Table 36: SWAMP Total Coliform Counts and *E. coli* Counts (MPN/100ml) in Sausal Creek in Years 4 and 5 as Determined by the Colilert Method

Station: SAU060	7/20/04	7/27/04	8/3/04	8/10/04	8/17/04	Median
Total Coliform	7300	5500	1800	17000	1200	5500
E. coli	260	120	160	150	160	164

* Counts are Most Probable Number per 100 milliliters (MPN/100ml). Values in red exceed the limit for freshwater recreation (126 MPN for the geomean).
Table from Water Quality Monitoring and Bioassessment in Selected San Francisco Bay Region Watersheds in 2004-2006, San Francisco Bay Regional Water Quality Control Board, 2008.

Summary: Water Quality

Several different sets of water quality and bacteria monitoring data have been collected in the Sausal Creek watershed. The Regional Water Quality Control Board's Surface Water Ambient Monitoring Program (SWAMP) provides high-quality monitoring data subjected to strict Quality Assessment/Quality Control (QA/QC) measures. In 2004-2005 SWAMP measured a comprehensive number of parameters at five stations on Sausal Creek. The results of the SWAMP monitoring found excessive levels of nutrients (nitrate and total phosphorus), slightly high water temperatures, and a few low dissolved oxygen measurements. Water and sediment samples were tested for a number of persistent pollutants including metals, pesticides, PCBs, and PAHs. Sediment samples from the downstream area of Sausal Creek had concentrations of chromium, mercury, and nickel that exceed the threshold effect concentrations (TEC). Water samples did not show any high contaminant levels. Bioassays on water and sediment found no acute toxicities, but sediment sample tests found hindered growth in the test organism.

FOSC water quality data lacks any description of methods or QA/QC measures and as such its accuracy and reliability cannot be established.

Bacterial data was collected by FOSC in 1999 and analyzed by the EPA, and shows high *E. coli* levels in all locations sampled. SWAMP bacterial monitoring in 2004 found lower *E. coli* levels, but levels still exceeded water contact recreation standards.

AQUATIC AND RIPARIAN HABITATS

Introduction

The Sausal Creek watershed, unlike most urban areas, has many open, unculverted creek channels. Compared to culverted reaches, these creeks have the ability to support aquatic and riparian habitats for fish and wildlife. One of the goals of this plan is to determine what watershed improvements are needed to reduce the negative effects of urbanization on these habitats. This section will review how urban development affects creeks and their habitats and will inventory open channel reaches and their enhancement potential.

In the Sausal Creek watershed, aquatic habitats consist of the stream channel bottom and banks in the creeks with perennial and intermittent, or seasonal, flow. Ephemeral creeks carry water only during and immediately after rainfall and are delineated using the topographic contours but are not indicated as creeks on the topo map. Most ephemeral creeks in this watershed are steep and short. Cobbledick Creek is not indicated as a blue line (perennial/seasonal) creek. Perennial and seasonal open channel creeks include: Palo Seco Creek and its tributary; Cinderella Creek, Shephard Creek downstream of Shepherd Canyon Park, and Sausal Creek (Figure 55).

Riparian habitat consists of the vegetation bordering the low flow channel and covering the adjacent floodplain. Riparian vegetation is dependent on a source of summer water. Willows and alders are the most abundant riparian plants along Sausal Creek and are considered “pioneer” species. Both species are able to rapidly colonize deposited sediment, stream banks, and channel edges. Alder has the ability to grow roots both above and below ground, creating an anchor along rocky, eroding channel edges. Willow can spread by seed or root runners as well as re-root and grow from broken stems and roots.

Other common plants found along streams in the watershed include trees—coast redwoods, California bay laurel, and big-leaf maple—and understory—Pacific dogwood, nine bark, and native blackberry. Uncommon riparian species include elk clover, red alder, box elder, rushes and sedges, California wild rose, red elderberry, and others (Appendix B). The distribution of plant species varies according to the type of stream channel, whether it is confined in a gorge or unconfined as occurs on an alluvial plain.

An important concept in the ecology of riparian systems is ecological succession. The diversity of riparian vegetation species varies over a continuum of the conditions created by flood events and associated changes in stream channel morphology. Willows and alders, as pioneer species, occur near the active channel in alluvial streams or along the edges and among rocks in confined channels, and are eroded out frequently. Their reproductive and adaptive strategy is tuned to a highly variable physical environment. Farther away from the channel, other species occur on the floodplain that are still riparian in nature but are adapted to less physical variation. These include big-leaf maple, California bay laurel, and coastal redwood. Among conifers, coastal redwood is unique in its ability to grow along streams and withstand the buildup of alluvium around its trunk. Redwoods can grow adventitious roots along its trunk as sediment accumulates. Redwood seeds are also known to germinate after the deposition of fresh alluvium.

Alluvial fans typically have oak savannah rather than riparian corridors due to the high infiltration rates and lack of perennial flow. As stream channels fill, erode, or meander, the composition of vegetation changes, creating a diverse habitat structure which serves the needs of numerous insects and animals.

In many areas of the channels in the Sausal Creek watershed, gravel deposits and stream morphology create pools, riffles, and glides. Riffles are typically areas of high aquatic insect production. Aquatic insects live attached to rocks and within the spaces between rocks. Some are the aquatic nymph stage of flying adult insects such as dragonflies, damselflies, and mayflies. Others spend their entire life cycle in the water. All must be able to hold on to the creek substrate in the current, or hide within or beneath the gravel.

Effects of Urbanization on Riparian and Aquatic Habitats

The urbanization of Sausal Creek began along the lower creek where the land is flat, and eventually extended up into the headwaters and onto steep slopes. Only one tributary—Palo Seco Creek—retains a largely undeveloped drainage basin. Shephard and Cobbledick Creeks have less intensive urban development than Sausal Creek, but are still highly impacted by impervious surfaces.
Creeks in a natural state are formed and changed by flood events. Each watershed has a unique set of features, including size and shape of the basin and stream network, topography, geology, vegetative cover, land use, and rainfall patterns. Over time, the creek's size, shape, and condition reflect watershed conditions. For example, large-scale grading, road building, and land disturbance for residential development in upper Sausal Creek watershed (Figure 17) likely increased soil erosion, including landslides in wet years, resulting in large volumes of sediment being delivered to Sausal Creek. The creek channel might have had increased over-bank flooding and reduced aquatic habitat due to the sedimentation. Once large areas of the watershed were paved and many creek channels replaced with storm drains, Sausal Creek experienced larger volumes of runoff over a shorter time and a decreased sediment supply. Erosion of the sediment stored in the creek bed and banks occurred, resulting in incision or entrenchment. Once the channel is incised, stormflows are confined to the channel and increase erosion. In addition, urbanization typically involves channelization of creeks to reduce the area the creek occupies in order to maximize buildable land.

During the urbanization process, the riparian habitat is eroded out as the creek channel incises. As the channel bottom erodes, the former floodplain is isolated from frequent inundation. The entrenched channel has high flow velocities precluding much sediment deposition and the germination of riparian trees. The habitat in the new incised channel is limited in area and diversity. As the channel deepens, the banks fail, eroding habitat remaining on the original floodplain.

Aquatic habitats are highly affected by the high flow velocities. Channel scour and frequent gravel movement decrease the abundance and diversity of aquatic insects. Sand transport can shred the insects. High water temperatures caused by the loss of riparian shading, persistent urban pollutants, and fine sediments also limit aquatic insects.

To revegetate the riparian corridor and achieve conditions which support natural ecosystem processes of succession and diversity, the effects of urbanization on flow volumes, velocities, and channel form have to be mitigated. Willow, the species most adapted to high velocity flows, can withstand a flow velocity of up to 7 ft./sec. and shear stresses of 2 lbs./ft^2. Sausal Creek typically exceeds these conditions during the 1-year frequency event. As is discussed in the watershed section (p. 213), changing these physical flow conditions requires a watershed approach.

Benefits and Limitations of Creek Restoration

Urban creek restoration typically means changing the stream channel by grading and possibly adding rock or removing a culvert and recreating a channel. A narrow band of vegetation, usually willows, is installed on the newly graded channel banks. The creek usually remains in the same area. It is uncommon for a floodplain to be created where storm flows can spread out and slow down due to space limitations of urban areas. The footprint of the riparian corridor is rarely wide enough to support ecological processes, or a diversity of plant species. The restored urban stream may continue to have physical conditions such as frequent high velocity flows, which scour the channel and reduce the abundance and diversity of aquatic insects and riffles and pools for spawning and rearing fish. By restoring only one reach of an urban creek, the habitat benefits that can be achieved are limited to what can be changed in this very limited area. A broader approach, integrating improvements in the watershed with creek projects to mitigate the effects of urbanization, offers the possibility for changing both the creek and the processes which have caused the degradation of the creek. A focus on watershed restoration instead of just creek restoration requires a greater level of analysis but has the potential to produce higher quality, more sustainable environmental conditions in habitat areas.

A number of studies have looked at the long-term changes in aquatic habitat conditions in restored urban creeks. One of these studies focused on changes in aquatic insect assemblages in a creek in the East Bay. A restored section of Baxter Creek in Poinsett Park was evaluated in 1999 and in 2004 (Purcell et. al. 2002; Purcell 2004). The creek was removed from a culvert, a new channel was graded and stabilized with rock, and willows were planted. The size of the new creek channel was restricted by adjacent urban development and no floodplain was created as part of the project.

Aquatic insects were monitored in 1999 and again in 2004. Samples were taken after the project was completed and were evaluated for taxa richness, number of taxa of EPT (pollutant intolerant taxa), and family richness. Habitat areas were also evaluated.

The restored reach was compared with an unrestored reach of Baxter Creek and a high quality habitat area of Strawberry Creek deemed “best attainable conditions.” The same sampling design was applied to all three creek reaches. The study found that the “restored” reach of Baxter Creek had slightly improved aquatic habitat conditions over the unrestored reach of Baxter Creek but showed no significant improvements in aquatic habitat between 1999 and 2004, and had lower quality habitat than the Strawberry Creek site. The study attributed the lack of improvement in aquatic habitat in the restored reach to the continued urban runoff and high velocity flows in the channel.

Studies of stream restoration in Australia (Walsh et. al. 2005) concluded:

> “Restoration of streams degraded by urbanization has usually been attempted by enhancement of instream habitat or riparian zones. Such restoration approaches are unlikely to substantially improve instream ecological conditions because they do not match the scale of the degrading process. Recent studies of urban impacts on streams in Melbourne, Australia, on water chemistry, algal biomass and assemblage composition of diatoms and invertebrates, suggested that the primary degrading process to streams in many urban areas is effective imperviousness (EI), the proportion of a catchment covered by impervious surfaces directly connected to the stream by stormwater drainage pipes. The direct connection of impervious surfaces to streams means that even small rainfall events can produce sufficient surface runoff to cause frequent disturbance through regular delivery of water and pollutants; where impervious surfaces are not directly connected to streams, small rainfall events are intercepted and infiltrated…Alternative drainage methods, which maintain a near-natural frequency of surface runoff from the catchment were identified as the best approach to stream restoration in urban catchments…”

Studies of urban stream restoration in the Seattle area (Booth 2005) found:

> “Undoing harm by catchment urbanization on stream channels and their resident biota is challenging because of the range of stressors in this environment. One primary way in which urbanization degrades biological conditions is by changing flow patterns; thus, re-establishing natural flow regimes in urban streams demands particular attention if

restoration is to have a chance for success. Enhancement efforts in urban streams typically are limited to rehabilitating channel morphology and riparian habitat, but such physical improvements alone do not address all factors affecting biotic health. Some habitat-forming processes such as the delivery of woody debris or sediment may be amenable to partial restoration, even in highly disturbed streams, and they constitute obvious high-priority actions. There is no evidence to suggest, however, that improving non-hydrologic factors can fully mitigate hydrologic consequences of urban development."

This plan focuses on changing the watershed processes which have the largest effects on streams and are the result of the high level of urbanization in the Sausal Creek watershed.

Stream Reach Description

Palo Seco and Sausal Creek are largely open, unculverted channels with perennial water flow. Shephard Creek is largely culverted. Cobbledick Creek is mostly an open channel but is very steep and mostly bordered with houses. Figure 55 depicts those reaches of creek in the Sausal Creek watershed which have an open channel and moderate slope.

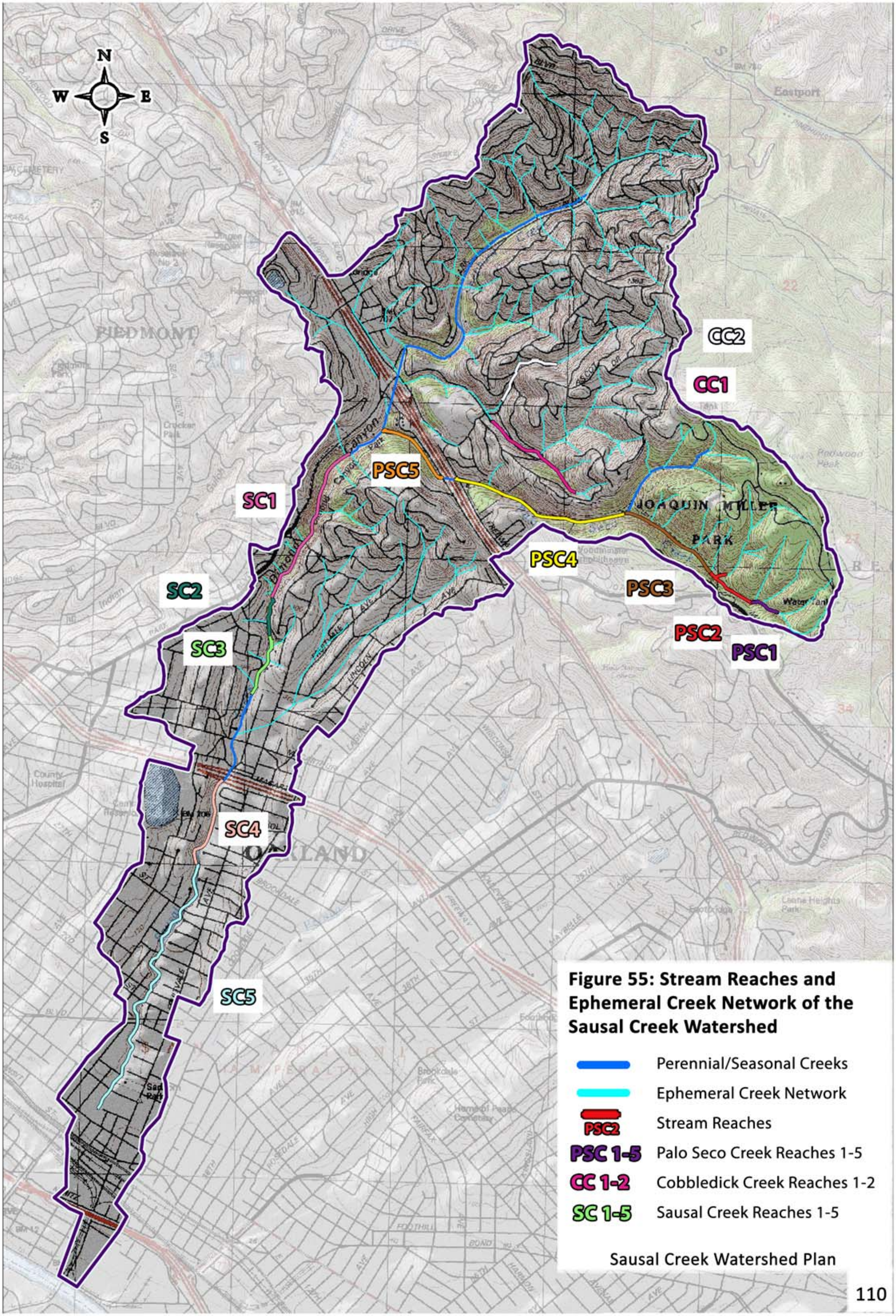

Figure 55: Stream Reaches and Ephemeral Creek Network of the Sausal Creek Watershed

Cobbledick Creek

Most of Cobbledick Creek and its tributaries have open channels with seasonal flow. With the exception of two areas, however, this sub-basin is private residential land. In addition, in many areas of this sub-basin homes border the creek or have foundations or deck piers next to or in the creek (Figure 56). In these private creeks, control and eradication of invasive plants such as broom, Himalayan blackberry, cape ivy, Algerian ivy, and blue periwinkle will reduce the spread of these problem plants into downstream habitat areas. Erosion control and bank stabilization may also be needed. Native shrubs and trees such as toyon, manzanita, oaks, and madrone occur as natural vegetation.

Cobbledick Creek 1 (CC1)
This reach along Larry Lane is bordered with houses. The channel is semi-confined between hillslopes and much of the former floodplain is filled with houses. The channel bed is fine sediment and gravel. Mixed conifers line the creek and Eucalyptus, Algerian ivy, and broom are common. A sediment/detention basin blocks the channel near the Ascot Road crossing (Figure 57). The dam creating this basin was overtopped and eroded portions of the dam and Larry Lane road fill. Downstream from this basin the creek channel consists of fill with a culvert and has a house on the fill. There is erosion at the outlet (C-2-01; Figure 79) Downstream of the Ascot Rd. crossing the creek channel is filled and the creek goes through a culvert under Joaquin Miller Elementary/Montara Middle schools.

Cobbledick Creek 2 (CC2)
This reach is Cottonwood Creek, which flows through Beaconsfield Canyon. The channel is semi-confined between hillslopes and the channel bed is mostly fine sediment with some gravel. Black cottonwoods line the creek and broom and Himalayan blackberry make up the understory. An old culvert in the creek bed has been filled by the creek and the creek has carved a new channel around the culvert. Neighborhood residents have removed numerous invasive plants and, with FOSC, have installed native plants. The downstream end of this reach has a rapidly eroding inlet where the creek drops into a storm drain.

Cobbledick Creek 3 (CC3)
This reach is made up of ephemeral creeks in an undeveloped but private 15-acre area. There are willows, elk clover, and dogwoods growing along one of the creeks.

Cobbledick Creek 4 (CC4)
This reach extends from the outlet of the culvert underneath the Joaquin Miller Elementary/Montara Middle schools to the confluence with Shephard Creek. The channel is lined by live oaks and Eucalyptus and has erosion in many locations with undercut trees.

Figure 56: Houses line the tributary channels in the Cobbledick Creek sub-basin. House and deck foundations are located within the area of the channel that is subject to bank erosion and failure.

Figure 57: Top: Tributary to Cobbledick Creek along Larry Lane (CC1) flows into a sediment basin. Bottom: Lack of maintenance of basin shows in this buried and largely nonfunctional standpipe.

Palo Seco Creek

The Palo Seco Creek sub-basin is the least developed area of the Sausal Creek watershed. Five different reaches of the creek were delineated based on physical features.

Palo Seco Creek 1 (PSC1)
This reach is the upper meadow area of Joaquin Miller Park. This channel is unconfined and low in slope with a low density of riparian vegetation. Dominant trees are coast redwoods and willows with an understory of Himalayan blackberry. The channel appears to have been relocated to one edge of the meadow area (Figure 58). Palo Seco Creek channel filled with fine sediment in 2006. Currently the meadow serves as a floodplain. A drop inlet into the culverted section of creek (PSC2) occurs at the downstream end of this reach.

Palo Seco Creek 2 (PSC2)
This reach of creek was culverted to create a meadow. This reach was likely lined by redwoods prior to clearcutting in the 1860s and park development projects in the 1930s and 1940s. This reach includes the confluence with Fern Ravine Creek, which is culverted from a picnic area to its confluence with culverted Palo Seco Creek. The drop inlet for Fern Ravine Creek frequently fills with bedload, and water creates an overland course to meet the open channel of Palo Seco Creek (Figures 59 and 60).

Palo Seco Creek 3 (PSC3)
This reach of Palo Seco Creek stretches from the culvert outlets at the downstream end of the meadow to the confluence with Cinderella Creek (Figures 61 and 62). The slope of the creek bed increases over this reach and the channel is semi-confined by adjacent hillslopes. The channel bed is fine sediment with some gravel and the channel contains several knickpoints (Erosion Sites 3 and 4, Figure 90). The creek channel is incised below these knickpoints and several trees have been undercut on the banks. Vegetation density along the creek is moderate with coast redwoods, California bay laurel, and live oak and an understory of Himalayan blackberry. The Lacan BMI station is located in this reach which showed good aquatic habitat conditions.

Palo Seco Creek 4 (PSC4)
This steep rockbound channel is lined by redwood and California bay laurel trees. Many trees, however, are covered with parasitic Algerian ivy and numerous invasive non-native holly trees are growing in the redwood forest (Figure 63). A SWAMP station and FOSC bacteria sampling station are located at the downstream end of this reach.

Palo Seco Creek 5 (PSC5)
This reach stretches from the Highway 13 culvert outlet to the confluence with Sausal Creek. The channel is confined with hillslopes, and the channel bed is mostly fine sediment with gravel. The density of vegetation is high, dominated by coast redwoods with Algerian ivy, Himalayan blackberry, and American elm. A small cement footbridge crosses the channel and there are several causes of erosion on the slopes including trail erosion and storm drain outlets. FOSC water quality/BMI sampling occurs in this reach. Rainbow trout have been observed in this reach.

Figure 58: Palo Seco Creek (PSC1) overflows onto a grassed floodplain and trail during larger flow events.

Figure 59: Top: Fern Ravine Creek, part of PSC2, in Joaquin Miller Park after the Jan 1, 2006 flood where the creek flowed out of its concrete channel and overland. Bottom: Filled-in culvert drop inlet.

Figure 60: Top: Fern Ravine Creek overland flow crosses the trail and spreads out into the middle and lower meadow area in PSC2. Bottom: Fern Ravine Creek joins Palo Seco Creek where it comes out of the culvert into a natural channel just downstream of the meadow.

Figure 61: Top: Palo Seco Creek at beginning of reach PSC3.
Bottom: Knickpoint in Palo Seco Creek where tree roots are serving as a grade control structure.

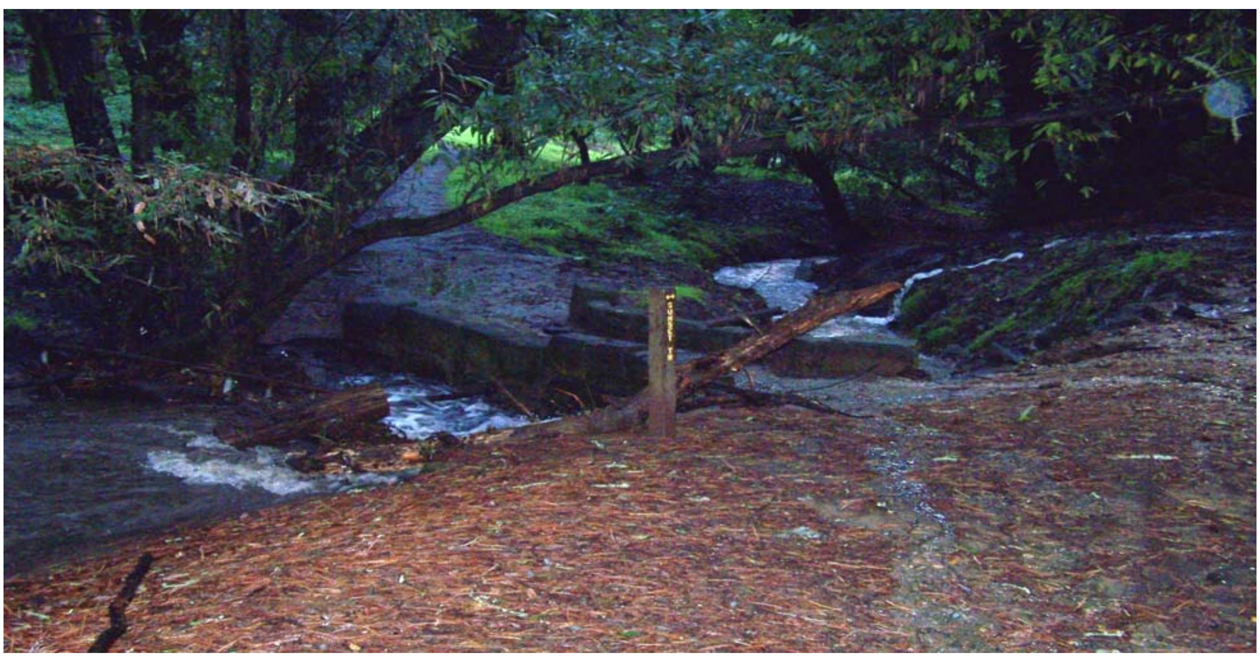

Figure 62: Top: Palo Seco Creek (PSC3) in the Jan. 1, 2006 flood event. Bottom: Small trail bridge with culverts serves as a grade control structure for Palo Seco Creek. Small trash rack visible upstream is also a grade control structure. Note sediment runoff from adjacent trails.

Figure 63: Palo Seco Creek (PSC4) during the Jan. 1, 2006 flood in its rock canyon and at its terminus at Joaquin Miller Court. Note Algerian ivy covering trees and slopes.

Since 2003, FOSC has been working to re-create the understory vegetation under the redwoods along the switchback trail. An erosion control project consisting of a swale was installed to divert flow from a storm drain outlet.

Shephard Creek

Shephard Creek has very little riparian or aquatic habitat and few feasible opportunities for native revegetation exist on the main creek. Controlling invasive non-native plants (Eucalyptus, broom, Acacia, pampas grass) in tributaries and on hillslopes will benefit downstream creek areas (Figures 45-47). This sub-basin has a large number of storm drains and most of the main creek channel has been culverted. Shepherd Canyon Park was once an open creek channel. A large amount of fill and a pipe was placed in the creek to create a flat area for the park. Escher Creek is an ephemeral tributary to Shephard Creek which was relocated to flow along the edges of Shepherd Canyon Park, and has been cleared of invasive plants and planted with native plants by the Shepherd Canyon Homeowners Association. Downstream of this park, the creek has an open channel up to Highway 13 and the confluence with Cobbledick Creek.

Sausal Creek

Sausal Creek extends from the confluence of Palo Seco Creek and Shephard Creek to San Francisco Bay.

Sausal Creek 1 (SC1)
SC1 extends from the confluence of Shephard and Palo Seco Creeks to the restoration project. The creek is confined in a relatively deep canyon lined by California bay laurels and white alders covered by parasitic Algerian ivy. Grade control structures, culverts, and cement lining cover most of the creek channel (Figures 64-66). Cobble dominated substrate has built up behind the stair steps of grade control structures. A major sewer line borders the creek and runs down the channel. There are numerous erosion sites from storm drains which outlet on the slopes of the canyon. Water quality, aquatic insect, and bacteria monitoring stations are located in this reach. Rainbow trout have been observed in this reach.

Sausal Creek 2 (SC2)
This is the 600 foot reach where a restoration project was completed in 2001. It begins one-quarter mile upstream from the El Centro culvert. Several grade control structures were removed and the sanitary sewer pipe in the middle of the creek was replaced. A series of rock weirs were installed along with some riprap at the base of the banks. Overstory California bay laurel trees were cut and willows and other native species were planted along the channel banks. The riparian corridor is narrow and no floodplain restoration was included in the project (Figures 67-69). FOSC and SWAMP water quality stations are located in this reach. Rainbow trout have been observed in this reach.

In 2001 the City of Oakland and FOSC completed a creek restoration project on Sausal Creek one-quarter mile upstream of the El Centro crossing. The project included removal of the old grade control structures (check dams), replacement of the sanitary sewer pipe in the creek, and cutting of the California bay laurel overstory. The creek channel was graded with rock weirs installed across the channel. Thousands of native plants were also installed both along the creek and on adjacent slopes.

Figure 64: These photos are examples of the drop structures in Sausal Creek (SC1) in Dimond Canyon.

Figure 65: Grade control structures in SC1 during the Jan.1 2006 flood.

**Figure 66: Top: Erosion of bay trees along Sausal Creek (SC1) in Dimond Canyon.
Bottom: Roots of white alder (SC3) protect banks during floods.**

Figure 67: Top: California bay laurel trees were trimmed to open up the creek corridor to more light and allow for willow growth as part of the restoration project in SC2. Bottom: The project in 2003 shows the narrow riparian corridor and wide trail.

Figure 68: Top: Vortex weir in a small flood in 2003. The weirs were installed as part of the restoration project. Bottom: Invasive non-native plants invade the new willows in the restoration project (SC2).

Figure 69: Top: Upstream end of El Centro culvert in SC3.
Bottom: Downstream pool at outlet of El Centro culvert.

Monitoring of the project in 2003 by FOSC compared percent cover and species diversity in the restoration reach and an upland area and another section of the creek. The results are shown in Table 37.

Table 37: FOSC Comparison of Percent Cover and Species Diversity in Sausal Creek Project

Vegetation Type	Riparian	Upland	Control
Bare Ground	44%	43%	9%
Native	41%	24%	11%
Non-native	14%	33%	80%
Unknown	1%	.2%	

Sausal Creek 3 (SC3)
This reach stretches from just upstream of the El Centro culvert through Dimond Park. The Sausal Creek channel would be unconfined with a floodplain if it were not channelized and culverted. The area downstream of the El Centro culvert is lined by white alders. The white alders are relatively old and do not appear to be regenerating. California bay laurel, live oak, California buckeye, and coast redwood also occur. The creek has been channelized and culverted through much of the Dimond Park (Figures 70-72). Along the downstream section, the right bank is residential with various types of revetments to protect against erosion. The left bank is parkland with native and ornamental trees. The channel is entrenched and eroding in this downstream area. The Whittle Road tributary flows into this reach. The City of Oakland is planning to change this reach by daylighting part of the creek out of the culvert west of Wellington Street, protecting the private property downstream on the right bank and installing native vegetation on the left bank. Water quality, aquatic insect, and bacteria monitoring stations are in this reach. Rainbow trout have been observed in this reach.

Sausal Creek 4 (SC4)
This reach extends from the Highway 580 culvert to 27th St. The creek channel would be naturally unconfined but due to urban development is highly entrenched and culverted. The stream bed is made of hard pan clay in many locations. The creek borders an intensively urbanized area and has been affected by the McKillop slide (Figures 73-74). This slide filled in Sausal Creek in 2006 and undercut several houses. A similar incident occurred in the 1970s and a culvert was installed to direct the creek away from the slide through William D. Wood Park. At the downstream end of the culvert a pump operated by Alameda County Flood Control lifts water up to the creek channel downstream. Water quality, aquatic insect, and bacteria monitoring stations are in this reach. Rainbow trout have been observed in this reach.

Sausal Creek 5 (SC5)
This reach extends from 27th St. to the culvert at the most downstream end of Sausal Creek. The creek channel would be naturally unconfined but due to urban development is highly entrenched and culverted. Houses line the creek (Figures 75-76). The streambed holds little gravel and has eroded down to clay hardpan. Banks are vertical and tall in many locations. Riparian vegetation is limited and primarily consists of non-native species, and shade canopy is sparse. One SWAMP station is located in this reach.


Figure 70: Left: White alder along Sausal Creek (SC3) with dead vines of Algerian ivy, a parasitic species. Right: Erosion of alders from the creek bank in the Jan 1, 2006 flood.

Figure 71: Top: Sausal Creek in Dimond Park (SC3). Bottom: Whittle Road tributary enters from its culvert into Sausal Creek.

Figure 72: Top: Sausal Creek in downstream area of Dimond Park where private residences border the creek (SC3). Failed gabions (rock-filled baskets) remain from prior bank stabilization project. Bottom: Large culvert carries Sausal Creek under meadow.

Figure 73: Top: Sausal Creek downstream of Hwy 580. The channel is entrenched and has little gravel in its bed or native trees on its banks. Bottom: Algerian ivy covers trees along many of the small ephemeral streams in the watershed and is a source of re-infestation to downstream restoration areas.

Figure 74: Sausal Creek at Barry Place and E. 27th St (SC4).

Figure 75: Top: Sausal Creek at Logan Road. Bottom: Sausal Creek at E. 22nd St (SC5).

Figure 76: Top: Sausal Creek at Foothill Blvd in SC5. Bottom: Grassy area on top of culverted section of Sausal Creek.

Aquatic Insects

An indicator of both the health of the aquatic ecosystem and water quality is the diversity and abundance of aquatic insects in a creek. Typically aquatic insects are monitored in creeks with perennial flows. Some families of aquatic insects are more tolerant of pollution than others. The term EPT refers to *Ephemeroptera*, *Plecoptera*, and *Trichoptera*, three orders of aquatic insects. Within the EPT are particular taxa that are highly sensitive to pollutants. If the number of taxa of EPT sensitive to pollution is high, then the pollutant levels may be low. If pollution-sensitive taxa are missing, then it is likely that water pollution, poor habitat conditions, or excessive channel scour is occurring. FOSC has carried out monitoring of aquatic insects in several locations, from 1998 to 2006 (Figure 54). Unfortunately, no QA/QC protocol for the sampling or insect identification methods or other information is available on this monitoring program. No station-specific features such as water temperatures, channel features, or riparian canopy levels were recorded when insect sampling was done. These deficiencies in the data sets limit their usefulness.

In 1999 a benthic macroinvertebrate (BMI) study in Sausal Creek was completed (Lacan et.al. 1999) Three stations were sampled: Palo Seco Creek upstream of the creek canyon, Sausal Creek in Dimond Park, and Sausal Creek at Hickory Court. Pebble counts, streamflow measurements, channel cross-sections, and evaluation of riparian canopy were done at each sampling site (Figure 54). Basic water quality parameters—pH, water temperature, dissolved oxygen, and specific conductivity—were also measured during the sampling as instantaneous measurements.

This study found a significant difference between the Palo Seco Creek station and the two stations on Sausal Creek in terms of taxa richness, percent of dominant taxon, and indices of functional feeding groups (FFGs). There are five functional feeding groups including scrapers, shredders, predators, filtering collectors, and gathering collectors. Table 38 lists the results of the sampling. These results show that Palo Seco Creek station has a healthy aquatic habitat. Lacan attributes the results to the undeveloped watershed and intact shade canopy of Palo Seco Creek. By comparison, the two Sausal Creek stations have low quality habitat. The authors state that the Sausal stations are highly affected by urbanization. Riparian forest canopy is inadequate to shade the creek at the Sausal Creek stations and the gravel substrate is frequently scoured, turning rocks and moving smaller gravel. The study cites channel incision, which increases flow velocities, steepens stream banks and often erodes riparian trees, along with the higher velocities of urban runoff, as major causes of the lack of healthy aquatic habitat at the Sausal Creek stations.

Table 38: Benthic Macroinvertebrate (BMI) Study in 1999

Site	**Metric**				
	Taxa Richness	**Shannon Diversity[1]**	**% Dominant Taxon**	**Hilsenhoff Biotic Index (HBI)[2]**	**Jaccard Coefficient[3]**
Palo Seco Creek	14	7.66	31.7	3.49	1 (ref.)
Dimond Park – Sausal Creek	7	3.38	46.4	2.52	0.3125
Hickory Court – Sausal Creek	8	2.61	72.1	3.18	0.2222

[1] Shannon Diversity: a diversity index that treats species as symbols and relative population sizes as probabilities
[2] Hilsenhoff Biotic Index (HBI): an index to assess low dissolved oxygen caused by organic loading in streams
[3] Jaccard Coefficient: A measure of the similarity between two individuals in a population
Source: Lacan, Eisenstein, and Soules. 1999. Hydrological and Ecological Assessment of Sausal Creek.

The San Francisco Bay Regional Water Quality Control Board's Surface Water Ambient Monitoring Program (SWAMP) completed BMI sampling at three stations in April 2005. These included SAU030 (Sausal Creek at E. 22nd Street), SAU080 (Sausal Creek in Dimond Park), and SAU130 (Palo Seco Creek) (Figure 55). The SWAMP program used the California Department of Fish and Game aquatic biology lab to complete the sampling and insect identification. The methodology used was an interim protocol based on the California Stream Bioassessment Procedure. Samples were collected and analyzed by scientific professionals.

The BMI results are listed in Table 39. For stations SAU030 and SAU080, the BMI assemblages were in poor condition. Taxonomic richness was low and sensitive EPT taxa were largely absent. These conditions were found for the majority of urban creeks in Oakland and Berkeley and are considered indicators of poor water quality and the high scour conditions in urban creeks. The sampling site on Palo Seco Creek (SAU130) largely drains parkland rather than urban land and demonstrated far better conditions. Taxonomic richness and percent sensitive EPT were much higher, with many pollution-intolerant taxa present. Tables 40-46 list the features of each sampling site.

The FOSC aquatic insect sampling (Table 47) lacks the level of detail completed by the SWAMP program and cannot be compared. This program could revise its methods to sample twice a year, use the SWAMP sampling protocol and send its samples to a professional lab in order to produce high quality results. In addition, as part of taking samples, an analysis of the sampled reach should be done to evaluate if site-specific conditions, water pollution, or some other feature is influencing the benthic macroinvertebrates.

Summary

BMI results from the 2005 SWAMP study and the 1999 Lacan study found similar results: low taxonomic richness and a near absence of sensitive EPT taxa at all the Sausal Creek stations. Stations on Palo Seco Creek showed significantly better conditions with higher taxonomic richness and a moderate percentage of sensitive EPT taxa. These results demonstrate the poor water quality conditions in the urban areas of Sausal Creek and the relatively good conditions on Palo Seco Creek, the only non-urban tributary.

The results of the BMI sampling clearly demonstrate the differences between creeks in the Sausal Creek watershed based on the level of impervious surfaces. Palo Seco Creek with a largely non-urbanized drainage basin has aquatic insect taxa richness indicative of very high quality habitat. Aquatic insect sampling in Sausal Creek in Dimond Canyon and downstream reaches demonstrates poor quality habitat conditions. These are likely the result of channel scouring flow velocities, loss of riparian habitat, urban stormwater pollutants, and high bacterial (*E. coli*) levels from leaking sanitary sewers as discussed in the water quality section.

Table 39: SWAMP BMI Sampling Results for Sausal Creek

Metric	SAU030 (Sausal Creek at E. 22nd Street)	SAU080 (Sausal Creek in Dimond Park)	SAU130 (Palo Seco Creek)	Metric Definitions
Coleoptera Taxa	3	1	5	Number of *Coleoptera* (beetle) taxa
Diptera Taxa	2	3	6	Number of *Diptera* (true fly) taxa
Ephemeroptera Taxa	1	1	3	Number of *Ephemeroptera* (mayfly) taxa
Hemiptera Taxa	0	0	0	Number of *Hemiptera* (true bug) taxa
Lepidoptera Taxa	0	0	0	Number of *Lepidoptera* (moth) taxa
Megaloptera Taxa	0	0	0	Number of *Megaloptera* (heligrammite) taxa
Odonata Taxa	1	0	0	Number of *Odonata* (dragonfly and damselfly) taxa
Plecoptera Taxa	0	1	3	Number of *Plecoptera* (stonefly) taxa
Trichoptera Taxa	0	0	8	Number of *Trichoptera* (caddisfly) taxa
Non-Insect Taxa	4	4	6	Number of non-insect taxa
Taxa Richness	11	10	31	Total number of invertebrate taxa
EPT Taxa	1	2	14	Number of *Ephemeroptera*, *Plecoptera*, and *Trichoptera* taxa
Abundance (#/sample)	2545	10752	672	Estimated number of organisms collected in entire sample
% EPT	45	65	60	Percent composition of *Ephemeroptera, Plecoptera,* and *Trichoptera*
% Sensitive EPT	0	1	35	Percent composition of EPT with tolerance values <3
% *Chironomidae*	21	16	6	Percent composition of *Chironomidae* (midges)
% *Coleoptera*	1	0	26	Percent composition of *Coleoptera* (beetles)
% *Oligochaeta*	32	17	3	Percent composition of *Oligochaeta* (worms)
% Non-Insect	33	18	5	Percent composition of non-insect organisms
% *Baetis*	45	64	24	Percent composition of *Baetis*
% *Simulium*	0	1	0	Percent composition of *Simulium* (black flies)
% COBS	99	97	33	Percent composition of *Chironomidae, Oligochaeta, Baetis,* and *Simulium*
% Intolerant	0	1	36	Percent of organisms with tolerance values <3
% Tolerant	1	0	1	Percent of organisms with tolerance values >7
Tolerance Value	5.23	5.13	3.45	Average tolerance value of all organisms
% Predator	1	1	40	Percent of organisms that feed on other organisms
% Collector-Filterer	0	1	3	Percent of organisms that filter fine particulate organic matter
% Collector-Gatherer	99	97	36	Percent of organisms that gather fine particulate organic matter
% Scraper	0	0	27	Percent of organisms that graze on periphyton
% Shredder	0	1	24	Percent of organisms that shred coarse particulate organic matter
% Other	0	0	0	Percent of organisms with other types of feeding

Table from Water Quality Monitoring and Bioassessment in Selected San Francisco Bay Region Watersheds in 2004-2006, San Francisco Bay Regional Water Quality Control Board, 2008.

Table 40: SWAMP BMI and PHAB Sampling Substrate Characteristics for Sausal Creek

Station	Site Name	Date Sampled	BMI	PHAB	BMI plots substrate type distribution (Percent, average of 8 estimated values)				
					Avg. % Fines & Sand	Avg. % Gravel	Avg. % Cobble	Avg. % Boulder	Avg. % Bedrock
SAU030	**Sausal Creek at E. 22nd St.**	**4/14/2005**	**X**	**X**	**25**	**46**	**28**	**2**	**0**
SAU080	**Sausal Creek at Dimond Park**	**4/14/2005**	**X**	**X**	**19**	**48**	**33**	**1**	**0**
SAU130	**Palo Seco**	**4/14/2005**	**X**	**X**	**24**	**60**	**16**	**0**	**0**

Table 41: SWAMP BMI Sampling Physical Habitat Characteristics for Sausal Creek

Station	Date	Avg. Slope (%)	Avg. Width of Wetted Channel (m)	SD of Avg. Width	Avg. Water Depth (cm)	SD of Avg. Depth	Flow Discharge at Sampling Time (m^3/sec)	Flow Discharge at Sampling Time (cfs)	Channel Conditions – Estimated Scores (out of 20)			Flow Habitat Units Distribution (% of total reach length)					
									Epifaunal Substrate/ Available Cover	Sediment Deposition	Channel Alterations	Pools	Glides	Runs	Riffles	Cascades/ Falls	Dry Channel
SAU030	4/14/2005	1.5	4.3	0.8	18.9	10.5	0.0068	2.4	5	6	2	20	47	0	31	2	0
SAU080	4/14/2005	3.0	3.3	0.6	12.5	8.3	0.049	1.7	16	14	17	13	29	0	55	6	0
SAU130	4/14/2005	7.1	1.3	0.2	8.0	6.1	0.014	0.5	14	7	15	5	11	0	79	5	0

Table 42: SWAMP BMI Sampling Physical Habitat Characteristics

Station	Date	Reach-Wide Substrate Composition (percent, derived from size-class determinations at each Transect and Intertransect Point)													Percent Substrate Smaller than Sand (<2mm)	Percent Substrate Fine Gravel or Smaller (<16mm)	Percent Substrate Larger than Fine Gravel (>16mm)	Percent Substrate as Bedrock
		% Bedrock – smooth	% Bedrock – rough	% Concrete/ asphalt	% Boulders – large (1000-4000mm)	% Boulders – small (250-1000mm)	% Cobble (64-250mm)	% Gravel – coarse (16-64mm)	% Gravel – fine (2-16mm)	% Sand (0.06-2mm)	% Fines (silts/ clay/ muck, <0.06 mm)	% Hardpan	% Wood (any size)	% Other Substrate				
SAU030	4/14/2005	0	0	39	0	3	5	17	21	12	0	0	3	0	12	33	64	0
SAU080	4/14/2005	0	0	0	3	27	26	13	13	6	1	3	9	0	7	20	69	0
SAU130	4/14/2005	0	0	6	3	7	19	24	24	11	3	0	3	0	14	39	59	0

Tables from Water Quality Monitoring and Bioassessment in Selected San Francisco Bay Region Watersheds in 2004-2006, San Francisco Bay Regional Water Quality Control Board, 2008.

Table 43: SWAMP BMI Sampling Physical Habitat Characteristics for Sausal Creek (continued)

Station	Date	Geometric Mean of Particulate Substrate Size[1] (mm) (boulders to fines)	Geometric Mean Substrate Diameter[2] (Dgm) Per revised calc	Estimated Geometric Mean Substrate Diameter[3] (mm) Anti-log of LSUB_DMM	Cobble Embeddedness (%)	Habitat & Shelter Value – Percent Cover of Habitat Elements (average of numeric-range-categories medians from 11 Habitat Plots)								
						Filamentous Algae Cover (%)	Macrophytes Cover (%)	Large Woody Debris Cover (%)	Small Woody Debris/ Bruch Cover (%)	Live Tree Roots Cover (%)	Over-hanging Vegetation Cover (%)	Undercut Banks Cover (%)	Boulders Cover (%)	Artificial Structures Cover (%)
SAU030	4/14/2005	18	11	10	25	1	0	0	0	1	4	1	3	59
SAU080	4/14/2005	95	81	182	49	4	0	0	2	4	12	5	14	3
SAU130	4/14/2005	26	19	23	55	0	0	1	5	3	10	2	15	1

[1] This represents the dominant size of bed material at the sample site

[2] Dgm=Geometric mean substrate diameter was calculated for all particulate substrate fractions plus bedrock and hardpan, per Kaufman 2008 (SWAMP 2008)

[3] Estimated geometric mean was calculated for all particulate substrate fractions plus bedrock and hardpan

Table 44: SWAMP BMI Sampling Physical Habitat Characteristics for Sausal Creek (continued)

Station	Date	Shelter Types Present (count)	Natural Shelter Cover (sum LW, brush, overhang, boulders, undercut) (%)	Big Shelters Cover (sum LW, boulder, artificial) (%)
SAU030	4/14/2005	7	9	63
SAU080	4/14/2005	7	33	17
SAU130	4/14/2005	7	33	18

Table from Water Quality Monitoring and Bioassessment in Selected San Francisco Bay Region Watersheds in 2004-2006, San Francisco Bay Regional Water Quality Control Board, 2008.

Table 45: SWAMP BMI Sampling Physical Habitat Characteristics for Sausal Creek

Station	Date	Average Shade and Canopy Cover (%&	Bank Vegetation Percent Cover on left bank and right bank, by Cover Type (Average of numeric-range-categories medians from 11 Riparian Plots)							Riparian Canopy Presence (proportion of reach) XPCAN
			Big Tree Canopy (%)	Small Tree Canopy (%)	Small Tree Understory (%)	Non-Wood Understory (%)	Woody Shrubs Ground Cover (%)	Non-Woody Ground Cover (%)	Barren Ground Cover (%)	
SAU030	4/14/2005	95	31	8	18	5	21	26	49	0.68
SAU080	4/14/2005	91	34	13	24	7	35	35	24	0.91
SAU130	4/14/2005	97	57	12	32	1	72	6	18	0.73

Table 46: SWAMP BMI Sampling Physical Habitat Characteristics for Sausal Creek

Station	Date	Human Disturbance Index by Activity (proximity-weighted index)											Combined Human Disturbance Index (all types) [1] W1_HALL
		Buildings	Landfill/ Trash	Logging Operations	Mining Activity	Park/ Lawn	Pasture/ Range/ Hayfield	Pavement/ Cleared Lot	Pipes (Inlets/ Outlets)	Roads/ Railroads	Row Crops	Wall/ Dyke/ Riprap/ Revetment/ Dam	
SAU030	4/14/2005	0.50	0.64	0.00	0.00	0.05	0.00	0.27	0.27	0.03	0.00	1.02	2.78
SAU080	4/14/2005	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	1.14
SAU130	4/14/2005	0.03	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.23

[1] Combined human disturbance index ranges from 0 (i.e., no human influence) in open space sites to 3.77 in highly urbanized sites

Tables from Water Quality Monitoring and Bioassessment in Selected San Francisco Bay Region Watersheds in 2004-2006, San Francisco Bay Regional Water Quality Control Board, 2008.

Table 47: Friends of Sausal Creek Aquatic Insect Volunteer Monitoring Results 1998-2006

Date	Palo Seco Creek		Sausal Creek	
	Total Number of Organisms	Total EPT	Total Number of Organisms	Total EPT
7/12/98			2722	152
8/16/98			430	198
9/20/98	444	398		
11/15/98			276	202
2/27/99	93	89		
3/27/99			65	43
4/25/99	510	485		
5/23/99			505	182
6/20/99	408	319		
8/15/99			113	80
10/24/99			599	219
11/21/99	665	608		
2/20/00			24	16
3/26/00	166	145		
4/30/00			804	165
5/21/00	378	298		
7/16/00			344	143
8/20/00	268	230		
9/17/00			235	97
11/19/00	242	225		
1/21/01			240	93
2/25/01	104	33		
3/18/01			64	28
4/22/01			280	103
5/20/01	299	233		
4/21/02			1004	104
6/16/02	126	94		
7/21/02			293	116
10/20/02	93	74		
11/17/02			208	170
1/19/03			88	81
2/23/03	90	69		
4/20/03			388	284
5/25/03	93	64		
6/15/03			335	200
7/20/03	227	187		
1/18/04			67	63
2/15/04	70	57		
3/21/04			266	257
4/18/04	94	78		
1/23/05			262	230
5/22/05	161	119		
7/24/05			259	97
11/20/05			170	45
2/19/06	280	80		
3/19/06			110	107
4/9/06	59	48		
7/16/06			321	235

Fish

Remarkably, rainbow trout (*Oncorhynchus mykiss*), the non-anadromous form of steelhead trout, have been seen in Sausal Creek and lower Palo Seco and Shephard Creeks (FOSC 2009). The majority of recorded observations are of adults. Three Sausal Creek sites were sampled for fish in July 1981. No fish were collected (Leidy 1984). In 1998 an electro-fishing survey of Cobbledick and Shephard Creeks along Scout Road and of Sausal Creek from the Montclair Golf Course to Canon Avenue was done (Hagan and Demgen 1998). No fish were found. The 1998 report concluded that the culvert under Highway 13 was a passage barrier. A survey of Palo Seco Creek during this study found four trout and concluded that the culvert under the Montclair Golf Course is a major migration barrier (Hagan and Demgen 1998). Another electrofishing survey including Sausal Creek in Dimond Canyon up to its confluence with Palo Seco Creek and in Shephard Creek along Scout Road found no fish (Lowe 2000). In 2001, the California Department of Fish and Game conducted a partial survey of Sausal Creek but ended the survey due to "low potential to restore salmonids" (Cleugh 2002).

Adult fish have been seen in a number of locations (FOSC 2009) by a variety of observers, including Palo Seco Creek and Sausal Creek from the Leimert Bridge down to the Barry Place/Hickory Street area just upstream of the 27th Street crossing (FOSC 2009, CEMAR). In February 2008, 11 trout were found dead from paint thinner being washed into the storm drain and creek (FOSC 2000). Only one of these observations was of juvenile trout in Palo Seco Creek. Rainbow trout in Sausal Creek and its tributaries are at great risk from one pollution event or large scouring flood event. Additionally, high water refuge areas in Sausal Creek are probably provided by the few undercut banks, failing drop structures, and concrete aprons.

Birds

Bird monitoring throughout the watershed has been on-going since 1998 with many sites surveyed. This effort created inconsistent data in frequency of visits and numbers, but documents presence/absence of species. The survey work was unsustainable and a reduced effort was begun in 2002 with eight sites visited throughout the watershed, focusing on the El Centro restoration. Data are collected quarterly using a circular plot method in which all birds seen or heard around a point are recorded during ten minutes. The data average 25 records per site, but have only been roughly analyzed. It is stored in the database Ebird at the Cornell University under Mark Rauzon. Preliminary analysis shows neo-tropical birds started breeding in the restoration sites in 2005, after the complete restoration of 2001/2002 matured. Wilson's Warblers began using the El Centro Area in 2005 and the Meander Area of alders in 2007. In 2009, Black-headed Grosbeaks were recorded on survey in the Meander Site, after the trees matured to a 25-30 foot height. Warbling Vireos and Pacific-slope Flycatchers have been present throughout this period of restoration in the over story and are increasing. Song Sparrows and Spotted Towhees also benefit from the creation of native low bushy cover. Fish-eating birds such as Belted Kingfisher and Great Blue Heron are recorded in the El Centro restoration area now seeking to eat trout. Red-shouldered Hawks and Red-tailed Hawks are seen hunting here (FOSC 2009).

EVALUATION OF WATERSHED EROSION SITES

A focused evaluation of several types of erosion sites was carried out in the Sausal Creek watershed. In general, the process of urbanization generates two phases of erosion. During the short-term development stage, grading and ground disturbance increases erosion. Once paved, the increased