Upper San Leandro Reservoir Watershed
Salmonid Habitat Assessment

Kaiser Creek

East Bay Municipal Utility District

Natural Resources Department

Fisheries & Wildlife Division

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Rainbow Trout Habitat Assessment

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INTRODUCTION

Rainbow trout (*Oncorhynchus mykiss*) habitat assessments were conducted in the spring of 2010 and 2011 on East Bay Municipal Utility District (EBMUD) lands located within the Upper San Leandro (USL) Reservoir watershed. This report provides a comprehensive evaluation of current habitat conditions as well as limiting factors for rainbow trout within the tributaries of EBMUD's USL Reservoir. Habitat assessments were conducted on sections of San Leandro, Redwood, Kaiser, Indian and Rimer creeks within the EBMUD property boundaries. Trout habitat upstream of EBMUD lands on Redwood, San Leandro and Rimer Creeks were not assessed.

WATERSHED OVERVIEW

The USL Watershed is located in the San Francisco Bay Area in Contra Costa and Alameda counties (Figure 1). The Watershed is approximately 30 square miles and contains roughly 80 miles of intermittent and perennial streams. The USL Watershed consists of the headwaters of San Leandro, Indian, Redwood, Kaiser, Buckhorn, Moraga and Rimer creeks. Upper San Leandro and Redwood creeks are minimally influenced by development, perennially flowing mostly through East Bay Regional Park District (EBRPD) lands and some private lands upstream of the EBMUD watershed. Kaiser Creek is completely contained within EBMUD watershed lands. Upper San Leandro, Redwood and Kaiser Creeks are known to provide high quality habitat for spawning and rearing rainbow trout. Buckhorn Creek is a tributary to Kaiser Creek located on EBMUD lands and privately owned grazed lands. Buckhorn Creek dries in most years and provides little, if any, potential habitat for rainbow trout. Indian Creek is a tributary of San Leandro Creek, which flows mostly through private lands upstream of a fish passage barrier near Canyon Road. Most of the Moraga and Rimer creek drainages are on private land within the town of Moraga and city of Orinda. Moraga and Rimer Creeks provide some spawning and rearing habitat for rainbow trout. Lower San Leandro Creek (below Chabot Dam) is highly urbanized and is known to provide some habitat for steelhead/rainbow trout between Highway 580 and Chabot Dam. Steelhead are likely a component of the Lower San Leandro Creek population as this creek stretch is open to anadromy despite the fish passage obstacles presented by channel modifications downstream.

O. MYKISS HABITAT REQUIREMENTS

Oncorhynchus mykiss may exhibit anadromy or freshwater residency. Resident individuals are typically referred to as rainbow trout while anadromous individuals are referred to as steelhead. Steelhead migrate from fresh water to the ocean and return to their natal creek as adults to spawn. Resident forms spend their entire life in the fresh water streams where they were born.

Chabot and Upper San Leandro Reservoir dams currently block steelhead migration to the USL Reservoir Watershed. *O. mykiss* in USL reservoir cannot access the ocean and instead use the reservoir in their adult life stage. These reservoir fish grow to a much larger size than creek residents and return to the tributary creeks to spawn.

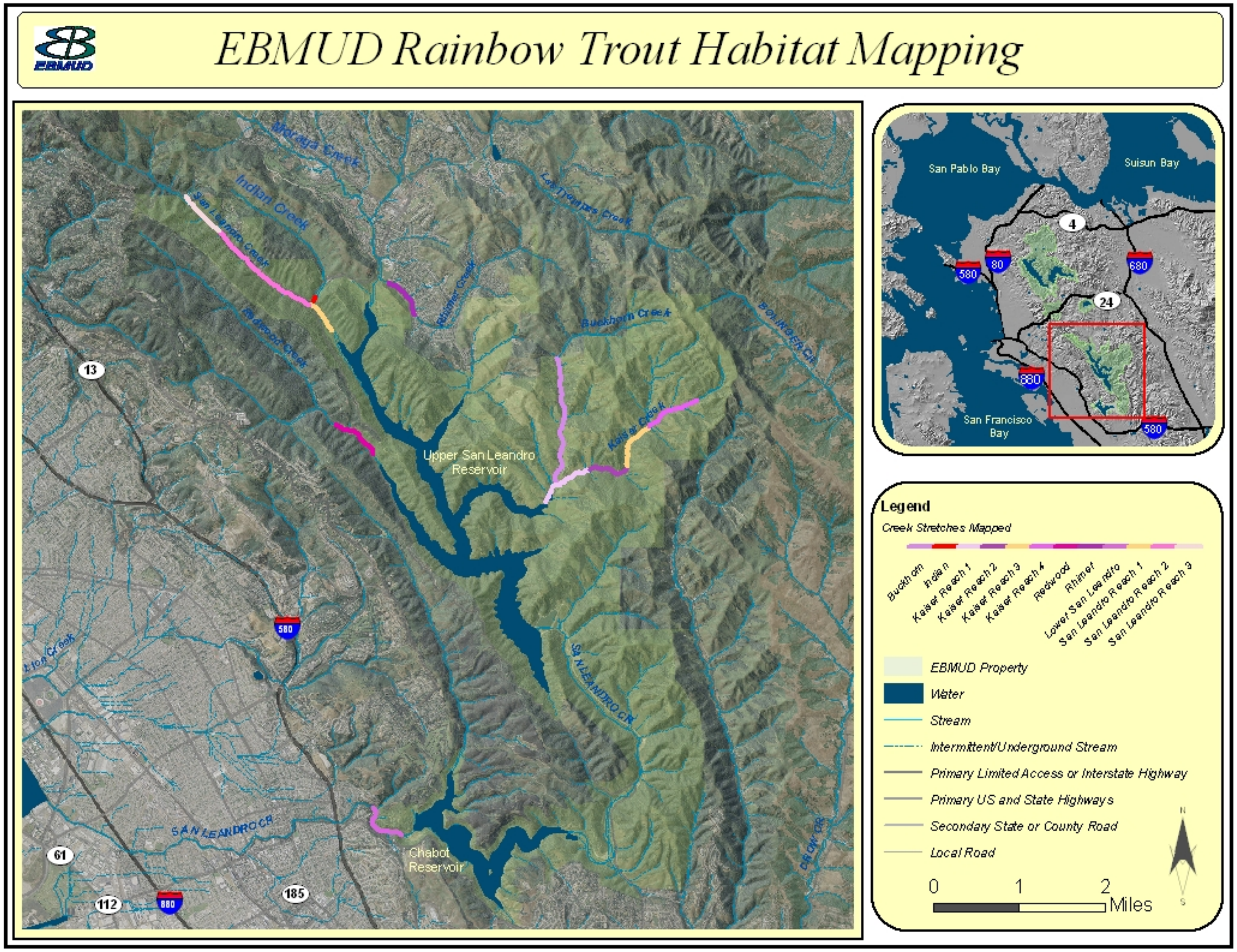

Figure 1. Overview of Upper San Leandro Reservoir Watershed Creeks

Rainbow trout exhibit a variable life history with each life history stage exhibiting some differences in habitat preference and utilization in fresh water environments. Spawning and rearing habitats are common limiting factors in local creeks and are required to maintain healthy rainbow trout populations. Pool habitats are of importance because they can provide preferred habitat characteristics for both spawning and rearing. In addition, pools are utilized to some degree by all life history stages of resident rainbow trout. Riffles are important habitats for food production and are often used extensively by young trout.

Preferred spawning habitat for rainbow trout in local streams is found in pool tail-outs where favorable flow and depth conditions are most often met and to a lesser degree in glides, runs or riffles. Steelhead typically prefer spawning gravel in the half inch to 4 inch size range (Reiser and Bjornn., 1979). Resident fish typically prefer gravel at the lower end of that size range. Ideal spawning substrate has a low percentage of fines resulting in high gravel permeability and high oxygen levels for developing eggs and embryos. Several researchers have associated increased amounts of fine sediments in gravel with a reduction in embryo survival (Reeves et al. 1991).

Rearing resident rainbow trout require pools with sufficient depth and low temperatures for over-summering. Cover and a sufficient food source are also important. Glide and riffle habitats may be commonly used by juveniles. In smaller local watersheds, juvenile rearing habitat is typically reduced during low summer flows, particularly in drought years. East Bay streams typically have lower base flows, lower gradient and reduced habitat complexity than is typically found in highly productive trout habitat. Despite these potential limiting factors, many local streams are capable of supporting healthy trout populations.

In local streams, higher temperatures are more of an issue for salmonids than low temperatures. In small streams, juvenile rearing temperatures are usually of greatest concern. The Steelhead Restoration and Management Plan for California lists the optimal temperature range for fry and juvenile rearing as 45 to 60^{o}F (7 to 15.5^{o}C) but also notes that they are known to exist in relatively high temperature regimes. However, rainbow trout adapted to local conditions would be expected to survive and do well in environments where temperatures climb above of 20^{o}C for short to intermediate periods of time.

METHODS

Habitats were classified using a modified Level IV classification system from the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al., 1998). The protocol was intended to determine the quality and quantity of habitat features of most importance to the persistence of rainbow trout/steelhead populations. The survey was completed by a two-person team: one person determined habitat attributes and the second person recorded the data. Data was recorded electronically using a GPS (Trimble ProXH) and analyzed using Microsoft Excel. A GPS position was recorded at the downstream end of each habitat unit. In some cases, habitat positions were digitized directly into the unit when satellite coverage was insufficient. GPS positions and associated descriptive data were also recorded for all passage obstacles.

One stream discharge measurement was taken during the survey period with a velocity meter (Marsh-McBirney Model 2000) using the velocity-area method (McMahon et. al., 1996).

Habitat types and lengths were recorded for every habitat unit encountered. Detailed data were recorded at every fifth habitat unit of each type encountered (20% sampling protocol). Detailed data included mean width, mean depth, maximum depth, shelter complexity, shelter cover, dominate and subdominant substrate, canopy cover and dominant canopy species. Detailed data were visually estimated with the exception of depths, widths and lengths which were measured with a stadia rod or 300 ft tape. Mean residual depth and maximum depth as well as depth of pool tail crest and embeddedness were recorded for every pool encountered.

Embeddedness, the degree to which large particles are surrounded or covered by fine sediment, was visually estimated by the percent of gravel or cobble that was buried in pool tail-outs. In some cases, larger substrate was largely absent and smaller substrate was used to estimate embeddedness. Spawning gravel area was estimated in all habitat units where flow, depth and gravel size were judged to be appropriate for spawning. Spawning gravel estimations were conservative but included habitat that did not have adequate flows at the time of survey but were expected to have appropriate flows during the spawning season based on channel characteristics. Substrate composition was assessed visually by estimating the percent of substrate in each size class for detailed habitat units. Size classes included: silt, sand, gravel, cobble, boulder and bedrock.

Estimates of shelter complexity and availability were taken for detailed habitat units. Shelter types included items that could provide cover for fish such as turbulence, undercut banks, rootwads, boulders, woody debris, terrestrial vegetation and aquatic vegetation. Shelter complexity was estimated and classified as low, medium or high based on the number of different fish shelter types present (0-3 for low, 4-5 for medium and 5 or more for high). The percent of available shelter was also documented within detailed habitat units. Percent shelter is a visual estimate of the amount of the habitat unit that provides shelter for salmonids. Percent canopy was also visually estimated for detailed habitat units. Percent canopy is a measure of the area of stream covered by over story canopy within a habitat unit.

Data collected for passage obstacles included: barrier type, jump pool depth, obstacle height and obstacle length where appropriate. The severity of each obstacle was assessed using the best judgment of the observer. Severity was evaluated based on the ability of adult trout to pass obstacles during the spawning season using guidelines of jump pool depths of at least 1.5 times obstacle height for passable structures. Obstacle height, configuration, length and pool depth were factored into estimations of obstacle severity. Total barriers were classified as red, temporal barriers as gray and passable obstacles as green.

HABITAT ASSESSMENT RESULTS

Habitat surveys were conducted on the major tributaries of Upper San Leandro Reservoir and San Leandro Creek below Chabot Dam within EBMUD property boundaries. Surveys were conducted in the spring of 2010 and 2011 by Bert Mulchaey, Jessica Purificato, Ariel Cowan and Jonathan Price of EBMUD.

Upper San Leandro Creek

A habitat mapping survey was conducted on Upper San Leandro Creek on 6/8, 6/14, 6/21, 6/23, 6/24 and 7/7/2010. Upper San Leandro Creek was divided into three sections for analysis based on geomorphic and habitat characteristics within the stream channel (Figure 1). Reach 1 represents the downstream portion of the creek mapped, stretching from 0.25 mi above the USL Reservoir to the culvert under Pinehurst Rd. Reach 1 gains approximately 30 ft in elevation over the 3,327 ft stretch. Reach 2 stretches from Pinehurst Rd. to the culvert at the City of Canyon Post Office. Reach 2 has a higher gradient than reach 1, gaining approximately 140 ft in elevation over the 10,447 ft stretch. Reach 3 represents the up most section of the creek mapped stretching from the Canyon Post office culvert to the north-west edge of EBMUD's property boundary. Reach 3 gains 50 feet in elevation over the 2,145 ft stretch. The total length of stream surveyed was 15, 819 feet. An additional 7,500 ft of creek exists upstream of the EBMUD property boundary. On 7/15 flow was measured at 0.16 cfs at the top of Reach 2. This measurement is representative of the flows experienced during the survey period.

Level II habitat types are shown in Table 1. Based on frequency of occurrence, Upper San Leandro Creek had 28% pool units, 44% riffle units and 28% flatwater units (Figure 2). Based on total length, this stretch had 29% pools, 37% riffles and 34% flatwater units (Figure 3). Reaches 1 and 2 had a pool/riffle ratio of 0.7 to 1 and reach 3 had a pool/riffle ratio of 0.4 to 1.

Fifteen Level IV habitat types were recorded in Upper San Leandro Creek (Table 2). Low gradient riffles (33.5%) and glides (28%) were the most frequent habitat types followed by lateral scour pools, root enhanced (12%) (Figure 4).

Mean residual depth and maximum depth for pools can be found in Table 3. Of the 147 pools encountered, 26% had a maximum depth of 2 feet or greater. Maximum pool depths ranged from 1 to 3.5 feet. Average pool depths were similar in all reaches with a value of 1.2 feet.

Gravel was the dominant substrate and sand and silt/clay were the subdominant substrate in Upper San Leandro Creek. Embeddedness estimated in spawning gravel areas, primarily pool tail-outs, and averaged 33%.

Shelter complexity was rated as medium in all reaches. Percent of shelter coverage averaged 28%. Terrestrial vegetation was the dominant cover type, making up 20% of the cover available for juvenile salmonids (Figure 5). Undercut bank (14%), small woody debris (14%), large woody debris (12%), surface turbulence (11%) and root wad (11%) were other common cover types. Mean canopy cover for Upper San Leandro Creek was 64%. California bay (*Umbellularia californica*) (34%) and redwood (*Sequoia sempervirens*) (32%) were the most dominant canopy species followed by willow (*Salix. sp*.) and alder (*Alnus rhombifolia*) (Figure 6). Percent canopy cover was consistent in all reaches varying from 62% to 68%.

The majority of suitable spawning gravel identified in Upper San Leandro Creek was found in Reach 2. Seventy two percent of all spawning gravel was found in this reach (Table 3) (Figure 7).

Kaiser Creek

A habitat mapping survey was conducted on Kaiser Creek on 7/7, 7/8, 7/12, 7/13 and 7/14/2010. Kaiser creek was divided into four sections for analysis based on geomorphic and habitat characteristics within the stream channel (Figure 1). Reach 1 represents the downstream section mapped on Kaiser Creek and stretches from 0.25 mile below Buckhorn Creek to 0.5 miles above the confluence with Buckhorn Creek. Reach 1 gains approximately 80 ft in elevation over the 4,374 ft stretch of creek. Reach 2 stretches from 0.5 miles above the confluence of Buckhorn creek to the culvert under Two Dog Rd. Reach 2 gains approximately 40 ft in elevation over the 4,388 ft stretch. Reach 3 stretches from Two Dog Rd. to the confluence of Callahan Creek. Reach 3 gains 75 ft in elevation over the 3,292 ft stretch. Reach 4 is the upstream section of Kaiser Creek mapped which stretches from the confluence of Callahan Creek to Rocky Ridge Loop Rd. Reach 4 gains approximately 330 ft in elevation over the 3,760 ft stretch. The total length of stream surveyed was 15,813 feet. On 7/15 flow was measured at 0.02 cfs at the top of Reach 2. This measurement is representative of the flows experienced during the survey period.

Level II habitat types are shown in Table 4. Based on frequency of occurrence, Kaiser Creek had 25% pool units, 48% riffle units and 27% flatwater units (Figure 8). Based on total length, this stretch had 30% pools, 39% riffles and 31% flatwater units (Figure 9). Kaiser Creek had a pool/riffle ratio of 0.5 to 1 (127 pools to 243 riffles, excluding flatwater). This figure is skewed lower, however, because of the 0.2 to 1 ratio in reach 4 which is too steep in gradient to provide much habitat for trout. Most of the creek has a pool to riffle ratio of about 0.7 to 1.

Fifteen Level IV habitat types were recorded in Kaiser Creek (Table 5). Glides (26%) and low gradient riffles (22%) were the most frequent habitat types followed by cascades and high gradient riffles (Figure 10).

Mean residual depth and maximum depth for pools can be found in Table 6. Of the 127 pools encountered, 28% had a maximum depth of 2 feet or greater. Maximum pool depths ranged from 1 to 3.3 feet. Average pool depths varied from 1.2 feet in reach 4 to 1.5 in reach 3 with a value of 1.3 feet for all mapped reaches.

Gravel was the dominant substrate and sand and silt/clay were the subdominant substrate in the 2 lower reaches of Kaiser Creek. Small cobble and boulders were dominant in the upper reaches. Embeddedness estimated in spawning gravel areas, which consisted primarily of primarily pool tail-outs, averaged 49%.
Shelter complexity was rated as medium in all reaches except reach 3 which had a low rating. Percent of shelter coverage averaged 32%. Surface turbulence and boulder were the

dominant cover types, making up 28% and 21% of the cover available for juvenile salmonids respectively (Figure 11). Root wads and small woody debris were other common cover types.

Mean canopy cover for Kaiser Creek was 70%. Willow (39%) and oak (*Quercus sp.*) (32%) were the most dominant canopy species followed by alder and California bay (Figure 12). Percent canopy cover was consistent in all reaches varying from 69%-73%.

The majority of suitable spawning gravel identified in Kaiser Creek was found in reaches 1, 3 and 4 (Table 6) (Figure 13).

Redwood Creek

A habitat mapping survey was conducted on Redwood Creek on 6/2 and 6/8/2011. The creek was mapped from the point of reservoir inundation up to the EBMUD property boundary at Pinehurst Road (Figure 1). Most of the suitable trout habitat on Redwood Creek exists on East Bay Park District land upstream of the EBMUD property boundary. The total length of stream surveyed was 3,969 feet and elevation ranged from 460 -510 ft along the creek stretch. An estimated 25,000 feet of creek exist above EBMUD property. On 5/28/2011, flow was measured at 0.15 cfs in the mapped section. This flow is slightly lower but similar to the flow experienced during the habitat mapping survey.

Level II habitat types are shown in Table 7. Based on frequency of occurrence, Redwood Creek had 37% pool units, 40% riffle units and 23% flatwater units (Figure 14). Based on total length, this stretch had 14% pools, 50% riffles and 36% flatwater units (Figure 15). The pool/riffle ratio was 0.9 to 1.

Fourteen Level IV habitat types were recorded in Redwood Creek (Table 8). Low gradient riffles (28.9%) and lateral scour pools (23.4%) were the most frequent habitat types followed by glides (14.1%) (Figure 16).

Mean residual depth and maximum depth for pools can be found in Table 8. Of the 46 pools encountered, 30% had a maximum depth of 2 feet or greater. Maximum pool depths ranged from 1 to 3.3 feet and the average mean pool depth was 1.4 feet.

Gravel was the dominant substrate and silt/clay were the subdominant substrate in this stretch of Redwood Creek. Embeddedness estimated in spawning gravel areas, which consisted primarily of primarily pool tail-outs, averaged 35.6%.

Shelter complexity was most often rated as medium in this stretch. Percent of shelter coverage averaged 34%. Surface turbulence was the dominant cover type, making up 27% of the cover available for juvenile salmonids (Figure 17). Root mass, boulder, terrestrial vegetation, large woody debris, and small woody debris were other common cover types.

Mean canopy cover for this section of Redwood Creek was 62%. Willow (57%) was the most dominant canopy species followed by alder (31%), California bay and oak (Figure 18).

Rimer Creek

A habitat mapping survey was conducted on Rimer Creek on 6/9/2011. The creek was mapped from the point of reservoir inundation to the EBMUD property boundary just downstream of Tharp Drive (Figure 1). The extent of suitable trout habitat on the approximately 12,000 feet of Rimer Creek upstream of the EBMUD property boundary is unknown due to the private ownership upstream. The total length of stream surveyed was 2,787 feet. Elevation along the mapped section of Rimer creek ranges from 460- 520 ft. On 7/13/2011 flow was measured at 0.39 cfs in the mapped section. This flow is similar to the flow experienced during the habitat mapping survey.

Level II habitat types are shown in Table 9. Based on frequency of occurrence, Rimer Creek had 31% pool units, 35% riffle units and 34% flatwater units (Figure 19). Based on total length, this stretch had 37% pools, 22% riffles and 41% flatwater units (Figure 20). The pool/riffle ratio was 0.9 to 1.

Fourteen Level IV habitat types were recorded in Rimer Creek (Table 10). Glides (21%) and low gradient riffles (19%) were the most frequent habitat types followed by plunge pools (11%) (Figure 21).

Mean residual depth and maximum depth for pools can be found in Table 10. Of the 25 pools encountered, 20% had a maximum depth of 2 feet or greater. Maximum pool depths ranged from 1.4 to 3.2 feet and the average mean pool depth was 1.4 feet.

Sand was the dominant substrate and boulder were the subdominant substrate in this stretch of Rimer Creek. Embeddedness estimated in spawning gravel areas, primarily pool tail-outs, and averaged 70%.

Shelter complexity was rated as low to medium. Percent of shelter coverage averaged 31%. Surface turbulence was the dominant cover type, making up 32% of the cover available for juvenile salmonids (Figure 22). Boulder (30%), bedrock shelf (8%) and root mass (7%) were other common cover types.

Mean canopy cover for this section of Rimer Creek was 29%. Oak (61%) was the most dominant canopy species followed by alder (22%). California bay, willow and madrone were less common (Figure 23).

Buckhorn Creek

A habitat mapping survey was conducted on Buckhorn Creek on 6/14 and 6/16/2011. The creek was mapped from the confluence with Kaiser Creek to the EBMUD property boundary (Figure 1). Buckhorn Creek upstream of this location consists of private land and EBMUD watershed. Approximately 7,000 feet of Buckhorn Creek's headwaters were not mapped due to the lack of flow and suitable trout habitat. The total length of stream surveyed was 9,418 feet. Elevation ranged from 480-620 ft over the mapped section of Buckhorn Creek. On 7/13/2011, flow was measured at 0.11 cfs in the mapped section. This flow is slightly lower but similar to the flow experienced during the habitat mapping survey.

Level II habitat types are shown in Table 11. Based on frequency of occurrence, Buckhorn Creek had 21% pool units, 45% riffle units and 34% flatwater units (Figure 24). Based on total length, this stretch had 23% pools, 44% riffles and 33% flatwater units (Figure 25). The pool/riffle ratio was 0.45 to 1.

Fifteen Level IV habitat types were recorded in Buckhorn Creek (Table 12). Low gradient riffles (35%) and glides (26%) were the most frequent habitat types followed by high gradient riffles (7%) (Figure 26).

Mean residual depth and maximum depth for pools can be found in Table 12. Of the 65 pools encountered, 12% had a maximum depth of 2 feet or greater. Maximum pool depths ranged from 1.8 to 3.1 feet and the average mean pool depth was 1.4 feet.

Sand was the dominant substrate and gravel were the subdominant substrate in this stretch of Buckhorn Creek. Embeddedness estimated in spawning gravel areas, primarily pool tail-outs, averaged 73%. Shelter complexity was rated as low to medium. Percent of shelter coverage averaged 29%. Surface turbulence was the dominant cover type, making up 33% of the cover available for juvenile salmonids (Figure 27). Boulder, and root mass were other common cover types.

Mean canopy cover for this section of Buckhorn Creek was 54%. California bay (43%) was the most dominant canopy species followed by willow (20%). Alder, maple, oak and box elder were present in smaller numbers (Figure 28).

Indian Creek

A habitat mapping survey was conducted on Indian Creek on 6/8/2011. The creek was mapped from the confluence with San Leandro Creek to the EBMUD property boundary and the culvert which presents a total barrier to fish migration. The extent of suitable trout habitat on the approximately 9,000 feet of Indian Creek upstream is unknown because it is under private ownership. The total length of stream surveyed was 785 feet. Elevation ranges from 490 -520 ft within the mapped stretch. On 5/28/2011 flow was measured at 0.13 cfs in the mapped section. This flow is representative of the flow experienced during the habitat mapping survey.

Level II habitat types are shown in Table 13. Based on frequency of occurrence, Indian Creek had 45% pool units, 30% riffle units and 25% flatwater units (Figure 29). Based on total length, this stretch had 54% pools, 12% riffles and 34% flatwater units (Figure 30). The pool/riffle ratio was 1.5 to 1.

Seven Level IV habitat types were recorded in Indian Creek (Table 14). Low gradient riffles (30%) and lateral scour pools (30%) were the most frequent habitat types followed by glides (20%) (Figure 31).

Mean residual depth and maximum depth for pools can be found in Table 14. Of the 9 pools encountered, 67% had a maximum depth of 2 feet or greater. Maximum pool depths ranged from 1.3 to 5 feet and the average mean pool depth was 2.1 feet.

Sand was the dominant substrate and silt/clay were the subdominant substrate in this stretch of Indian Creek. No spawning areas were found in lower Indian Creek, thus embeddedness was not estimated.

Shelter complexity was rated as medium. Percent of shelter coverage averaged 31%. Terrestrial vegetation was the dominant cover type, making up 18% of the cover available for juvenile salmonids (Figure 32). Large woody debris (18%), small woody debris (16%) and surface turbulence (16%) were other common cover types.

Mean canopy cover for this section of Indian Creek was 61%. California bay (61%) was the most dominant canopy species followed by redwood (31%) (Figure 33).

Lower San Leandro Creek (Below Chabot Reservoir)

A habitat mapping survey was conducted on Lower San Leandro Creek on 6/21 and 6/22/2011. The creek was mapped from the weir above Highway 580 to Chabot Dam (Figure 1). Most of this section of Lower San Leandro Creek is within Chabot Park with some EBMUD watershed lands and private ownership. The total length of stream surveyed was 5,039 feet. Elevation ranged from 80-120 ft along the creek stretch. On 6/16/2011 flow was measured at 0.06 cfs in the mapped section. This flow is slightly lower but similar to the flow experienced during the habitat mapping survey.

Level II habitat types are shown in Table 15. Based on frequency of occurrence, Lower San Leandro Creek had 41% pool units, 41% riffle units and 17% flatwater units (Figure 34). Based on total length, this stretch had 69% pools, 20% riffles and 11% flatwater units (Figure 35). The pool/riffle ratio was 1 to 1.

Fifteen Level IV habitat types were recorded in Lower San Leandro Creek (Table 16). Lateral scour pool (25%) and mid-channel pool (18%) were the most frequent habitat types followed by low gradient riffles (14%) (Figure 36).

Mean residual depth and maximum depth for pools can be found in Table 16. Of the 41 pools encountered, 59% had a maximum depth of 2 feet or greater. Maximum pool depths ranged from 1.4 to 5 feet and the average mean pool depth was 2.4 feet.

Gravel was the dominant substrate and small cobble were the subdominant substrate in this stretch of Lower San Leandro Creek. Embeddedness estimated in spawning gravel areas, primarily pool tail-outs, and averaged 48%.

Shelter complexity was rated as medium. Percent of shelter coverage averaged 32%. Boulder was the dominant cover type, making up 21% of the cover available for juvenile salmonids (Figure 37). Surface turbulence, large woody debris and terrestrial vegetation were other common cover types.

Mean canopy cover for this section of Lower San Leandro Creek was 62%. California bay (32%) was the most dominant canopy species followed by willow (25%). alder, cottonwood, eucalyptus, maple and walnut were present in smaller numbers (Figure 38).

DISCUSSION

Upper San Leandro Creek

Migration Barriers

This habitat mapping effort and previous spawning surveys have confirmed that there are currently no significant barriers to adult fish migration on Upper San Leandro Creek within the EBMUD watershed upstream of USL Reservoir. A few potential barriers have been noted upstream of EBMUD property in the upper creek where habitat is rarely suitable for trout spawning and rearing due to stream gradient and low flows. On rare occasions, woody debris jams judged to be significant passage obstacles have been removed from the creek by EBMUD staff. These efforts have helped maintain fish access to the highest quality spawning and rearing habitat in Upper San Leandro Creek.

Temperature

EBMUD has collected hourly water temperatures in Upper San Leandro Creek from thermographs deployed at 2 locations since 1997. One site at the lower end of Reach 2 and the other is on EBRPD property upstream of the reaches mapped for this survey. EBMUD temperature monitoring indicates that creek temperatures are not a major limiting factor for rainbow trout in Upper San Leandro Creek. The San Leandro Creek riparian corridor is intact and provides overhanging vegetation to keep creek temperatures within a good range for salmonids. The highest hourly temperature recorded in over a decade of temperature monitoring was 21^{o}C in June of 2009. Temperatures seldom approach 20^{o}C in Upper San Leandro Creek and rarely exceed that temperature for more than a few hours.

Rearing Habitat

San Leandro Creek upstream of USL Reservoir has an abundance of habitat for rearing resident rainbow trout. The creek has a pool to riffle ratio of 0.7 to 1, providing ample deep water and riffle habitat for fish. Shelter complexity consistently rated as medium. The quality and quantity of shelter was good, providing significant amounts of habitat for rearing fish. Benthic macroinvertebrate sampling in the past has demonstrated that a diverse and abundant aquatic insect population provides an ample food source for rearing trout in Upper San Leandro Creek.

Spawning Habitat and Sediment

Areas with suitable spawning gravel for rainbow trout exist in most reaches of Upper San Leandro Creek. Reach 2 and the lower end of Reach 3 have the best quality and the largest quantity of spawning gravels. These reaches have the best spawning habitat characteristics with good flows, proper gradient, good cover and relatively low embeddedness. The quality of these spawning areas has been demonstrated by high usage of these areas by spawning fish observed during EBMUD spawning surveys. Embeddedness in these reaches averages about 30%. Many pool tail-outs in these reaches have suitable spawning areas which are sufficient to support a significant amount of spawning.

Upper San Leandro Creek has low to moderate levels of fine sediments. Much of the spawning substrate was in the 30 to 40% embedded range which is enough to cause some reduction in emergence from redds (Reiser and Bjornn, 1979). The embeddedness is not in a range, however, that would cause severe declines in redd recruitment.

Summary

Upper San Leandro Creek has a sizeable and thriving rainbow trout population and all the necessary habitat components to support all trout life history stages. There are substantial amounts of habitat available to rearing fish with suitable water temperatures, quality shelter, and a diverse and abundant food source. There are no major barriers to fish migrating upstream from USL Reservoir. Smaller passage obstacles in the reaches of the creek upstream of the EBMUD watershed may limit the distribution of fish. However, these barriers are not a major limiting factor for trout because habitat upstream is limited and is only suitable for spawning and rearing in the wettest years. Habitat data and robust populations of trout in Upper San Leandro Creek indicate that the effects of gravel embeddedness on spawning success in this creek are limited.

Kaiser Creek

Migration Barriers

This habitat mapping effort and previous spawning surveys indicate that there are no significant barriers to fish migration in the lower and middle reaches of Kaiser Creek. A few total barriers have been noted in the headwaters of Kaiser Creek where habitat is rarely suitable for trout spawning and rearing due to large substrate and high gradient. On rare occasions, woody debris jams in Kaiser Creek have been removed by EBMUD staff when judged to be significant passage obstacles. These efforts have helped maintain fish access to the highest quality spawning and rearing habitat in Kaiser Creek.

Temperature

EBMUD has collected hourly water temperatures in Kaiser Creek from thermographs deployed at 2 locations since 1997. One site is in Reach 2 and the other is at the top of Reach 3. EBMUD temperature monitoring indicates that creek temperatures are not a limiting factor for rainbow trout in Kaiser Creek. Springs in the upper watershed provide cool water temperatures for the resident trout population. The Kaiser Creek riparian corridor is intact and provides overhanging vegetation to keep creek temperatures within a good range for salmonids. The highest hourly temperature recorded in over a decade of temperature monitoring was 20^{o}C in June of 2009.

Rearing Habitat

Kaiser Creek has considerable habitat for rearing resident rainbow trout. The creek has a pool to riffle ratio of 0.5 to 1. This ratio appears low but is the result of a very low pool to riffle ratio in Reach 4 which does not provide much habitat for trout. It should also be noted that a significant amount of flatwater habitat (which is excluded from this number) is present in Kaiser Creek. EBMUD biologists have noted significant usage of these flatwater areas by rearing trout during creek surveys. Fish may be able to use flatwater in a similar manner to deep water pool habitat in Kaiser Creek as a result of the cool water temperatures and the abundance of large cover items, such as boulders. Shelter complexity consistently rated as medium in Kaiser Creek. The quality and quantity of shelter was quite good, providing significant amounts of habitat for rearing fish. Benthic macroinvertebrate sampling in the past has indicated that a diverse and abundant aquatic insect population provides an ample food source for rearing trout in Kaiser Creek.

Spawning Habitat and Sediment

Areas with suitable spawning gravel for rainbow trout exist in most reaches of Kaiser Creek. Data from this survey indicate that Reach 1 has the highest density of spawning gravel. However, EBMUD spawning surveys have demonstrated that most trout spawning typically occurs in Reach 3. Reach 3 is likely preferred by spawning adults because the combination of flow, gradient, and cover characteristics are more favorable for spawning than in Reach 1.

Kaiser Creek has considerable levels of fine sediments. Embeddedness is estimated to be close to 50% on average and may be a limiting factor to productivity in Kaiser Creek. Much of the spawning substrate was in the upper 40% embedded range which is enough to cause some mortality and a significant reduction in emergence from redds (Reiser and Bjornn, 1979).

Summary

Kaiser Creek has a significant rainbow trout population and all the necessary habitat components to support all trout life history stages. There are considerable amounts of habitat available for rearing fish with suitable water temperatures, quality shelter, and a diverse food source. There are no major passage barriers between USL Reservoir and the best spawning and rearing habitat in the creek. Embeddedness, which degrades salmonid spawning habitat, is probably the most significant limiting factor to rainbow trout reproduction and rearing in Kaiser Creek.

Redwood Creek

Migration Barriers

This habitat mapping effort and previous spawning surveys have confirmed that there are no significant barriers to adult fish migration on Redwood Creek within the EBMUD watershed upstream of USL Reservoir. Most of Redwood Creek's suitable trout habitat is on EBRPD lands upstream of EBMUD's property boundary. Observations by EBRPD staff indicate that fish continue to have access to the highest quality spawning and rearing habitat in Redwood Creek upstream (Peter Alexander pers. comm.).

Temperature

EBMUD has collected hourly water temperatures in Redwood Creek from thermographs deployed at 2 to 3 locations since 1997. One site was within the surveyed reach. This thermograph took data for approximately 8 years before high flows swept the logger away and left the site unsuitable for temperature measurement. The other 2 locations are on EBRPD property upstream of the reaches mapped for this survey on the east and west forks of the creek. Hourly temperatures are currently available through 2010 for these 2 sites.

EBMUD temperature monitoring indicates that creek temperatures are not a major limiting factor for rainbow trout in Redwood Creek. The Redwood Creek riparian corridor is intact and provides overhanging vegetation to keep creek temperatures within a good range for salmonids. Maximum recorded temperatures typically reach into the high teens (^{o}C) in the summer and rarely exceed 20^{o}C.

Rearing Habitat

Redwood Creek upstream of USL Reservoir has significant habitat for rearing resident rainbow trout, particularly on EBRPD lands. The creek has a pool to riffle ratio of 0.9 to 1, providing ample deep water and riffle habitat for fish. Shelter complexity consistently rated as medium. The quality and quantity of shelter was good, providing significant amounts of habitat for rearing fish. Benthic macroinvertebrate sampling in the past has demonstrated that a diverse and abundant aquatic insect population provides an ample food source for rearing trout in Redwood Creek.

Spawning Habitat and Sediment

Areas with suitable spawning gravel for rainbow trout exist in most reaches of Redwood Creek upstream of USL Reservoir. However, most of the spawning habitat present in

Redwood Creek exists on EPRPD lands which were not mapped as part of this survey. The stretches on EPRPD lands likely have the best quality and the largest quantity of spawning gravels. The quality of these spawning areas has been demonstrated by EBMUD/EPRPD spawning surveys. Many pool tail-outs in these reaches have suitable spawning areas which, in aggregate, are sufficient to support a significant amount of spawning. Embeddedness measured in spawning gravel areas observed during this survey averaged about 36%. The embeddedness is not in a range, however, that would cause severe declines in redd recruitment.

Summary

Redwood Creek has a thriving rainbow trout population and all the necessary habitat components to support all trout life history stages. There are considerable amounts of habitat available for rearing fish with suitable water temperatures, quality shelter, and a diverse food source. There are no known passage barriers between USL Reservoir and the best spawning and rearing habitat in the creek. Embeddedness, which degrades salmonid spawning habitat and limits macroinvertebrate diversity, is likely only a small limiting factor for trout populations.

Rimer Creek

Migration Barriers

This habitat mapping effort and previous spawning surveys have confirmed that there are no significant barriers to adult fish migration on Rimer Creek within the EBMUD watershed upstream of USL Reservoir. Most of Rimer Creek is developed and in private ownership upstream of EBMUD's property boundary. It is unknown if any barriers or suitable trout habitat exist upstream.

Temperature

EBMUD has not monitored temperatures in Rimer Creek. The Rimer Creek riparian corridor in the surveyed section is somewhat impacted with low overall canopy cover due to some encroachment on the riparian corridor by local residents. Consistent observations of trout by EBMUD staff indicate that creek temperatures are suitable for salmonids.

Rearing Habitat

Rimer Creek has some habitat for rearing resident rainbow trout within the mapped stretch. This creek section has a pool to riffle ratio of 0.9 to 1, providing deep water and riffle habitat for fish. Shelter complexity rated as low to medium. Habitat complexity in the section surveyed was negatively affected by a lack of large and small woody debris which was likely removed by creekside residents or local government for flood control purposes. EBMUD has not sampled benthic macroinvertebrates in Rimer Creek. A somewhat impaired macroinvertebrate community would be expected as the result of the significant development along most of the creek. Benthic macroinvertebrate diversity and densities appear to be good enough to support a small trout population.

Spawning Habitat and Sediment

Very little spawning habitat for rainbow trout was identified in the surveyed reach of Rimer Creek. It is likely that additional spawning habitat in Rimer Creek exists upstream of the section mapped in this survey. Spawning habitat in the surveyed reach did not appear to be sufficient to produce the rearing trout observed in this stretch. Embeddedness measured in spawning gravel areas observed during this survey averaged a very high 70% which is in a range that would likely cause severe declines in redd recruitment.

Summary

The rainbow trout population appears to be small but persistent in the section of Rimer Creek within the EBMUD watershed boundary. There is some habitat available for rearing trout with suitable water temperatures, some shelter, and a food source of unknown quality and quantity. There are no passage barriers between USL Reservoir and the lower creek. Spawning gravel embeddedness and pollution are likely limiting factors for trout populations in Rimer Creek.

Buckhorn Creek

Migration Barriers

This habitat mapping effort has confirmed that no barriers exist to fish migration in the lower and middle sections of Buckhorn Creek. Surveys are planned for the upper section of Buckhorn Creek to look for passage obstacles or barriers.

Temperature

EBMUD has monitored temperatures in Buckhorn Creek since 1998 but monitoring locations often dry in the summer months. Most of the creek dries up in average and low rainfall years, making it unlikely that a trout population could persist long-term in this drainage.

Rearing Habitat

Buckhorn Creek does not provide rearing habitat for trout in most years as it typically dries in the summer. Trout have been observed in the creek on rare occasions.

Spawning Habitat and Sediment

Very little spawning habitat for rainbow trout was identified in the surveyed reach of Buckhorn Creek. Embeddedness averaged a very high 74% during the survey, which is in a range that would cause severe declines in redd recruitment if spawning were to occur.

Summary

Buckhorn Creek does not likely provide habitat for rainbow trout in most years and does not provide the needed habitat components to support trout populations in the long-term. If fish were to spawn in Buckhorn Creek, most of the progeny would likely succumb in average or dry years as little if any refuge exists in the creek during the summer season under these conditions.

Indian Creek

Migration Barriers

This habitat mapping effort has confirmed that most of Indian Creek is unavailable to trout due to a total barrier (a hanging culvert) 785 feet upstream of the confluence with Upper San Leandro Creek. Most of the Indian Creek watershed is privately owned ranchland upstream of EBMUD's property boundary. Barriers in the upper creek and extent of trout spawning habitat above the EBMUD watershed boundary are unknown.

Temperature

EBMUD has monitored temperatures in Indian Creek since 1998. The Indian Creek riparian corridor in the surveyed section is intact with a high degree of canopy cover. Temperatures in the lower creek rarely reach above 20^oC and are suitable for trout.

Rearing Habitat

The Indian Creek stretch surveyed has very limited habitat for rearing resident rainbow trout. This creek section has a pool to riffle ratio of 1.5 to 1, but riffle habitats lack any substrate larger than sand. Shelter complexity is rated as medium. EBMUD has not sampled benthic macroinvertebrates in Indian Creek. An impaired macroinvertebrate community might be expected as the result of excessive amounts of fine sediment in the lower creek.

Spawning Habitat and Sediment

No spawning habitat for rainbow trout was identified in the surveyed reach of Indian Creek. It is possible that some spawning habitat in Indian Creek exists upstream of the section mapped in this survey.

Summary

Indian Creek does not likely provide habitat for rainbow trout population within the EBMUD watershed boundary. It is currently unknown if any resident trout population persists in the creek upstream of EBMUD property.

Lower San Leandro Creek (Below Chabot Reservoir)

Migration Barriers

There are no total barriers to fish migration on Lower San Leandro Creek below Chabot Dam. Two potential passage obstacles were identified by the barrier assessment survey including the concrete flood control channel near San Francisco Bay and a weir located several hundred feet upstream of Highway 580. Both of theses structures were judged to be passable during at least some flows typically experienced during the spawning season.

Temperature

EBMUD temperature monitoring indicates that creek temperatures may be limiting factor for steelhead or rainbow trout in Lower San Leandro Creek. The Lower San Leandro Creek riparian corridor has a large non-native vegetation component but is somewhat intact and provides overhanging vegetation to keep creek temperatures mostly within acceptable ranges for salmonids. Maximum recorded temperatures in the summer have reached 22^{o}C in some instances in Lower San Leandro Creek. The creek experiences temperatures that are likely stressful to salmonids in some years.

Rearing Habitat

Lower San Leandro Creek has some habitat for rearing resident rainbow trout. Most of the suitable habitat for salmonids exists upstream of highway 580. The stretch of creek surveyed has a pool to riffle ratio of 1 to 1, providing ample deep water and riffle habitat for fish. Shelter complexity consistently rated as medium in Lower San Leandro Creek. Shelter complexity is sufficient to provide significant amounts of habitat for rearing fish. EBMUD has not sampled benthic macroinvertebrates in Lower San Leandro Creek. An impaired macroinvertebrate community might be expected as the result of excessive amounts of fine sediment in the creek and effects of urbanization.

Spawning Habitat and Sediment

Suitable spawning areas were identified within Chabot Park which makes up the bulk of the stretch surveyed. Several of the pool tail-outs in this area have suitable spawning areas. Collectively, these spawning areas are sufficient to support salmonid spawning. Lower San Leandro Creek has considerable levels of fine sediments. Embeddedness is estimated to be close to 50% on average. Much of the spawning substrate was embedded enough to cause some mortality and a significant reduction in emergence from redds (Reiser and Bjornn, 1979). Spawning substrate appeared angular in nature, which could have a detrimental effect on redd construction in spawning areas. Some of this angular substrate consisted of rip/rap added to the channel but much of it appeared to be of natural origin.

Summary

Lower San Leandro Creek is a highly altered environment, suffering from pollution, invasive species, urbanization and effects of upstream dams. Despite this, Lower San Leandro Creek supports a salmonid population and the upstream section of the creek has the necessary habitat components to support all salmonid life history stages. Small numbers of salmonids have persisted in the suitable habitat found above Highway 580. Very little habitat for salmonids exists downstream of Highway 580. The population is likely bolstered in wet years by trout (wild and stocked) from the upstream reservoirs which escape during periodic spill events. The extent to which steelhead contribute to the population is unknown.

MANAGEMENT RECOMMENDATIONS

EBMUD's East Bay Watershed Management Plan and the EBMUD East Bay Habitat Conservation Plan dictate that watershed management be done in a manner that sustains and improves native trout habitat. Continued monitoring and study of fish populations in watershed creeks is recommended to inform proper management. EBMUD's fisheries monitoring program should include spawning surveys, barrier surveys, population sampling and benthic macroinvertebrate surveys. EBMUD should also continue to educate the public and promote pollution prevention to local residents that live on watershed creeks.

EBMUD watershed management should continue to prioritize protection and enhancement of riparian corridors on these creeks. It should also continue to conduct management activities that limit erosion and excessive inputs of sediment into these creeks. In particular, it would be useful to determine sediment sources in the Kaiser Creek watershed and find ways to limit excessive sediment input to the creek.

Most of Redwood Creek is on EPRPD property. It is a recommended that habitat mapping effort be completed on the EBRPD lands to help determine the quality and quantity of trout habitat present in Redwood Creek.

On Rimer Creek, EBMUD should continue to educate the public about this resource and work with residents to reduce creek-side impacts. A survey of the trout population and habitat upstream of EBMUD property is recommended to better understand the size and viability of the Rimer Creek population.

It is not known whether Indian Creek has suitable trout rearing habitat in the upper watershed. A survey of the habitat upstream of EBMUD property is recommended to determine the quality of habitat upstream of the fish passage barrier and the feasibility or merit of providing passage for trout at this structure.

Lower San Leandro Creek should be managed to sustain and improve its native salmonid population. Continued monitoring should help determine the extent to which anadromous fish contribute to the population. EBMUD should continue to educate the public about the resource and encourage local agencies and citizens to reduce the impacts of urbanization on the creek.

CONCLUSION

Habitat mapping efforts and data from EBMUD fisheries surveys demonstrate that quality habitat for rainbow trout exists within most of the USL Reservoir tributaries. The quality and quantity of habitat in these tributaries varies greatly depending on local annual precipitation. USL Reservoir provides habitat for adult trout which can quickly boost resident populations in the tributaries following drought years. San Leandro, Redwood and Kaiser creeks provide the majority of the high quality trout habitat in the watershed. These creeks likely maintain high quality habitat under all but the most severe drought conditions. Salmonid reproduction and sufficient habitat suitability has been documented in lower Rimer Creek. Moraga and Rimer creeks may provide additional habitat on private land upstream of the EBMUD watershed. Buckhorn Creek does not likely provide habitat for trout except in abundant water years. Indian Creek may have some habitat potential if passage issues are addressed.

EBMUD fish surveys over the past few decades have documented a robust rainbow trout population in USL Reservoir and its tributaries. These trout are a unique resource due to the lack of hatchery influence in the population, which has maintained a genetic similarity to wild ocean-run steelhead. This population is well adapted to local conditions in the East Bay and thus has unique value as a potential source for re-establishing steelhead/rainbow trout populations in local watersheds. Results of this habitat assessment confirm that significant habitat for this species exists within the tributaries of the USL Reservoir watershed. While these creeks face similar issues that affect many local urban watersheds, these creeks retain some of the best quality rainbow trout habitat in the San Francisco East Bay Area.

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TABLES

Level II Habitat Type	% Occurrence	# Occurrences	% Length	Length (ft)
Pool	28%	147	29%	4,591
Riffle	44%	224	37%	5,717
Flatwater	28%	142	34%	5,353

Table 1. Upper San Leandro Creek Frequency of Level II Habitat Types.

Habitat Type	# Habitat Units	# Units Fully Measured	Mean Length (ft)	Total Length (ft)	Avg. Mean Depth (ft)	Max Depth (ft)	Mean Shelter Rating	Total Spawning Gravel Area (sq ft)	Avg. % Spawning Gravel Embeddedness
Cascade	4	1	25	100	0.3	0.6	60%		
Culvert	4		40	158					
Glide	141	28	38	5325	0.5	1.3	25%	919	31%
High Gradient Riffle	47	9	27	1253	0.2	0.6	32%		
L Scour Pool	25	6	33	823	1.3	2.7	22%	193	36%
L Scour Pool Bedrock	5	1	28	140	1.1	2	18%	75	28%
L Scour Pool Boulder	5	1	24	122	1.1	1.7	45%	18	36%
L Scour Pool Log	27	6	23	629	1.3	3.5	51%	145	36%
L Scour Pool Root	57	12	36	2067	1.2	2.6	30%	480	32%
Low Gradient Riffle	173	33	25	4364	0.2	0.7	26%	80	
Mid-Channel Pool	20	5	31	625	1.1	3.2	25%	162	38%
Non-Specific Pool	1	1	12	12	1.0	1.4	25%	16	35%
Plunge Pool	6	2	23	139	1.3	2.4	35%	49	36%
Run	1	1	28	28	0.5	0.7	50%		
Step Pool	1	1	34	34	1.1	1.8	60%		
Total	517			15819					

Table 2. Upper San Leandro Creek Level IV Habitat Statistics.

Reach Summary	Reach 1	Reach 2	Reach 3
Length (ft)	3227	10447	2145
# of habitats	103	344	70
% Pools	31	30	19
% Riffle	43	43	49
% Flatwater	27	27	32
Pool/Riffle Ratio (by habitat occurrence)	0.7	0.7	0.4
Length of pools (ft)	933	3186	472
# of pool habitats	31	103	13
Avg Pool Length	30	31	36
Avg Pool Depth	1.2	1.2	1.2
Max Pool Depth	2.5	3.5	2.1
% of pools < 2 ft max depth	65%	72%	85%
Avg spawning gravel embededness within pools	39	35	26
Area (sq ft) of spawning gravel within pools	200	789	149
Total area of spawning gravel area	322	1535	280
Shelter Complexity	Medium	Medium	Medium
Average % Shelter Rating	28%	29%	28%
Dominant Shelter Type	Terrestrial Vegetation	Undercut Bank	Surface Turbulence
Subdominant Shelter Type	Small Woody Debris	Terrestrial Vegetation	Terrestrial Vegetation
Dominant Substrate Composition	Gravel	Gravel	Gravel
Subdominant Substrate Composition	Sand	Sand	Silt/Clay
Average % Canopy	62%	64%	68%
Dominant Canopy Type	Willow	Bay/Redwood	Alder/Redwood

Table 3. Upper San Leandro Creek Habitat Characteristics by Reach

Level II Habitat Type	% Occurrence	# Occurrences	% Length	Length (ft)
Pool	25%	127	30%	4,728
Riffle	48%	243	39%	6,127
Flatwater	27%	134	31%	4,938

Table 4. Kaiser Creek Frequency of Level II Habitat Types

Habitat Type	# Habitat Units	# Units Fully Measured	Mean Length (ft)	Total Length (ft)	Avg. Mean Depth (ft)	Max Depth (ft)	Mean Shelter Rating	Total Spawning Gravel Area (sq ft)	Average % Spawning Gravel Embeddedness
Backwater Pool	1	1	10	10	1.10	1.4	50%		
Bedrock Sheet	4	1	14	55	0.03	0.2	20%		
Cascade	64	13	40	2553	0.06	0.7	39%	38	42%
Culvert	2	0		20					
Glide	132	27	37	4887	0.08	1.2	29%	267	47%
High Gradient Riffle	63	13	21	1339	0.04	0.5	31%	8	25%
L Scour Pool	14	3	42	593	1.31	2.3	23%	53	51%
L Scour Pool Bedrock	8	2	43	342	1.38	3.8	20%	58	51%
L Scour Pool Boulder	7	2	22	155	1.67	3.6	30%	16	30%
L Scour Pool Log	16	4	42	670	1.23	2.5	36%	27	55%
L Scour Pool Root	38	8	41	1570	1.47	3.3	33%	145	52%
Low Gradient Riffle	112	22	19	2180	0.03	0.6	30%	47	45%
Mid-Channel Pool	22	4	42	918	1.25	2.9	30%	76	53%
Plunge Pool	15	4	19	281	1.29	2.3	40%	71	44%
Run	1	1	21	21	0.30	0.4	35%		
Step Pool	5	2	31	155	1.02	1.7	43%	10	25%
Step Run	1	1	30	30	0.30	0.6	40%		
Trench Pool	1	1	34	34	2.00	2.9	50%	2	40%
Total	506	109		15813					

Table 5. Kaiser Creek Level IV Habitat Statistics

Reach Summary	Reach 1	Reach 2	Reach 3	Reach 4
Length (ft)	4373.7	4388	3292	3760
# of habitats	125	142	103	136
% Pools	28.8%	30%	28%	15%
% Riffle	41.6%	43%	45%	62%
% Flatwater	29.6%	27%	27%	23%
Pool/Riffle Ratio (by habitat occurrence)	0.7	0.7	0.6	0.2
Length of pools (ft)	1436	1674	1241	377
# of pool habitats	36	42	29	20
Avg Pool Length	40	40	43	19
Avg Pool Depth	1.4	1.3	1.5	1.2
Max Pool Depth	3.8	3.3	3.6	2.3
% of pools < 2 ft max depth	72%	71%	66%	80%
Avg spawning gravel embededness within pools	59	44	49	45
Area (sq ft) of spawning gravel within pools	139	150	83	86
Total area of spawning gravel area	265	193	159	201
Shelter Complexity	Medium	Medium	Low	Medium
Average % Shelter Rating	30	32	31	35
Dominant Shelter Type	Surface Turbulence	Surface Turbulence	Surface Turbulence	Boulder
Subdominant Shelter Type	S. Woody Debris	Boulder	Boulder	Surface Turbulence
Dominant Substrate Composition	Gravel	Gravel	S. Cobble	Boulder
Subdominant Substrate Composition	Sand/Silt/Clay	Sand	Sand/Boulder	S. Cobble
Average % Canopy	69%	69%	71%	73%
Dominant Canopy Type	Willow	Bay/Alder	Bay	Alder

Table 6. Kaiser Creek Habitat Characteristics by Reach

Level II Habitat Type	% Occurrence	# Occurrences	% Length	Length (ft)
Pool	37%	46	14%	356
Riffle	40%	51	50%	1286
Flatwater	23%	29	36%	925

Table 7. Redwood Creek Frequency of Level II Habitat Types

Habitat Type	# Habitat Units	#Units Fully Measured	Habitat Occurrenc e %	Mean Length (ft)	Total Length (ft)	Total Length %	Avg. Mean Depth (ft)	Max Depth (ft)	% Shelter	Mean % Canopy	Total Spawning Gravel Area (sq ft)	Avg. % Spawning Gravel Embededness
Backwater Pool												
Bedrock Sheet												
Cascade	1	1	0.8%	27	27	0.8%	0.4	0.7	15.0	65.0	0	100.0
Culvert	2	0	1.6%	70	140	4.0%	0	4	0.0	0.0	0	100.0
Dammed Pool	2	2	1.6%	141	281	8.1%	1.8	3.3	32.5	75.0	25	30.0
Glide	18	4	14.1%	38	680	19.6%	0.43	0.9	30.0	45.0	203	37.7
High Gradient Riffle	13	3	10.2%	17	225	6.5%	0.3	0.7	38.3	51.7	8	25.0
L Scour Pool	2	1	1.6%	30	60	1.7%	1.5	2.1	75.0	75.0	6	45.0
L Scour Pool Bedrock												
L Scour Pool Boulder	2	1	1.6%	34	68	2.0%	0.9	1.9	35.0	85.0	14	25.0
L Scour Pool Log	19	5	14.8%	28	537	15.5%	1.4	3.2	57.0	73.0	218	41.8
L Scour Pool Root	7	2	5.5%	34	238	6.9%	1.5	2.8	27.5	60.0	87	30.8
Low Gradient Riffle	37	8	28.9%	15	537	15.5%	0.2	0.5	28.8	55.6	100	25.0
Mid-Channel Pool	11	4	8.6%	31	342	9.9%	1.2	1.9	26.3	58.8	80	39.2
Plunge Pool	3	1	2.3%	31	92	2.6%	2	3.1	30.0	40.0	60	42.5
Run	9	2	7.0%	24	214	6.2%	0.5	0.8	20.0	45.0	15	50.0
Step Pool												
Step Run	2	1	1.6%	16	31	0.9%	0.7	0.9	60.0	80.0	0	0.0
Trench Pool												

Table 8. Redwood Creek Level IV Habitat Statistics

Level II Habitat Type	% Occurrence	# Occurrences	% Length	Length (ft)
Pool	30.9%	25	37.4%	1043
Riffle	34.6%	28	22.0%	614
Flatwater	34.6%	28	40.5%	1130

Table 9. Rimer Creek Frequency of Level II Habitat Types

Habitat Type	# Habitat Units	#Units Fully Measured	Habitat Occurrence %	Mean Length (ft)	Total Length (ft)	Total Length %	Avg. Mean Depth (ft)	Max Depth (ft)	% Shelter	Mean % Canopy	Total Spawning Gravel Area (sq ft)	Avg. % Spawning Gravel Embededness
Backwater Pool												
Bedrock Sheet	2	1	3%	27.5	55	2%	0.2	0.5	5.0	25	0	0
Cascade	1	1	1%	24.7	74	3%	0.1	0.7	30.0	75	0	0
Culvert												
Dammed Pool												
Glide	17	3	21%	39.8	677	24%	0.1	1	46.7	7	25	73.3
High Gradient Riffle	8	2	10%	24.5	196	7%	0.1	0.5	22.5	20	0	0
L Scour Pool												
L Scour Pool Bedrock												
L Scour Pool Boulder	2	1	3%	53.0	106	4%	1.3	1.9	30.0	25	2	42.5
L Scour Pool Log	1	1	1%	20.0	20	1%	1.4	1.8	25.0	85	2	90
L Scour Pool Root	2	1	3%	27.0	54	2%	1.4	1.8	40.0	30	2	85
Low Gradient Riffle	15	4	19%	19.3	289	10%	0.3	0.7	28.8	11	0	0
Mid-Channel Pool	8	2	10%	48.0	365.0	13%	1.1	1.9	17.5	15	10	65
Plunge Pool	9	2	11%	39.0	350.0	13%	1.6	3.2	35.0	15	15	67
Run	6	2	8%	25.2	151	5%	0.4	0.7	25.0	23	0	0
Step Pool	1	1	1%	38.0	38	1%	1.2	1.4	40.0	40	0	0
Step Run	5	2	6%	60.4	302	11%	0.2	0.9	40.0	16	0	0
Trench Pool	3	1	4%	55.0	110	4%	2.2	3.1	50.0	17	0	0

Table 10. Rimer Creek Level IV Habitat Statistics

Level II Habitat Type	% Occurrence	# Occurrences	% Length	Length (ft)
Pool	21%	65	23%	2151
Riffle	45%	143	44%	4094
Flatwater	34%	108	33%	3098

Table 11. Buckhorn Creek Frequency of Level II Habitat Types

Habitat Type	# Habitat Units	#Units Fully Measured	Habitat Occurrence %	Mean Length (ft)	Total Length (ft)	Total Length %	Avg. Mean Depth (ft)	Max Depth (ft)	% Shelter	Mean % Canopy	Total Spawning Gravel Area (sq ft)	Avg. % Spawning Gravel Embededness
Backwater Pool												
Bedrock Sheet												
Cascade	10	2	3.1%	9	92	1.0%	0.1	0.5	15	73	0	0.0
Culvert	1	0	0.3%	8	75	0.8%	1.0	1.5			0	0.0
Dammed Pool												
Glide	95	20	29.5%	279	2788	29.6%	0.1	0.9	30	55	61	87.5
High Gradient Riffle	23	5	7.1%	64	636	6.8%	0.1	0.6	24	65	0	0.0
L Scour Pool	9	2	2.8%	25	252	2.7%	1.2	2.0	25	73	18	76.3
L Scour Pool Bedrock	3	1	0.9%	13	127	1.3%	1.3	2.0	25	30	3	50.0
L Scour Pool Boulder	11	3	3.4%	32	324	3.4%	1.1	1.8	40	63	29	70.8
L Scour Pool Log	7	2	2.2%	15	154	1.6%	1.2	2.1	60	35	6	87.5
L Scour Pool Root	16	4	5.0%	62	623	6.6%	1.2	2.1	25	73	18	83.8
Low Gradient Riffle	114	21	35.4%	337	3366	35.7%	0.0	1.2	21	49	4	70.0
Mid-Channel Pool	11	3	3.4%	40	399	4.2%	1.2	2.9	33	47	15	70.0
Plunge Pool	2	1	0.6%	5	46	0.5%	1.3	2.0	30	80	8	70.0
Run	11	3	3.4%	25	252	2.7%	0.1	0.6	37	38	0	0.0
Step Pool												
Step Run	3	1	0.9%	6	58	0.6%	0.2	0.5	50	5	0	0.0
Trench Pool	6	2	1.9%	23	226	2.4%	1.2	3.1	53	65	2	70.0
Total	322	70	100.0%	942	9418	100.0%	0.3	3.1	29	54	164	73.6

Table 12. Buckhorn Creek Level IV Habitat Statistics

Level II Habitat Type	% Occurence	# Occurence	% Length	# Length
Pool	45	9	54	269.00
Riffle	30	6	12	170.00
Flatwater	25	5	34	346.00

Table 13. Indian Creek Frequency of Level II Habitat Types

Habitat Type	# Habitat Units	# Units Fully Measured	Habitat Occurrence %	Mean Length (ft)	Total Length (ft)	Total Length %	Avg. Mean Depth (ft)	Max Depth (ft)	% Shelter Rating	Total Spawning Gravel Area (sq ft)	Average % Spawning Gravel Embeddedness
Backwater Pool											
Bedrock Sheet											
Cascade											
Culvert											
Glide	4	1	20%	57	228	29%	0.5	0.8	10	0	0
High Gradient Riffle											
L Scour Pool											
L Scour Pool Bedrock											
L Scour Pool Boulder											
L Scour Pool Log	2	1	10%	39.5	79	10%	2.3	3.1	40	0	0
L Scour Pool Root	4	1	20%	41.5	166	21%	1.6	3	20	0	0
Low Gradient Riffle	6	2	30%	16	96	12%	0.1	0.5	15	0	0
Mid-Channel Pool	2	1	10%	74.5	149	19%	1.25	1.3	40	0	0
Plunge Pool	1	1	5%	26	26	3%	3.5	5	40	0	0
Run	1	1	5%	40	40	5%	0.5	0.7	50	0	0
Step Pool											
Step Run											
Trench Pool											

Table 14. Indian Creek Level IV Habitat Statistics

Level II Habitat Type	% Occurrence	# Occurrences	% Length	Length (ft)
Pool	41.40%	41	69.30%	3491
Riffle	41.40%	41	19.40%	978
Flatwater	17.20%	17	11.30%	570
Total		99		5039

Table 15. Lower San Leandro Creek Frequency of Level II Habitat Types

Habitat Type	# Habitat Units	#Units Fully Measured	Habitat Occurrence %	Mean Length (ft)	Total Length (ft)	Total Length %	Avg. Mean Depth (ft)	Max Depth (ft)	Mean Shelter Rating	% Canopy	Total Spawning Gravel Area (sq ft)	Avg. % Spawning Gravel Embededness
Backwater Pool	1	1	1.0%	23.0	23.0	0.5%	1.1	1.5	40.0	85	0	0.0
Bedrock Sheet												
Cascade												
Channel Confl Pool	1	1	1.0%	51.0	51.0	1.0%	1.3	1.8	25.0	50	30	40.0
Culvert												
Dammed Pool	1	1	1.0%	185.0	185.0	3.7%	1.6	2.0	35.0	80	0	0.0
Glide	15	4	15.2%	34.4	516.0	10.2%	0.4	0.8	33.8	59	55	45.0
High Gradient Riffle	13	3	13.1%	22.0	286.0	5.7%	0.2	0.4	15.0	47	0	0.0
L Scour Pool	1	1	1.0%	35.0	35.0	0.7%	1.2	1.5	30.0	45	0	0.0
L Scour Pool Bedrock	4	1	4.0%	109.8	439.0	8.7%	1.7	3.1	25.0	60	86	48.3
L Scour Pool Boulder	3	1	3.0%	86.3	259.0	5.1%	2.3	3.0	35.0	60	43	53.3
L Scour Pool Log	15	4	15.2%	84.7	1271.0	25.2%	1.8	3.7	48.8	53	62	57.5
L Scour Pool Root	3	1	3.0%	82.7	248.0	4.9%	1.9	2.9	25.0	40	11	50.0
Low Gradient Riffle	28	6	28.3%	24.7	692.0	13.7%	0.2	0.5	33.3	43	0	0.0
Mid-Channel Pool	10	3	10.1%	89.5	895.0	17.8%	1.5	5.0	20.0	65	102	43.8
Plunge Pool												
Run	1	1	1.0%	24.0	24.0	0.5%	0.4	0.6	0.0	60	0	0.0
Step Pool	2	1	2.0%	42.5	85.0	1.7%	1.0	1.4	60.0	65	0	0.0
Step Run	1	1	1.0%	30.0	30.0	0.6%	0.5	0.7	50.0	60	0	0.0
Trench Pool												

Table 16. Lower San Leandro Creek Level IV Habitat Statistics

FIGURES

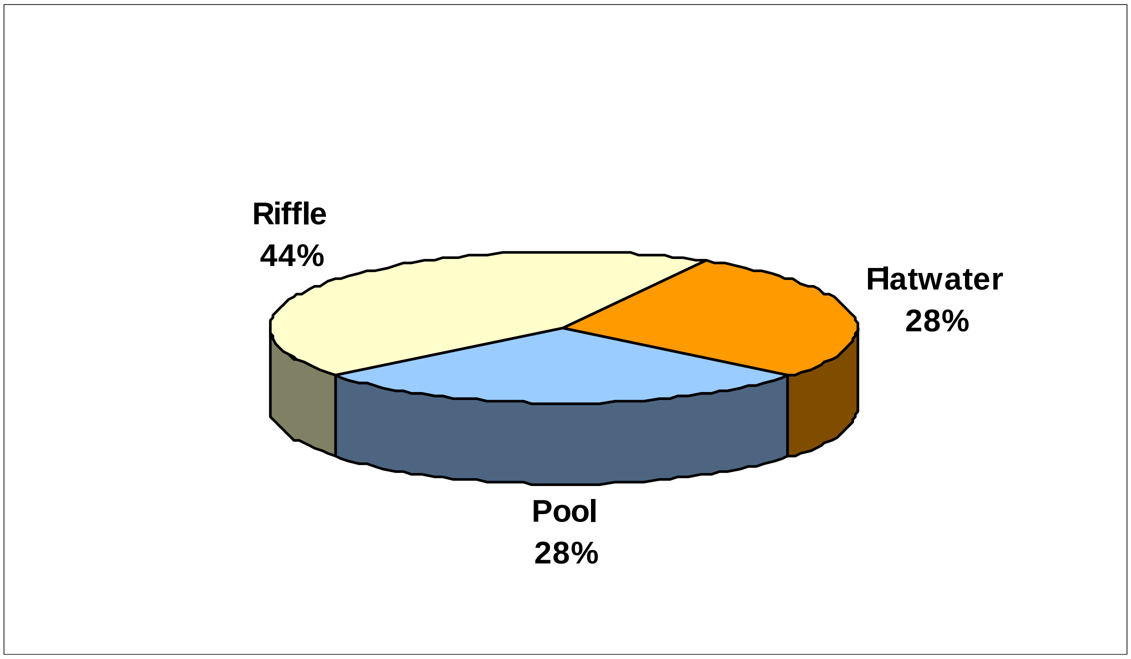

Figure 2. Upper San Leandro Creek Frequency of Habitat Types by Occurrence

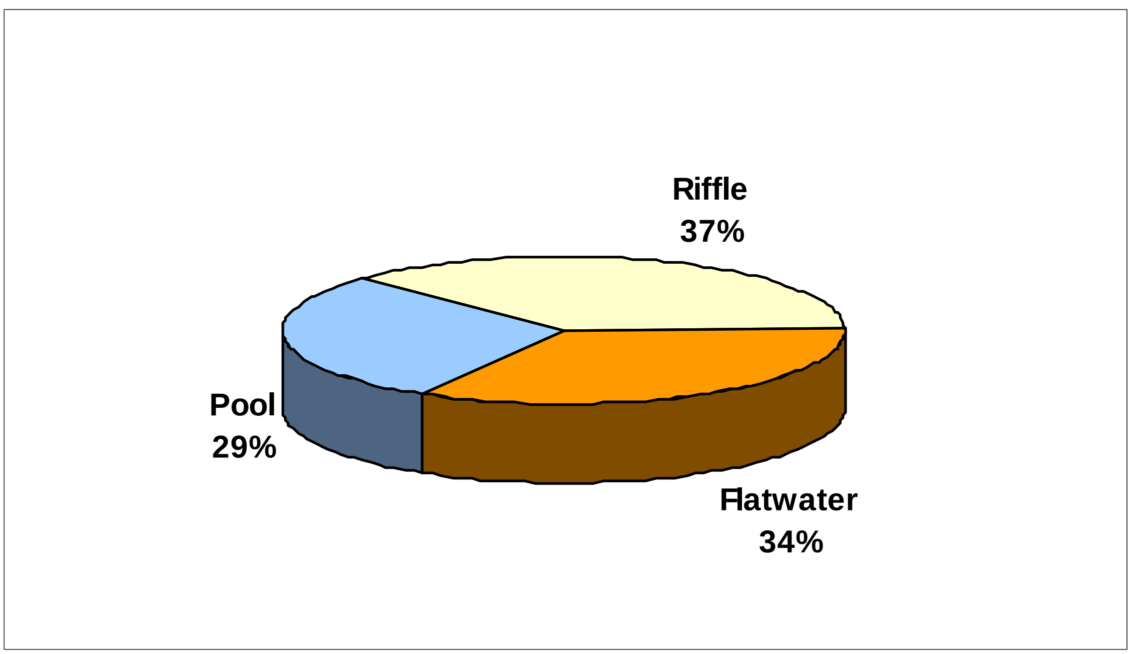

Figure 3. Upper San Leandro Creek Frequency of Habitat Types by Length

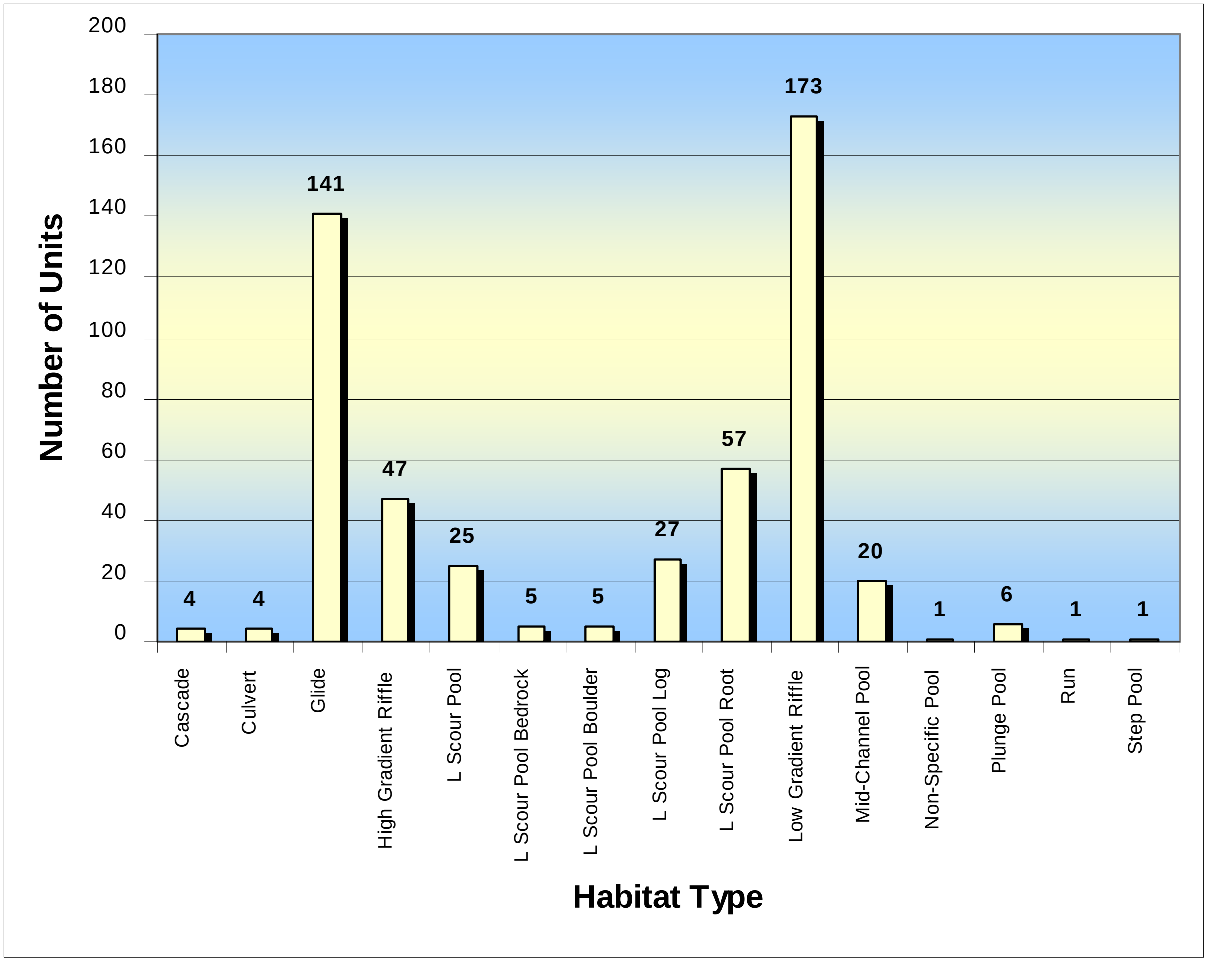

Figure 4. Upper San Leandro Creek Habitat Types

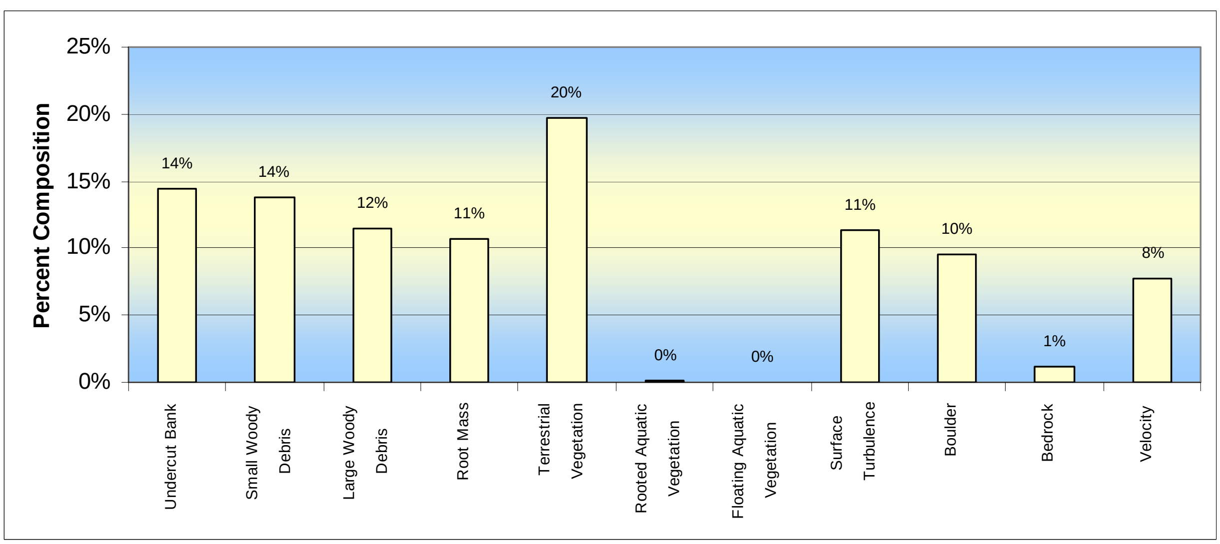

Figure 5. Upper San Leandro Creek Shelter Types and Percentages

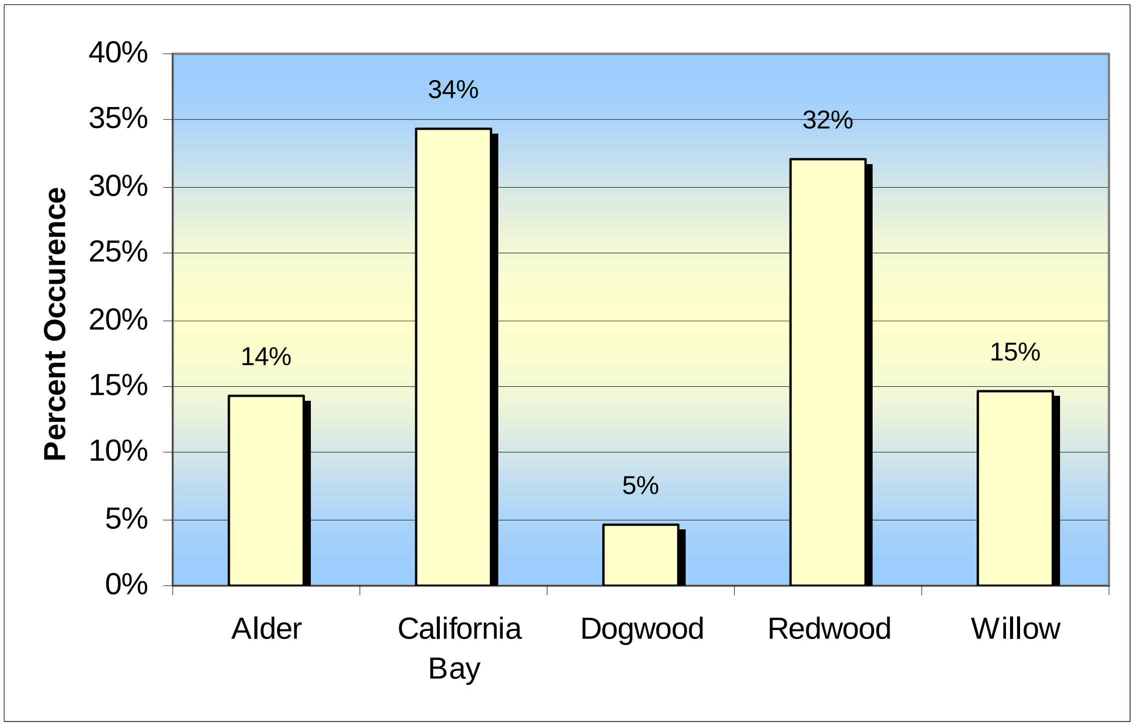

Figure 6. Upper San Leandro Creek Canopy Composition

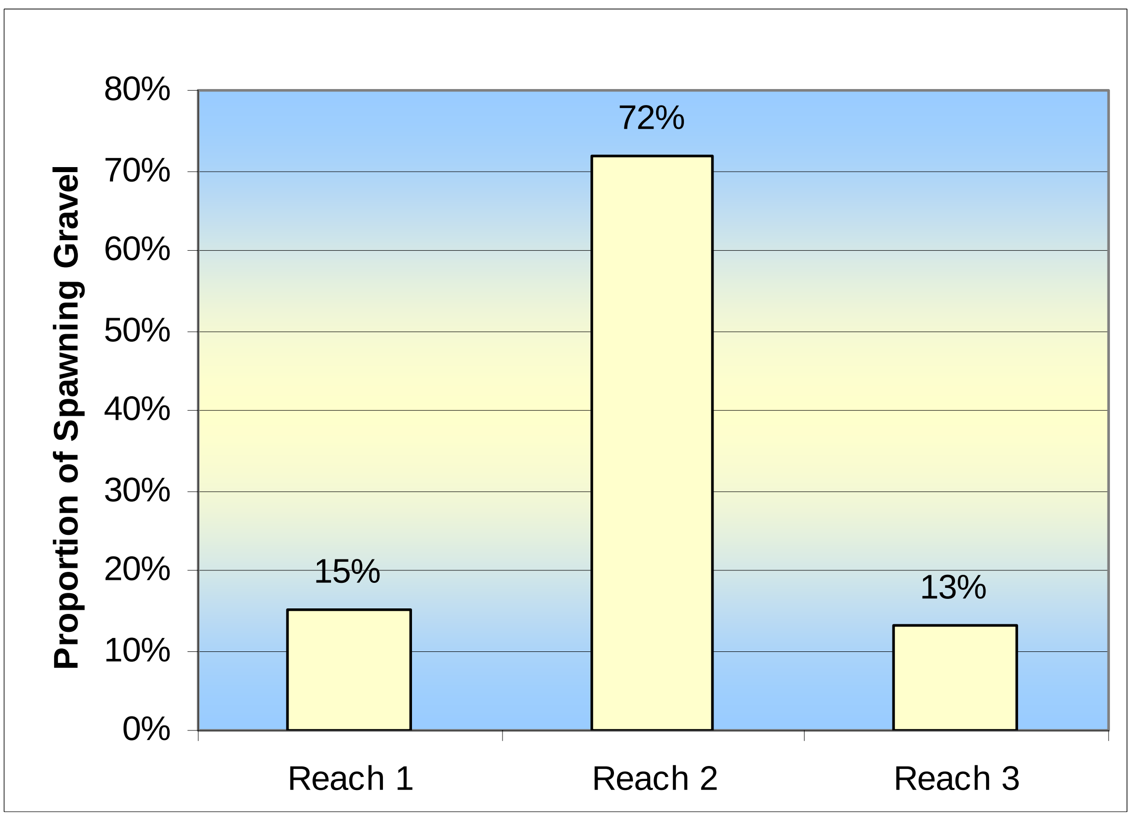

Figure 7. Upper San Leandro Creek Distribution of Spawning Substrate by Reach

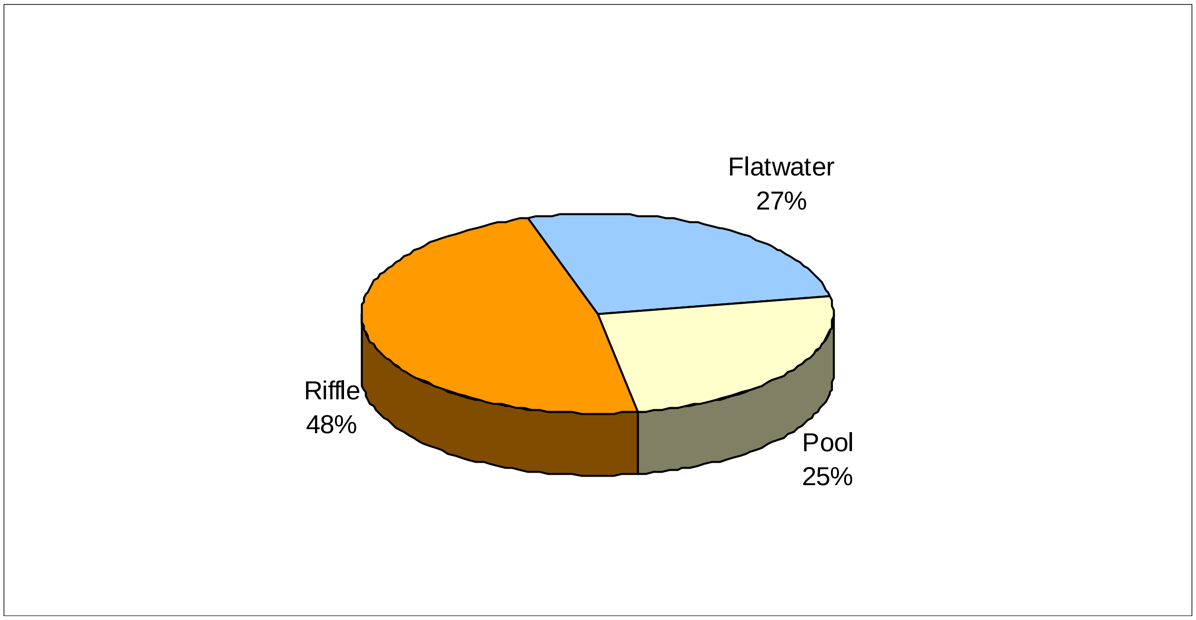

Figure 8. Kaiser Creek Frequency of Habitat Types by Occurrence

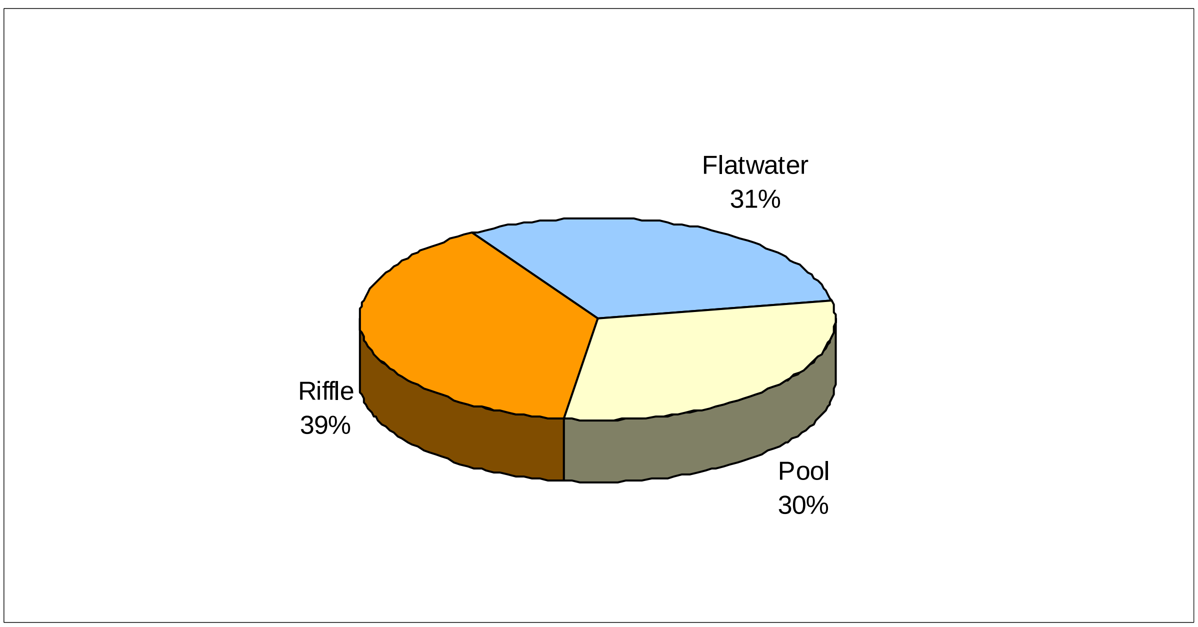

Figure 9. Kaiser Creek Frequency of Habitat Types by Length

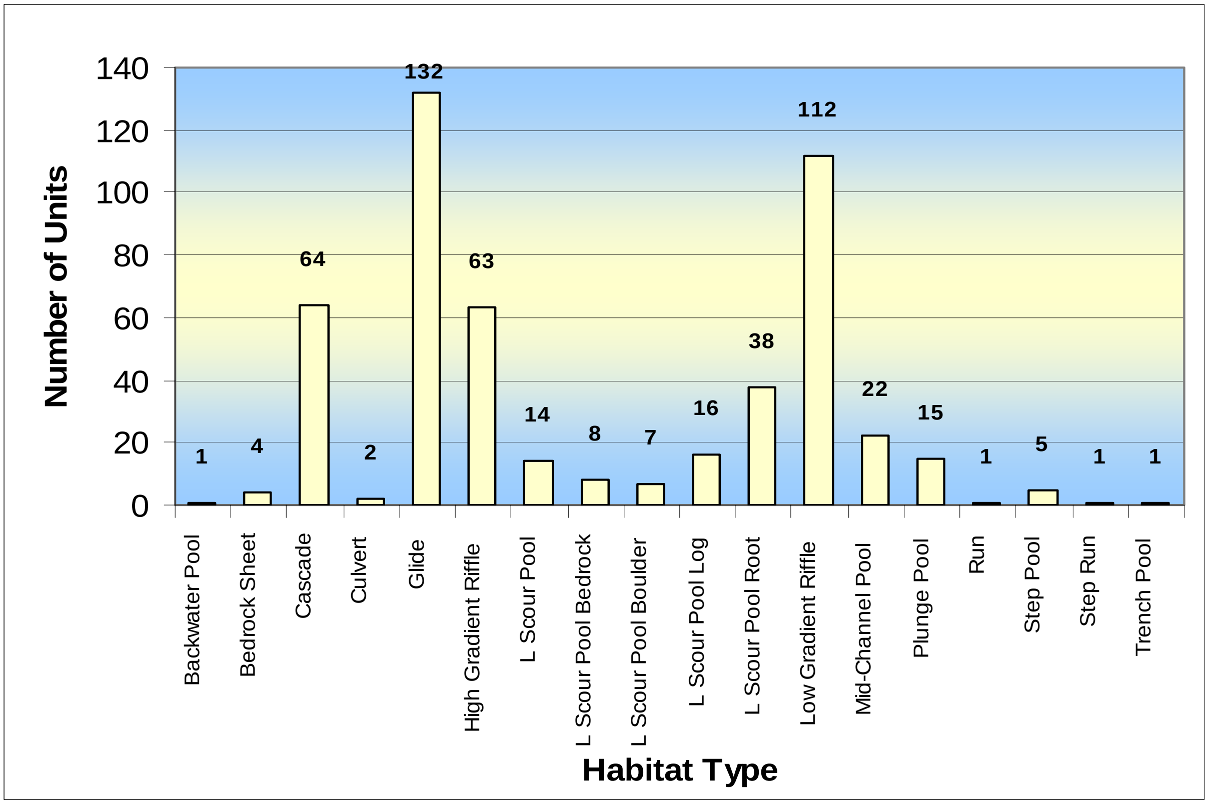

Figure 10. Kaiser Creek Habitat Types

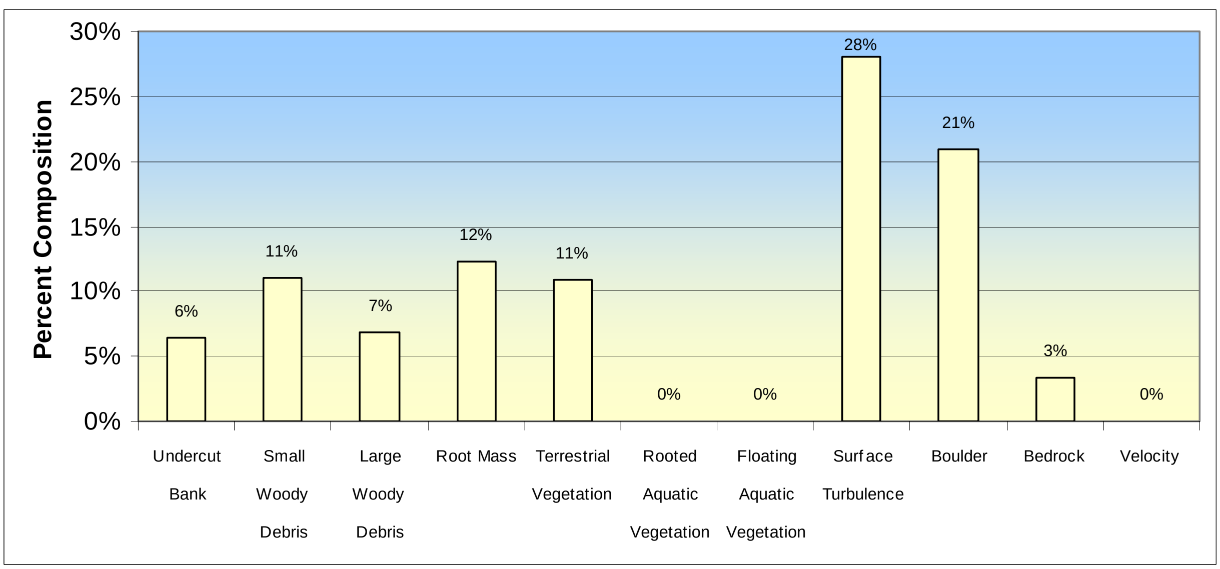

Figure 11. Kaiser Creek Shelter Types and Percentages

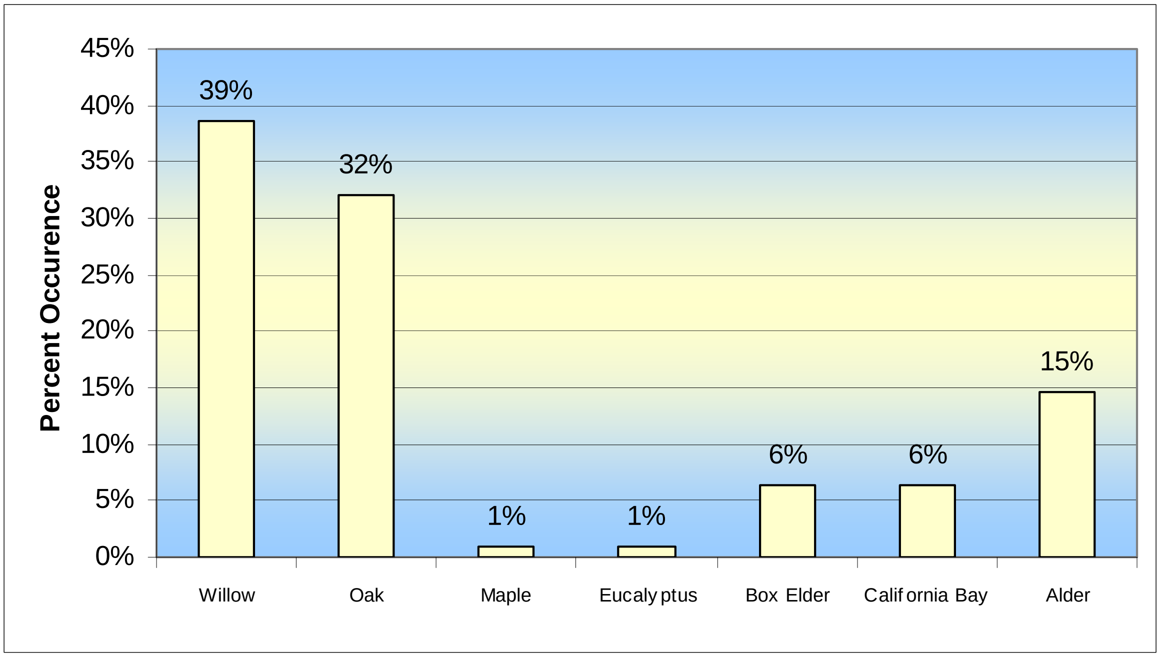

Figure 12. Kaiser Creek Canopy Composition

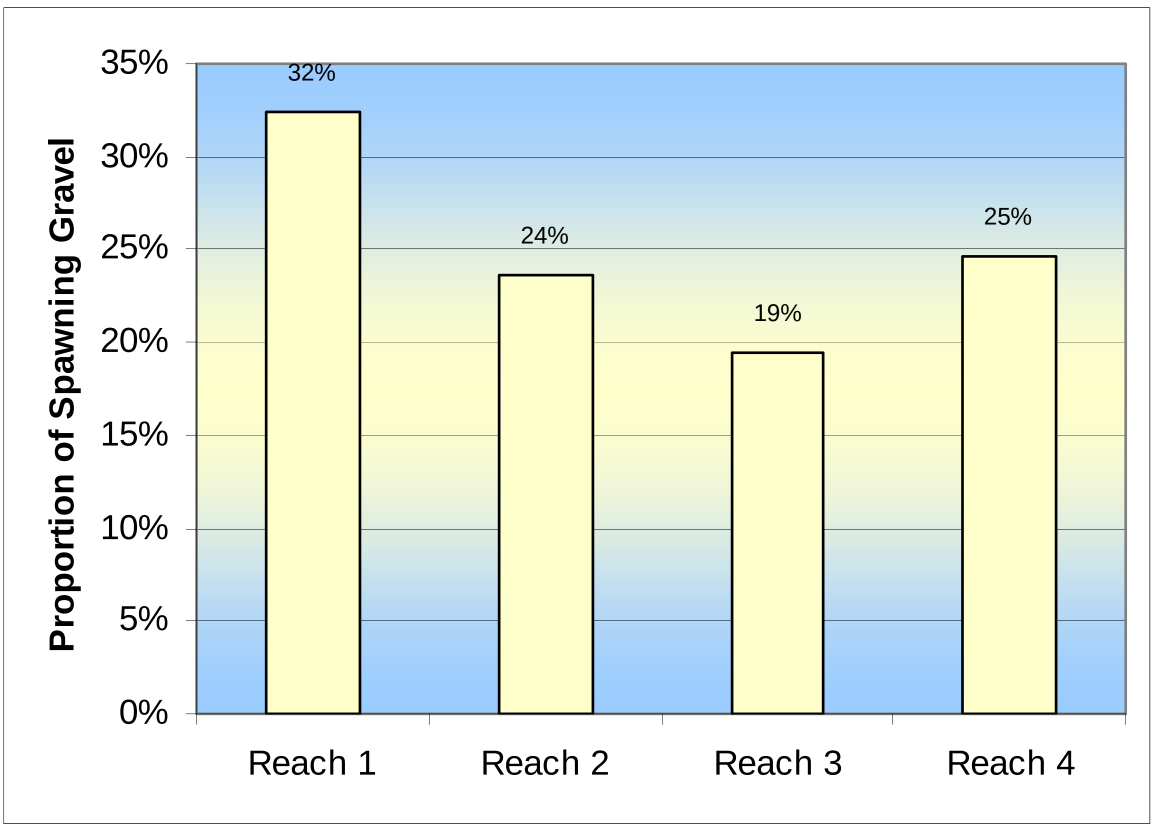

Figure 13. Kaiser Creek Distribution of Spawning Substrate by Reach

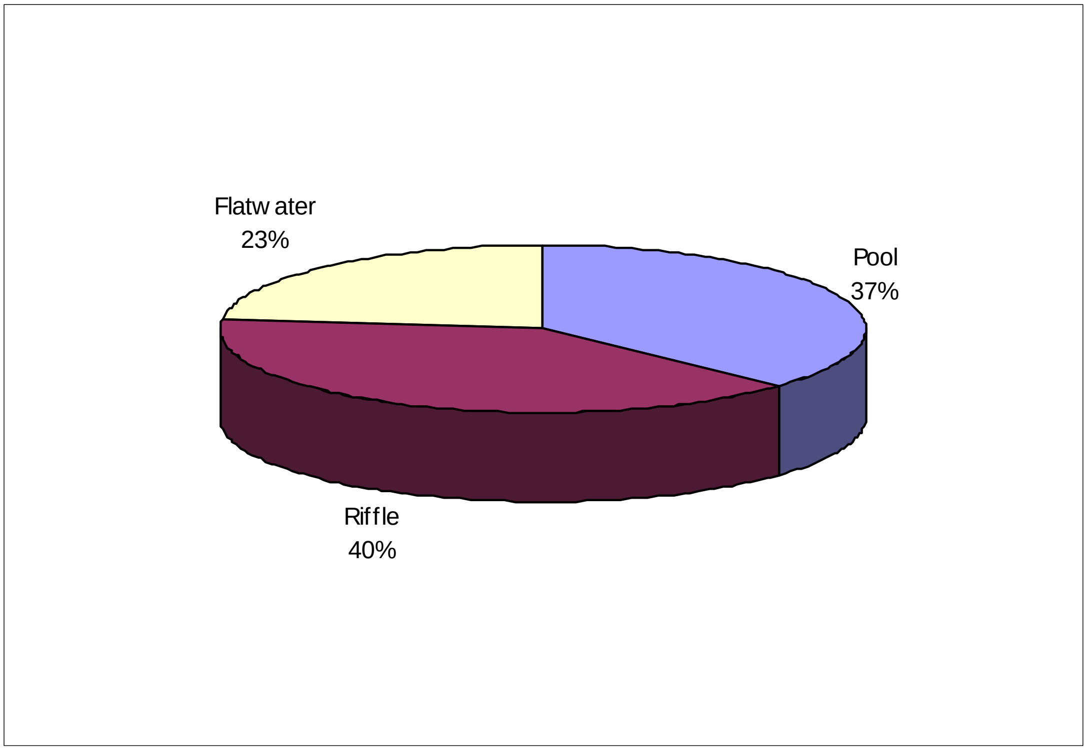

Figure 14. Redwood Creek Frequency of Habitat Types by Occurrence

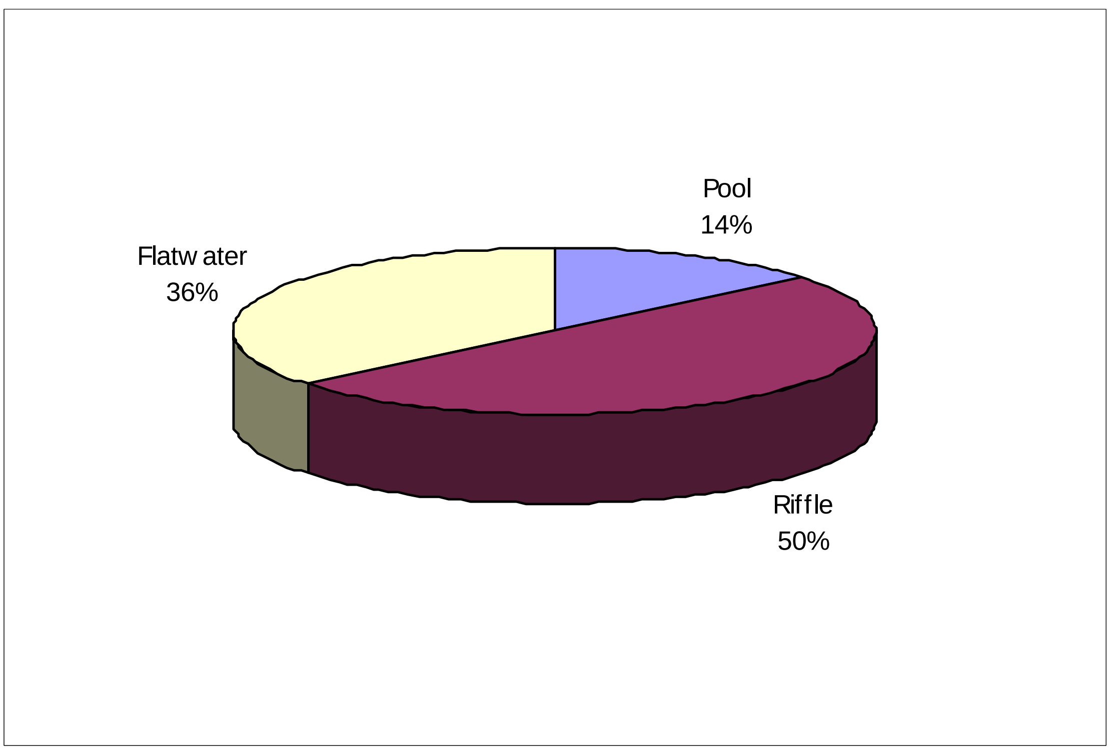

Figure 15. Redwood Creek Frequency of Habitat Types by Length

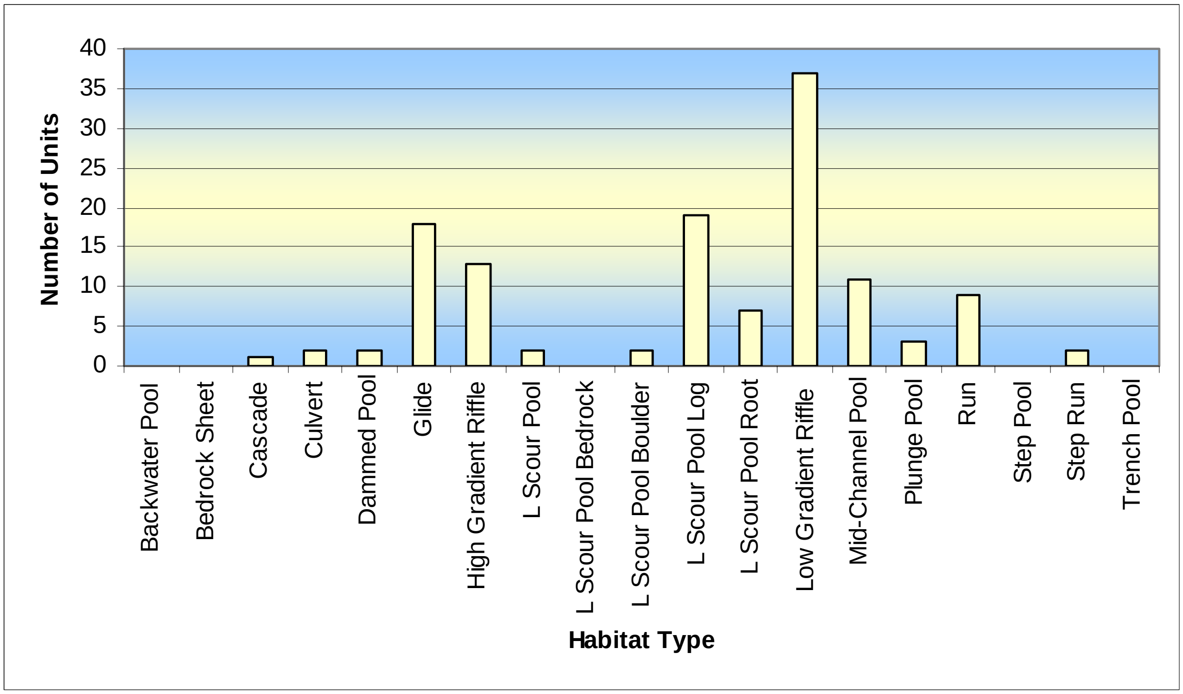

Figure 16. Redwood Creek Habitat Types

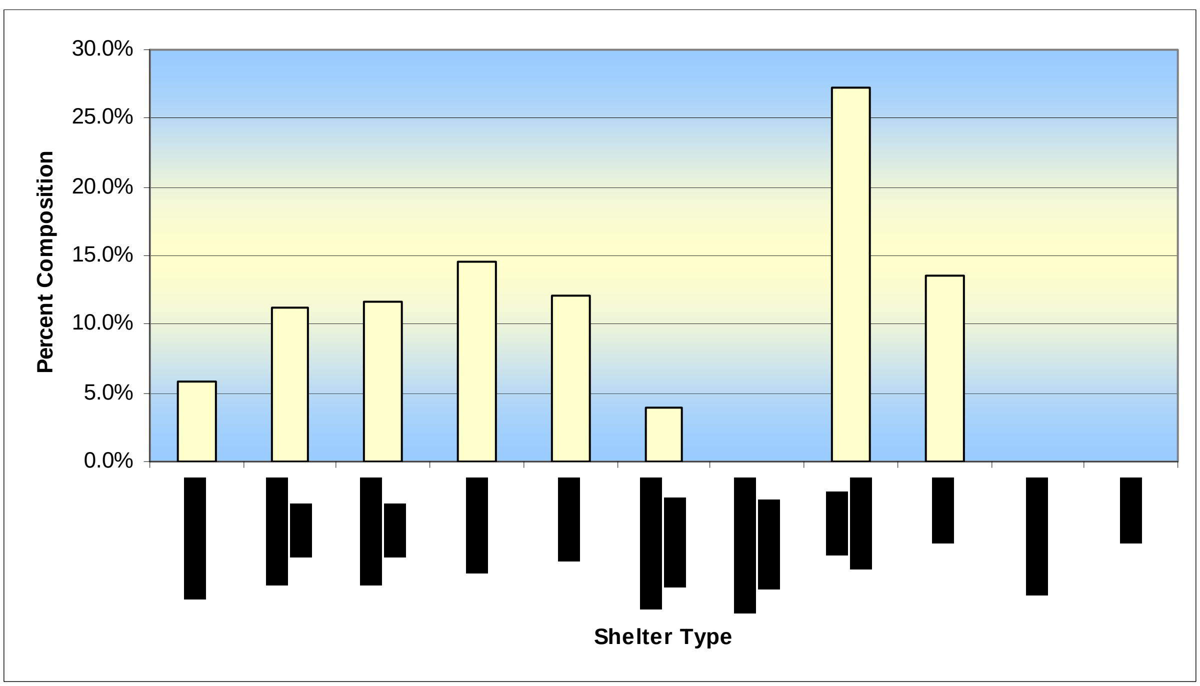

Figure 17. Redwood Creek Shelter Types and Percentages

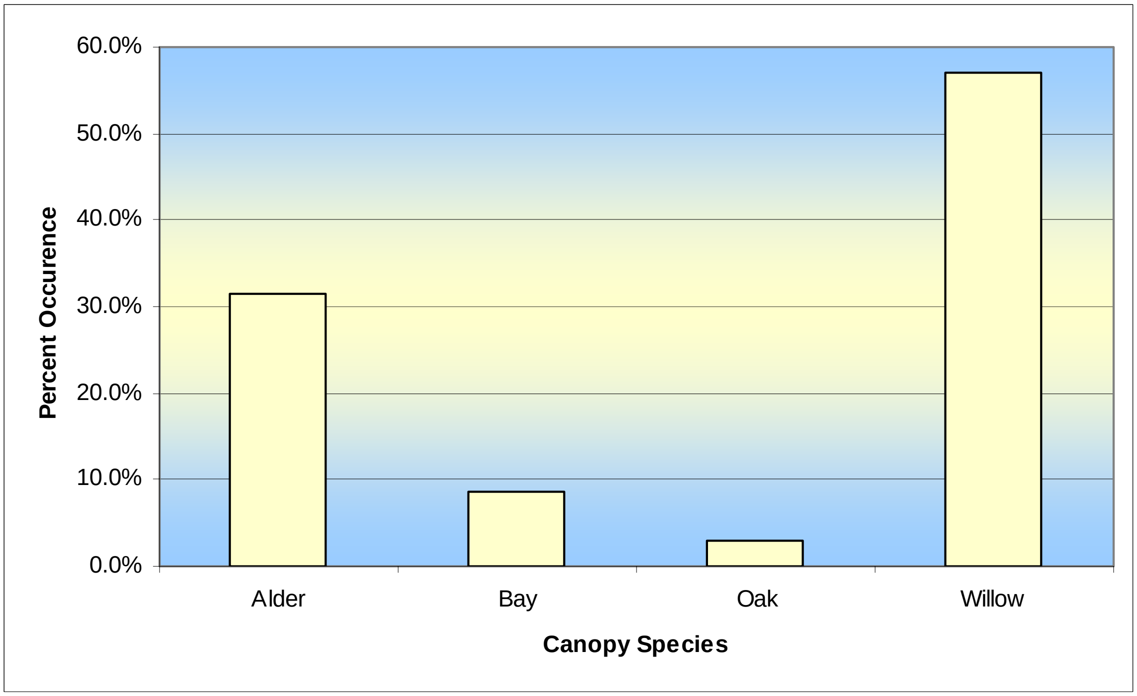

Figure 18. Redwood Creek Canopy Composition

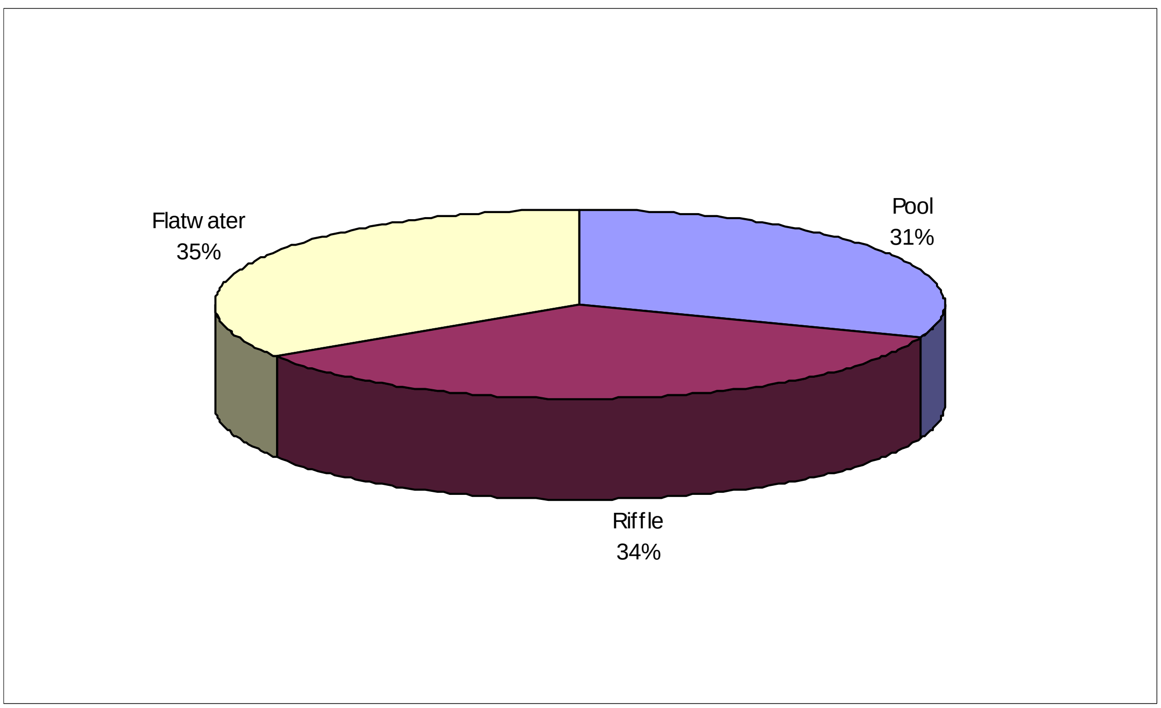

Figure 19. Rimer Creek Frequency of Habitat Types by Occurrence

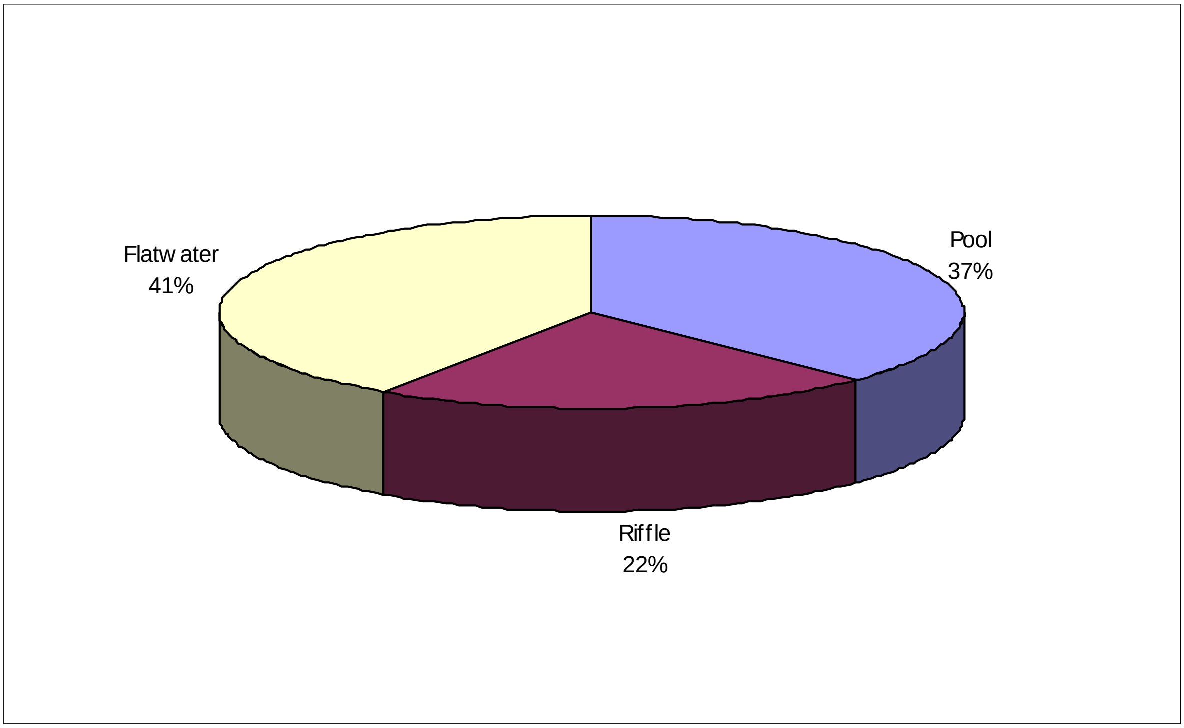

Figure 20. Rimer Creek Frequency of Habitat Types by Length

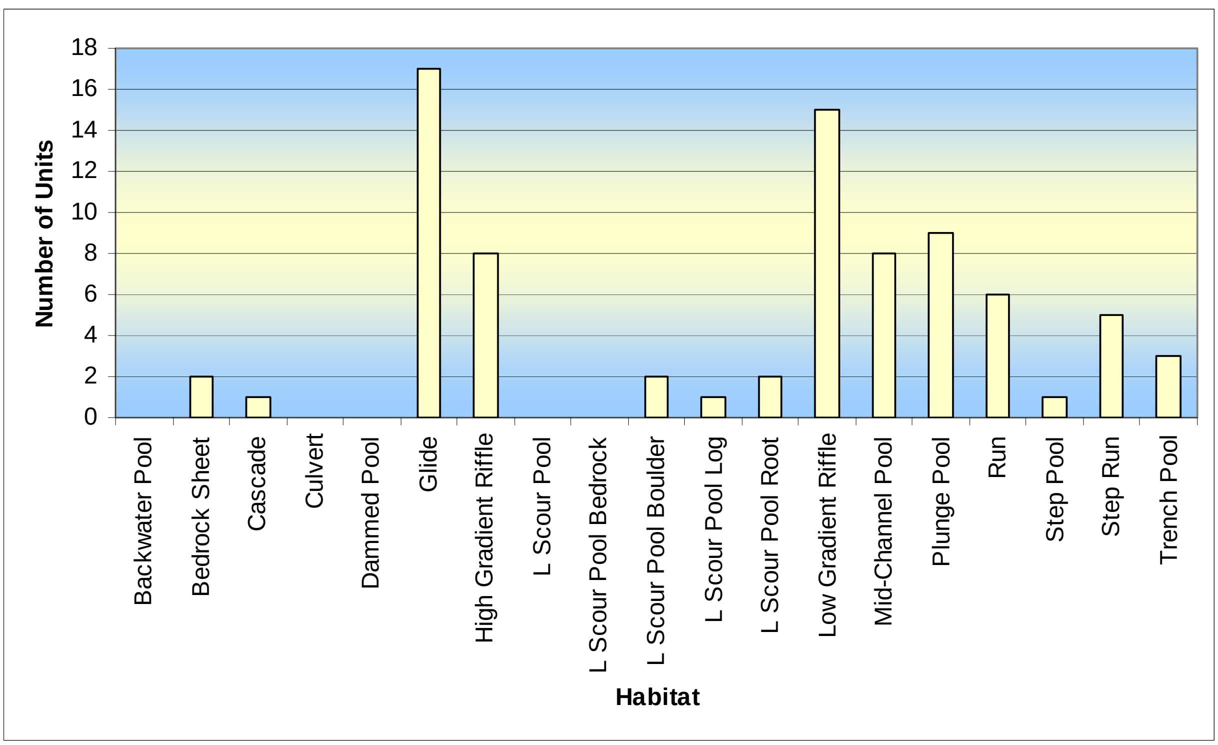

Figure 21 Rimer Creek Habitat Types

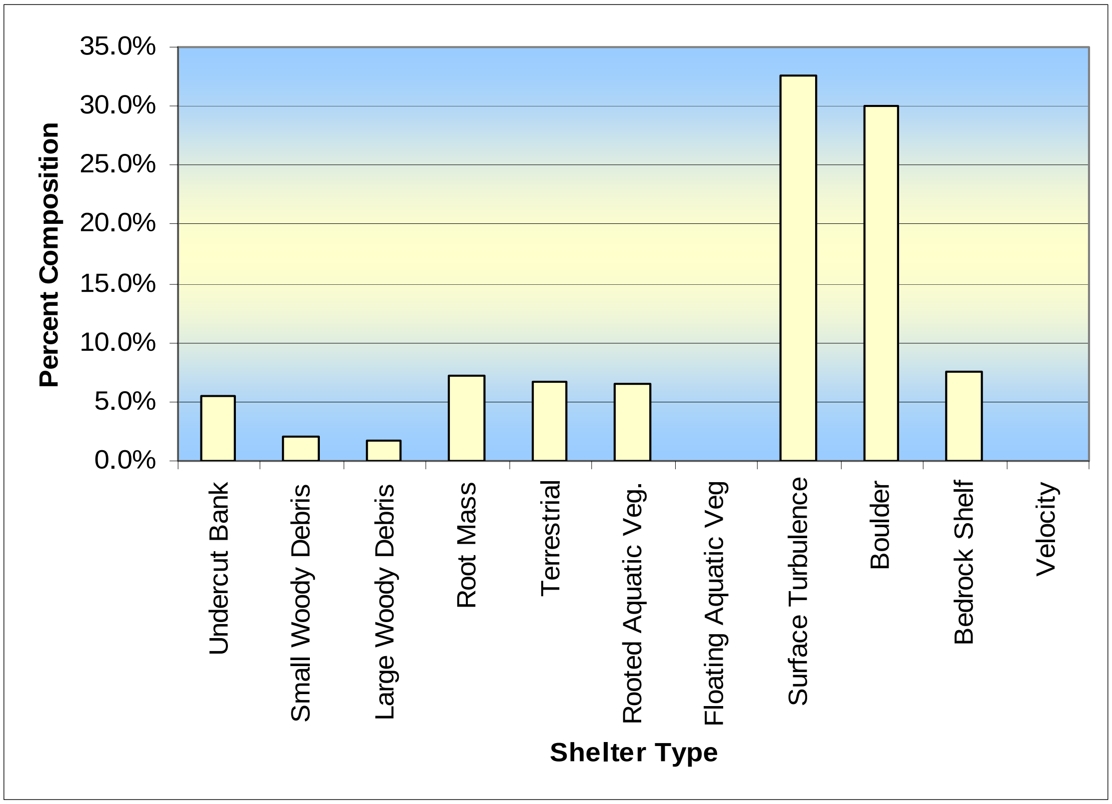

Figure 22. Rimer Creek Shelter Types and Percentages

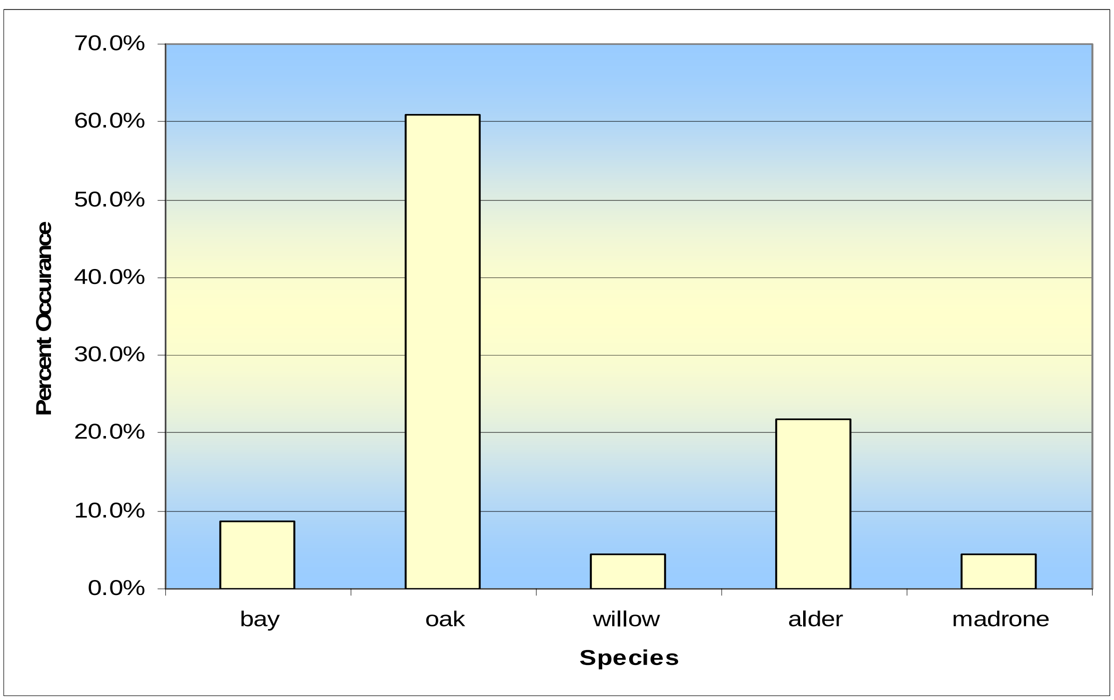

Figure 23. Rimer Creek Canopy Composition

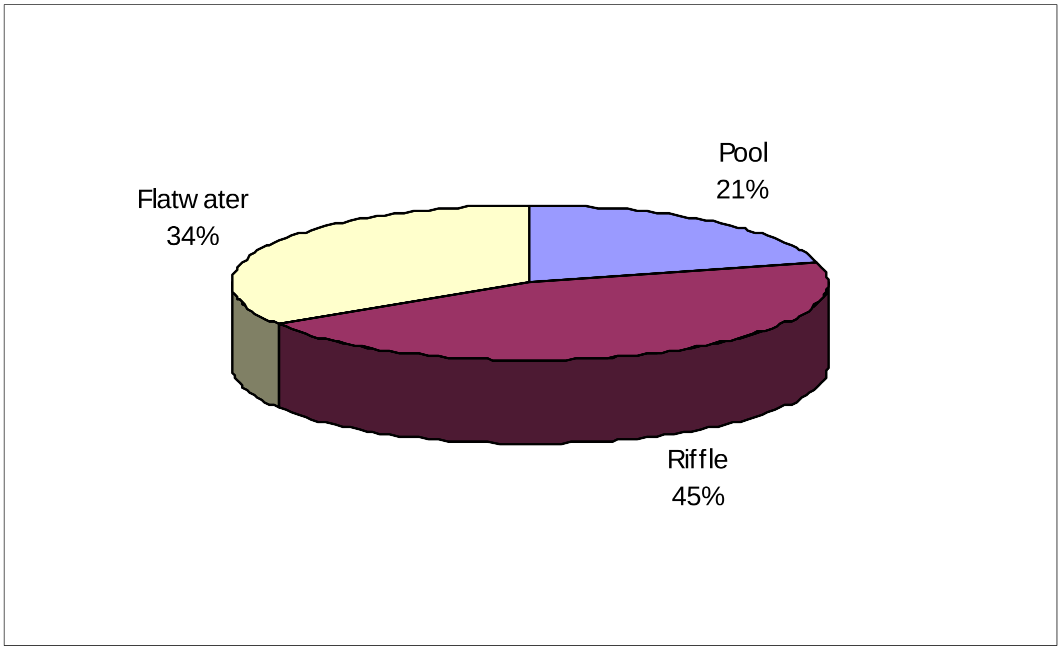

Figure 24. Buckhorn Creek Frequency of Habitat Types by Occurrence

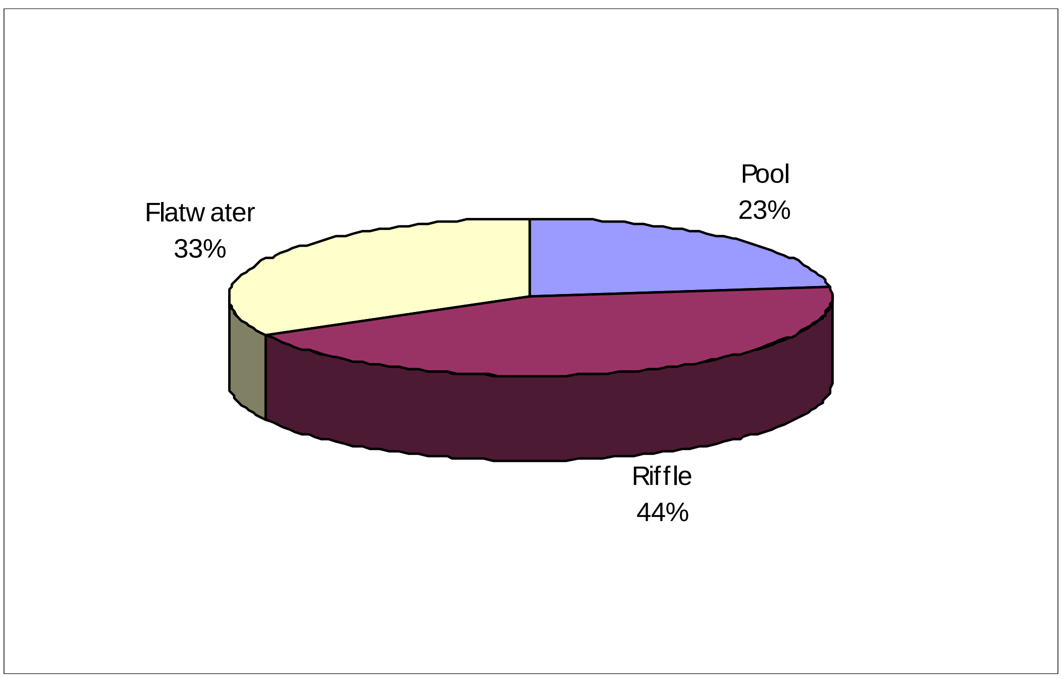

Figure 25. Buckhorn Creek Frequency of Habitat Types by Length

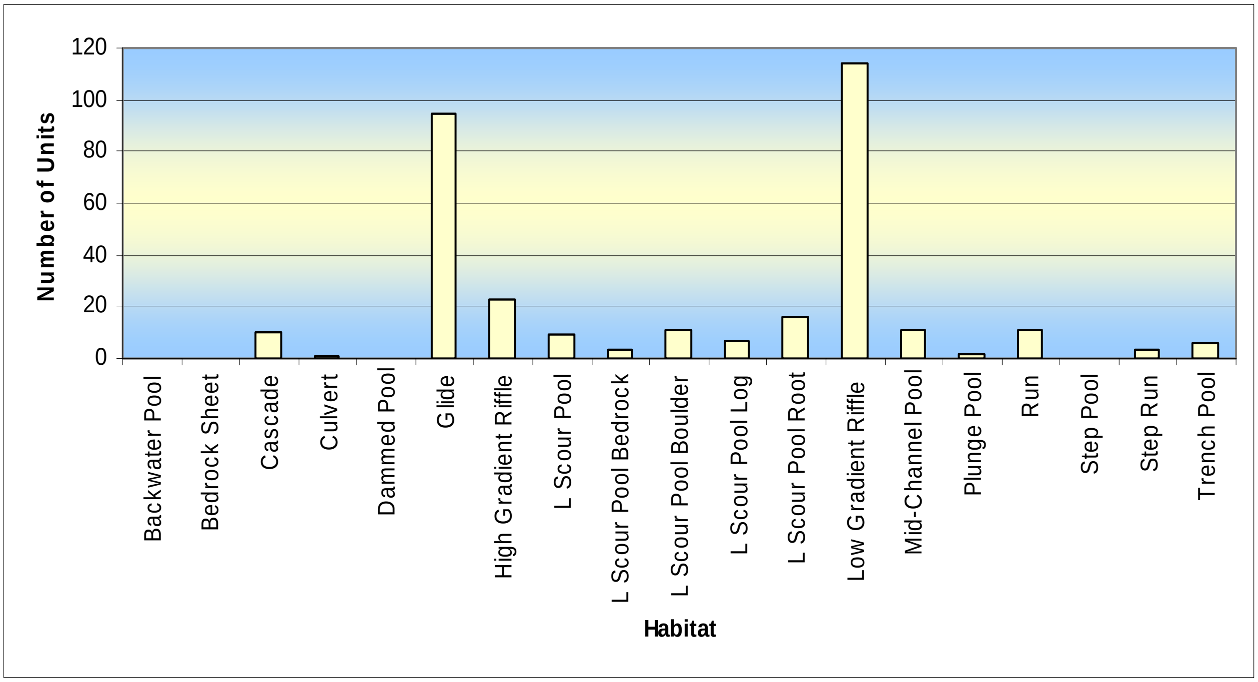

Figure 26. Buckhorn Creek Habitat Types

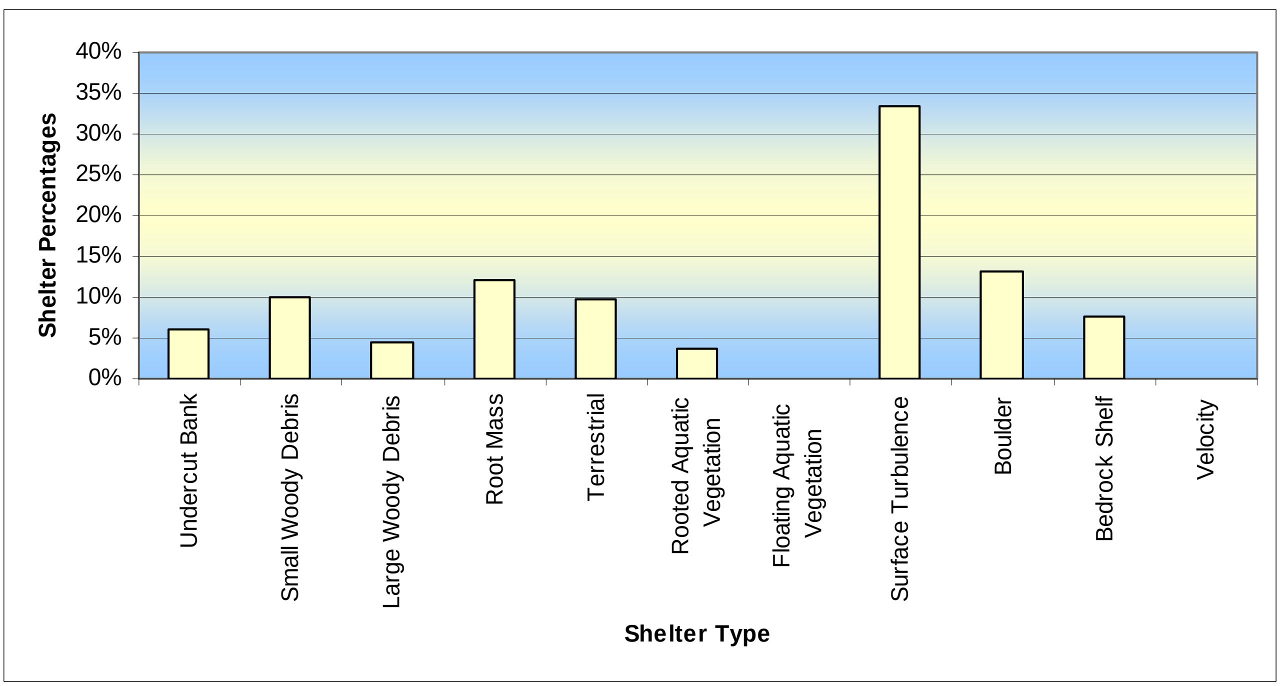

Figure 27. Buckhorn Creek Shelter Types and Percentages

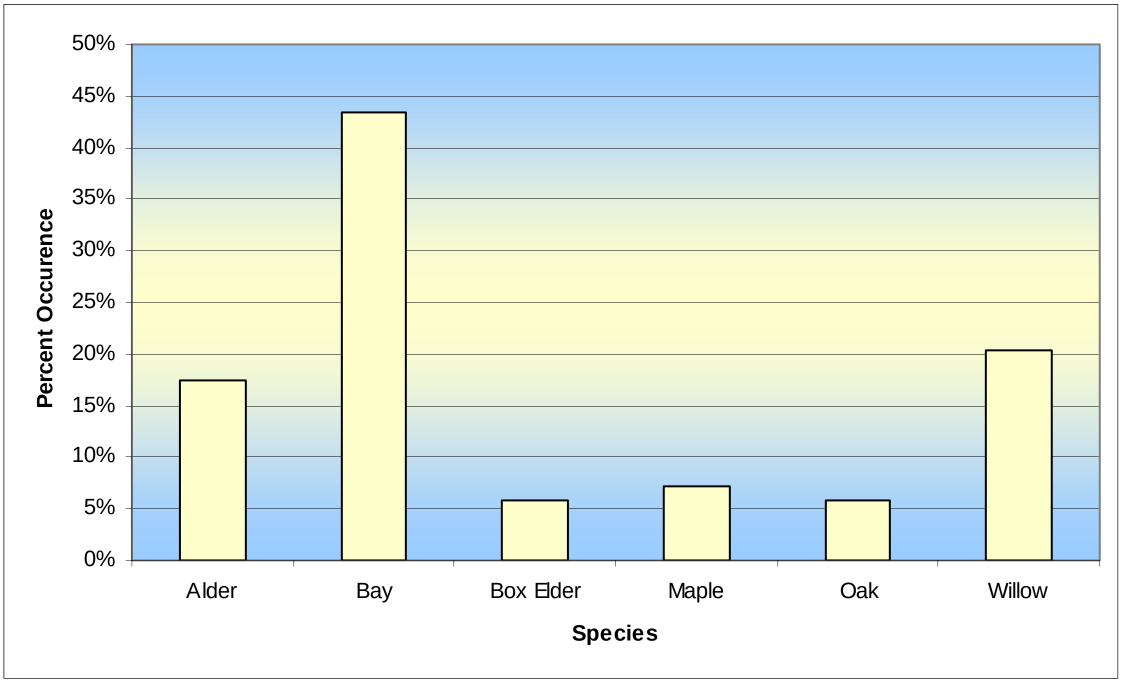

Figure 28. Buckhorn Creek Canopy Composition

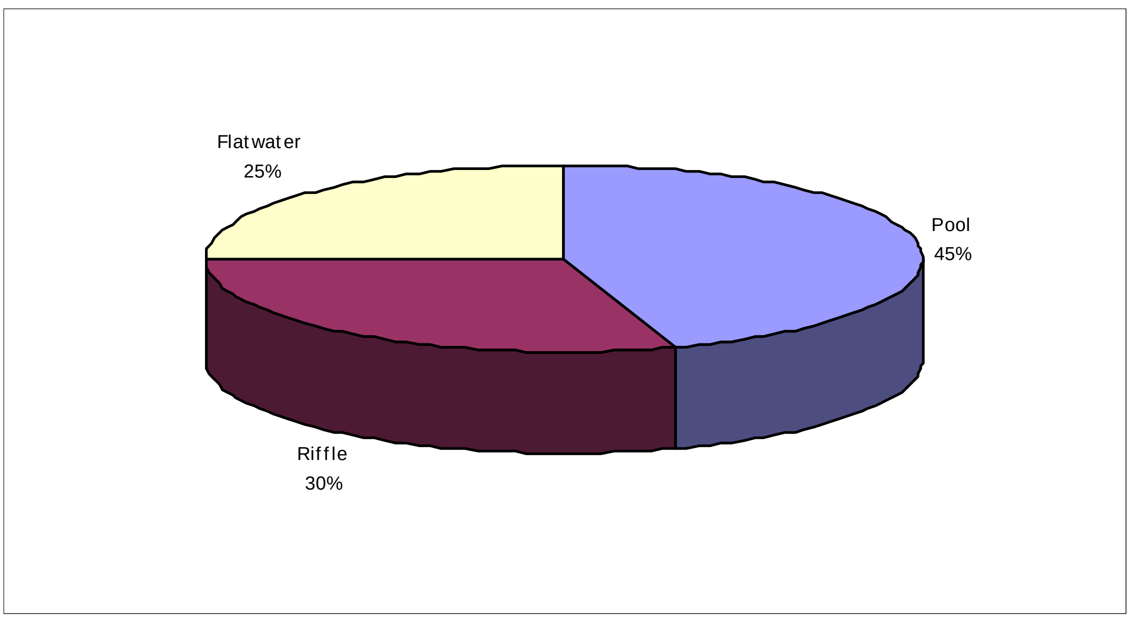

Figure 29. Indian Creek Frequency of Habitat Types by Occurrence

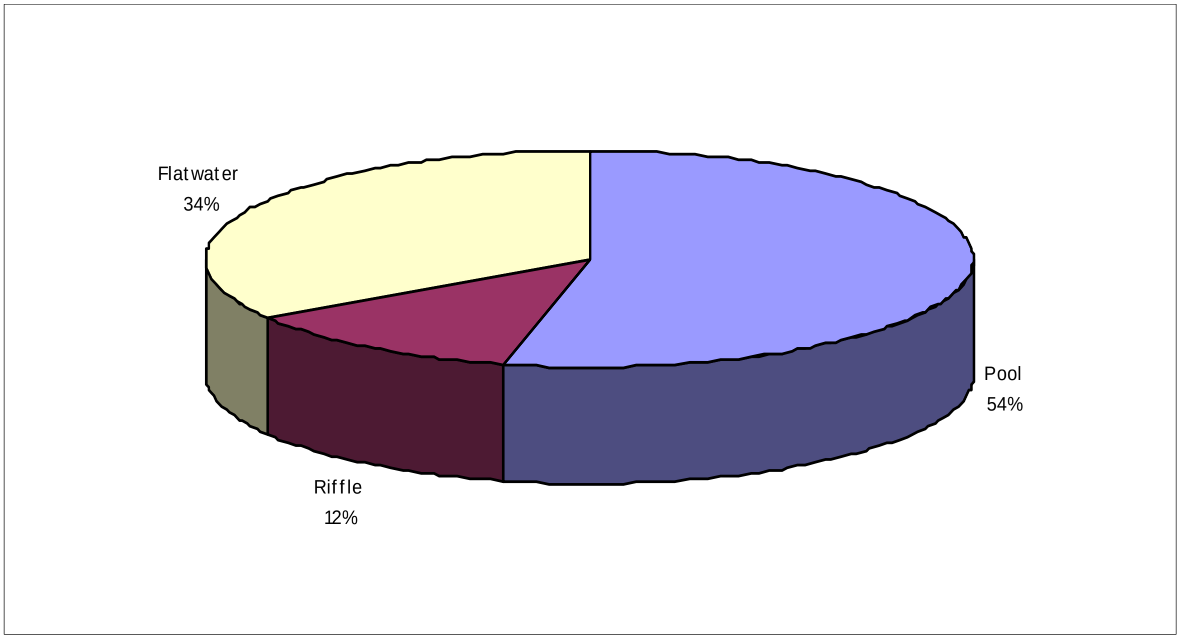

Figure 30. Indian Creek Frequency of Habitat Types by Length

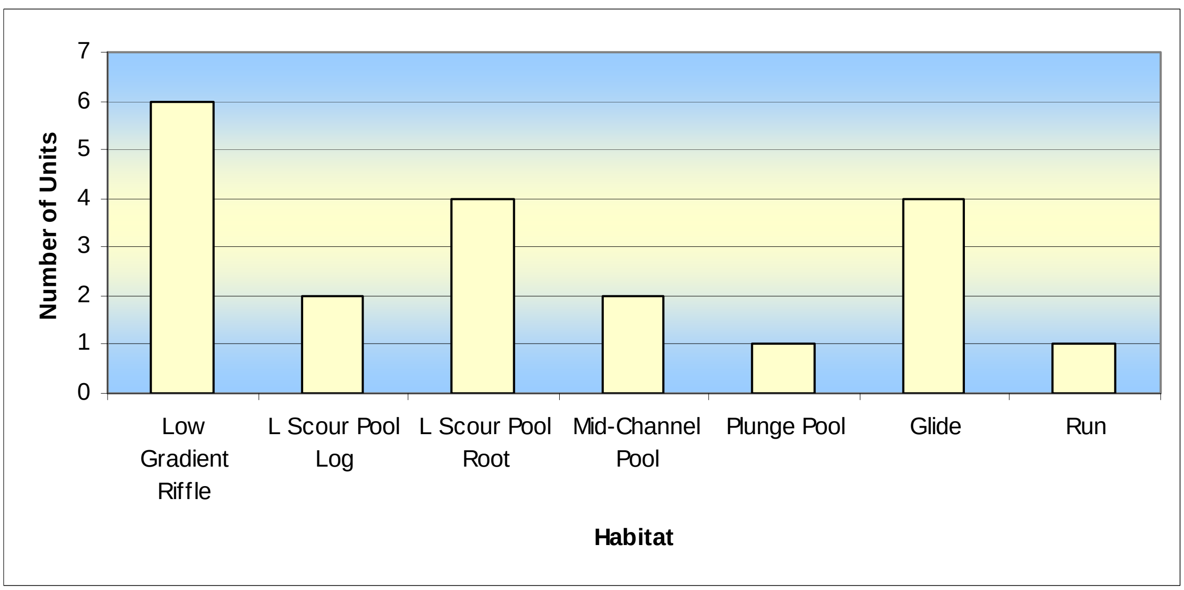

Figure 31. Indian Creek Habitat Types

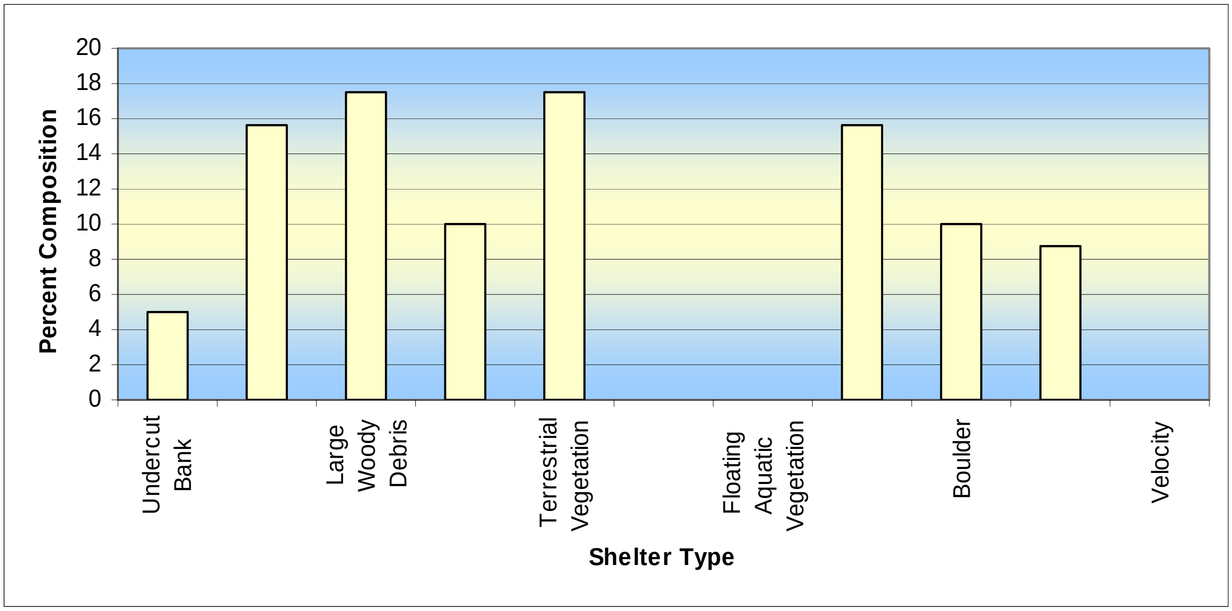

Figure 32. Indian Creek Shelter Types and Percentages

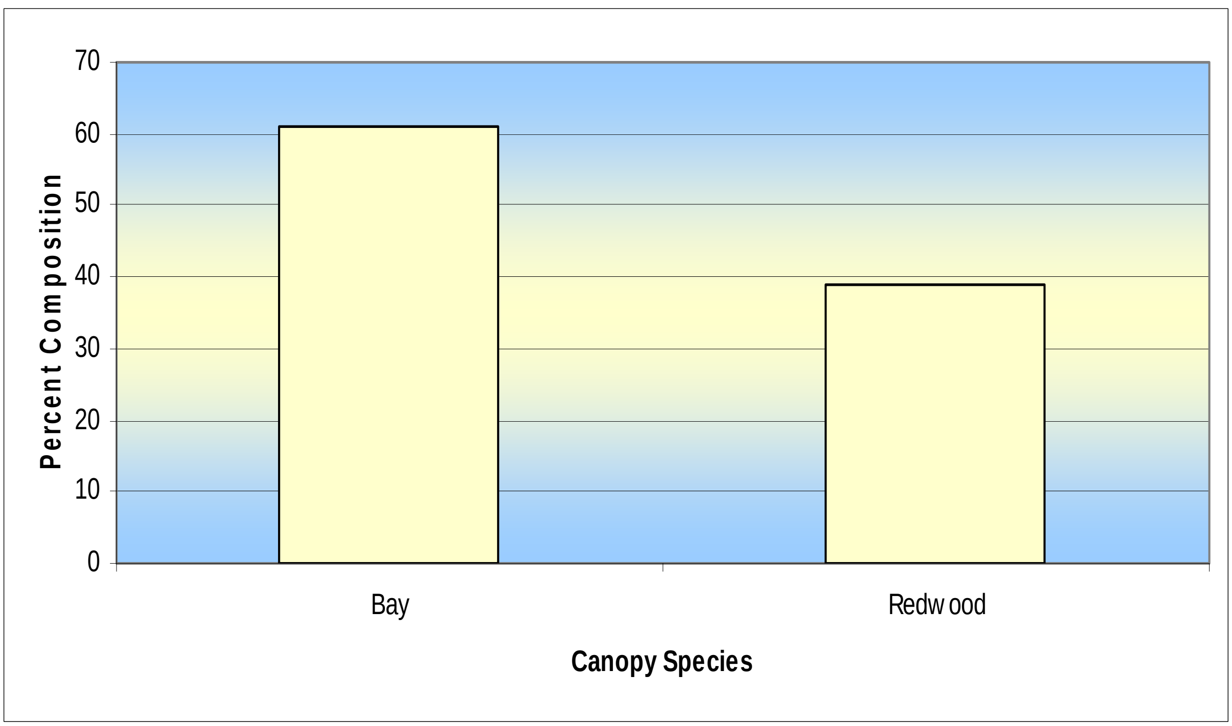

Figure 33. Indian Creek Canopy Composition

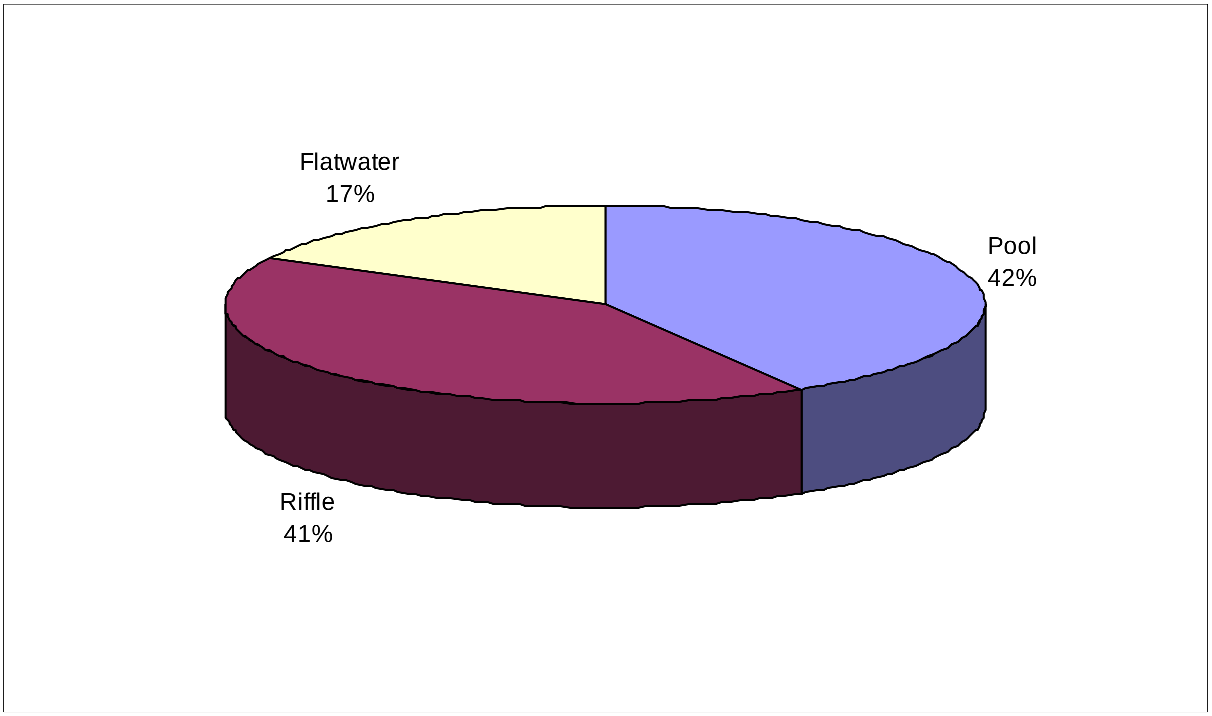

Figure 34. Lower San Leandro Creek Frequency of Habitat Types by Occurrence

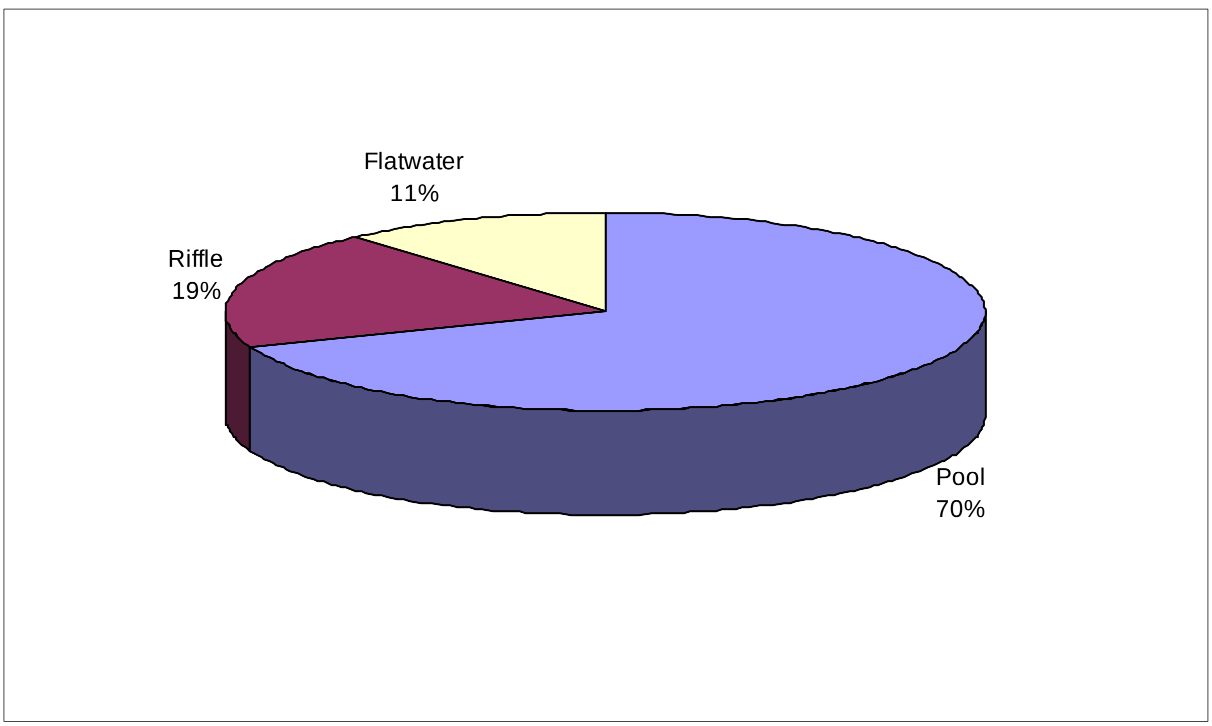

Figure 35. Lower San Leandro Creek Frequency of Habitat Types by Length

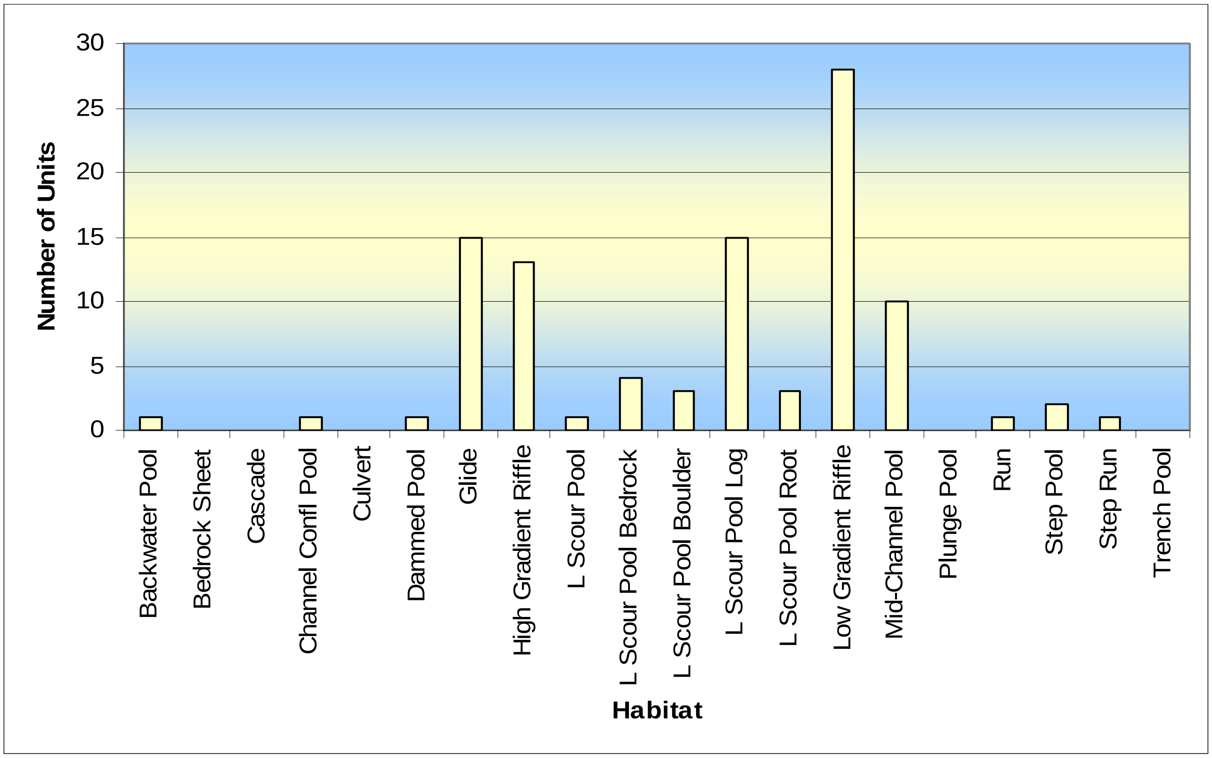

Figure 36. Lower San Leandro Creek Habitat Types

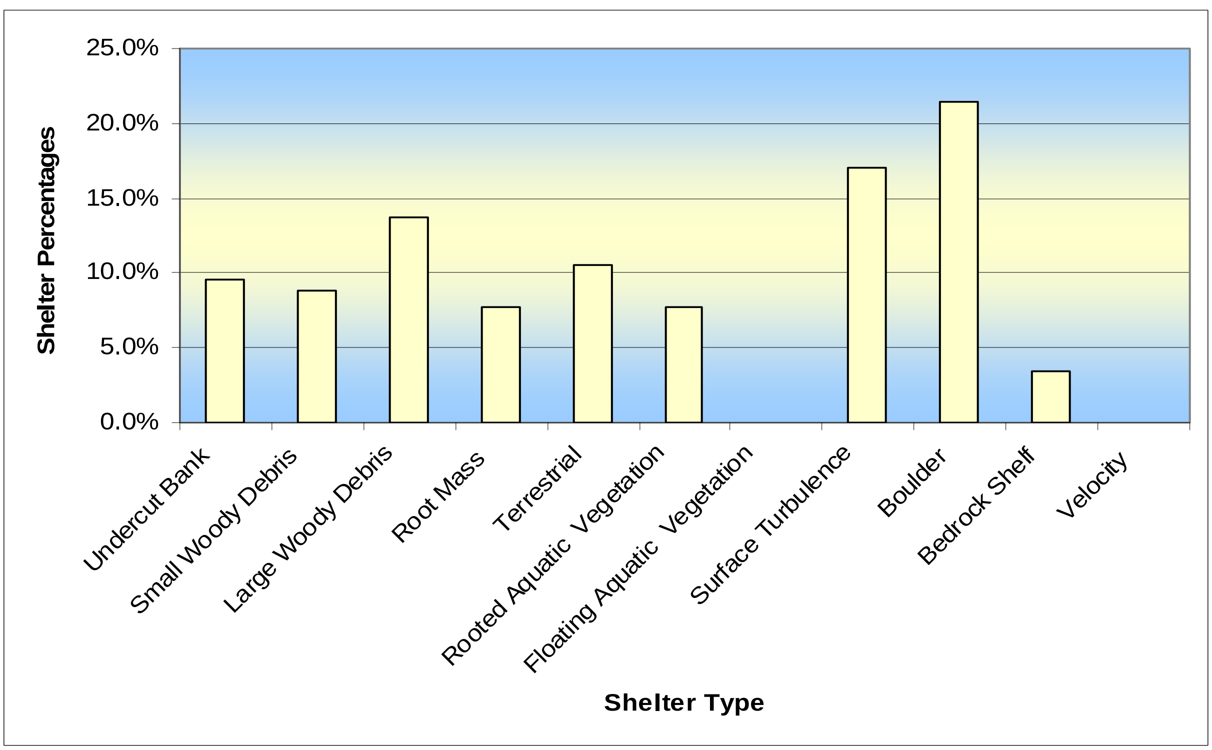

Figure 37. Lower San Leandro Creek Shelter Types and Percentages

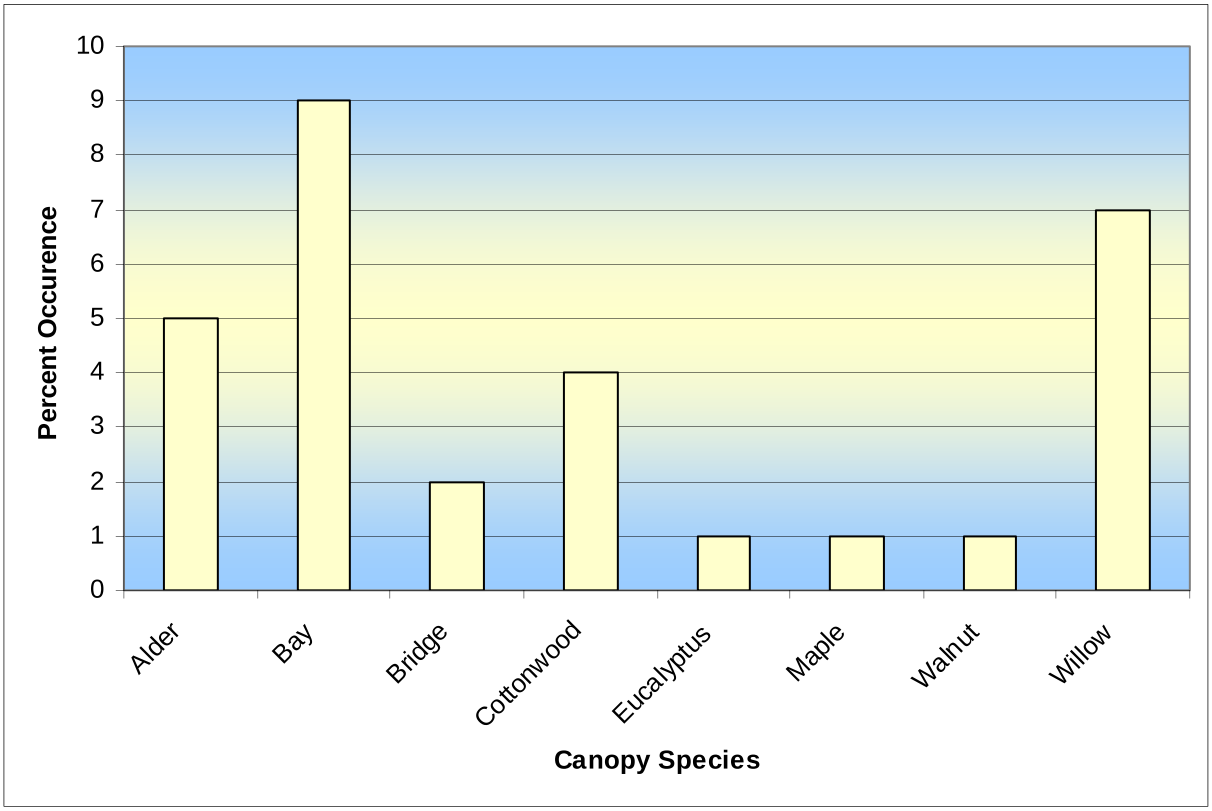

Figure 38. Lower San Leandro Creek Canopy Composition