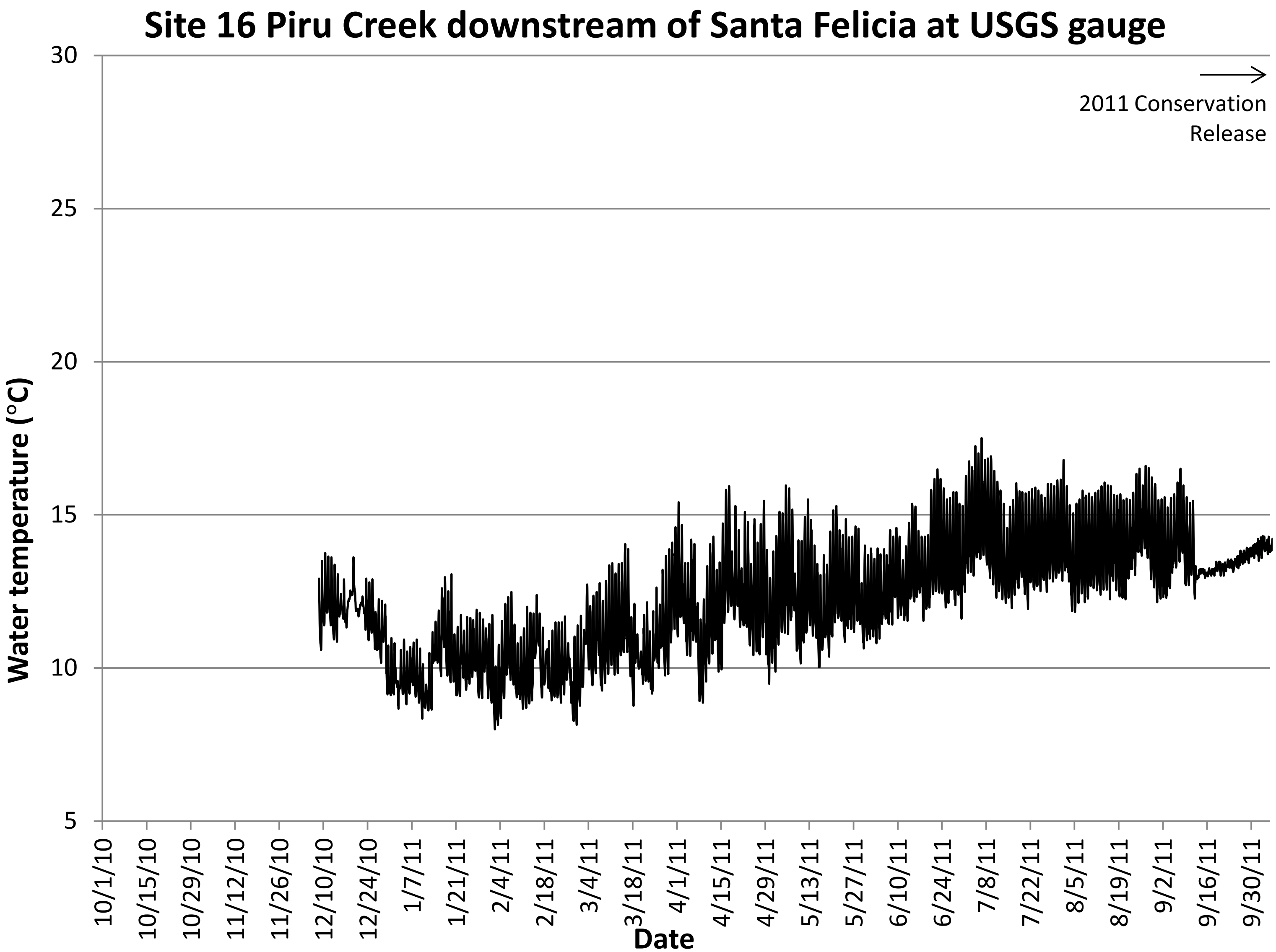


Figure 19. Piru Creek downstream of Santa Felicia Dam at USGS gauge weir



Appendix B

Photos

Photo 1 – Santa Clara River Estuary Smolt Relocation Site Open

Photo 2 – Santa Clara River Estuary Smolt Relocation Site Closed

Photo 3 – Santa Clara River (near Santa Paula) Resident Rainbow Trout Relocation Site

Photo 4 – Sespe Creek Resident Rainbow Trout Relocation Site

Photo 5 – Santa Paula Creek Resident Rainbow Trout Relocation Site

Photo 6 – Santa Clara River Steelhead Smolt Length Measurement

Photo 7 - Santa Clara River Steelhead Smolt

Photo 8 – Santa Clara River Resident Rainbow Trout with Black Spot Disease (Larval Trematode Infection)

Photo 9 - Upstream Migration Monitoring Infrared Scanners

Photo 10 – Upstream Migration Monitoring Surveillance System

Photo 11 – DIDSON Trailer Mount with ATV

Photo 12 – DIDSON Deployed Below Freeman Diversion Dam

Photo 13 – Fish Screen Bay Stranding Survey

Photo 14 – Fish Trap Bay Water Temperature Monitoring Site

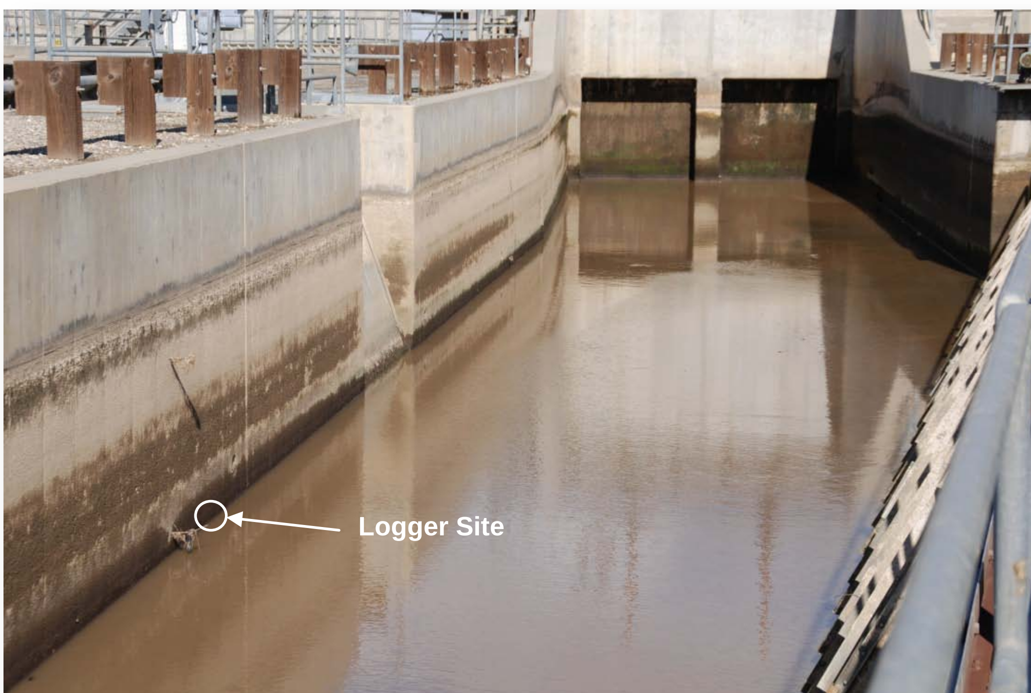


Photo 15 – Fish Screen Bay Water Temperature Monitoring Site

Photo 16 – Santa Paula Creek at Steckel Park Water Temperature Monitoring Site

Photo 17 – Santa Paula Creek below Sisar Creek Confluence Water Temperature Monitoring Site

Photo 18 – Piru Creek D/S of Temescal Property Water Temperature Monitoring Site

Photo 19 - Piru Creek in Pool D/S of Old USGS Gauge Water Temperature Monitoring Site

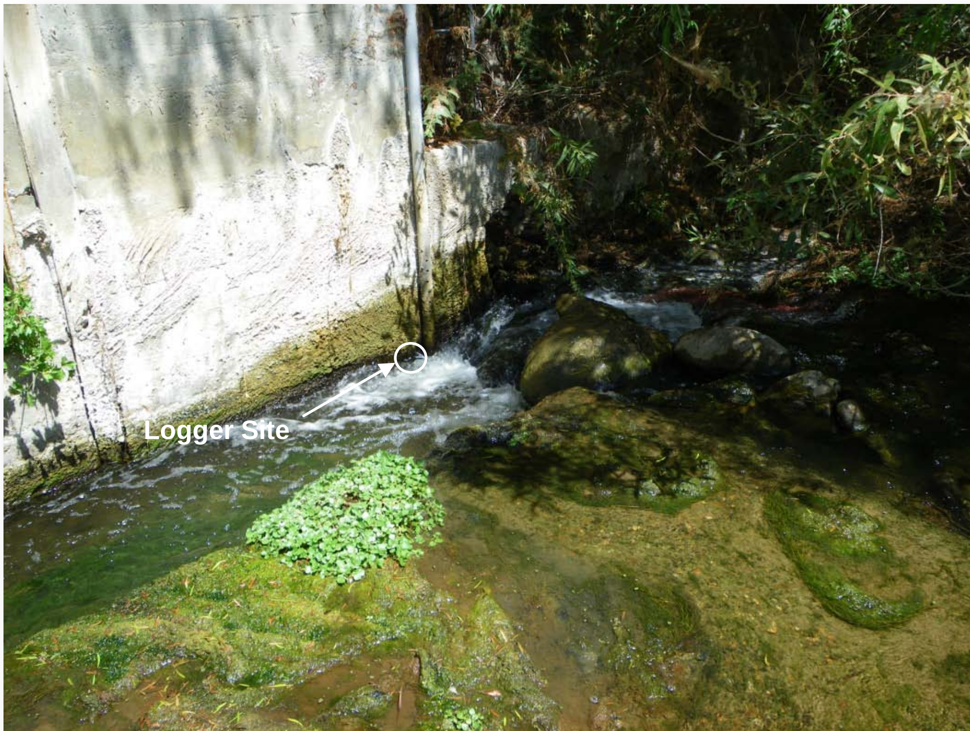


Photo 20 – Piru Creek at Old USGS Gauge Water Temperature Monitoring Site

Photo 21 – Piru Creek Approximately 500 Feet Upstream of Most Upstream Bridge

Photo 22 – Piru Creek in Pool D/S of Release Channel and Spillway #1

Photo 23 – Piru Creek in Riffle D/S of Release Channel and Spillway #2

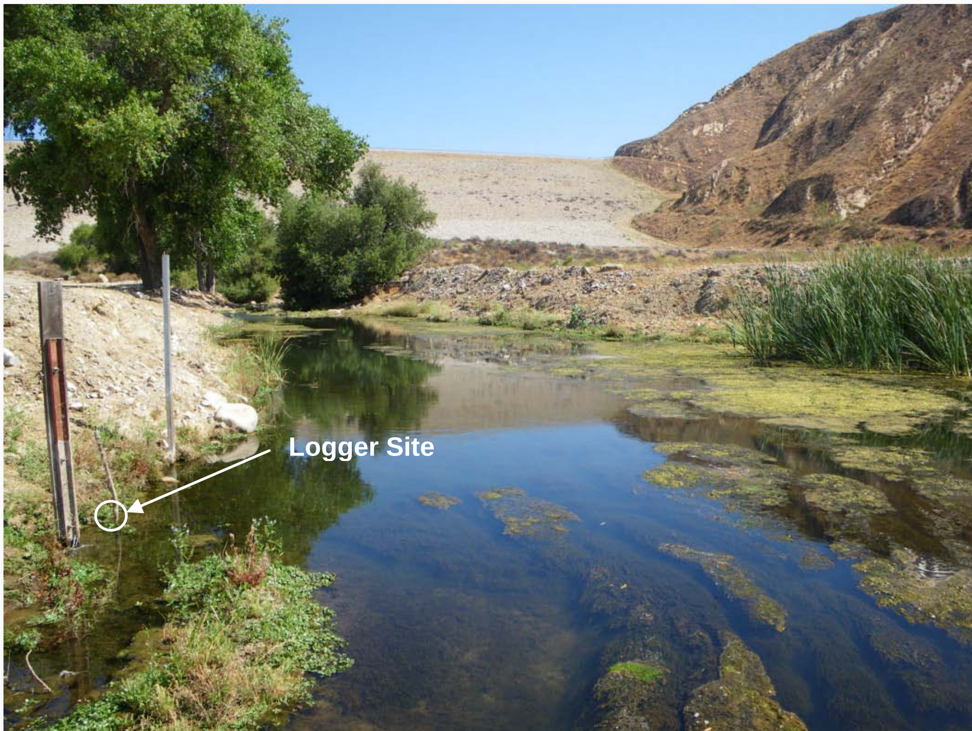


Photo 24 – Piru Creek at USGS Gauge Directly Downstream of Santa Felicia Dam Water Temperature Monitoring Site

Freeman Diversion panoramic photos

12/22/10

2/20/11

2/21/11

2/25/11

2/27/11

2/28/11

3/1/11

3/2/11

3/3/11

3/7/11

3/8/11

3/9/11

3/12/11

3/14/11

3/15/11

3/16/11

3/17/11

3/18/11

3/19/11

4/5/11

4/12/11

4/13/11

4/14/11

4/16/11

4/17/11

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