APPENDIX B. DETAILED ANALYSIS OF 2009 STEELHEAD MONITORING IN THE SAN LORENZO, SOQUEL, APTOS AND CORRALITOS WATERSHEDS

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Scope of Work

In fall 2009, 4 Santa Cruz County watersheds were evaluated for habitat quality and sampled for juvenile steelhead to compare with past results. Refer to maps in **Appendix A** that delineate reaches and sampling sites. The mainstem San Lorenzo River and 7 tributaries were sampled with a total of 19 sites. Eight half-mile segments were habitat typed to assess habitat conditions and select habitats of average quality to sample. In reaches that were not habitat typed, the same habitats were sampled in 2008 and 2009. Tributaries included Branciforte, Zayante, Lompico, Bean, Fall, Newell, Boulder and Bear creeks. Eight steelhead sites were sampled below anadromy barriers in Soquel Creek and its branches. Eight half-mile segments were habitat typed. In the Aptos Creek watershed, 2 sites in Aptos Creek and 2 sites in Valencia Creek were sampled, and the 4 associated half-mile segments were habitat typed. In the Corralitos sub-watershed of the Pajaro River drainage, 4 sites were sampled in Corralitos Creek, 2 sites were sampled in Shingle Mill Gulch and 2 sites were sampled in Browns Valley Creek, along with 7 associated half-mile segments habitat typed. Lower Shingle Mill Reach 1 was not habitat typed, with the same habitats sampled in 2008 and 2009.

Annual monitoring of juvenile steelhead began in 1994 in the San Lorenzo and 1997 in Soquel Creek. The Corralitos sub-watershed was previously sampled in 1981, 1994, 2006─2008. Aptos Creek was previously sampled in 1981, 2006─2008.

For annual comparisons, fish were divided into two age classes and three size classes. Age classes were young-of-the-year (YOY) and yearlings and older. The size classes were Size Class I (<75 mm Standard Length (SL)), Size Class II (between 75 and 150 mm SL) and Size Class III (>=150 mm SL). Juveniles in Size Classes II and III were considered to be “smolt-sized,” based on scale analysis of out-migrating smolts by Smith (**2005**), because most fish of that size would grow sufficiently in the following spring to smolt. Fish below that size very rarely smolt the following spring.

I-1. Steelhead and Coho Salmon Ecology

Migration. Adult steelhead in small coastal streams tend to migrate upstream from the ocean through an open sandbar after several prolonged storms; the migration seldom begins earlier than December and may extend into May if late spring storms develop. Many of the earliest migrants tend to be smaller than those entering the stream later in the season. Adult fish may be blocked in their upstream migration by barriers such as bedrock falls, wide and shallow riffles and occasionally log-jams. Man-made objects, such as culverts, bridge abutments and dams are often significant barriers. Some barriers may completely block upstream migration, but many barriers in coastal streams are passable at higher streamflows. If the barrier is not absolute, some adult steelhead are usually able to pass in most years, since they can time their upstream movements to match optimal stormflow conditions. We located partial migrational barriers in the San Lorenzo River Gorge caused by a wide riffle that developed below a bend in 1998 (Rincon riffle) and a large boulder field discovered in 1992 that created a falls (above Four Rock). Both of these impediments were probably passable at flows above approximately 50-70 cubic feet per second (cfs) as they were observed in 2002. A split channel had developed at the Rincon riffle by 2002 and in 2007 there existed a steep cascade where the channels rejoined, making adult steelhead passage up the main channel difficult. In 2008, the steep cascade was gone, offering much easier fish passage up the main channel. The boulder field at Four Rock was partially modified in 2008, though we have not examined the results. In most years these are not passage problems. However, in drought years and years when storms are delayed, they can be serious barriers to steelhead and especially coho salmon spawning migration. In the West Branch of Soquel Creek, there are Girl Scout Falls I and II that impede adult passage. Based on juvenile sampling, it appears that adult steelhead pass Girl Scout Falls I in most years but seldom pass Girl Scout Falls II.

Coho salmon often have more severe migrational problems because their migration period, November through early February, is often prior to the stormflows needed to pass shallow riffles, boulder falls and partial logjam barriers. Access is also a greater problem for coho salmon because they die at maturity and cannot wait in the ocean an extra year if access is poor due to failure of sandbar breaching during drought or delayed stormflow. In recent years until 2008, the rainfall pattern has generally brought early winter storms to allow for good coho access to the San Lorenzo system, though only a small number of apparent strays have been detected at the Felton fish ladder and trap.

Smolts (young steelhead and coho salmon which have physiologically transformed in preparation for ocean life) in local coastal streams tend to migrate downstream to the lagoon and ocean in March through early June. In streams with lagoons, young-of-the-year (YOY) and yearling fish may spend several months in this highly productive lagoon habitat and grow rapidly. In some small coastal streams, downstream migration can occasionally be blocked or restricted by low flows due primarily to heavy streambed percolation or early season stream diversions. Flashboard dams or sandbar closure of the stream mouth or lagoon are additional factors that adversely affect downstream migration. However, for most local streams, downstream migration is not a major problem except under drought conditions.

Spawning. Steelhead and coho salmon require spawning sites with gravels (from 1/4" to 3 1/2" diameter) having a minimum of fine material (sand and silt) and with good flows of clean water moving over and through them. Flow of oxygenated water through the redd (nest) to the fertilized eggs is restricted by increased fine materials from sedimentation and cementing of the gravels with fine materials. Flushing of metabolic wastes is also hindered. These restrictions reduce hatching success. In many local streams, steelhead appear to successfully utilize spawning substrates with high percentages of coarse sand, which probably reduces hatching success. Steelhead spawning success may be limited by scour from winter storms in some Santa Cruz County streams. Steelhead that spawn earlier in the winter are more likely to have their redds washed out or buried by the greater number of winter and spring storms that will follow. However, unless hatching success has been severely reduced, survival of eggs and alevins is usually sufficient to saturate the limited available rearing habitat in most small coastal streams and San Lorenzo tributaries. However, in the mainstem San Lorenzo River downstream of the Boulder Creek confluence, spawning success in the river may be an important limiting factor. The production of YOY fish is related to spawning success, which is a function of the quality of spawning conditions, the pattern of storm events and ease of spawning access to upper reaches of tributaries, where spawning conditions are generally better.

Rearing Habitat. In the mainstem San Lorenzo River, downstream of the Boulder Creek confluence, many steelhead require only one summer of residence before reaching smolt size. This is also the case in the Soquel Creek mainstem and lagoon. Except in streams with high summer flow volumes (greater than about 0.2 to 0.4 cubic feet per second (cfs) per foot of stream width), steelhead require two summers of residence before reaching smolt size. This is the case for most juveniles inhabiting tributaries of the San Lorenzo River and the mainstem upstream of the Boulder Creek confluence. This is also the case for most juveniles in the East and West Branches of Soquel Creek, as well as in the Aptos watershed (except its lagoon) and the Corralitos sub-watershed except in wetter years such as 2006. Juvenile steelhead are generally identified as YOY (first year) and yearlings (second year). The slow growth and often two-year residence time of most local juvenile steelhead indicate that the year class can be adversely affected by low streamflows or other problems (including over-wintering survival) during either of the two years of residence. Nearly all coho salmon, however, smolt after one year under most conditions, despite their smaller size.

Growth of YOY steelhead and coho salmon appears to be regulated by available insect food (determined by substrate conditions in fastwater habitat and insect drift rate), although escape cover (hiding areas, provided by undercut banks, large rocks which are not buried or "embedded" in finer substrate, surface turbulence, etc.) and water depth in pools, runs and riffles are also important in regulating juvenile numbers, especially for larger fish. Densities of yearling and smolt-sized steelhead in small streams, the upper San Lorenzo (upstream of the Boulder Creek confluence) and San Lorenzo tributaries, are usually regulated by water depth and the amount of escape cover during low-flow periods (July−October) and by over-winter survival in deep and/or complex pools. In most small coastal streams, availability of this "maintenance habitat" provided by depth and cover appears to determine the number of smolts produced

(**Alley 2006a; 2006b; 2007; Smith 1982**). Abundance of food (aquatic insects and terrestrial insects that fall into the stream) and fast-water feeding positions for capture of drifting insects in "growth habitat" (provided mostly in spring and early summer) determine the size of these smolts. It was determined that in portions of a watershed that are capable of growing YOY juvenile steelhead to smolt size their first growing season (Size Class II =>75 mm Standard Length in fall), the density of YOY that obtain this size was positively associated with the mean monthly streamflow for May–September (**Alley et al. 2004**). Furthermore, it has been shown that the density of slower growing YOY in tributaries was positively associated with the annual minimum annual streamflow (**Alley et al. 2004**). Aquatic insect production is maximized in unshaded, high gradient riffles dominated by relatively unembedded substrate larger than about 4 inches in diameter.

Yearling steelhead growth usually shows a large increase during the period of March through June. Larger steelhead then may smolt as yearlings. For steelhead that stay a second summer, mid to late summer growth is very slight in many tributaries (or even negative in terms of weight) as flow reductions eliminate fast-water feeding areas and reduce insect production. A short growth period may occur in fall and early winter after leaf-drop of riparian trees, after increased streamflow from early storms, and before water temperatures decline below about 48ºF or water clarity becomes too turbid for feeding. The "growth habitat" provided by higher flows in spring and fall (or in summer for the mainstem San Lorenzo River) is very important, since ocean survival to adulthood increases exponentially with smolt size.

During summer in the mainstem San Lorenzo River downstream of the Boulder Creek confluence, steelhead use primarily fast-water habitat where insect drift is the greatest. This habitat is found in deeper riffles, heads of pools and faster runs. YOY and small yearling steelhead that have moved down from tributaries can grow very fast in this habitat if streamflows are high and sustained throughout the summer. The shallow riffle habitat in the upper mainstem is used almost exclusively by small YOY, although most YOY are in pools. In the warm mainstem Soquel Creek, downstream of Moores Gulch, juvenile steelhead utilize primarily heads of pools in all but the highest flow years, with some YOY using shallower runs and riffles. Upstream of Moores Gulch in summer on the mainstem and in the two Branches (East and West), juvenile steelhead use primarily pool habitat where cover is available and deeper step-runs. Riffles are used by primarily YOY and more so in the upper mainstem than the branches where they become more shallow.

Pools and step-runs are the primary habitat for steelhead in summer in San Lorenzo tributaries, the upper San Lorenzo River above the Boulder Creek confluence, the Aptos watershed and the Corralitos sub-watershed because riffles and runs are very shallow, offering limited escape cover. Primary feeding habitat is at the heads of pools and in deeper pocket water of step-runs. The deeper the pools, the more value they have. Higher streamflow enhances food availability, surface turbulence (as overhead cover) and habitat depth, all factors that increase steelhead densities and growth rates. Where found together, young steelhead use pools and faster water in riffles and runs/step-runs, while coho salmon use primarily pools, being poorer swimmers.

Juvenile steelhead captured during fall sampling included a smaller size class of juveniles less than (<) 75 mm (3 inches) Standard Length (SL); these fish would almost always require another growing season before smolting. The larger size class included juveniles 75 mm SL or greater (=>) and constituted fish that are called "smolt size" because a majority will likely out-migrate the following spring and because fish smaller than this very rarely smolt the following spring. Smolt size was based on scale analysis of out-migrant smolts captured in 1987-89 in the lower San Lorenzo River. This size class in fall may include fast growing YOY steelhead inhabiting the mainstems of the San Lorenzo River and Soquel Creek, lower reaches of larger San Lorenzo tributaries, and lower reaches of Corralitos and Aptos creeks. It also includes slower growing yearlings and older fish inhabiting all watershed reaches.

A basic assumption in relating juvenile densities to habitat conditions where they are captured is that juveniles do not move substantially from where they are captured during the growing season. This assumption is reasonable because at sites in close proximity, such as adjacent larger mainstem and smaller tributary sites, there are consistent differences in fish size, such as juveniles that are consistently larger in the mainstem sites where streamflow is greater and there is more food (**D. Alley pers. observation)**. In other cases, there are differences in fish size between sunny productive habitats and shady habitats where food is scarce. This indicates a lack of movement between sites. In addition, Davis (**1995**), during a study of growth rates in various habitat types, marked juvenile steelhead in June in Waddell Creek and recaptured the same fish in September in the same (or immediately adjacent) habitats where they had been marked. Evidence is lacking that would indicate ecologically significant juvenile movement upstream during the dry season, and the concern that summer flashboard dams without ladders may impede upstream movements of juvenile salmonids appears unfounded. Shapovalov and Taft (**1954**), after 9 consecutive years of fish trapping on Waddell Creek, detected very limited upstream juvenile steelhead movements; most of the relatively limited movement was in the winter.

Overwintering Habitat. Shelter for fish against high winter flows is provided by deeper pools, undercut banks, side channels, large unembedded rocks and large wood clusters. Over-wintering survival is usually a major limiting factor, since yearling fish are usually less than 10-20% as abundant as YOY. Extreme floods (i.e. 1982 and 1998) may make overwintering habitat the most critical for steelhead production. In the majority of years when bankfull or greater stormflows occur, these refuges are critical, and it is unknown how much refuge is needed. The remaining coho streams, such as Gazos, Waddell and Scott creeks, have considerably more instream wood than others (**Leicester 2005**).

I-2. Project Purpose and General Study Approach

The 2009 fall fish sampling and habitat evaluation included comparison of 2009 juvenile steelhead densities at sampling sites and rearing habitat conditions with those in 1997–2001 and 2003–2008 for the San Lorenzo River mainstem and 8 tributaries and in 1997−2009 for the Soquel Creek mainstem and branches. 2009 site densities were compared to multi-year averages. Trends in habitat conditions and steelhead densities were examined for mainstem and tributary sites having multi-year data. Habitat conditions were assessed primarily from measured streamflow, escape cover, water depth and consistent visual estimates of streambed composition and embeddedness.

Fall steelhead densities and habitat conditions in 2009 in the Corralitos Creek sub-watershed were compared to those in 1981, 1994 and 2006−2008. Fall 2009 steelhead densities and habitat conditions in the Aptos Creek watershed were compared to those in 1981 and 2006−2008. 2009 site densities were compared to multi-year averages.

DETAILED METHODS

M-1. Choice of Reaches and Vicinity of Sample Sites

Prior to 2006, juvenile steelhead densities were estimated by reach, an index of juvenile steelhead production was estimated by reach and by watershed. Indices of adult steelhead population size were also calculated from juvenile population indices. Since 2006, fish densities at average habitat quality sampling sites in previously determined reach segments have been compared to past years' fish densities. The proportion of habitat types sampled at each site within a reach was kept similar between years so that site densities could be compared between years for each reach. However, site density did not necessarily reflect fish densities for an entire reach because the habitat proportions sampled were not exactly similar to the habitat proportions of the reach. In most cases, habitat proportions at sites were somewhat similar to habitat proportions in the reach because sampling sites were more or less continuous and lengths of each habitat type were somewhat similar. However, in reaches where pools are less common, such as Reach 12a on the East Branch of Soquel Creek and Reach 2 in lower Valencia Creek, a higher proportion of pool habitat was sampled than exists in the respective reaches. More pool habitat was sampled because larger yearlings utilize, almost exclusively, pool habitat in small streams, and changes in yearling densities in pools are most important to monitor. In these two cases, site densities of yearlings were higher than reach densities. Prior to 2006, actual reach density and fish production could be compared between years and between reaches because fish densities by habitat type were extrapolated to reach density and an index of reach production with reach proportions of habitat types factored in.

The mainstem San Lorenzo was divided into 13 reaches, based on past survey work (**Table 1a;**

Appendix A map, Figure 2). Much of the San Lorenzo River was surveyed during a past water development feasibility study in which general geomorphic differences were observed (**Alley 1993**). This work involved survey and determination of reach boundaries in the mainstem and certain tributaries, including Kings and Newell creeks (**Tables 1a-b; Appendix A map, Figure 2**). In past work for the San Lorenzo Valley Water District, Zayante and Bean creeks were surveyed and divided into reaches. Previous work for the Scotts Valley Water District required survey of Carbonera Creek and reach determination, although it has not been sampled since 2001. Considerations for reach boundaries in Lompico Creek were similar to those for other tributaries, including summer baseflows, past road impacts and bridge crossings, water diversion impacts and extent of perennial channel. The half-mile segment surveyed and sampled in Lompico Creek was mostly in the lowermost Reach 13e and included some of Reach 13f with two bridge crossings.

In each tributary and the upper mainstem of the San Lorenzo, the uppermost extent of steelhead use was approximated in past years to make watershed population estimates. For the upper San Lorenzo River, topographic maps were used with attention to change in gradient and tributary confluences to designate reach boundaries (**Table 1b; Appendix A map, Figure 2**). The uppermost reach boundaries for Bean and Bear creeks were based on a steep gradient change seen on the topographic map, indicative of passage problems. The Deer Creek confluence was used on Bear Creek, although steelhead access continues somewhat further. Known barriers were upper reach boundaries in Carbonera, Fall, Newell, Boulder and Kings creeks. The extent of perennial stream channel in most years was used for setting boundaries on Branciforte, Zayante and Lompico creeks. Steelhead estimates in Zayante Creek stopped at the Mt. Charlie Gulch confluence in past years, although steelhead habitat exists above in Zayante Creek and Mt. Charlie Gulch in many years. Steelhead habitat in the Zayante tributary, Lompico Creek, was first sampled in 2006.

In 2009, sampled tributaries of the San Lorenzo included Zayante, Lompico, Bean, Fall, Newell, Boulder, lower Bear and lower Branciforte creeks. Refer to **Table 1c, Appendix A, Figure 2** and page 2 for a list of sampling sites and locations in 2009. Half-mile segments in the vicinity of sampling sites were habitat typed to select sampling sites with average habitat conditions. Steelhead inhabit other tributaries, and in the past, 9 major tributaries were sampled. Other tributaries known to contain steelhead from past sampling and observation include (from lower to upper watershed) Eagle Creek in Henry Cowell State Park, Lockhart Gulch, Mountain Charlie Gulch in the upper Zayante Creek drainage, Love Creek, Clear Creek, Two Bar Creek, Logan Creek tributary to Kings Creek and Jamison Creek (a Boulder Creek tributary). Other creeks likely to provide limited steelhead access and perennial habitat in some years for relatively low densities of steelhead include Glen Canyon and Granite creeks in the Branciforte system; Powder Mill Creek, Gold Gulch (lower mainstem San Lorenzo tributaries); and Ruins and Mackenzie creeks (2 small Bean Creek tributaries). This list is not exhaustive for steelhead. Resident rainbow trout undoubtedly exist upstream of steelhead migrational barriers in some creeks and especially upper Boulder Creek above the bedrock chute near the Boulder Creek Country Club.

In Soquel Creek, reach boundaries downstream of the East and West Branch confluence were determined from our habitat typing and stream survey work in September 1997. For reaches on the East and West branches, boundaries were based on observations made while hiking to sampling sites, observations made during previous survey work, and reach designations made by Dettman during earlier work (**Dettman and Kelley 1984**). Changes in habitat characteristics that necessitated reach boundary designation often occurred when stream gradient changed. Stream gradient is often associated with changes in habitat type proportions, pool depth, substrate size distribution and channel type. Other important factors separating reaches are a change in tree canopy closure or significant tributary confluences that increase summer baseflow and/or may be locations of sediment input from tributaries in the winter.

The 7.1 miles of Soquel Creek (excluding the lagoon) downstream of the East and West Branches were divided into 8 reaches (**Table 2a; Appendix A of watershed maps**). The lagoon was designated Reach 0. The 7 miles of the East Branch channel between the West Branch confluence and Ashbury Gulch were divided into 4 reaches. The upstream limit of steelhead in this analysis was considered Ashbury Gulch due to the presence of a bedrock falls and several boulder drops constituting Ashbury Falls immediately downstream. These impediments likely prevent adult access to areas above the falls in most years. Furthermore, the salmonid size distribution of previous years at Site 18 above Ashbury Falls (delineated in **Table 2b**) indicated that a higher proportion of larger resident rainbow trout was present in the population upstream of Reach 12b. The West Branch had 2 reliable steelhead reaches (13 and 14a). The upper West Branch reach was shortened in 2000 when a bedrock chute (Girl Scout Falls I) was observed upstream of Olson Road (formerly Olsen Road) near the Girl Scout camp. This chute is likely impassable during many stormflows. Therefore, juvenile steelhead population estimates for previous years were reduced to exclude potential juvenile production above this passage impediment. Sampling in 2003 and 2005 indicated that steelhead likely passed Girl Scout Falls I but not Girl Scout Falls II. Sampling in 2004 indicated that some steelhead might have passed Girl Scout Falls II, although young-of-the-year production above Girl Scout Falls II was approximately half what it was downstream. Sampling in 2005 and 2006 indicated that adult steelhead did not pass Girl Scout Falls II. After 2006, the sampling site upstream of Girl Scout Falls II was dropped from the scope.

In 2002, the upper West Branch was surveyed. Significant impediments to salmonid migration were found and used as reach boundaries. Reach 14b was designated between Girl Scout Falls I and Girl Scout Falls II. Reach 14c was designated between Girl Scout Falls II and Tucker Road (formerly Tilly’s Ford). Reach 14d was designated between Tucker Road and Laurel Mills Dam.

Soquel Creek sites included 4 mainstem sites with one in Reach 1 (Site 1) upstream of the lagoon (downstream of Bates Creek), one in the lower mainstem below Moores Gulch in Reach 3 (Site 4), one in the upper mainstem in Reach 7 (Site 10) and one in the upper mainstem in Reach 8 (Site 12) (**Table 2b**). Half-mile segments encompassing these sites were habitat typed to determine sampling sites with average habitat quality, except 0.8 miles were habitat typed in Reach 1. Sampling sites were chosen to represent the lower East Branch Reach 9 (Site 13a) and the upper East Branch Reach 12a (Site 16) (**Table 2b**) in the upper Soquel Creek watershed where most of the spawning usually occurs. On the

West Branch, one sampling site was chosen downstream of Girl Scout Falls I and Hester Creek in Reach 13 (Site 19). The reach between Girl Scout Falls I and II was habitat typed (Reach 14b) and sampled (Site 21) in 2009. Landowner objection in 2006 prevented our surveying and sampling of Reach 14a in the future.

In the Aptos Creek watershed, 2 sites were sampled in Aptos Creek, representing the low-gradient Reach 2 above the Valencia Creek confluence and the higher gradient Reach 3 in Nisene Marks State Park (**Appendix A map**). Two sites on Valencia Creek were sampled in the vicinity of historical sites previously sampled in 1981 (**Table 3**). Reach 2 was above passage impediments near Highway 1 where a new fish ladder was constructed. Reach 3 was above the passage impediment that has been retrofitted at the Valencia Road culvert crossing. Half-mile segments in the vicinity of historical sampling sites were habitat typed so that pools with average habitat quality could be chosen for sampling, along with adjacent fastwater habitat. Site numbers were consistent with 1981 numbering.

In the Corralitos Creek sub-watershed of the Pajaro River Watershed, sampling sites were chosen based on historical sampling locations (**Smith 1982; Alley 1995a**) and historical reach designations determined in 1994 (**Alley 1995a**). Reach delineations were based on previous stream survey work of streambed conditions, streamflow and habitat proportions by Alley of the extent of steelhead distribution in sub-watershed in 1981 and past knowledge of streamflow and sediment inputs from tributaries by Smith and Alley during drought and flood (**Table 4a; Appendix A**). Half-mile segments were habitat typed in the vicinity of the historical sampling sites to identify pools with average habitat quality and their adjacent fastwater habitat to sample. Site numbers were kept consistent with the original 1981 designations to prevent confusion.

In Corralitos Creek, 4 reaches were chosen: Reach 1 downstream of the water diversion dam (Site 1), Reach 3 downstream of Rider Creek as streamflow steadily increased toward the diversion dam (Site 3), Reach 6 upstream of Rider Creek (a historical sediment source) and the Eureka Canyon Road crossing at RM 2.95 (box culvert baffled in 2008) that is a partial passage impediment (Site 8) and Reach 7 upstream of Eureka Gulch, a historical sediment source (Site 9) (**Tables 4a and 4b; Appendix A map**).

In Shingle Mill Gulch, Reach 1 was chosen below the partial passage impediment at the second road crossing (Site 1) and Reach 3 above the second (approach modified in 2008) and third road crossings and the steep Reach 2. Reach 3 is a lower gradient, low flow reach downstream of Grizzly Flat (Site 3) (**Tables 4a and 4b; Appendix A map**).

In Browns Valley Creek, Sites 1 and 2 were chosen to represent the 2 reaches previously delineated there (**Tables 4a and 4b; Appendix A map**). The diversion dam demarcated the reach boundaries because of its potential effect on surface flow and a change in channel type. Other valuable steelhead habitat exists in Ramsey Gulch and Gamecock Canyon Creek (**Smith 1982**).

M-2. Classification of Habitat Types and Measurement of Habitat Conditions

In each watershed, ½-mile stream segments were habitat-typed using a modified CDFG Level IV habitat inventory method; with fish sampling sites chosen within each segment based on average habitat conditions. See sampling methods for more details. Habitat types were classified according to the categories outlined in the California Salmonid Stream Habitat Restoration Manual (**Flosi et al. 1998**). Some habitat characteristics were estimated according to the manual's guidelines, including length, width, mean depth, maximum depth, shelter rating and tree canopy (tributaries only in 1998). More data were collected for escape cover than required by the manual to obtain more detailed, biologically relevant information.

M-3. Measurement of Habitat Conditions

During habitat typing in 2009, as in past years, visual estimates of substrate composition and embeddedness were made. The observer looked at the habitat and made mental estimates based on what he saw with his trained eye. Therefore, these estimates are somewhat subjective, with consistency between data collectors requiring calibration from one to the other. An assumption is that the same data collector will be consistent in visual estimates. If more than one data collector contributed to the same study, the original observer trained the others to be consistent (“calibrated”) on visual estimates. Changes in visual estimates of substrate abundance or embeddedness of about 10% or more between sites and years probably represent real changes in habitat quality. The previous years' data was not reviewed prior to data collection so as not to bias current data.

Fine Sediment. Fine sediment was visually estimated as particles smaller than approximately 0.08 inches. In the Santa Cruz Mountains, there is little gradual gradation in particle size between sand and larger substrate, making visual estimates of fines relatively easy. There is generally a shortage of gravel-sized substrate. The comparability of these visual estimates to data collection via pebble counts would depend on the skill of the visual estimator and the skill of the pebble count collectors. Untrained volunteers tend to select larger substrate to pick up and measure during pebble counts, resulting in an overestimate of particle size composition of the streambed. The accuracy of pebble counts is also dependent on sample size. Neither the pebble count nor the visual estimate will provide data for substrate below the streambed surface. The McNeil Sampler may be used for core samples, and results from this method may not comparable to the other methods. The substrate that may be sampled with core sampling is restricted by the diameter of the sampler. Both the pebble count method and the core sampling method are too labor intensive for habitat typing. We do not believe more in-depth estimates than those taken for percent fines during habitat typing are necessary for purposes of this fishery study. It is best to have annual consistency in data collecting personnel during habitat typing, however.

Embeddedness. Embeddedness was visually estimated as the percent that cobbles and boulders larger than 150 mm (6 inches) in diameter were buried in finer substrate. Previous to 1999, the cobble range included substrate larger than 100 mm (4 inches). The change in cobble size likely had little effect on embeddedness estimates. The reason the cobble size was increased to 150 mm was because substrate smaller than that probably offered little benefit for fish escape cover, and embeddedness of smaller substrate was not a good indicator of habitat quality for fish.

Cobbles and boulders larger than approximately 150 mm in diameter provided good, heterogeneous habitat for aquatic insects in riffles and runs and some fish cover if embedded less than 25%. Cobbles and boulders larger than 225 mm provided the best potential fish cover if embedded less than 25%.

Tree Canopy Closure. Tree canopy closure was measured with a densiometer. Included in the tree canopy closure measurement were trees growing on slopes considerable distance from the stream. The percent deciduous value was based on visual estimates of the relative proportion of deciduous canopy closure provided to the stream channel. Tree canopy closure directly determines the amount of solar radiation that reaches the stream on any date of the year, but the relationship changes as the sun angle changes through the seasons and with stream orientation. Our measure of canopy closure estimated the percent of blue sky blocked by the vegetative canopy and was not affected by the sun angle.

Greater tree canopy inhibits warming of the water and is critically important in small tributaries. Increased water temperature increases the metabolic rate and food requirements of steelhead. Tree canopy in the range of 75-90% is optimal in the upper mainstem San Lorenzo River (Reaches 10-12) and tributaries because water temperatures are well within the tolerance range of juvenile steelhead and coho salmon. If reaches with low summer baseflow become unshaded, water temperature rapidly increases. Limited openings (10-15%) in the canopy provide some sunlight during the day for algal growth and visual feeding by fish. In the San Lorenzo River system, it is important that the tributaries remain well shaded so that tributary inflows to the mainstem are sufficiently cool to prevent excessively high water temperatures in the lower mainstem river (Reaches 1-5), where tree canopy is often in the 30-75% range. There is an inverse relationship between tree canopy and insect production in riffles, which allows faster steelhead growth in larger, mainstem reaches, especially downstream of the Zayante Creek confluence, having deeper, fastwater feeding areas, despite the elevated temperatures and steelhead metabolic rate (and associated food requirements.) In addition, very dense shading reduces visibility of drifting insect prey and reduces fish feeding efficiency. However, as fast-water feeding areas diminish in smaller stream channels with less streamflow further up the watershed, high water temperatures may increase steelhead food demands beyond the benefits of greater food production in habitat lacking in fast-water feeding areas. Here is where shade canopy must increase to maintain cooler water temperature and lowered metabolic rate and food requirements of juvenile steelhead.

Escape Cover− Sampling Sites. The escape cover index for each habitat type within sampled sites was quantitatively determined in the same manner in 1994-2001 and in 2003-2009. The importance of escape cover is that the more there is in a habitat, the higher the production of steelhead, particularly for steelhead => 75 mm SL. Water depth itself provides some escape cover when 2 feet deep and good escape cover when it is 3 feet deep (1 meter) or greater. Escape cover was measured as the ratio of the linear distance under submerged objects and undercut banks within the habitat type that fish at least 75 mm (3 inches) Standard Length (SL) could hide under, divided by the length of the habitat type. The summer escape cover (as unembedded cobbles, undercut banks and instream wood) also provides overwintering habitat in the tributaries. This allowed annual comparisons for the habitats at historical sites.

<u>Escape Cover− Habitat Typing Method by Reach.</u> Reach segment averages in 1997−2000, 2003, 2005−2009 for escape cover by habitat type were determined from habitat typed segments. Reach cover indices were determined for habitat types in reach segments for purposes of annual comparisons. The escape cover index for each habitat type in a half-mile segment was measured as the ratio of linear feet of cover under submerged objects that Size Class II and III juveniles could hide under for all of that habitat type in the segment divided by total feet of stream channel as that habitat type in the reach segment. Objects of cover included unembedded boulders, submerged woody debris, undercut banks, bubble curtains and overhanging tree branches and vines that entered the water. Man-made objects, such as boulder rip-rap, concrete debris and plywood also provided cover. Escape cover constituted areas where fish could be completely hidden from view. This was not a measure of the less effective overhead cover that may be caused by surface turbulence or vegetation hanging over the water but not touching. Steelhead habitat is illustrated in the following drawings.

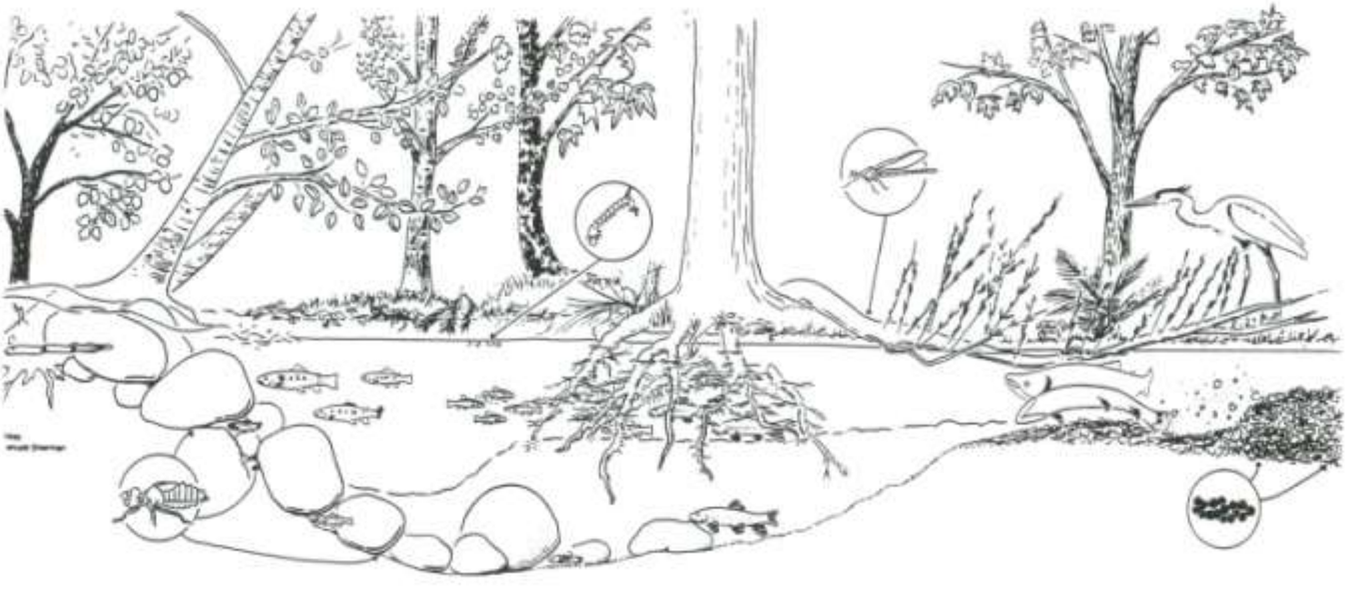
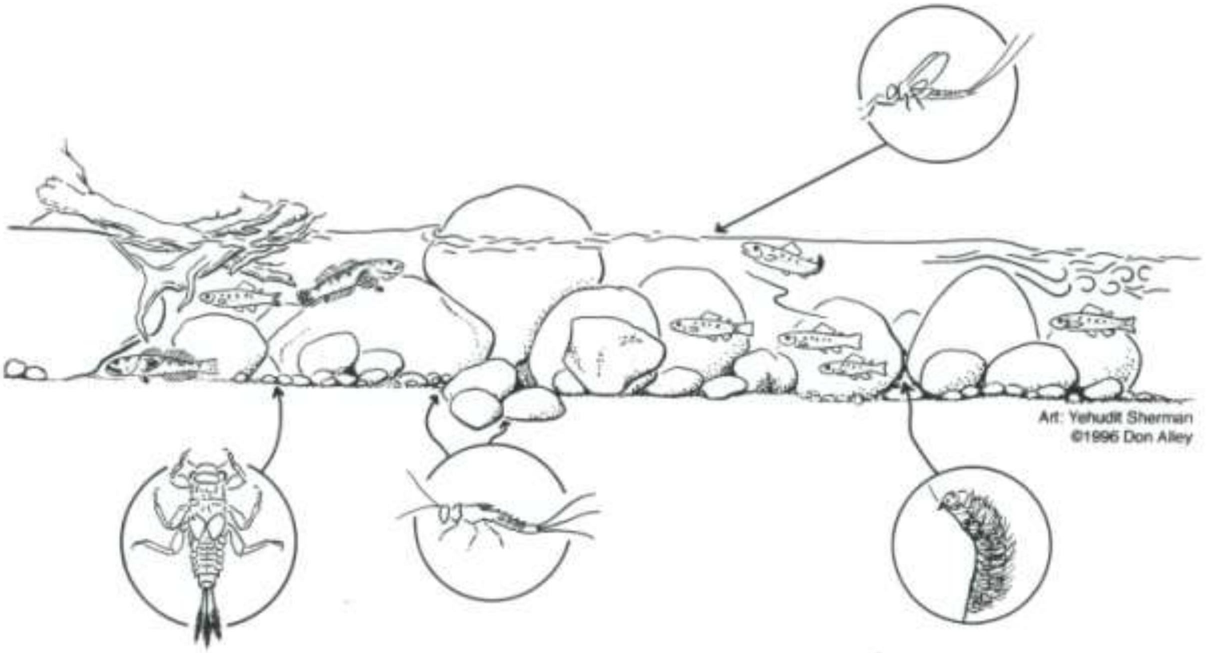


Illustration of pool habitat (stream flowing from left to right) showing escape cover under boulders and undercut bank with tree roots. Juvenile steelhead are feeding at the head of the pool. (Female steelhead covering her redd of eggs after spawning at the tail of the pool.)



Art: Yehudit Sherman
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Illustration of riffle habitat (stream flowing from left to right) showing escape cover under rootwad and boulders. (Juvenile steelhead are holding feeding positions, facing upstream.)

Water Depth, Channel Length and Width. Water depth is important because deeper habitat is utilized more heavily by steelhead, especially by larger fish. Deeper pools are associated with scour objects that often provided escape cover. Mean depth and maximum depth were determined with a dip net handle, graduated in half-foot increments. Soundings throughout the habitat type were made to estimate mean and maximum depth. Annual comparisons of habitat depth were possible because measurements were taken in the fall of each year. Minimum depth was determined approximately one foot from the stream margin in earlier years. Stream length was measured with a hip chain. Width in each year was measured with the graduated dip net except in wider habitats of the mainstem. In wider habitats (greater than approximately 20 feet), a range finder was used to measure width.

Streamflow. For 1995 and 1998 onward, the Marsh McBirney Model 2000 flowmeter was more extensively used at most sampling sites. Streamflow measurement was beyond the project scope and budget in 2006−2009. Even so, streamflow was measured in 2006 at historical sites in the San Lorenzo watershed in fall before any fall storms, as in past years. Mean column velocity was measured at 20 or more verticals at each cross-section. After 2006, streamflow measurements made by Santa Cruz County staff were used for annual comparisons.

M-4. Choice of Specific Habitats to be Sampled Within Reaches

Based on the habitat typing conducted in each reach prior to fish sampling, representative habitat units were selected with average habitat quality values in terms of water depth and escape cover to determine fish densities by habitat type. In mainstem reaches of the lower and middle San Lorenzo River (Sites 1, 2, 4, 6 and 8), riffles and runs that were close to the average width and depth for the reach were sampled by electrofishing. Pools in these reaches were divided into long pools (greater than 200 feet long) and short pools (less than 200 feet) and at least one pool of each size class was either snorkel censused or electrofished. The exception was Reach 1, which had only one pool less than 200 ft long, which was not censused. Only a long pool was censused in Reach 1 (which historically consisted of a long pool and a short pool). In these mainstem reaches, most fish were in the fastwater habitat of riffles, runs and the heads of pools and fish were not using most of the pool habitat. Some of the pools are hundreds of feet long with very few juveniles, except for those at the heads of pools.

For all other reaches in this study, in the upper San Lorenzo River above the Boulder Creek confluence, all San Lorenzo tributaries and in the Aptos and Corralitos watersheds, the location of representative pools with average habitat quality in terms of water depth and escape cover determined the pool habitat to be sampled. Pools were deemed representative if they had escape cover ratios and water depths similar to the average values for all pools in the half-mile segment that was habitat typed within the reach. Therefore, pools that were much deeper or much shallower than average or had much less or much more escape cover than average were not sampled. Once the pools were chosen for electrofishing, adjacent riffles, step-runs, runs and glides were sampled, as well. In these smaller channel situations, these latter habitat types showed great similarity to most other habitats of the same type. Namely, all riffles had similar depth and escape cover; all runs had similar depth and escape cover; all step-runs had similar depth and escape cover; and all glides had similar depth and escape cover.

Sampled units may change from year to year since habitat conditions change, and locations of individual habitat units may shift depending on winter storm conditions. Our assumption is that fish sampling of mean habitat quality will reflect representative habitat for the reach and provide average fish densities for each habitat type in the reach. The assumption is that there is a correlation between fish density and habitat quality in that better habitat has more fish. Past modeling has indicated that increased densities of smolt-sized juveniles are positively associated with greater water depth and escape cover in small, low summer flow streams (**Smith 1984**). Site densities were determined by calculating the number of juveniles present in each sampled habitat from electrofishing and/or snorkel censusing and adding those to numbers of juveniles from other habitats. The total number of fish was divided by the total lineal feet sampled at the site.

The proportion of habitat types sampled at each site within a reach were kept similar between years so that site densities could be compared for each reach. However, site density did not necessarily reflect fish densities for the entire reach because the habitat proportions sampled were not necessarily similar to the habitat proportions of the reach. In most cases, habitat proportions at sites were similar to habitat proportions in the reach because sampling sites were more or less continuous. However, in reaches where pools were less common, such as Reach 12a on the East Branch of Soquel Creek and in Reach 2 of Valencia Creek, a higher proportion of pool habitat was sampled than existed in the respective reaches. In these two cases, site densities were higher than reach densities. Prior to 2006, actual reach density and fish production could be compared between years and between reaches because fish densities by habitat type were extrapolated to reach density and an index of reach production according to reach proportions of habitat types.

M-5. Consistency of Data Collection Techniques in 1994-2001 and 2003-2009

Habitat conditions were measured at the monitoring sites in 2009 consistent with methods used in 1981 and 1994-2001 and 2003−2008 in the San Lorenzo River and Soquel Creek watersheds. Donald Alley, the principal investigator and data collector in 1994−2001 and 2003−2009, had also collected the fish and habitat data at approximately half or more of the sites in the 1981 study for the County Water Master Plan that included the 4 watersheds in the current study, except for Aptos Creek (**Smith 1982**). His qualitative estimates of embeddedness, streambed composition and habitat types were calibrated to be consistent with those of Dr. Smith, the primary investigator for the 1981 sampling program. Mr. Alley's method of measuring escape cover for smolt-sized (=>75 mm SL) and larger steelhead was consistent through the years, although the escape cover index in 1981 was based upon linear cover per habitat perimeter and later escape cover indices were based on linear cover per habitat length. In 2006−2008, Chad Steiner habitat typed 4 reaches in the Aptos Watershed, 2 reaches in Branciforte Creek, 2 reaches in Browns Valley Creek and 2 reaches in Shingle Mill Creek, after working with Alley since 2001. In 2009, some of Steiner's reaches were temporarily suspended due to change in project scope. One reach segment in Branciforte Creek and one in Shingle Mill Creek were not included. During electrofishing from 1996 onward, block nets were used to partition off habitats at all electrofishing sites. This prevented steelhead escapement. A multiple-pass method was used in each habitat with at least three passes.

From 1998 onward, underwater visual (snorkel) censusing was incorporated with electrofishing so that pool habitat in the mainstem San Lorenzo River, which had been electrofished in past years, could be effectively censused despite it being too deep in 1998 (a high-flow year) for backpack electrofishing. Snorkel censusing was also used to obtain density estimates in deeper pools previously unsampled prior to 1998 at Sites 2, 3, 7, 8 and 9, in an effort to increase the accuracy of production estimates. A better juvenile production estimate and predictions of adult returns were made with snorkel-censusing of pool habitat in the mainstem San Lorenzo River for 1998–2005. In 2006−2009, deeper pools were snorkel-censused at Sites 1, 2, 4, 6 and 8 in the lower and middle mainstem to determine site densities only. All other watersheds were sampled by electrofishing.

The City of Santa Cruz funded a separate San Lorenzo watershed sampling effort in 2002. Their data were not included in this report except in graphs of total juvenile density at some sites because their methods were inconsistent with ours. The method used for choosing fish sampling sites was not stated in their report. For our review of their findings, please refer to our 2003 censusing report (**Alley 2004**).

Table 1a. Defined Reaches in the Mainstem San Lorenzo River.

Refer to Appendix A for map designations.
Surveyed reach segments within reaches indicated by asterisk)

Reach #	Reach Boundaries	Reach Length (ft)
0	Water Street to Tait Street Diversion CM0.92 – CM1.92	5,277
1	Tait Street Diversion to Buckeye Trail Crossing CM1.92 - CM4.73	14,837
2*	Buckeye Trail Crossing to the Upper End of the Wide Channel Representation on the Felton USGS Quad Map CM4.73 - CM6.42	8,923
3	From Beginning of Narrow Channel Representation in the Gorge to the Beginning of the Gorge (below the Eagle Creek Confluence) CM6.42 - CM7.50	5,702
4	From the Beginning of the Gorge to Felton Diversion Dam CM7.50 - CM9.12	8,554
5	Felton Diversion Dam to Zayante Creek Confluence CM9.12 - CM9.50	2,026
6	Zayante Creek Confluence to Newell Creek Confluence CM9.50 - CM12.88	17,846
7	Newell Creek Confluence to Bend North of Ben Lomond CM12.88 - CM14.54	8,765
8*	Bend North of Ben Lomond to Clear Creek Confluence in Brookdale CM14.54 - CM16.27	9,138
9	Clear Creek Confluence to Boulder Creek Confluence CM16.27 - CM18.38	11,137
10	Boulder Creek Confluence to Kings Creek Confluence CM18.38 - CM20.88	13,200
11*	Kings Creek Confluence to San Lorenzo Park Bridge Crossing CM20.88 - CM24.23	17,688
12	San Lorenzo Park Bridge to Gradient Change, North of Waterman Gap CM24.23 - CM26.73	13,200
	TOTAL	136,293 (25.8 miles)

Table 1b. Defined Reaches in Major Tributaries of the San Lorenzo River.

Creek- Reach #	Reach Boundaries (Downstream to Upstream)	Reach Length (ft)
Zayante 13a	San Lorenzo River Confluence to Bean Creek Confluence CM0.0-CM0.61	3,221
13b	Bean Creek Confluence to Trib. Draining from S.Cruz Aggregate Quarry CM0.61-CM2.44	9,662
13c	Santa Cruz Aggregate Tributary to Lompico Creek Confluence CM2.44-CM3.09	3,432
13d*	Lompico Creek Confluence to Mt. Charlie Gulch Confluence CM3.09-CM5.72	13,886
Lompico 13e	Lompico Creekmouth to 1st Culvert Crossing CM0.0-CM0.5	4,265
Lompico 13f	1st Culvert Crossing to Carol Road Bridge CM0.5-CM1.77	5,077
Lompico 13g	Carol Road Bridge to Mill Creek Confluence CM1.77-CM2.35	3,046
Lompico 13h	Mill Creek Confluence to End of Perennial Channel CM2.35-CM3.73	7,311
Bean 14a	Zayante Creek Confluence to Mt. Hermon Road Overpass CM0.0-CM1.27	6,706
14b*	Mt. Hermon Road Overpass to Ruins Creek Confluence CM1.27-CM2.15	4,646
14c	Ruins Creek Confluence to Gradient Change Above the Second Glenwood Road Crossing CM2.15-CM5.45	17,424
Fall 15*	San Lorenzo River Confluence to Boulder Falls CM0.0-CM1.58	8,342
Newell 16*	San Lorenzo River Confluence to Bedrock Falls CM0.0-CM1.04	5,491
Boulder 17a*	San Lorenzo River Confluence to Foreman Creek Confluence CM0.0-CM0.85	4,488
17b	Foreman Creek Confluence to Narrowing of Gorge Adjacent Forest Springs CM0.85-CM2.0	6,072
17c	Narrow Gorge to Bedrock Chute At Kings Highway Junction with Big Basin Way CM2.0-CM3.46	7,709

Creek- Reach #	Reach Boundaries (Downstream to Upstream)	Reach Length (ft)
Bear 18a	San Lorenzo River Confluence to Unnamed Tributary at Narrowing of the Canyon Above Bear Creek Country Club CM0.0-CM2.42	12,778
18b	Narrowing of the Canyon to the Deer Creek Confluence CM2.42-CM4.69	11,986
Kings 19a	San Lorenzo River Confluence to Unnamed Tributary at Former Fragmented Dam Abutment Location CM0.0-CM2.04	10,771
19b	Tributary to Bedrock-Boulder Cascade CM2.04-CM3.73	8,923
Carbonera 20a	Branciforte Creek Confluence to Old Road Crossing and Gradient Increase CM0.0-CM1.38	7,293
20b	Old Road Crossing to Moose Lodge Falls CM1.38-CM3.39	10,635
Branciforte 21a*	Carbonera Creek Confluence to Granite Creek Confluence CM1.12-CM3.04	10,138
21b	Granite Creek Confluence to Tie Gulch Confluence CM3.04-CM5.73	14,203
	TOTAL	177,806 (33.7 miles)

Table 1c. Fish Sampling Sites in the San Lorenzo Watershed.
(2009 Sites Indicated by Asterisk.)

Reach #	Sampling Site # -Channel Mile	MAINSTEM SITES Location of Sampling Sites
0	*0a –CM1.6	Above Water Street Bridge
0	0b –CM2.3	Above Highway 1 Bridge
1	*1 -CM3.8	Paradise Park
2	*2 –CM6.0	Lower Gorge in Rincon Reach, Downstream of Old Dam Site
3	3 -CM7.4	Upper End of the Gorge
4	*4 -CM8.9	Downstream of the Cowell Park Entrance Bridge
5	5 -CM9.3	Downstream of Zayante Creek Confluence
6	*6 -CM10.4	Below Fall Creek Confluence
7	7 -CM13.8	Above Lower Highway 9 Crossing in Ben Lomond
8	*8 -CM15.9	Upstream of the Larkspur Road (Brookdale)
9	9 -CM18.0	Downstream of Boulder Creek Confluence
10	10 -CM20.7	Below Kings Creek Confluence
11	*11 -CM22.3	Upstream of Teilh Road, Riverside Grove
12	12a -CM24.7	Downstream of Waterman Gap and Highway 9
	12b -CM25.2	Waterman Gap Upstream of Highway 9

Table 1c. Fish Sampling Sites in the San Lorenzo Watershed, with 2009 Sites indicated by Asterisk (continued).

Reach #	Sampling Site # -Channel Mile	TRIBUTARY SITES Location of Sampling Sites
13a	*13a-CM0.3	Zayante Creek Upstream of Conference Drive Bridge
13b	13b-CM1.6	Zayante Creek Above First Zayante Rd crossing
13c	*13c-CM2.8	Zayante Creek downstream of Zayante School Road Intersection with E. Zayante Road
13d	*13d-CM4.1	Zayante Creek upstream of Third Bridge Crossing of East Zayante Road After Lompico Creek Confluence
13e	*13e-CM0.4	Lompico Creek upstream of the fish ladder and downstream of first bridge crossing.
14a	14a-CM0.1	Bean Creek Upstream of Zayante Creek Confluence
14b	*14b-CM1.8	Bean Creek Below Lockhart Gulch Road
14c	14c-CM4.7	Bean Creek 1/2-mile Above Mackenzie Creek Confluence and Below Golpher Gulch Rd.
15	*15 -CM0.8	Fall Creek, Below Wooden Bridge
16	*16 -CM0.5	Newell Creek, Upstream of Glen Arbor Road Bridge
17a	*17a-CM0.2	Boulder Creek Just Upstream of Highway 9
17b	*17b-CM1.6	Boulder Creek Below Bracken Brae Creek Confluence
17c	17c-CM2.6	Boulder Creek, Downstream of Jamison Creek
18a	*18a-CM1.5	Bear Creek, Just Upstream of Hopkins Gulch
18b	18b-CM4.2	Bear Creek, Downstream of Bear Creek Road Bridge and Deer Creek Confluence
19a	19a-CM0.8	Kings Creek, Upstream of First Kings Creek Road Bridge
19b	19b-CM2.5	Kings Creek, 0.2 miles Above Boy Scout Camp and Upstream of the Second Kings Creek Road Bridge
20a	20a-CM0.7	Carbonera Creek, Upstream of Health Services Complex
20b	20b-CM1.9	Carbonera Creek, Downstream of Buelah Park Trail
21a	21a1-CM1.5	Branciforte Creek, Upstream of the Highway 1 Overpass
21a	*21a2-CM2.8	Branciforte Ck, Downstream of Granite Creek Confluence
21b	21b-CM4.6	Branciforte Ck, Upstream of Granite Crk Confl. and Happy Valley School

Table 2a. Defined Reaches on Soquel Creek.

(Refer to Appendix A for map designations. Surveyed reach segments indicated by asterisk.)

Reach #	Reach Boundaries (Downstream to Upstream)	Reach Length (ft)
0	Soquel Creek Lagoon	3,168
1*	Upper Lagoon's Extent to Soquel Avenue CM0.6 - CM1.41	4,449
2	Soquel Avenue to First Bend Upstream CM1.41 - CM1.77	2,045
3*	First Bend Above Soquel Avenue to Above the Bend Closest to Cherryvale Avenue CM1.77 - CM2.70	4,827
4	Above the Bend Adj. Cherryvale Ave to Bend at End of Cherryvale Ave CM2.70 – CM3.54	4,720
5	Above Proposed Diversion Site to Sharp Bend Above Conference Center CM3.54 - CM4.06	3,041
6	Sharp Bend Above Conference Center to the Moores Gulch Confluence CM4.06-CM5.34	6,640
7*	Moores Gulch Confluence to Above the Purling Brook Road Crossing CM5.34 - CM6.41	5,569
8*	Above Purling Brook Road Crossing to West Branch Confluence CM6.41 - CM7.34	5,123

	Subtotal	39,582 (7.5 miles)
9a*	West Branch Confluence to Mill Pond Diversion CM7.34 - CM9.28	10,243
9b	Mill Pond Diversion to Hinckley Creek Confluence CM9.28 - CM9.55	1,425
10	Hinckley Creek Confluence to Soquel Creek Water District Weir CM9.55 - CM10.66	5,856
11	Soquel Creek Water District Weir to Amaya Creek Confluence CM10.66 - CM11.79	5,932
12a*	Amaya Creek Confluence to Gradient Increase CM11.79 – 12.56	4,062
12b	Gradient Increase to Ashbury Gulch Confluence CM12.56 - CM14.38	9,647

	SUBTOTAL	76,747 (14.5 miles)

Table 2a. Defined Reaches on Soquel Creek (continued).

Reach #	Reach Boundaries (Downstream to Upstream)	Reach Length (ft)
13*	West Branch Confluence to Hester Creek Confluence on West Branch CM0.0 - CM0.98	5,173
14a	Hester Creek Confluence to Girl Scout Falls I CM0.98- CM2.26	6,742
	SUBTOTAL	88,662 (16.8 miles)
14b*	Girl Scout Falls I to Girl Scout Falls II CM2.26 - CM2.89	3,311
14c	Girl Scout Falls II to Tucker Road (Tilly’s Ford) CM2.89 - CM4.07	6,216
14d	Tucker Road (Tilly’s Ford) to Laurel Mill Dam-1,465 ft Below Confluence of Laurel and Burns Creeks on West Branch CM4.07 - CM6.56	13,123
	TOTAL	111,312 (21.1 miles)

Table 2b. Locations of Sampling Sites by Reach on Soquel Creek.

(An asterisk indicates sampling in 2009.)

Reach #	Site # -Channel Mile	Location of Sampling Sites
1	*1 -CM1.2	Below Grange Hall
2	2 -CM1.6	Near the USGS Gaging Station
3	**3 -CM2.1**	**Above Bates Creek Confluence**
3	***4 -CM2.7**	**Upper Reach 3, Adjacent Cherryvale Ave Flower Fields**
4	**5 -CM2.9**	**Near Beach Shack (Corrugated sheet metal)**
4	**6 -CM3.4**	**Above Proposed Diversion Site**
5	**7 -CM3.9**	**Upstream to Proposed Reservoir Site, End of Cherryvale**
6	**8 -CM4.2**	**Adjacent to Rivervale Drive Access**
6	**9 -CM4.8**	**Below Moores Gulch Confluence, Adjacent Mountain School**
7	***10 -CM5.5**	**Above Moores Gulch Confluence and Allred Bridge**
7	**11 -CM5.9**	**Below Purling Brook Road Ford**
8	***12 -CM7.0**	**Below and Above Soquel Creek Road Bridge**
9a	*13a-CM8.9	Below Mill Pond
9b	**13b-CM9.2**	**Below Hinckley Creek Confluence**
10	**14 -CM9.7**	**Above Hinckley Creek Confluence**
11	**15 -CM10.8**	**Above Soquel Creek Water District Weir**
12a	***16 -CM12.3**	**Above Amaya Creek Confluence**
12b	**17 -CM13.0**	**Above Fern Gulch Confluence**
	18 -CM15.2	**Above Ashbury Gulch Confluence One Mile**
13	***19 -CM0.2**	**West Branch below Hester Creek Confluence**
14a	**20 -CM2.0**	**West Branch Near End of Olson Road**
14b	***21 -CM2.4**	**Above Girl Scout Falls I (Added in 2002)**
14c	**22 -CM3.0**	**Above Girl Scout Falls II (Added in 2002)**

Table 3. Locations of Sampling Sites by Reach in the Aptos Watershed.

(An asterisk indicates sampling in 2006−2009.)

Reach #	Site # -Channel Mile	Location of Sampling Sites
Aptos Creek		
1	1 −CM0.4	Below Mouth of Valencia Creek
2	2 −CM0.5	Just Upstream of Valencia Creek Confluence
2	*3 −CM0.9	Above Railroad Crossing in County Park near Center
3	*4 −CM2.9	In Nisene Marks State Park, 0.3 miles above First Bridge Crossing
Valencia Creek		
1	1 −CM0.9	0.9 miles Up from the Mouth
2	*2 −CM2.85	Below Valencia Road Crossing and above East Branch
3	*3 −CM3.26	Above Valencia Road Crossing

Table 4a. Defined Reaches in the Corralitos Sub-Watershed.

(Refer to Appendix A for map designations. Reach segments surveyed within reaches are indicated by asterisk.)

Reach #	Reach Boundaries (Downstream to Upstream)	Reach Length (ft)
Corralitos Creek		
1*	Browns Creek Confluence to 0.25 miles Below Diversion Dam CM0.00 – CM10.25	4,171
2	0.25 miles below Diversion Dam to Diversion Dam CM10.25.6 - CM10.5	1,320
3*	Diversion Dam to Rider Creek Confluence CM10.5 – CM11.77	6,706
4	Rider Creek Confluence to Box Culvert Crossing above Rider Creek Confluence CM11.77 – CM12.87	3,643
5*	First Bridge Crossing Above Rider Creek to Clipper Gulch Confluence CM12.46 – CM12.87	2,165
6*	Clipper Gulch Confluence to Eureka Gulch Confluence CM12.87 – CM13.33	2,429
7*	Eureka Gulch Confluence to Shingle Mill Gulch Confluence CM13.33 –CM13.98	3,432
Shingle Mill Gulch		
1	From Corralitos Creek Confluence to Second Eureka Canyon Road Crossing on Shingle Mill Gulch CM0.0 – CM0.35	1,848
2	From 2nd Eureka Canyon Road Crossing of Shingle Gulch to 3rd Road Crossing CM0.35 – CM0.62	1,420
3*	3rd Eureka Canyon Road Crossing of Shingle Mill Gulch to Beginning of Steep (Impassable) Gradient on Rattlesnake Gulch CM0.62 –CM1.35	3,858
	Total	30,992 (5.9 miles)
*Browns Valley Creek **		
1*	First Bridge Crossing on Browns Valley Road below the Diversion Dam to the Diversion Dam	1,015
2*	From Diversion Dam to Redwood Canyon Creek Confl.	4,468
	Total	5,483 (1.04 miles)

* More steelhead habitat exists above Reach 2 in Browns Valley Creek and in Redwood Canyon Creek, Ramsey Gulch and Gamecock Canyon Creek. Varying amounts of perennial steelhead habitat exists downstream of Reach 1, depending on bypass flows from the diversion dam.

Table 4b. Locations of Sampling Sites by Reach in the Corralitos Sub-Watershed.

(An asterisk indicates sampling in 2009.)

Corralitos Creek

Reach #	Site # -Channel Mile	Location of Sampling Sites
1	*1 -CM10.1	Downstream of Diversion Pipe Crossing
2	2 -CM10.3	Below Diversion Dam to Around the Bend
3	3a-CM10.6	Just Upstream of Diversion Dam
	*3b-CM11.1	0.6 miles Upstream of Diversion Dam (above Las Colinas Drive)
	4 -CM11.3	Below Rider Creek Confluence below bridge crossing
	5 -CM11.4	Below Rider Creek confluence and upstream of bridge crossing
4	6 -CM11.4	Upstream of Rider Creek Confluence
5	7 -CM12.0	Upstream of First Bridge Crossing above Rider Creek Confluence
6	*8 -CM12.9	Downstream of Eureka Gulch near Clipper Gulch
7	*9 -CM13.6	0.4 miles Above Eureka Gulch Confluence
Shingle Mill Gulch		
1	*1 -CM0.3	Below Second Bridge on Shingle Mill Gulch
2	2 -CM0.5	Above Second Bridge on Shingle Mill Gulch
3	* 3 -CM0.9	At and Above Washed Out Check Dams below Grizzly Flat on Shingle Mill Gulch
Browns Valley Creek		
1	*1 -CM1.9	Between First Browns Valley Road Crossing and Diversion Dam Upstream
2	*2 -CM2.7	Above Diversion Dam but Below Redwood Canyon Creek Confluence

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M-6. Juvenile Steelhead Densities at Sampling Sites - Methods

Electrofishing was used at sampling sites to determine steelhead densities according to two juvenile age classes and three size classes in all 4 watersheds. Block nets were used at all sites to separate habitats during electrofishing. A three-pass depletion process was used to estimate fish densities. If there was poor depletion on 3 passes, a fourth pass was performed and the fish captured in 4 passes were assumed to be a total count of fish in the habitat. Electrofishing mortality rate has been approximately 1% or less over the years. Snorkel-censusing was used in deeper pools that could not be electrofished at sites in the mainstem reaches of the San Lorenzo River, downstream of the Boulder Creek confluence. For the middle mainstem reaches included in Table 2 of Appendix C, underwater censusing of deeper pools was incorporated into density estimates with electrofishing data from more shallow habitats.

Visual censusing was judged inappropriate in other habitats because it would be inaccurate in fastwater habitat in the mainstem and in 80-90% of the habitat in tributaries. For example, twenty-four of 26 sampled tributary pools had more than 20 fish in 2005. Most tributary sites are well shaded and many pools have substantial escape cover, making it very difficult to count all of the juveniles, much less divide them into size and age classes. Riffles, step-runs, runs and glides are usually too shallow to snorkel in tributaries. Dense shading in most tributaries also reduces snorkeling effectiveness.

In larger rivers of northern California, density estimates from electrofishing are commonly combined with those determined by underwater observation in habitats too deep for electrofishing. Ideally, underwater censusing would be calibrated to electrofishing data in habitat where capture approached 100%. Calibration was originally attempted by Hankin and Reeves (**1988**) for small trout streams. Their intent was to substitute snorkel censusing for electrofishing. However, attempts at calibration of the two methods of censusing in large, deep pools of the mainstem San Lorenzo River was judged impractical, beyond the scope of the study and probably inadequate.

Two divers were used in snorkel censusing. Visual censusing of deeper pools occurred prior to electrofishing of sites. In wide pools, divers divided the channel longitudinally into counting lanes, combining their totals after traversing the habitat in an upstream direction. Divers would warn each other of juveniles being displaced into the other's counting lane to prevent double- counting. For juveniles near the boundaries of adjacent counting lanes, divers would verbally agree to who would include them in their tallies. In narrower pools, divers would alternate passes through the pool to obtain replicates to be averaged. In most pools, three replicate passes were accomplished per pool. The relative proportions of steelhead in the three Size Classes obtained from electrofishing were considered in dividing visually censused steelhead into size and age classes. The average number of steelhead observed per pass in each age and size category became the density estimate. In Reaches 1-4, most juveniles were greater than 75 mm SL, and yearlings were considerably larger than YOY fish. Therefore, it was relatively easy to separate fish into size and age classes. In Reaches 6-9, more juveniles are normally around 75 mm SL, leading to a small error for some individuals in deciding division between Size Classes 1 and 2. There was no difficulty in distinguishing age classes.

Steelhead were visually censused for two size classes of pools in the San Lorenzo. There were short pools less than approximately 200 feet in length and those more than approximately 200 feet. Juvenile densities in censused pools were extrapolated to other pools in their respective size categories. Steelhead were censused by size and age class, as in electrofishing. If less than 20 juveniles were observed in a pool, the maximum number observed on a pass was the estimate. When 20 or more fish were observed, the average of the three passes was the best estimate.

Visual censusing offered realistic density estimates of steelhead in deeper mainstem pools. It was the only practical way to inventory such pools, which were mostly bedrock- or boulder- scoured and had limited escape cover. Visibility was 15 feet or more, making the streambed and counting lanes observable. Very few steelhead used these pools in 1999-2001 and 2003-2009, compared to 1998 when mainstem baseflow was considerably higher (minimum of 30 cubic feet per second at the Big Trees Gage compared to approximately 20 cfs or less in later years).

M-7. Age and Size Class Divisions

With electrofishing data, the young-of-the-year (YOY) age class was separated from the yearling and older age class in each habitat, based on the site-specific break in the length-frequency distribution (histogram) of fish lengths combined into 5 mm groupings. Also, scale analysis was utilized for fish captured at lower mainstem sites in the San Lorenzo River and Soquel Creek. Density estimates of age classes in each habitat type were determined by the standard depletion model used with multiple pass capture data. Densities were expressed in fish per 100 feet of channel. Density estimates were measured in the lowest baseflow period of the year when juvenile salmonids remain in specific habitats without up or downstream movement. Density is typically provided per channel length by convention and convenience. Channel length may be accurately measured quickly. If the density measure is consistent from year to year, valid comparisons can be made.

Depletion estimates of juvenile steelhead density were applied separately to two size categories in each habitat at each site. The number of fish in Size Class 1 and combined Classes 2 and 3 were recorded for each pass. The size class boundary between Size Classes 1 and 2 was 75 mm Standard Length (SL) (3 inches) because smaller fish would almost always spend another growing season in freshwater before smolting and entering the ocean the following spring. Although some fish larger than 75 mm SL stayed a second year in the stream, the majority of fish captured during fall sampling that were larger than 75 mm SL were found to smolt the very next spring to enter the ocean. These assumptions are based on scale analysis, back-calculated annuli and standard length determinations by Smith of steelhead smolts captured in spring of 1987 and 1989 (**Smith unpublished**). He found that 97% of a random sample (n=248) of yearling smolts in spring were 76 mm SL or longer after their first growing season. In addition, about 75% of smolts that were 75 mm SL or larger at their first annulus (n=319) smolted as yearlings. All 2-year old smolts from a random sample (n=156) were larger than 75 mm SL after 2 growing seasons prior to smolting. Also, 95% of these 2-year olds were at least 60 mm SL after their first growing season, indicating that few YOY less than 60 mm SL after their first growing season survived to smolt.

The depletion method estimated the number of fish in each sampled habitat in two size categories; those less than (<) 75 mm SL (Class 1) and those equal to or greater than (=>) 75 mm SL (Classes 2 and 3). Then, the number of juveniles => 75 mm SL (Class 2) was estimated separately from the juveniles =>

150 mm SL (Class 3). This was done by multiplying the proportion of each size class (Class 2 and 3 separately) in the group of captured fish by the estimate of fish density for all fish => 75 mm SL. A density estimate for each habitat type at each site was then determined for each size class. Densities in each habitat type were added together and divided by the total length of that habitat type at the sampling site to obtain a density estimate by habitat type.

The depletion method was also used to estimate the number of fish in each sampled habitat based on 2 age classes: young-of-the-year (YOY) and yearling and older (1+) age classes. Age classes in the mainstem San Lorenzo and mainstem Soquel Creek were determined by scale analysis of a spectrum of fish sizes in 2007. A total of 28 larger San Lorenzo juvenile steelhead and 10 larger Soquel Creek juveniles were aged by scale analysis, along with 20 juveniles from Soquel Lagoon. These limited results showed that the majority of fish => 75 mm SL in the mainstems and lagoon were YOY, but also included yearlings that moved into the mainstem after slow tributary growth in their first year. These data provided information for age class division for both watersheds. Scale analysis, along with past experience of growth rates, and breaks in fish length histograms were used to discern age classes at other sampling sites. Density estimates determined by size class and age class were not the same when YOY reached Size Class II by fall.

In 2009, as in previous years, the lower mainstems of the San Lorenzo River and Soquel Creek, some YOY steelhead reached Size Class 2 size in one growing season, as did a few in the middle mainstem San Lorenzo and upper mainstem of Soquel Creek. In this monitoring report, sampling site densities were compared for 12 years in the San Lorenzo system by size and age (1997−2001 and 2003−2009) and for 13 years in Soquel Creek (1997−2009). At each sampling site, habitat types were sampled separately, with density estimates calculated for each habitat. Then these density estimates were combined and divided by the stream length of the entire site for annual site density

DETAILED RESULTS

R-1. Capture and Mortality Statistics

For this study overall in 2009, 2,607 juvenile steelhead were captured by electrofishing among all 38 sites, with 21 mortalities (0.81% mortality rate). A total of only 12 juvenile steelhead were visually censused in pools at 5 San Lorenzo mainstem sites. Seven mainstem sites and 11 tributary sites were sampled in the San Lorenzo watershed in 2009, with a total of 1,242 juvenile steelhead captured and 13 mortalities (1.05%). A total of 678 juvenile steelhead were captured at 8 sites in the Soquel watershed in 2009 with 4 mortalities (0.59%). A total of 160 juveniles steelhead were captured in the Aptos Watershed at 4 sites with one mortality (0.63%). A total of 527 juveniles were captured in the Corralitos watershed at 8 sites with three mortalities (0.57%).

R-2. Habitat Change in the San Lorenzo River Mainstem and Tributaries, 2008 to 2009

Refer to **Appendix A** for maps of reach locations. A summary table of habitat change for all reaches is provided in **Table 42**. Weighing the relative importance of streamflow as an aspect of habitat quality with other habitat parameters is not clear cut, especially when exact streamflow measurements are limited. Most of the steelhead growth occurs in the spring throughout this watershed when the quantity of baseflow is most important. All reaches had higher baseflow, especially during the important spring growth period, due to later storms in 2009. This provided more food and better growth rate in all reaches in 2009 (**Figures 50 and 51**).Overall habitat quality improved slightly in the lower and middle mainstem reach segments that were habitat typed (Reaches 2 and 8). Improvement came from higher baseflow, deeper run/step-run habitat in Reach 2, more fastwater habitat in Reach 2, deeper riffles and more riffle habitat in Reach 8, less embeddedness in pools and riffles of Reach 8 and increased riffle escape cover in Reach 8, although riffle cover was much less in Reach 2 (**Tables 5b, 5c, 6, 9 and 10**). At the repeated lower mainstem Site 4, overall habitat quality improved primarily due to increased baseflow with increased stream width and much more escape cover provided by small instream wood and more overhanging willow, although substrate conditions worsened with increased riffle embeddedness while habitat depth remained similar. Repeated Site 6 in middle mainstem Reach 6 had slightly improved overall habitat quality with higher baseflow (more riffle habitat) and more escape cover in the run, with slightly shallower depth and similar substrate conditions.

The upper mainstem Reach 11 that encompassed the Teihl Road Bridge had slightly improved overall habitat conditions with slight deepening of average pool depth and reduced run embeddedness, along with slightly higher baseflow. Percent fines and pool escape cover were similar between years.

In San Lorenzo River tributaries, of the 5 reaches monitored and compared between 2008 and 2009, 2 reaches had similar overall habitat quality compared to 2008 (one in lower Branciforte 21a-2 and one in middle Bean 14b), two reaches had improvement (50% more cover in upper Zayante Creek 13d pools, although greater run/step-run embeddedness, and deeper pools in lower Boulder Creek 17a, although escape cover was slightly less) and one reach had lower habitat quality (Fall Creek 15 had 20% less pool escape cover). Repeated Zayante Site 13a had overall improved habitat quality with increased baseflow, greater channel width, greater pool depth and more escape cover in all habitats, having substrate conditions similar between years. Repeated Zayante Site 13c had similar habitat quality to 2008 with positives that offset negatives. There was increased baseflow and decreased embeddedness, though habitat depth was similar and pool escape cover was slightly less. Repeated Lompico Site 13e had overall improved habitat quality with slightly increased baseflow, slightly increased maximum pool depth, more pool escape cover and less embeddedness than in 2008. Repeated Boulder Site 17b had overall improved habitat quality with increased baseflow, increased pool depth and escape cover and reduced pool embeddedness. Repeated Bear Site 18a had overall slight improvement in habitat quality with deeper pools having slightly more escape cover and increased baseflow, though percent fines were increased in all habitats and embeddedness was substantially increased in a corner pool.

In comparing Newell Creek between 2006 and 2009, habitat quality had declined overall, with shallower pool habitat and increased fine sediment in pools, although pool escape cover and pool embeddedness were similar between years.

Table 5a. Fall STREAMFLOW (cubic feet/ sec) Measured by Flowmeter at SAN LORENZO Sampling Sites Before Fall Storms, 1995-2001 and 2003-2006 by D.W. ALLEY & Associates.

Site # - Location	1995	1996	1998	1999	2000	2001	2003	2004	2005	2006
1- SLR/ Paradise Pk	22.9	25.5	34.3	26.2	21.7	19.6				26.2
2- SLR/Rincon				24.0	21.1	17.2				
3-SLR Gorge	23.3	20.5								
4-SLR/Henry Cowell	18.7		32.7	23.3	21.8	15.5				24.1
5- SLR/Below Zayante			31.9							
6- SLR/ Below Fall	14.6		23.4	12.8	11.6	9.4	10.6	8.8	18.9	14.3
7- SLR/ Ben Lomond	5.8				5.4	3.7	5.4	3.7	8.1	
8- SLR/Below Clear Ck	4.2		10.3	4.9	4.2	3.1	4.2	2.7	7.1	6.4
9- SLR/Below Boulder Ck	4.6		7.2	3.5		3.0	3.7	2.1	5.8	
10- SLR/Below Kings Ck				3.0	1.1	1.3	0.6	0.52	1.4	
11- SLR/ Teihl Rd			1.7	0.8	0.8	0.4	0.9	0.63	1.5	
12a- SLR/Lower Waterman G			1.0	0.7						
13a- Zayante below Bean			8.5	6.3	5.2	4.7	5.4	5.1	7.4	7.8*
13b- Zayante above Bean			3.9	2.9	2.8	1.9	2.1	1.7	3.2	2.8
14b- Bean below Lockhart G	1.5		1.1	1.1	1.0	1.1	1.1	0.77	1.0	1.1
15- Fall	2.0		3.4	2.2	1.7	1.7				
16- Newell	1.6				0.51					
17a- Boulder	2.0		2.2		1.1	1.0	1.25	0.9	1.6	1.7
18a- Bear				0.45	0.61	0.34	0.6	0.51	0.90	1.1
19a- Lower Kings			1.1	0.11	0.17	0.02				
20a- Lower Carbonera	0.33	0.36								
21a-2- Branciforte			0.80							

*Streamflow in lower Zayante Creek done 3 weeks earlier than usual and before other locations.

Table 5b. Fall/Late Summer STREAMFLOW (cubic feet/ sec) Measured by Santa Cruz County Staff in 2006 − 2009 and Obtained from Stream Gages.

Location	2006	2007	2008	2009
SLR at Sycamore Grove	34.8	14.6	14.2	−
SLR at Big Trees	26	11	12	13
SLR above Love Cr	13.14	5.42 After*	3.8	−
SLR below Boulder Cr	7.49	2.87 After	3.1	−
SLR @ Two Bar Cr	1.81	0.78	0.39	−
Zayante @ SLR	6.51	3.80	−	−
Zayante below Lompico Cr	1.21	0.96	0.41	0.43
Bean adjacent Mt. Hermon	2.6	1.9	2.1	2.2
Bean Below Lockhart Gulch	1.37	0.72	0.79	0.89
Newell Cr @ Rancho Rio	1.18	1.16	1.11	−
Boulder Cr @ SLR	2.09	0.84	1.04	0.97
Bear Cr @ SLR	1.87	0.37	0.27	−
Branciforte @ Isabel Lane			0.3	0.25
Soquel Cr at USGS Gage	6.6**	1.4**	0.65**	1.2**
Soquel Cr @ Bates Cr	5.73	-	1.08	
W. Branch Soquel @ S.J. Olive Springs	2.17	1.75 After	−	−
W. Branch above Hester Creek (Soquel Creek Water District Weir/ Brook Kraeger - preliminary)	1.48 (15 Sep)	1.04 (15 Sep)	−	−
E. Branch Soquel @ 152 Olive Springs Rd.	-	1.01 After	−	−
E. Branch below Amaya and above Olive Springs Quarry (Soquel Creek Water District Weir/ Brook Kraeger- preliminary)	1.53 (15 Sep)	0.43 (15 Sep)	−	−
Aptos Cr @ Valencia Cr	2.48	1.21 After	0.77	0.53
Valencia Cr @ Aptos Cr			0.007	0.34 (May)
Corralitos Cr below Browns Valley Road Bridge	15.94 (May)	0.49 (May)	dry	1.71 (May)
Corralitos Cr @ Rider Cr	3.35	2.50 After	1.44	−
Browns Cr @ 621 Browns Valley Rd	0.96	0.30 After	0.32	−

* After 2 early October storms that increased baseflow.

** Estimated from USGS Hydrographs for September 1.

Table 5c. Habitat Proportions in Habitat-Typed Reaches of the San Lorenzo, Soquel, Aptos and Corralitos Watersheds in 2008 and 2009.

Reach	2008 Pool Habitat In Feet/ Percent / # Habitats	2009 Pool Habitat In Feet/ Percent / # Habitats	2008 Riffle Habitat Feet/ Percent / # Habitats/ Riffle Width (ft)	2009 Riffle Habitat Feet/ Percent / # Habitats/ Riffle Width (ft)	2008 Run/Step-run Habitat Feet/ Percent / # Habitats/ Width (ft)	2009 Run/ Step-run Habitat Feet/ Percent / #Habitats/ Width (ft)
Low. San Lorenzo #1	1948/63%/ 6		501/ 16%/ 8/ 26 ft		634/ 21%/ 6/ 38 ft	
Low. San Lorenzo #2	2321/70%/ 10	2194/65%/ 10	572/ 17%/ 12/ 26 ft	696/ 21%/ 9/ 21 ft	400/ 12%/ 6/ 24.5 ft	490/ 14%/ 6/ 27 ft
Low. San Lorenzo #4	3227/77%/ 11		494/ 12%/ 10/ 29 ft		460/ 11%/ 8/ 30 ft	
Mid. San Lorenzo #6	3280/75%/ 13		523/ 12%/ 10/ 29 ft		596/ 15%/ 8/ 29 ft	
Mid. San Lorenzo #8	3459/85%/ 14	3467/84%/ 13	169/ 4%/ 5/ 20 ft	262/ 6%/ 7/ 17 ft	438/ 11%/ 9/ 15 ft	392/ 10%/ 8/ 19 ft
Up. San Lorenzo #11	2205/68%/ 21	2066/66%/ 23	253/ 8%/ 11	279/9%/ 12	775/ 24%/ 11	801/ 25%/ 16
Zayante #13a	1740/64%/ 13		530/ 20%/ 12		443/ 16%/ 7	
Zayante #13c	2108/74%/ 22		235/ 8%/ 10		505/ 18%/ 10	
Zayante #13d	1850/72%/ 36	1840/71%/ 36	120/ 5%/ 8	124/ 5%/ 8	593/ 23%/ 15	636/ 24%/ 15
Lompico #13e	1557/51%/ 37		304/ 10%/ 10		1198/ 39%/ 28	
Bean #14b	2049/70%/ 29	1804/64%/ 27	506/ 17%/ 19	433/15%/ 18	352/ 12%/ 11	588/21%/ 15
Bean #14c	909/ 78%/ 20		104/ 9% 7		157/ 13%/ 5	
Fall #15	528/ 17%/ 26	587/19%/ 23	2098/68%/ 30	2123/68%/ 23	472/ 15%/ 16	400/13%/ 8
Newell #16	1421/59%/ 15 (2006)	1565/64%/ 15	477/20%/ 16 (2006)	481/20%/ 15	521/21%/ 10 (2006)	396/16%/ 11
Boulder #17a	1514/ 55%/ 22	1489/52%/ 17	260/ 10%/ 12	234/ 8%/ 9	963/ 35%/ 17	1136/40%/ 15
Boulder #17b	1554/ 66%/ 25		127/ 5%/ 6		682/ 37%/ 13	
Bear #18a	2393/ 73%/ 22		213/ 6%/ 7		374/ 11%/ 6	
Branciforte #21a-1	2380/ 85%/ 20		290/ 10%/ 13		125/ 5%/ 5	

Branciforte #21a-2	2079/ 75% 27	2152/77%/ 26	256/ 9%/ 20	239/ 9%/ 18	453/ 16%/ 14	403/ 14%/ 13
Reach	**2008 Pool Habitat In Feet/ Percent / # Habitats**	**2009 Pool Habitat In Feet/ Percent/ # Habitats**	**2008 Riffle Habitat In Feet/ Percent/ # Habitats**	**2009 Riffle Habitat In Feet/ Percent/ # Habitats**	**2008 Run/Step-run Habitat Feet/ Percent / # Habitats**	**2009 Run/ Step-run Habitat Feet/ Percent / #Habitats**
Soquel #1	3293/ 76%/ 15	3583/82%/ 16	392/ 9%/ 10	465/11%/ 11	648/ 15%/ 9	341/8%/ 8
Soquel #3a	2308/ 68%/ 18	2423/64%/ 18	320/ 9%/ 14	587/15%/ 17	769/ 23%/ 10	802/21%/ 13
Soquel #7	2569/ 67%/ 21	2599/63%/ 18	393/ 10%/ 12	588/14%/ 15	899/ 23%/ 14	906/22%/ 13
Soquel #8	2122/ 72%/ 16	1904/65%/ 14	391/ 13%/ 11	406/14%/ 11	440/ 15%/ 7	627/21%/ 11
E. Branch Soquel #9a	1653/ 54%/ 18	1588/53%/ 18	328/ 11%/ 14	435/14%/ 16	1105/ 36%/ 17	1001/33%/ 16
E. Branch Soquel #12a	1728/ 74%/ 30	1035/39%/ 24	18/ 1% 1	170/6%/ 9	583/ 25%/ 16	1439/54%/ 22
W Branch Soquel #13	1833/ 67%/ 16	1844/69%/ 15	446/ 16%/ 16	402/15%/ 15	468/ 17%/ 12	440/16%/ 8
W. Branch Soquel #14b	2214/ 69%/ 31	2366/73%/ 29	333/ 10%/ 17	179/ 5%/ 12	662/ 21%/ 15	711/22%/ 16
Aptos #2	2085/ 77% 21	2154/80%/ 21	526/ 20%/ 20	406/15%/ 21	90/ 3%/ 3	138/5%/ 5
Aptos #3	1911/ 66%/ 23	1881/67%/ 22	762/ 26%/ 21	654/23%/ 21	226/ 8%/ 9	279/10%/ 10
Valencia #2	638/ 23%/ 15	720/26%/ 15	710/ 25%/ 25	756/27%/ 28	1438/ 52% 18	1309/47%/ 15
Valencia #3	1954/ 73% 43	1993/77%/ 41	484/ 18%/ 38	418/16%/ 41	239/ 9%/ 11	191/ 7%/ 13
Corralitos #1	1478/ 54%/ 21	1357/50%/ 19	734/ 27%/ 24	693/25%/ 26	532/ 19%/ 12	676/25%/ 12
Corralitos #3	1392/ 53%/ 23	1427/54%/ 23	685/ 26%/ 22	784/30%/ 25	571/ 22%/ 13	427/16%/ 10
Corralitos #5/6	1532/ 51%/ 28		323/ 11%/ 13		1121/ 38%/ 19	
Corralitos #7	1406/ 52% 45		74/ 3%/ 6		1226/ 45%/ 27	
Shingle Mill #1	950/ 45%/ 50		344/ 16%/ 31		789/ 38%/ 26	
Shingle Mill #3	1681/ 63%/ 63		663/ 26%/ 46		306/ 11%/ 16	
Browns Valley #1	1537/ 56%/ 32		504/ 19%/ 20		683/ 25%/ 19	

Browns Valley #2	1633/ 60%/ 43		646/ 24%/ 31		426/ 16% 19	

Table 6. Averaged Mean and Maximum WATER DEPTH (ft) of Habitat in SAN LORENZO Reaches Since 2003.

Reach	Pool 2003	Pool 2005	Pool 2006	Pool 2007	Pool 2008	Pool 2009	Riffle 2003	Riffle 2005	Riffle 2006	Riffle 2007	Riffle 2008	Riffle 2009	Run/ Step-Run 2003	Run / Step Run 2005	Run / Step Run 2006	Run / Step Run 2007	Run / Step Run 2008	Run/ Step Run 2009
1- L. Main			2.5/ 4.4	1.8/ 3.0	1.85 / 3.4				1.1/ 1.5	0.8/ 1.2	0.7/ 1.2				2.4/ 3.1	1.0/ 1.5	0.9/ 1.35	
2- L. Main	3.0/ 5.2 (2000			2.5/ 4.1	2.6/ 5.1	**2.5/ 4.4**	1.2/ 2.0 (2000			0.9/ 1.4	0.8/ 1.3	**0.8/ 1.4**	1.7/ 2.4 (2000			1.4/ 2.2	1.3/ 1.9	**1.3/ 2.3**
3- L. Main																		
4- L. Main			2.6/ 4.4	1.9/ 3.8	2.0/ 3.6				0.9/ 1.5	0.7/ 1.2	0.5/ 1.0				1.6/ 2.2	1.4/ 2.1	0.9/ 1.5	
5- L. Main																		
6- M. Main	1.9/ 3.5	1.9/ 3.4	2.2/ 4.3	1.7/ 3.4	1.6/ 3.1		0.6/ 0.9	0.9/ 1.4	0.8/ 1.3	0.6/ 1.0	0.55/ 0.9		1.2/ 1.9	1.1/ 2.1	1.3/ 1.85	0.9/ 1.3	0.8/ 1.1	
7- M. Main	1.8/ 3.7	2.0/ 3.5					0.6/ 1.0	0.7/ 1.1					0.9/ 1.4	1.1/ 1.4				
8- M. Main	2.5/ 5.2	2.6/ 5.8	2.7/ 5.5	2.3/ 4.3	2.3/ 4.7	**2.8/ 5.1**	0.6/ 1.0	1.0/ 1.5	1.1/ 1.6	0.6/ 1.0	0.45/ 0.7	**0.65/ 1.0**	1.0/ 1.4	1.3/ 2.1	1.3/ 2.25	0.8/ 1.2	0.8/ 1.2	**0.7/ 1.0**
9- M. Main	1.7/ 3.0	1.9/ 3.5					0.6/ 1.1	0.7/ 1.1					0.8/ 1.2	1.0/ 1.4				
10- U. Main	1.4/ 2.9	1.4/ 2.8					0.3/ 0.5	0.4/ 0.7					0.5/ 0.9	0.7/ 1.0				
11- U. Main		1.1/ 2.0	1.1/ 2.1	1.0/ 1.9	0.9/ 1.8	**1.05/ 1.8**		0.4/ 0.7	0.5/ 0.8	0.2/ 0.4	0.25/ 0.5	**0.25/ 0.4**		0.5/ 1.0	0.6/ 1.1	0.4/ 0.6	0.4/ 0.7	**0.4/ 0.75**
12b- U. Main		1.3/ 2.2						0.3/ 0.6						0.5/ 0.8				
Zayante 13a	1.1/ 2.1	1.5/ 2.5	1.6/ 2.6	1.4/ 2.2	1.5/ 2.5		0.7/ 1.1	0.6/ 0.9	0.6/ 0.9	0.5/ 0.8	0.4/ 0.8		0.7/ 1.2	0.8/ 1.1	0.85/ 1.2	0.6/ 1.0	0.6/ 0.9	
Zayante 13b	1.5/ 2.4	1.7/ 2.9					0.5/ 0.7	0.5/ 0.9					0.8/ 1.1	0.7/ 1.2				
Zayante 13c	1.2/ 2.2	1.35 / 2.4		1.2/ 2.2	1.2/ 2.2		0.4/ 0.7	0.5/ 0.8		0.2/ 0.5	0.2/ 0.6		0.5/ 1.0	0.7/ 1.0		0.5/ 0.9	0.4/ 0.8	
Zayante 13d	1.1/ 1.7	1.1/ 2.1	1.35 / 2.1	1.0/ 1.5	1.0/ 1.55	**0.9/ 1.5**	0.4/ 0.6	0.5/ 0.7	0.45/ 0.8	0.3/ 0.5	0.2/ 0.5	**0.25/ 0.5**	0.8/ 1.3	0.8/ 1.4	0.9/ 1.4	0.6/ 1.0	0.5/ 0.9	**0.55/ 0.9**
Lompico 13e			1.1/ 1.8	0.8/ 1.5	1.0/ 1.7				0.3/ 0.6	0.15 /0.4	0.1/ 0.3				0.45/ 0.8	0.35/ 0.65	0.3/ 0.5	
Bean 14a	0.8/ 1.6	1.0/ 1.9					0.4/ 0.7	0.4/ 0.7					0.6/ 1.2	0.7/ 1.1				
Bean 14b	0.9/ 1.5	1.0/ 1.9		1.1/ 1.8	1.0/ 1.8	**1.2/ 1.9**	0.3/ 0.6	0.3/ 0.5		0.2/ 0.4	0.2/ 0.4	**0.2/ 0.4**	0.6/ 0.9	0.6/ 0.8		0.4/ 0.8	0.4/ 0.65	**0.4/ 0.6**
Bean 14c	1.0/ 1.7	1.0/ 1.7	1.0/ 1.8	0.8/ 1.5	0.9/ 1.7		0.1/ 0.3	0.1/ 0.3	0.2/ 0.3	0.03 /0.1	0.03/ 0.1		0.25/ 0.4	0.2/ 0.5	0.35/ 0.5	0.1/ 0.2	0.06/ 0.1	
Fall 15	1.0/ 1.8 (2000				0.9/ 1.4	**0.9/ 1.4**	0.2/ 0.5 (2000				0.4/ 0.8	**0.35/ 0.75**	0.4/ 0.6 (2000				0.6/ 0.9	**0.5/ 1.0**
Newell 16			1.6/ 2.8			**1.3/ 2.4**			0.3/ 0.5			**0.25/ 0.45**			0.6/ 0.9			**0.4/ 0.7**
Boulder 17a		1.8/ 2.9	2.0/ 3.1	1.7/ 2.7	1.6/ 2.6	**1.8/ 2.9**		0.5/ 0.9	0.6/ 1.0	0.4/ 0.7	0.4/ 0.7	**0.35/ 0.7**		0.7/ 1.2	0.9/ 1.4	0.6/ 1.0	0.6/ 0.95	**0.65/ 1.05**
Boulder 17b		1.7/ 2.8	1.7/ 2.8	1.6/ 2.7	1.5/ 2.7			0.4/ 1.0	0.6/ 1.0	0.4/ 0.75	0.3/ 0.6			0.7/ 1.2	0.8/ 1.4	0.6/ 1.1	0.55/ 0.95	

Reach	**Pool 2003**	**Pool 2005**	**Pool 2006**	**Pool 2007**	**Pool 2008**	**Pool 2009**	**Riffle 2003**	**Riffle 2005**	**Riffle 2006**	**Riffle 2007**	**Riffle 2008**	**Riffle 2009**	**Run/ Step-Run 2003**	**Run/ Step Run 2005**	**Run/ Step Run 2006**	**Run/ Step Run 2007**	**Run/ Step Run 2008**	**Run/ Step Run 2009**
Boulder 17c		1.9/ 2.9						0.4/ 0.8						0.9/ 1.5				
Bear 18a	2.0/ 3.4	2.0/ 3.4	2.0/ 3.35	1.4/ 2.4	1.3/ 2.55		0.4/ 0.7	0.4/ 0.7	0.6/ 0.9	0.2/ 0.4	0.2/ 0.4		0.6/ 0.9	0.7/ 1.1	0.8/ 1.25	0.4/ 0.7	0.35/ 0.7	
Bear 18b																		
Branciforte 21a-1				1.2/ 2.2	1.35/ 2.3					0.15/0.3	0.2/ 0.3					0.3/ 0.5	0.3/ 0.6	
Branciforte 21a-2			1.1/ 1.9	1.0/ 1.7	0.9/ 1.7	**1.0/ 1.8**			0.3/ 0.5	0.2/ 0.4	0.2/ 0.35	**0.2/ 0.35**			0.5/ 1.0	0.4/ 0.7	0.45/ 0.65	**0.45/ 0.65**
Branciforte 21b		1.1/ 1.7						0.4/ 0.7						0.3/ 0.6				

Table 7. Average PERCENT FINE SEDIMENT* IN SAN LORENZO Reaches River Since 2003.

Reach	**Pool 2003**	**Pool 2005**	**Pool 2006**	**Pool 2007**	**Pool 2008**	**Pool 2009**	**Riffle 2003**	**Riffle 2005**	**Riffle 2006**	**Riffle 2007**	**Riffle 2008**	**Riffle 2009**	**Run/ Step Run 2003**	**Run/ Step Run 2005**	**Run/ Step Run 2006**	**Run/ Step Run 2007**	**Run/ Step Run 2008**	**Run/ Step Run 2009**
1			80	65	77				20	15	20				40	46	46	
2	70 (2000			42	54	**48**	25 (2000			10	13	**13**	50 (2000			26	23	**26**
4			75	46	47				20	13	10				50	42	37	
6	70	70	75	61	68		25	20	25	17	12		35	40	38	18	23	
7	70	70					25	20					50	40				
8	55	65	60	41	47	**44**	25	20	20	7	6	**12**	40	25	25	11	16	**25**
9	70	60					25	15					30	30				
10	60	70					20	15					25	35				
11	55	35	40	32	52	**40**	40	15	25	10	9	**12**	45	25	15	24	14	**14**
12b	50	35					35	35					40	10				
Zayante 13a	85	65	65	59	62		40	25	35	22	19		70	50	40	36	31	
Zayante 13b	65	65					30	30					45	30				
Zayante 13c	50	45		45	47		25	10		9	12		30	20		27	34	
Zayante 13d	40	40	50	38	44	**46**	25	25	15	13	13	**12**	25	25	40	21	29	**28**
Lompico 13e			50	49	54				20	15	20				30	24	29	
Bean 14a	80	70					40	25					70	35				
Bean 14b	85	80		67	66	**67**	45	15		18	9	**13**	80	45		58	34	**34**
Bean 14c	70	60	65	42	37		25	5	15	6	6		40	30	40	28	10	
Fall 15	74 (2000				64	**69**	50 (2000				30	**34**	63 (2000				48	**50**
Newell 16			25			**46**			5			**11**			20			**19**
Boulder 17a		30	35	31	27	**28**		20	5	12	9	**11**		15	20	17	13	**11**
Boulder 17b		30	35	31	32			5	10	5	5			15	15	12	14	
Boulder 17c		25						5						5				
Bear 18a	55	50	60	41	46		15	15	15	7	11		25	20	25	13	13	
Branciforte 21a-1				65	62					7	10					30	16	
Branciforte 21a-2			75	50	42	**38**			40	12	8	**8**			55	35	21	**13**
Branciforte 21b		55						15						65				

* Fine sediment was visually estimated as particles less than approximately 2 mm (0.08 inches).

Table 8. Average EMBEDDEDNESS IN SAN LORENZO Reaches Since 2003.

Reach	Pool 2003	Pool 2005	Pool 2006	Pool 2007	Pool 2008	Pool 2009	Riffle 2003	Riffle 2005	Riffle \2006	Riffle 2007	Riffle 2008	Riffle 2009	Run/ Step Run 2003	Run/ Step Run 2005	Run/ Step Run 2006	Run/ Step Run 2007	Run/ Step Run 2008	Run/ Step Run 2009
1			59	50	52				31	23	26				49	48	48	
2				26	38	**36**	30* (2000			13	18	**16**	30* (2000)			23	25	**32**
3																		
4			64	43	45				37	19	33				47	37	42	
5																		
6	52	49	56	45	51		27	31	31	18	21		38	46	41	34	39	
7	53	54					34	27					49	40				
8	49	53	56	40	46	**33**	32	25	28	18	30	**19**	44	29	35	28	26	**32**
9	52	39					32	25					40	31				
10	38	39					32	27					32	34				
11		58	48	34	47	**48**		30	33	22	30	**22**		45	27	31	43	**33**
12b		58						27						45				
Zayante 13a	44	45	54	44	51		33	29	23	25	30		41	44	50	36	47	
Zayante 13b	44	46					36	25					43	39				
Zayante 13c	48	48		36	49		29	25		19	28		33	38		31	44	
Zayante 13d	41	47	51	55	49	**49**	35	48	37	30	33	**43**	33	43	42	39	37	**41**
Lompico 13e			55	52	47				42	16	19				46	37	32	
Bean 14a	46	45					32	21					49	37				
Bean 14b	35	41		45	44	**44**	35	20		22	14	**16**	41	29		36	22	**35**
Bean 14c	49	50	62	39	42		19	27	36	8	15		43	46	52	25	29	
Fall 15	47 (2000				48	**52**					25	**28**	44 (2000)				40	**41**
Newell 16			36			**42**			12			**20**			33			**31**
Boulder 17a		34	48	37	37	**38**		24	29	18	21	**18**		30	33	27	31	**27**
Boulder 17b		36	43	33	35			14	24	22	17			29	34	33	34	
Boulder 17c		31						18						13				
Bear 18a	48	42	54	33	48		28	22	35	28	34		47	30	41	36	43	
Branciforte 21a-1				60	58					31	24					55	41	
Branciforte 21a-2			68	62	46	**49**			41	30	28	**28**			59	36	33	**28**
Branciforte 21b		41						28						32				

* Data from sampling sites and not reach segments.

Table 9. Reach-wide ESCAPE COVER Index (Habitat Typing Method*) in RIFFLE HABITAT in MAINSTEM Reaches of the SAN LORENZO, Based on Habitat Typed Segments.

Reach	1998	1999	2000	2003	2005	2006	2007	2008	2009
1	0.187	0.244	0.084	-	-	0.270	0.257	0.200	
2	-	0.503	0.260	-	-		0.228	0.287	0.132
3	0.250	0.216	0.257	-	-				
4	0.125	0.078	0.109	-	-	0.183	0.354	0.141	
5	0.032	0.001	0.222	-	-				
6	**0.099**	**0.093**	**0.042**	**0.027**	**0.152**	**0.101**	**0.072**	**0.082**	
7	**0.148**	**0.146**	**0.050**	**0.130**	**0.187**				
8	**0.335**	**0.173**	**0.124**	**0.080**	**0.320**	**0.241**	**0.123**	**0.036**	**0.156**
9	**0.038**	**0.080**	**0.043**	**0.066**	**0.161**				
10	0.011	0.039	0.012	0.018	0.040				
11	0.025	0.020	0.017	-	0.056	0.014	0.005	0.010	0.027
12	0.086	0.022	0.036	-	0.044				

*Habitat Typing Method = linear feet of escape cover divided by habitat typed channel length as riffle habitat.

Table 10. Reach-wide ESCAPE COVER Index (Habitat Typing Method*) in RUN HABITAT in MAINSTEM Reaches of the SAN LORENZO, Based on Habitat Typed Segments.

Reach	1998	1999	2000	2003	2005	2006	2007	2008	2009
1	0.273	0.130	0.064	-	-	0.131	0.120	0.151	
2	0.228	0.136	0.100	-	-		0.282	0.226	0.196
3	0.186	0.113	0.144	-	-				
4	0.234	0.159	0.091	-	-	0.125	0.204	0.221	
5	0.071	0.249	0.261	-	-				
6	**0.145**	**0.107**	**0.044**	**0.068**	**0.098**	**0.101**	**0.049**	**0.044**	
7	**0.038**	**0.030**	**0.023**	**0.165**	**0.074**				
8	**0.129**	**0.152**	**0.131**	**0.154**	**0.164**	**0.103**	**0.168**	**0.087**	**0.079**
9	**0.138**	**0.051**	**0.036**	**0.046**	**0.098**				
10	0.072	0.041	0.081	0.062	0.057				
11	0.026	0.016	0.022	-	0.021	0.0084	0.0068	0.014	0.032
12	0.031	0.069	0.126	-	0.048				

*Habitat Typing Method = linear feet of escape cover divided by habitat typed channel length as run habitat.

Table 11. ESCAPE COVER Index (Habitat Typing Method*) in POOL HABITAT in MAINSTEM Reaches of the SAN LORENZO, Based on Habitat Typed Segments.

Reach	2003	2005	2006	2007	2008	2009
1	-	-	0.271	0.186	0.205	
2	-	-		0.076	0.058	0.046
3	-	-				
4	-	-	0.203	0.275	0.290	
5	-	-				
6	**0.077**	**0.077**	**0.044**	**0.083**	**0.088**	
7	**0.134**	**0.105**				
8	**0.026**	**0.027**	**0.039**	**0.057**	**0.030**	**0.049**
9	**0.037**	**0.070**				
10	0.054	0.051				
11	0.054 (2000)	0.059	0.031	0.034	0.035	0.042
12	-	0.178				

*Habitat Typing Method = linear feet of escape cover divided by habitat typed channel length as pool habitat.

Table 12. ESCAPE COVER Index (Habitat Typing Method*) for POOL HABITAT in TRIBUTARY Reaches of the SAN LORENZO.

Reach	1998	1999	2000	2003	2005	2006	2007	2008	2009
Zayante 13a	0.320	0.069	0.056	0.169	0.081	0.074	0.071	**0.086**	
Zayante 13b	0.150	0.093	0.072	0.130	0.087				
Zayante 13c	0.114	0.110	0.095	0.110	0.109		0.102	**0.099**	
Zayante 13d	0.145	0.191	0.132	0.237	0.269	0.126	0.117	**0.118**	**0.181**
Lompico 13e						0.089	0.082	**0.095**	
Bean 14a	0.248	0.143	0.186	0.124	0.155				
Bean 14b	0.378	0.280	0.205	0.288	0.212		0.231	**0.171**	**0.179**
Bean 14c	0.259	0.093	0.100	0.142	0.141	0.131	0.142	**0.131**	
Fall 15	0.380		0.330					**0.375**	**0.295**
Newell 16	0.285		0.325			0.120			**0.125**
Boulder 17a	0.131	0.051	0.061	-	0.108	0.064	0.076	**0.058**	**0.047**
Boulder 17b	0.129	0.141	0.164	-	0.232	0.100	0.140	**0.155**	
Boulder 17c	0.250	0.072	0.057	-	0.143				
Bear 18a	0.069	-	0.103	0.119	0.114	0.074	0.088	**0.087**	
Branciforte 21a-1							0.140	**0.136**	
Branciforte 21a-2						0.121	0.134	**0.151**	**0.164**
Branciforte 21b	0.147	0.083	0.102	-	0.189				

*Habitat Typing Method = linear feet of escape cover divided by habitat typed channel length as pool habitat.

Table 13. ESCAPE COVER Index (Habitat Typing Method*) for RUN/STEP-RUN HABITAT in TRIBUTARY Reaches of the SAN LORENZO.

Reach	1998	1999	2000	2003	2005	2006	2007	2008	2009
Zayante 13a	0.127	0.059	0.059	0.065	0.031	0.038	0.027	**0.009**	
Zayante 13b	0.060	0.127	0.087	0.152	0.103				
Zayante 13c	0.116	0.095	0.070	0.016	0.070		0.051	**0.074**	
Zayante 13d	0.050	0.098	0.143	0.223	0.297	0.071	0.101	**0.130**	**0.136**
Lompico 13e						0.001	0.042	**0.020**	
Bean 14a	0.060	0.058	0.092	0.051	0.086				
Bean 14b	0.045	0.048	0.041	0.107	0.050		0.138	**0.141**	**0.056**
Bean 14c	-	0.018	0.023	0.015	0.012	0.009	0.0	**0.0**	
Fall 15								**0.110**	**0.092**
Newell 16	0.072		0.129			0.020			**0.065**
Boulder 17a	0.188	0.093	0.170	-	0.135	0.169	0.138	**0.113**	**0.100**
Boulder 17b	0.116	0.156	0.137	-	0.194	0.102	0.114	**0.105**	
Boulder 17c	0.019	0.122	0.107	-	0.114				
Bear 18a	0.073	-	0.177	0.063	0.088	0.063	0.027	**0.030**	
Branciforte 21a-1							0.087	**0.040**	
Branciforte 21a-2						0.028	0.045	**0.037**	**0.045**
Branciforte 21b	0.138	0.014	0.087	-	0.133				

*Habitat Typing Method = linear feet of escape cover divided by habitat typed channel length as run habitat.

R-3. Habitat Change in Soquel Creek and Its Branches, 2008 to 2009

Refer to **Appendix A** for maps of reach locations. A summary table of habitat change for all reaches is provided in **Table 42**. Weighing the relative importance of streamflow as an aspect of habitat quality against other habitat parameters is not clear cut. Most of the steelhead growth occurs in the spring throughout this watershed when the quantity of baseflow is most important. All reaches had higher baseflow in 2009 than 2008, especially in the spring due to later storms in 2009 (**Figures 54 and 55**). This provided more food and better growth rate in all reaches, especially when YOY densities were reduced. Of the 8 reach segments examined, 3 had negative habitat change, two had similar habitat quality and three had improvement (lower mainstem 3a, East Branch 12a (SDSF) and West Branch 13). In the **lower mainstem,** Reach 1 had similar habitat quality between 2008 and 2009, offsetting differences being improved baseflow and modest reduction in pool escape cover (15% less). Reach 3 had overall better habitat quality with regard to higher baseflow, deeper pools and less embedded runs but had poorer habitat in terms of 15% less pool escape cover (**Tables 14−17**). For **upper mainstem** Reaches 7 and 8 below the Branch confluences, Reach 7 had overall habitat quality decline with 47% less pool escape cover and increased fine sediment in pools, although improvement occurred regarding deeper pools and runs and higher baseflow. Reach 8 had improved habitat regarding higher baseflow, deeper pools and runs, with less sediment and embeddedness in fastwater habitat, but overall decreased habitat quality with 43% less pool escape cover. Reach 9a in the **lower East Branch** showed the consistent pattern of overall habitat decline with 33% less escape cover in pools with improvement regarding higher baseflow, deeper average pool depth and run depth. Reach 12a in the SDSF in the **upper East Branch** had overall improved habitat quality with significantly more baseflow (visual estimate of 0.15 cfs compared to a mere 0.01— 0.02 cfs trickle the previous year), deeper pool habitat (likely due to shallow pools in 2008 being typed as step-runs in 2009), reduced riffle embeddedness and 40% more pool escape cover.

In the **lower West Branch**, Reach 13 had overall improved habitat quality with higher baseflow, deeper runs and less fine sediment in pools. Pool depths were similar between years, though pools were more embedded with a modest 9% reduction in escape cover. The **middle West Branch** Reach 14b between Girl Scout Falls I and II had similar overall habitat quality to 2008 in that baseflow was increased in 2009 while pools had 12% less escape cover, with other habitat parameters similar except greater run/step-run depth and greater run embeddedness.

Table 14. Averaged Mean and Maximum WATER DEPTH (ft) of Habitat in SQOUEL CREEK Reaches Since 2003 with Pool Depths Since 2000.

Reach	Pool 2000	Pool 2003	Pool 2005	Pool 2006	Pool 2007	Pool 2008	Pool 2009	Riffle 2003	Riffle 2005	Riffle 2006	Riffle 2007	Riffle 2008	Riffle 2009	Run/ Step Run 2003	Run/ Step Run 2005	Run/ Step Run 2006	Run/ Step Run 2007	Run/ Step Run 2008	Run/ Step Run 2009
1	1.3/ 2.5	1.4/ 2.7	1.1/ 2.8		1.2/ 2.7	1.2/ 2.8	**1.15/ 2.7**	-/ 0.5	-/ 0.7		0.3/ 0.4	0.2/ 0.4*	**0.25/ 0.45**	-/ 0.7	-/ 0.8		0.4/ 0.5	0.3/ 0.5	**0.35/ 0.5**
2	1.0/ 1.9	1.0/ 1.6	1.0/ 1.7					-/ 0.5	-/ 0.6					-/ 0.7	-/ 1.1				
3	1.3/ 2.4	1.35/ 2.5	1.3/ 2.3	1.4/ 2.5 *	1.4/ 2.3 *	1.2/ 2.3 *	**1.4/ 2.35**	-/ 0.5	-/ 0.7	0.5/ 0.8 *	0.3/ 0.5 *	0.2/ 0.4 *	**0.25/ 0.4**		-/ 1.0	0.7/ 1.0 *	0.4/ 0.6 *	0.3/ 0.6 *	**0.45/ 0.7**
4	1.3/ 2.3	1.2/ 2.6	1.1/ 2.6					-/ 0.6	-/ 0.8					-/ 0.7	-/ 0.9				
5	1.3/ 2.2	1.2/ 2.2	1.2/ 2.3					-/ 0.5	-/ 0.7					-/ 0.8	-/ 0.9				
6	1.3/ 2.4	1.45/ 2.5	1.25 / 2.2					-/ 0.6	-/ 0.7					-/ 0.8	-/ 0.9				
7	1.4/ 2.4	1.6/ 2.9	1.2/ 2.2	1.3/ 2.3 *	1.2/ 2.1 *	1.2/ 2.2 *	**1.35/ 2.4**	-/ 0.7	-/ 0.8	0.5/ 0.8 *	0.3/ 0.6 *	0.3/ 0.5 *	**0.35/ 0.55**	-/ 0.9	-/ 0.9	0.8/ 1.2 *	0.3/ 0.6 *	0.4/ 0.7 *	**0.5/ 0.8**
8	1.5/ 2.7	1.6/ 2.9	1.4/ 2.7		1.5/ 2.9 *	1.4/ 2.5 *	**1.6/2.8**	-/ 0.6	-/ 0.8		0.4/ 0.6 *	0.2/ 0.4 *	**0.3/ 0.45**	-/ 0.9	-/ 0.9		0.5/ 0.9 *	0.4/ 0.7 *	**0.5/ 0.75**
9	1.4/ 2.3		1.3/ 2.1	1.5/ 2.5	1.3/ 2.2	1.2/ 2.3	**1.45/ 2.3**		-/ 0.6	0.4/ 0.6	0.2/ 0.4	0.2/ 0.4	**0.2/ 0.45**		-/ 0.9	0.6/ 1.0	0.4/ 0.6	0.4/ 0.6	**0.5/ 0.75**
10	1.5/ 2.4																		
11	1.9/ 3.3																		
12 a	1.1/ 1.6		1.1/ 1.7	1.3/ 2.05	0.8/ 1.4	0.6/ 1.1	**1.0/ 1.5**		-/ 0.6	0.45 / 0.8	0.1/ 0.2	0.02 /0.1	**0.25/ 0.45**		-/ 1.1 S.run	0.7/ 1.2	0.3/ 0.7	0.2/ 0.5	**0.45/ 0.8**
12 b	1.3/ 2.0		1.1/ 1.6						-/ 0.5						-/ 1.0 S.run				
13	1.3/ 2.7				1.1/ 2.2 *	1.1/ 2.3 *	**1.25/ 2.3**				0.3/ 0.5 *	0.3/ 0.5 *	**0.3/ 0.5**				0.5/ 0.8 *	0.4/ 0.7 *	**0.5/ 0.8**
14 a	1.3/ 2.4		1.0/ 1.8	1.4/ 2.4					-/ 0.5	0.5/ 0.8					-/ 0.7	0.6/ 1.0			
14 b		1.5/ 2.6 2002		1.6/ 2.9	1.4/ 2.4	1.3/ 2.4	**1.35/ 2.5**			0.4/ 0.6	0.2/ 0.4	0.2/ 0.4	**0.25/ 0.5**			0.7/ 1.0	0.5/ 0.8	0.4/ 0.7	**0.5/ 0.8**
14 c		1.4/ 2.4 2002																	

*Partial, ½-mile segments habitat typed in 2006–2009. Previously, the entire reach was habitat typed.

Table 15. Average PERCENT FINE SEDIMENT in Habitat-typed Reaches in SOQUEL CREEK Since 2003 with Pool Sediment Since 2000.

Reach	Pool 2000	Pool 2003	Pool 2005	Pool 2006	Pool 2007	Pool 2008	Pool 2009	Riffle 2003	Riffle 2005	Riffle 2006	Riffle 2007	Riffle 2008	Riffle 2009	Run/ Step Run 2003	Run/ Step Run 2005	Run/ Step Run 2006	Run/ Step Run 2007	Run/ Step Run 2008	Run/ Step Run 2009
1	81	73	84		59	64	**59**	21	25		18	13	**14**	45	36		29	16	**16**
2	71	69	80					20	24					47	34				
3	77	70	75	62 *	55 *	57 *	**58**	25	17	14 *	17 *	15*	**8**	34	43	29 *	29 *	20*	**19**
4	69	72	61						21						29				
5	72	66	69						21						27				
6	68	59	63						14						26				
7	80	66	69	69 *	52 *	59 *	**70** *		17	21 *	20 *	23*	**16** *		35	33 *	25*	25*	**20** *
8	70	59	64		46 *	56 *	**58** *		16		14 *	15*	**5** *		24		25 *	64*	**28***
9	65		56	62	47	49	**42**	13	17	12	13	10	**6**		25	30	24	26	**19**
10	63																		
11	56																		
12a	48		33	40	29	34	**35**		9	12	6	10	**12**		15 (S.run)	21 (S.run)	20 (S.run)	21 (S.run)	**19 (S.run)**
12b	49		36						5						18				
13	73				64 *	75 *	**58** *				26 *	18*	**11***				29 *	26*	**20***
14a	71		55	66					15	14					31 (run)	28 (run)			
14b				51	40	55	**52**			15	9	10	**8**			35 (run)	26 (run)	20 (run)	**20 (run)**
14c																			

*Partial, ½-mile segments habitat typed in 2006–2009. Previously, the entire reach was habitat typed.

Table 16. Average EMBEDDEDNESS in Pool and Fastwater (Riffle and Run) Habitat of SOQUEL CREEK Reaches Since 2003 with Pool Embeddedness Since 2000.

Reach	**Pool 2000**	**Pool 2003**	**Pool 2005**	**Pool 2006**	**Pool 2007**	**Pool 2008**	**Pool 2009**	**Riffle 2003**	**Riffle 2005**	**Riffle 2006**	**Riffle 2007**	**Riffle 2008**	**Riffle 2009**	**Run/ Step Run 2003**	**Run/ Step Run 2005**	**Run/ Step Run 2006**	**Run/ Step Run 2007**	**Run/ Step Run 2008**	**Run/ Step Run 2009**
1	47	55	57		48	35	**37**	33	25		22	18	**19**	55	35		29	29	**23**
2	55	60	56					39	34					69	46				
3	57	59	58	55*	40*	39*	**37***	30	27	27*	17*	22*	**19***	46	42	46*	28*	33*	**23***
4	55	58	61					40	31					54	48				
5	51	52	55					36	27					48	42				
6	52	50	53					31	28					43	40				
7	49	53	53	56*	42*	44*	**41***	33	30	25*	25*	23*	**23***	43	43	39*	35*	39*	**38***
8	53	49	60		44*	43*	**45***	38	29		25*	17*	**17***	46	45		35*	48*	**33***
9	56		59	54	47	44	**50**		34	26	18	22	**26**		45	50	37	47	**42**
10	51																		
11	54																		
12a	55		53	53	55	54	**59**		29	30	41	45	**34**		37 (S.run)	38 (S.run)	47 (S.run)	39 (S.run)	**46 (S.run)**
12b	51		59						30						47				
13	55				50*	42*	**53***				26*	23*	**22***				39*	29*	**37***
14a	50		58	57					47	18					59 (run)	34 (run)			
14b		55 2002		57	47	44	**44**	33 2002		32	17	19	**16**	47 (run) 2002		46 (run)	25 (run)	27 (run)	**38 (run)**
14c		61 2002						30 2002						45 2002					

*Partial, ½-mile segments habitat typed in 2006–2009. Previously, the entire reach was habitat typed.

Table 17. POOL ESCAPE COVER Index (Habitat Typing Method*) in SOQUEL CREEK, Based on Habitat Typed Segments.

Reach	Pool 2000	Pool 2003	Pool 2005	Pool 2006	Pool 2007	Pool 2008	Pool 2009
1	0.091	0.103	0.107		0.147	**0.134**	**0.116**
2	0.086	0.055	0.106				
3	0.085	0.092	0.141	0.178 * **	0.177 **	**0.131** ******	**0.112** ******
4	0.041	0.071	0.086				
5	0.061	0.023	0.075				
6	0.082	0.102	0.099				
7	0.089	0.101	0.129	0.141 **	0.164 **	**0.170** ******	**0.089** ******
8	0.047	0.036	0.060		0.070 **	**0.071** ******	**0.037** ******
9	0.146		0.101	0.086	0.117	**0.147**	**0.100**
10	0.100						
11	0.068						
12a	0.113		0.222	0.175	0.121	**0.097**	**0.143**
12b	0.129		0.158				
13	0.077				0.081 **	**0.069** ******	**0.060**
14a	0.064			0.048			
14b		0.051 (2002)		**0.058**	0.076	**0.080**	**0.069**
14c		0.068 (2002)					

* Habitat Typing Method = linear feet of escape cover divided by reach length as pool habitat.

** Partial, ½-mile segments habitat typed in 2006–2009. Previously, the entire reach was habitat typed.

R-4. Habitat Change in Aptos and Valencia Creeks, 2008 to 2009

Refer to **Appendix A** for maps of reach locations. A summary table of habitat change for all reaches is provided in **Table 41**. The January 1982 storm caused severe streambank erosion and landsliding throughout the Santa Cruz Mountains, and streams have been recovering since. The 1997-98 winter also brought significant stormflow and sedimentation into some watersheds by 1999, such as the San Lorenzo River (**Alley 2000**). Weighing the relative importance of streamflow as an aspect of habitat quality with other habitat parameters is not clear cut, especially when not stream gage is present and exact streamflow measurements are very limited. Most of the steelhead growth occurs in the spring throughout this watershed when the quantity of baseflow is most important. Based on hydrographs from stream gages in other watersheds (**Figures 50-55**), all reaches had higher baseflow, especially in the spring due to later storms in 2009. This provided more food and better growth rate in all reaches in 2009. From 2008 to 2009, similar overall habitat conditions existed in the 4 monitored reaches of Aptos and Valencia creeks, with similar habitat depth, escape cover, embeddedness, fine sediment and embeddedness in pools and riffles, except that the lower Reach 2 in Aptos had 10% less pool cover in 2009. Changes occurred in the less important non-pool habitat, including less fine sediment and less escape cover in runs of Aptos Reach 2, less riffle and run cover in Aptos Reach 3, increased run cover in Valencia Reach 2 and less run embeddedness in Valencia Reach 3 (**Tables 18-20**).

Table 18. Average POOL HABITAT CONDITIONS and Escape Cover Indices for Reaches in APTOS, VALENCIA, CORRALITOS, SHINGLE MILL and BROWNS Creeks in 2006–2009 (and at Sampling Sites in Aptos/ Valencia in 1981 and in Corralitos/ Browns in 1981 and 1994).

Reach #/ Sampling Site #	Mean Depth/ Maximum Depth				Escape Cover*				Embeddedness						Percent Fines					
	2006	2007	2008	2009	2006	2007	2008	2009	1981	1994	2006	2007	2008	2009	1981	1994	2006	2007	2008	2009
Aptos #2/#3- in County Park	1.4/3.0	1.1/2.3	1.1/2.1	1.0/2.1	0.123	0.133	0.172	0.155	35		82	49	47	48	75		85	76	60	53
Aptos #3/#4- Above Steel Bridge Xing (Nis. Marks)	1.3/2.4	1.2/2.2	1.1/2.2	1.2/2.3	0.059	0.102	0.132	0.127	35		80	59	57	56	65		78	62	63	57
Valencia #2/#2- Below Valencia Road Xing	0.7/1.2	0.8/1.4	0.6/1.3	0.6/1.2	0.115	0.148	0.131	0.143	35		88	70	45	51	85		93	98	88	79
Valencia #3/#3- Above Valencia Road Xing	1.0/1.7	0.9/1.6	0.7/1.4	0.8/1.5	0.119	0.154	0.210	0.217	55		82	56	55	53	70		83	78	79	76
Corralitos #1/#1- Below Dam		1.25/1.95	1.3/2.0	1.5/2.1		0.106	0.152	0.123	65	40		35	44	49	45	40		37	50	54
Corralitos #3/#3- Above Colinas Drive	1.5/2.6	1.3/2.3	1.1/2.0	1.2/2.0	0.138	0.191	0.172	0.121	60	45	52	41	46	52	45	35	47	38	50	53
Corralitos #6/#8- Below Eureka Gulch	1.3/2.2	1.1/1.9	1.0/1.8	1.1/1.9	0.061	0.084	0.090	0.093	54	50	54	42	45	58	35	20	45	35	48	56
Corralitos #7/#9- Above Eureka Gulch	1.2/1.8	1.0/1.6	0.9/1.5	1.0/1.5	0.160	0.185	0.171	0.125	56	60	47	37	40	45	35	15	33	30	29	41
Shingle Mill #1/#1- Below 2nd Road Xing	1.15/1.8	0.8/1.3	0.8/1.3		0.180	0.198	0.214		42	45	71	58	58		23	8	49	33	26	
Shingle Mill #3/#3- Above 3rd Road Xing	1.15/1.8	0.9/1.4	0.8/1.3	0.9/1.5	0.190	0.196	0.223	0.264	60		71	62	62	59			55	38	34	45
Browns Valley #1/#2- Below Dam	1.4/2.4	1.1/1.8	1.2/1.9	1.2/1.9	0.051	0.127	0.156	0.185	58	37	71	60	56	57	38	47	61	40	35	38
Browns Valley #2/#2- Above Dam	1.45/2.35	1.0/1.7	1.0/1.6	1.0/1.6	0.120	0.161	0.155	0.198	73	47	69	59	56	54	47	37	53	36	32	35

* Habitat typing method = total feet of linear pool cover divided by total habitat typed channel length as pool habitat.

Table 19. Average RIFFLE HABITAT CONDITIONS for Reaches in APTOS, VALENCIA, CORRALITOS, SHINGLE MILL and BROWNS Creeks in 2006–2009 (and at Sampling Sites only in Aptos/Valencia in 1981 and Corralitos/ Browns in 1981 and 1994).

Reach #/ Sampling Site #	Mean Depth/ Maximum Depth				Escape Cover*				Embeddedness						Percent Fines					
	2006	2007	2008	2009	2006	2007	2008	2009	1981	1994	2006	2007	2008	2009	1981	1994	2006	2007	2008	2009
Aptos #2/#3- in County Park	0.4/ 0.7	0.3 / 0.6	0.2 / 0.4	0.2 / 0.4	0.007	0.061	0.027	0.058	50		48	21	23	25	68 riffle & run		26	14	11	11
Aptos #3/#4- Above Steel Bridge Xing (Nisene Marks)	0.5/ 0.8	0.3 / 0.7	0.4 / 0.7	0.3 / 0.6	0.004	0.026	0.075	0.033	40		47	34	32	34	30 riffle & run		25	16	16	17
Valencia #2/#2- Below Valencia Road Xing	0.3/ 0.4	0.2 / 0.4	0.2 / 0.4	0.1 / 0.3	0.003	0.022	0.010	0	15		54	29	36	37	48 riffle & run		50	36	47	49
Valencia #3/#3- Above Valencia Road Xing	0.3/ 0.5	0.2 / 0.4	0.15 / 0.3	0.2 / 0.25	0.004	0.010	0.052	0	30		56	15	18	19	30 riffle & run		33	17	11	11
Corra- litos #1/#1- Below Dam		0.3 / 0.5	0.5 / 0.7	0.4 / 0.6		0.033	0.046	0.045	60	30		17	26	29	20	20		10	17	23
Corra- litos #3/#3- Above Colinas Drive	0.5/ 0.9	0.4 / 0.6	0.4 / 0.6	0.4 / 0.6	0.028	0.080	0.066	0.027	53	30	26	12	23	24	35	10	18	7	17	14
Corra- litos #6/#8- Below Eureka Gulch	0.4/ 0.7	0.3 / 0.5	0.2 / 0.5	0.3 / 0.5	0.021	0.034	0.015	0.037	50	50	28	22	27	31	25	5	14	12	19	17
Corra- litos #7/#9- Above Eureka Gulch	0.5/ 0.8	0.3 / 0.5	0.25/ 0.6	0.3 / 0.5	0.041	0.0	0.061	0.022	60	30	33	23	29	40	35	7	7	8	8	14

Shingle Mill #1/#1-Below 2nd Road Xing	0.25/0.5	0.1/0.3	0.1/0.3		0.022	0.029	0.037		45	40	19	30	26		10	0	31	3	2	
Shingle Mill #3/#3-Above 3rd Road Xing	0.2/0.3	0.1/0.2	0.1/0.2	0.1/0.25	0.020	0	0	0	20		25	30	25	20			5	4	3	5
Browns Valley #1/#2-Below Dam	0.4/0.7	0.2/0.4	0.3/0.5	0.2/0.45	0	0.017	0.026	0.028	60	45	36	36	26	29	20	10	15	9	10	12
Browns Valley #2/#2-Above Dam	0.3/0.6	0.2/0.4	0.2/0.4	0.2/0.4	0	0.005	0.007	0.004	35		40	33	35	33			15	13	12	11

* Habitat typing method = total feet of linear riffle cover divided by total habitat typed channel length as riffle habitat.

Table 20. Average RUN or STEP-RUN (More Commonly Used by Fish) HABITAT CONDITIONS for Reaches in APTOS, VALENCIA, CORRALITOS, SHINGLE MILL and BROWNS VALLEY Creeks in 2006–2009 (and at Sampling Sites only in Aptos/Valencia in 1981 and Corralitos/ Browns in 1981 and 1994).

Reach #/ Sampling Site #	Mean Depth/ Maximum Depth				Escape Cover*				Embeddedness						Percent Fines					
	2006	2007	2008	2009	2006	2007	2008	2009	1981	1994	2006	2007	2008	2009	1981	1994	2006	2007	2008	2009
Aptos #2/#3- in County Park	0.75/ 1.4 run	0.4 / 0.8 run	0.4 / 0.6 run	0.4 / 0.6 run	0.030	0.023	0.067	0.025	40		66	32	38	33	68 riffle & run		53	52	47	34
Aptos #3/#4- Above Steel Bridge Xing (Nisene Marks)	0.7 / 1.0 run	0.55/ 0.95 run	0.5 / 0.8 run	0.5 / 0.8 run	0.014	0.007	0.138	0.053			61	44	47	46	30 riffle & run		39	25	28	20
Valencia #2/#2- Below Valencia Road Xing	0.3 / 0.6 run	0.3 / 0.6 run	0.25/ 0.55 run	0.25/ 0.55 run	0.018	0.025	0.015	0.538			77	-	35	55	48 riffle & run		90	98	96	96
Valencia #3/#3- Above Valencia Road Xing	0.4 / 0.7 run	0.4 / 0.6 run	0.4 / 0.5 run	0.4 / 0.5 run	0.008	0.031	0.078	0.085			59	29	44	32	30 riffle & run		48	33	50	44
Corralitos #1/#1- Below Dam		0.45/ 0.8 both	0.6 / 0.8 run	0.5 / 0.8 run		0.035	0.055	0.031				25	43	39				25	27	36
Corralitos #3/#3- Above Colinas Drive	0.75/ 1.1 run	0.6 / 0.9 run	0.5 / 0.8 run	0.6 / 0.8 run	0.017	0.052	0.052	0.029	60	40	43	16	34	39	90	60	25	19	20	24
Corralitos #6/#8- Below Eureka Gulch	0.6 / 0.95 step-run	0.4 / 0.9 step-run	0.4 / 0.9 step-run	0.5 / 0.9 Step-run	0.010	0.046	0.044	0.046	60	50	48	27	32	36	49	5	21	16	21	24
Corralitos #7/#9- Above Eureka Gulch	0.8 / 1.3 step-run	0.5 / 1.0 step-run	0.4 / 0.8 step-run	0.5 / 0.9 Step-run	0.063	0.055	0.051	0.044			34	40	34	47			16	18	22	23
Shingle Mill #1/#1- Below 2nd Road Xing	0.6 / 1.2 step-run	0.4 / 0.8 step-run	0.4 / 0.8 step-run		0.013	0.034	0.037		45	30	48	35	41		18	5	19	5	6	

Shingle Mill #3/#3- Above 3rd Road Xing	0.4 / 0.8 step-run	0.3 / 0.6 step-run	0.3 / 0.6 Step-run	0.4 / 0.7 Step-run	0.023	0.060	0.079	0.082			45	38	40	40			18	14	14	12
Browns Valley #1/#1- Below Dam	0.6 / 1.05 step-run	0.4 / 0.6 run	0.4 / 0.65 run	0.45/ 0.65 run	0.015	0.038	0.056	0.031	70	35	58	42	41	41	35	10	36	15	18	18
Browns Valley #2/#2- Above Dam	0.6 / 1.05 step-run	0.4 / 0.65 run	0.4 / 0.6 both	0.4 / 0.7 both	0.015	0.066	0.067	0.069			58	39	37	34			32	19	14	16

* Habitat typing method = total feet of linear run and step-run cover divided by total habitat typed channel length as run and step-run habitat.

R-5. Habitat Change in Corralitos, Shingle Mill and Browns Valley Creeks, 2008 to 2009

Refer to **Appendix A** for maps of reach locations. A summary table of habitat change for all reaches is provided in **Table 41**. Weighing the relative importance of streamflow as an aspect of habitat quality with other habitat parameters is not clear cut, especially when exact streamflow measurements are limited. Most of the steelhead growth occurs in the spring throughout this watershed when the quantity of baseflow is most important. All reaches had higher baseflow, especially in the spring due to later storms in 2009 (**Figures 54 and 55**). This provided more food and better growth rate in all reaches. Reach 1 below the Corralitos diversion dam continued to experience higher summer baseflow than in 2007 due to increased bypass from the diversion dam. Overall habitat quality for Reach 1 was similar as pool escape cover declined 20%, with higher baseflow and greater pool depth in 2009. Fine sediment and embeddedness conditions were similar in pools and fastwater habitat. Escape cover and depth in fastwater habitats were similar in 2009 (**Tables 18-20**).

Reach 3 on Corralitos Creek below Rider Creek had reduced habitat quality in 2009 due to 30% less pool escape cover and less riffle cover, although baseflow was greater and pool depths were similar between years. Run embeddedness lessened.

Reaches 5/6 above the box culvert and below Eureka Gulch had slightly improved habitat quality between 2008 and 2009, with higher baseflow, deeper pool habitat and more riffle cover, but more pool embeddedness. Other habitat parameters were similar. Habitat quality in Reach 7 above Eureka Gulch declined despite higher baseflow. The decline was due to 27% less pool escape cover, increased fine sediment in pools, increased embeddedness in all habitat types and less riffle cover. Habitat depths were similar between years.

In Shingle Mill Gulch, baseflow was very low for the third year, with only Reach 3 habitat typed. Habitat quality improved with slightly higher baseflow, deeper pools and runs and an 18% increase in pool cover in 2009, although fine sediment increased in pools. Repeated Shingle Mill Site 1 had slightly improved habitat quality with slightly higher baseflow and slightly more pool escape cover, although percent fines increased. Habitat depth and embeddedness were similar between years.

On Browns Creek, overall habitat quality improved in 2009 in Reach 1 below the Redwood Canyon Creek confluence due to an 18% increase in pool escape cover and increased baseflow. In Reach 2, overall habitat quality improved due to a 28% increase in pool escape cover and increased baseflow. Other habitat parameters were similar between years in both reach segments.

R-6. Instream Wood Contribution to Pool Escape Cover in Habitat-Typed Segments

The average total escape cover per reach segment was 55 feet (**Table 21**). All reach segments were approximately ½ mile in length except Soquel 1, which was 0.8 miles. Reaches with relatively little total pool escape cover (less than 150 feet) included in ascending order, Boulder 17a, Soquel 8, SLR 11, Soquel 13, Corralitos 7, Corralitos 5/6, Soquel 14b and Soquel 12a.

For the most part in the 4 watersheds, instream wood contributed a small amount and less than 30% of the total pool escape cover (16 of 28 segments) (**Table 21; Figure 53**). The 8 reach segments that provided the most wood as pool escape cover in ascending order were Soquel 9a, Fall 15, Aptos 4, Soquel 1 (0.8 miles), Aptos 3, Soquel 3a, Bean 14b (much artificially added small wood) and Valencia 3. Most of the wood that provided escape cover was large wood =>1 foot diameter (**Figure 54**).

Reach segments which had the least wood cover in pools were those with steep canyon walls (Boulder 17a, Zayante 13d and Soquel 14b), those below dams (Newell 16) and those with roads or houses (or over-zealous streamside residents) in close proximity (Corralitos 7, Soquel 7 and SLR mainstem 11).The 8 reach segments that provided the least wood as pool escape cover in ascending order were Boulder 17a, Corralitos 7, SLR mainstem 8, Newell 16, Zayante 13d, Soquel 14b, Soquel 7 and SLR mainstem 11. Wood provided no pool escape cover in segments of Boulder 17a or Corralitos 7.

Reach segments in which wood contributed some but less than 10% of the total pool escape cover included SLR mainstem 2 (all habitats), SLR mainstem 8 (all habitats), Zayante 13d and Newell 16 (**Table 21; Figure 54**). Reach segments in which wood contributed 10-20% included Branciforte 21a-2, Soquel 7, Soquel 14b, Shingle Mill 3, Corralitos 1, Browns 1 and Browns 2. The average contribution was 25.4% for the 28 reach segments inventoried. Reach segments in which wood contributed 20-30% included Soquel 1, Soquel 12a and Corralitos 5/6. Reach segments in which wood contributed more than 30% of the escape cover included SLR mainstem 11, Bean 14b, Fall 15, Soquel 3a, Soquel 8, Soquel 9a, Soquel 13, Aptos 3, Aptos 4, Valencia 2, Valencia 3, and Corralitos 3.

Table 21. 2009 Contribution of Instream Wood to Pool Escape Cover in Habitat-Typed Reach Segments of the San Lorenzo, Soquel, Aptos and Corralitos Watersheds.

Stream	Reach Segment	Cover (ft) As Large Wood in Pools (=>1 ft. dia)	Cover (ft) As Small Wood in Pools (<1 ft. dia)	Total Wood Cover in Pools (ft)	Total Pool Cover (ft)	% of Pool Cover as Instream Wood
SLR Mainstem	2 (all habitats)	23	0	23	290	7.9
SLR Mainstem	8 (all habitats)	4	0	4	241.5	1.7
SLR Mainstem	11	25	4	29	87.5	33.1
Zayante	13d	13	0	13	332.5	3.9
Bean	14b	75.5	77 (much artificial)	152	322.5	47.1
Fall	15	78	4	82	173	47.4
Newell	16	3	6	9	195.5	4.6
Boulder	17a	0	0	0	69.5	0
Branciforte	21a-2	40	16	56	352	15.9
Soquel	1	64	35	99	416.5	23.8
Soquel	3a	77	29	106	272	39.0
Soquel	7	22	4	26	231.5	11.2
Soquel	8	31.5	8	39.5	70.5	56.0
Soquel	9a	74	8	82	159	51.6
Soquel	12a	33	0	33	148.5	22.2
Soquel	13	44	0	44	111	39.6
Soquel	14b	18	0	18	162.5	11.1
Aptos	3	94	10.5	104.5	333	31.4
Aptos	4	66	20.5	86.5	238.5	36.3
Valencia	2	57.5	6	63.5	103	61.7
Valencia	3	173	35.5	208.5	431.5	48.3
Corralitos	1	26	5	31	167	18.6
Corralitos	3	55	5	60	172.5	34.8
Corralitos	5/6	17.5	10	27.5	136.5	20.1
Corralitos	7	0	0	0	156.5	0
Shingle Mill	3	49.5	14.5	64	401	16.0
Browns	1/2	38	8	46	279.5	16.5
Browns	2	33.5	3.5	37	328	11.3
Median		**35.8**	**5.5**	**41.8**	**213.5**	**21.2**
Average		**44.1**	**11.1**	**55.1**	**227.9**	**25.4**

JUVENILE STEEELHEAD DENSITY COMPARISONS

R-7. 2009 Densities in the San Lorenzo Drainage Compared with Those Since 1997

All figures presented within the text may be found in color in the FIGURES section after the REFERENCES AND COMMUNICATIONS.).In the mainstem San Lorenzo River, total juvenile steelhead densities were lower in 2009 than 2008 (6 of 6 sites) (**Figure 1; Table 22**). This was due to lower young-of-the-year (YOY) densities in 2009 than 2008 (6 of 6 sites) (**Figure 2; Table 23**). Yearling densities between years were similarly low (**Table 24**). All six sites had below average total densities with 9−12 years of data. Lower than average total densities were due to lower than average young-of-the-year (YOY) and yearling densities in 2009 (6 of 6 sites with long term averages) (**Figure 2; Tables 22 and 24**). Yearling densities have 3been consistently low in the mainstem, downstream of the Boulder Creek confluence since monitoring began in 1994, with a slight downward trend since 1998 (**Table 24**). Lower YOY densities in 2009 resulted in lower densities of small, Size Class I juveniles (<75 mm SL) (**Table 25**). Densities of Size Class II (75 mm SL) (mostly fast-growing YOY) were lower in 2009 at 3 of 6 compared sites and similar at the other three (**Table 26**). Densities of these important larger juveniles (soon to smolt) were below average in 2009 at all 6 sites (**Figure 3)**. Since densities of larger juveniles in the lower and middle mainstem are determined primarily by YOY densities and their growth rates, the slightly positive physical changes detected in 2 reach segments and 2 other repeated sampling sites along with higher baseflows throughout were insufficient to increase the smolt ratings from 2008 to 2009 at any of the mainstem sites below Boulder Creek confluence (**Table 42; Figure 25)**. Only Sites 2 and 4 in the lower mainstem rated as high as “Fair” in terms of Size Class II and III densities, with Sites 1, 8 and 11 rated “Poor” and Site 6 rated “Very Poor.”

Site densities of YOY in the mainstem below the Boulder Creek confluence have been low from 1999 onward (**Table 23**). 1997 was unusual with considerable rain prior to 1 March with little afterwards, resulting in very stable spawning conditions after March 1 and baseflows near the average median flow. 1998 was a very wet year with so much baseflow that steelhead were in high densities at the heads of pools and even further back where water velocity was still high, unlike other years when they primarily reared in runs and riffles. The one exception to low steelhead densities after 1998 was the rebound in YOY densities in 2008 in Reach 4 in Henry Cowell Park (**Table 23**). Unfortunately, in 2008, a smaller proportion of YOY reached smolt size at that site than if streamflow had been higher in May−September (**Figure 25; Alley 2009**). YOY recruitment into the mainstem from tributaries has apparently been minimal from 1999 onward, except for possibly at Site 4 in 2008 from lower Zayante Creek. The mainstem will need more recruitment of YOY from tributaries, improved spawning gravel and higher baseflow to the middle mainstem to greatly increase the smolt ratings there.

It was the winter of 1999 when substantial sediment entered the middle mainstem from erosion in upstream tributaries that occurred from the 1998 high peak-flow event (19,400 cfs at Big Trees), followed by the 1999 water year that had a relatively low peak flow (3,200 cfs at Big Trees) that apparently could not transport the sediment out of the system. Despite the fact that substrate conditions have improved in riffles and runs in terms of reduced fine sediment and embeddedness since then, substrate in glides where spawning occurs apparently has not, and spawning habitat in the mainstem remains poor in quality and primarily sand and fine gravel.

Table 22. Density of Juvenile Steelhead for ALL SIZES at MAINSTEM SAN LORENZO RIVER Monitoring Sites (Stream Habitat) in 1997-2001 and 2003-2009.

Sample Site	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	2009	Avg.
0a				5.4								2.4	3.9
0b				4.3	5.2								4.8
1	34.2*	26.9	17.6	3.4	7.6				1.2	1.9	7.0	3.4	11.5
2a	74.9	21.4	4.6	3.9	13.5					14.8	20.6	9.2	20.4
2b				24.8	15.4								20.1
3	83.9	73.5	29.0	33.0	36.0								51.1
4	86.9	37.8	39.6	12.0	33.1				16.6	21.3	71.2	28.4	38.5
5		133.8	46.2	4.5	23.6								52.0
6	45.4	46.0	14.1	4.0	10.9	4.7	8.7	6.7	4.5	24.0	21.4	13.2	17.0
7	149.3	21.7	11.8	7.6	15.5	29.4	38.9	11.0					35.7
8	158.6	140.1	48.2	11.2	21.4	32.3	21.6	20.3	13.7	5.5	33.0	18.0	40.3
9	126.8	77.3	27.6	12.0	29.6	17.4	10.9	17.1					39.8
10	69.1	17.9	10.9	18.4	19.7	51.9	44.6	21.9					31.8
11	73.0	10.9	33.4	28.7	5.1	57.2	45.7	32.3	3.0	21.3	47.6	6.8	30.4
12a	56.8	30.8	21.1	39.9	49.8								39.7
12b		32.2	25.9	43.5	30.4	51.9	48.4	98.2					47.2

* Density in number of fish per 100 feet of stream.

Table 23. Density of Juvenile Steelhead for the YOUNG-OF-THE-YEAR Age Class at MAINSTEM SAN LORENZO RIVER Monitoring Sites (Stream Habitat) in 1997-2001 and 2003-2009.

Sample Site	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	2009	Avg.
0a				2.2								1.2	1.7
0b				3.3	2.3								2.8
1	32.3*	25.6	12.6	1.8	6.8				1.2	1.6	7.0	2.7	10.2
2a	66.3	19.2	3.2	2.7	11.0					13.7	19.0	8.1	17.9
2b				21.2	12.1								16.7
3	84.3	68.2	24.7	29.4	29.6								47.2
4	86.2	32.9	34.2	10.5	30.5				13.9	20.7	69.8	26.5	36.1
5		132.4	38.5	3.5	22.8								49.3
6	42.0	44.4	13.2	3.3	10.6	4.4	8.5	5.9	4.2	23.4	20.6	11.1	16.0
7	143.5	19.8	5.7	3.6	12.0	9.7	38.0	11.2					32.9
8	152.0	135.3	44.2	10.9	21.0	30.5	20.9	18.7	11.6	5.5	31.2	16.3	41.5
9	119.9	69.7	23.4	11.0	28.9	17.6	10.0	15.4					37.0
10	65.8	11.7	6.5	13.4	5.9	45.1	40.5	18.4					27.2
11	64.2	6.8	27.6	16.4	21.8	49.8	34.5	29.6	1.5	20.8	46.1	4.4	27.0
12a	50.9	27.9	5.4	34.4	37.3								31.2
12b		24.2	14.3	37.9	15.8	44.4	39.3	89.1					37.9

*Density in Number of Juveniles per 100 feet of Stream.

Table 24. Density of Juvenile Steelhead for YEARLINGS AND OLDER at MAINSTEM SAN LORENZO RIVER Monitoring Sites in 1997-2001 and 2003-2009.

Sample Site	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	2009	Avg.
0a				2.2								1.2	1.7
0b				1.0	2.9								2.0
1	1.6*	1.4	2.9	1.9	0.5				0	0.3	0	0.7	1.1
2a	7.9	1.5	0.9	1.2	1.5					0.9	0.4	1.0	1.9
2b				2.4	2.0								2.2
3	5.2	5.3	3.9	4.4	6.6								5.1
4	7.6	4.7	2.2	1.2	0.5				2.4	0.2	0.3	0.4	2.2
5		2.9	5.4	1.0	0.8								2.5
6	4.6	2.2	0.8	0.7	0.5	0.3	0.2	0.8	0.3	0.7	0.03	0	0.9
7	6.0	2.5	6.3	4.8	3.6	0.4	0.3	3.0					3.0
8	5.4	4.2	4.1	0.3	0.4	2.0	2.6	2.4	1.6	0	2.0	1.5	2.2
9	4.3	8.1	2.5	1.0	0.6	0.8	1.9	2.5					2.5
10	3.3	6.4	4.6	5.5	4.1	6.8	2.7	4.7					4.7
11	8.8	3.9	6.5	11.2	4.7	7.4	3.0	7.1	1.5	0.6	1.1	2.5	4.9
12a	5.9	3.2	15.7	5.5	12.9								8.6
12b		6.8	12.6	5.5	14.3	7.5	9.1	9.3					9.3

*Density in Number of Juveniles per 100 feet of Stream.

Table 25. Density of Juvenile Steelhead for SIZE CLASS I (<75 mm SL) at MAINSTEM SAN LORENZO RIVER Monitoring Sites (Stream Habitat) in 1997-2001 and 2003-2009.

Sample Site	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	2009	Avg.
0a				0								0	0
0b				0	0								0
1	3.3*	0.2	2.2	0	0.7				0	0.3	2.1	0	1.0
2a	7.9	1.3	0.4	0.2	2.5					3.7	8.4	1.2	3.2
2b				1.2	6.7								4.0
3	47.7	9.4	3.7	5.9	18.1								17.0
4	63.0	8.6	6.8	3.1	17.6				0.5	15.4	58.1	14.5	20.8
5		19.1	5.2	0	8.1								8.1
6	35.1	20.5	11.2	1.8	8.4	4.1	8.3	4.7	2.2	22.8	19.2	10.7	12.4
7	126.7	11.7	2.9	1.5	8.6	23.6	35.0	4.9					26.9
8	138.6	118.7	37.4	8.0	20.5	27.9	19.9	13.2	7.9	4.8	29.4	14.5	36.8
9	102.2	57.5	18.5	6.2	28.4	15.4	9.6	12.2					31.3
10	65.8	9.6	4.4	10.1	12.2	45.1	39.8	17.6					25.6
11	64.2	4.1	26.9	15.6	18.7	49.8	34.5	19.3	0	20.8	44.9	3.7	25.2
12a	50.9	26.2	5.4	34.4	40.3								31.4
12b		19.5	4.1	37.0	17.4	44.4	39.3	87.6					35.6

* Density in number of fish per 100 feet of stream.

Table 26. Density of Juvenile Steelhead for SIZE CLASS II/ III (=>75 mm SL) at MAINSTEM SAN LORENZO RIVER Monitoring Sites (Stream Habitat) in 1997-2001 and 2003-2009.

Sample Site	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	2009	Avg.
0a				5.4								2.4	3.9
0b				4.3	5.2								4.8
1	30.9*	26.7	15.4	3.4	6.9				1.2	1.6	4.9	3.4	10.5
2a	67.0	20.1	4.2	3.7	11.0					11.1	12.2	8.0	17.2
2b				23.6	8.7								16.2
3	36.2	64.1	25.3	27.1	17.9								34.1
4	23.8	29.2	32.8	8.9	15.5				16.2	6.0	13.2	13.9	17.7
5		114.7	41.0	4.5	15.5								43.9
6	10.3	25.5	2.9	2.2	2.5	0.6	0.4	2.0	2.3	1.2	2.2	0.5	4.4
7	22.6	10.0	8.9	6.1	6.9	5.8	3.9	6.1					8.8
8	20.0	21.4	10.8	3.2	0.9	4.4	1.7	7.1	5.8	0.7	3.6	3.5	6.9
9	24.6	19.8	9.1	5.8	1.2	2.0	1.3	4.9					8.6
10	3.3	8.3	6.5	8.3	7.5	6.8	4.8	4.3					6.2
11	8.8	6.8	6.5	13.1	6.4	7.4	11.2	13.0	3.0	0.6	2.8	3.1	6.9
12a	5.9	4.6	15.7	5.5	9.5								8.2
12b		12.7	21.8	6.5	13.0	7.5	9.1	10.6					11.6

* Density in number of fish per 100 feet of stream.

In tributaries of the San Lorenzo River, total juvenile steelhead densities were much lower in 2009 than 2008 (9 of 10 sites) due to lower YOY densities (9 of 10 sites), the exception being the Lompico Site 13e, where YOY densities returned to relatively high 2007 levels (**Figures 1 and 2; Tables 27 and 28**). Nine of 11 tributary sites had below average total and YOY densities in 2009 (11−12 years of data at most sites). Four of 10 tributary sites had slightly higher yearling densities and 2 had double in 2009 compared to 2008. Two of 10 tributary sites had slightly higher Size Class II juvenile densities, with 4 other sites doubling this size class density (**Figure 3; Tables 29 and 30**). These increased site densities of larger fish was consistent with similar or positive change in physical habitat in 4 of 5 habitat-typed reach segments and increased baseflow throughout. The low YOY densities at Zayante 13a and Bean 14b allowed some YOY to reach Size Class II due to reduced competition for food.

Seven of 11 tributaries sites had “Below Average” Size Class II (smolt) densities, with Newell 16, Boulder 17a and Bear 18a much below average. Smolt ratings included one rated “Poor” (Bear 18a) three rated “Below Average” (Lompico 13e, Newell 16, and Boulder 17a), four rated “Fair” (Zayante 13a, Zayante 13c, Bean 14b and Boulder 17b) and only one rated “Good” (Zayante 13d) (**Tables 41 and 42**). In 2009, Fall Creek had the highest density of yearling and older steelhead and Size Class II juveniles in the watershed in 2009. Some of them may have been residents.

Continued low yearling and Size Class II and III densities in middle Bean 14b, lower Boulder Creek 17a and lower Bear Creek 18a may have resulted from early yearling out-migration associated with higher spring growth rates resulting from high water clarity in the absence of much stormflow. YOY density the previous fall was near average and in the median range for these tributaries at 60+YOY/100 ft. The peak flow for winter 2008/2009 was only 3,820 cfs at Big Trees on 15 February, in between the 1.3 and 1.5 year bankfull storms of 2,800 and 4,300 cfs, respectively. This was compared to peak flows of 7,570 cfs and 1,210 cfs in 2008 and 2007, respectively. Rearing habitat conditions in Bean 14b were similar to 2008 conditions. Rearing habitat conditions had improved in lower Boulder 17a in 2009. The low yearling density in Lompico 13e and Branciforte 21a-2 may have resulted from a combination of relatively low YOY densities the previous fall and poor overwintering survival. Rearing conditions in Branciforte 21a-2 were similar to 2008 conditions.

The especially low yearling and Size Class 2 and 3 densities in Newell Creek 16 in 2009 were consistent with low densities in other drier years, while densities of larger fish are greater in wetter years such as 1998, 1999 and 2006. With low streamflows in spring 2009, starvation of YOY and yearlings may have been an important limiting factor in Newell Creek. During habitat typing in 2009, large pockets of thick, decomposing organic material were noted in some pools of Newell Creek because winter flows had been insufficient to scour it out.

Yearling and Size Class 2 and 3 densities in upper Zayante 13d and Fall 15 continued to be relatively high in 2009, presumably due to better rearing habitat and better overwintering survival than other sites. Escape cover and overwintering cover were higher at Zayante 13d due to higher incidence of larger, unembedded boulders and at Fall 15 due to higher incidence of instream wood.

Table 27. TOTAL DENSITY of Juvenile Steelhead at SAN LORENZO TRIBUTARY Monitoring Sites in 1997-2001 and 2003-2009.

Sample Site	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	2009	Avg.
Zayante 13a		83.0	104.0	46.6	54.8	68.3	69.9	53.6	17.0	66.9	84.8	29.9	61.7
Zayante 13b	74.9*	50.7	74.9	24.9	38.0	70.0	65.1	53.3					56.5
Zayante 13c		69.0	61.9	25.8	40.0	123.6	63.4	78.2	18.0	94.4	112.2	74.1	69.1
Zayante 13d		82.2	105.0	57.5	84.1	243.8	145.3	99.7	69.8	80.5	131.7	105.5	109.5
Lompico 13e									26.2	108.3	27.8	123.3	71.4
Bean 14a		44.2	45.9	17.0	38.0	50.9	31.9	54.0					45.4
Bean 14b	73.0	115.6	92.1	48.3	65.5	146.4	78.5	103.5	13.1	8.9	67.6	11.2	68.7
Bean 14c		78.2	22.7	87.5	36.8	41.3	99.6	87.4	66.0	18.2	Dry		59.7
Fall 15	84.5	82.7	85.0	55.0	59.8						84.0	48.7	71.4
Newell 16	94.9	76.3	40.5	28.8	40.3				26.0			18.6	46.5
Boulder 17a	134.2	149.2	68.5	32.0	61.1	60.0	38.6	40.1	30.7	62.7	69.9	13.6	63.4
Boulder 17b	100.7	74.9	49.5	43.0	51.8	98.6	54.2	70.2	57.6	45.1	97.8	44.0	65.6
Boulder 17c		42.8	33.9	36.0	39.4	75.8	81.5	67.4					53.9
Bear 18a	118.5	81.2	76.0	33.6	58.8	86.8	87.7	87.9	52.9	47.3	69.6	20.7	68.5
Bear 18b		69.5	116.1	67.6	63.5								79.2
Kings 19a		10.8	0.5	8.4	7.6								6.8
Kings 19b	52.7	22.9	44.9	37.5	41.6								39.9
Carbonera 20a	13.4	21.0	18.9	9.7	19.6								16.5
Carbonera 20b		53.4	51.7	45.2	45.2								48.9
Branciforte 21a-1										6.6	3.3		5.0
Branciforte 21a-2	70.0	60.2	47.1	65.2	45.2				29.5	49.1	33.0	20.0	35.3
Branciforte 21b		67.8	57.6	59.6	57.5			20.4					52.1

*** Density in number of fish per 100 feet of stream.**

Table 28. Density of Juvenile Steelhead for YOUNG-OF-THE-YEAR Fish (and Size Class I Juveniles in Most Years) at SAN LORENZO TRIBUTARY Monitoring Sites in 1997-2001 and 2003-2009.

Sample Site	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	2009	Avg.
Zayante 13a		80.0	96.4	29.0	52.9	64.4	68.3	50.1	14.6	62.1	82.3	26.1	57.0
Zayante 13b	64.9*	43.5	60.6	7.7	31.2	60.4	58.7	48.1					46.9
Zayante 13c		66.9	50.2	9.4	30.9	112.9	53.2	74.2	17.1	85.1	109.4	65.0	61.3
Zayante 13d		77.4	77.7	41.9	67.0	220.6	130.0	88.5	68.0	63.1	107.0	88.6	93.6
Lompico 13e									24.2	96.9	21.4	118.4	65.2
Bean 14a		43.4	42.0	11.1	36.0	46.4	30.0	50.9					37.1
Bean 14b	60.7	104.3	59.0	41.3	60.2	137.3	70.3	84.7	10.9	0	63.0	4.9	58.1
Bean 14c		71.8	6.9	76.6	18.1	23.0	87.4	81.5	61.1	5.6	Dry		48.5
Fall 15	79.6	74.8	68.1	45.1	45.4						68.2	30.6	58.8
Newell 16	77.1	67.6	17.7	19.9	35.6				20.1			15.0	39.5
Boulder 17a	119.2	141.5	50.7	22.9	55.9	45.6	31.3	36.5	25.3	55.9	64.9	9.3	55.0
Boulder 17b	91.8	68.0	36.2	33.9	38.9	84.1	48.0	62.0	56.1	35.1	94.1	33.3	56.8
Boulder 17c		37.6	15.3	27.5	30.7	64.0	69.7	61.3					43.7
Bear 18a	100.2	72.4	57.9	12.6	50.8	75.0	76.6	75.2	51.0	41.7	64.5	19.1	59.7
Bear 18b		66.6	89.2	58.3	48.1								65.6
Kings 19a		9.8	0	6.6	6.0								5.6
Kings 19b	48.2	20.8	32.1	31.5	28.5								32.2
Carbonera 20a	9.1	17.2	13.2	5.6	16.5								12.3
Carbonera 20b		50.9	40.3	29.7	33.4								38.6
Branciforte 21a-1										2.8	2.7		2.8
Branciforte 21a-2	64.6	54.1	35.5	47.2	34.2				30.6	47.6	27.3	12.5	39.3
Branciforte 21b		60.1	44.2	45.8	49.4			9.1					41.7

*** Density in number of fish per 100 feet of stream.**

Table 29. Density of Juvenile Steelhead for YEARLING and OLDER Fish at SAN LORENZO TRIBUTARY Monitoring Sites in 1997-2001 and 2003-2009.

Sample Site	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	2009	Avg.
Zayante 13a		3.0	7.6	17.7	1.9	3.9	1.6	3.5	3.2	4.9	2.1	2.6	4.8
Zayante 13b	10.0*	7.2	14.3	17.2	6.8	9.6	6.4	5.2					13.2
Zayante 13c		2.1	11.7	16.4	9.1	10.7	10.2	4.0	1.0	8.8	2.9	9.1	7.8
Zayante 13d		4.7	27.3	15.6	17.1	23.2	15.3	11.2	1.7	17.4	24.0	16.9	15.8
Lompico 13e									1.9	11.3	6.4	4.9	6.1
Bean 14a		0.8	3.9	5.9	2.0	4.5	1.9	3.1					4.6
Bean 14b	12.3	11.3	33.1	7.0	5.3	9.1	8.2	18.8	2.0	8.9	3.7	5.6	10.5
Bean 14c		6.4	15.8	10.9	18.7	18.3	12.2	5.9	4.1	5.4	Dry		10.8
Fall 15	4.9	7.9	16.9	9.9	14.4						15.8	18.0	12.5
Newell 16	17.8	8.7	22.8	8.9	4.7				5.4			3.9	10.3
Boulder 17a	15.0	7.7	17.8	9.1	5.2	14.4	7.3	3.6	5.9	6.8	5.8	4.1	8.6
Boulder 17b	8.9	6.9	13.3	9.1	12.9	14.5	6.2	8.2	1.1	9.8	3.8	10.7	8.8
Boulder 17c		5.2	18.6	8.5	8.7	11.8	11.8	6.1					10.4
Bear 18a	18.3	7.8	18.1	21.0	8.0	11.8	11.1	12.7	1.6	5.7	5.1	2.0	10.3
Bear 18b		2.9	26.9	9.3	15.4								13.6
Kings 19a		1.0	0.5	1.8	1.6								1.2
Kings 19b	4.5	2.1	12.8	6.0	13.1								7.7
Carbonera 20a	4.3	3.8	5.7	4.1	3.1								4.2
Carbonera 20b		2.5	11.4	15.5	11.8								10.3
Branciforte 21a-1										3.9	0.5		2.2
Branciforte 21a-2	5.4	6.1	11.6	18.0	11.0				0	1.5	5.7	7.5	7.4
Branciforte 21b		7.6	13.4	11.1	8.1			11.3					12.7

*** Density in number of fish per 100 feet of stream.**

Table 30. Density of Juvenile Steelhead for SIZE CLASS II/III (=>75 mm SL) Fish at SAN LORENZO TRIBUTARY Monitoring Sites in 1998-2001 and 2003-2008.

Sample Site	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	2009	Avg.
Zayante 13a	12.3*	13.5	17.7	1.9	3.9	1.6	31.4	11.7	4.9	6.3	12.1	10.6
Zayante 13b	14.9	19.9	17.2	7.1	9.6	6.4	17.3					13.2
Zayante 13c	14.7	16.8	16.4	9.5	10.7	10.2	15.0	12.6	8.8	4.4	10.4	11.8
Zayante 13d	10.7	27.3	15.6	17.1	23.2	5.3	15.7	17.3	17.4	22.5	16.9	18.1
Lompico 13e								5.7	11.3	6.4	4.9	7.1
Bean 14a	2.1	3.9	5.9	2.0	4.5	1.9	12.0					4.6
Bean 14b	11.3	33.1	7.1	5.3	9.1	8.2	39.4	11.9	8.9	4.7	10.9	13.7
Bean 14c	6.4	15.8	10.9	18.4	18.3	12.2	12.4	17.1	5.4	Dry		13.0
Fall 15	13.3	16.9	9.9	13.0						15.8	18.7	14.6
Newell 16	14.9	22.8	8.9	4.7				16.2			4.4	12.0
Boulder 17a	21.9	17.8	9.1	5.2	16.9	7.3	9.0	18.2	6.8	7.2	5.5	11.5
Boulder 17b	11.5	13.3	9.1	12.9	14.5	6.2	8.2	13.7	9.8	3.8	10.7	10.3
Boulder 17c	5.2	18.6	8.5	8.7	11.8	11.8	8.4					10.4
Bear 18a	13.0	18.1	21.0	8.0	11.8	11.1	13.7	13.6	5.7	5.1	2.5	11.3
Bear 18b	6.2	26.9	9.3	13.2								13.9
Kings 19a	6.2	0.5	1.8	1.6								2.5
Kings 19b	6.2	12.8	6.0	10.0								8.8
Carbonera 20a	11.5	5.7	4.1	3.1								6.1
Carbonera 20b	11.4	11.4	15.5	11.8								12.5
Branciforte 21a-1									3.9	0.5		2.2
Branciforte 21a-2	8.5	11.6	18.0	10.8				10.8	1.5	5.7	7.5	6.2
Branciforte 21b	14.8	13.4	11.1	8.1			16.0					12.7

*** Density in number of fish per 100 feet of stream.**

R-8. 2009 Densities in Soquel Creek Compared with Those Since 1997

In Soquel Creek in 2009, total juvenile steelhead densities were generally much lower than in 2008 (6 of 7 sites) (**Figure 4; Table 31**). Total densities were below average at 6 of 8 sampled sites in 2009, with 9−13 years of data. This was due to much lower than average YOY densities in 2009 (6 of 8 sites) (**Figure 5; Table 32**). 2009 yearling densities remained similarly low as in 2008, but remained similarly higher at Site 16 on the East Branch in the SDSF (**Table 33**). Yearling densities were slightly above average at 5 of 8 sites, with double the average at Site 16, as has been consistent with densities there during the last 3 dry years. Densities of small Size Class I juveniles were generally much less than in 2008 (5 of 7 sites) due to the low densities of YOY and slow growth rates (**Table 34**). Densities of Size Class II and III juveniles were more than in 2008 at all 7 repeated sites due to similar yearling densities between years and faster YOY growth rate allowing some to reach Size Class II in 2009. This faster growth rate was likely due to reduced competition between fewer YOY and higher spring baseflows in 2009, providing more food and allowing some to grow faster (**Figures 26, 51 and 52**). These faster YOY growth rates were particularly evident in the two upper mainstem sites and lower East and West Branch sites. Of the 8 sampling sites rated according to Size Class II and III (smolt) densities, 6 of 7 sites in 2009 had improved ratings over 2008, and the SDSF Site 16 remained “Fair” in both years (**Tables 41 and 42**). These improved ratings were inconsistent with negative physical habitat change observed in 3 of 8 reaches (Main 10, Main13 and E. Branch 13a). Apparently, the much lower YOY densities and increased baseflow allowed sufficient increased growth rates of YOY into Size Class II to overcome other negative habitat changes. Three were rated “Below Average” (Main 1, Main 10 and W. Branch 21), and the other 4 were rated “Fair” (Main 4, Main 12, E. Branch 13a, E. Branch 16 and W. Branch 19). It must be pointed out, however, that a higher proportion of pool habitat was sampled in E. Branch 16 in the SDSF than exists there, thus elevating the site density of larger fish above the likely reach density.

Table 31. TOTAL Juvenile Steelhead SITE DENSITIES (fish/ 100 ft) at Monitoring Sites in SOQUEL CREEK in 1997–2009.
(Resident rainbow trout likely present at Sites 18 and 22).

Sample Site	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg
1- Near GrangeHall	2.9	5.6	3.0	2.4	3.5	7.4	2.5	1.7	9.5	-	15.8	8.7	7.7	6.0
2- Adj. USGS Gage	4.5	9.4	1.2	5.9	7.7	-	4.1	3.5	4.2	-	-	-		5.1
3- Above Bates Ck	13.2	50.6	7.6	2.2	8.4	14.8	-	-	7.9	-	-	-		15.0
4- Adj. Flower Fld	49.6	20.7	6.8	5.5	23.0	33.3	7.7	20.1	9.2	3.2	23.5	63.0	18.6	21.8
5-Adj. Beach Shk	50.3	20.6	8.1	9.2	28.0	-	-	-	-	-	-	-		23.2
6- End of Cherryvale	24.7	9.4	2.6	5.3	5.7	47.69	15.9	13.1	16.1	-	-	-		15.6
7- Adj. Orchard	96.6	14.0	5.6	2.0	27.5	-	-	-	-	-	-	-		29.1
8- Below Rivervale	21.0	10.7	4.1	4.9	12.4	59.2	-	-	-	-	-	-		18.7
9- Adj. Mt. School	61.6	18.4	5.1	7.9	20.7	94.8	26.2	45.8	26.8	-	-	-		28.2
10- Above Allred	54.2	11.9	9.1	9.2	15.5	70.7	19.9	37.2	26.2	12.1	54.3	105.8	18.0	34.2
11- Below Purling Br	81.9	13.1	10.5	13.1	31.6	-	-	-	-	-	-	-		30.0
12- Near Soquel Ck Bridge	83.5	19.5	17.4	12.0	34.4	65.5	20.1	48.5	21.3	-	50.7	61.8	37.4	39.3
13a- Below Mill Pond	79.4	57.6	21.5	22.8	26.2	142.0	33.3	110.5	46.9	3.2	35.0	57.9	22.8	50.7
13b- Below Hinckley	-	-	17.0	24.4	47.3	110.6	-	-	-	-	-	-		49.8
14- Above Hinckley	49.6	47.7	23.6	18.5	37.7	107.6	86.0	78.0	39.5	-	-	-		54.2
15- Below Amaya Ck	137.9	79.9	55.4	39.0	38.3	91.6	-	-	-	-	-	-		73.7
16- Above Amaya Ck*	153.2	179.7	283.5	122.6	85.7	121.9	134.6	98.7	127.3	69.4	57.0	76.0	107.2	124.4
17- Above Fern Glch*	138.3	104.2	170.9	93.8	96.3	129.5	102.4	117.2	157.3	-	-	-		123.4
18- Above Ashbury G*	44.1	24.5	53.0	-	-	-	-	-	-	-	-	-		40.5
19- Below Hester Ck	62.3	21.7	32.1	27.6	37.8	-	-	-	-	8.3	26.5	70.7	43.1	32.3
20- Above Hester Ck	-	28.2	36.9	37.7	28.3	52.1	49.1	87.2	50.2	22.9		-		43.6
21- Above GS Falls I	-	-	-	-	-	119.0	112.9	99.4	102.0	44.2**	68.3**	-	49.9	85.1
22- Abv GS Falls II	-	-	-	-	-	65.5	27.5	58.1	5.5	8.6	-	-		33.1

*** Raw data obtained from the Soquel Demonstration State Forest, 1997–1999.**
**** Raw Data obtained from NOAA Fisheries in 2006 and 2007.**

Table 32. SITE DENSITIES (fish/ 100 ft) of Juvenile Steelhead by YOUNG-OF-THE-YEAR AGE CLASS at Monitoring Sites in SOQUEL CREEK in 1997–2009.

(Resident rainbow trout likely present at Sites 18 and 22).

Sample Site	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg
1- Near GrangeHall	6.1	4.3	1.0	0.9	2.8	6.7	1.7	1.2	8.6	-	14.6	8.0	6.1	5.2
2- Adj. USGS Gage	4.1	8.3	0.4	5.3	6.3	-	4.9	3.5	2.6	-	-	-		4.4
3- Above Bates Ck	11.7	48.0	5.6	2.0	8.2	14.1	-	-	6.7	-	-	-		13.8
4- Adj. Flower Fld	45.7	18.2	6.2	3.5	19.9	28.8	7.1	19.4	8.7	2.4	22.2	61.4	14.4	19.8
5-Adj. Beach Shk	54.0	19.2	5.8	7.6	27.2	-	-	-	-	-	-	-		22.8
6- End of Cherryvale	21.1	8.3	2.4	4.4	5.1	46.4	15.8	12.8	12.9	-	-	-		14.4
7- Adj. Orchard	94.0	13.6	5.2	1.6	26.4	-	-	-	-	-	-	-		28.2
8- Below Rivervale	18.9	9.9	3.9	1.7	11.4	57.2	-	-	-	-	-	-		17.2
9- Adj. Mt. School	53.4	16.0	4.5	4.9	18.8	92.5	22.7	43.6	22.2	-	-	-		31.0
10- Above Allred	52.2	10.8	7.8	7.9	12.9	68.8	17.2	36.3	22.3	11.8	51.9	105.3	17.1	30.4
11- Below Purling Br	78.3	12.4	9.5	10.2	31.7	-	-	-	-	-	-	-		28.4
12- Near Soquel Ck Bridge	79.8	18.7	14.4	11.2	33.1	65.1	19.7	48.6	9.3	-	49.2	61.5	33.5	37.0
13a- Below Mill Pond	75.3	57.4	20.9	24.5	24.0	73.4	30.9	109.9	41.7	2.5	34.6	55.0	21.4	44.0
13b- Below Hinckley	-	-	16.2	22.0	45.9	109.5	-	-	-	-	-	-		48.4
14- Above Hinckley	46.9	46.6	24.7	14.6	37.2	104.6	83.7	76.8	36.7	-	-	-		52.4
15- Below Amaya Ck	139.0	76.9	49.6	35.8	35.4	87.1	-	-	-	-	-	-		70.6
16- Above Amaya Ck*	148.6	171.9	271.6	123.8	77.6	113.9	131.1	96.4	122.4	65.8	37.1	67.3	93.5	116.9
17- Above Fern Glch*	131.9	101.3	159.4	84.7	8.1	112.4	4.4	10.1	147.9	-	-	-		113.4
18- Above Ashbury G*	29.4	24.8	33.3	-	-	-	-	-	-	-	-	-		29.2
19- Below Hester Ck	60.6	5.7	30.8	27.0	36.6	-	-	-	-	8.3	24.9	70.4	38.3	33.6
20- Above Hester Ck	-	30.6	36.3	34.3	26.2	49.2	45.3	84.9	49.4	21.5	-	-		41.9
21- Above GS Falls I	-	-	-	-	-	107.2	104.0	93.7	98.7	42.7**	63.2**	-	44.9	79.2
22- Abv GS Falls II	-	-	-	-	-	56.2	24.7	53.2	1.0	6.1	-	-		28.2

*** Raw data obtained from the Soquel Demonstration State Forest, 1997–1999.**

**** Raw data obtained from NOAA Fisheries in 2006 and 2007.**

Table 33. SITE DENSITIES (fish/ 100 ft) of Juvenile Steelhead by YEARLING AND OLDER AGE CLASS at Monitoring Sites in SOQUEL CREEK in 1997–2009.

(Resident rainbow trout likely present at Sites 18 and 22).

Sample Site	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg.
1- Near GrangeHall	1.2	1.5	1.0	1.9	0.7	0.6	0.9	0.5	1.0	-	1.0	0.7	1.6	1.1
2- Adj. USGS Gage	0.6	1.2	0.4	0.5	1.4	-	0	0	1.3	-	-	-		0.7
3- Above Bates Ck	2.5	2.6	2.0	0.5	0.2	0.5	-	-	1.3	-	-	-		1.4
4- Adj. Flower Fld	2.2	1.5	0.9	2.0	0.7	2.6	0.6	0.7	0.6	0.7	2.2	1.6	1.9	1.3
5-Adj. Beach Shk	2.8	1.4	2.0	1.6	0.5	-	-	-	-	-	-	-		1.7
6- End of Cherryvale	3.2	1.7	0.7	1.0	0.5	1.3	0	0.3	3.1	-	-	-		1.3
7- Adj. Orchard	2.2	0.5	0.4	0.4	1.1	-	-	-	-	-	-	-		0.9
8- Below Rivervale	1.0	0.9	0.7	3.1	1.4	1.6	-	-	-	-	-	-		1.5
9- Adj. Mt. School	3.4	1.7	1.3	4.7	1.7	2.6	3.6	2.3	4.5	-	-	-		2.9
10- Above Allred	1.3	1.1	1.3	1.1	0.9	1.8	3.0	0.2	2.9	0.4	4.3	0.4	0.7	1.3
11- Below Purling Br	2.7	0.6	2.2	4.1	0.3	-	-	-	-	-	-	-		2.0
12- Near Soquel Ck Bridge	3.6	0.5	2.0	1.1	0.9	0.3	0.5	0	1.9	-	1.5	0.3	3.2	1.3
13a- Below Mill Pond	7.1	0	1.1	2.9	2.1	2.6	2.1	0.6	5.3	0.7	0.7	2.9	1.6	2.2
13b- Below Hinckley	-	-	1.1	4.7	1.4	2.0	-	-	-	-	-	-		2.3
14- Above Hinckley	2.6	1.0	1.6	4.8	1.9	2.9	1.4	0.6	2.8	-	-	-		2.2
15- Below Amaya Ck	0	2.5	6.7	4.0	2.9	4.3	-	-	-	-	-	-		3.4
16- Above Amaya Ck*	3.6	5.4	11.6	2.8	8.1	8.0	3.5	2.3	4.4	3.5	20.0	11.0	13.1	7.5
17- Above Fern Gch*	5.7	3.1	11.5	6.9	18.2	17.0	7.8	7.1	9.6	-	-	-		9.7
18- Above Ashbury G*	13.8	9.6	19.8	-	-	-	-	-	-	-	-	-		14.4
19- Below Hester Ck	1.2	0.4	1.6	1.2	1.2	-	-	-	-	0.3	1.6	0.4	4.6	1.4
20- Above Hester Ck	-	0.3	0.3	3.0	2.1	2.9	3.8	2.3	1.0	0.6	-	-		1.8
21- Above GS Falls I	-	-	-	-	-	11.9	8.8	5.3	2.1	1.2**	5.1**	-	4.9	5.6
22- Abv GS Falls II	-	-	-	-	-	9.3	2.8	4.9	4.5	2.5	-	-		4.8

*** Raw data obtained from the Soquel Demonstration State Forest, 1997–1999.**

**** Raw Data obtained from NOAA Fisheries in 2006 and 2007.**

Table 34. SITE DENSITIES (fish/ 100 ft) of Juvenile Steelhead by SIZE CLASS I at Monitoring Sites in SOQUEL CREEK in 1997–2009.

(Resident rainbow trout likely present at Sites 18 and 22).

Sample Site	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg.
1- Near GrangeHall	1.7	0.2	0	0	0.5	3.5	0.3	0.5	0	-	9.2	4.9	2.6	2.0
2- Adj. USGS Gage	0.9	0.2	0	0	2.2	3.5	1.7	1.9	0	-	-	-		0.9
3- Above Bates Ck	1.8	0	0	0.9	4.0	10.4	-	-	0	-	-	-		2.4
4- Adj. Flower Fld	20.1	1.5	0	0.5	7.6	20.0	4.4	13.8	0	0.4	17.2	58.1	10.5	11.8
5-Adj. Beach Shk	38.2	0	0.3	1.1	21.6	-	-	-	-	-	-	-		12.2
6- End of Cherryvale	14.3	0	0	0	2.8	42.9	13.7	12.5	0.4	-	-	-		9.6
7- Adj. Orchard	71.6	1.0	1.6	0.4	21.5	-	-	-	-	-	-	-		19.2
8- Below Rivervale	11.7	0.2	1.0	0.2	6.3	49.6	-	-	-	-	-	-		11.5
9- Adj. Mt. School	36.7	1.1	0.4	0.5	6.6	79.7	12.7	27.1	2.1	-	-	-		18.5
10- Above Allred	43.2	0	3.3	0	9.4	60.8	13.8	34.7	3.5	5.8	43.0	102.7	11.8	25.5
11- Below Purling Br	60.5	0.9	4.1	2.8	29.1	-	-	-	-	-	-	-		19.5
12- Near Soquel Ck Bridge	68.1	3.8	9.2	5.9	28.9	60.1	16.3	44.0	4.5	-	45.9	60.4	25.5	31.1
13a- Below Mill Pond	60.2	30.4	13.0	16.4	23.1	138.3	29.8	109.9	20.8	0	31.8	53.9	11.6	41.5
13b- Below Hinckley	-	-	3.2	15.8	43.9	105.1	-	-	-	-	-	-		42.0
14- Above Hinckley	27.4	26.9	11.8	3.5	24.3	101.7	78.9	76.1	17.8	-	-	-		40.9
15- Below Amaya Ck	130.4	64.1	38.2	30.5	35.4	84.9	-	-	-	-	-	-		63.9
16- Above Amaya Ck*	143.3	164.8	267.8	114.7	77.6	113.9	131.1	96.4	118.2	60.3	37.1	66.0	94.1	114.3
17- Above Fern Glch*	130.3	90.1	151.7	82.4	78.1	112.4	94.4	110.1	130.9	-	-	-		108.9
18- Above Ashbury G*	29.2	20.6	33.2	-	-	-	-	-	-	-	-	-		27.7
19- Below Hester Ck	60.1	20.4	23.4	24.5	36.6	-	-	-	-	3.6	21.7	65.0	29.0	31.6
20- Above Hester Ck	-	20.6	33.2	32.4	26.2	49.2	45.3	84.9	47.3	17.1	-	-		39.6
21- Above GS Falls I	-	-	-	-	-	107.2	103.1	91.8	90.0	30.1**	61.3**	-	43.1	75.2
22- Abv GS Falls II	-	-	-	-	-	56.2	24.7	50.9	0.3	3.9	-	-		27.2

*** Raw data obtained from the Soquel Demonstration State Forest, 1997–1999.**
**** Raw data obtained from NOAA Fisheries in 2006 and 2007.**

Table 35. SITE DENSITIES (fish/ 100 ft) of Juvenile Steelhead by SIZE CLASS II/III at Monitoring Sites in SOQUEL CREEK in 1997–2009.
(Resident rainbow trout likely present at Sites 18 and 22).

Sample Site	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg
1- Near GrangeHall	1.2	5.4	3.0	2.4	3.0	3.9	2.3	1.2	9.5	-	6.6	3.8	5.1	3.9
2- Adj. USGS Gage	3.6	9.4	0.8	5.9	5.5	-	2.4	1.6	4.2	-	-	-		4.2
3- Above Bates Ck	11.4	50.6	7.6	1.3	4.4	4.4	-	-	7.9	-	-	-		12.5
4- Adj. Flower Fld	29.5	19.2	6.8	5.0	15.4	13.3	3.3	6.3	9.2	2.8	6.3	4.9	8.1	10.1
5-Adj. Beach Shk	18.1	20.6	7.8	8.1	6.4	-	-	-	-	-	-	-		12.2
6- End of Cherryvale	10.4	9.4	2.6	5.3	2.9	4.7	2.2	0.6	15.7	-	-	-		6.0
7- Adj. Orchard	25.0	13.0	4.0	1.6	6.0	-	-	-	-	-	-	-		9.9
8- Below Rivervale	9.3	10.5	3.1	4.7	6.1	9.6	-	-	-	-	-	-		7.2
9- Adj. Mt. School	24.9	17.3	4.7	7.4	14.1	15.1	13.5	18.7	24.7	-	-	-		15.6
10- Above Allred	11.0	11.9	5.8	9.2	6.1	9.9	6.1	2.5	22.7	6.3	11.3	3.1	6.2	8.7
11- Below Purling Br	21.4	12.2	6.4	10.3	2.5	-	-	-	-	-	-	-		10.6
12- Near Soquel Ck Bridge	15.4	15.7	8.2	6.1	5.5	5.4	3.8	4.5	16.8	-	4.8	1.5	11.9	8.3
13a- Below Mill Pond	19.2	27.2	8.5	6.4	3.1	3.7	3.5	0.6	26.1	3.2	3.1	4.0	11.2	9.2
13b- Below Hinckley	-	-	13.8	8.6	3.4	5.5	-	-	-	-	-	-		7.8
14- Above Hinckley	22.2	20.8	11.8	15.0	13.4	5.9	7.1	1.9	21.7	-	-	-		13.3
15- Below Amaya Ck	7.5	15.8	17.2	8.5	2.9	6.7	-	-	-	-	-	-		9.8
16- Above Amaya Ck*	9.9	14.9	15.7	7.9	8.1	8.0	3.5	2.3	9.1	9.1	20.0	10.0	13.1	10.1
17- Above Fern Glch*	8.0	14.1	19.2	11.4	18.2	17.1	8.0	7.1	26.4	-	-	-		14.4
18- Above Ashbury G*	14.9	3.9	19.8	-	-	-	-	-	-	-	-	-		12.9
19- Below Hester Ck	2.2	1.3	8.7	3.1	1.2	-	-	-	-	4.7	4.8	5.7	14.1	5.1
20- Above Hester Ck	-	7.6	3.7	5.3	2.1	2.9	3.8	2.3	2.9	5.8	-	-		4.0
21- Above GS Falls I	-	-	-	-	-	11.8	9.8	7.6	12.0	14.1**	7.5**	-	6.8	10.0
22- Above GS Falls II	-	-	-	-	-	9.3	2.8	7.2	5.2	4.7	-	-		5.8

*** Raw data obtained from the Soquel Demonstration State Forest, 1997–1999.**
****Raw data obtained from NOAA Fisheries in 2006 and 2007.**

R-9. Comparison of 2009 Densities in Aptos and Valencia Creeks with Previous Years

In the Aptos Creek watershed, total juvenile steelhead densities in 2009 were much lower than in 2008 and below average at all 4 sites (two in Aptos and two in Valencia) (**Figure 7; Tables 36**). Total densities were down because of much lower YOY densities in 2009 that were below average at all 4 sites (**Figure 8; Table 37**). On the other hand, 2009 yearling densities were slightly higher at 3 of 4 sites except upper Aptos and were above average at both Valencia sites (**Table 38**). Consistent with YOY densities, densities of smaller juveniles (Size Class I < 75 mm SL) were also much less in 2009 than 2008 and below average at all 4 sites (**Table 39**). Despite the low YOY densities in 2009, densities of larger juveniles (Size Classes II and III => 75 mm SL) were similar but greater in 2009 than in 2008 at all 4 sites and above average at both sites in Valencia Creek **(Figure 9; Table 40**). Of the four sampling sites rated by densities of Size Class II and III juveniles (smolt-sized), the two sites in Aptos Creek were rated “Below Average” and “Fair” (**Tables 41 and 42**). The two sites in Valencia Creek were rated “Fair” and “Good.” It must be pointed out, however, that a higher proportion of pool habitat was sampled in lower Valencia than exists in the reach, thus elevating the site density of larger fish above the likely reach density.

The similar yearling and Size Class II densities in 2009 and 2008 were consistent with similar habitat quality between years. However, the much higher Size Class II densities in Valencia Creek than Aptos Creek could not be explained by differences in habitat quality. Although pools in Valencia Creek had comparable escape cover to those in Aptos Creek (**Table 18**), pools were much deeper in Aptos Creek (**Table 18**), Aptos Creek had less fine sediment (**Tables 18 and 19**),more streamflow and produced faster growth rates. The only higher habitat rating for Valencia Creek was the segment-wide escape cover rating for its upper reach above Valencia Road Bridge compared to those in Aptos Creek (**Table 18**). The higher Valencia Creek yearling densities in 2008 and 2009 (**Table 38**) were also incongruous with the consistently lower densities of YOY for recruitment into the yearling age class in Valencia Creek in 2006−2008 (**Table 37**).

Table 36. TOTAL DENSITY of Juvenile Steelhead at Monitoring Sites in APTOS, VALENCIA, CORRALITOS, SHINGLE MILL and BROWNS VALLEY Creeks, 1981, 1994 and 2006–2009.

Sample Site	1981	1994	2006	2007	2008	2009	Avg.
Aptos #3- in County Park	35.2*	-	26.2	61.7	45.4	8.5	35.4
Aptos #4- above steel Bridge Xing (Nisene Marks)	43.0	-	38.6	26.8	89.3	8.0	41.1
Valencia #2- below Valencia Road Crossing	33.1	-	28.3	43.0	38.5	22.7	33.1
Valencia #3- Above Valencia Road Crossing	29.8	-	33.4	23.0	55.5	26.3	33.6
Corralitos #1- Below Dam				36.2	69.9	34.2	46.8
Corralitos #3- Above Colinas Drive	39.1	18.6	35.5	42.1	35.9	14.9	31.0
Corralitos #8- Below Eureka Gulch	81.9	28.6	49.0	52.9	55.9	51.9	53.4
Corralitos #9- Above Eureka Gulch	86.1	29.9	87.1	38.5	61.7	73.2	62.8
Shingle Mill #1- Below 2nd Road Crossing	24.5	30.0	33.9	16.2	18.8	6.7	21.7
Shingle Mill #3- Above 2nd Road Crossing	32.6	-	22.9	12.7	24.5	21.8	22.9
Browns Valley #1- Below Dam	54.3	22.5	101.6	35.4	36.5	25.6	46.0
Browns Valley #2- Above Dam	71.6	18.5	99.5	79.0	44.8	54.9	61.4

* Density in number of fish per 100 feet of stream.

Table 37. Density of Juvenile Steelhead for YOUNG-OF-THE-YEAR Fish at Monitoring Sites in APTOS, VALENCIA, CORRALITOS, SHINGLE MILL and BROWNS VALLEY Creeks, 1981, 1994, 2006–2009.

Sample Site	1981	1994	2006	2007	2008	2009	Avg.
Aptos #3- in County Park	24.4*	-	23.7	54.0	43.4	3.3	29.8
Aptos #4- above steel Bridge Xing (Nisene Marks)	37.1	-	35.2	9.8	84.6	3.9	34.1
Valencia #2- below Valencia Road Crossing	16.6	-	24.5	26.6	27.5	8.9	20.8
Valencia #3- Above Valencia Road Crossing	16.6	-	20.5	4.7	41.5	7.8	18.2
Corralitos #1 Below Dam				27.0	61.2	26.5	38.2
Corralitos #3- Above Colinas Drive	33.9	10.2	24.6	30.6	27.6	9.8	22.8
Corralitos #8- Below Eureka Gulch	59.7	14.3	45.0	44.0	46.6	39.3	41.6
Corralitos #9- Above Eureka Gulch	55.8	16.7	78.4	31.3	44.6	54.0	46.8
Shingle Mill #1- Below 2nd Road Crossing	14.3	5.7	25.1	2.9	13.2	0	10.2
Shingle Mill #3- Above 2nd Road Crossing	18.6	-	19.5	6.0	23.9	18.4	17.3
Browns Valley #1- Below Dam	26.9	7.0	96.6	15.3	25.0	8.9	30.0
Browns Valley #2- Above Dam	66.1	12.8	94.7	47.0	32.2	43.0	49.3

* Density in number of fish per 100 feet of stream.

Table 38. Density of Juvenile Steelhead for YEARLING AND OLDER Fish at Monitoring Sites in APTOS, VALENCIA, CORRALITOS, SHINGLE MILL and BROWNS VALLEY Creeks, 1981, 1994 and 2006–2009.

Sample Site	1981	1994	2006	2007	2008	2009	Avg.
Aptos #3- in County Park	10.8*	–	3.1	7.6	2.3	5.2	5.8
Aptos #4- above steel Bridge Xing (Nisene Marks)	5.9	–	3.0	17.1	4.9	3.9	4.5
Valencia #2- below Valencia Road Crossing	16.5	–	3.8	16.4	11.0	13.8	12.3
Valencia #3- Above Valencia Road Crossing	13.2	–	12.9	11.5	14.0	18.5	14.0
Corralitos #1 Below Dam				9.1	8.7	6.9	8.2
Corralitos #3- Above Colinas Dr.	5.2	8.4	10.8	11.5	8.3	5.3	8.3
Corralitos #8- Below Eureka Gulch	22.2	14.3	4.0	9.0	9.4	13.2	12.0
Corralitos #9- Above Eureka Gulch	30.3	13.2	9.5	7.2	17.1	19.2	16.1
Shingle Mill #1- Below 2nd Road Crossing	10.2	24.3	9.0	13.3	5.6	6.7	11.5
Shingle Mill #3- Above 2nd Road Crossing	14.0	–	3.4	6.7	0.7	7.2	6.8
Browns Valley #1- Below Dam	27.4	15.5	4.3	19.6	11.5	12.9	15.2
Browns Valley #2- Above Dam	5.5	7.7	2.8	32.0	12.6	11.9	12.1

* Density in number of fish per 100 feet of stream.

Table 39. Density of Juvenile Steelhead for SIZE CLASS I Fish (<75 mm SL) at Monitoring Sites in APTOS, VALENCIA, CORRALITOS, SHINGLE MILL and BROWNS VALLEY Creeks, 1981, 1994, 2006–2009.

Sample Site	1981	1994	2006	2007	2008	2009	Avg.
Aptos #3- in County Park	24.4*	-	7.2	50.8	39.4	3.3	25.1
Aptos #4- above steel Bridge Xing (Nisene Marks)	37.1	-	28.5	9.0	83.8	0	31.7
Valencia #2- below Valencia Road Crossing	16.6	-	24.5	26.6	27.5	8.9	20.8
Valencia #3- Above Valencia Road Crossing	16.6	-	20.5	5.7	41.5	7.8	18.4
Corralitos #1 Below Dam				27.0	61.2	20.5	36.2
Corralitos #3- Above Colinas Drive	33.9	10.2	16.2	30.6	27.6	5.6	17.5
Corralitos #8- Below Eureka Gulch	59.7	14.3	35.8	43.0	46.6	36.6	39.4
Corralitos #9- Above Eureka Gulch	55.8	16.7	45.5	31.3	44.6	53.5	41.3
Shingle Mill #1- Below 2nd Road Crossing	14.3	5.7	17.7	2.9	13.2	0	9.0
Shingle Mill #3- Above 2nd Road Crossing	32.4	-	19.5	6.0	23.9	18.4	20.1
Browns Valley #1- Below Dam	26.9	7.0	84.6	18.1	25.0	8.9	28.5
Browns Valley #2- Above Dam	66.1	12.8	82.6	48.8	32.2	43.0	47.6

* Density in number of fish per 100 feet of stream.

Table 40. Density of Juvenile Steelhead for SIZE CLASS II/III Fish (=>75 mm SL) at Monitoring Sites in APTOS, VALENCIA, CORRALITOS, SHINGLE MILL and BROWNS VALLEY Creeks, 1981, 1994 and 2006–2009.

Sample Site	1981	1994	2006	2007	2008	2009	Avg.
Aptos #3- in County Park	10.8*	–	19.0	10.9	6.0	5.2	10.4
Aptos #4- above steel Bridge Xing (Nisene Marks)	5.9	–	10.1	17.8	5.5	8.0	9.5
Valencia #2- below Valencia Road Xing	16.5	–	3.8	16.4	11.0	13.8	12.3
Valencia #3- Above Valencia Road Xing	13.2	–	12.9	10.5	14.0	18.5	13.9
Corralitos #1 Below Dam				9.1	8.7	13.7	10.5
Corralitos #3- Above Colinas Dr.	5.2	8.4	19.3	11.5	8.3	9.3	10.3
Corralitos #8- Below Eureka Gulch	22.2	14.3	13.2	9.9	9.4	15.3	14.1
Corralitos #9- Above Eureka Gulch	30.3	13.2	41.6	7.2	17.1	19.7	21.5
Shingle Mill #1- Below 2nd Road Xing	10.2	24.3	16.2	13.3	5.6	6.7	12.7
Shingle Mill #3- Above 2nd Road Xing and check dams	4.0	–	3.4	6.7	0.7	7.2	4.4
Browns Valley #1- Below Dam	27.4	15.5	17.0	17.4	11.5	12.9	16.9
Browns Valley #2- Above Dam	5.5	5.7	16.9	30.2	12.6	11.9	13.8

* Density in number of fish per 100 feet of stream.

R-10. Comparison of 2009 Densities in the Corralitos Sub-Watershed

In the Corralitos Creek sub-watershed, total and YOY juvenile steelhead densities were generally lower in 2009 than 2008 (6 of 8 sites) and generally below average (6 of 8 sites), though close to average at 3 of the below average sites (**Figure 10; Table 36**). The two uppermost sites in Corralitos (#9) and Browns creeks (#2) had increased total density in 2009 due to increased YOY density at those sites (**Figure 11; Table 37**). 2009 YOY densities were above average at only 2 if 8 sites (Corralitos 9 and upper Shingle Mill 3 just slightly), and close to average at Browns Site 2. Yearling densities were similar between 2009 and 2008, with them slightly higher at 5 sites in 2009. Yearling densities were below average at 5 of 8 sites but near average at 6 sites (**Table 38**). Densities of smaller Size Class I juveniles in 2009 followed the same pattern as YOY densities with them less than 2008 at 6 of 8 sites, excepting upper Corralitos 9 and upper Browns 2 (**Table 39**). 2009 densities of Size Class II and III juveniles were similar to those in 2008 at 5 of 8 sites and greater at 7 of 8 sites (**Figure 12; Table 40**). The slight increases in smolt density in Corralitos 3 and 9 from 2008 to 2009 were inconsistent with the net negative physical habitat changes (**Table 42**). However, the reduced YOY densities (less competition) and increased spring baseflows (more food) at Corralitos 1 and 3 (as indicated by Corralitos Creek hydrographs at Freedom (Figures 59 and 60) allowed some YOY to reach smolt size in 2009 and offset negative physical habitat changes. Densities of these important larger juveniles that would smolt soon were below average at 5 of 8 sites, with 4 sites near average. Of the 8 sampling sites rated according to Size Class II and III (smolt) densities, only one had an improved smolt rating in 2009 (Shingle Mill 3) (**Tables 41 and 42**). In 2009, two sites were rated “Below Average” (Shingle Mill 1 and 3), and the other 6 were rated “Fair.”

With regard to adult steelhead passage above the Corralitos Creek diversion dam between Corralitos Site 1 and Site 3, adult steelhead have passed the dam in 2006─2009. This is based on consistently moderate YOY densities above the dam at Corralitos Sites 8 and 9 during those years (**Table 37**). The dam may have hindered late spawners in 2008 because the highest YOY density that year was at the Corralitos site below the dam. There was no clear indication that the new dam hindered adult passage in winter 2009 because YOY densities at the two uppermost Corralitos sites were higher than below the dam. YOY densities were consistent with past years despite the overall decline in YOY densities in other watersheds of the Santa Cruz Mountains. The reduced YOY densities at Corralitos Sites 1 and 3 in 2009 may indicate that fewer adults spawned downstream of the dam and downstream of Rider Creek in 2009. The same reduced spawning may have occurred downstream of the Browns Creek diversion dam.

R-11. Rating of Smolt Rearing Habitat in 2009, Based on Site Densities of Smolt-Sized Fish

Smolt habitat was rated at sampling sites, based on smolt-sized (=>75 mm SL) fish density according to the rating scheme developed by Smith (**1982**) (**Tables 41 and 42**). In this scheme, the average standard length for smolt-sized fish was calculated for each site. If the average was less than 89 mm SL, then the density rating according to density alone was reduced one level. If the average was more than 102 mm

SL, then the rating was increased one level. (Note: the rating scale was applied to all sites, and lower San Lorenzo sites were rated very good and excellent in 1981.) This scheme assumed that rearing habitat was usually near saturation with smolt-sized juveniles, at least at tributary sites, and that spawning rarely limited juvenile steelhead abundance.

Table 41. Rating of Steelhead Rearing Habitat For Small, Central Coastal Streams.*
(From Smith 1982.)

Very Poor - less than 2 smolt-sized fish per 100 feet of stream.**

Poor* - from 2 to 4 " " "**

Below Average - 4 to 8 " " "

Fair - 8 to 16 " " "

Good - 16 to 32 " " "

Very Good - 32 to 64 " " "

Excellent - 64 or more " " "

* Drainages sampled included the Pajaro, Soquel and San Lorenzo systems, as well as other smaller Santa Cruz County coastal streams. Nine drainages were sampled at over 106 sites.
** Smolt-sized fish were at least 3 inches (75 mm) Standard Length at fall sampling and would be large enough to smolt the following spring.
***The average standard length for smolt-sized fish was calculated for each site. If the average was less than 89 mm SL, then the density rating according to density alone was reduced one level. If the average was more than 102 mm SL, then the rating was increased one level.

Table 42. 2009 Sampling Sites Rated by Smolt-Sized Juvenile Density (=>75 mm SL) and Average Smolt Size in Standard Length, with Physical Habitat Change from 2008 Conditions.

Site	2008 Smolt Density (per 100 ft)/ Avg Smolt Size (mm)	2008 Smolt Rating	2009 Smolt Density (per 100 ft)/ Avg Smolt Size (mm)	2009 Smolt Rating	Physical Habitat Change by Reach Since 2008
Low. San Lorenzo #1	4.9/ 91 mm	Below Average	3.4/125 mm	Below Average	-
Low. San Lorenzo #2	12.2/ 88 mm	Fair	8.0/105 mm	Very Good	Slight Positive
Low. San Lorenzo #4	13.2/ 82 mm	Below Average	13.9/85 mm	Below Average	Site Positive
Mid. San Lorenzo #6	2.2/ 82 mm	Very Poor	0.5/ 76 mm	Very Poor	Site Slight Pos.
Mid. San Lorenzo #8	3.6/ 87 mm	Very Poor	3.5/ 95 mm	Poor	Slight Positive
Up. San Lorenzo #11	2.8/ 98 mm	Poor	3.1/ 99 mm	Poor	Slight Positive
Zayante #13a	6.3/ 92 mm	Below Average	12.1/ 85 mm	Below Average	Site Positive
Zayante #13c	4.4/ 98 mm	Below Average	10.4/ 91 mm	Fair	Site Similar
Zayante #13d	22.5/ 89 mm	Good	16.9/ 97 mm	Good	Positive
Lompico #13e	6.4/ 89 mm	Below Average	4.9/ 92 mm	Below Average	Site Positive
Bean #14b	4.7/ 117 mm	Fair	10.9/ 101 mm	Fair	Similar
Bean #14c	Dry	-	-	-	-
Fall #15	15.8/ 107 mm	Good	18.7/ 111 mm	Very Good	Negative
Newell #16			4.4/94 mm	Below Average	Neg. Since 2006
Boulder #17a	7.2/ 112 mm	Fair	5.5/ 98 mm	Below Average	Slightly Positive
Boulder #17b	3.8/ 102 mm	Below Average	10.7/ 96 mm	Fair	Site Positive
Bear #18a	5.1/ 105 mm	Fair	2.5/ 88 mm	Very Poor	Site Slight Pos.
Branciforte #21a-1	0.5/ 133 mm	Poor	-	-	-
Branciforte #21a-2	5.7/ 105 mm	Average	7.5/ 117 mm	Fair	Similar
Soquel #1	3.8/ 96 mm	Poor	5.1/ 93 mm	Below Average	Similar
Soquel #4	4.9/ 98 mm	Below Average	8.1/ 96 mm	Fair	Slight Positive
Soquel #10	3.1/ 92 mm	Poor	6.2/ 80 mm	Poor	Negative
Soquel #12	1.5/ 82 mm	Very Poor	11.9/ 86 mm	Below Average	Negative
East Branch Soquel #13a	4.0/ 99 mm	Poor	11.2/ 88 mm	Below Average	Negative
East Branch Soquel #16	10.0/ 100 mm	Fair	13.1/ 98 mm	Fair	Positive
West Branch Soquel #19	5.7/ 82 mm	Poor	14.1/ 92 mm	Fair	Positive
West Branch Soquel #21	-	-	6.8/ 97 mm	Below Average	Similar
Aptos #3	6.0/ 93 mm	Below Average	5.2/ 120 mm	Fair	Similar
Aptos #4	5.5/ 112 mm	Good	8.0/ 99 mm	Fair	Similar
Valencia #2	11.0/ 92 mm	Fair	13.8/ 94 mm	Fair	Similar
Valencia #3	14.0/ 93 mm	Fair	18.5/ 95 mm	Good	Similar
Corralitos #1	8.7/ 105 mm	Good	13.7/ 96 mm	Fair	Similar
Corralitos #3	8.3/ 104 mm	Good	9.3/ 112 mm	Good	Negative
Corralitos #8	9.4/ 95 mm	Fair	15.3/ 105 mm	Good	Slightly Positive
Corralitos #9	17.1/ 100 mm	Good	19.7/ 102 mm	Good	Negative
Shingle Mill #1	5.6/ 98 mm	Below Average	6.7/ 103 mm	Fair	Site Slight Pos.
Shingle Mill #3	0.7/ 83 mm	Very Poor	7.2/ 85 mm	Poor	Positive
Browns #1	11.5/ 102 mm	Good	12.9/ 98 mm	Fair	Positive
Browns #2	12.6/ 103 mm	Good	11.9/ 98 mm	Fair	Positive

For 2009, the breakdown of smolt-sized juvenile ratings for the 37 sampling sites was the following;

2 (5%) = "**Very Poor**"
4 (11%) = "**Poor**"
11 (30%) = "**Below Average**"
13 (35%) = "**Fai**r"
6 (16%) = "**Good**"
1 (3%) = "**Very Good**"

Therefore, 46% (17 of 37) of the sites were rated less than fair in 2009 compared to 53% in 2008. Sites that had less than fair densities in 2009 included 6 of 7 mainstem San Lorenzo sites (Site 0a not included in Table 41), lower Zayante, Lompico, Newell, lower Boulder, lower Bear, 3 of 4 mainstem Soquel sites, lower East and West Branch Soquel sites and the upper Shingle Mill site.

R-12. Statistical Analysis of Annual Difference in Juvenile Steelhead Densities

The trend in fish densities between 2008 and 2009 was analyzed by using a paired t-test (**Snedecor and Cochran 1967; Sokal and Rohlf 1995; Elzinga et al. 2001**). Comparisons were made for total density, age class densities and size class densities (AC1, AC2, SC1, SC2). The paired t-test is among the most powerful of statistical tests, where the difference in mean density (labeled "mean difference" in the analysis) is tested. This test was possible because the compared data were taken at the same sites between years with consistent average habitat conditions between years, as opposed to re-randomizing each year. The null hypothesis for the test was that among all compared sites, the site-by-site difference between years 2008 and 2009 was zero. The non-random nature of the initial choice of sites was necessary for practical reasons and does not violate the statistical assumptions of the test; the change in density is a randomly applied effect (i.e. non-predictable based on knowledge of the initial sites) that does not likely correlate with the initial choice of sites. So, the mean difference is a non-biased sample.

The null hypothesis was that the difference in mean density was zero. Results from 2009 were compared to 2008, such that a positive difference indicated that the densities in 2009 were larger than in 2008 on average. A p-value of 0.05 meant that there was only a 5% probability that the difference between densities was zero and a 95% probability that it was not zero. A 2-tailed test was used, meaning that an increase or a decrease was tested for. The confidence limits tell us the limits of where the true mean difference was. The 95% confidence interval indicated that there was a 95% probability that the true mean difference was between these limits. If these limits included zero, then it could not be ruled out that there was no difference between 2008 and 2009 densities. The 95% confidence limits are standard and a p-value of < 0.05 is considered significant.

With 12 comparable sites in the San Lorenzo drainage, no differences in site density were statistically significant (**Table 43**). With only 1 site repeatedly sampled in both years, steelhead densities at Soquel Creek sites could not be statistically compared. With only 1 site repeatedly sampled in the Aptos watershed, steelhead densities at Aptos/Valencia creek sites could not be statistically compared. With 7 sites compared, the increase in Size Class II and III densities at 6 of 7 sites was statistically significant (**Table 44**).

Table 43. Paired T-test for the Trend in Steelhead Site Densities by Size Class and Age Class at All Repeated Sites In the San Lorenzo Watershed (2009 to 2008; n=12).

Statistic	s.c. 1	s.c. 2	a.c. 1	a.c. 2	All Sizes
Mean difference	-24.02	0.53	-24.17	0.80	-23.19
Df	11	11	11	11	11
Std Error	12.62	1.06	12.45	0.86	12.16
t Stat	-1.90	0.50	-1.94	0.93	-1.91
P-value (2-tail)	0.084	0.626	0.078	0.3710	0.083
95% CL (lower)	-51.80	- 1.81	-51.56	-1.08	-49.96
95% CL (upper)	3.76	2.87	3.22	2.68	3.57

Table 44. Paired T-test for the Trend in Steelhead Site Densities by Size Class and Age Class at All Repeated Sites In the Corralitos Creek Watershed (2009 to 2008; n=7).

Statistic	s.c. 1	s.c. 2	a.c. 1	a.c. 2	All Sizes
Mean difference	-10.69	3.07	-8.74	-1.20	-7.53
Df	6	6	6	6	6
Std Error	6.77	1.03	6.04	1.25	6.35
t Stat	-1.58	2.99	-1.45	0.96	-1.19
P-value (2-tail)	0.1654	0.0243	0.1981	0.3759	0.2810
95% CL (lower)	-27.24	0.56	-23.53	-1.87	-23.07
95% CL (upper)	5.87	5.58	6.04	4.27	8.02

R-13. Adult Trapping Results at the Felton Dam's Fish Ladder and 2009 Planting Records

The trap in the fish ladder at the City of Santa Cruz Felton Diversion dam was operated by Terry Umstead (aquaculture teacher), San Lorenzo Valley High School students and other volunteers for 10 days during the winter of 2006-2007 and 2007-2008. During the winter of 2008-2009, it was used for 20 nonconsecutive days (18 February‒27 March) beginning the morning of 18 February through the afternoon of 20 February; morning of 26 February through the morning of 27 February; morning of 3 March through the morning of 6 March; morning of 10 March through the morning of 13 March; morning or 18 March through the morning of 20 March; morning of 24 March through the morning of morning of 27 March. The 2009 trapping (as the previous two years) encompassed major stormflows of the winter but was late for trapping coho salmon (**Figure 54)**. **In 2009, a total of 145 adult steelhead =>14 inches Fork Length and one adult coho salmon were captured; 79 (54%) steelhead were hatchery clipped.** The coho salmon was captured on the first day of trapping in 2009. In 2008 during the period 5−15 February, a total of 78 adult steelhead =>14 inches Fork Length were captured; 20 (26%) were hatchery clipped. In 2007 during a similar period (15−21 February), a total of 53 adult steelhead =>18 inches Fork Length were captured; 17 (32%) were hatchery clipped. No coho salmon were captured in 2007 or 2008, likely due to the late trapping period. More adult steelhead were trapped in 2006, with 247 adult steelhead and 2 coho salmon captured in 2 months from mid-January to late March. But trapping was over much shorter periods in 2007 and 2008. The 2006 total was less than the 371 adult steelhead and 18 adult coho captured in 2005 over a longer time period, but trapping began and ended later in the 2006 season than in 2005 and began after several storm events in 2006. Since in all years the trap has operated for only a small portion of the adult migration period, no comparisons among years can be used to estimate adult abundance or trends.

Based on the planting log from the Monterey Bay Salmon and Trout Native Anadromous Fish Hatchery at Big Creek, on 30-31 March 2009 an estimated 50,524 juvenile smolts (3,715 lbs.) were planted at each of the following locations*:

San Lorenzo River downstream from the Crossing Street diversion (10,744 smolts; 30 Mar 2009)
San Lorenzo River downstream from the Crossing Street diversion (12,240 smolts; 31 Mar 2009)
San Lorenzo River at Paradise Park (12,104 smolts; 30 Mar 2009)
San Lorenzo River at Paradise Park (12,240 smolts; 31 Mar 2009)
San Lorenzo River at Paradise Park (3,196 smolts; 31 Mar 2009)

Additional non-smolt juvenile steelhead were planted in January 2010 from the MBSTNAF Hatchery. This was due to concern that the hatchery's water quality might become compromised after the Bonny Doon Fire the previous summer. An estimated 25,000 juvenile steelhead (1,250 pounds) were planted on 7 and 14 January 2010 at the following locations:

San Lorenzo River at Highlands County Park in Ben Lomond (5,000 juveniles; 7 Jan 2010)
San Lorenzo River at Highlands County Park in Ben Lomond (5,000 juveniles; 14 Jan 2010)
San Lorenzo River at Henry Cowell Park Bridge in Felton (5,000 juveniles; 7 January 2010)
San Lorenzo River at Henry Cowell Park Bridge in Felton (5,000 juveniles; 14 January 2010)
San Lorenzo River at Henry Cowell Park Bridge in Felton (5,000 juveniles; 14 January 2010)

*Records provided by Carla Moss, Hatchery Manager.

Table 45. Adult Steelhead Trapping Data from the San Lorenzo River With Adult Return Estimates.

Trapping Year	Trapping Period	Number of Adults	Location
1934-35	?	973	Below Brookdale (1)
1938-39	?	412	Below Brookdale (1)
1939-40	?	1,081	Below Brookdale (1)
1940-41	?	671	Near Boulder Ck (2)
1941-42	Dec 24 - Apr 11	827	Near Boulder Ck (2)
1942-43	Dec 26 - Apr 22	624	Near Boulder Ck (3)
1976-77	Jan-Apr	1,614	Felton Diversion (4)
1977-78	Nov 21 - Feb 5	3,000 (Estimate)	Felton Diversion (4)
1978-79	Jan-Apr	625 (After drought)	Felton Diversion (4)
1979-80	Jan-Apr ?	496 (After drought)	Felton Diversion (4)
1982-83		1,506	Alley Estimate from 1981 Mainstem Juveniles only
1994-95	6 Jan- 21 Mar (48 of 105 days-Jan-15 Apr)	311 (After drought)	Felton Diversion (5) Monterey Bay Salmon & Trout Project
1996-97		1,076 (estimate)	Alley Estimate from 1994 Mainstem Juveniles only
1997-98		1,784 (estimate)	Alley Estimate from 1995 Mainstem Juveniles only
1998-99		1,541 (estimate)	Alley Revised Estimate from 1996 Mainstem Juveniles only
1999-2000	17 Jan- 10 Apr	532 (above Felton)	Monterey Bay Salmon & Trout Project
1999-2000		1,300 (estimate)	Alley Index from 1997 Mainstem Juveniles only
2000-01	12 Feb- 20 Mar	538 (above Felton)	Monterey Bay Salmon & Trout Project
2000-01		2,500 (estimate)	Alley Index from 1998 Juveniles in Mainstem and 9 Tributaries
2001-02		2,650 (estimate)	Alley Index from 1999 Juveniles in Mainstem and 9 Tributaries
2002-03		1,650 (estimate)	Alley Index from 2000 Juveniles in Mainstem and 9 Tributaries
2003-04		1,600 (estimate)	Alley Index from 2001 Juveniles in Mainstem and 9 Tributaries
2003-04	28 Jan- 12 Mar	1,007 Steelhead 14 Coho	SLV High School-Felton Diversion Dam
2004-05	12 Dec 29 Jan	371 Steelhead 18 Coho	SLV High School-Felton Diversion Dam
2005-06	17 Jan- 24 Mar	247 Steelhead 2 Coho	SLV High School-Felton Diversion Dam
2006-07	15 Feb- 21 Feb	54 Steelhead	SLV High School-Felton Diversion Dam
2007-08	05 Feb- 15 Feb	78 Steelhead	SLV High School-Felton Diversion Dam
2008-09	18 Feb- 27 Mar	145 Steelhead 1 Coho	SLV High School-Felton Diversion

(1) Field Correspondence from Document # 527, 1945, Div. Fish and Game.
(2) Field Correspondence from Document #523, 1942, Div. Fish and Game.
(3) Inter-office Correspondence, 1943, Div. Fish and Game.
(4) Kelley and Dettman (1981). (5) Dave Strieg, Big Creek Hatchery, 1995.

DISCUSSION OF 2009 RESULTS

D-1. Causal Factors for Below Average 2009 YOY Steelhead Density at Most Sites

Although we have no estimates of adult returns in the sampled watersheds, it would appear that reduced adult steelhead returns with reduced spawning, combined with poor egg and YOY survival best explain the much below average YOY densities at most sites in all 4 watersheds. Unlike previous drier years, YOY densities were low at lower watershed sites where they are usually higher for a drier year. Three consecutive years with poor ocean conditions related to the decadal oscillation of ocean currents likely lead to poor juvenile survival in the ocean and poor adult returns. Trapping data from Scott Creek indicated relatively low adult returns in winter 2008-2009, where adult escapement estimates in water years 2006─2009 were 219, 259, 293 and 126, respectively (**Sean Hayes, NOAA Fisheries personal communication**). The same relatively low 2009 returns were detected at the San Clemente Dam on the Carmel River for those years, where counts were 368, 222, 412 and 95, respectively (**Kevan Urquhart, personal communication**).

The highest spawning success and YOY production was in upper watershed reaches in 2009. Unlike previous dry years in Soquel Creek where YOY densities increased in the lower watershed and decreased in the upper watershed, the opposite was true in 2009. Adults apparently had sufficient winter streamflow to access the upper East Branch Site 16 in the SDSF because YOY densities were the highest there. However, YOY densities in lower East Branch Site 13a and all mainstem sites, as well as the lagoon (lowest in 13 years though similar to 2001) were below average. Similar patterns were seen in the San Lorenzo drainage, with YOY densities much higher in the headwaters tributary Lompico Site 13e, Zayante 13c below Lompico and upper Zayante Site 13d than lower Zayante 13a (11-year low). YOY densities were higher in upper Boulder Site 17b than lower Boulder Site 17a (12-year low). Lower Bear Site 18a had especially low YOY densities (lowest in 8 years), and all mainstem sites had much below average YOY densities. In the Aptos watershed, YOY densities were much less than 2008 and below average despite similar habitat quality between years. It appears that there was insufficient spawning or egg survival to fully seed lower tributary and mainstem sites. There may have been higher egg mortality in 2009 than 2008 because most stormflow came after March 1 in 2009, after early spawning was attempted with insufficient flows and after many nests were in the streambed and subject to scour. In 2008 the main stormflows came before March 1. However, this is likely not the primary factor because 2009 was an overall dry year without sizeable storms to destroy redds **(Figure 57)**, and other recent years having late stormflows did not show a similar decline in YOY densities (1999, 2003, 2005) with the exception of 2006, which had the highest stormflows in March and April of a very wet year. At least in 2009 there was a month in March and April which provided higher flows for late spawners to successfully spawn.

Below median baseflow in 2009 (**Figures 25 and 26**) likely provided less rearing habitat for YOY than more average and wetter years, resulting in relatively higher YOY mortality from starvation and predation. However, baseflow was higher in 2009 than 2008, and YOY densities were consistently higher in 2008 in all 4 sampled watersheds, except at a few upper watershed sites. At some of these upper sites, baseflow differences between years were most pronounced, such as Site 13d on Zayante Creek and Site 16 on the East Branch Soquel, where rearing habitat was better in 2009 due to increased baseflow, deeper pools and more pool escape cover. A decline in rearing habitat quality was not a cause for decreased YOY density in the San Lorenzo because overall habitat quality worsened in only one monitored reach (Fall 15) and improved in 12 of 14 reach segments in 2009. Overall habitat quality declined in only 3 of 7 monitored reach segments in Soquel Creek, none in Aptos/Valencia creeks and only 2 of 8 reach segments in Corralitos/Browns creeks with similar baseflows. Thus, reduced habitat quality was not a cause of lower YOY densities.

D-2. Annual Trend in YOY and Yearling Densities Compared to Other Coastal Streams

YOY steelhead densities in 2009 continued to be low in Scott, Waddell and Gazos creeks (**Smith 2009**). Data from those creeks were consistent with below average YOY densities at a majority of sites in the San Lorenzo, Soquel, Aptos and Corralitos watersheds. In Scott Creek, average YOY steelhead site densities for 2007─2009 were 49, 20 and 24.2 fish/ 100 ft, respectively, indicating similarly low YOY densities in 2009 compared to 2008 and less than half the previous 10-year average. Smith attributed low YOY densities in Scott Creek to possible impacts of low baseflow, the early, large October stormflow prior to sampling (although sites sampled prior to the storm had below average densities) and flame retardant toxicity in Big Creek, the mainstem below Big Creek and the uppermost Scott Creek site. In Waddell Creek, average YOY steelhead site densities for 2007─2009 have been 13, 23 and 10.4 fish/ 100 ft, indicating a large decrease in 2009. Smith attributed low YOY densities in Waddell Creek to past suspected fish kills in the East Branch and mainstem that have significantly reduced adult returns. He suspects that lightweight solvents (not usually affecting sculpins) are the cause, originating in the Last Chance Creek sub-watershed. Surprisingly, the highest YOY density in Waddell Creek in 2009 was in the East Branch, downstream of Last Chance. Gazos Creek averaged 16.7 YOY/ 100 ft in 2009 and was not sampled in 2008. However, this was less than half the 16-year average of 37 YOY/ 100 ft. Low YOY densities in Gazos were attributed by Smith to be poor spawner access due to two large logjams blocking adult access.

YOY densities in Scott, Waddell and Gazos creeks in 2009 were similar to those found in the mainstem San Lorenzo, lower San Lorenzo tributary sites, mainstem Soquel, all sites in Aptos and Valencia creeks, one of 4 Corralitos sites, both Shingle Mill sites and the lower Browns Creek site.

Average 1+/2+ densities in Scott Creek for 2007─2009 were 10, 8 and 7 fish/ 100 feet, with a 17-year average of 9 fish/ 100 feet and a sizeable standard error of 5.4 (**Smith 2009**). Average 1+/2+ density in Waddell Creek for 2007─2009 were 2, 1 and 2 fish/ 100 ft, with 13-year average since 1997 being only 3 fish/ 100 ft. Average 1+/2+ density in Gazos Creek for 2007 and 2009 were 4 and 9 fish/ 100 ft, with 16-year average being 8 fish/ 100 ft. In these creeks, these were likely the only fish reaching Size Class II. So, Size Class II and III densities in Scott Creek and Gazos creeks were similar to densities at the 3 lower sites in the mainstem Soquel and the West Branch Soquel site but less than 3 East Branch sites, more than in 5 of 7 mainstem San Lorenzo sites, similar to 3 of 10 San Lorenzo tributary sites with intermediate densities, similar to Aptos site densities but less than Valencia creek site densities, generally less than in the Corralitos sub-watershed except similar to densities in Shingle Mill Gulch.

Average Size Class II abundance at sites in Waddell Creek in 2009 was less than in all sites sampled in our four watersheds, except for the mainstem San Lorenzo Site 6 below Fall Creek and lower Bear Site 18a, tributary to the San Lorenzo.

D-3. Data Gaps

Annual monitoring of steelhead needs to continue through the next drought period and beyond to assess the extent of population recovery. The level of fish monitoring and habitat analysis was greatly reduced after 2000 in the San Lorenzo River drainage, a year in which the mainstem was sampled at 16 sites (13 reach segments habitat typed), and 9 tributaries were sampled at 20 sites (20 reach segments habitat typed). At that time, indices of juvenile and adult steelhead population sizes were possible. By 2009, sampling was reduced to less than half that of 2000 and 2001, while habitat typing was reduced to less than 1/3. In 2009, 7 mainstem sites (3 reach segments habitat typed) and 8 tributaries were sampled at 11 sites (6 reach segments habitat typed). Population indices were not possible after 2001. Many upper mainstem and upper tributary sites were discontinued. Carbonera and Kings creeks are no longer sampled. While site densities are valuable, the relative contributions of mainstem reaches and tributaries to total juvenile population size are lost when only site densities are reported, rather than the total production of the reaches that the sites represent. The relative importance of mainstem reaches compared to tributaries in production of large juveniles is lost when only site densities are considered. Calculation of an *index of adult returns* is the most meaningful way to compare the value of annual juvenile population numbers because it weights the juveniles according to size categories and size-dependent survival rates. Although the index may not precisely predict actual adult numbers, it reflects *relative* adult contribution between reaches and between years.

Sampling in Soquel Creek was reduced from 19 sites (14 reaches) in 2004 to 15 sites (14 reaches) in 2005 to 6 sites (6 reaches) in 2006 and increased to 8 sites (8 reaches) in 2009. In 2006, annual estimation of juvenile steelhead population size and calculation of adult indices from juvenile population size ceased in Soquel Creek for the first time since 1994. This is a significant loss in monitoring information. Recent data gaps in the heavily impacted mainstem of Soquel Creek have occurred. In 2008 and 2009, 2.5 miles of mainstem were habitat typed, when all 7.2 miles were habitat typed in the past to assess habitat quality.

With the change in County management guidelines for large instream wood, incidence of large instream wood should be annually monitored. The wood survey completed in 2002 on Soquel Creek (**Alley 2003c**) could be repeated periodically for comparison purposes.

There is a shortage of streamflow data on the San Lorenzo River mainstem and tributaries. More stream gages should be established and maintained in the watershed to better correlate streamflow with habitat conditions and fish densities and to detect insufficient streamflow. Mainstem locations for additional gages would include Waterman Gap, above and below the Boulder Creek confluence on the mainstem. Tributaries that need better gaging include Zayante Creek (above and below the Bean Creek confluence), Bean Creek (below Lockhart Gulch and just below the Mackenzie Creek confluence), Fall Creek above the water diversion and Boulder Creek (near the mouth).

There is no stream gage in the Aptos watershed. It would be beneficial to have stream gages on lower Valencia Creek and Aptos Creek near the lagoon. Any future management of Aptos Lagoon would benefit from continuous streamflow data in relation to sandbar manipulation. It is a valuable tool on Soquel Creek with the USGS gage in Soquel Village. The only stream gage data for the Corralitos watershed is at Freedom. This is below the City of Watsonville diversions and is in a percolating reach that is dry in summer. It would be beneficial to install stream gages at the diversion dams on Browns Valley and Corralitos Creeks. Then the streamflow above and below the diversions could be monitored.

If stream gaging proves prohibitively expensive, streamflow should be annually measured in mid-May and mid-September at the proposed gage locations in the San Lorenzo watershed, as well as in the mainstem at Paradise Park, at the Henry Cowell Park bridge, downstream of the Fall Creek confluence (under Graham Hill Road bridge), downstream of the Clear Creek confluence (near Larkspur Bridge), downstream of the Boulder Creek confluence (along Erwin Way), and in the upper valley near the Mountain Store (downstream of Kings Creek) and at the Teihl Road bridge. Streamflow should also be measured in Bear Creek below Hopkins Gulch and in Newell Creek (Glen Arbor Road Bridge).

We are aware that County staff measure streamflow each year but noted that many former sites have been removed or are measured only occasionally. It would be beneficial if more streamflow sites could be added to the Soquel, Aptos and Corralitos watersheds and if sites in the San Lorenzo watershed could be visited more regularly in the fall before early storms. 2009 had the most incomplete streamflow record thus far.

In Soquel Creek, streamflow should ideally be measured in mid-May and mid-September on the mainstem below Highway 1, near the Soquel Village USGS gage, adjacent at the Mountain School and at the Soquel Creek Road Bridge. In East Branch Soquel, streamflow should be measured just upstream of the West Branch confluence, just downstream of Mill Pond and in the SDSF at the Long Ridge Road crossing. In the West Branch Soquel, streamflow should be measured just upstream of the East Branch confluence.

In Aptos Creek, streamflow should ideally be measured in mid-May and mid-September just upstream of the lagoon, adjacent to the County Park and upstream of the metal bridge. On Valencia Creek, streamflow should be measured between the fish ladder and Valencia Road crossing. In Corralitos Creek, streamflow should ideally be measured in mid-May and mid-September downstream of the

Watsonville diversion, upstream of the Watsonville diversion, downstream of the Rider Creek confluence, downstream of the Eureka Gulch confluence and upstream of the Eureka Gulch confluence. In Browns Valley Creek, streamflow should be measured downstream of the Watsonville diversion and upstream of the Watsonville diversion.

TRENDS IN JUVENILE STEELHEAD DENSITY AND HABITAT CONDITIONS IN THE SAN LORENZO RIVER, 1997−2009

Trend in Juvenile Densities in the Lower and Middle Mainstem San Lorenzo River

The lower San Lorenzo mainstem (downstream of the Zayante Creek confluence) and middle mainstem (between the Boulder and Zayante creek confluences) have become less productive for juvenile steelhead in both the YOY age class and the Size Class II and III categories from 1999 onward (**Figures 13, 15 and 17**). Fall YOY densities are very sensitive to timing of stormflow events, with higher YOY densities occurring when larger stormflows are absent after approximately March 1. This indicates that redds are scoured by later storms and/or small YOY are washed away by later storms. 1997, 2002 and 2008 were years with primarily early winter storms. No data were available from the HTH report (**2003**) regarding YOY or Size Class II and III densities in 2002. However, HTH found that total juveniles densities increased in 2002. But juvenile densities were less in years between these and in 2009. Density comparisons in 2002 with other years are weakened because different methods were employed by H.T. Harvey & Associates (HTH) (**2003**) in choosing sampling sites. However, we saw the same increased densities in the adjacent Soquel Creek in 2002 as did HTH in the San Lorenzo to strengthen the comparison.

The years 1998 and 2006 had similarly wet winters prior to fall sampling, making them good for comparison. However, the mainstem had substantially higher juvenile densities in 1998 than 2006. However, it does not appear that declines in rearing habitat conditions could fully explain the diminished juvenile densities in 2006. Habitat conditions in 1998 that were better than in 2006 in both the lower and middle mainstem (depicted for Reaches 4 (lower mainstem) and 8 (middle mainstem), respectively) included greater depth in fastwater habitat (riffles) (**Figures 27 and 30**), higher water velocity due to higher streamflow (**Figure 25**) (and likely greater insect drift) and more escape cover in fastwater habitat in the middle mainstem Reach 8 (0.33 (33 feet of cover per 100 feet of stream) in 1998 and 0.24 in 2006) (**Figure 31**). Riffle escape cover had not improved by 2009 (0.16) (**Table 9**). However, certain riffle habitat parameters were better in 2006 compared to 1998 in the lower mainstem Reach 4, such as greater escape cover (0.18 compared to 0.13 in riffles) (more overhanging willows in 2006) (**Figure 28**) and less percent fines (**Figure 29**). Percent fines in Reach 8 riffles in 1998 and 2006 were identical at 20% (**Figure 32**), with it improved to 12% in 2009). Percent fines in runs had improved from 35% in 1998 to 25% in 2006, which is what it was in 2009 (**Table 7**). Run escape cover for Reach segment 8 in 1998 was 0.13 compared to 0.10 in 2006, indicating a decline in 2006, which had not improved by 2009 (0.08) (**Table 10**). When Site 8 fastwater data from the same habitats were averaged for embeddedness, we see little change from 1998 (35%) to 2006 (30%) to 2009 (35%). We suspect that there were fewer adult spawners in 2006 than 1998 and/or reduced spawning success in 2006 to mostly explain the decline in juvenile densities between 1998 and 2006. Fewer tributary YOY likely seeded the mainstem in 2006.

Declining riffle depth at Site 8 for 2006─2008 was reversed in 2009 (**Figure 30**) presumably due to slightly increased spring baseflow (**Table 5b; Figure 25**) and perhaps deeper pockets due to reduced embeddedness and substrate improvement (**Table 8**). The 2005─2008 decline in riffle escape cover was also reversed in 2009 (**Figure 31**).

Densities of Size Class II and III juvenile in the lower and middle mainstem were higher in the years 1997−1999 than later years, with relatively low densities from 2000 until 2009, and 2007 having the lowest densities measured in the last 13 years (**Figure 17**). The 5-site average shows this trend. Sites 1, 6 and 8 have been at less than 7 smolt-sized juveniles per 100 feet the last 7 years compared to 10-24 per 100 feet in 2007, 21-29 per 100 feet in 1998 and 3-16 in 1999. Site 4 below the Zayante Creek confluence showed a similar pattern, just with relatively higher fish densities each year compared to the other sites. Later wet years of 2005 and 2006 did not bring higher densities of these larger juveniles as occurred after the wet 1997-1998 winter. The lower and middle mainstem have become less important in producing larger juveniles in recent years. In order for adult returns to increase substantially, the mainstem will need to again support at least the densities of Size Class II and III juveniles that were present in 1997−99.

Rearing habitat conditions in fastwater riffle habitat in Reach 4 in 2008 had improved since 1999 regarding more escape cover (declined since 2007) (**Figure 28**) and reduced percent fines (embeddedness similar (**Alley 2000**)) (**Figure 29**). However, 1999 riffle conditions were better with regard to greater habitat depth compared to 2008, as were all other years deeper than 2008, partially because of the low baseflows in late summer 2008 (**Figure 27**). If baseflows had been the same in 1997 and 2008, habitat conditions in Reach 4 riffles may have been similar between years for percent fines and escape cover, but riffles would have been considerably deeper in valuable pockets of maximum depth in 1997. It appeared that the arrangement and composition of boulders and sediment in riffles shifted during the high stormflow of February 1998 (19,400 cfs at Big Trees gage), resulting in fewer deep pockets.

Rearing habitat conditions in riffle habitat in Reach 8 (middle mainstem) in 2009 have improved since 1999 regarding reduced embeddedness (43% in 1999 (**Alley 2000**) and 19% in 2009) (**Table 8 and Figure 32**). However, 1999 riffle conditions were better with regard to slightly more escape cover (**Figure 31**) and greater habitat depth compared to 2009, primarily because of the low baseflows in late summer 2009 (**Figure 30**). If baseflows had been the same in 1997 and 2009, habitat conditions in Reach 8 riffles may have been similar between years with regard to depth, but 1997 had less percent fines (none in riffles and 10% in runs) compared to 2009 (12% in riffles and 25% in runs). 1997 the riffles had deeper maximum depth pockets (1.2 feet) compared to 2009 (1.0 feet) but both years had similar average riffle depth (0.7 feet in 1997 and 0.65 feet in 2009). We have no reach segment estimates for escape cover and embeddedness in 1997 for comparisons.

The upper mainstem site in this analysis is upstream of major tributaries and may be categorized with tributary sites because YOY grow slow there as in most tributary sites.

Ecological Considerations for the Lower and Middle Mainstem

The density and size of juvenile steelhead in the lower and middle mainstem San Lorenzo River is dependent upon a number of factors; 1) number of spawning adults, 2) spawning effort in these segments after large, sediment-moving, redd-scouring storms are over for the wet season, 3) spawning success (survival rate from egg to emerging fry), 4) the number of juveniles that enter the lower and middle mainstem from tributaries, 5) survival of emerging YOY in spring and 6) the rearing habitat quality primarily in fastwater habitat (riffles, runs and heads of pools) in the spring and summer (higher baseflow increases juvenile growth rate and size of YOY). The lower and middle mainstem are inhabited by primarily fast growing YOY with much fewer yearlings. In relatively drier winter/springs, more spawning effort usually occurs in the lower and middle mainstem and less in the tributaries due to more limited access to the upper watershed reaches. In the last 12 years, 2001, 2002 2004, 2007, 2008 and 2009 were relatively dry, based on averaged mean monthly streamflow (May–September) (**Figure 25**). Spawning success is likely greater in drier years in the lower and middle mainstem because fewer storms are likely to destroy spawning redds after spawning. However, shallow water depth in spawning glides may make it more difficult for adults to spawn, and water percolates more slowly through the gravels to buried eggs in drier years to provide adequate oxygen and remove metabolic wastes, which may reduce egg and sac-fry survival rates. 2009 was a dry year in which most stormflow came later in the season mid-February to early March. The distribution of YOY was unusual for a dry year, with higher YOY densities in the upper watershed sites compared to lower sites. Apparently, there was sufficient stormflow for some adult steelhead to reach upper sites, but the adults that spawned in the lower watershed had their redds destroyed and/or their small YOY washed away by the later storms. Also, there may have been much fewer adults spawning over the 2008-2009 winter, making spawning effort and YOY densities spotty. Years in which most of the larger winter storms occur early in the winter, and they are of sufficient number to maintain a high but steady decline in the hydrograph through the late winter and spring with the help of smaller stormflows, will have maximum spawning success later in the spawning season and maximum juvenile survival after emergence in the lower and middle mainstem. The years of 1997, 2002 and 2008 were examples of this hydrologic pattern (**Figures 54, 59 and 66**). The year 2007 had few late winter storms but also had few early winter storms, as well, it being the driest of the last 13 years (**Figure 65**).

In wetter years, more spawning effort occurs in the upper reaches of the watershed, namely in the upper mainstem and the tributaries. Relative wet years included 1997, 1998, 1999, 2000, 2005 and 2006 (**Figures 25, 54-57 and 63-64**). Spawning success and survival of emerging YOY may be reduced in the lower and middle mainstem in these years due to later storms that destroy redds and wash away emerging YOY (except in 1997 when stormflow nearly ceased after 1 March). There may be fewer of the large yearlings in those mainstem segments because either growth rate may have been substantial in early spring to encourage yearlings to smolt. Large storms may also reduce overwinter survival of yearlings, as well. However, after wetter winters, the baseflow will be higher, and growth rate of YOY in the lower and middle mainstem will be substantial. The density of Size Class II and III juveniles may be relatively higher in the fall following the high baseflow spring and summer due to a higher proportion of YOY reaching this smolt size their first summer, as reflected in their densities in 1997−1999 (**Figure 17**).

Habitat quality will need to improve substantially in the lower and middle mainstem to increase adult returns. Retention of more large, instream wood will promote scour to deepen pools, create patches of coarser spawning gravel and provide escape cover for juvenile steelhead rearing and overwinter survival. Better retention of winter storm runoff in Scotts Valley and Felton will reduce stormflow flashiness that increases streambank erosion and sedimentation leading to poorer spawning and rearing conditions. Better retention of storm runoff will also increase winter recharge of aquifers to increase spring and summer baseflow, which will increase YOY steelhead growth into Size Classes II and III in the lower mainstem.

Trends in Juvenile Densities in San Lorenzo River Tributaries and the Upper Mainstem

Looking for overall trends in juvenile densities for all of the tributaries combined is difficult. Each tributary drains a sub-watershed with its own climate, geology, gradient, habitat proportions, residential density and level of human activities (logging, bridge building, road and bridge maintenance and water extraction). Adult spawning access and habitat conditions do not necessarily fluctuate annually in parallel between sub-watersheds. Some sub-watersheds are accessible in most years while others are difficult to pass in drier winters. Some sub-watersheds are more stable regarding sedimentation while others are more erosive. Some have high annual variability in baseflow while others are stable. The relative size of each sub-watershed affects the level of summer/fall baseflow in each.

Most of the juvenile population in tributaries consists of YOY juveniles. YOY densities at tributary sites are influenced by several factors; 1) number of adults returning to the respective tributaries, 2) spawning effort, 3) spawning success, 4) survival of emerging YOY in late winter and spring and 5) rearing habitat quality in primarily pools. Spawning conditions are better in the tributaries than the mainstem, but late stormflows may be very successful in destroying many spawning redds because of the high percentage of fines in spawning glides in nearly all tributary spawning sites. Water velocities from late stormflows may also wash newly emerged YOY away, with high mortality in the face of little instream wood to provide velocity shelter.

For tributary sites and the upper mainstem (above the Boulder Creek confluence as represented by Reach 11), there was a general decline in total densities from 1997 to 2000, with a general increase from 2000 to 2003, followed by a general decline from 2003 to 2007, a rebound in 2008 followed by an overall decline in 2009 at these sites with long-term records (**Figures 13 and 14**).

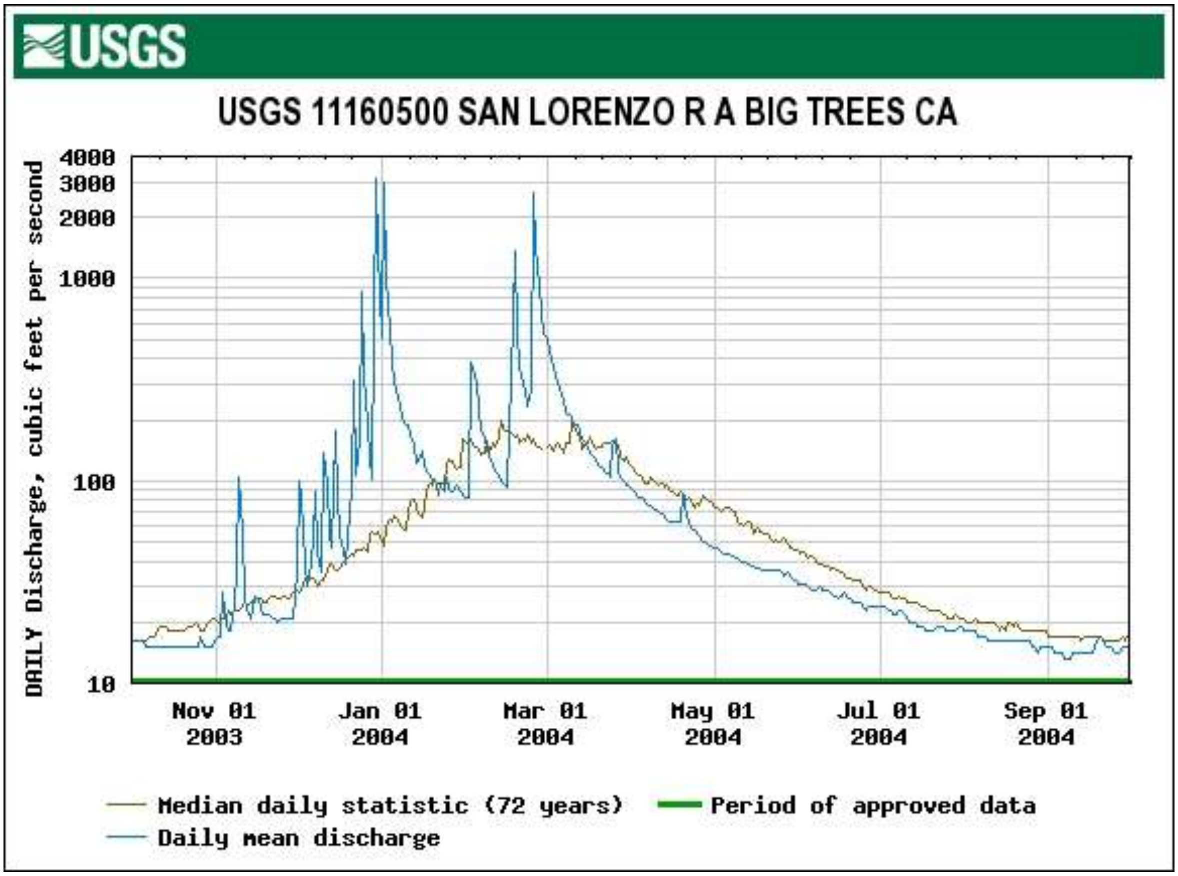
The extremely high juvenile density measured in 2002 at Site 11 by HTH (**2003**) seemed highly unusual, considering our 15 other years of sampling experience with Reach 11 in the upper mainstem. In 2007 and 2008, total densities bounced back up in Zayante Bean and Bear creeks, only to decline in

2009 to 2006 levels. Since most juveniles were YOY, their densities followed the same trend (**Figures 15 and 16**). Although there were no YOY data available in 2002, we can guess that YOY densities followed the same trend as total densities. YOY densities fluctuated greatly through the years at certain sites. YOY density at Site 14c in upper Bean Creek fluctuated the most. This reach is greatly impacted by well pumping. During the 2003–2009 period, Site 14b in middle Bean Creek surprisingly had no YOY in 2007 and very low densities in 2009, presumably because a long segment of the creek upstream of the site was dry and prevented YOY recruitment. YOY density at Site 13c on Zayante Creek annually fluctuated up and down, and Site 13d on Zayante Creek declined significantly in 2007, with its 2007 density the second lowest in 13 years. However, it rebounded in 2008 and declined somewhat in 2009. The 2007 sampling site in Reach 13d had been upstream of a major landslide that had created a steep boulder cluster in the channel during the winter of 2005−2006. This boulder cluster may have been a passage impediment in 2007 that resulted in reduced spawning and juvenile recruitment upstream. This possible impediment was modified in 2008. The 2009 sampling site was above this modified boulder cluster.

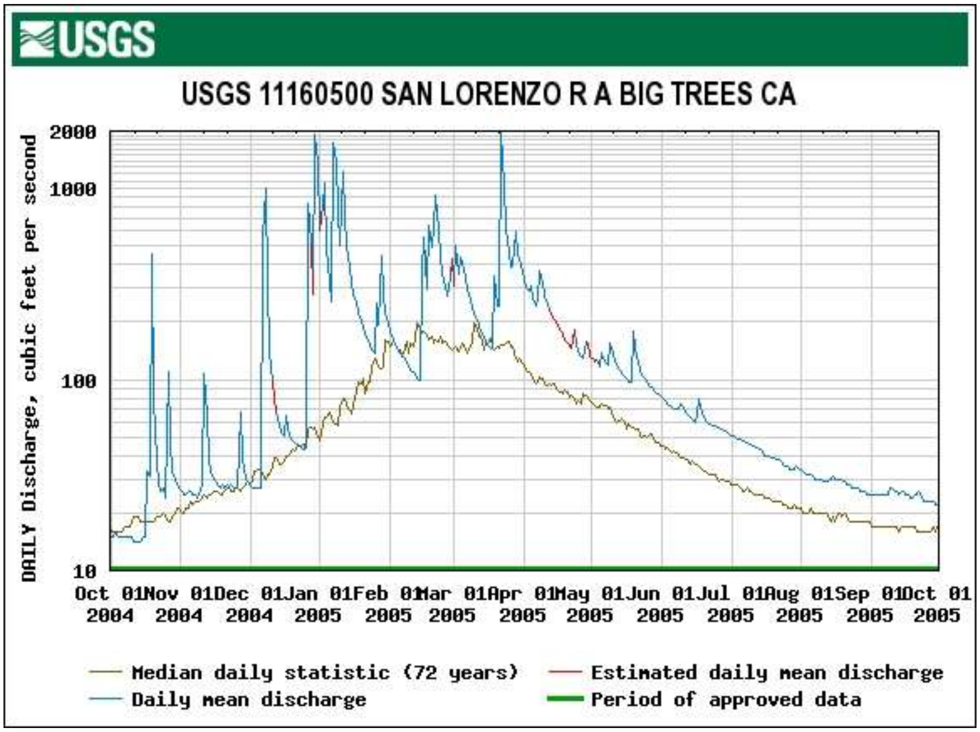
YOY densities in San Lorenzo tributaries may be relatively higher in years like 1997 and 2002 because of no large, late storms but smaller late storms sufficient to promote spawning through the winter and spring. YOY densities in tributaries may also be higher in wet years, such as 1998, which had high winter flows for good spawning access and high baseflows later on for good rearing habitat, with no large stormflows occurring between March and June but still adequate spawning flows for late spawners. 1999 had relatively large stormflows in April and May that may have reduced YOY survival, which may have also been the case in 2006 and 2009. The year 2000 had multiple large stormflows from January through early March, making egg survival likely difficult, followed by rapid decline in baseflow with no storms except for a short one in late April. In addition, it was hypothesized that there were reduced adult returns in 2000 associated with the El Niño storm pattern and associated ocean conditions. There was likely high mortality of smolts in winter of 1997-1998 due to large flood flows. The El Niño period began in summer 1997 and persisted through spring and summer of 1998. Warm water, low macronutrient levels and low chlorophyll and primary production along the continental shelf characterized the event. Poor smolt survival in the ocean may have resulted from high competition for food under warm water conditions, contributing to low adult returns in 2000.

The drier-to-moderate rainfall years of 2001–2004 and 2008 likely allowed for relatively higher egg and young YOY survival, with enough small storms to allow adult access to tributaries and the largest storms occurring in early winter. Years 2004, 2005 and 2008 produced similar YOY densities as 1999 with very different hydrographs (**Figure 54 and Appendix E**). The years 2004 and 2008 had no significant storms after early March and below average baseflows after that. The year 2005 had periodic stormflows throughout March, April and early May, with above average baseflows through the summer. YOY densities declined in 2006 with periodic stormflows through mid-May as in 2005, but the storms were of larger dimension and lasted longer in 2006, thus likely leading to poor egg and young YOY survival (**Appendix E**). The year 2007 had only very small storms in January that would have provided limited access to tributaries and only two moderate stormflows in March that would have provided access and flows conducive to spawning in tributaries, likely limiting spawning effort in the tributaries (**Appendix E**). Egg survival was likely good but competition for food associated with low baseflow in April−May likely reduced YOY survival in 2007. The low 2009 YOY densities had four negative factors at work, including likely fewer spawners after 3 previous years with poor ocean conditions and low smolt-sized juvenile densities in 2006, low spawning flows in early winter followed by the main stormflows occurring later in the winter/early spring in a short time frame to scour previous redds and wash away emerging YOY, but a below-average baseflow in late spring to limit rearing habitat (**Figure 54**).

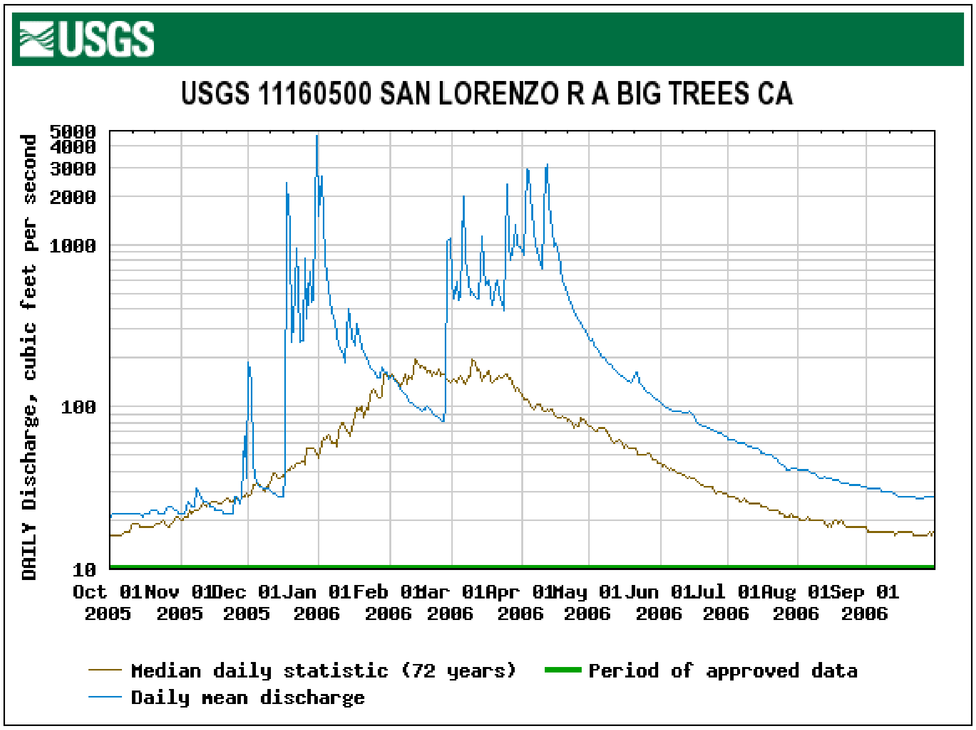
Appendix E. 2004 Daily Average Discharge and Median Daily Flow on Record for the USGS Gage On the San Lorenzo River at Big Trees.



Appendix E. 2005 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.



Appendix E. 2006 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.



Appendix E. 2007 Daily Average Discharge and Median Daily Flow on Record for the USGS Gage On the San Lorenzo River at Big Trees.

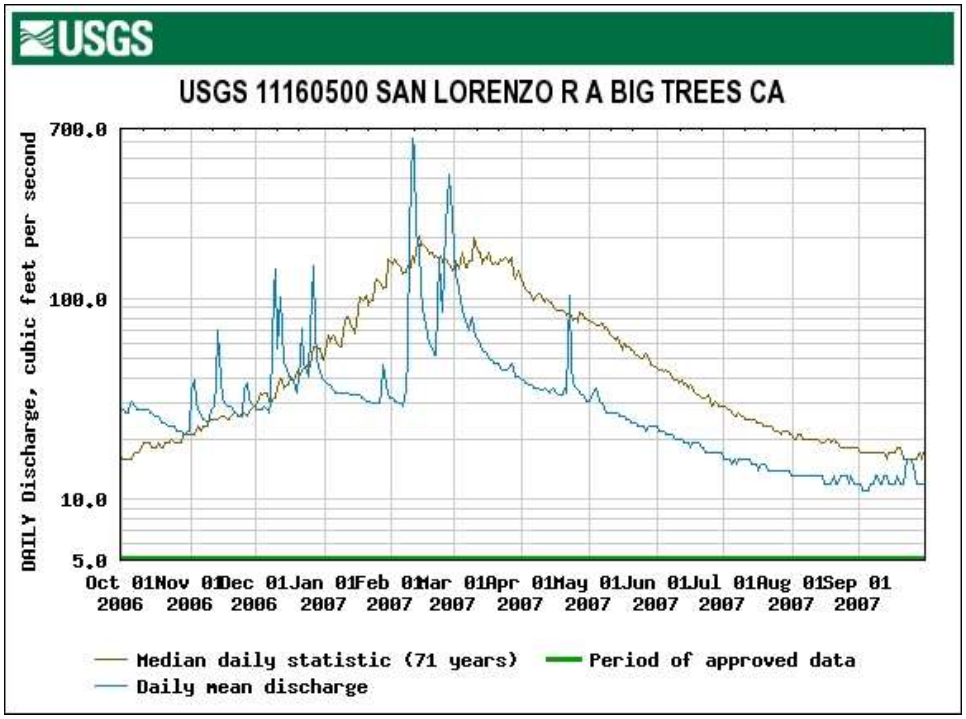


Figure 55. 2008 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.

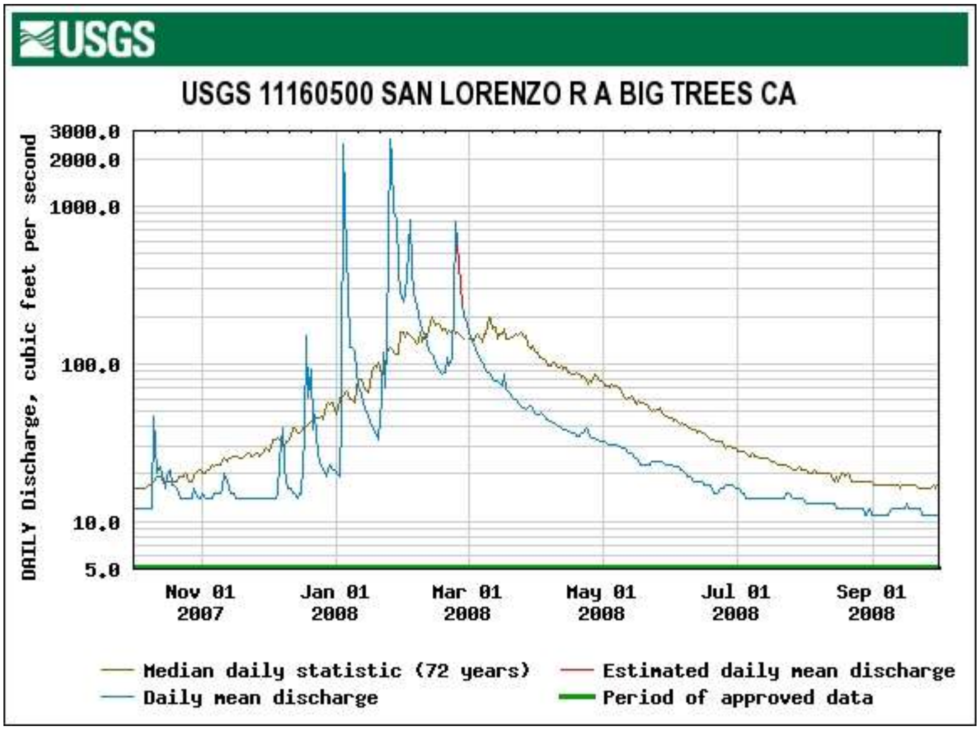
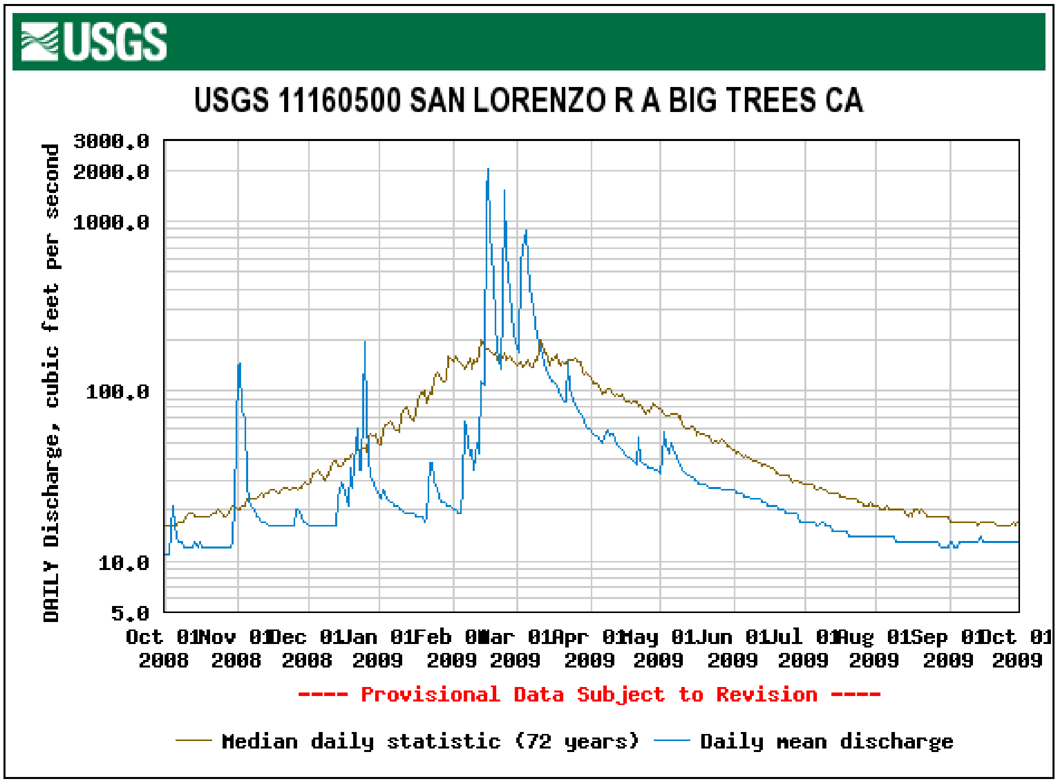


Figure 54. 2009 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.

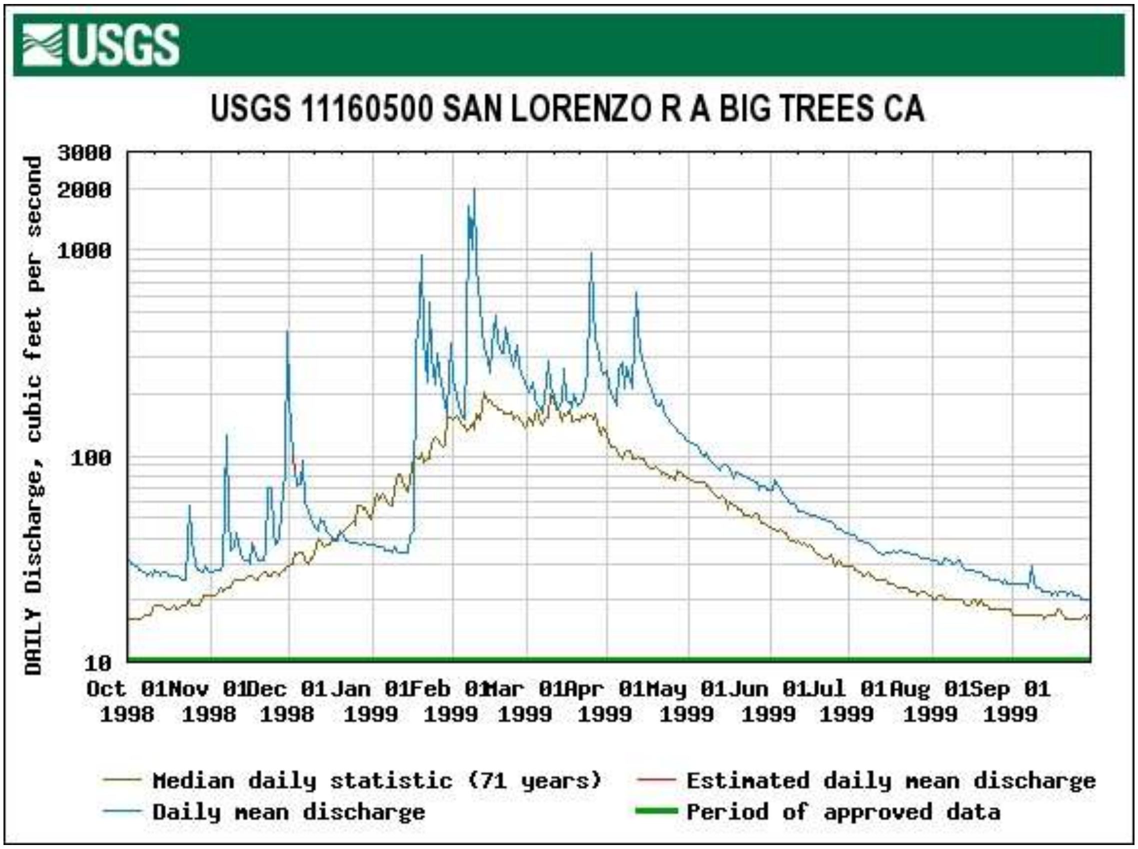


Tributary densities of larger Size Class II and III juveniles (almost entirely yearlings) in fall are determined mainly by 1) over-wintering survival from the previous winter, 2) growth rate in spring that may allow early smolting of yearlings their first spring and 3) rearing habitat quality through the summer.

Tributary densities of Size Class II and III (smolt size) showed no general trend, though as a group, they were relatively low in 2007−2009 at mainstem and tributary sites (**Figures 17 and 18**). Years that had overall low tributary site densities of larger juveniles were 2001, 2004, 2007─2009, all of which had relatively low averaged mean monthly streamflow for May−September over the last 13 years and below the median daily flow for the years of record (**Figures 54, 55 and Appendix E**). After wetter winters, densities of larger juveniles generally increased, as occurred in 1998, 1999, 2003, 2005 and 2006. Densities were similar between 1997 and 1998 but generally increased in 1999 to a 13-year high, particularly in Zayante, upper Boulder and Bear creeks. In 1999, the winter had only 1 peak flow that was near bankfull in early February and continued to rain through April for a relatively wet winter but without creating bankfull flow intensity (**Appendix E**). Spring and summer baseflow in 1999 was above the median (**Figure 25**). Densities of these larger juveniles declined at all sites under consideration in the drier years of 2007─2008 except for upper Zayante Creek #13d, which increased in 2008 to the highest in the watershed. In 2009, densities increased at some tributary sites and continued to plummet at others during another dry year, remaining low on average.

The highest overall Size Class II and III densities at most tributary sites occurred in 1999, which was a relatively wet year without stormflows that continued through April with only one possibly reaching bankfull streamflow (2,800– 4,300 cfs at Big Trees; (**Alley 1999a**) in early February at 3,200 cfs. The averaged mean monthly streamflow for May–September was intermediate for the last 13 years (**Figure 25**). 1999 had a much above median daily baseflow for May–September (**Appendix E**). When one takes a less detailed look at the changes in larger juvenile densities at tributary sites, there has been little overall change except in 2007–2009. In these last 3 years, they mostly declined substantially, compared to earlier years. If adult returns are to substantially improve, densities of these larger, soon to smolt, juveniles must greatly increase from much improved tributary habitat quality.

Appendix E. 1999 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.



Annual trends in Size Class II and III densities at the upper Zayante Site 13d did not correlate well with changes in reach-wide pool depth for the years of available data. However, no reach data were available for drier years of 2001, 2002 or 2004 (**Figure 33**). Density changes in upper Zayante Creek were associated with changes in sampling site escape cover in pools until densities leveled out from 2004 onward, except for a positive blip in 2008, despite reduced escape cover from 2000 onward (**Figures 18 and 34b**). They may have remained constant because of higher baseflow in 2006 and higher over-winter survival in 2007─2009 after mild winters. Densities increased in 2008 as escape cover remained similar at Site 13d but declined somewhat despite increased escape cover in 2009 (**Figure 34b**). Density changes also coincided well with changes in reach-wide escape cover in 1998–2000 and 2003 (**Figure 34a**). However, somewhat higher reach-wide escape cover in 2005 did not correspond to high Size Class II and III fish density in that year, presumably because escape cover at sampled pools remained similar between 2004 and 2005. The decline in step-run percent fines was only positively associated with increased densities from 2001 to 2003, but pool escape cover was also relatively high in 2003 to encourage higher fish densities (**Figure 35**).

In analyzing habitat change in an important western tributary reach, it was noted that overall rearing habitat quality in Boulder Reach 17a has declined from 1997 to 2008 due to reach-wide pool filling (**Figure 36**) and reduced pool escape cover (**Figure 37a**), although reduced fines in step-runs/ runs was a positive change (**Figure 38**). 2009 showed a reversal in shallowing pools and percent fines remained similarly low as in 2008, but escape cover did not improve.

For the lower Boulder Creek Site 17a, annual changes in density of Size Class II and III juveniles were correlated with reach-wide changes in pool depth for the years of data (1998–2000 and 2005–2008) until 2009 when smolt densities remained low despite increased pool depth (**Figures 18 and 36**). Changes in smolt density were not well correlated with changes in escape cover in sampled pools or with reach-wide changes in pool escape cover (**Figures 37a-b**). The poor correlation may result from no consideration of step-run escape cover and depth in a reach where step-runs are a large proportion of the habitat and deep enough to be inhabited by larger juveniles. Also, except for 1997 and 2007, the annual differences in pool escape cover were small in sampled pools that generally lacked much escape cover. Therefore, other factors may have played larger roles in determining densities. The 2007 density was much less than the 2006 density, despite increased pool escape cover in 2007. However, large yearlings from the previous wet year may have smolted and out-migrated in spring 2007 prior to fall sampling, leading to small fall yearling densities. Densities were at times positively correlated with increased percent fines in step-runs, though percent fines did not increase substantially except from 1998 to 1999 (**Figure 38**). This is the opposite of what was expected because increased percent fines indicates a decline in habitat quality. Apparently the negative effect of increased percent fines measured in 1999 and 2006 were overcome by relatively high streamflow and water velocity, greater water depth in step-runs and better feeding stations in step-runs and the heads of pools.

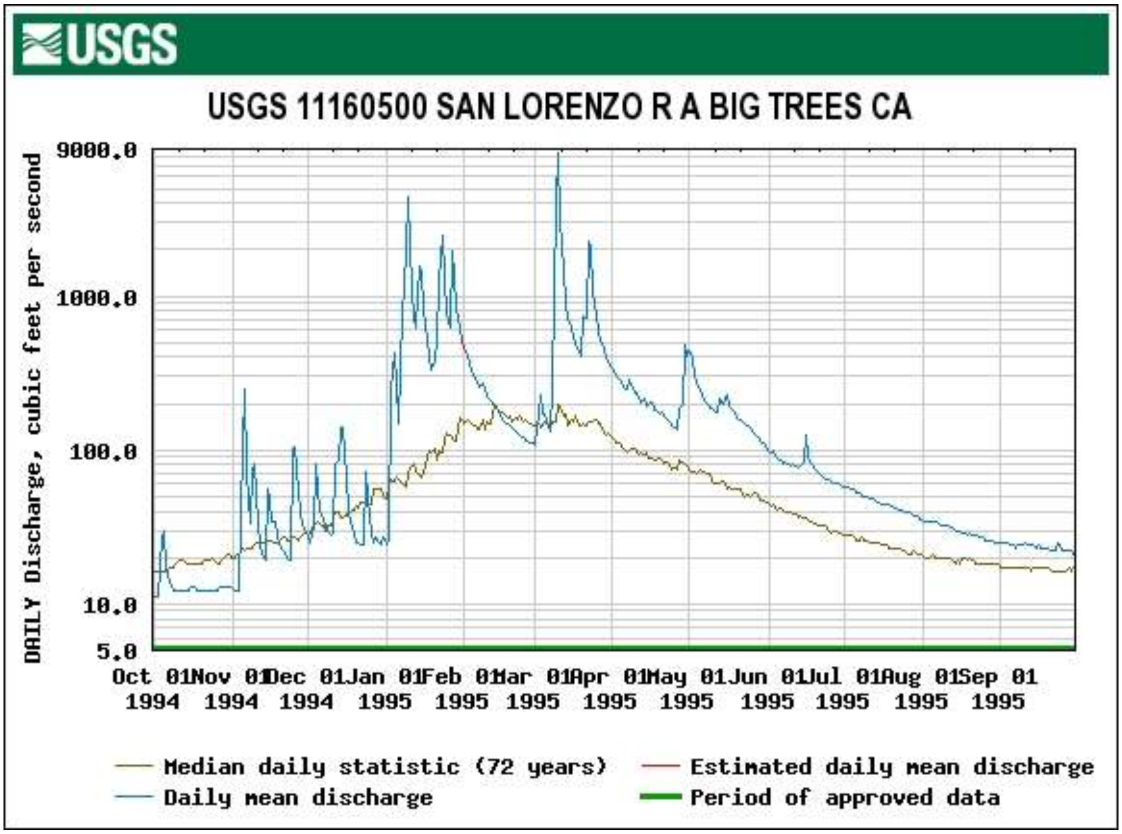
Habitat Trends in the Lower and Middle Mainstem of the San Lorenzo River

In the lower mainstem (downstream of the Zayante Creek confluence) habitat conditions in Reach 4 (above the gorge and below the Felton water diversion) were analyzed in 1997─2008, with no habitat typing in 2009. Habitat in riffles was focused on in the lower and middle mainstem because warm water temperatures there will increase energy requirements of juvenile steelhead, forcing them to select fastwater habitat where water velocity and insect drift are maximized. Since 1995, the largest peak flows have occurred in 1994/1995, 1997/1998 and 2005/2006 (**Appendix E**). The largest stormflows measured at the Big Trees Gage since 1995 were 10 March 1995 (14,200 cfs), 10 December 1997 (11,400 cfs), 3 February 1998 (19,400 cfs), 16 December 2003 (13,200 cfs), 1 January 2004 (11,200 cfs) and 31 December 2005 (13,300 cfs), and all were much above the estimated range of bankfull discharge (2,800−4,300 cfs) (**Alley 1999a**) that would be capable of mobilizing the streambed. These storms (and the onslaught of sediment coming in from the upper watershed and especially the Zayante sub-watershed) brought streambank erosion, bankfull channel widening, channel braiding, large trees entering the channel (subsequently cut up and lost during later stormflows). General channel instability occurred in upper Reach 4 (Henry Cowell Park) of the lower mainstem after the 1997/1998 winter, causing substantial streambank erosion and washing large sycamores into the active channel (**Alley 1999a**).

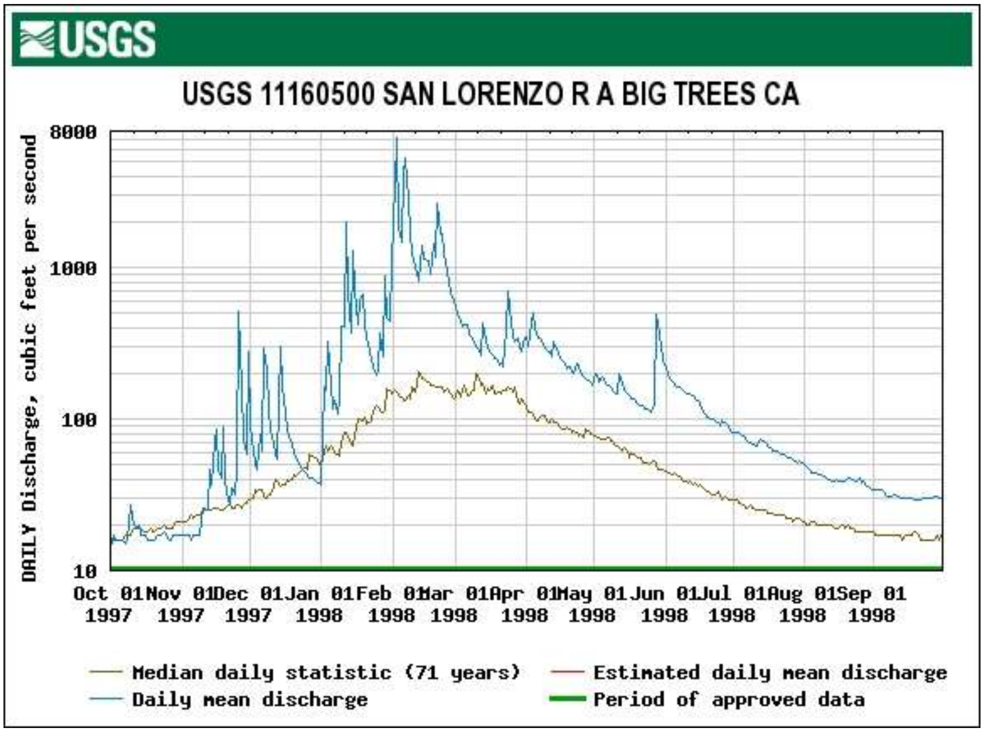
Water depth in riffles in the late summer/ fall is mainly influenced by 1) baseflow, 2) wetted channel width and 3) the degree of winter filling in between the larger cobbles and boulders with fine sediment/sand (sedimentation) and smaller rocks. Average wetted channel width for habitat typed riffles in Reach 4 in fall 1997–2000 and 2006–2008 was 33, 35, 30 (1999), 39, 39, 25 and 29 feet, respectively. By comparing the averaged mean monthly flow (May through September) at the Big Trees Gage immediately upstream with riffle depth in Reach 4, it was evident that habitat substrate conditions in riffles were likely best in 1997 (deepest riffles despite low baseflows; low percent fines) and 2007 (deeper in 2007 than in 2001 and 2002 despite lower baseflow; low percent fines) (**Figures 25 and 27–29**). Riffle habitat had deteriorated from 2007 to 2008 despite similar baseflow and percent fines. Riffle embeddedness had worsened from 2007 to 2008 (19 to 33%) (**Table 8**), and channel width had increased to make riffle depths shallower in 2008 (**Table 5c**).

Substantial filling of deep riffle pockets was detected in Reach 4 in 1999 (extreme shallowing of maximum depth evident) (**Figure 27**), with improvement observed in 2000. Reduced escape cover in 1999 was consistent with sedimentation that year (**Figure 28**). However, riffle embeddedness at Sample Site 4 was inconsistent with sedimentation in 1999, with riffle embeddedness for 1997–2000 being 40, 45, 30 (1999) and 45%, respectively. Embeddedness improved in 1999 despite apparent filling of pockets. Reach-wide riffle embeddedness for 2006–2007 showed improvement from previous years at 37 and 19%, respectively, but increased back to 33% in 2008. Apparently, the wet winter of 2005/2006 did not cause the erosion and sedimentation that the wetter winter of 1997/1998 had produced. Percent fines were relatively high during the 1998–2001 years. Percent fines were reduced by 2007 and 2008, approaching 1997 levels. The relatively high riffle escape cover in 2007 was created by primarily overhanging willows along the channel margin, root masses and large instream wood and very little from cracks and crevices in the substrate. In 2008, riffle escape cover declined substantially in Reach 4 apparently because the high peak flow in January had removed overhanging vegetation and some instream wood. In summary, although rearing habitat conditions in Reach 4 riffles in 2008 have improved since 1999 regarding more escape cover and reduced percent fines, 1997 riffle conditions were better with regard to habitat depth, and riffles in 1999 were also deeper and had similar embeddedness compared to 2008. Riffle habitat conditions declined from 2007 to 2008 regarding shallower depth, much less escape cover and higher embeddedness.

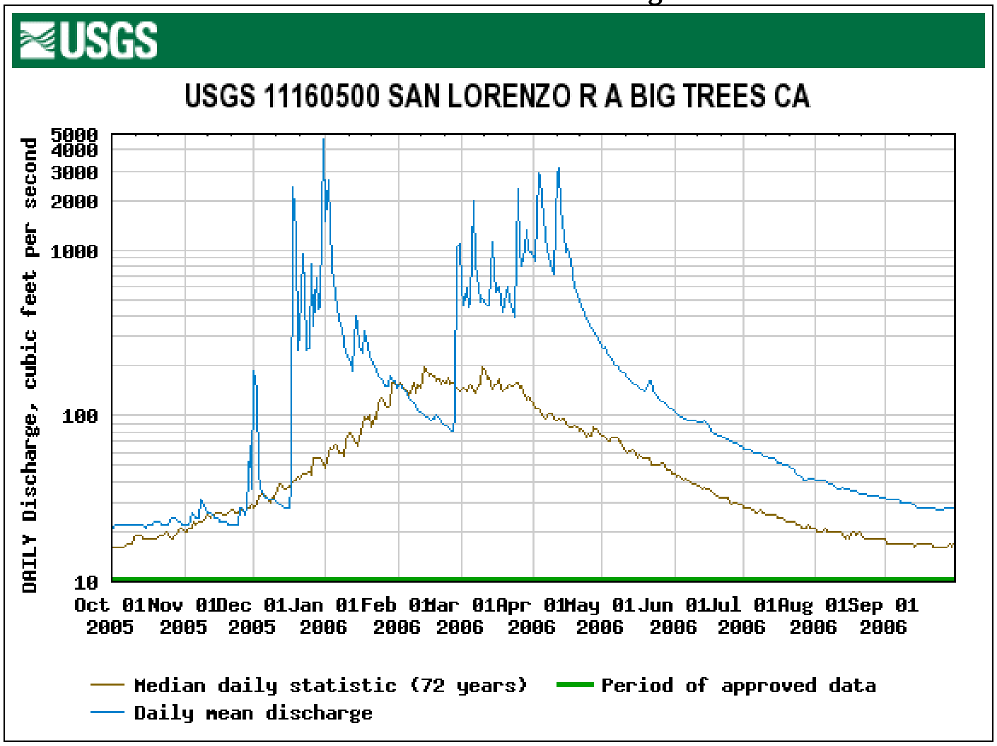
Appendix E. The 1995 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.



Appendix E. The 1998 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.



Appendix E. The 2006 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.



In the middle mainstem (between the Zayante and Boulder creek confluences) habitat conditions in Reach 8 (from upper Ben Lomond to Brookdale past the Alba Creek confluence and ending at the Clear Creek confluence) were analyzed since 1997. Riffle habitat was focused on because under warm water conditions in the middle mainstem, juvenile steelhead are found primarily in fastwater habitat. Habitat conditions in Reach 8 were best in the wet year of 1998 (highest baseflow, greatest depth, fastest water velocity and most escape cover) (**Figures 30, 31 and Appendix E**). As in Reach 4, we see the dip in riffle depth in 1999, indicating filling by sediment and smaller rocks and gravels, and subsequent improvement in 2000. Changes in riffle depth approximately followed changes in averaged mean monthly streamflow (May-September) except maximum riffle depth continued to decline in 2002 and 2003 despite greater streamflow (**Figure 25**). Riffle filling may have occurred in 2002 and 2003 after relatively high peak flows during winter that were much above bankfull (7,880 cfs in 2002 and 13,200 cfs in 2003). Then improved riffle depth was detected in fall 2004 despite lower baseflow and sizeable preceding winter peak flow (11,200 cfs). Conditions in 2005 and 2006 were also relatively good with high baseflow (**Figure 25**), high riffle depth (**Figure 30**) and relatively high escape cover (**Figure 31**). As in Reach 4, percent fines in riffles greatly improved in 2007 and 2008 since 1998 and were approaching the 1997 low, but increased slightly in 2009 (**Figure 32**). Embeddedness in the same sampled riffle in 1997, 2007─2009 was 35%, 18%, 30 and 19%, respectively (**Table 8**), indicating that 2007 and 2009 had some of the best substrate conditions in 13 years when the low percent fines are also considered. Substrate conditions had declined regarding embeddedness in 2008 after the higher peak flow (7,570 cfs). Overall rearing habitat conditions in 2007 were not as good as in 1997 with regard to depth, though percent fines and embeddedness were similar. The deep pockets in riffles that existed in 2007 had filled in 2008 and returned in 2009 as embeddedness had improved after a winter with a lower peak flow (3,820 cfs). Unfortunately, reach-wide escape cover was not measured in riffles in 1997 for comparisons. However, escape cover in 2009 was half that in 1998 or 2005, indicating reduced habitat quality in that regard. If baseflows had been the same in 1997 and 2009, habitat conditions in Reach 8 riffles would have been better in 1997 due to more escape cover in 1997.

Habitat Trends in San Lorenzo Tributaries

In general, in comparing sub-watersheds on the west side of the drainage (largest being Fall and Boulder) with those on the east side, those on the west side are "generally" steeper in gradient, are from granitic origin (rather than shale and sandstone) and generally with larger boulders present in their lower reaches, they flow through deeper and narrower canyons without floodplains, are relatively more shaded and cooler and are impacted by primarily surface water diversions and logging. The sub-watersheds from the east (largest being Branciforte-Carbonera, Zayante-Bean, Newell, Bear and Kings) are generally lower gradient, are mostly from shale and sandstone origin (except Branciforte-Carbonera), have reaches that do not always flow through narrow canyons, are sporadically less shaded by primarily deciduous trees, and they are warmer.

Streamside vegetation plays little role in pool formation in Boulder Creek on the west side but plays an important role in Fall Creek. The flatter sub-watersheds of the eastern tributaries are more impacted than the western tributaries by higher residential and urban density, more human activities (more paved surfaces, quarrying, logging and business- and road-generated chemical pollution) and greater water extraction primarily from wells (except Lompico Creek, which has a surface diversion). The upper mainstem has a mix of substrate influences from western and eastern tributaries but is generally low gradient with short riffles and long pools, except where gradient increases in the upper reaches beginning near Waterman Gap.

In Zayante Creek, the largest eastern sub-watershed of the San Lorenzo system, habitat trends were analyzed in Reach 13d since 1998, when habitat typing of tributary reaches began. This was the uppermost reach under study and downstream of Mountain Charlie Gulch. Pool habitat was focused on for depth and escape cover parameters because in smaller tributary channels, most juvenile steelhead inhabit pools, with important Size Class II and III juveniles restricted to primarily pools and step-runs. In Reach 13d, annual changes in pool depths paralleled annual changes in averaged mean monthly streamflow record at Big Trees gage (May–September) except for additional shallowing from 2000 to 2003, caused by streambed filling despite increased baseflow in 2003 (**Figures 25 and 33**). However, percent fines in step-runs declined substantially through the period to 2007, only to increase substantially in 2008 and continue in 2009 (30%) (**Figure 35**). Percent fines in step-runs in 2007 were at a 12-year low (13%). The important reach-wide pool escape cover showed improvement from 1998 to 2005 but substantial reduction in 2006 and continued low in 2007 and 2008, but rebounded in 2009 (18 feet per 100 feet of stream) to near 1999 levels (**Figure 34a**). (Escape cover and depth in sampled pools mirrored, as much as possible, annual reach-wide changes to sample average habitat conditions but should not be used to detect reach-wide trends (**Figure 34b**).) Rearing habitat conditions improved in Zayante Reach 13d from 1998 to 2009. Although it appeared that pools were deeper in 1998, this was likely caused by step-runs in 1998 being typed as pools in 2009, a year with much reduced baseflow. With higher baseflow in 1998, the proportion of pools in the reach was 50%, and the proportion of step-runs was 40% compared to 71% pools and 23% step-runs in 2009 (**Alley 1999a**). Pool escape cover was greater in 2009 and percent fines in step-runs was similar to 1998.

In Boulder Creek, the largest western sub-watershed of the San Lorenzo system, habitat trends were analyzed in Reach 17a since 1998. Overall rearing habitat quality in Boulder Reach 17a has declined from 1997 to 2008 (as it had in Reach 13d) due to reach-wide pool filling and reduced pool escape cover. Pools had deepened in 2009, but escape cover continued to be low in both pools and step-runs, indicating slightly improved habitat conditions over those in 2008. Embeddedness in pools, riffles and runs/step-runs has remained similar in 2005─2009. Percent fines in valuable step-run habitat of Boulder Creek 17a increased from 1998 to 1999 but declined to a low in 2005 and maintained a low level in 2007─2009 (**Figure 38**). This aspect of rearing habitat improved since 1998.

Annual changes in reach-wide pool depths of lower Boulder Reach 17a did not parallel annual changes in averaged mean monthly streamflow record at Big Trees gage (May–September) in 1998–2000 but did so in 2005–2009. Pool depth in 1999 remained similar to 1998 and actually improved despite reduced baseflow (**Figures 25 and 36**). Pool depth increased in wet 2006 and declined in the dry years

2007 and 2008, with an increase in 2009 despite similar baseflow. The 2009 deepening was mostly due to pool scouring, though, because baseflow was likely similar between years. Overall pool filling appeared evident from 1999 to 2008 from reduced pool depths beyond the effects of baseflow differences, especially for maximum pool depth. This trend was reversed in 2009. Reduced pool escape cover, reach-wide, was evident from the wet year of 1998 to the dry year of 2009 (**Figure 37a**). The residence time of instream wood in Boulder Creek is limited because it tends to be flushed out in a channel with steep to near vertical banks being common. Reach-wide pool escape cover was highest in 1998, declined considerably in 1999, rebounded in 2005 but declined in 2006 and remained low in 2007─2009. High escape cover at the sampled pool habitat in 1997 in the same vicinity of later sampling offered evidence that escape cover was once much higher (**Figure 37b**) than in 2009. Escape cover in runs and step-runs was higher than in pools, but was unchanged from 2008 and much less than previous years, showing a similar decline as pool escape cover (**Table 13**). Escape cover was generally less in lower Boulder Creek 17a than in Reach 13d in Zayante Creek over the 12-year period. Percent fines in Boulder Reach 17a were generally less than in the Zayante Creek Reach 13d, including in 2009 (**Figures 35 and 38**).

TRENDS IN JUVENILE STEELHEAD DENSITY AND HABITAT CONDITIONS IN SOQUEL CREEK, 1997−2009

Trends in Juvenile Steelhead Density and Habitat Quality in the Soquel Creek Mainstem

At the 4 mainstem sites tracked for the past 13 years, annual trends in total and YOY juvenile densities paralleled each other, for the most part (**Figures 19 and 21**). Because the juvenile population in the mainstem is largely YOY, spawning effort, spawning success and early YOY survival largely dictate total juvenile densities in these reaches. In drier years with milder winter stormflows (or mostly early stormflows and few late stormflows) and reduced baseflow, total and YOY juvenile steelhead densities were relatively higher in the Soquel Creek mainstem than in wetter years (**Tables 19, 21 and 26**). The years of highest YOY and total juvenile density corresponded to years with the lowest averaged mean monthly streamflow (May–September), indicating the drier years or at least years with few late winter and spring storms (**Figure 26**). 2009 did not fit this pattern because although it was dry, the storms came later and were in a short time frame. These drier years are also typically the years when the lagoon population of juveniles is the greatest, although 2009 did not fit the typical pattern (**Alley 2010**). The typical inverse relationship may be explained by reasoning that during milder winters, adult spawners probably have limited access to the upper watershed, having more shallow riffles and other impediments to pass. Thus they expend more spawning effort in the mainstem. Also, in drier years, survival of eggs and emerging YOY may be increased without substantial late stormflows to scour or smother redds and wash away YOY. We learned from our spawning gravel study, which involved streambed coring and particle size analysis, that spawning gravel conditions in the mainstem were reasonably good in 2002, a year that was likely without large bankfull stormflows that would move considerable sediment (**Alley 2003c**). Exceptions to this inverse relationship were 2001 and 2009, when YOY and total juvenile densities were relatively low despite mild winters (except for the uppermost mainstem site with densities all increasing from 2000 to 2001). Higher YOY and total densities occurred in 1997, 2002, 2004, 2007 and 2008.

The pattern of densities of larger Size Class II and III juveniles in relation to baseflow is more complex than for YOY. In wetter years, there may be less spawning effort and spawning success in the mainstem until late in the spawning season. However, the above median daily baseflow results in faster water velocity, increased insect drift and deeper feeding stations in fastwater habitat, at least in the spring. All of these factors promote faster growth rate, leading to a higher proportion of YOY reaching Size Class II their first year and higher densities of larger juveniles. In these wet years there may be relatively low YOY densities, yet relatively high Size Class II densities. The wet years of 1998 and 2005 are in this category (**Figures 23 and 26**). However, 2006 was very wet but did not generate high Size Class II and III densities. This was likely because YOY densities were so low in the mainstem (many large storms occurred in April and May to destroy mainstem steelhead redds, and spawning access to the upper watershed was good even in late spring), that faster growth rate could not make up for the fewer YOY juveniles in the mainstem (**Figure 78**).

The other year having especially high densities of larger juveniles in the mainstem was 1997, which had large storms before 1 February to boost the baseflow and virtually nothing after that. Very stable conditions for spawning and YOY emergence were created. That year had high YOY densities, and a high proportion reached Size Class II, presumably because spawning effort and success were likely high in early February. This would allow early emergence and early spring growth despite the lower baseflow later on. The year 2002 had a similar hydrograph pattern to 1997 in that the larger stormflows came early (but they were smaller than in 1997), and a series of smaller storms came in February and March (**Figure 74**). Most spawning may have occurred later in 2002 than 1997, leaving primarily late emerging YOY that would have less time to grow to Size Class II than in 1997, before baseflow diminished in late spring. So, 2002 had high densities of YOY in the mainstem, but not as many reached Size Class II as in 1997. In addition, 1997 had much more escape cover for larger juveniles than 2002, as indicated in Reaches 1 (**Figure 40a**) and Reach 7 (**Figure 43a**). Instream wood was common in 1997, and escape cover was relatively high in all mainstem reaches after high peak flows in January 1995 and December 1996 (**Alley 2003b**). The years 2004, 2007 and 2008 had previously mild winters (**Figures 76, 79 and 80**), likely had heavy spawning in the mainstem, and produced relatively high densities of YOY. However, baseflow was insufficient to grow many to Size Class II, leading to low mainstem densities of Size Class II and III juveniles. The rebound in smolt-sized juveniles from 2008 to 2009 in the mainstem likely resulted from much less competition between YOY due to their very low density, allowing a higher proportion to reach smolt-size the first growing season.

Since 1997, rearing habitat quality in the lower mainstem (as indicated by Reach 1) has improved with regard to increased average maximum pool depth and has declined with regard to reduced escape cover (**Figures 39 and 40a**). During the instream wood survey in 2002, this reach was noted for its lack of large wood (**Alley 2003c**). However, riffle conditions for aquatic insects and steelhead food supply have improved regarding less embeddedness (**Figure 41**). In the lower mainstem, densities of larger juveniles were not well associated with rearing habitat conditions. Spring and summer baseflow and associated growth rate of YOY appeared to overshadow non-flow related habitat conditions to determine densities of larger juveniles. This was partly a result of extremely low yearling densities in the mainstem. After the two winters with the lowest peak flows since sampling began, 1994 (900 cfs) and 2007 (614 cfs), slightly higher densities of yearlings were detected at some mainstem sites compared to other years. This may indicate that if more overwintering shelter was present (in the form of large instream wood), survival of yearlings might increase in the mainstem of Soquel Creek (**Alley 1995a; 2008**).

In summary, since 1997 in Reach 1, rearing habitat quality has improved with increased average maximum pool depth and has declined with regard to reduced escape cover. However, riffle conditions for aquatic insects and steelhead food supply have improved. During the instream wood survey in 2002, this reach was noted for its lack of large wood (Alley 2003c).

In the upper mainstem (upstream of the Moores Gulch confluence in Reach 7), densities of larger juveniles (Size Class II and III) (**Figure 23**) were not associated with reach-wide changes in pool depth or escape cover, except for escape cover in 1997. However, fluctuations in larger juveniles were consistent with fluctuations in pool escape cover at sampling sites (except 2004 and 2009), but the amplitude of fluctuations was inconsistent (**Figure 43b**). Spring and summer baseflow and associated growth rate of YOY appeared to overshadow non-flow related habitat conditions to determine densities of larger juveniles. This was partly a result of low yearling densities in the mainstem. In 2009, there were so few YOY at Site 10 that the reduced competition allowed a higher proportion to grow into Size Class II than in 2008 despite the low baseflow of a drier year.

Habitat conditions in Reach 7 (between the Moores Gulch confluence and the Purling Brook ford) were analyzed since 1997. Overall rearing habitat quality declined since 1997 in the upper mainstem (as indicated by Reach 7) regarding pools filling with sediment and less escape cover (**Figures 42 and 43a**), though maximum pool depth increased slightly in 2008 and 2009. During the instream wood survey in 2002, this reach was noted for its lack of large wood (**Alley 2003c**).

Changes in reach-wide pool depth somewhat paralleled changes in averaged mean monthly flow rate (May- September) until 2005 (**Figures 26 and 42**). In 2005, depths decreased despite increased streamflow, indicating pool filling with sediment. Data from the lower half of the reach in 2006−2009 indicated that that pool depth has not likely recovered since 2005, leading to an overall decline in pool depth since 1997. Reach-wide escape cover was highest in 1997, showed a substantial two-thirds decline by 1999 and a steady increase to 2008, only to decline to 199 levels in 2009 (**Figure 43a**). (Escape cover at sampling sites varied more than it did reach-wide, indicating the difficulty in finding pool habitat that fit average conditions for both depth and escape cover in this reach (**Figure 43b**).) Riffle and run embeddedness at sampling sites fluctuated annually since 1997 and had improved by 2009 by more than 10% and beyond the range of error for visual estimates (**Figure 44**). It did not fluctuate in an inverse way to averaged mean monthly streamflow (May-September), as might be expected if one assumed that higher winter flow would bring more erosion and sedimentation that would lead to increased embeddedness. However, streamflow in the late spring and summer does not necessarily correlate positively with the size of stormflows earlier in the winter. 2008 had a much higher peak flow on 25 January (2,310 cfs) than occurred in 2007 (614 cfs), though its baseflow was less. In 2009, the maximum peak flow on 23 February 2009 was 2,070 cfs, with higher baseflow in 2009 than 2008. In addition, if the larger storms occur early in the winter, there is more time and lower flows after to transport sediment away than if larger storms occur later in the winter. We see the largest increase in embeddedness in 2001 when the largest storm came in early March (**Appendix E**). We see the largest decrease in embeddedness in 2002 when the largest storms came in November and early January (**Figure 73**). However, the decrease in 2005 came despite the largest storm in April. In summary, overall rearing habitat quality declined in Reach 7 since 1997 because of pool filling with sediment and less escape cover, though pool depth increased and embeddedness in fastwater habitat declined during the 2007─2009 drier years. During the instream wood survey in 2002, this reach was noted for its lack of large wood (Alley 2004).

Trends in Juvenile Steelhead Density and Habitat Quality in the East Branch Soquel Creek

In the East Branch of Soquel Creek, trends in juvenile steelhead densities were tracked since 1997 at Sites 13a (Reach 9a) and 16 (Reach 12a in the Soquel Demonstration State Forest (SDSF). Site 13a is located downstream of the Amaya Creek confluence, the quarry water diversion, the Hinckley Creek confluence and the Mill Pond water diversion and outfall (under new ownership prior to the 2006 sampling) (Map in **Appendix A**). Site 13a is in a geomorphically unstable reach where streambank erosion and fallen trees are common, and streambed rocks are poorly sorted by size (**Barry Hecht, personal observation**). Habitat conditions in Reach 9a may change considerably during high winter stormflows. Site 16 is located in the Soquel Demonstration State Forest (SDSF) and above permanent water diversions. During and after drier winters, spawning access and summer baseflow are usually much less at Site 16 than Site 13a. Usually, less than 10% of the juveniles at these sites were larger yearlings. YOY growth rate is less at Site 16, with only a few YOY reaching Size Class II after the wettest winters. A higher proportion of YOY reach Size Class II in wetter years because more food is available during higher spring baseflow.

In East Branch Soquel Creek, total and YOY densities annually fluctuated in a dissimilar fashion in the lower East Branch (Site 13a) compared to the upper East Branch (Site 16), except they increased at both locations from 2001 to 2002 and decreased at both locations in 2006 (**Figures 20 and 22**). After reaching a 13-year high in 2004, total and YOY densities in the lower East Branch declined in 2005 and then again in 2006 to almost zero but rebounded in 2007 and 2008. As was the pattern at other downstream sites in 2009, total and YOY densities declined at Site 13a. Higher YOY densities in most dry years in the lower East Branch may have resulted from 1) greater spawning effort than in wetter years, 2) more spawning success and 3) higher survival of YOY after emergence. In wetter years, more adult steelhead likely continued further up the East Branch into the SDSF. Though 2008 and 2009 had relatively low baseflows (especially 2008) because of few winter storms, there were storms in excess of 2,000 cfs peak flow that were absent in 2007 to provide better spawning access than 2007. These sizeable stormflows brought correspondingly higher YOY density at Site 16 in the SDSF in 2008 and 2009. The 2009 baseflow appeared to be elevated due to the 2008 fire upstream of Site 16. With the streambed instability of the lower East Branch, redd (nest) scour or burial in sediment may have been more common in winters with higher stormflows. During the instream wood inventory in 2002, this reach was identified as one with small quantities of large instream wood (**Alley 2003c**). If the incidence of large instream wood were to increase substantially, rearing habitat quality and improved over-winter survival in intermediate to wetter years may play more important roles in increasing Size Class II and III densities.

In Reach 9a, since the same pools were sampled for steelhead in 1997–1999 and for 2000–2004, and sampled pools in 2000 were chosen to represent average habitat conditions for escape cover for the reach in 2000, then graphing of pool escape cover at sampled pools since 1997 may reflect general trends in escape cover. Overall rearing habitat quality has declined in the lower East Branch from 1997 to 2009, with regard to reduced pool escape cover (**Figures 46a-b**). However, other habitat conditions have improved with pool depths deepening since 2005, even during drier years with lower baseflows (**Figure 45**). Run and step-run habitat has improved since 2000 regarding less percent fines (**Figure 47**), and riffle embeddedness has also improved (lessened) since 2005 (**Figure 48**). Other factors related to the turbidity and thin silt layer on the substrate observed at the sampling site in 2006 and 2007 (downstream of the Mill Pond outfall) may also indicate reduced habitat quality. Turbidity and the fine silt layer seemed more localized in 2008 immediately below the Mill Pond outfall and was absent in 2009.

At Site 13a, annual densities of Size Class II and III juveniles (**Figure 24**) were not associated with changes in pool escape cover at sampling sites except in 2008 when densities increased with more escape cover (**Figure 46b**). Insufficient years of data were available for reach-wide changes in pool depth, escape cover or percent fines in run and step-run habitat to make comparisons with trends in juvenile densities (**Figures 45, 46a and 47**). In 2007-2008, YOY and total densities were positively correlated with increased pool escape cover at sampling sites. In 2005–2006, densities were not associated with these habitat parameters. In 2008, increased densities of larger juveniles were positively associated with increased maximum pool depth and higher escape cover at the interrupted, incomplete sample site. (Capture of coho salmon at the first pool in 2008 prevented the sampling of a pool with less escape cover.) However, densities of larger juveniles increased in 2009 despite reduced pool escape cover. This may have happened because more YOY reached Size Class II in 2009 with reduced competition between fewer YOY.

Average embeddedness in riffles and runs at sampling sites generally increased through the years as Size Class II densities declined in 1997–2000 (**Figure 48**). But densities were not associated with changes in embeddedness in 2001–2005. The relatively high density in 1997 was consistent with the highest escape cover in sampled pool habitat (provided by instream wood) in 13 years.

The typical disconnect between non-streamflow related rearing habitat conditions and Size Class II and III densities in the lower East Branch indicated that rearing habitat quality within the observed range in the last 13 years was overshadowed by poor over-winter survival of yearlings in years that were not wet enough to grow many YOY to Size Class II. Over-winter survival did not appear good in any year. The effect of non-streamflow related rearing habitat conditions was also overshadowed by the added potential for growth of some YOY to Size Class II in intermediate to wet years, or even drier years if YOY density was low, such as 2009. The years with highest densities of Size Class II and III juveniles in the lower East Branch occurred in 1998 and 2005 (**Figure 24**), two relatively wet years (**Appendix E**) with moderate YOY densities (**Figure 22**). There had been a steady decline in densities of large juveniles from 1998 to a low in 2004. Higher growth rate during these high spring-baseflow years of 1998 and 2005 (**Figure 26**) allowed a higher proportion of YOY to reach Size Class II, leading to higher densities of larger juveniles in 1998 and 2005.

In summary, data indicated that overall rearing habitat quality in 2009 in Reach 9a of the lower East Branch was similar to 2000 conditions with regard to pool depth but worse with less pool escape cover.

Other factors related to the turbidity and thin silt layer on the substrate observed at the sampling site in 2006 and 2007 may indicate lower habitat quality in the upper part of the reach, though it was more localized in 2008 and absent in 2009. During the instream wood inventory in 2002, this reach was identified as one with small quantities of large instream wood (Alley 2003c). Retention of more instream wood would enhance overwintering survival of yearling steelhead and rearing habitat.

In the upper East Branch at Site 16 in the SDSF, densities of Size Class II and III (nearly all yearlings) increased during 1997–1999, with a steady decline to less than one-fifth the 1999 density by 2004. Then the density increased up to the highest density in 13 years in the dry year of 2007 (**Figure 24**). The relatively high density of Size Class II and III juveniles (20/ 100 ft) was likely due to at least moderate numbers of YOY in 2006 and good over-winter survival of yearlings during a mild winter. However, the yearling density declined substantially in 2008 to reduce the density of larger juveniles. This was partially due to low recruitment of YOY from 2007 (**Figure 22**), poor rearing conditions with very low baseflows and likely a bankfull event during the 2007/2008 winter that flushed some yearlings downstream. Then Size Class II and III densities increased in 2009 with higher baseflow after a fire, higher YOY densities in 2008 for higher recruitment to yearlings and a milder winter to allow greater overwinter survival than 2008.

The three highest Size Class II and III densities in the upper East Branch did not correspond to any hydrologic category. They were 1998 (very wet year), 1999 (intermediate rainfall year with relatively mild peak flow) and 2007 (very dry year). Both 1998 and 1999 had sufficient spring baseflows to grow some YOY into Size Class II. The dry year likely had very good over-winter survival of yearlings, although rearing conditions worsened. In addition, adult access may have been hampered in the dry 2006/2007 winter, resulting in lower YOY production and reduced competition for food to benefit yearlings. Retrieval of PIT-tagged juveniles has indicated very limited movement of tagged individuals from their original locations. If the incidence of large instream wood were to increase substantially in the East Branch Soquel Creek, rearing habitat quality and improved over-winter survival of yearlings may play more important roles in increasing Size Class II and III densities.

In the Upper East Branch (above the stream gaging station) habitat conditions in Reach 12a (between Amaya Creek confluence to the gradient increase and the beginning of bedrock pools) were analyzed primarily since 2000. Data indicated that habitat quality in 2008 in Reach 12a of the SDSF was similar to conditions in 2000, after flow-related conversion of step-run habitat to shallow pool habitat was taken into account in the dry years of 2007 and 2008 (**Figure 49**). However, pool rearing habitat quality increased in years between (greater pool depth in 2006; much greater pool escape cover in 2004 and higher amounts of pool escape cover in all years between 2000 and 2008 (**Figures 50a and 50b**)).

As in Reach 9a, reach-wide pool depth in Reach 12a increased in 2006, consistent with higher averaged mean monthly streamflow (May–September) and decreased in 2007 and 2008, consistent with lower baseflow (**Figures 26 and 49**). Then with higher baseflow in 2009 after a fire (visually estimated at 0.15 cfs), pool depth increased. Level of baseflow likely affected reach-wide measure of pool depth because former step-run habitat during higher baseflow conditions may have become shallow pool habitat in 2007 and 2008 with only a trickle of streamflow. Reach-wide pool depths in 2007 and 2008 were less than in 2000 but may have been due more to conversion of step-run habitat to pool habitat in a very dry year than to pools filling with sediment. Reach-wide escape cover increased from 2000 to 2005, decreased in 2006−2008 to just less than 2000 levels and then increased in 2009 to above 2007 levels **(Figure 50a**). Since sampled pools in 2000 were chosen to represent average habitat conditions for depth and escape cover for the reach in 2000 and were sampled repeatedly for fish for 5 years, graphing of pool escape cover at the same sampled pools for 2000–2004 may reflect general trends in escape cover for the reach. These results from sampled pools indicated that pool escape cover increased from 2000 to 2002, declined in 2003 and increased to an 8-year high in 2004 (**Figure 50b**). Then it declined reach-wide in 2006─2008 down to slightly less than the 2000 level but improved slightly in 2009. Reach-wide percent fines in important step-run habitat declined less than 10% since 2000, not indicating a real change to 2009 (**Figure 51**). Percent fines at sampled step-runs were similar between 2000 and 2009, as well (**Figure 52**).

At Site 16, annual densities of Size Class II and III juveniles were not positively correlated with changes in pool escape cover at sampling sites, except in 2008 and 2009 (**Figure 50b**). In fact, densities were the lowest in 2004 when pool escape cover at sampling sites was the highest. Densities increased from 2004 to 2007 despite a decline in pool escape cover at sampling sites. Insufficient years of data were available for reach-wide changes in pool depth and escape cover or in percent fines in run and step-run habitat for comparison to trends in juvenile densities (**Figures 49, 50a and 51**). Densities of Size Class II and III juveniles were not positively associated with changes in these habitat parameters but, in fact, increased despite reach-wide decline in pool escape cover for 2005–2007. However, the decline in these smolt-sized fish in 2008 did correlate with decreased pool depth and escape cover (**Figures 49, 50a and 50b**). But it also coincided with low YOY densities in 2007 for low recruitment as yearlings. Smolt-sized juvenile densities increased in 2009 with increased pool depth and escape cover but also coincided with a larger YOY density in 2008 to recruit from compared to 2007. The density decline in 2000–2004 was associated with relatively high percent embeddedness in riffles and step-runs at sampling sites except for the less embeddedness in 2003 (**Figure 52**). Densities increased in 2005 with less embeddedness.

The apparent disconnect between rearing habitat conditions and Size Class II and III densities at Site 16 except in 2008 when baseflow was a trickle and 2009 when baseflow was likely enhanced by previous forest fire, indicated that rearing habitat quality within the observed range in most of the last 13 years was overshadowed by 1) poor over-winter survival of yearlings in years that were not wet enough to grow many YOY to Size Class II, 2) the potential for growth of some YOY to Size Class II in intermediate to wet years and 3) high over-winter survival of yearlings in mild dry years. If the incidence of large instream wood were to increase substantially, rearing habitat quality and improved over-winter survival in intermediate to wetter years may play more important roles in increasing Size Class II and III densities.

In summary, although improvement in pool rearing habitat in Reach 12a was detected in some years (greater pool depth in 2006 and much greater pool escape cover in 2004), data indicate that habitat quality in 2009 was similar to conditions in 2000. Percent of fines in runs and step-runs has decreased to improve conditions, but embeddedness has remained similar since 2000. Increased incidence of large instream wood would substantially improve rearing habitat in this reach with limited pool development, shallow pools and very limited escape cover in most years.

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FIGURES

Figure 1. Total Juvenile Steelhead Site Densities in the San Lorenzo River in 2009 Compared to the Average Density. (Averages based on 2 to 12 years of data since 1997.)

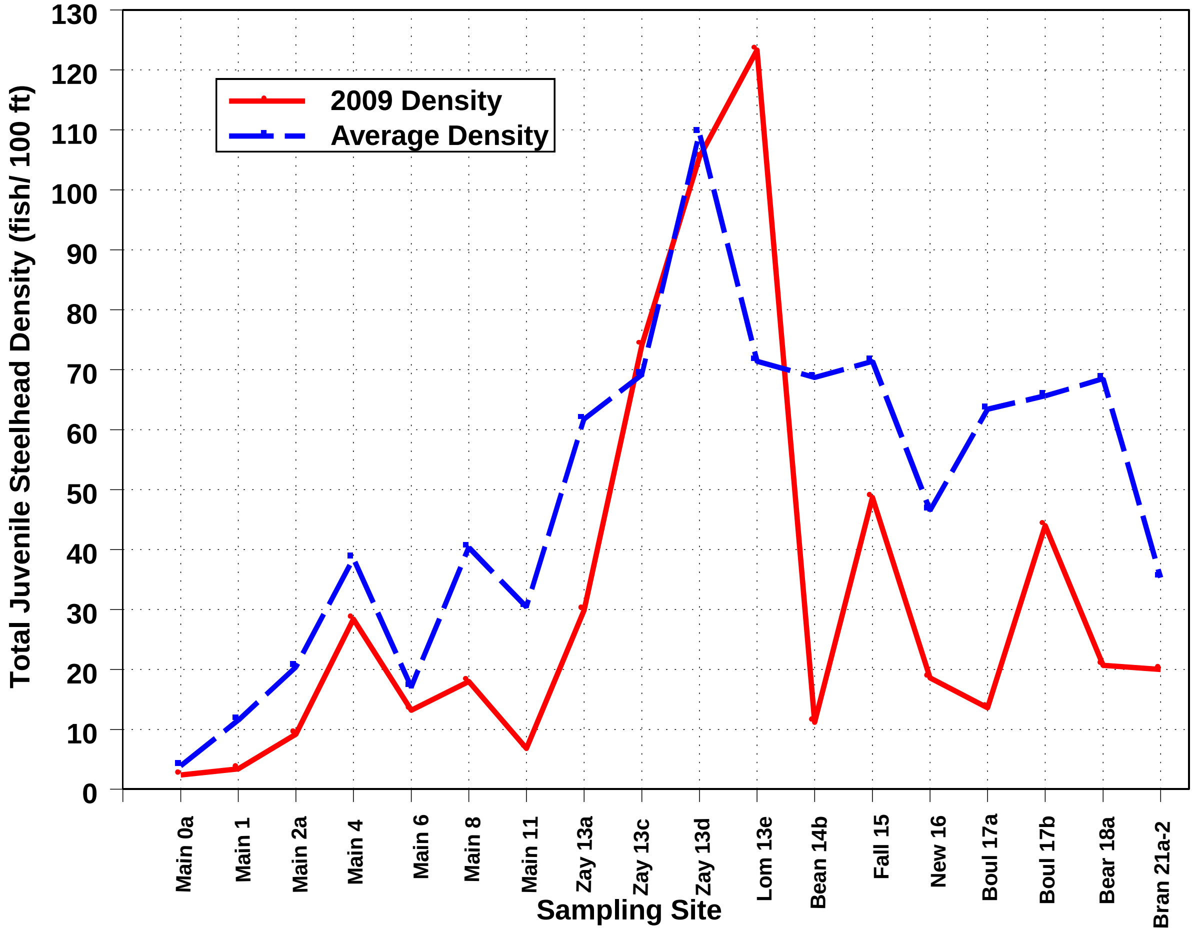


Figure 2. Young-of-the-Year Steelhead Site Densities in the San Lorenzo River in 2009 Compared to Average Density. (Averages based on 2 to 12 years of data.)

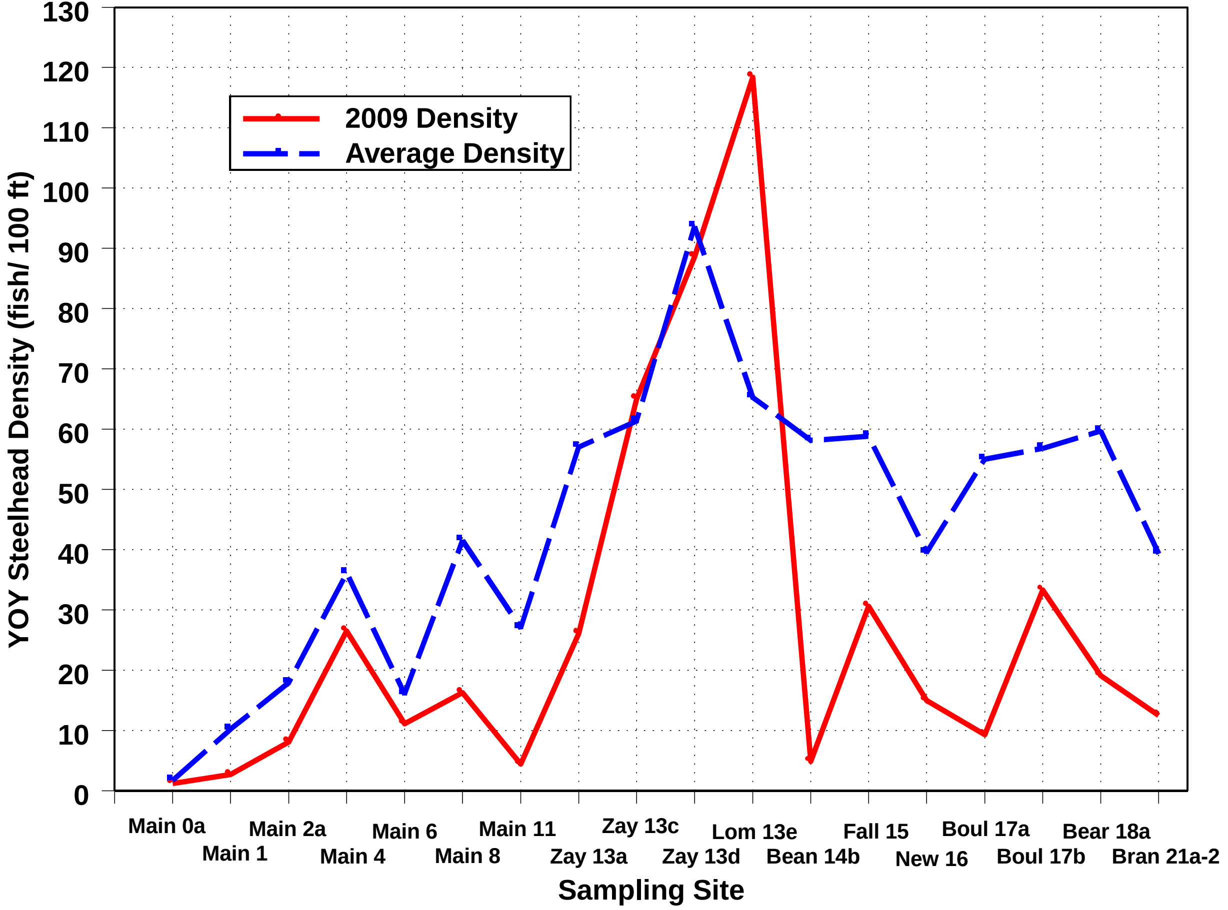


Figure 3. Size Classes II and III Steelhead Site Densities in the San Lorenzo River in 2009 Compared to Average Density. (Averages based on 2 to 12 years of data.)

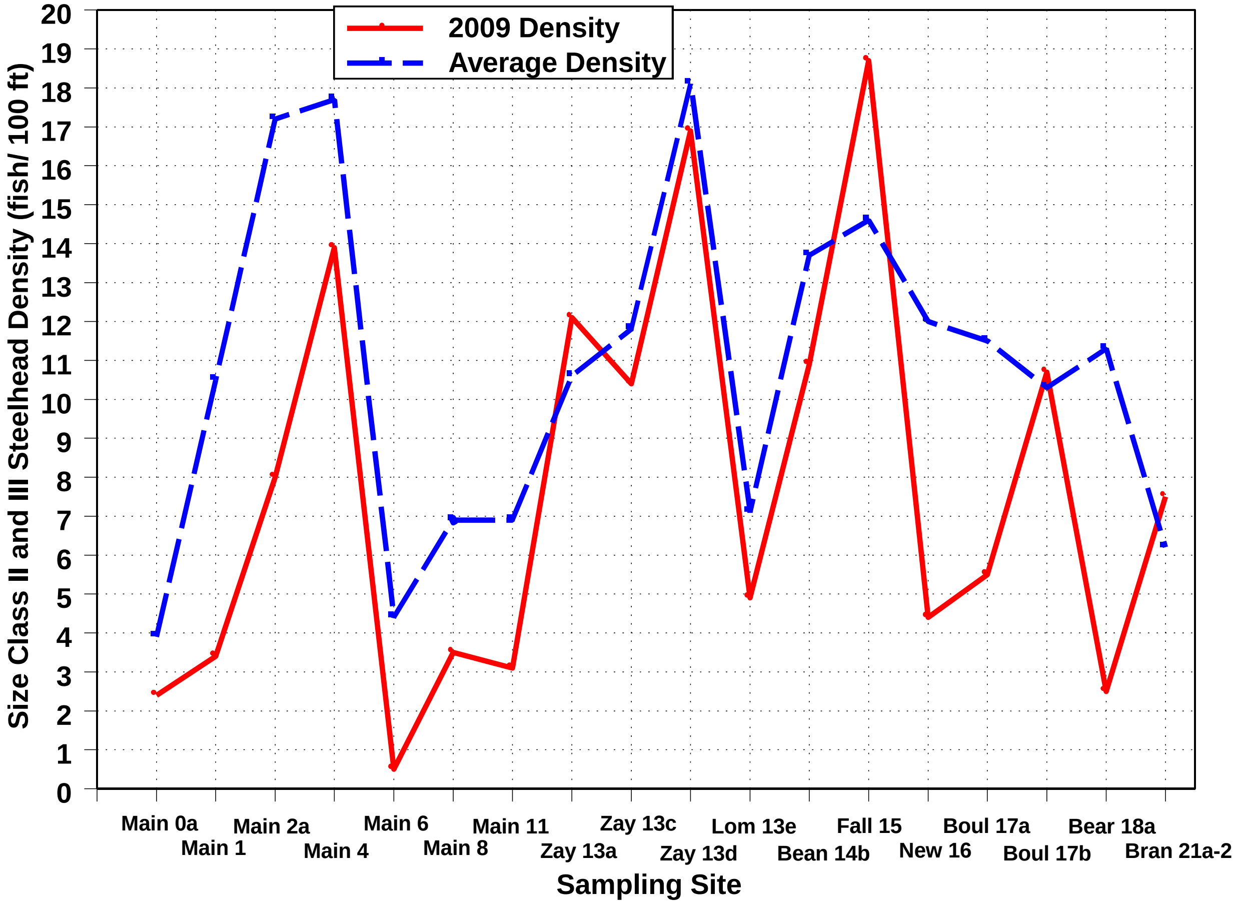


Figure 4. Total Juvenile Steelhead Site Densities in Soquel Creek in 2009 Compared to the 13-Year Average (9th year at West Branch #19).

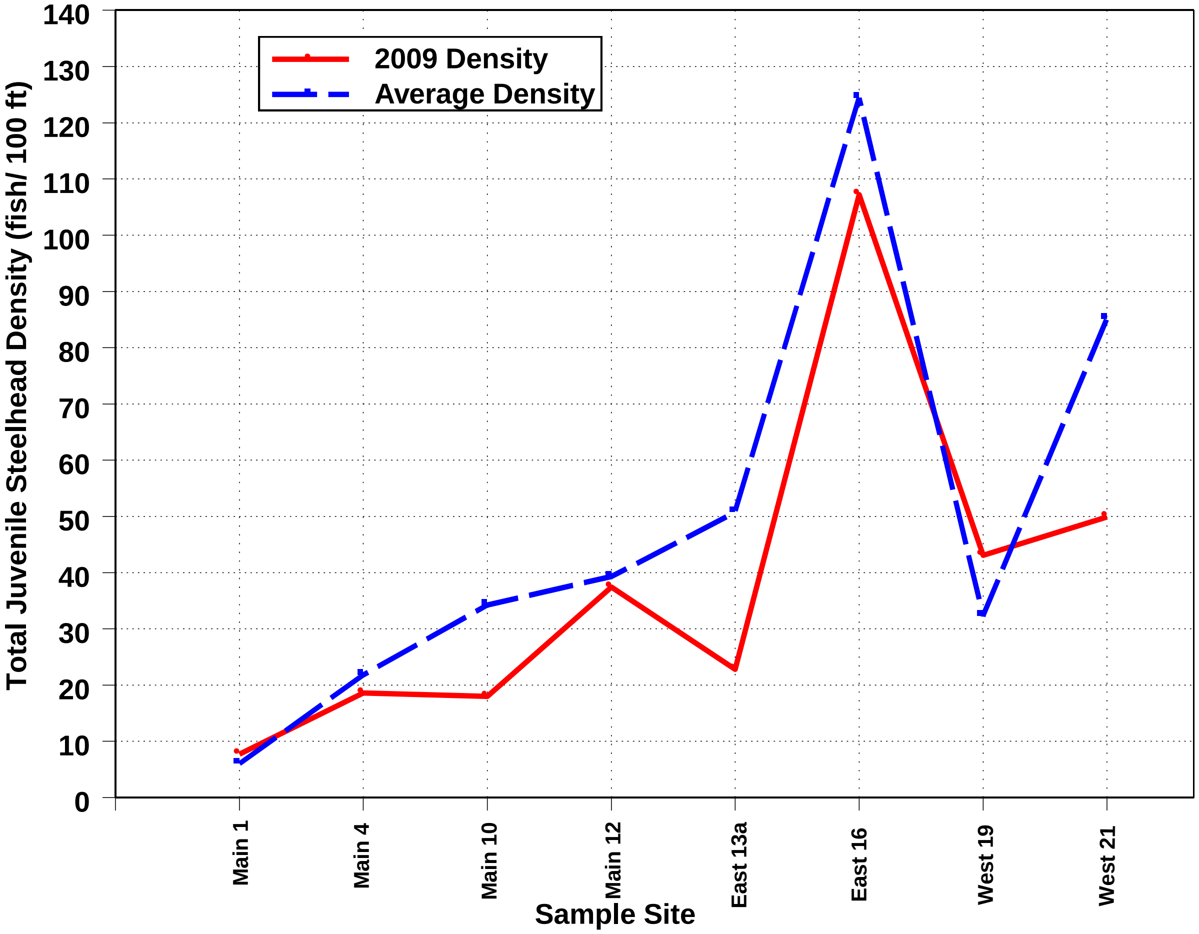


Figure 5. Young-of-the-Year Steelhead Site Densities in Soquel Creek in 2009 Compared to the 13-Year Average (9th year for West Branch #19).

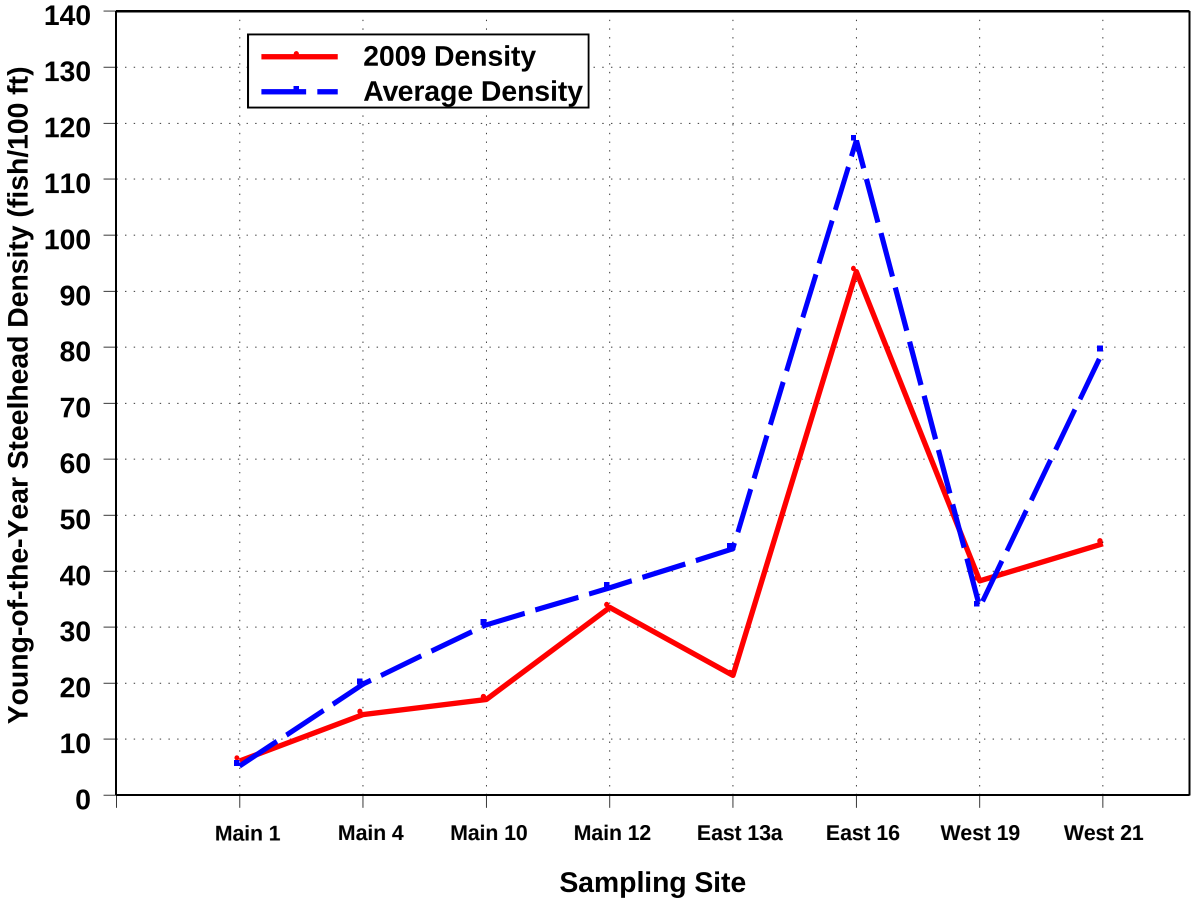


Figure 6. Size Class II and III Steelhead Site Densities in Soquel Creek in 2009 Compared to the 13-Year Average (9th year for West Branch #19).

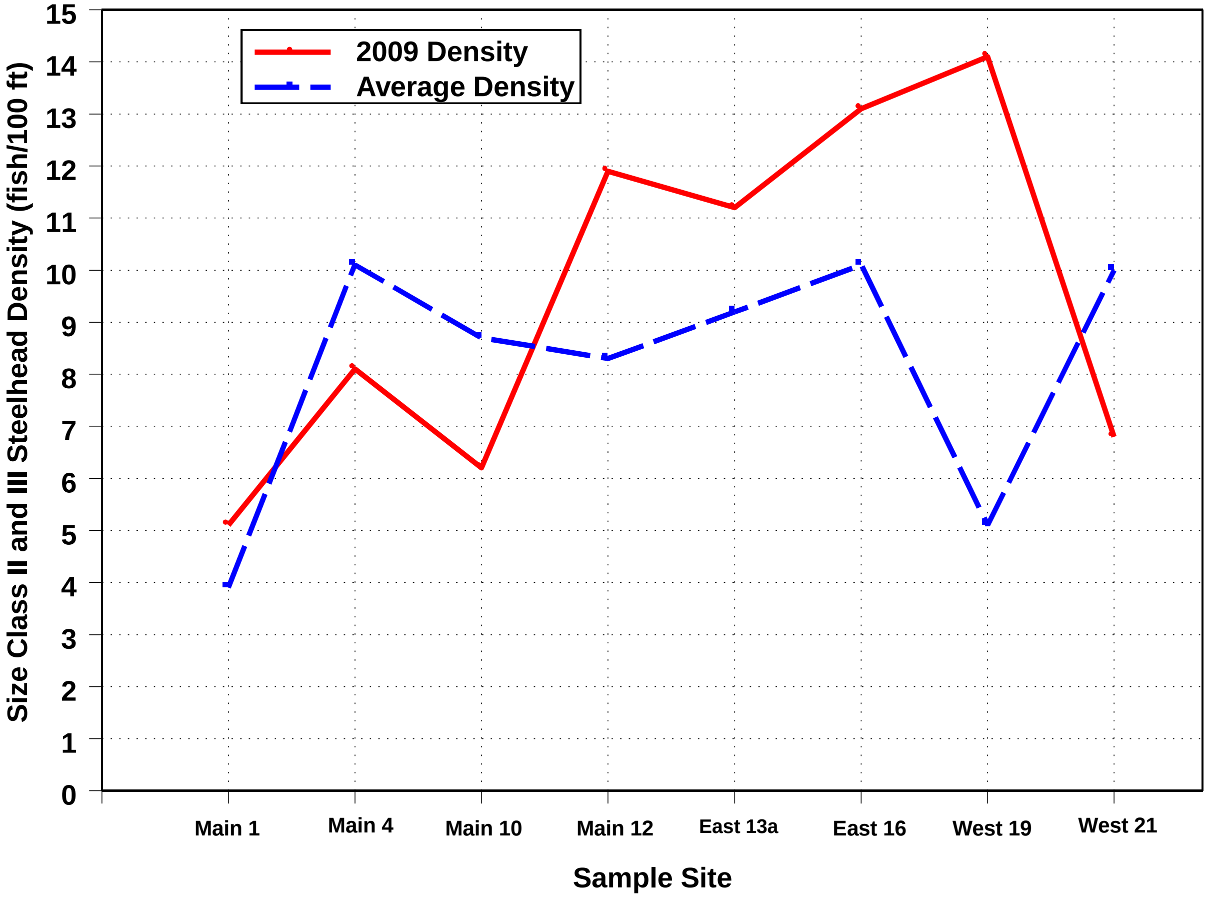


Figure 7. Total Juvenile Steelhead Site Densities in Aptos and Valencia Creeks in 2008 and 2009, with a 5-Year Average (1981; 2006-2009).

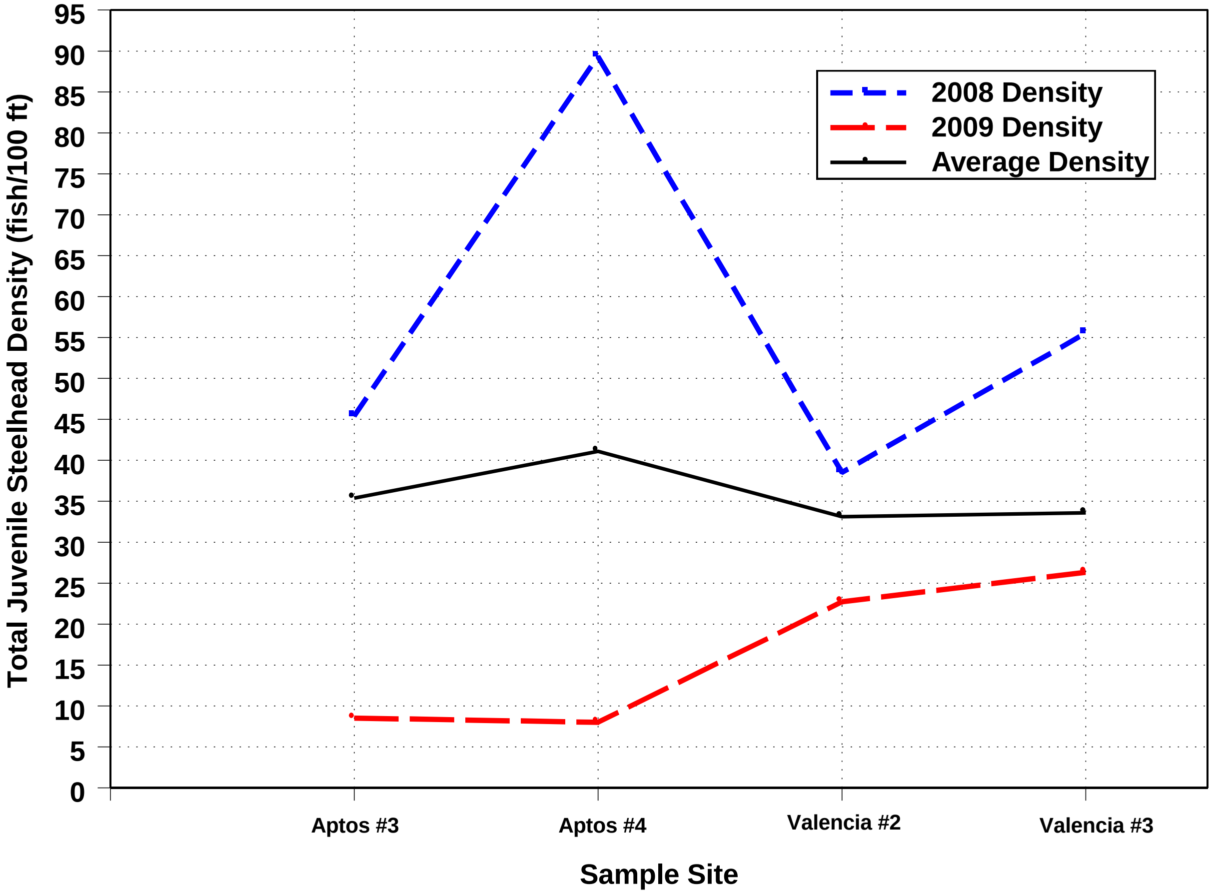


Figure 8. Young-of-the-Year Steelhead Site Densities in Aptos and Valencia Creeks in 2008 and 2009, with a 5-Year Average (1981; 2006-2009).

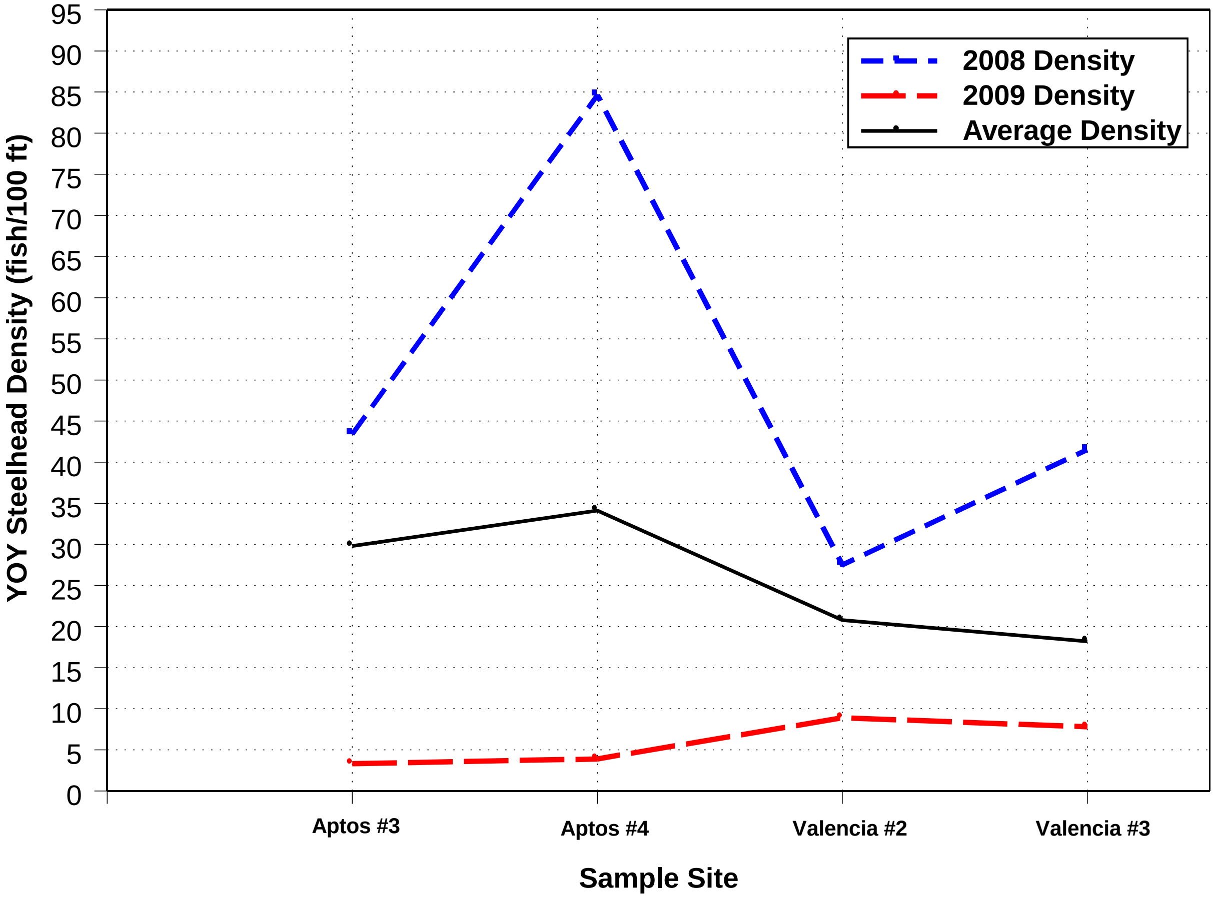


Figure 9. Size Class II and III Steelhead Site Densities in Aptos and Valencia Creeks in 2008 and 2009, with a 5-Year Average (1981; 2006-2009).

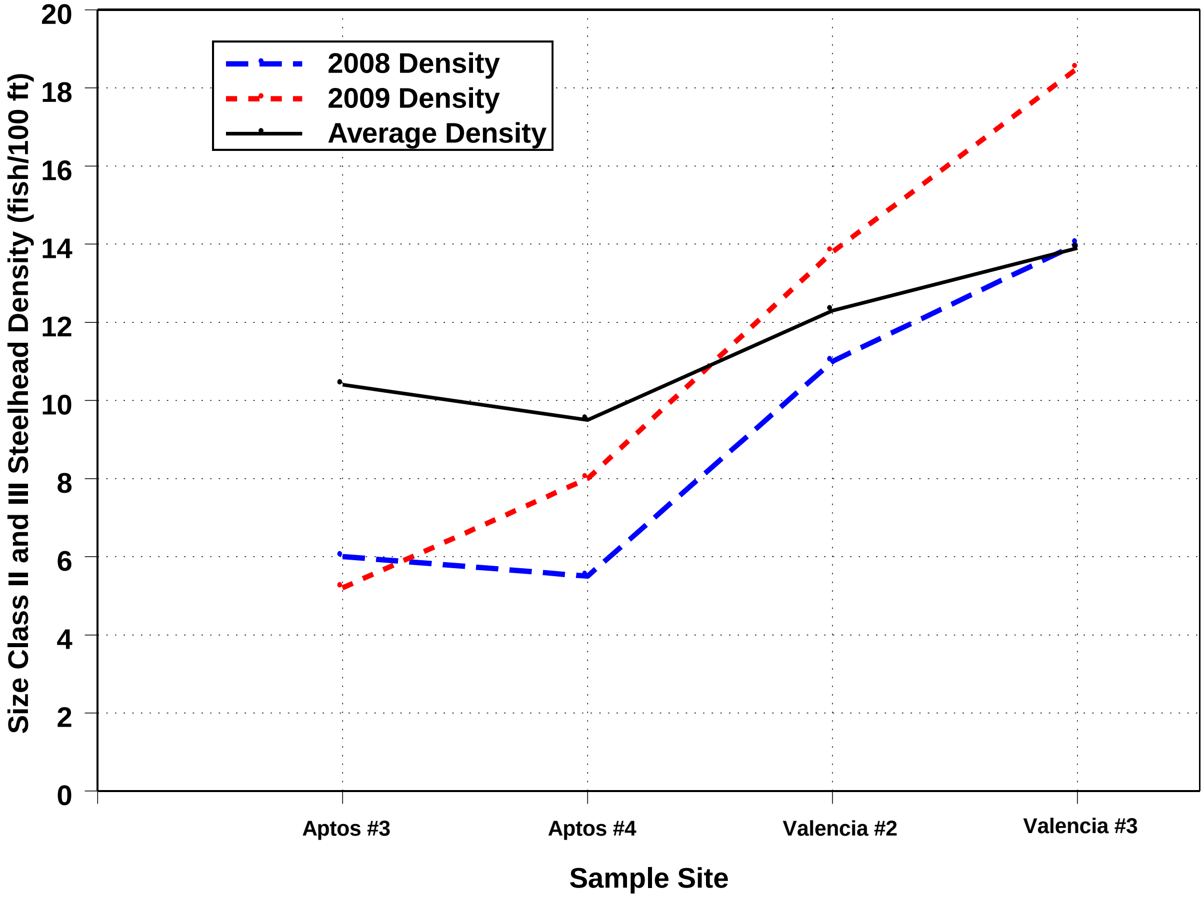


Figure 10. Total Juvenile Steelhead Site Densities in Corralitos, Shingle Mill and Browns Creeks in 2008 and 2009, with a 6-Year Average (1981; 1994; 2006-2009).

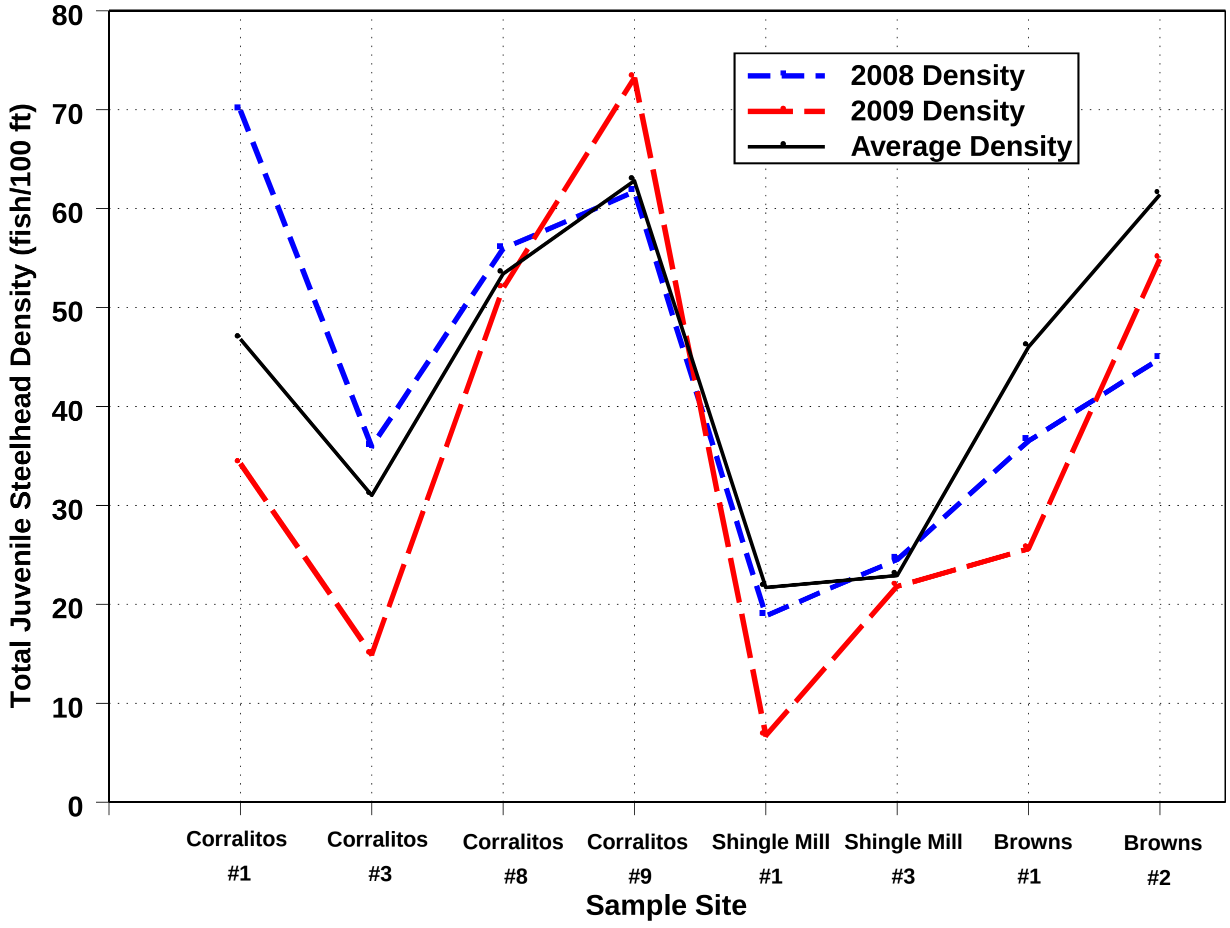


Figure 11. Young-of-the-Year Steelhead Site Densities in Corralitos, Shingle Mill and Browns Creeks in 2008 and 2009, with a 6-Year Average (1981;1994; 2006-2009).

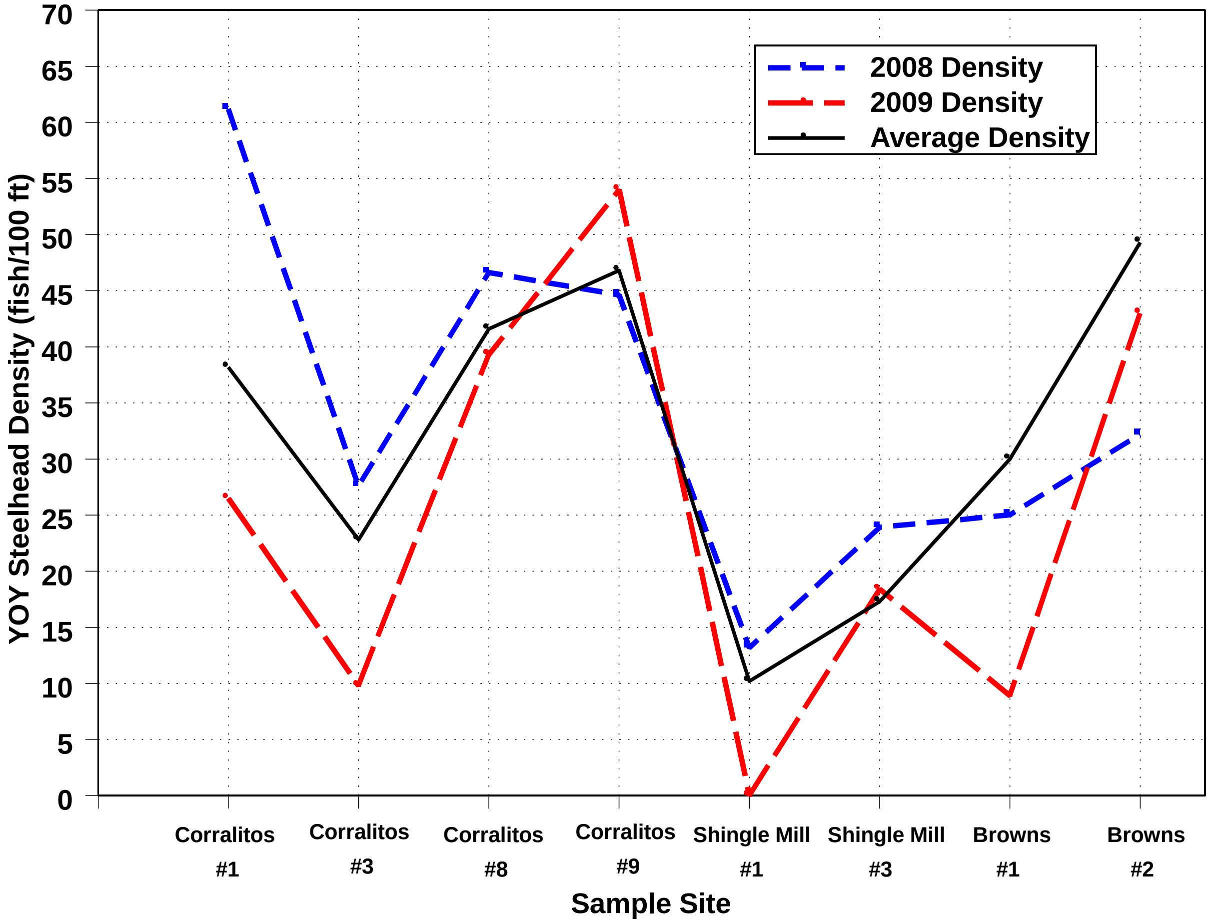


Figure 12. Size Class II and III Steelhead Site Densities in Corralitos, Shingle Mill and Browns Creeks in 2008 and 2009, with a 6-Year Average (1981; 1994; 2006-2009).

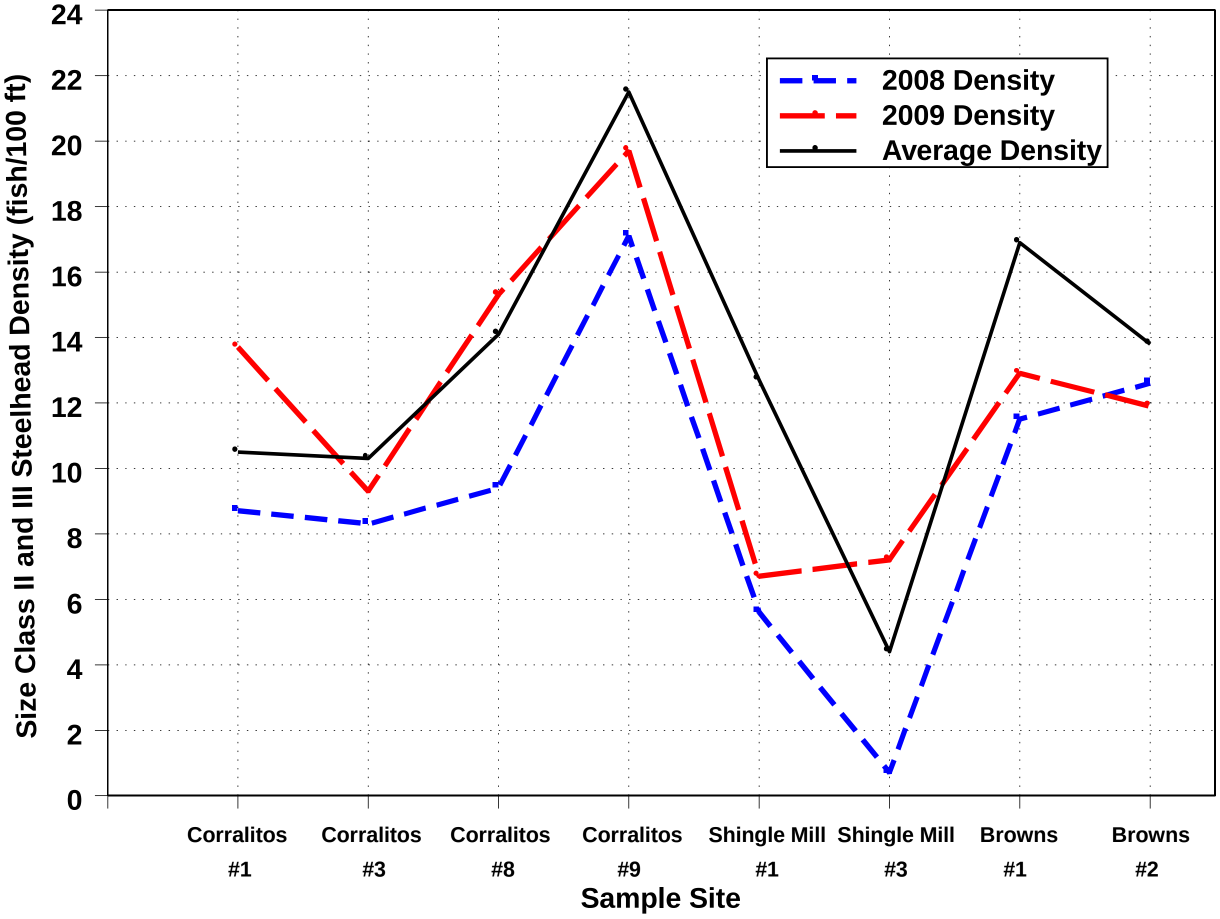


Figure 13. Plot of Annual Total Juvenile Densities at San Lorenzo Mainstem Sites, 1997-2009.

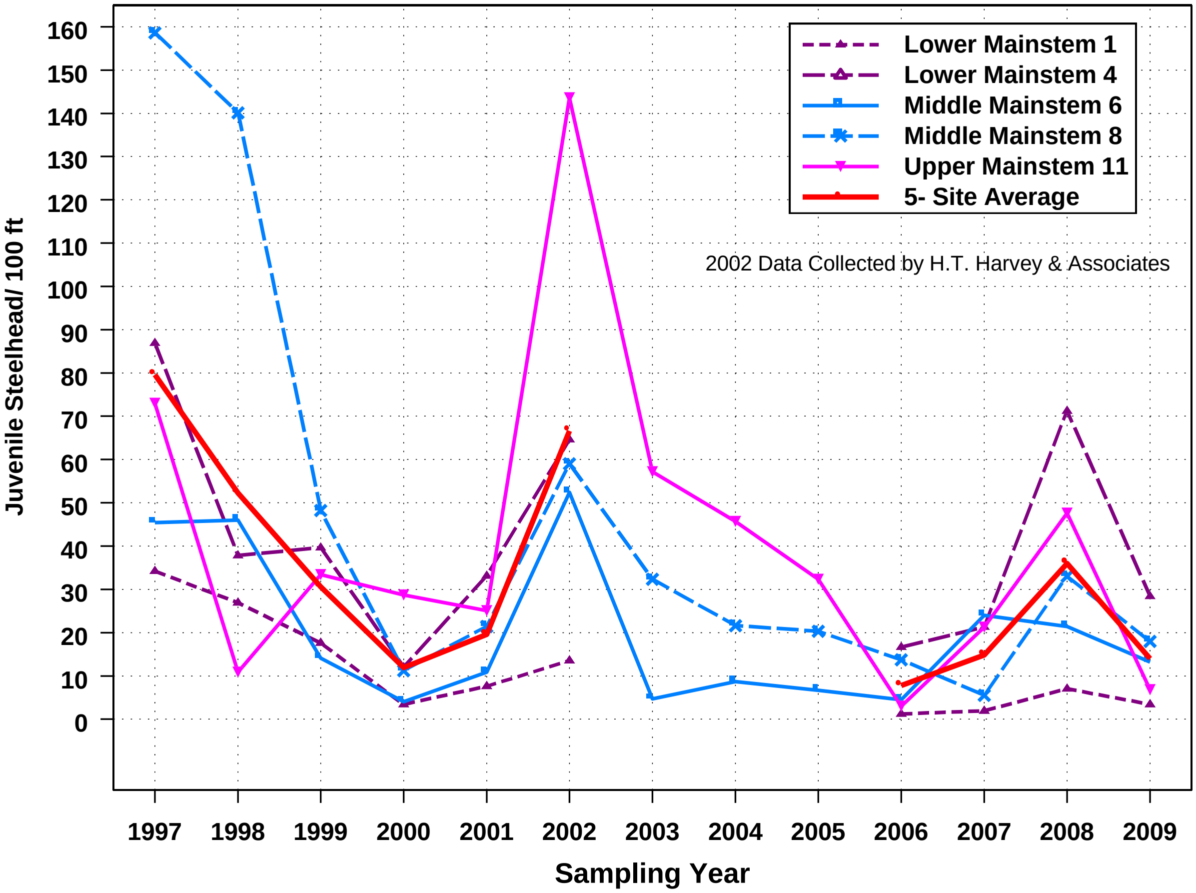


Figure 14. Plot of Annual Total Juvenile Densities at San Lorenzo Tributary Sites, 1997-2009.

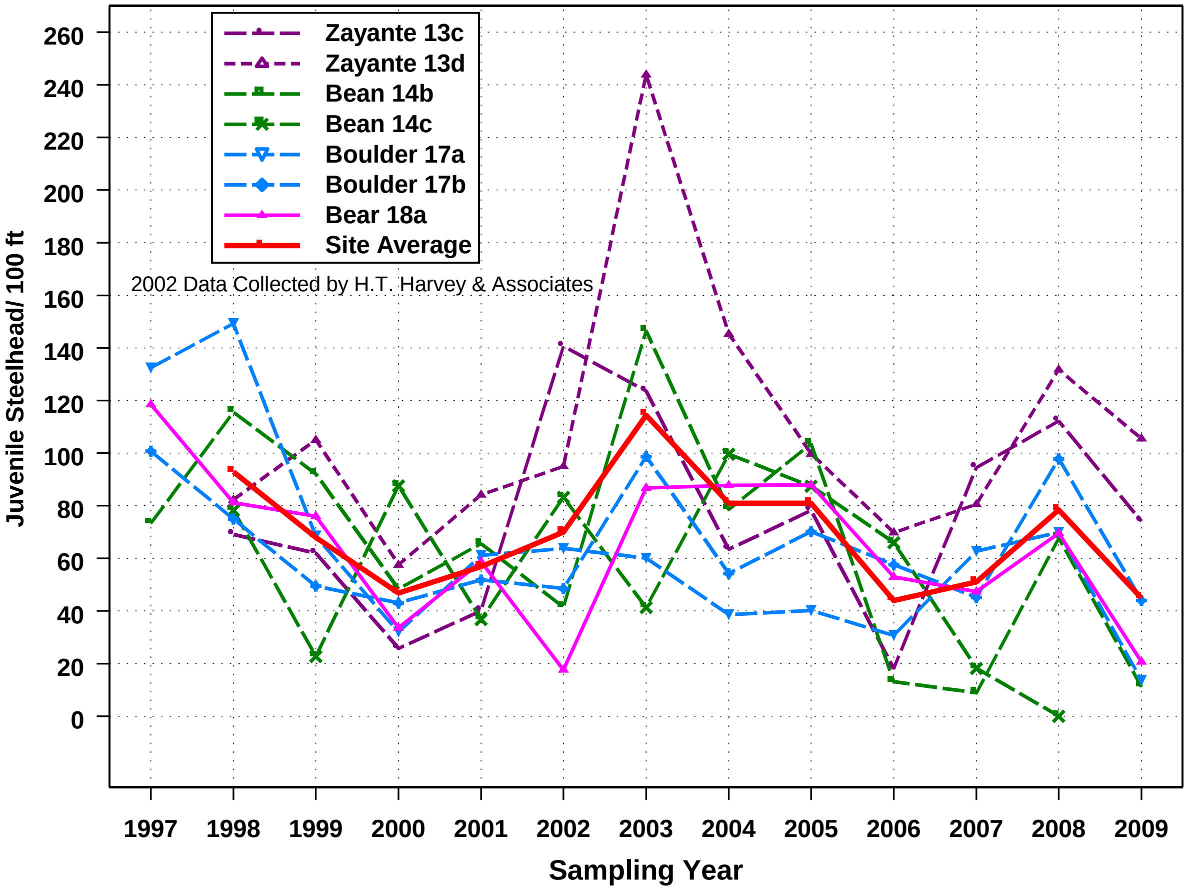


Figure 15. Plot of Annual YOY Juvenile Densities at San Lorenzo Mainstem Sites, 1997-2009.

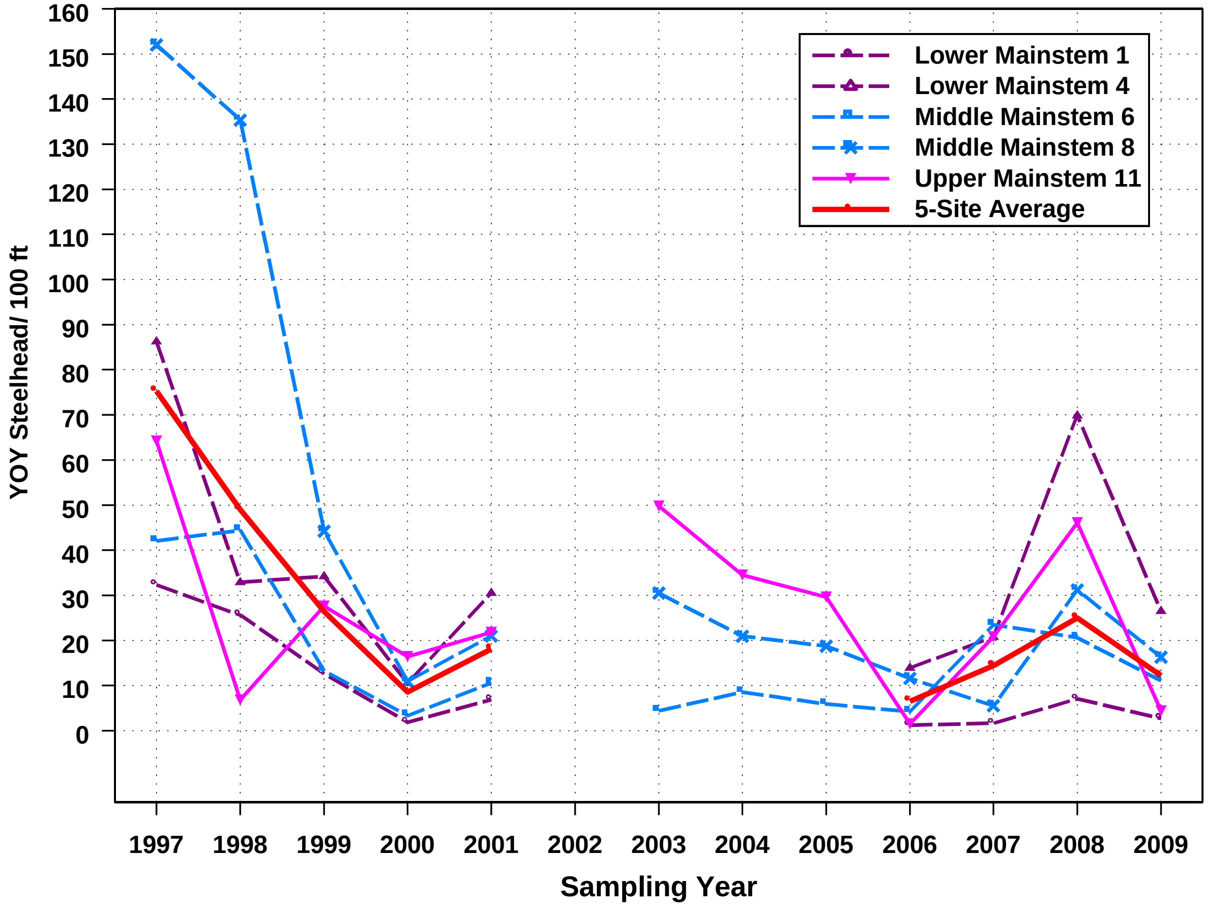


Figure 16. Plot of Annual YOY Juvenile Densities at San Lorenzo Tributary Sites, 1997-2009.

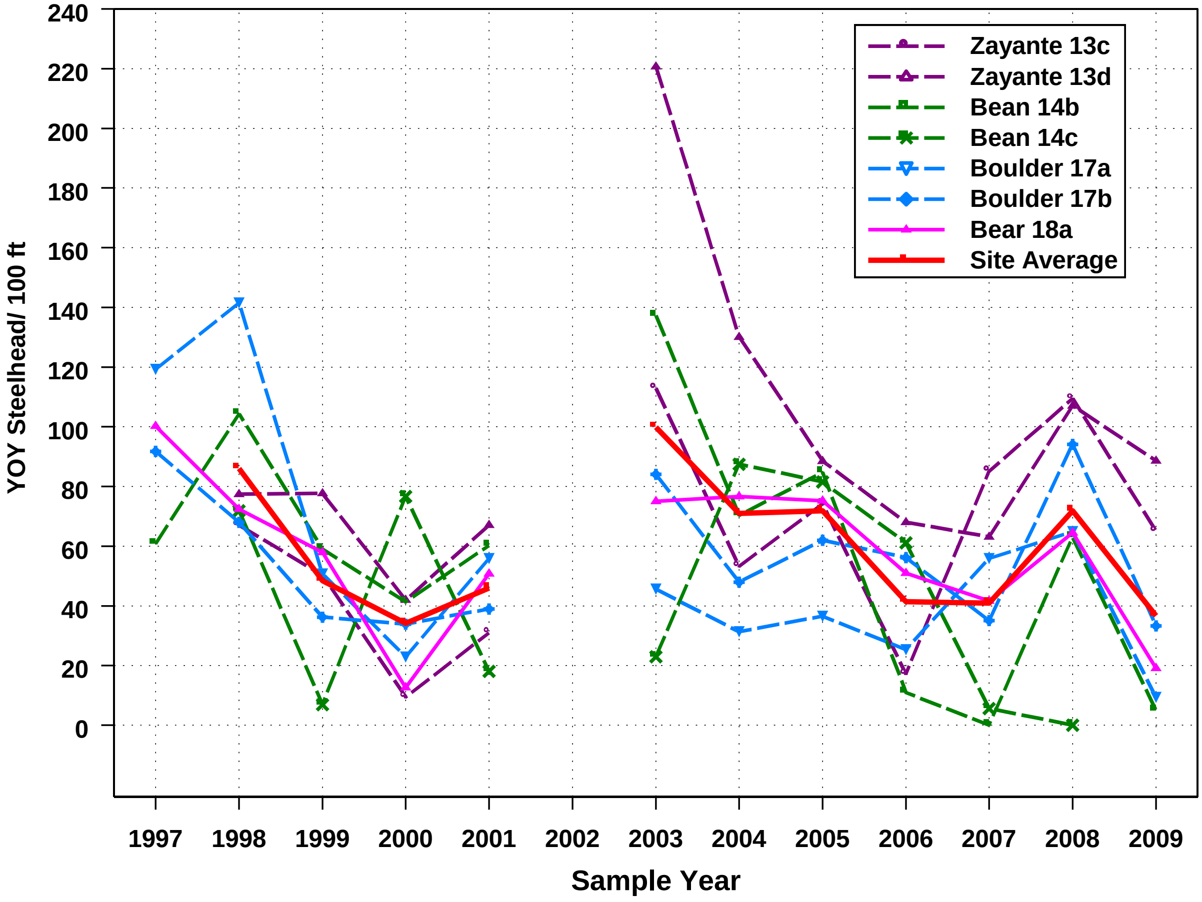


Figure 17. Scatter Plot of Annual Size Class II/ III Juvenile Densities at San Lorenzo Mainstem Sites, 1997-2009.

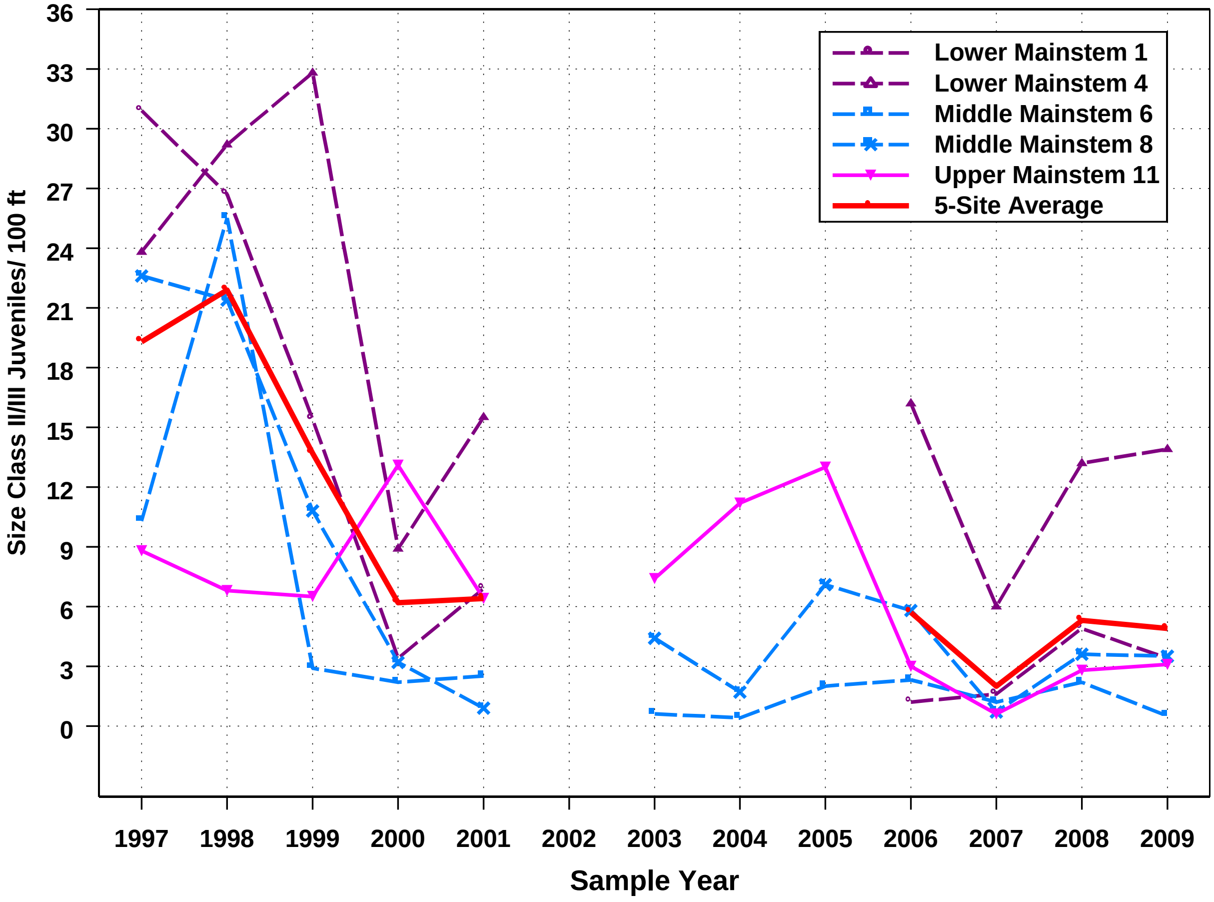


Figure 18. Plot of Annual Size Class II/ III Juvenile Densities at San Lorenzo Tributary Sites, 1997-2009.

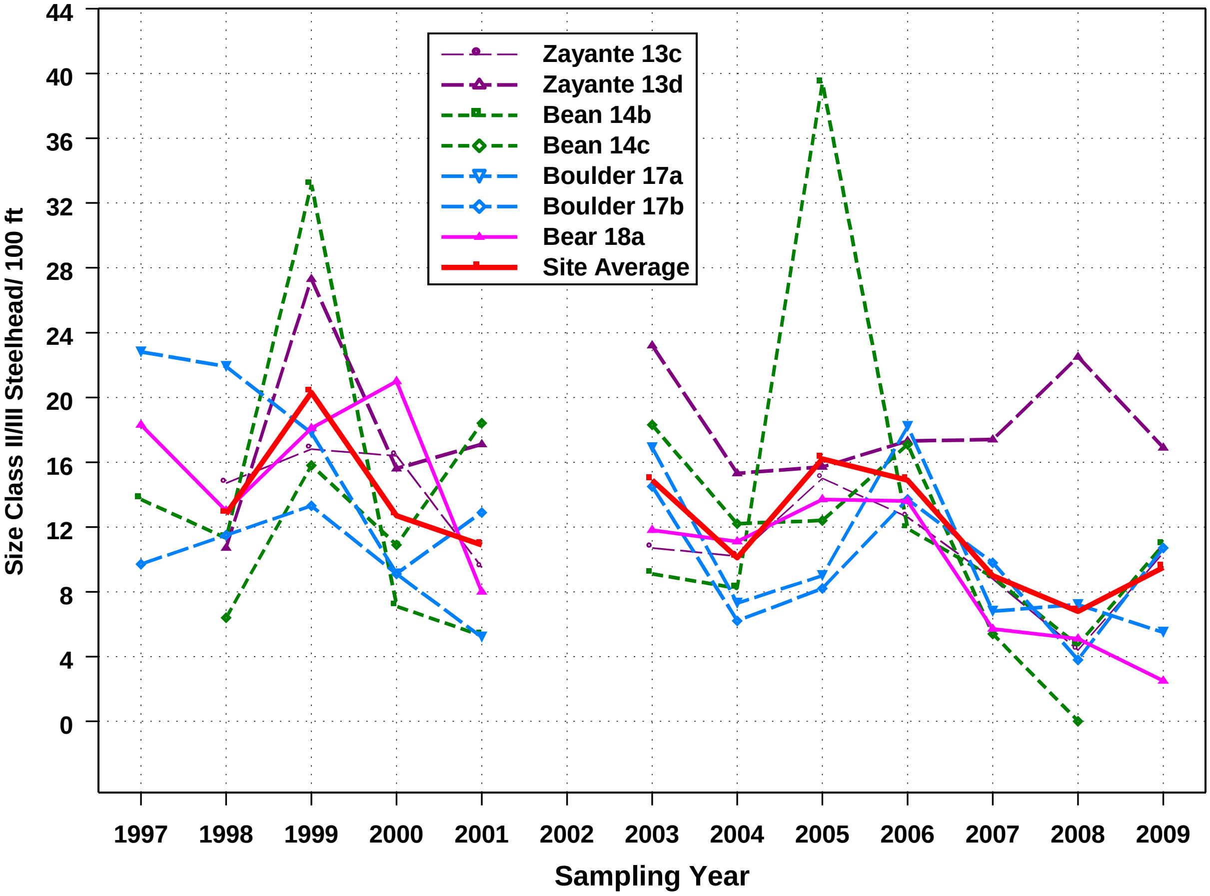


Figure 19. Plot of Annual Total Juvenile Densities at Mainstem Soquel Creek Sites, 1997-2009.

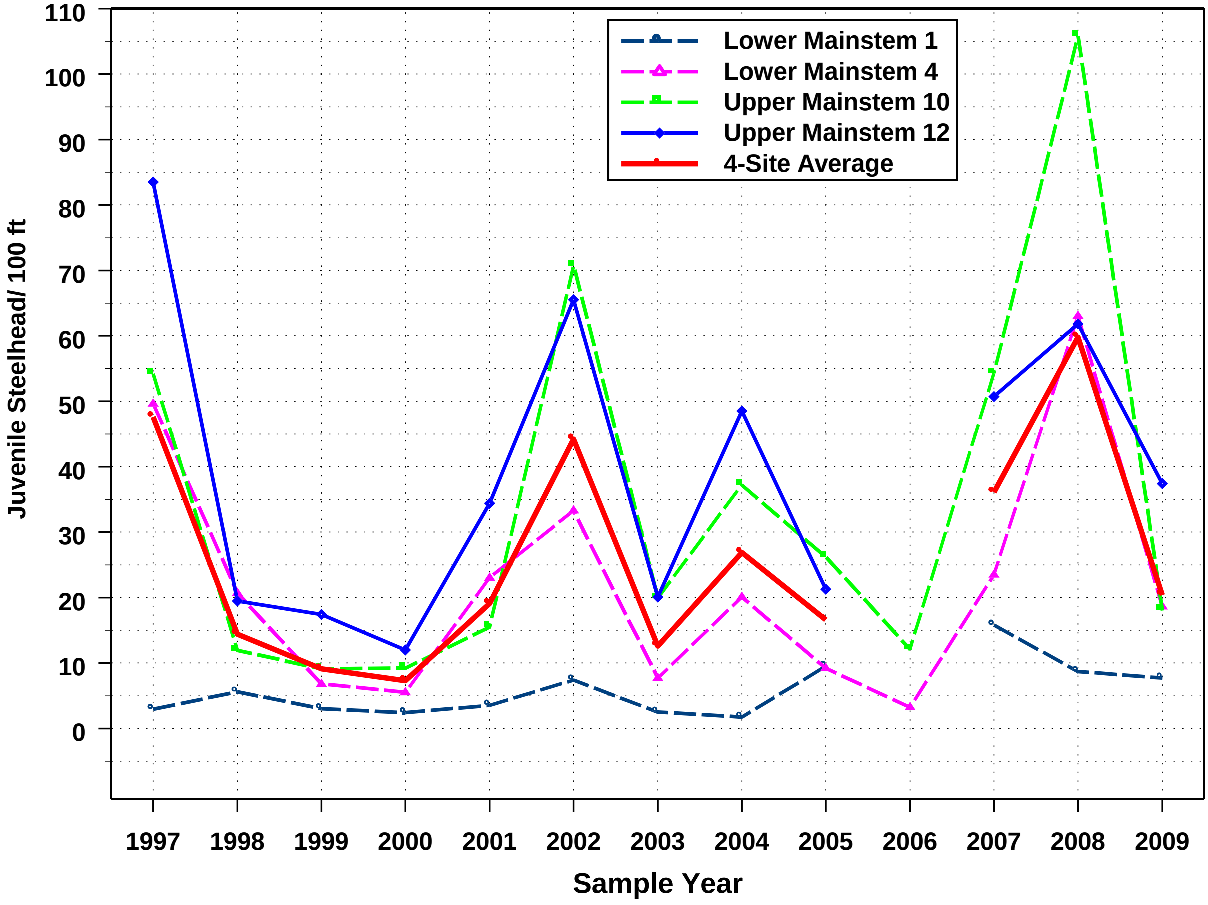


Figure 20. Plot of Annual Total Juvenile Densities at East Branch Soquel Creek Sites, 1997-2009.

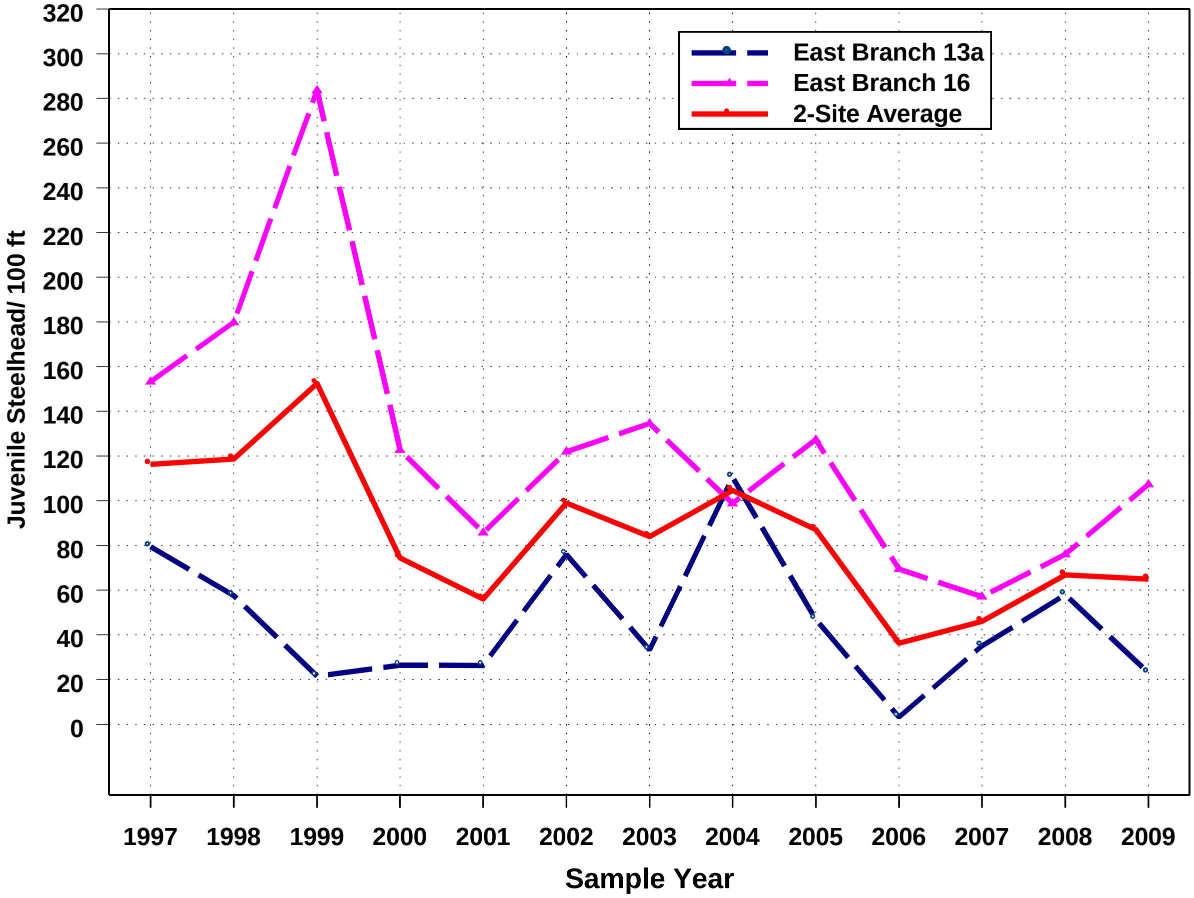


Figure 21. Plot of Annual YOY Densities at Mainstem Soquel Creek Sites, 1997-2009.

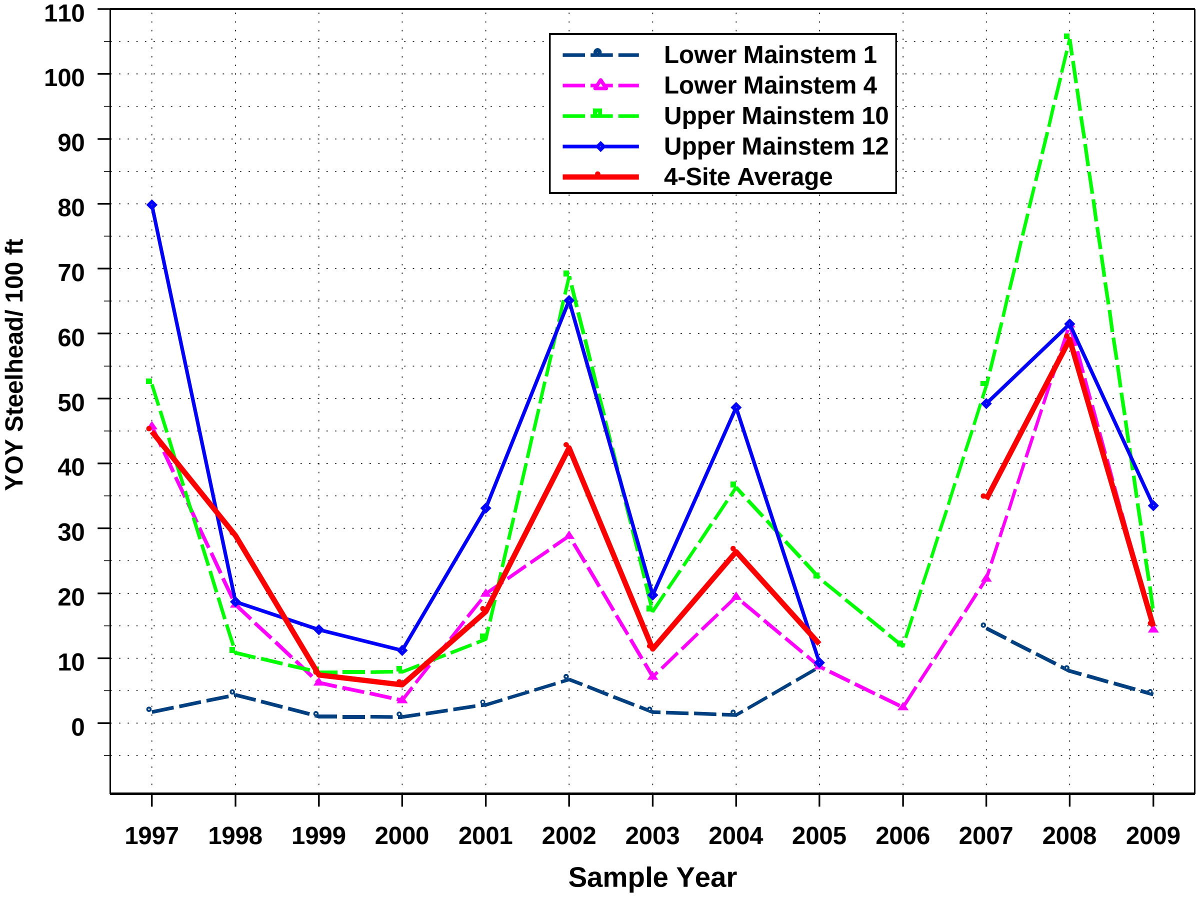


Figure 22. Plot of Annual YOY Densities at East Branch Soquel Creek Sites, 1997-2009.

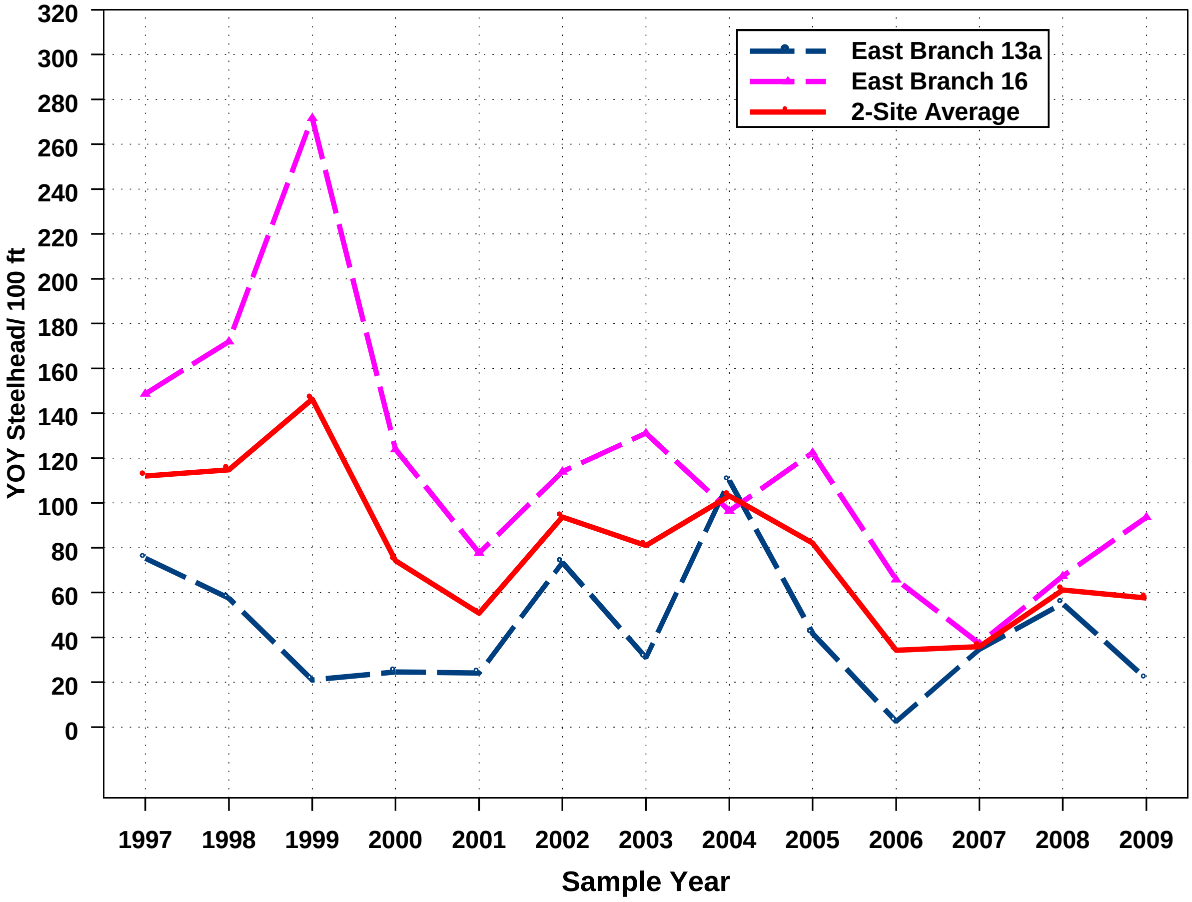


Figure 23. Plot of Annual Size Class II/ III Juvenile Densities at Soquel Mainstem Sites, 1997-2009.

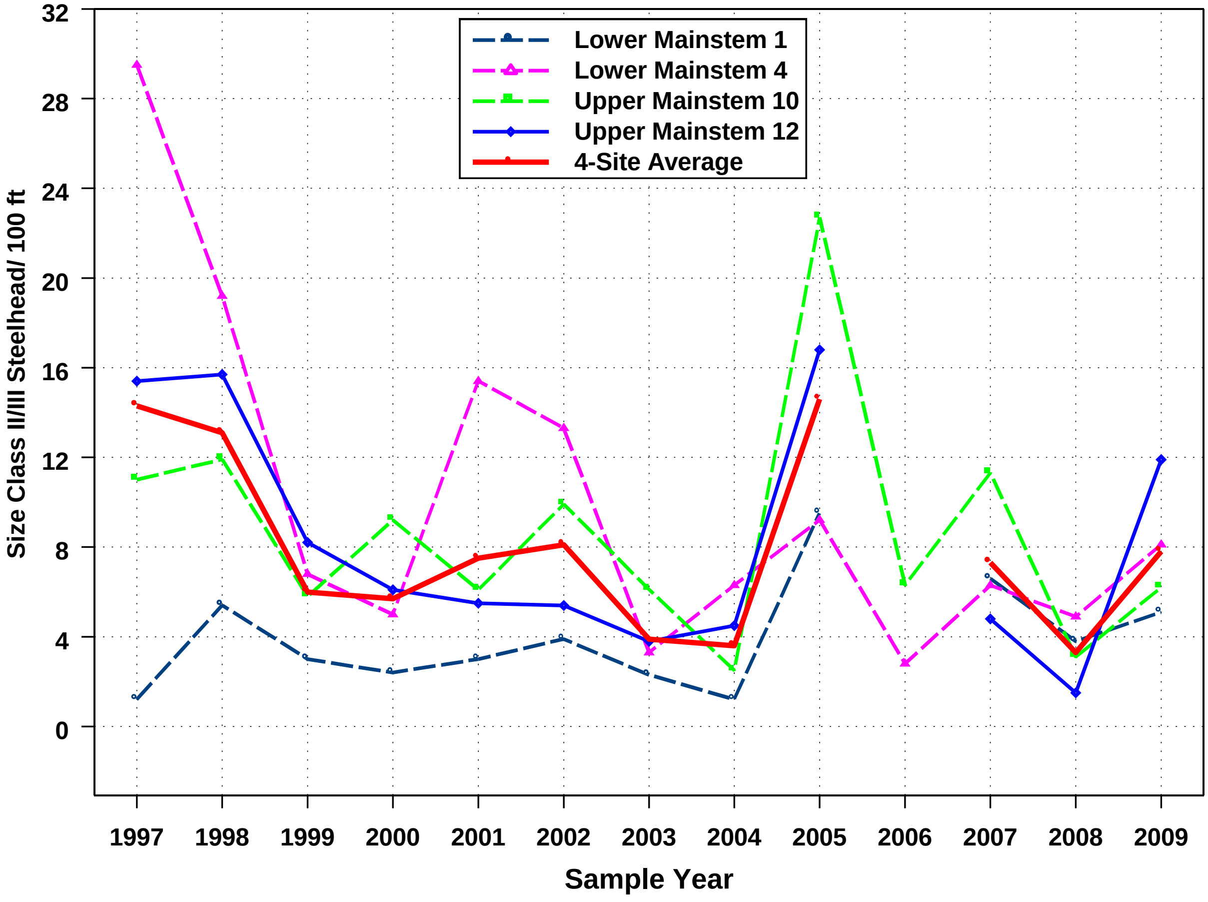


Figure 24. Plot of Annual Size Class II/ III Juvenile Densities at East Branch Soquel Creek Sites, 1997-2009.

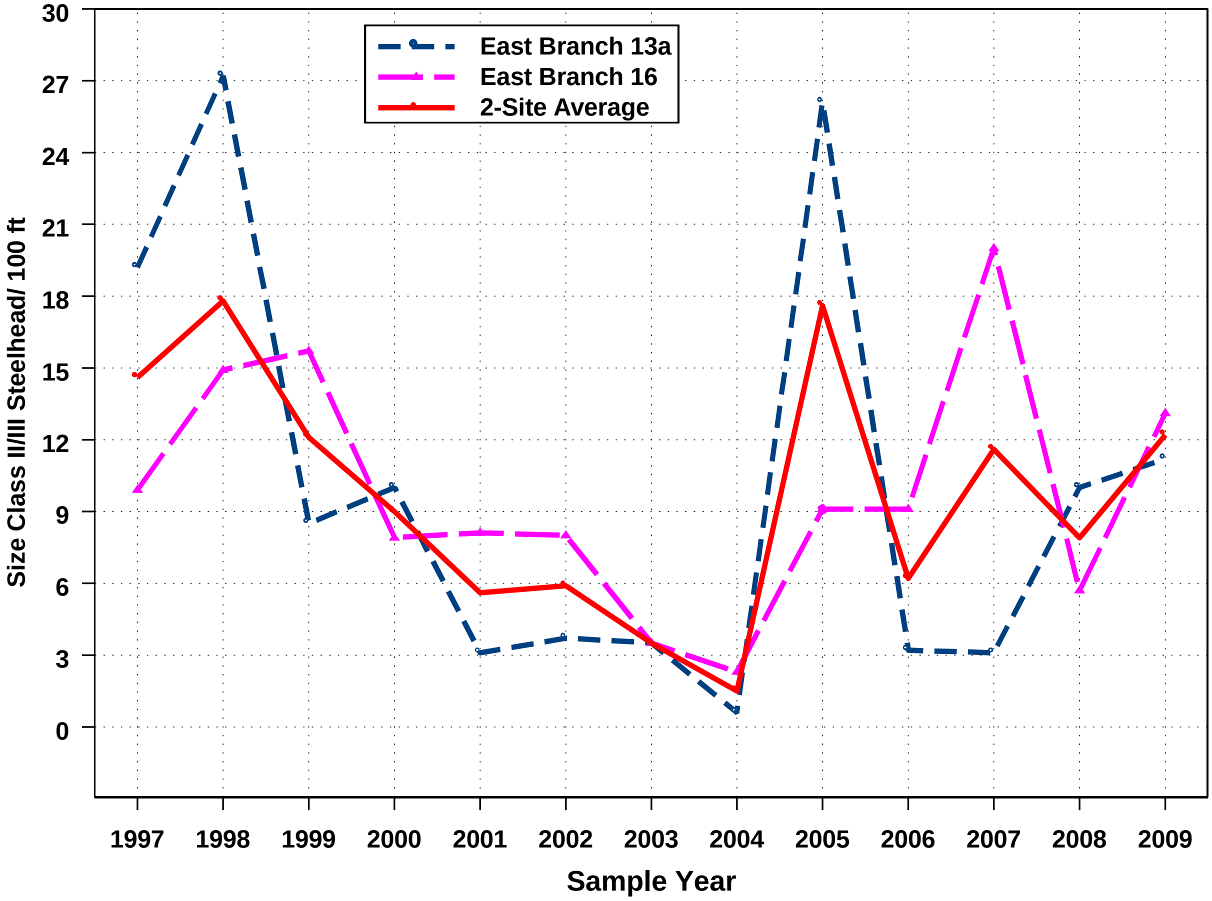


Figure 25. Averaged Mean Monthly Streamflow for May–September, 1997–2009 at the Big Trees Gage on the San Lorenzo River.

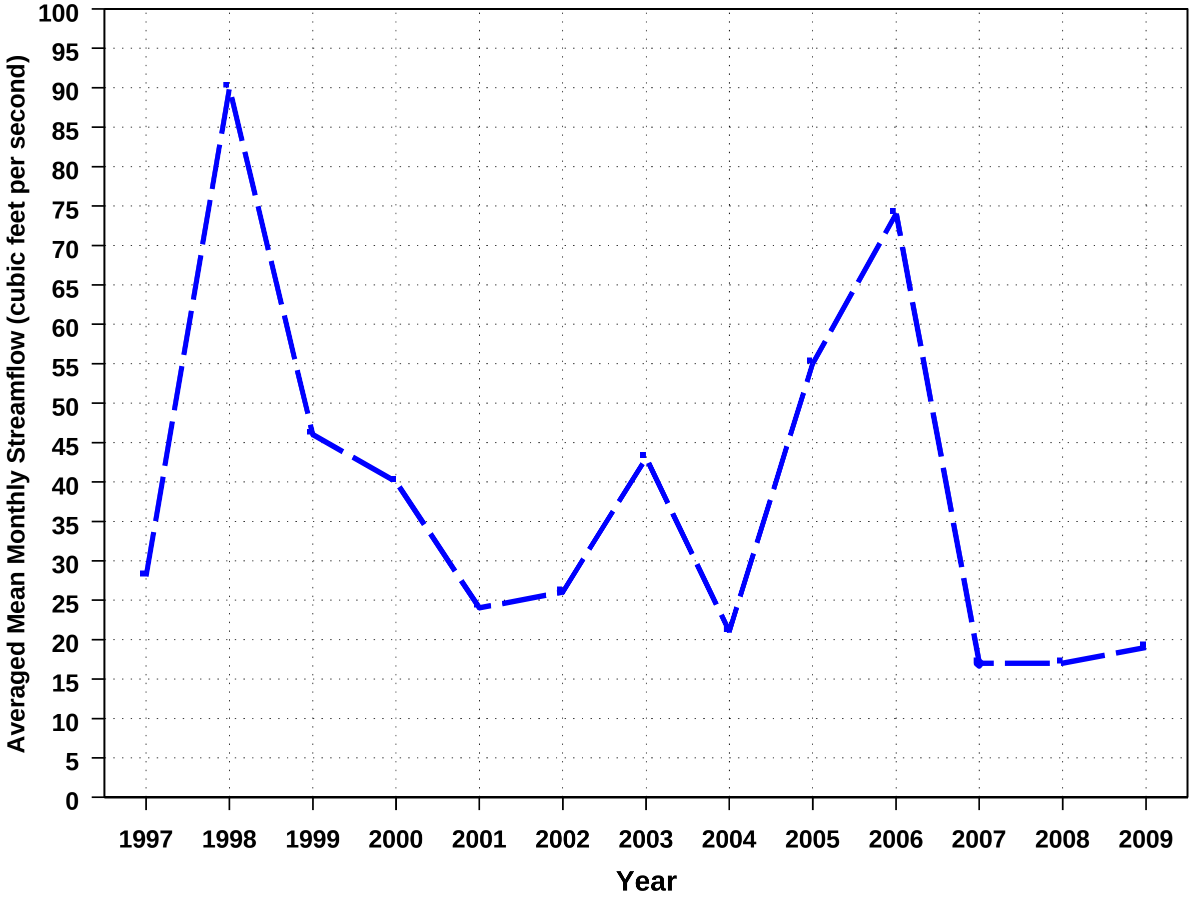


Figure 26. Averaged Mean Monthly Streamflow for May–September, 1997–2009 at the Soquel Village Gage on Soquel Creek.

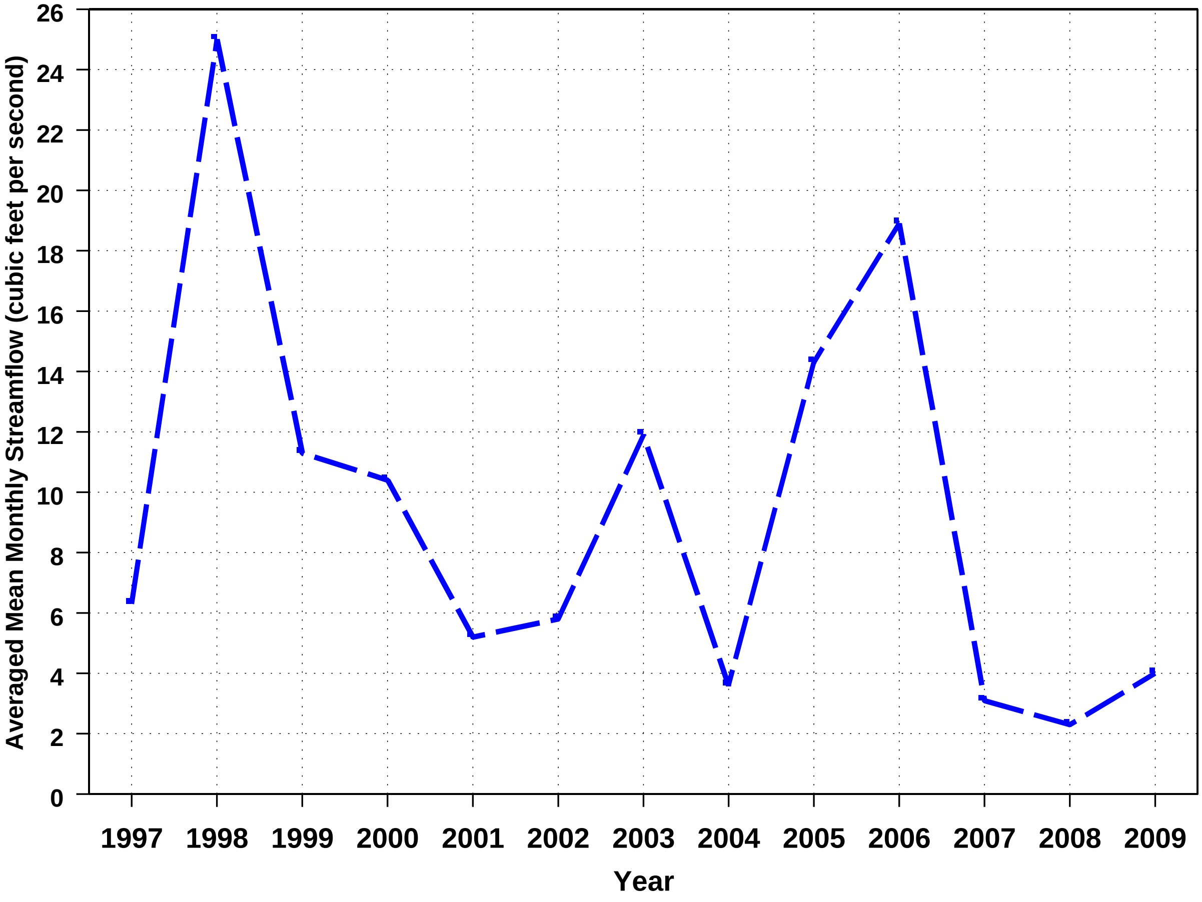


Figure 27. Averaged Maximum and Mean Riffle Depth in Reach 4 of the Lower Mainstem San Lorenzo River, 1997-2002 and 2006-2008.

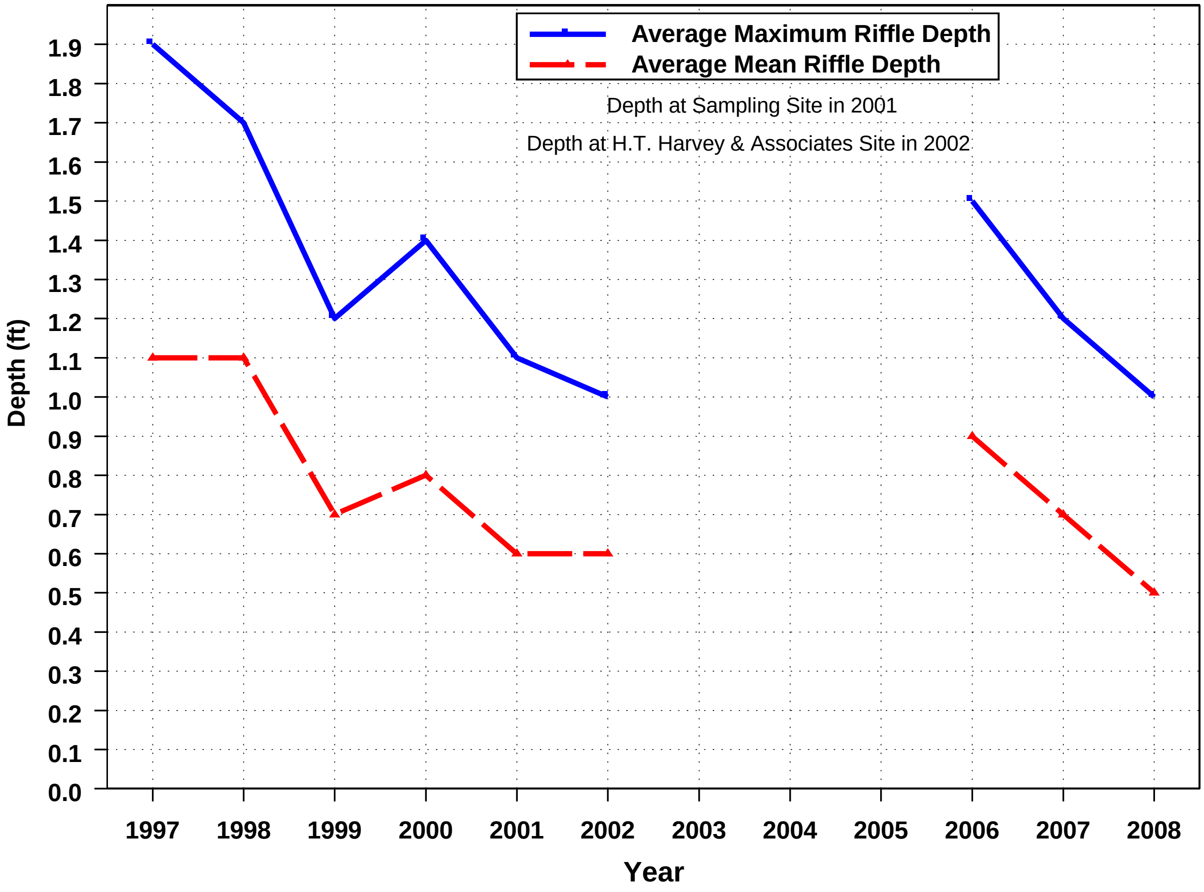


Figure 28. Escape Cover Index for Riffle Habitat in Reach 4 of the Lower Mainstem San Lorenzo River, 1998-2000 and 2006-2008.

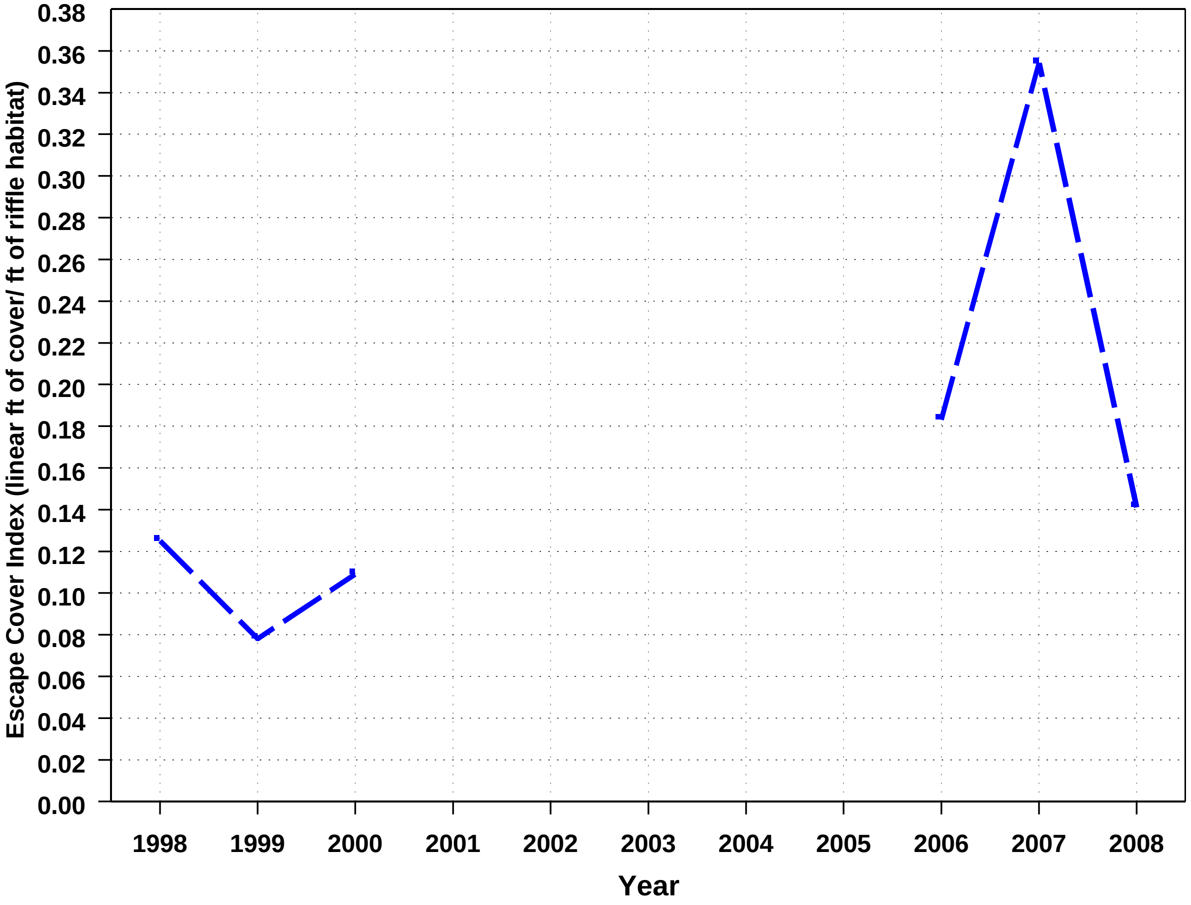


Figure 29. Averaged Percent Fines in Riffle Habitat in Reach 4 of the Lower Mainstem San Lorenzo River, 1997-2001 and 2006-2008.

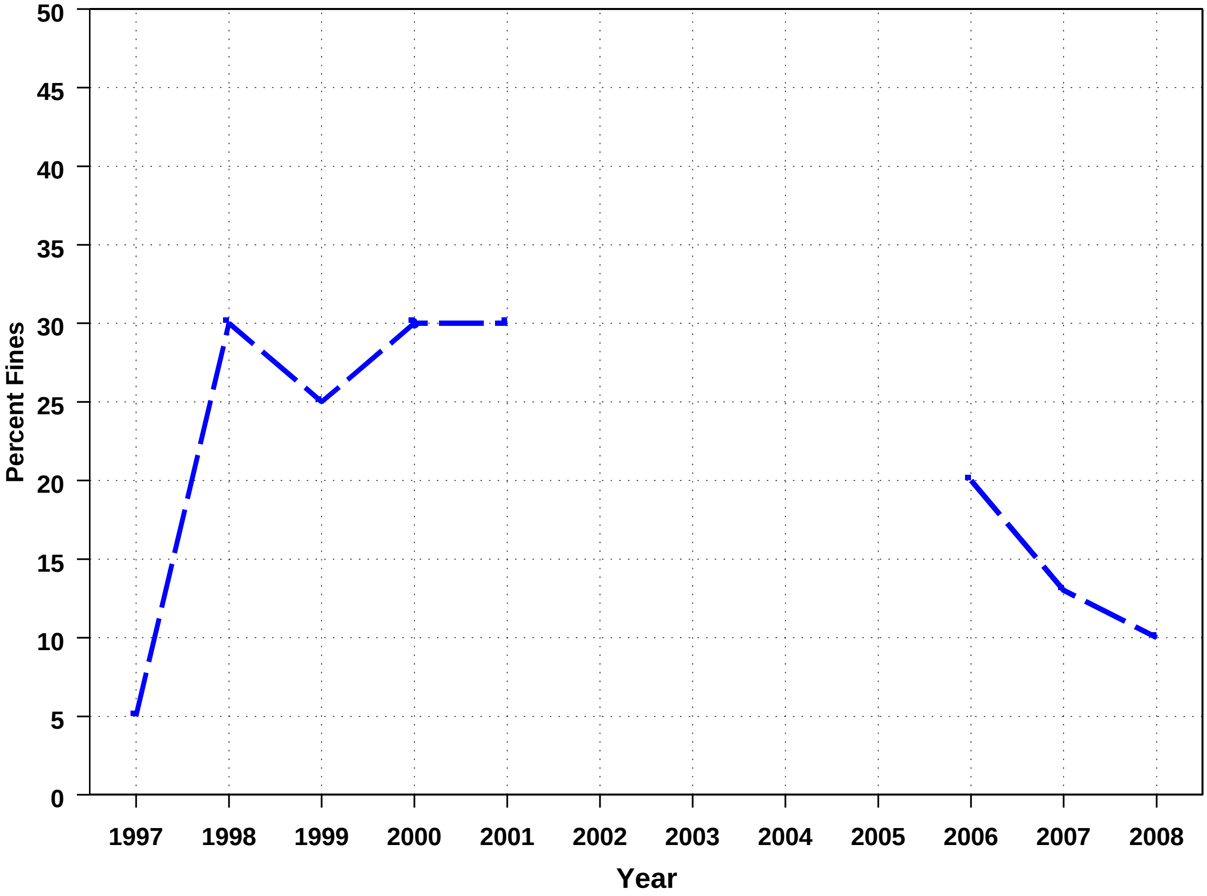


Figure 30. Averaged Maximum and Mean Riffle Depth in Reach 8 of the Middle Mainstem San Lorenzo River, 1997-2009.

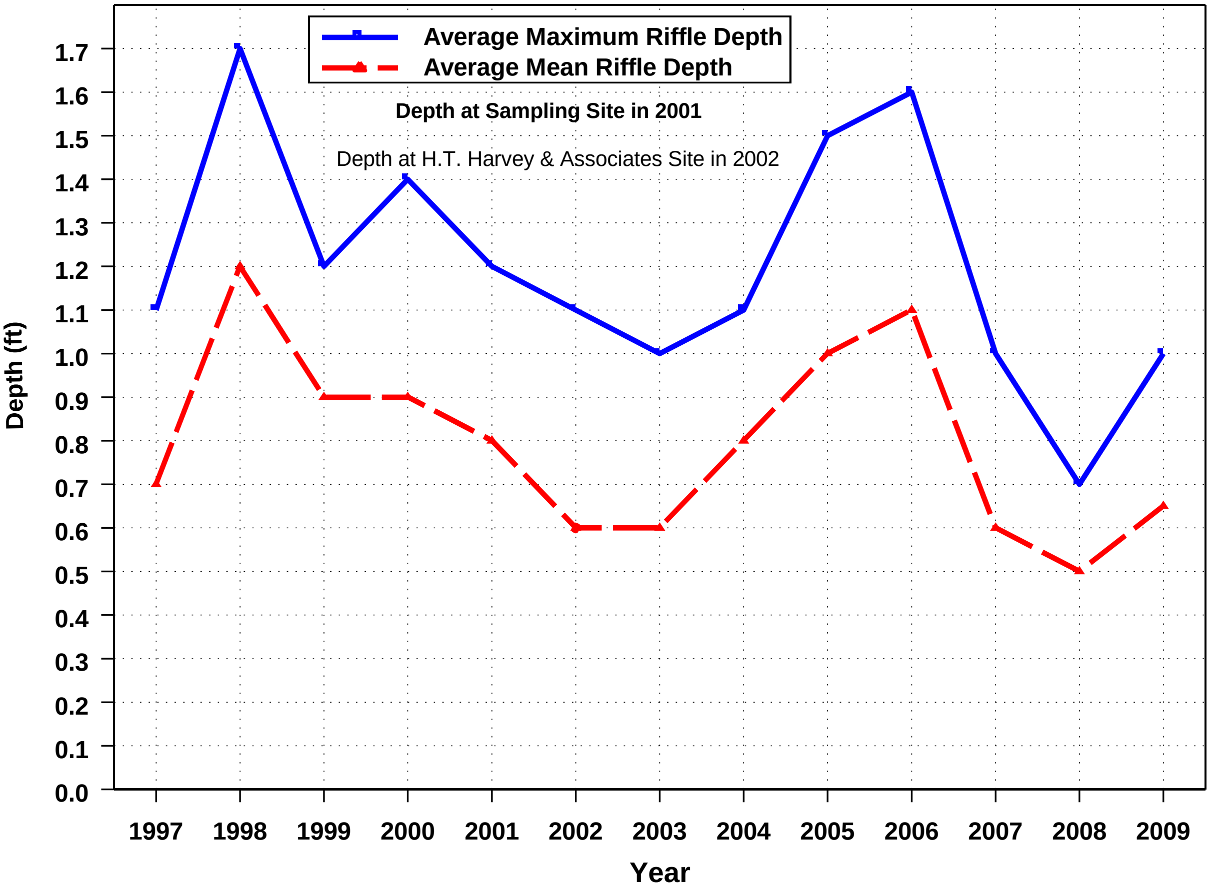


Figure 31. Escape Cover Index for Riffle Habitat in Reach 8 of the Middle Mainstem San Lorenzo River, 1998-2000, 2003 and 2005-2009.

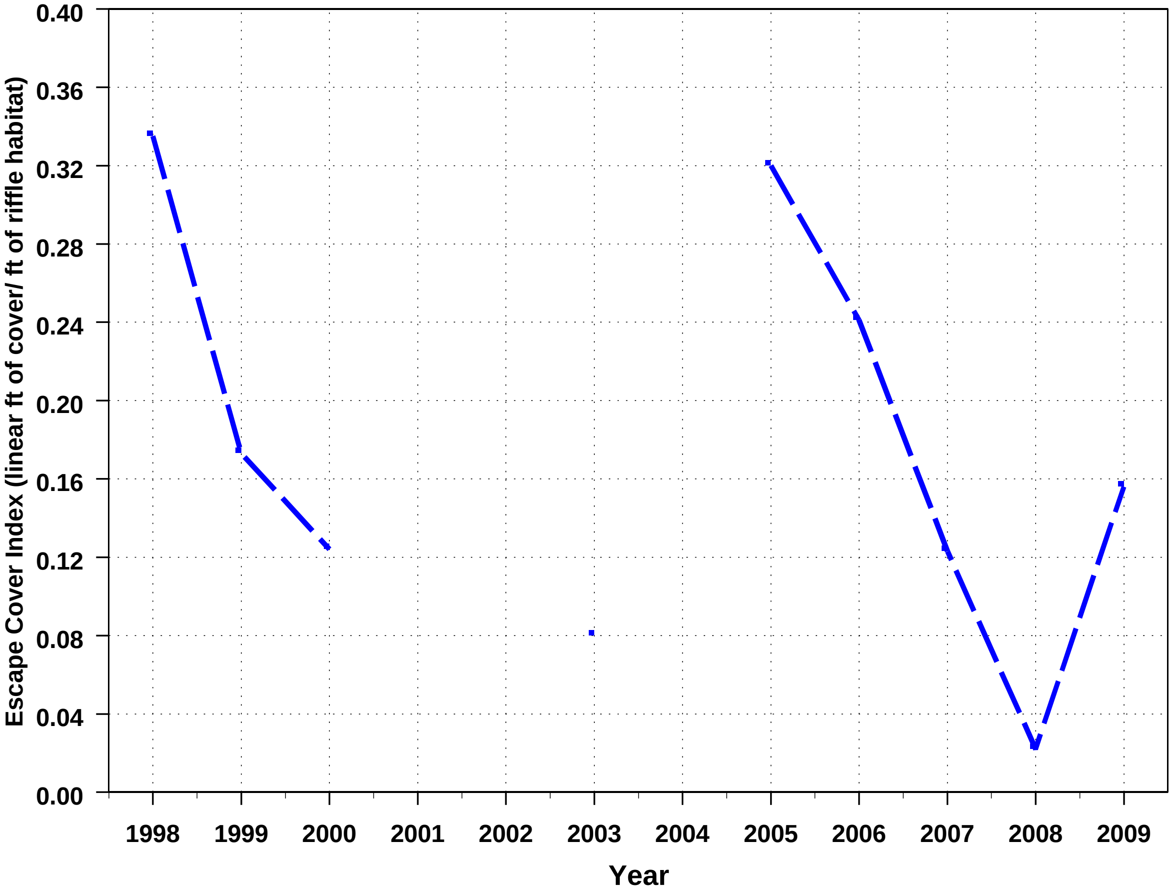


Figure 32. Averaged Percent Fines in Riffle Habitat in Reach 8 of the Middle Mainstem San Lorenzo River, 1997-2001, 2003 and 2005-2009.

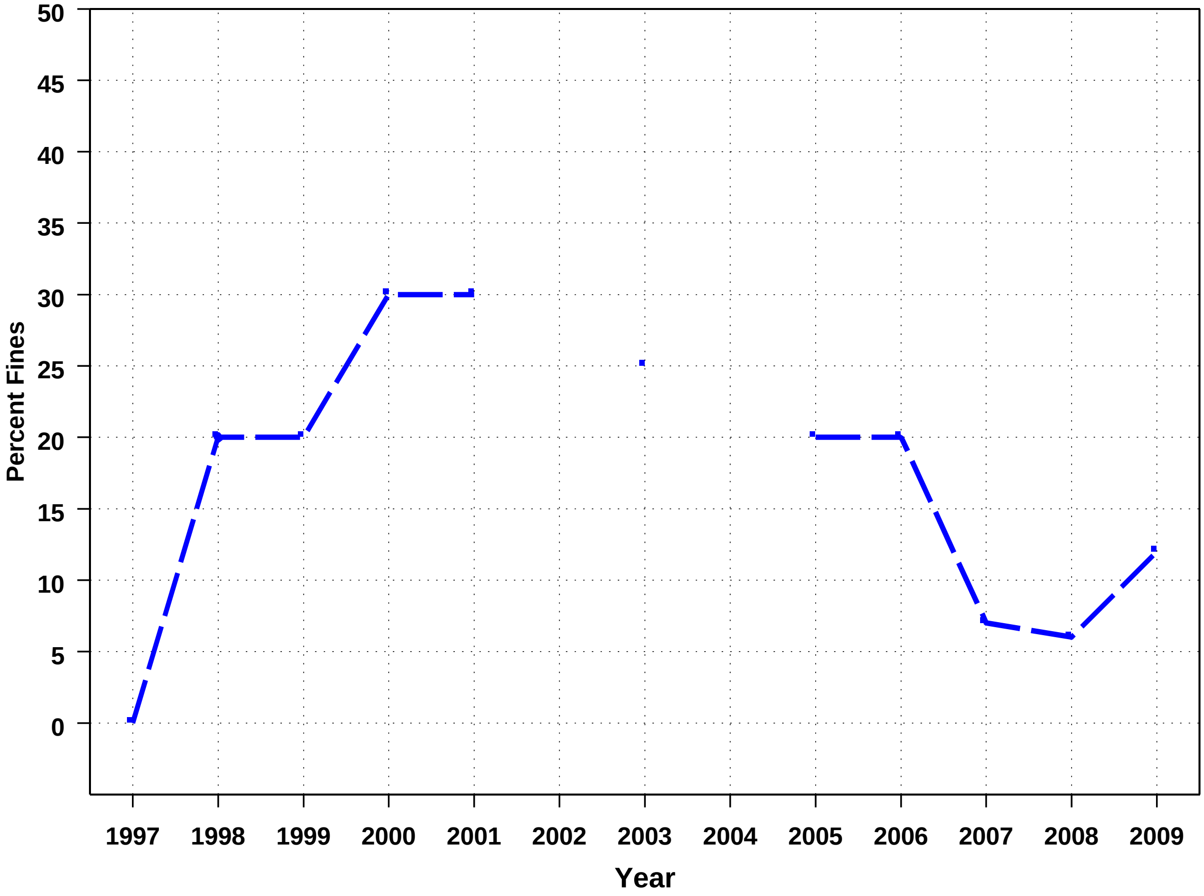


Figure 33. Averaged Maximum and Mean Pool Depth in Reach 13d of Zayante Creek, 1998-2000, 2003 and 2005-2009.

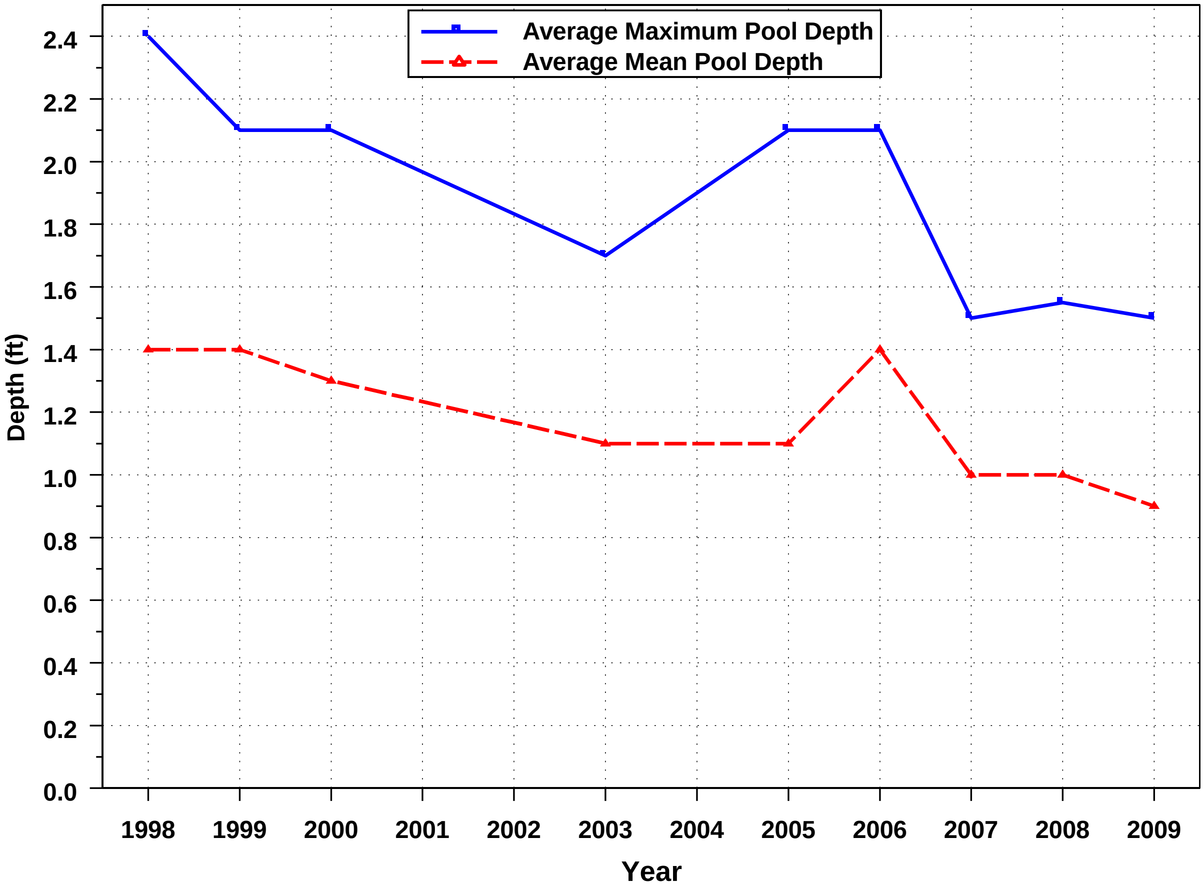


Figure 34a. Escape Cover Index for Pool Habitat in Reach 13d of Zayante Creek, 1998-2000, 2003 and 2005-2009.

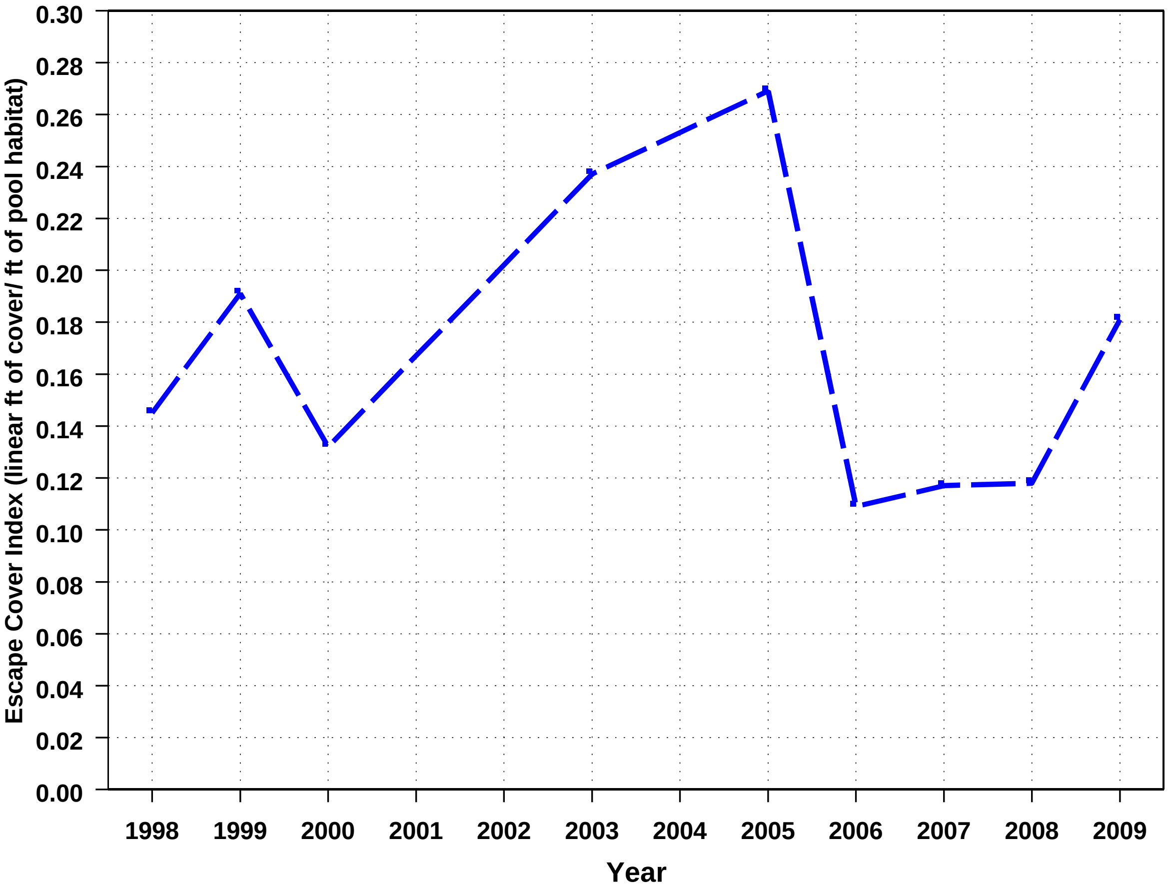


Figure 34b. Escape Cover Index for Pool Habitat at Site 13d in Zayante Creek, 1998-2001 and 2003-2009.

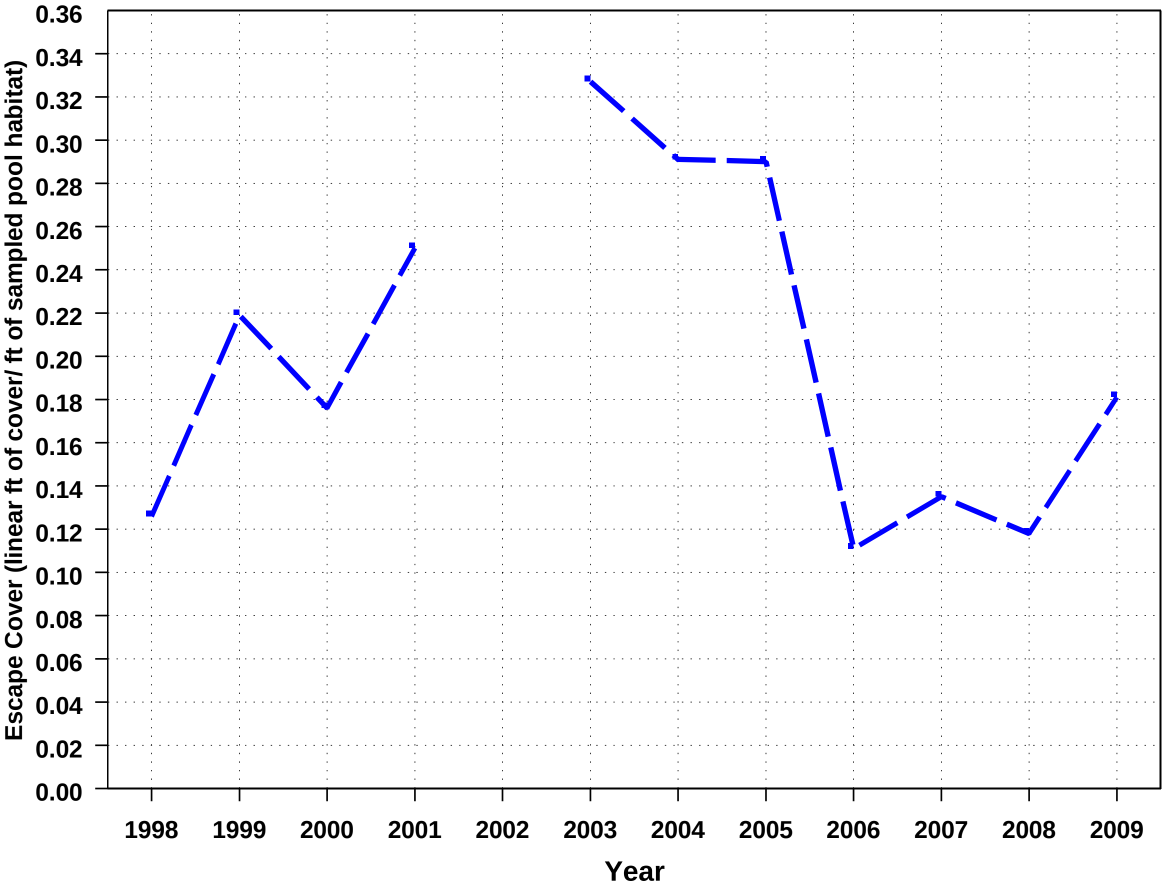


Figure 35. Averaged Percent Fines in Step-Run Habitat in Reach 13d of Zayante Creek, 1998-2001, 2003-2009.

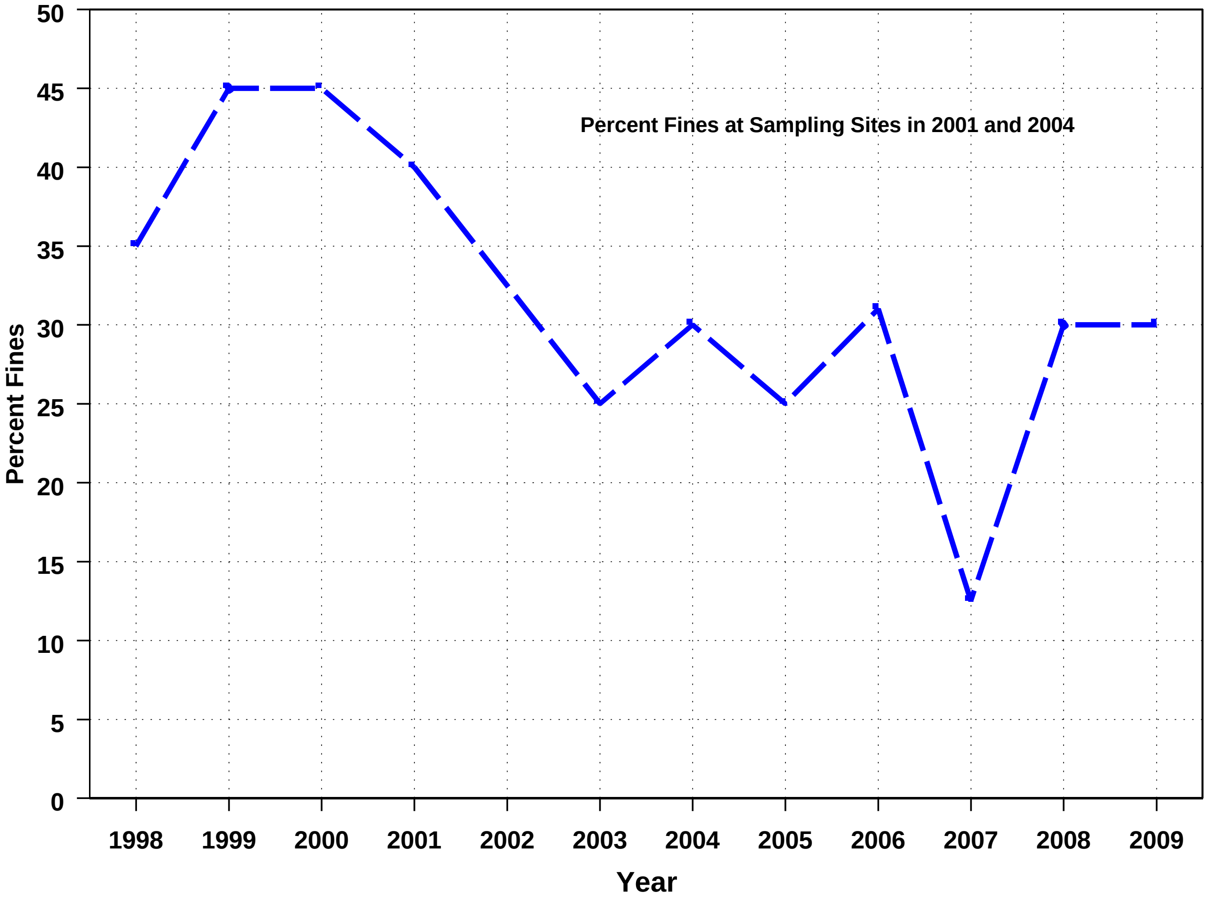


Figure 36. Averaged Maximum and Mean Pool Depth in Reach 17a of Boulder Creek, 1998-2000 and 2005-2009.

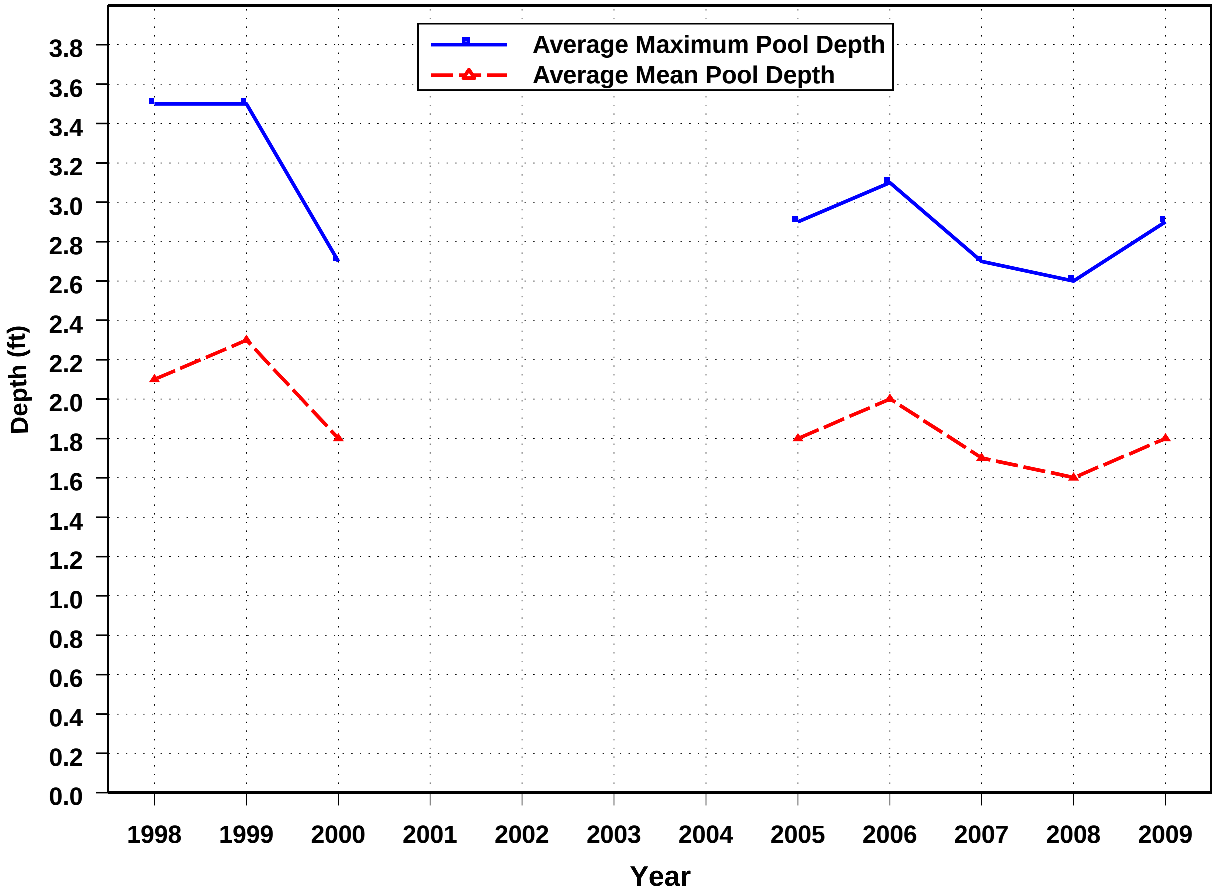


Figure 37a. Escape Cover Index for Pool Habitat in Reach 17a of Boulder Creek, 1998-2000 and 2005-2009.

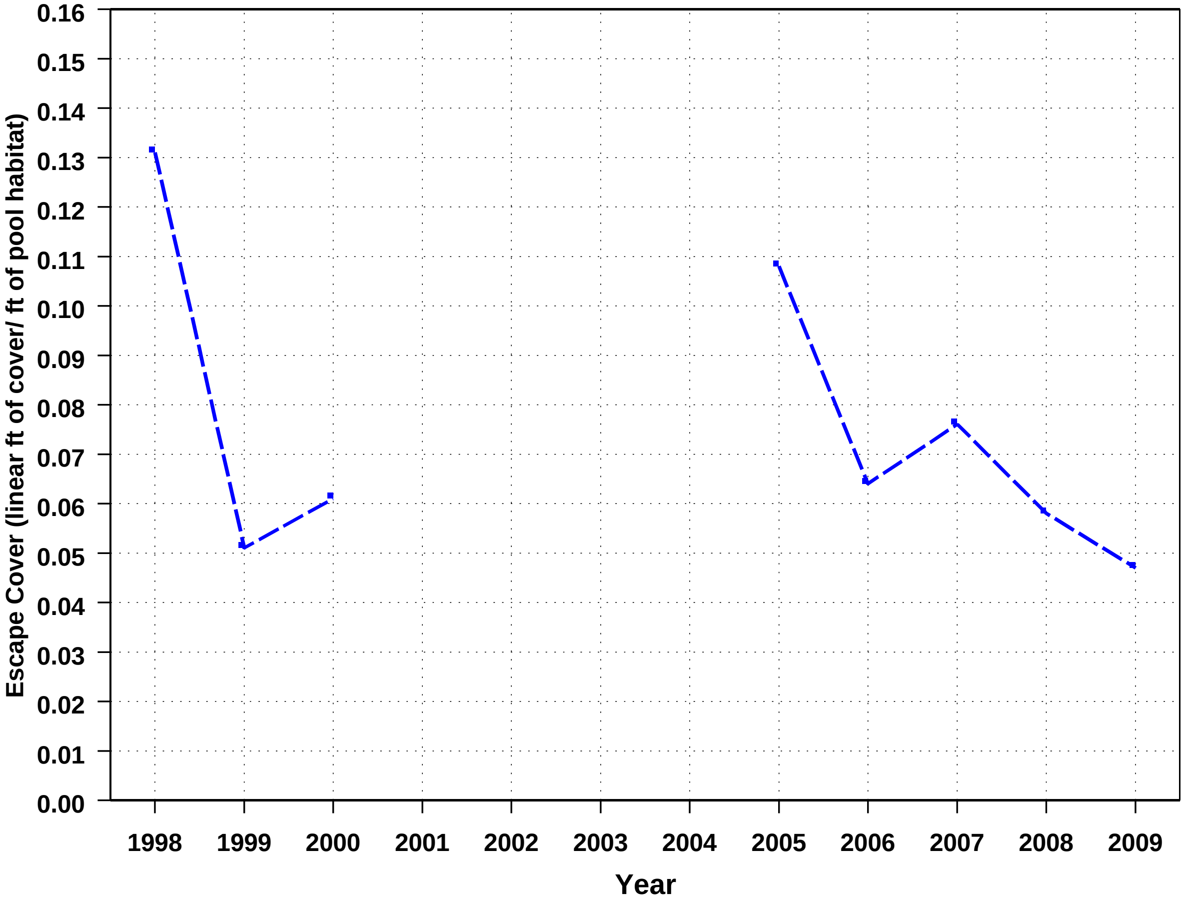


Figure 37b. Escape Cover Index for Pool Habitat at Site 17a in Boulder Creek, 1997-2001 and 2003-2009.

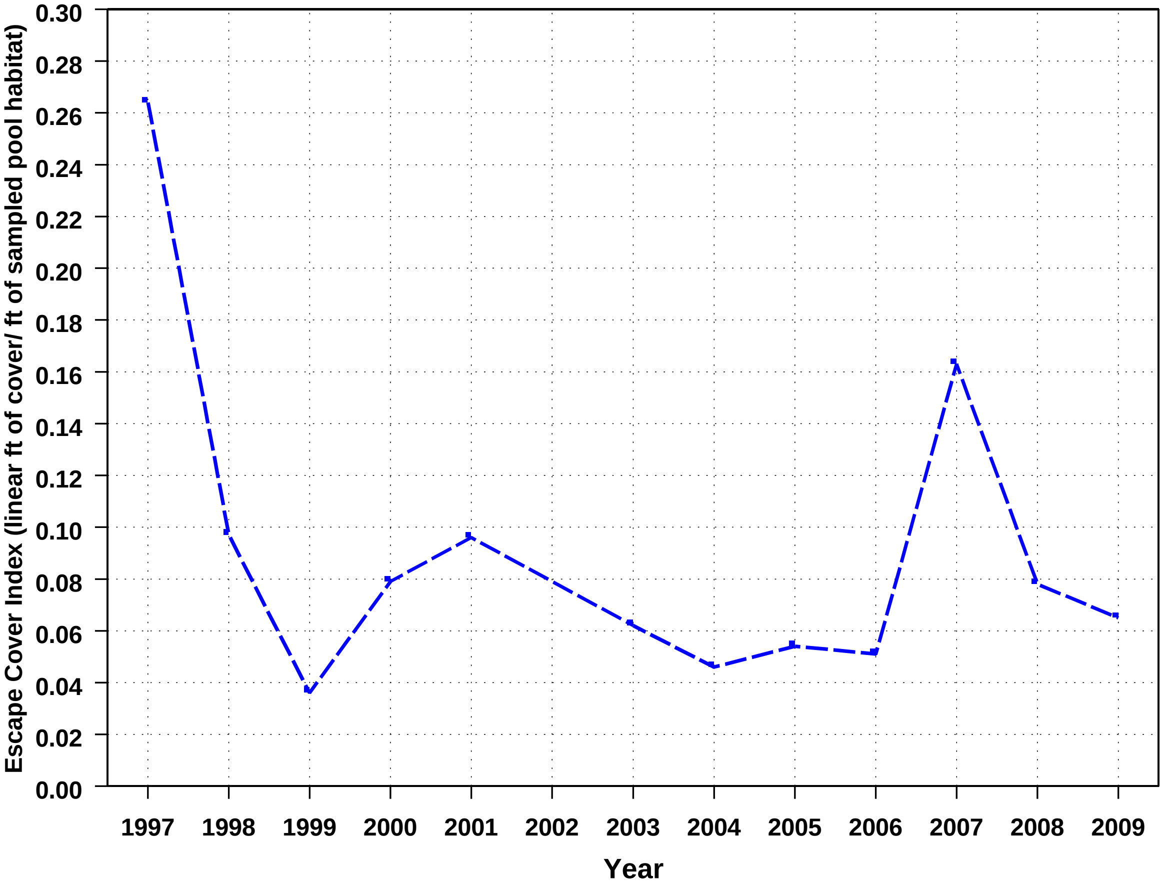


Figure 38. Averaged Percent Fines in Step-Run Habitat in Reach 17a of Boulder Creek, 1998-2001 and 2003-2009.

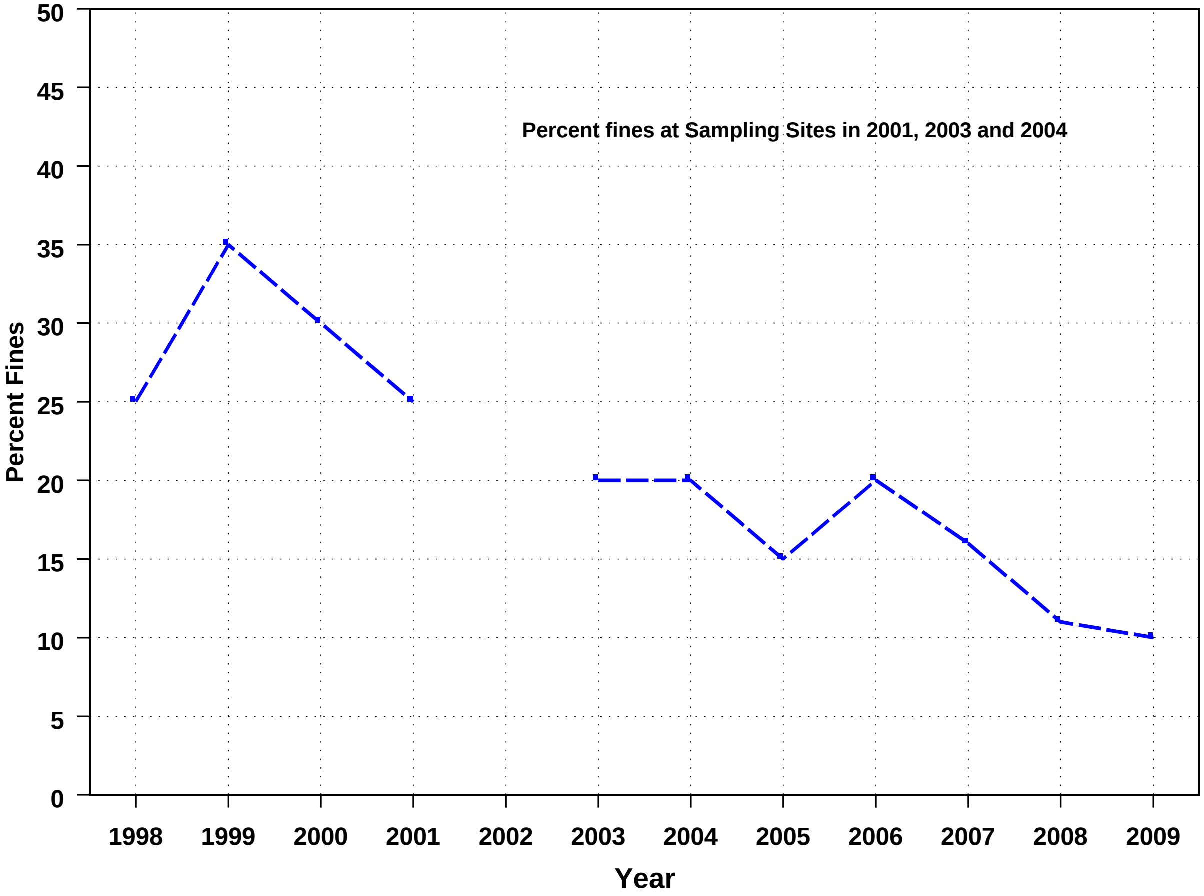


Figure 39. Averaged Maximum and Mean Pool Depth in Reach 1 of Soquel Creek, 1997-2009.

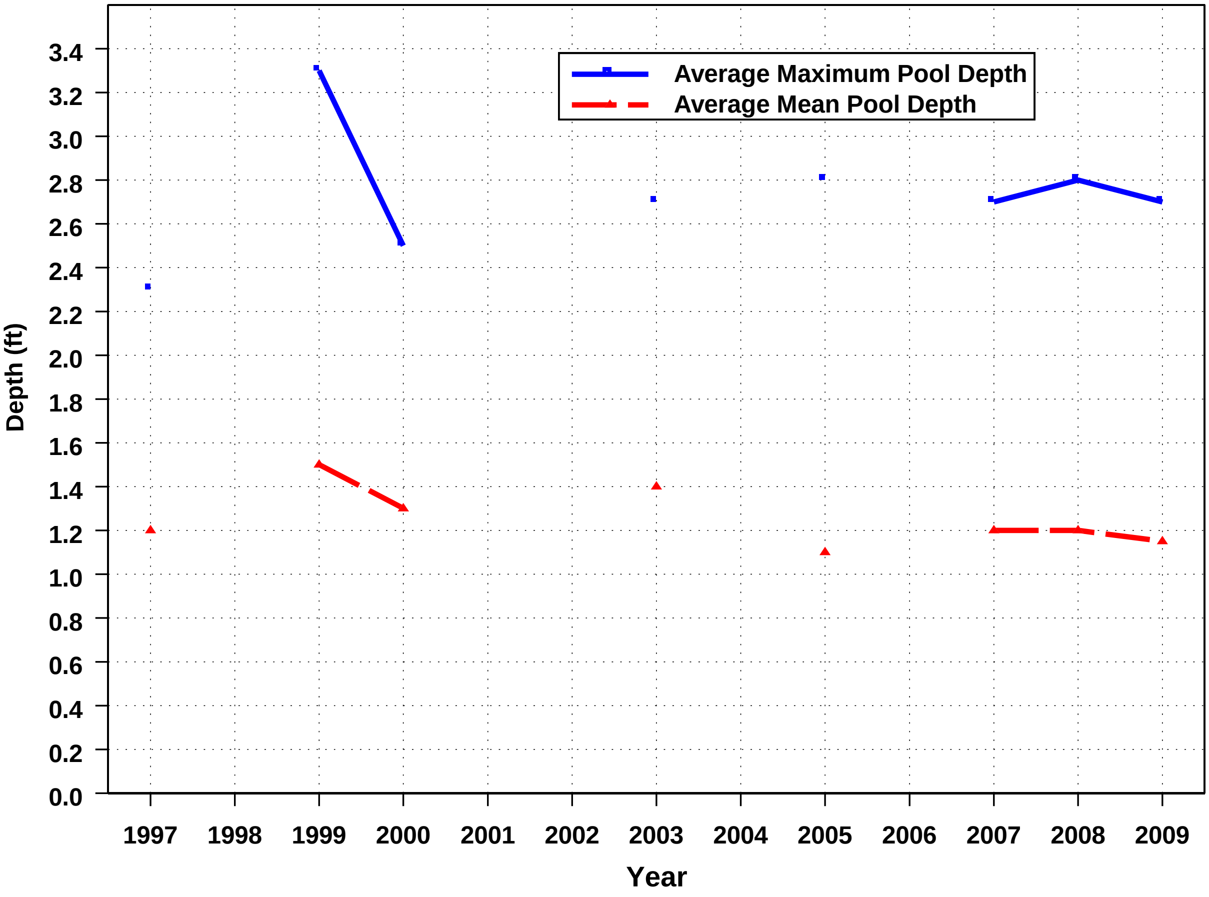


Figure 40a. Escape Cover Index for Pool Habitat in Reach 1 of Soquel Creek, 1997-2009.

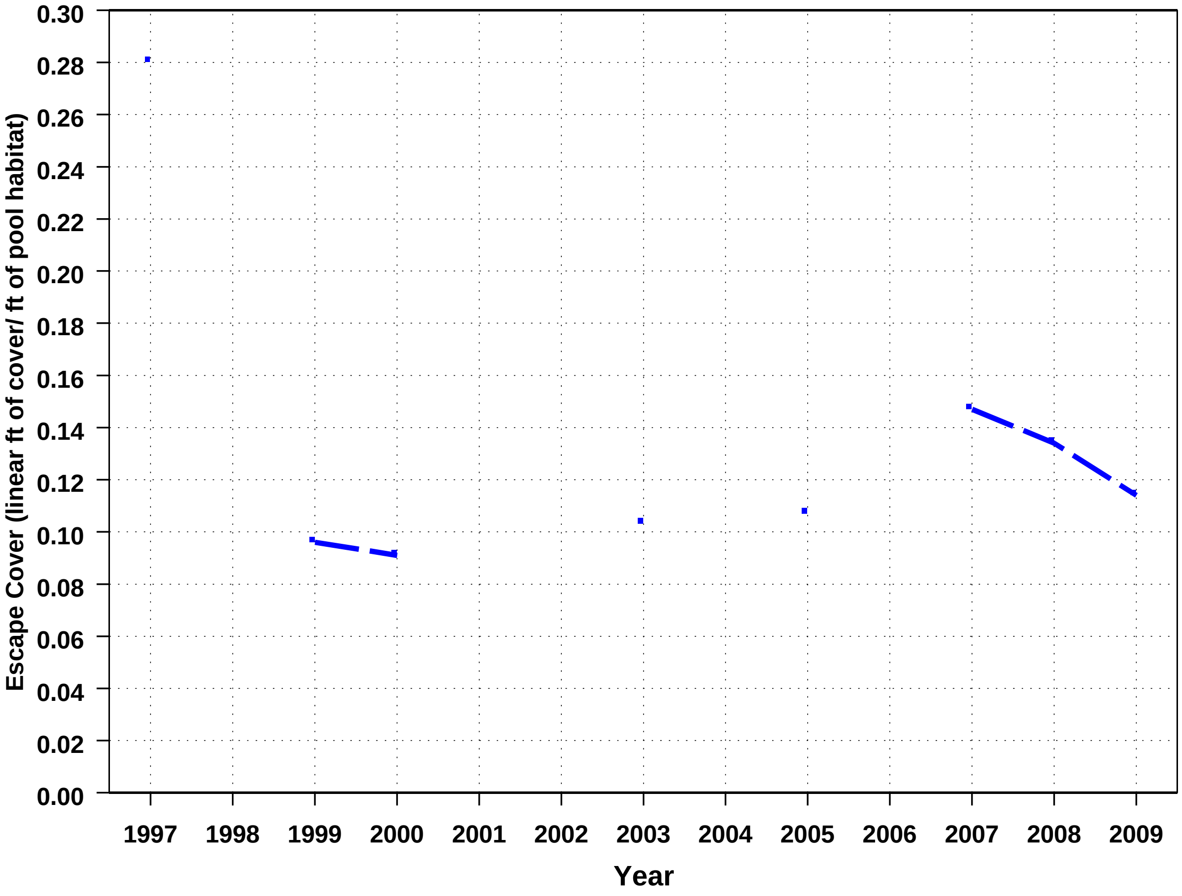


Figure 40b. Escape Cover Index for Pool Habitat at Site 1 in Soquel Creek, 1997-2005 and 2008-2009.

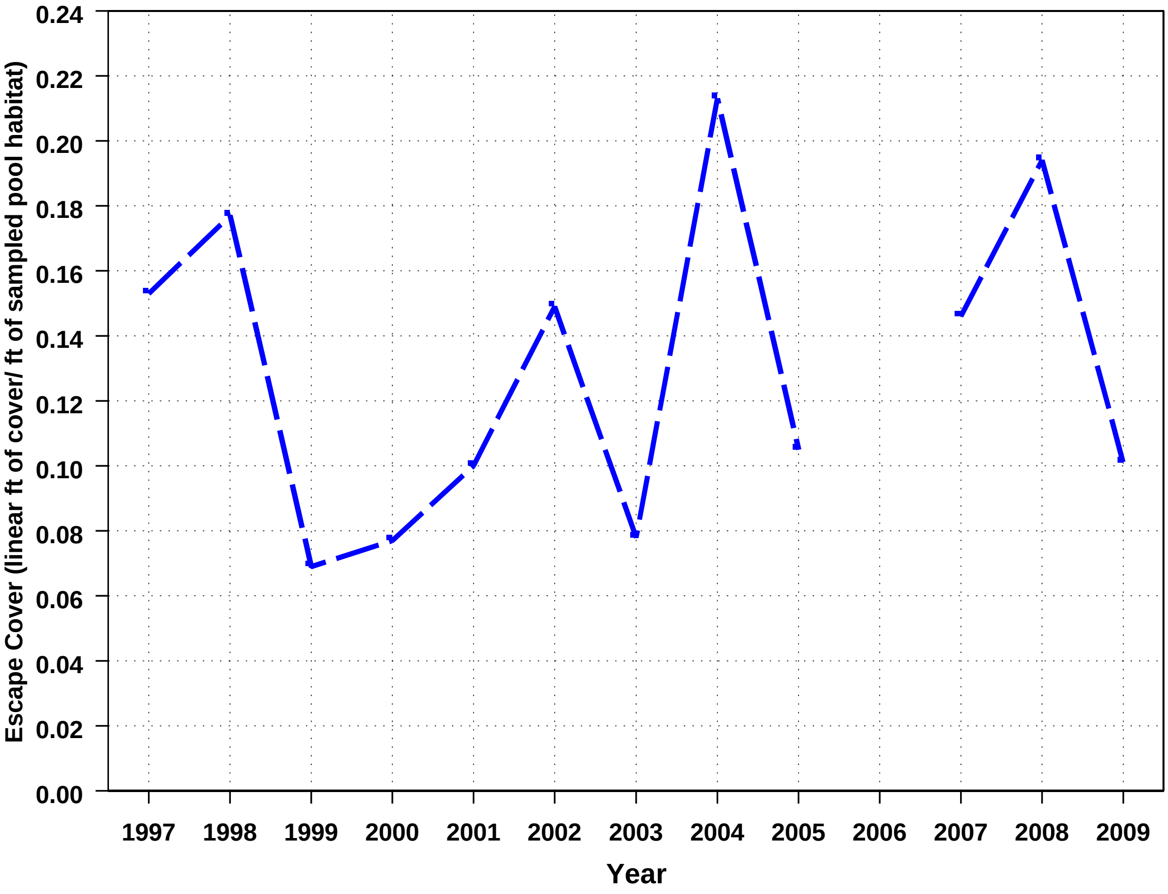


Figure 41. Average Embeddedness for Riffle and Run Habitat at the Sampling Site in Reach 1, of Soquel Creek, 1997-2009.

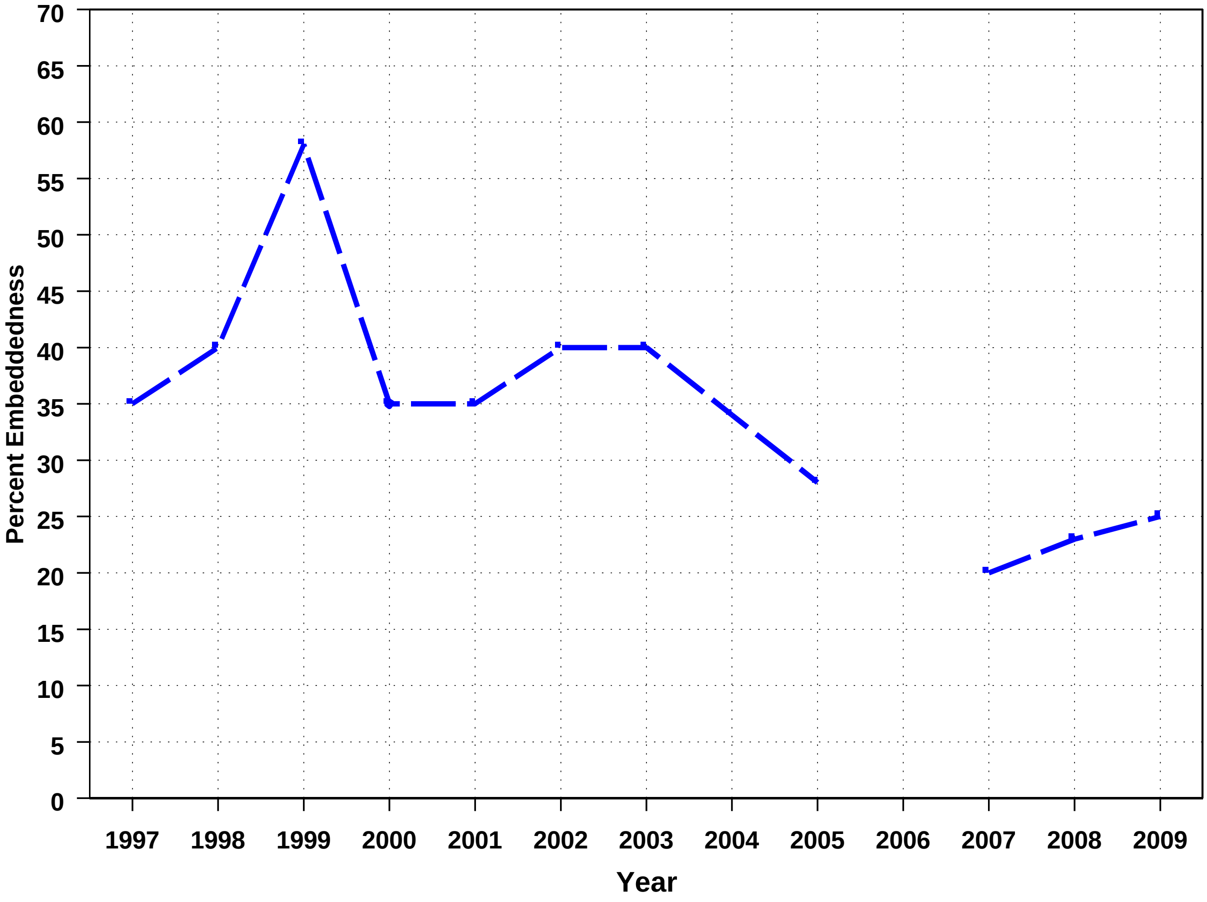


Figure 42. Averaged Maximum and Mean Pool Depth in Reach 7 (Above Moores Gulch) of Soquel Creek, 1997-2009.

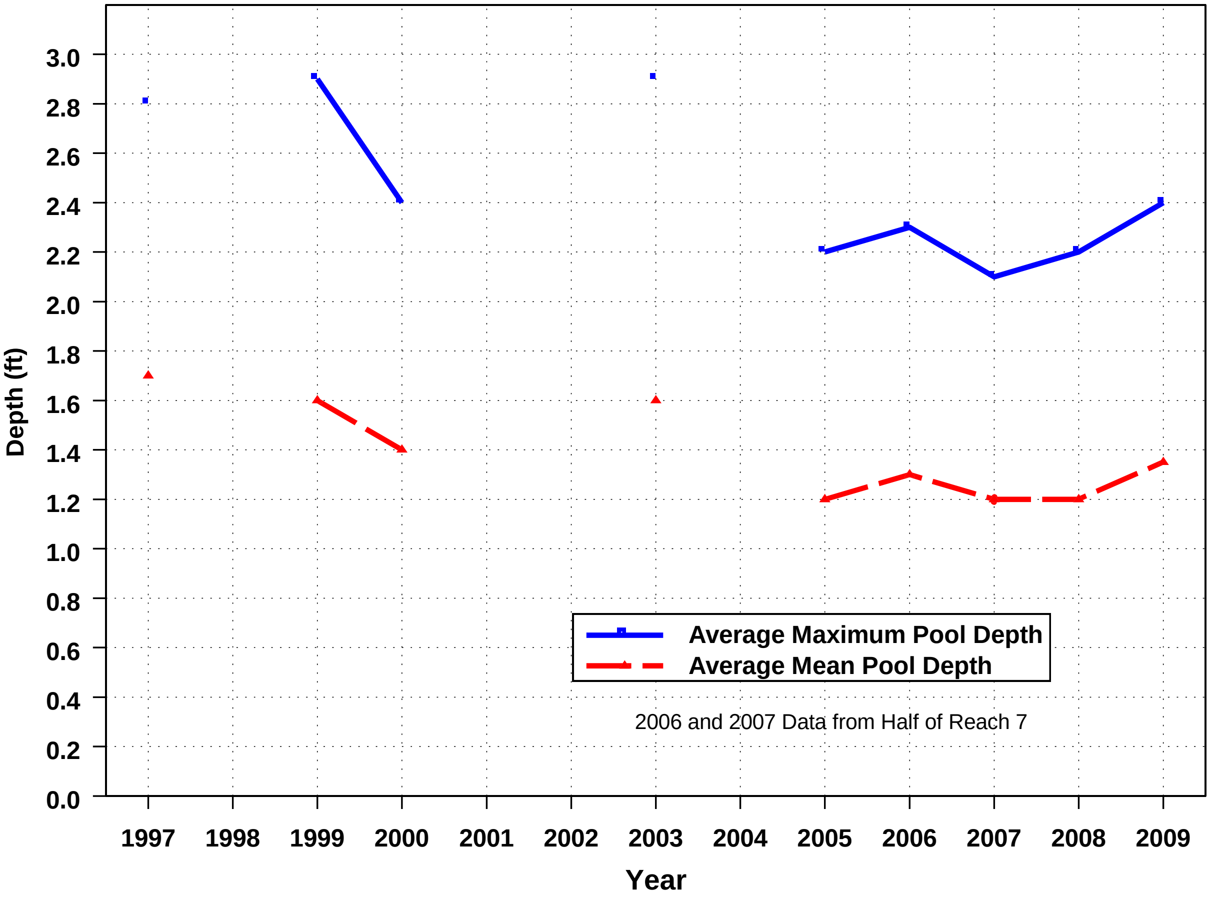


Figure 43a. Escape Cover Index for Pool Habitat in Reach 7 (Above Moores Gulch) of Soquel Creek, 1997-2009.

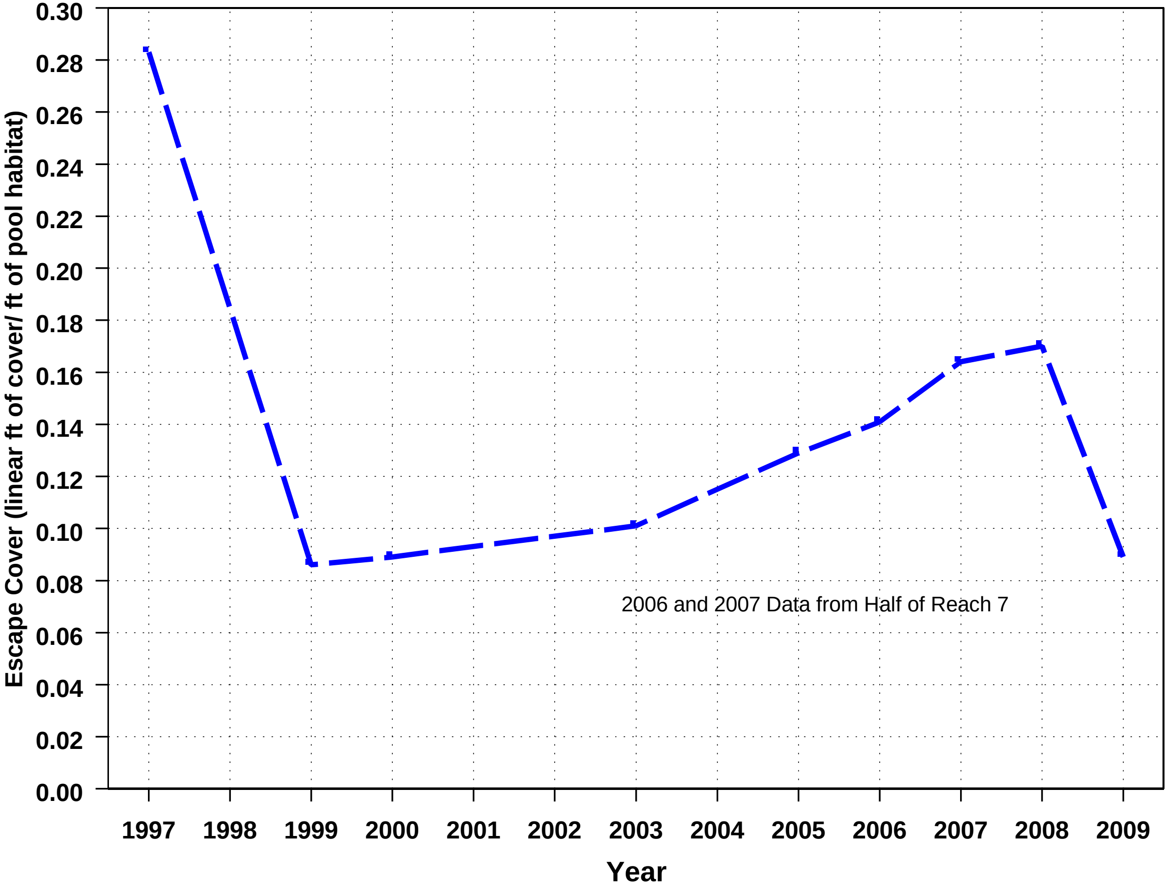


Figure 43b. Escape Cover Index for Pool Habitat at Site 10 (Reach 7 Above Moores Gulch) in Soquel Creek, 1997-2009.

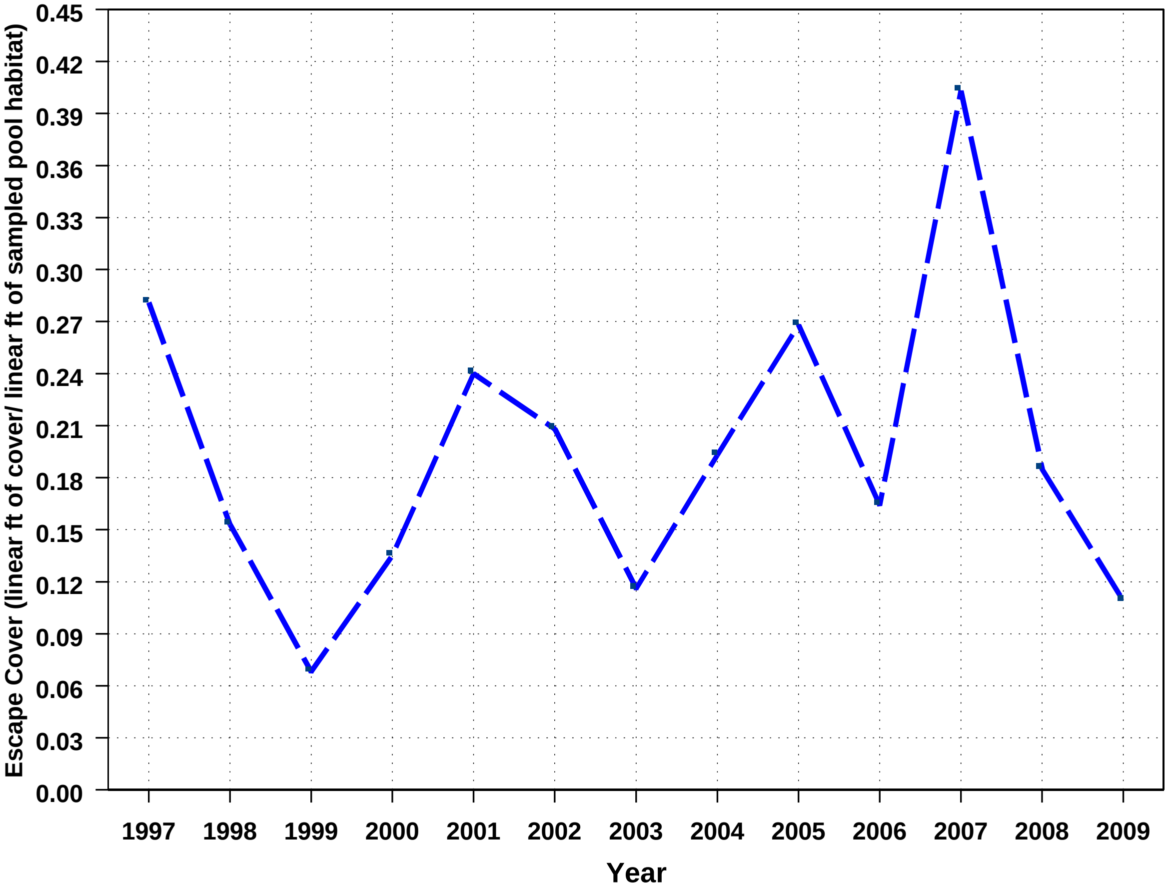


Figure 44. Average Embeddedness for Riffle and Run Habitat at Sampling Site 10 in Reach 7 (Above Moores Gulch) of Soquel Creek, 1997-2009.

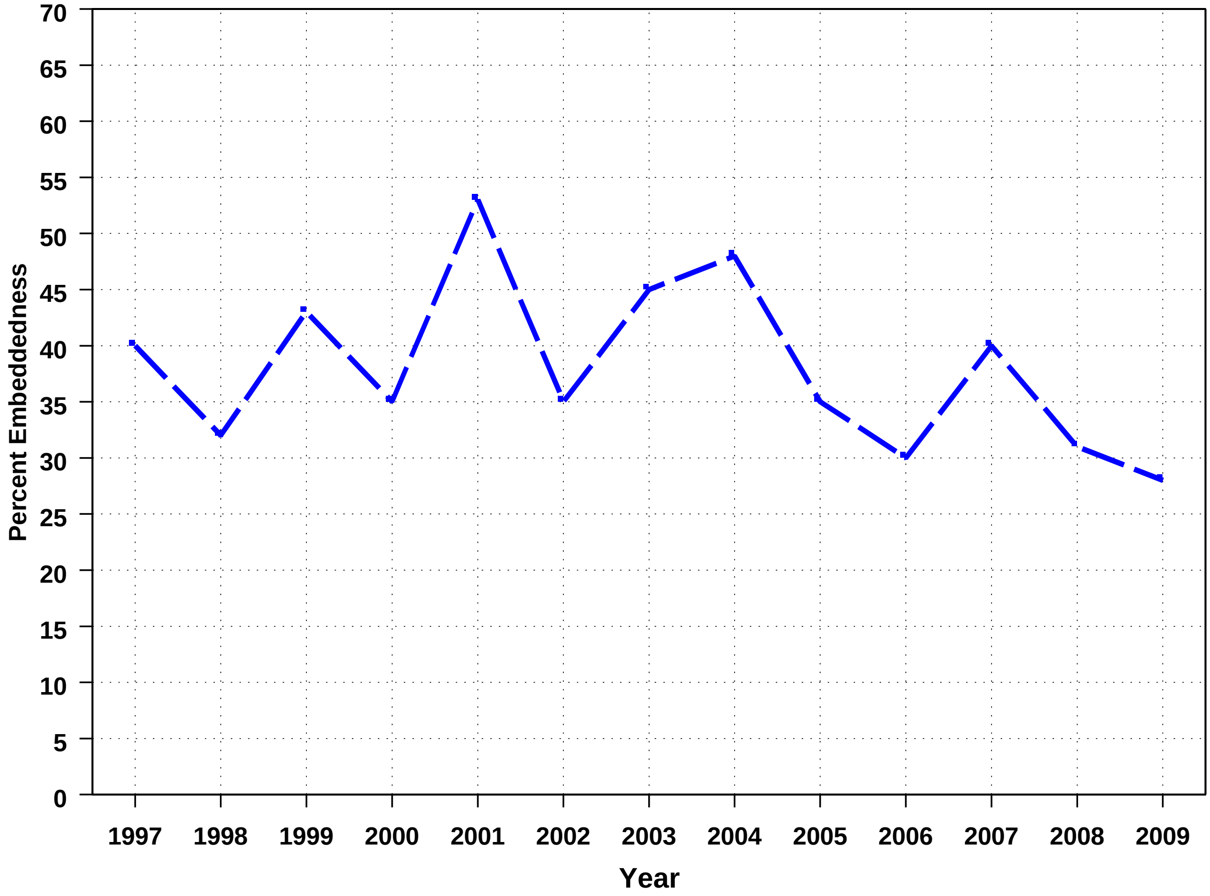


Figure 45. Average Maximum and Mean Pool Depth in Reach 9a (below Mill Pond) of East Branch Soquel Creek, 2000 and 2005-2009.

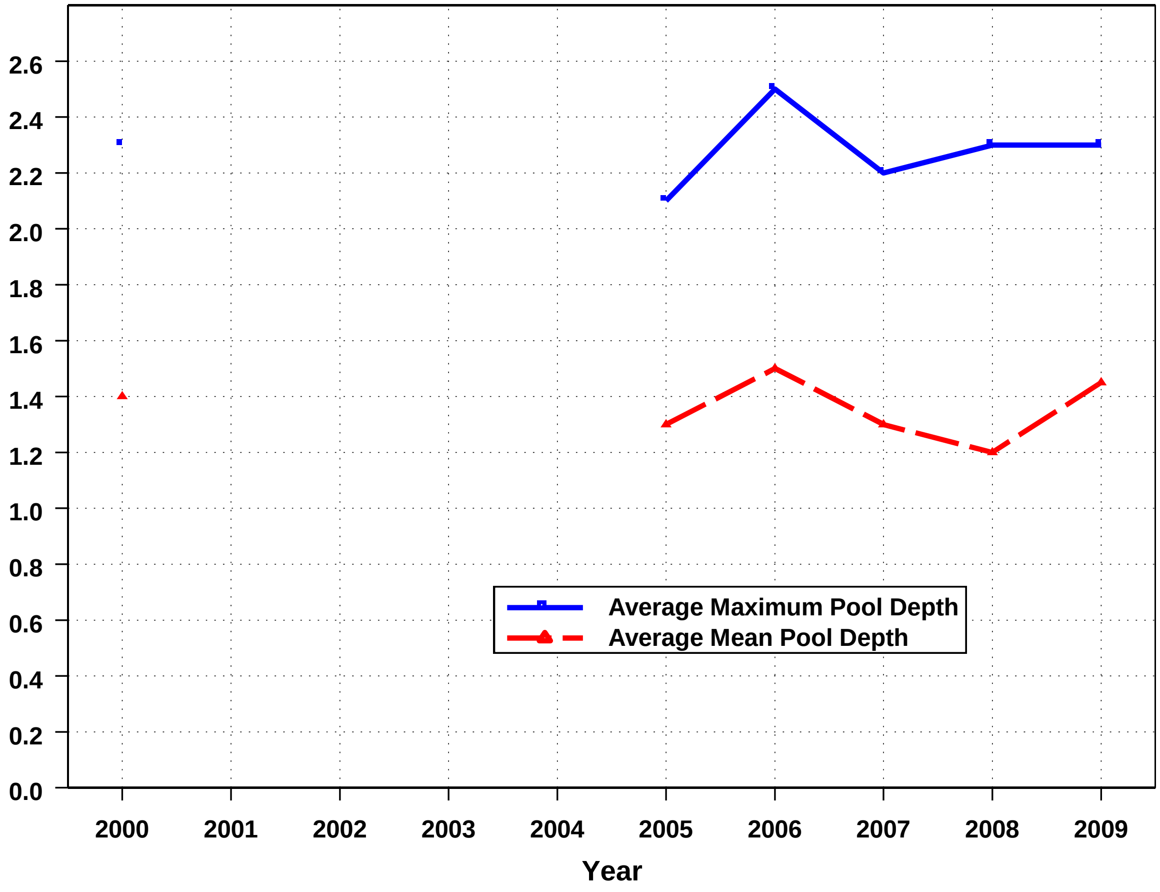


Figure 46a. Escape Cover Index for Pool Habitat in Reach 9a (below Mill Pond) of East Branch Soquel Creek, 2000 and 2005-2009.

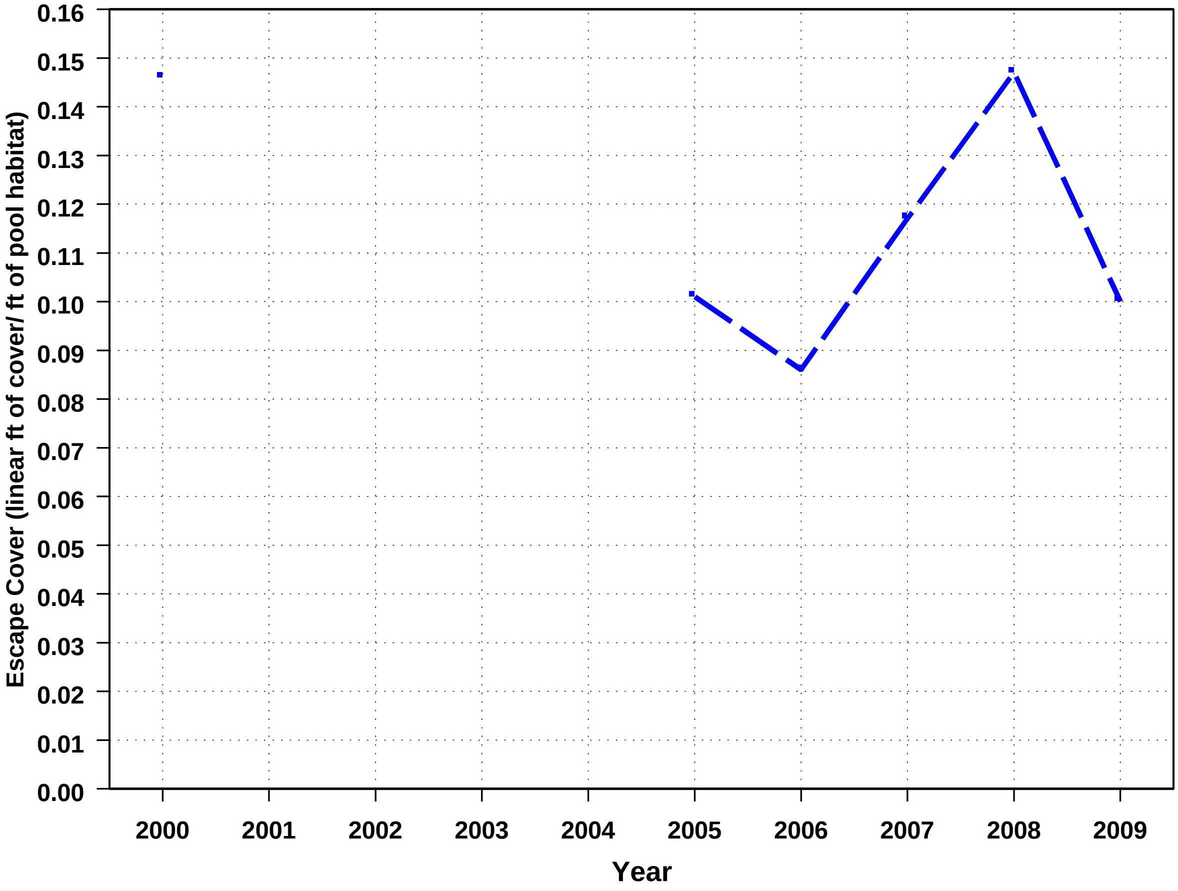


Figure 46b. Escape Cover Index for Pool Habitat at Site 13a (Reach 9a below Mill Pond) in East Branch Soquel Creek, 1997-2009.

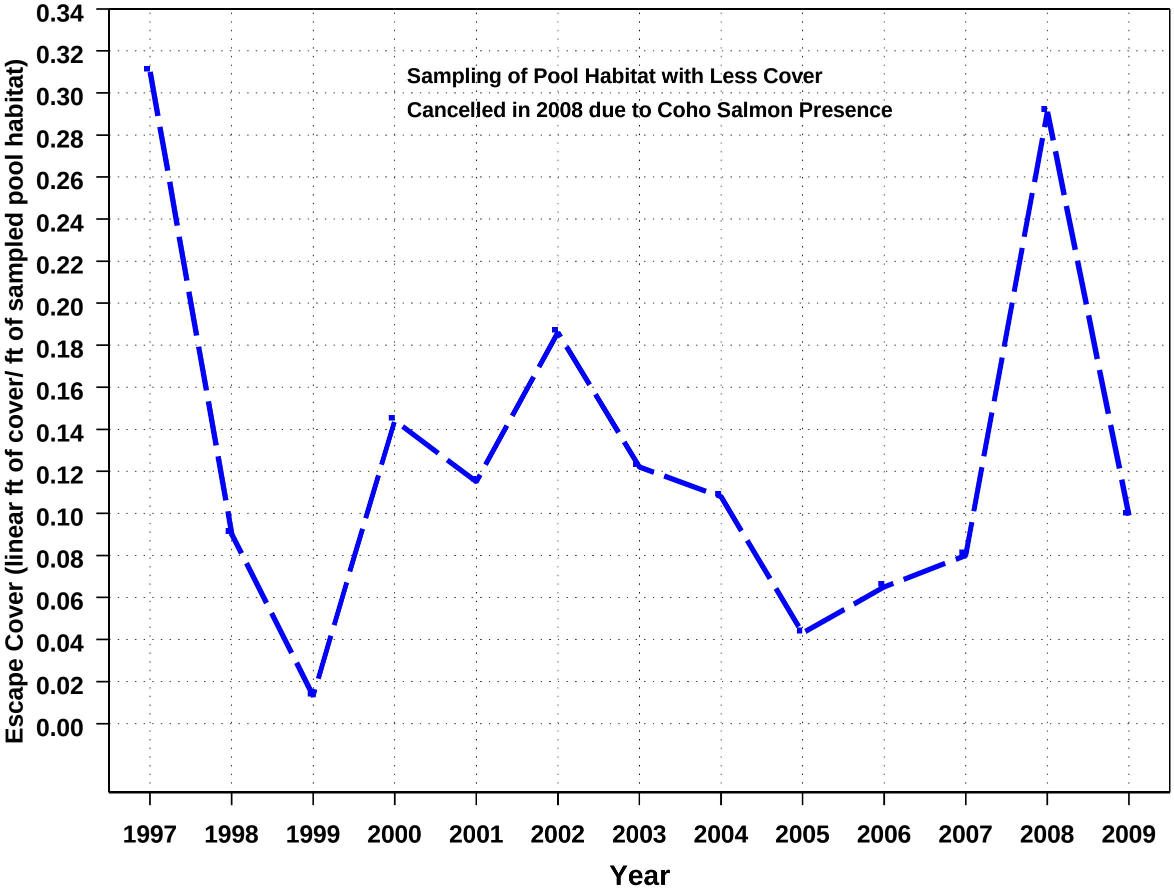


Figure 47. Averaged Percent Fines in Run and Step-Run Habitat in Reach 9a (below Mill Pond) of East Branch Soquel Creek, 2000 and 2005-2009.

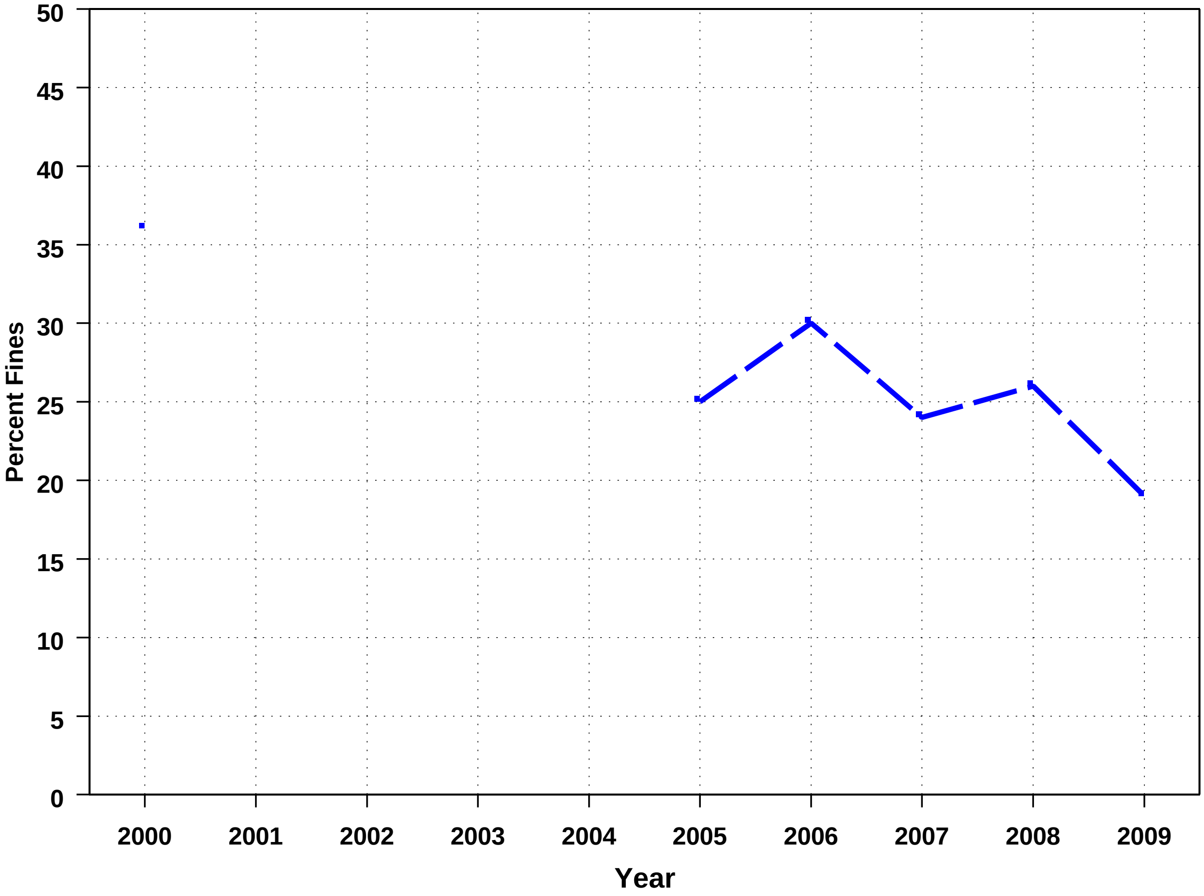


Figure 48. Average Embeddedness for Riffle Habitat in Reach 9a (below Mill Pond) of East Branch Soquel Creek, 2005-2009.

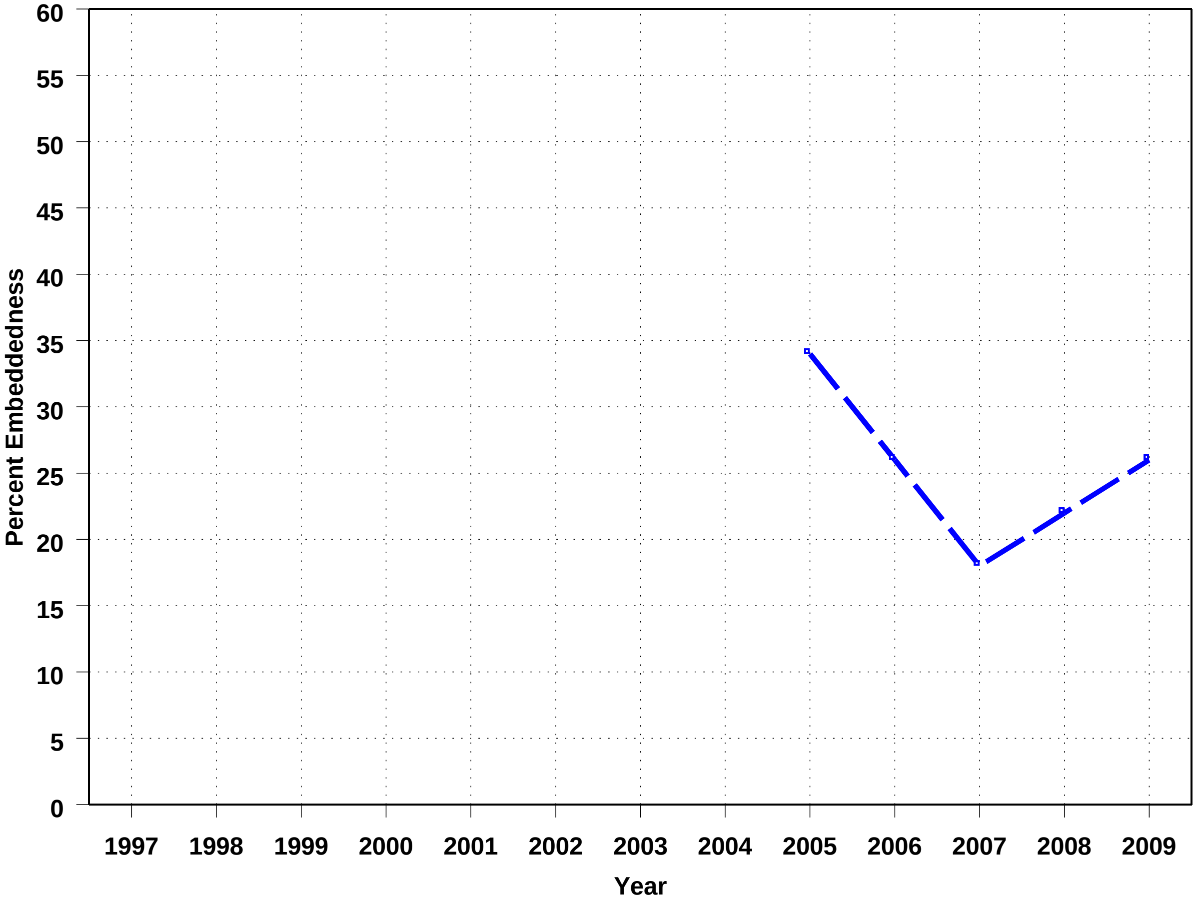


Figure 49. Averaged Maximum and Mean Pool Depth in Reach 12a (SDSF) of East Branch Soquel Creek, 2000 and 2005-2009.

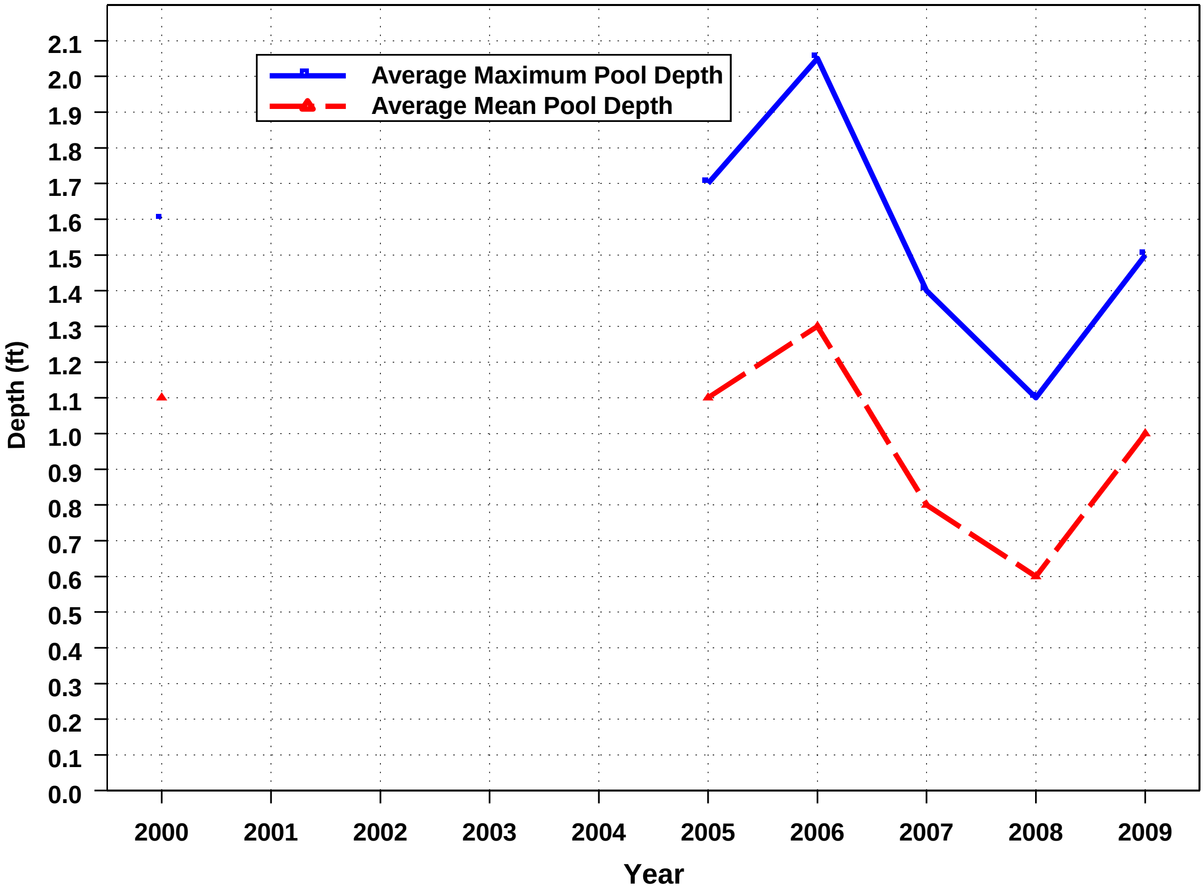


Figure 50a. Escape Cover Index for Pool Habitat in Reach 12a (SDSF) of East Branch Soquel Creek, 2000 and 2005-2009.

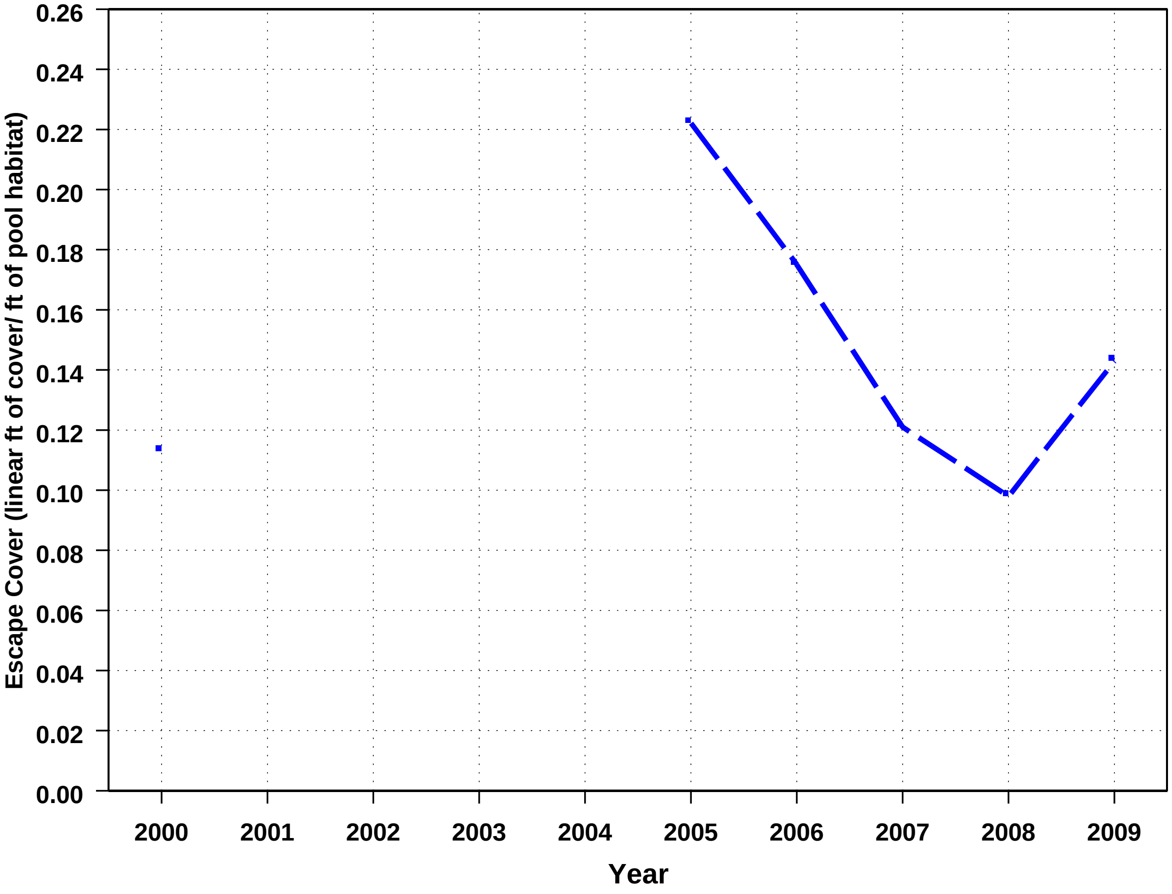


Figure 50b. Escape Cover Index for Pool Habitat at Site 16 (Reach 12a in SDSF) in East Branch Soquel Creek, 2000-2009.

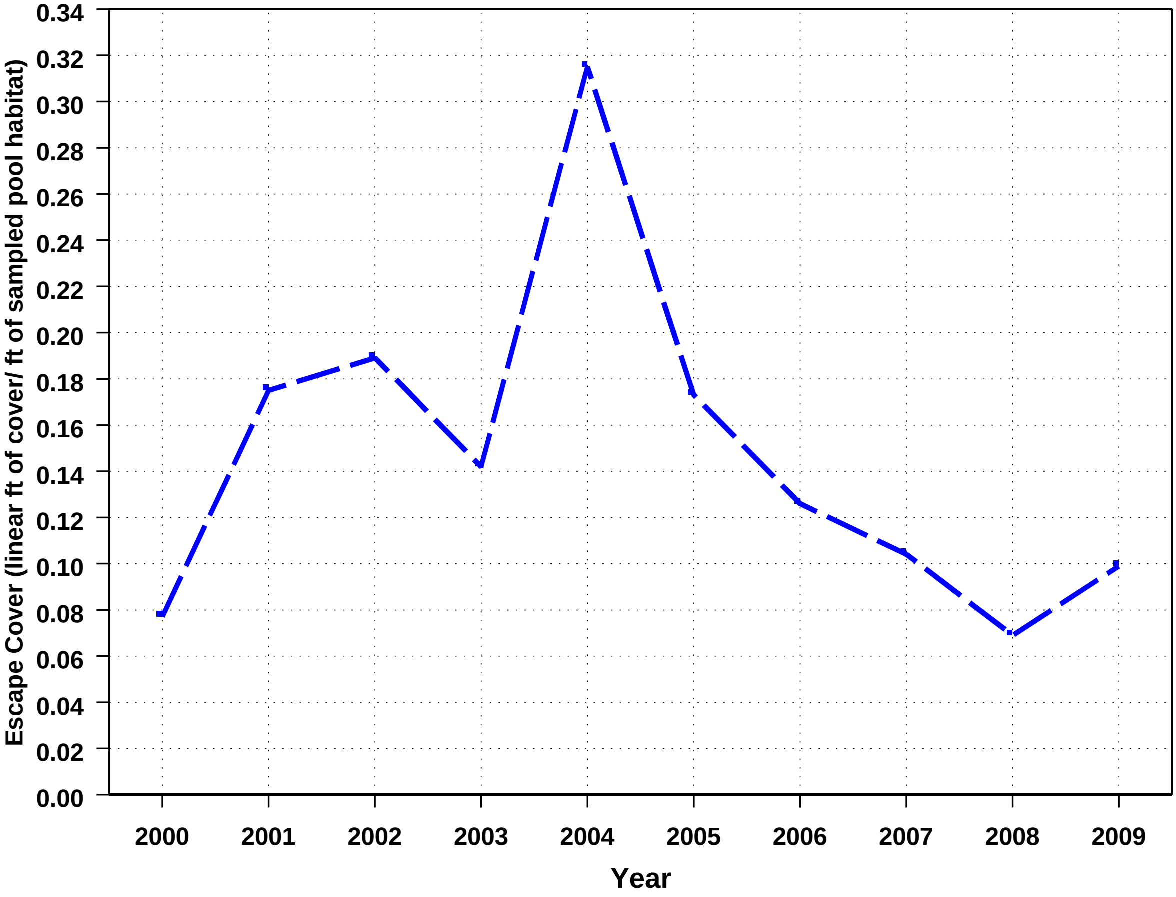


Figure 51. Averaged Percent Fines in Step-Run Habitat in Reach 12a (SDSF) of East Branch Soquel Creek, 2000 and 2005-2009.

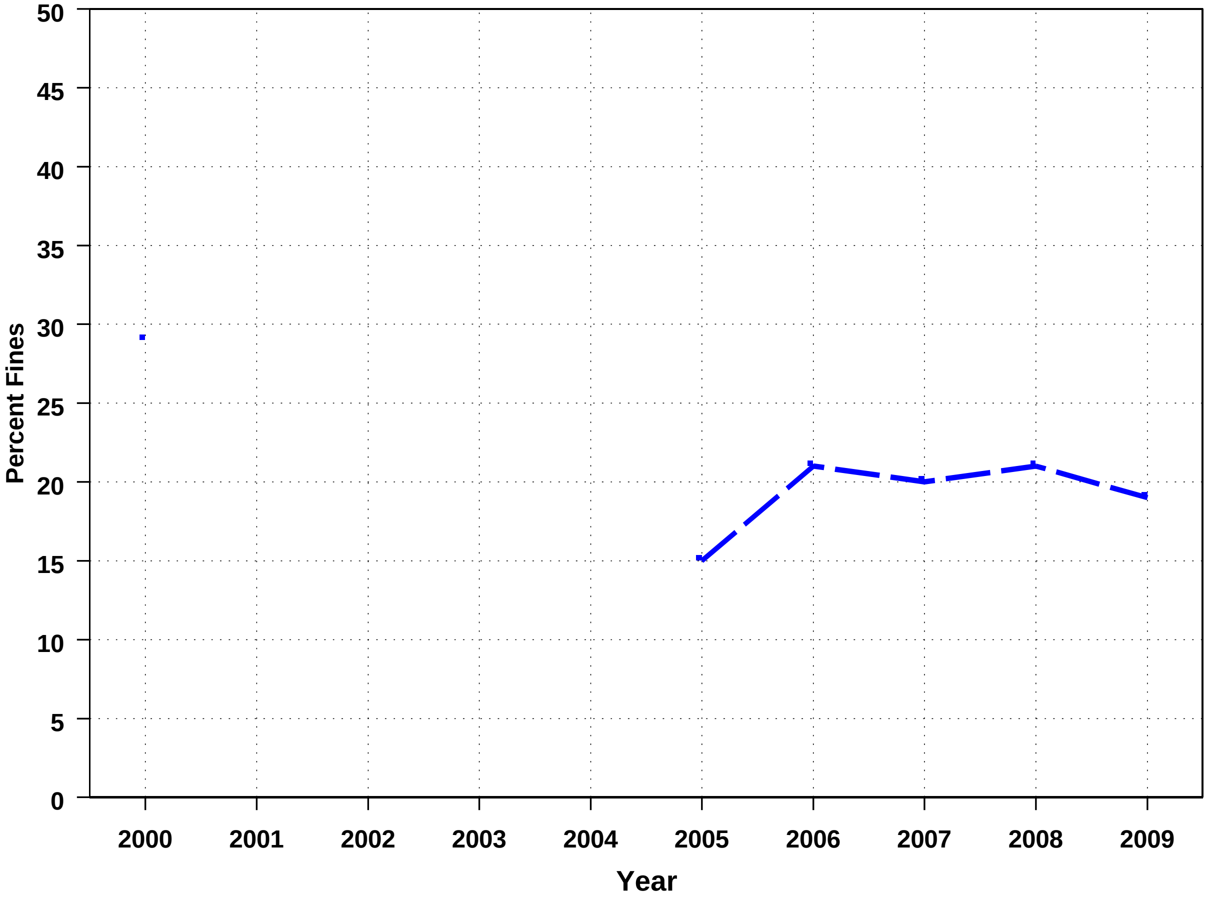


Figure 52. Average Embeddedness for Riffle and Step-run Habitat at the Sampling Site in Reach 12a (SDSF) of East Branch Soquel Creek, 2000-2009.

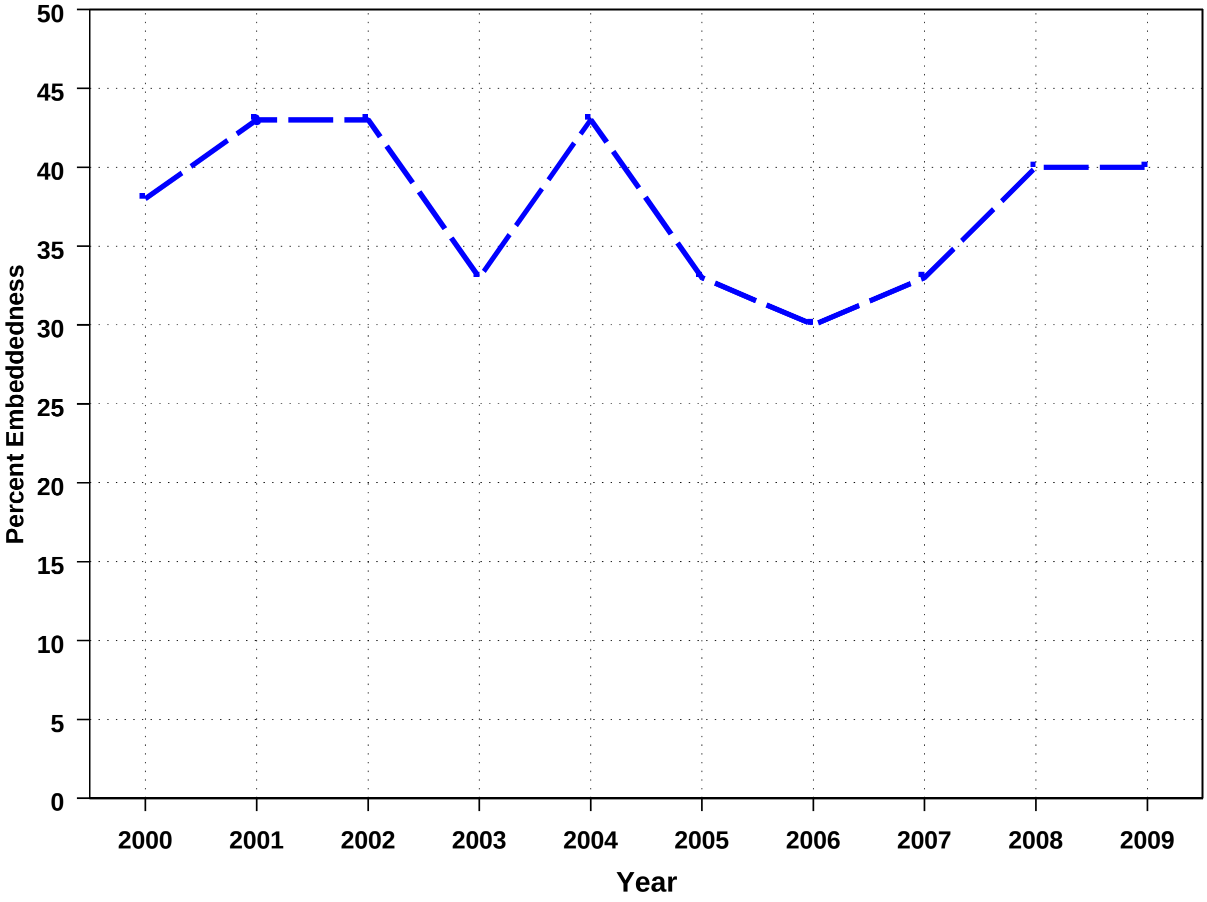


Figure 53. Pool Escape Cover Provided by Instream Wood in Half-Mile Reach Segments of the San Lorenzo, Soquel, Aptos and Corralitos Watersheds in Fall 2009.

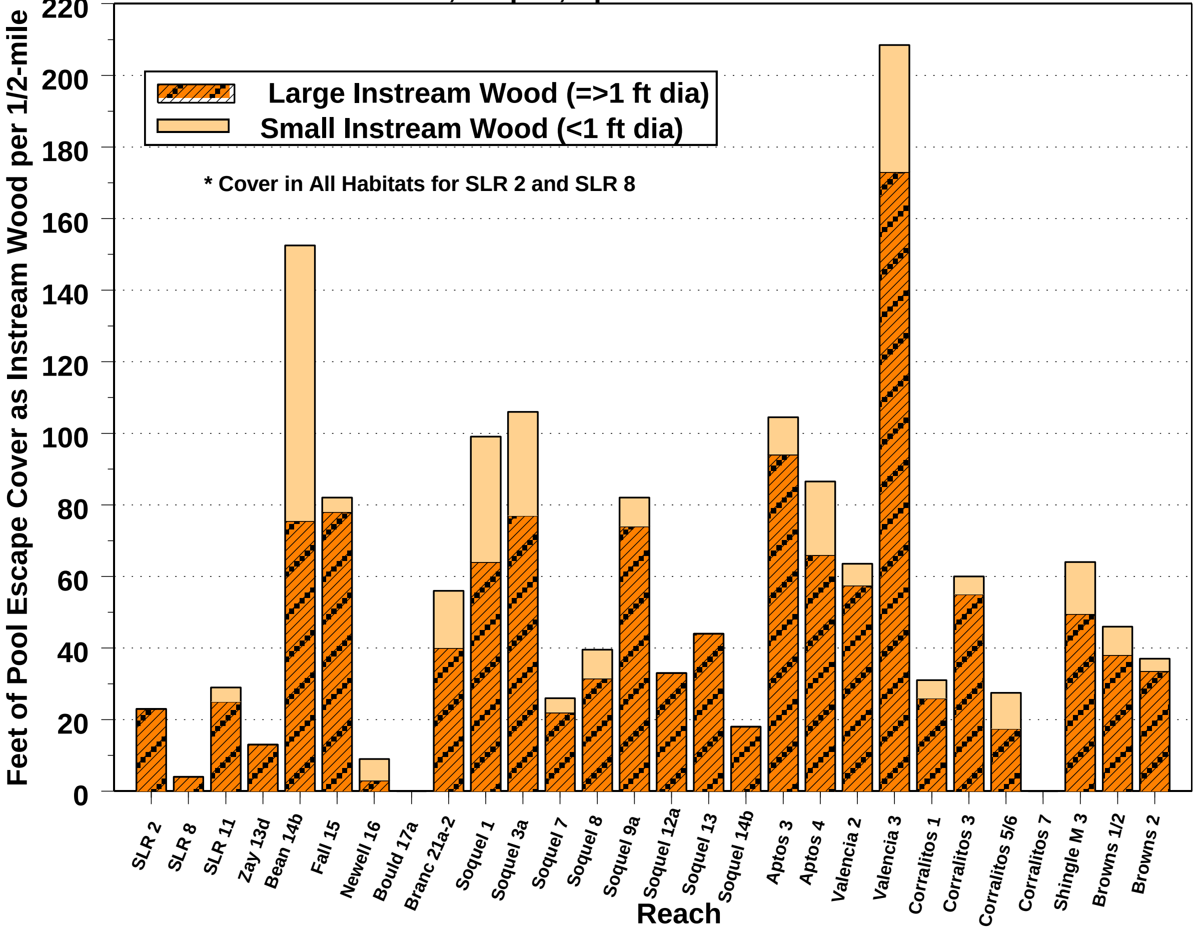


Figure 54. Total Pool Escape Cover per Half-Mile Reach Segment, With Wood Contribution, in the San Lorenzo, Soquel, Aptos and Corralitos Watersheds in Fall 2009.

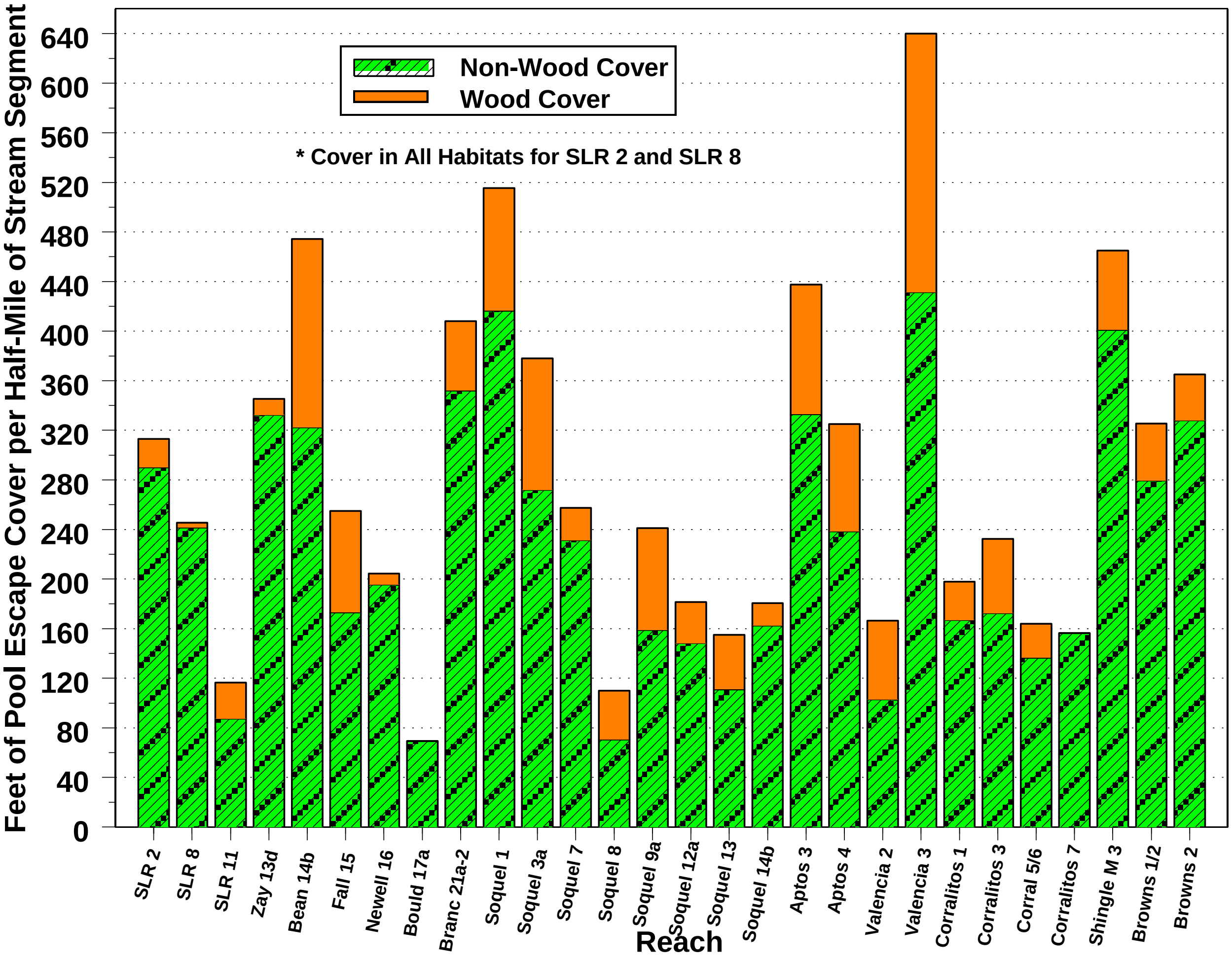


Figure 55. The 2009 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.

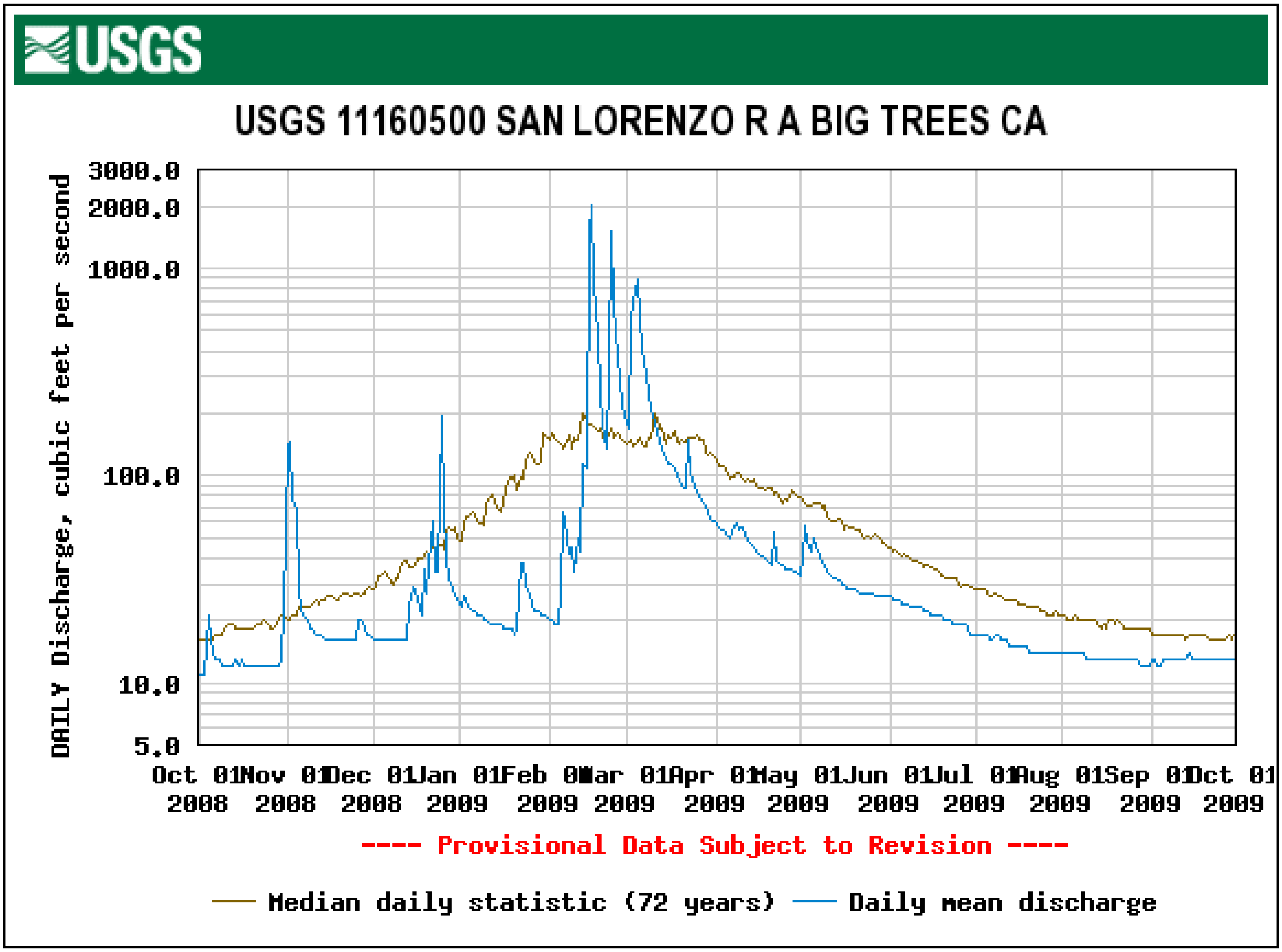


Figure 56. The 2008 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.

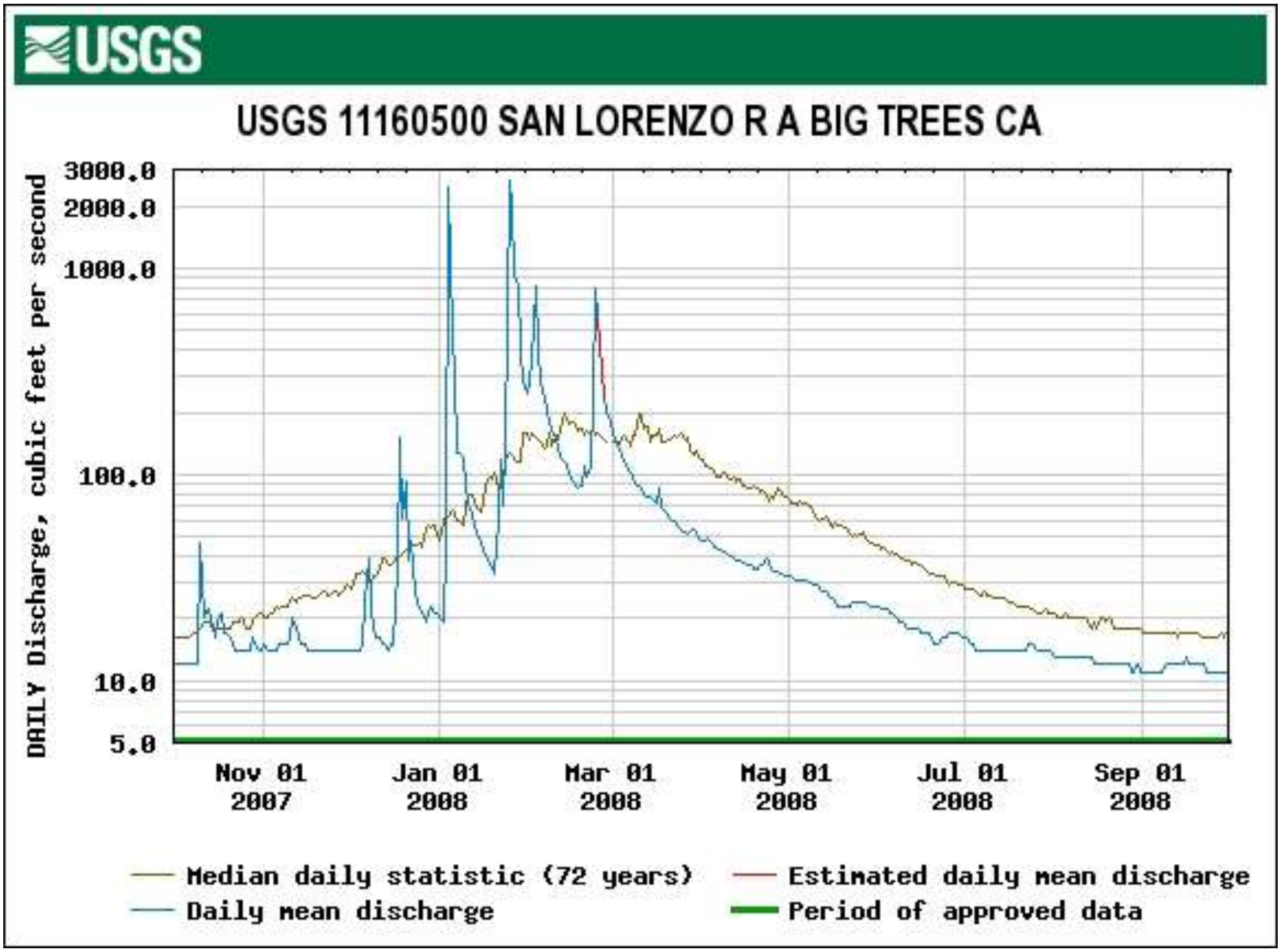


Figure 57. The 2009 Daily Mean and Median Flow at the USGS Gage on Soquel Creek at Soquel.

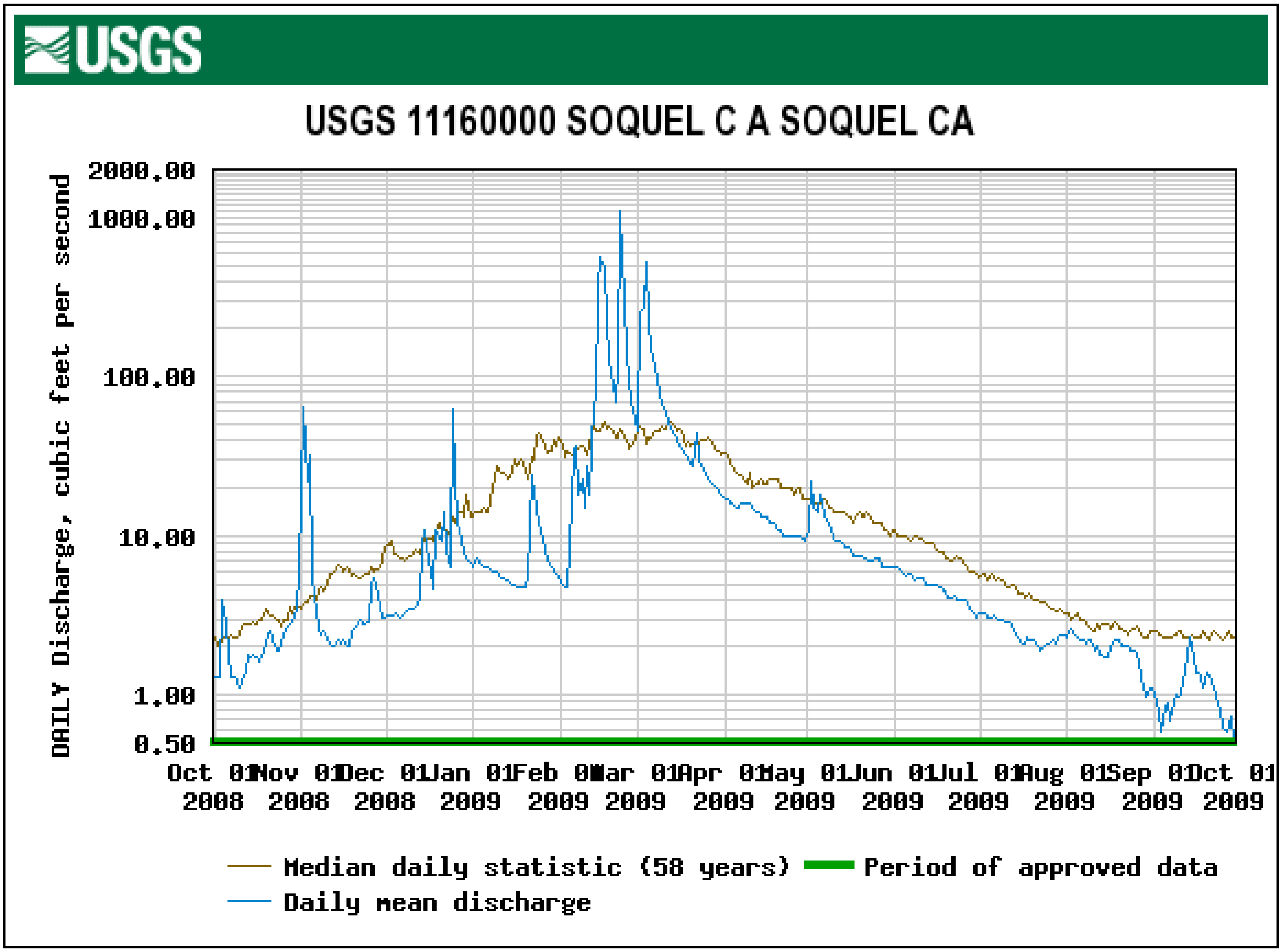


Figure 58. The 2008 Daily Mean and Median Flow at the USGS Gage on Soquel Creek at Soquel.

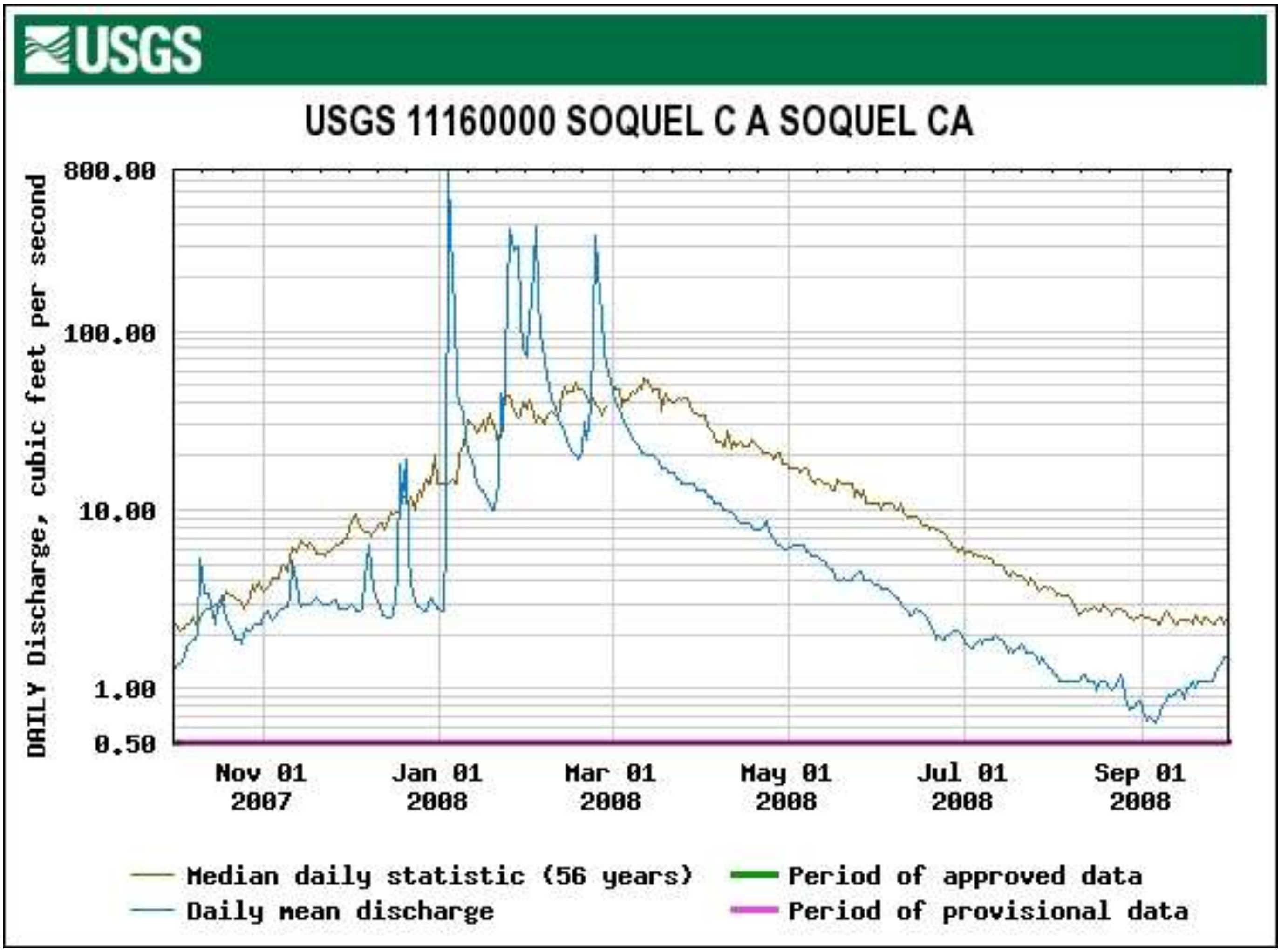


Figure 59. The 2009 Daily Mean and Median Flow at the USGS Gage on Corralitos Creek at Freedom. (USGS website would not provide a logarithmic scale of discharge).

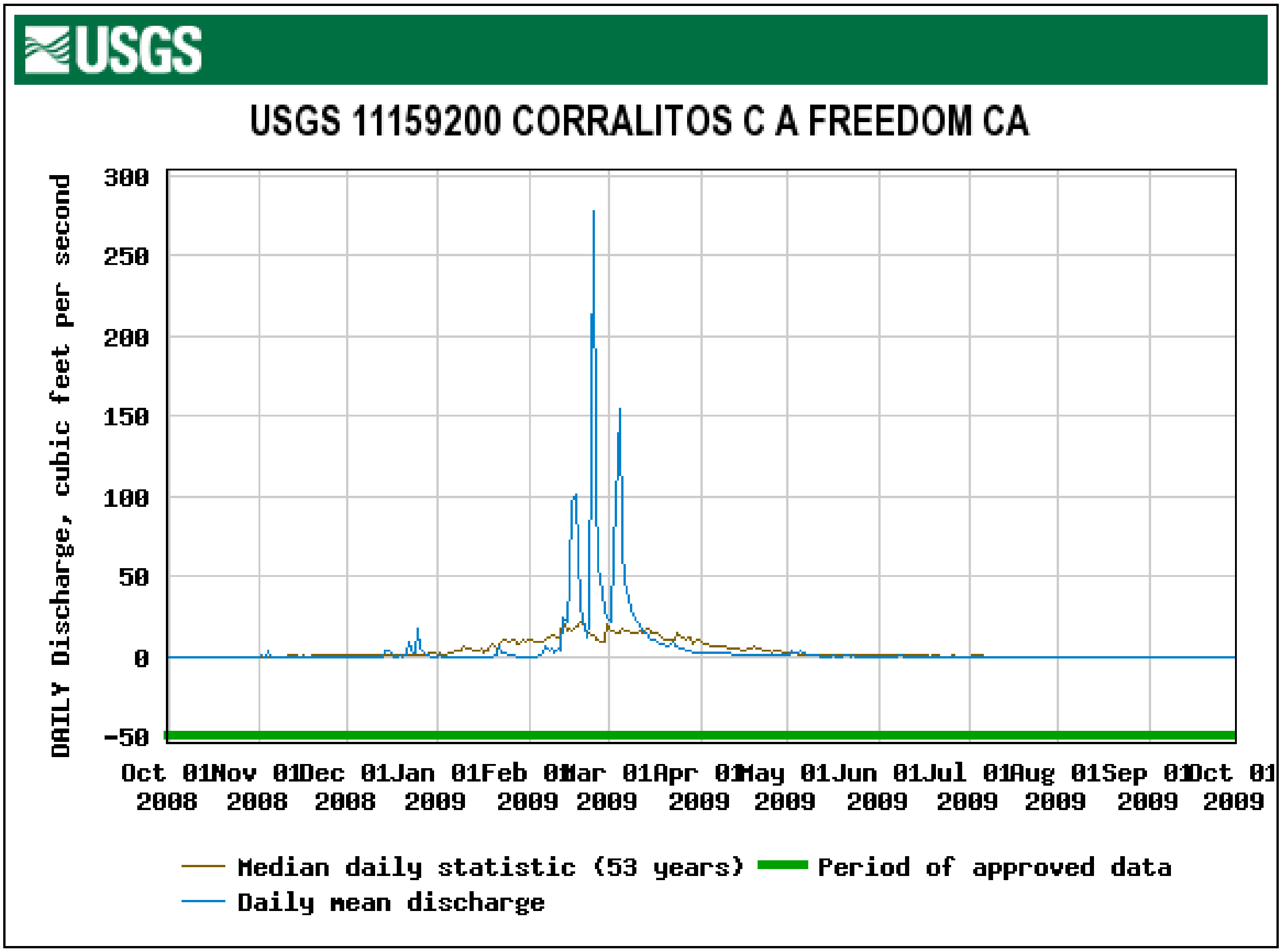
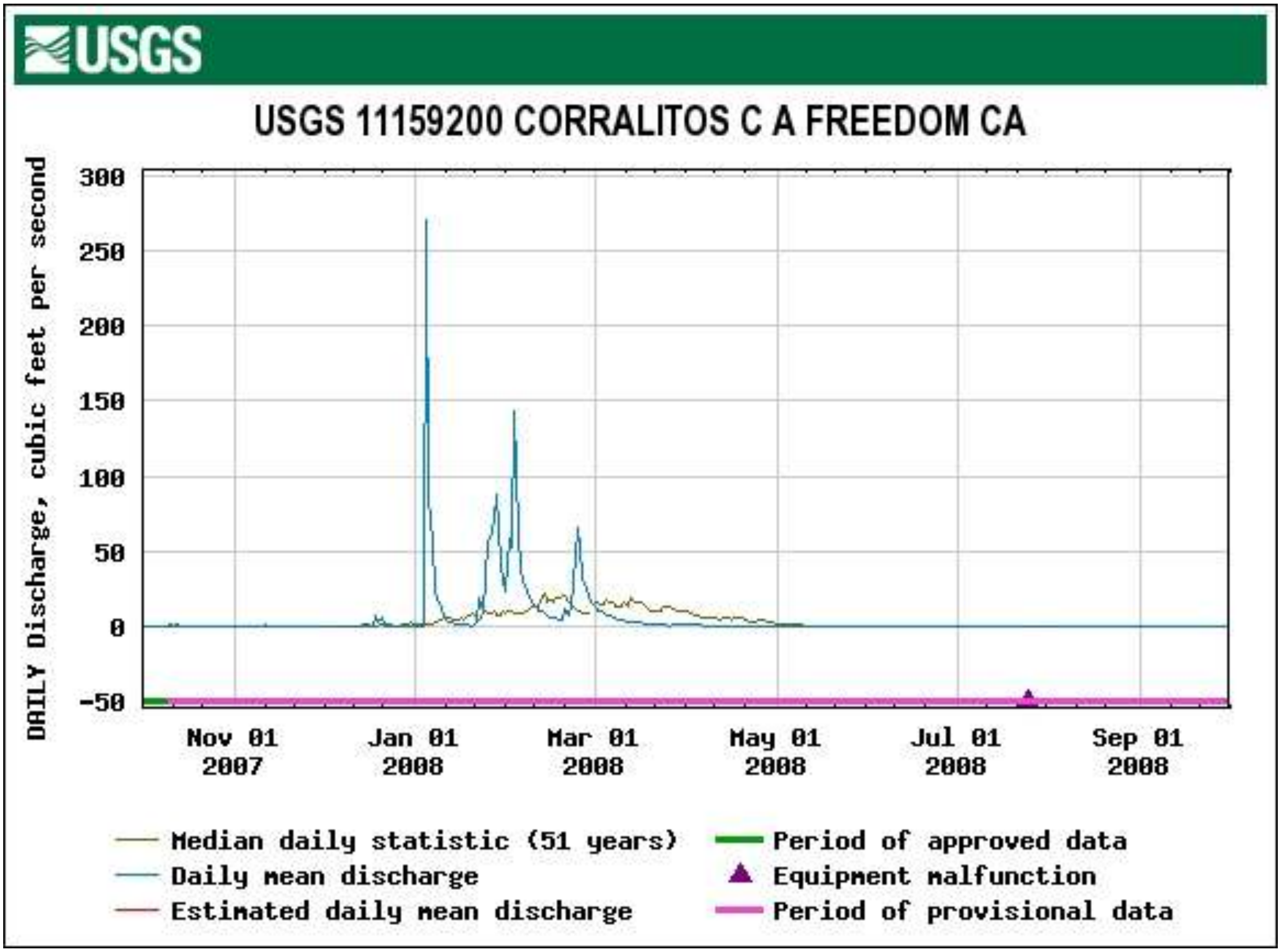
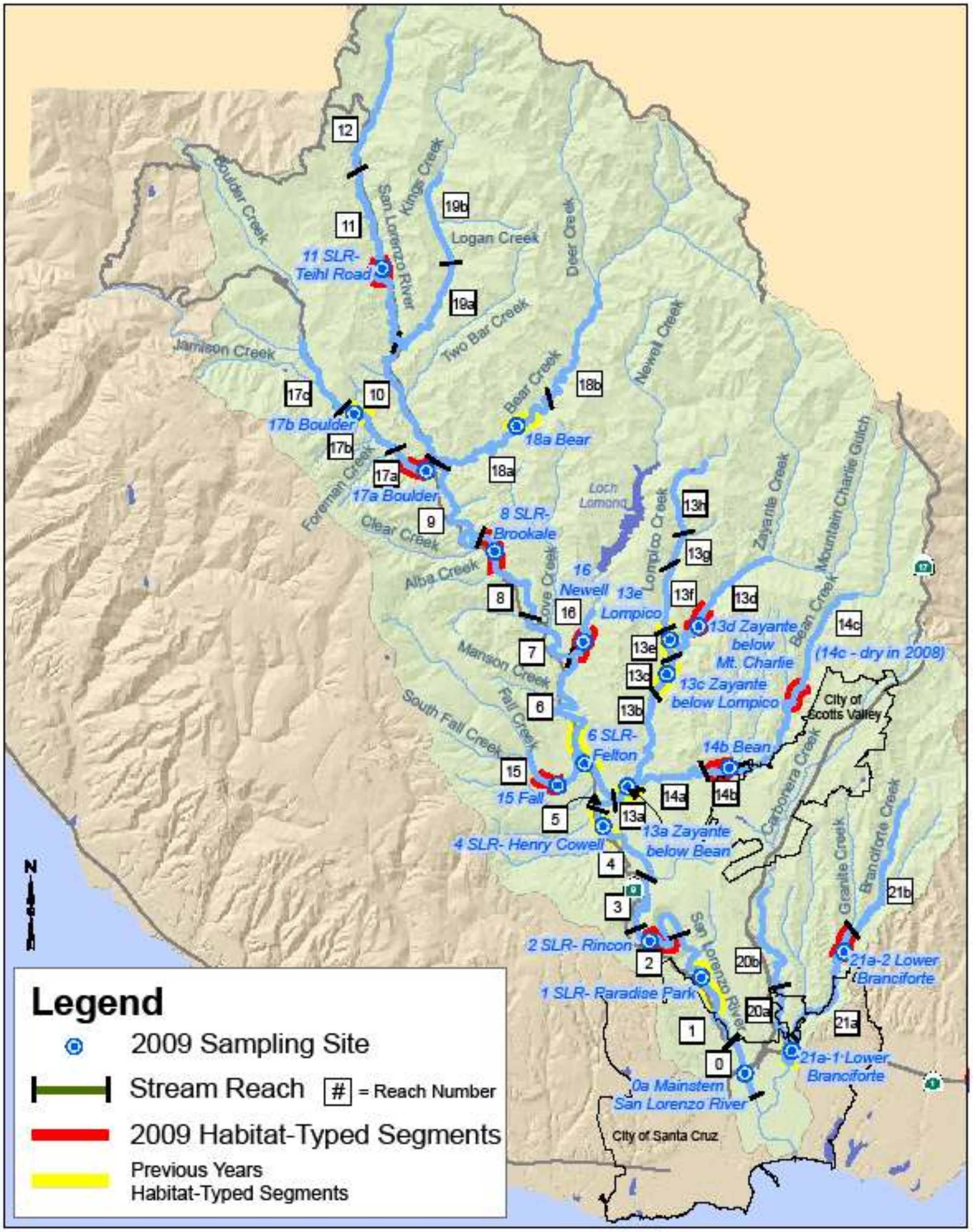


Figure 60. The 2008 Daily Mean and Median Flow at the USGS Gage on Corralitos Creek at Freedom. (USGS website would not provide a logarithmic scale of discharge).



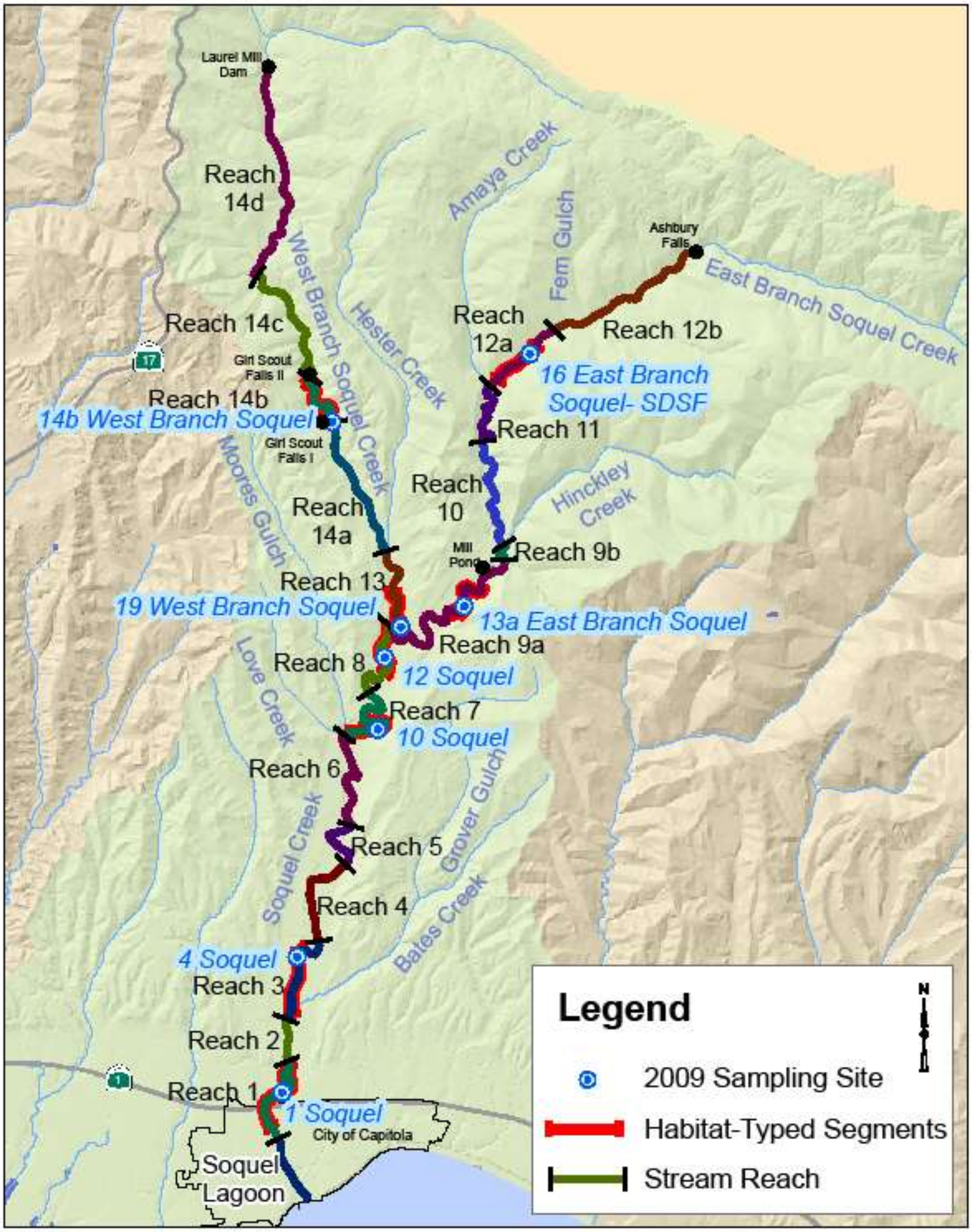
APPENDIX A. Watershed Maps.

Figure 1. Santa Cruz County Watersheds.



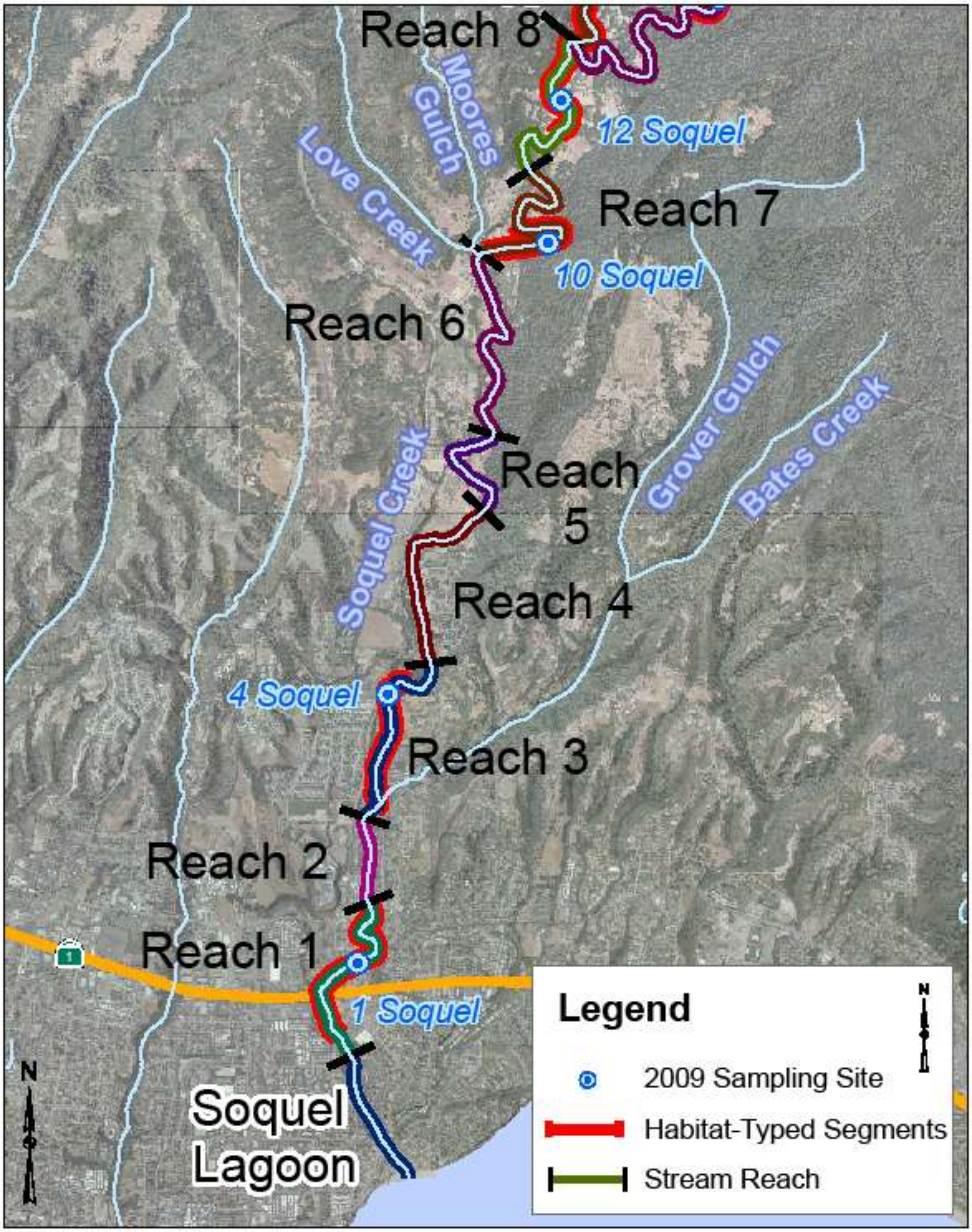
012-09 2010

Figure 2. San Lorenzo River Watershed



012-09 2010

Figure 3. Soquel Creek Watershed.



012-09 2010

Figure 4. Lower Soquel Creek (Reaches 1–8 on Mainstem).

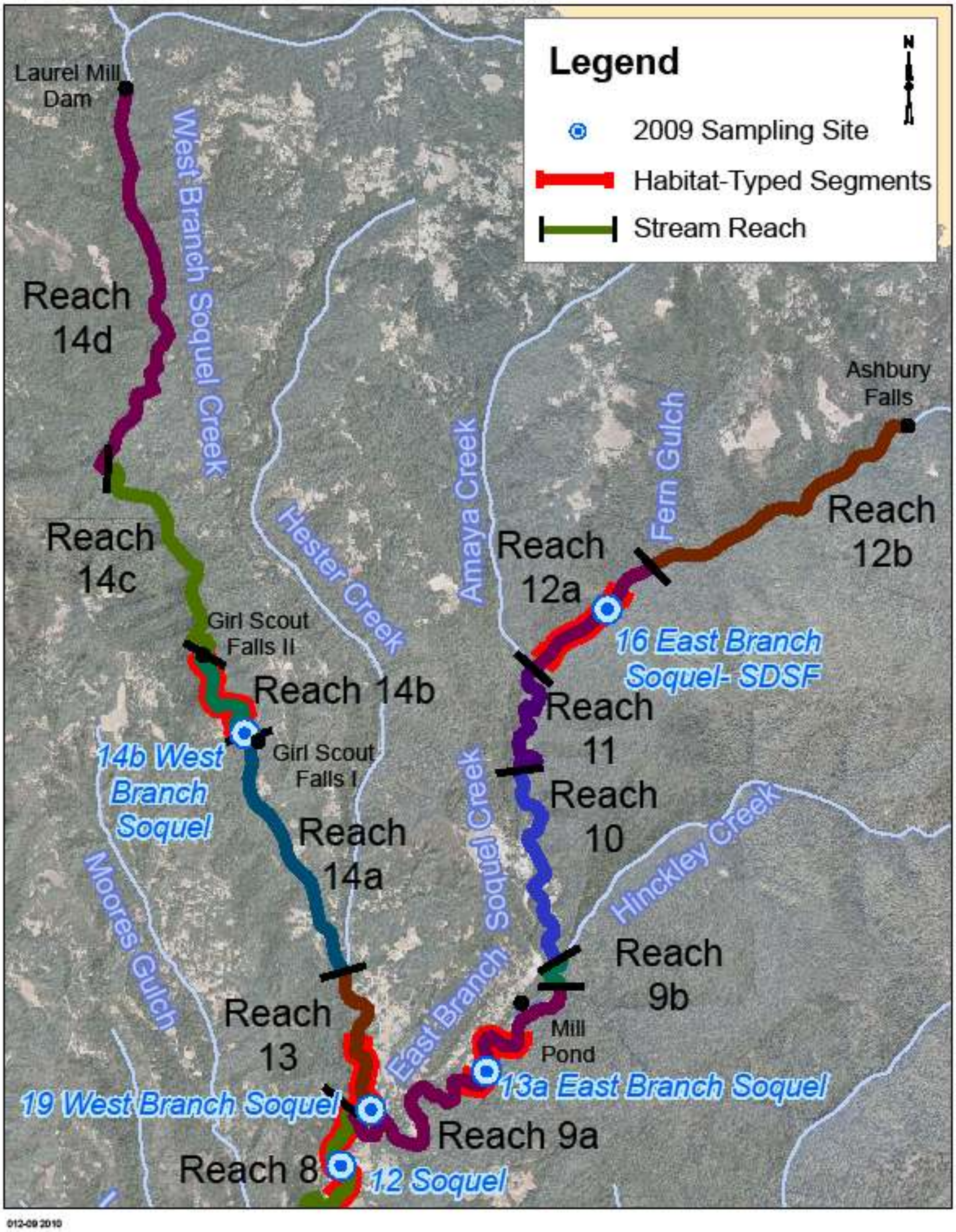
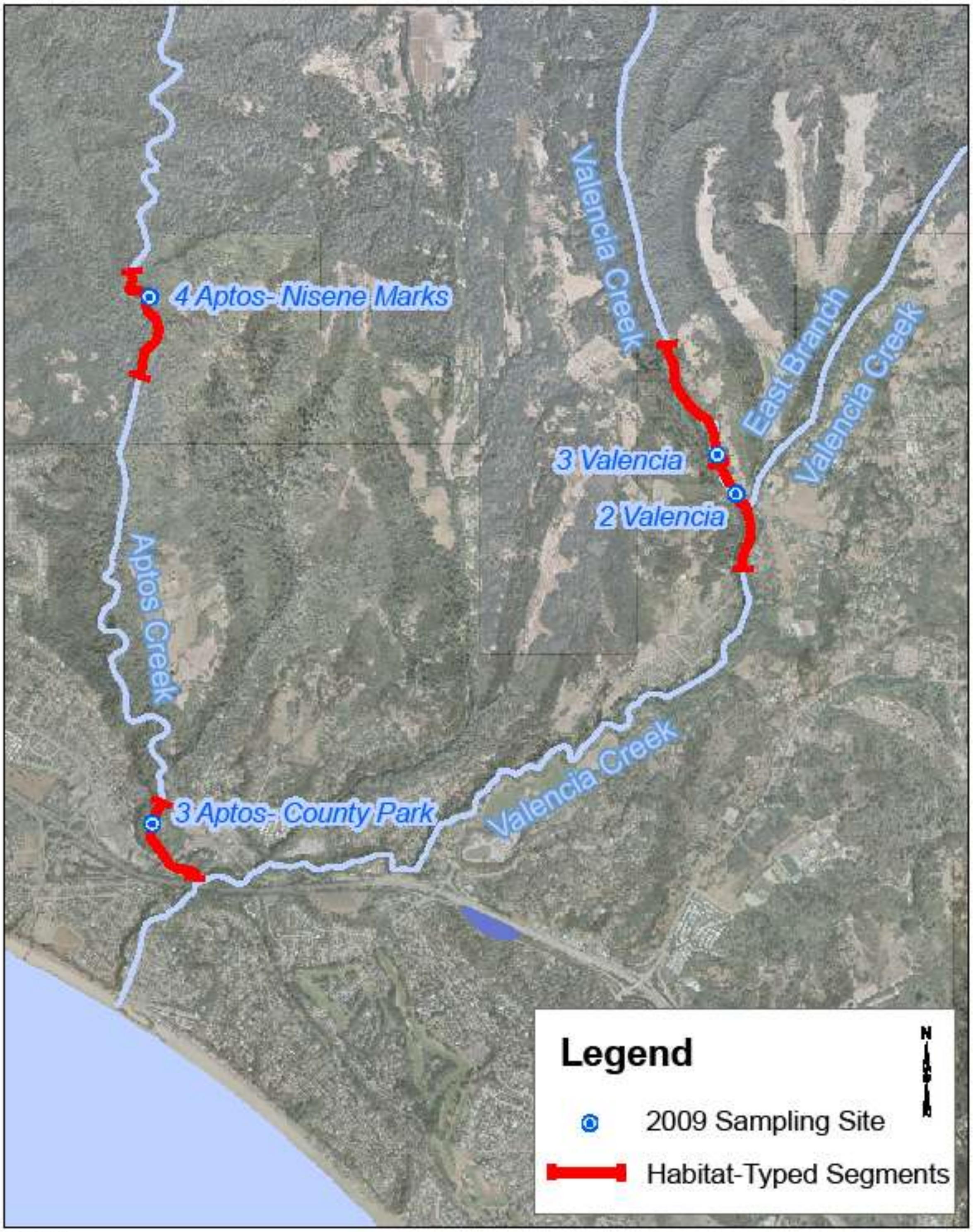


Figure 5. Upper Soquel Creek Watershed (East and West Branches).



012-09 2010

Figure 6. Map from Smith (1982) with Site #3 designation on Valencia Creek at 2006 location.

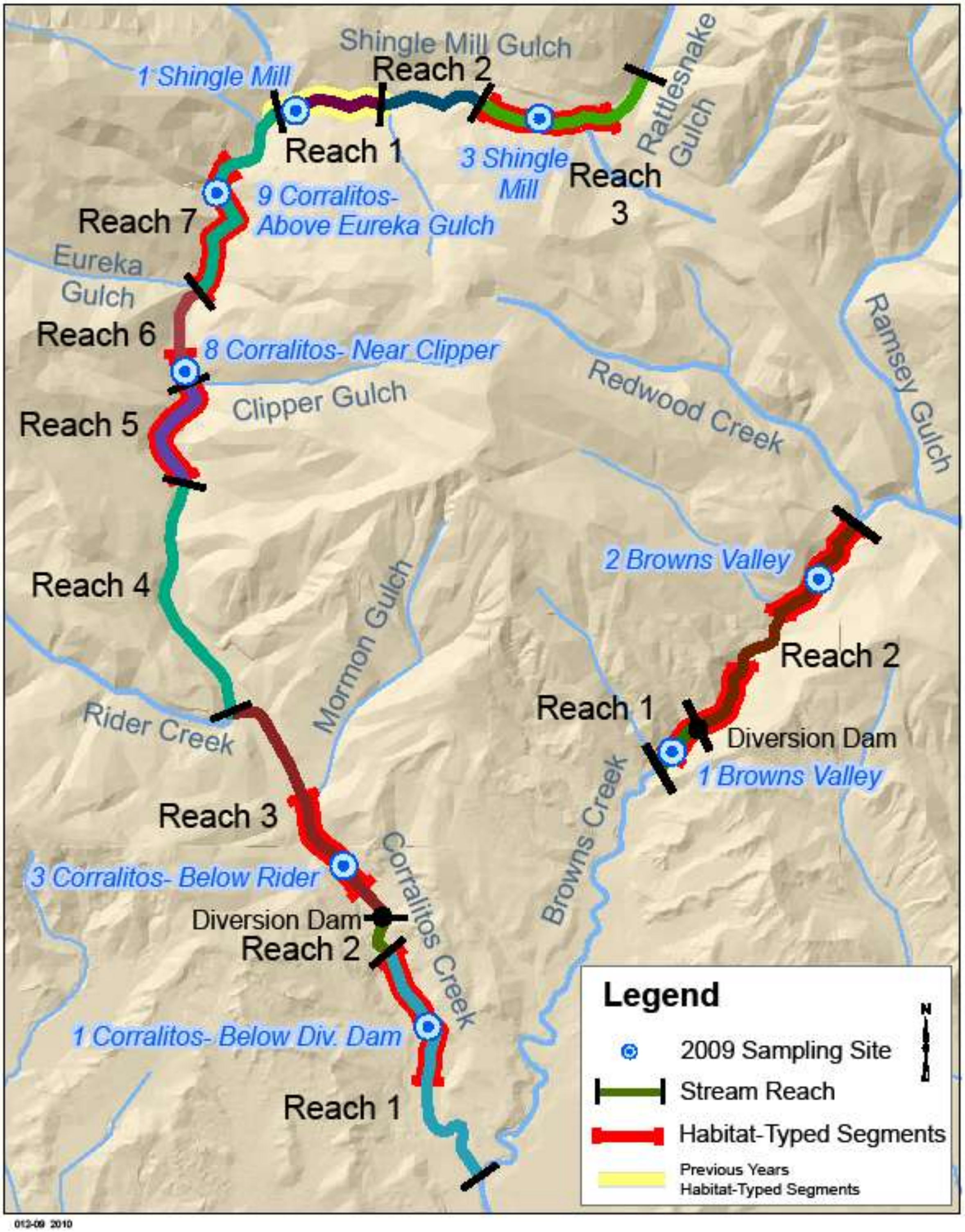


Figure 7. Upper Corralitos Creek Sub-Watershed of the Pajaro River Watershed.