Unified Stream Assessment in Seven Watersheds in San Mateo County, California

SAN MATEO COUNTYWIDE
Water Pollution Prevention Program
Clean Water. Healthy Community.

A Program of the City/County Association of Governments

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Prepared for the
San Mateo Countywide Water Pollution Prevention Program

by

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SUMMARY

Introduction

During fall 2007, the San Mateo Countywide Water Pollution Prevention Program (the Program) performed creek walks in seven watersheds in San Mateo County – the Atherton, Redwood, Burlingame, Sanchez, Easton, Mills, and Millbrae Creek watersheds. The primary objective was to characterize physical conditions and features of creek channels and riparian corridors as part of the Program's screening-level water quality monitoring activities.

Methods

The creek walks were conducted using the Unified Stream Assessment (USA) protocol developed by the Center for Watershed Protection. The USA is a rapid assessment tool used to collect data on instream and riparian habitat conditions and identify possible influencing factors and opportunities for improvement. Each study creek was delineated into reaches. Each reach represented a relatively uniform set of conditions within the creek corridor. Factors that contributed to delineating a reach included land use in the immediate vicinity, elevation, creek order, access, and total length. The study reaches were typically less than one mile long, began and ended at major creek crossings or grade changes, and reflected the general condition of the area adjacent to the creek. Tributaries were generally considered separate reaches. Creek sections were not assessed if inaccessible (e.g., due to culverts or dense vegetation) or if little apparent urban influence was present.

A single overall assessment was conducted for each reach. This reach level assessment qualitatively evaluated characteristics such as base flow, dominant substrate, water clarity, biota, shading, and active channel dynamics. Each reach was ranked for overall stream condition and overall buffer and floodplain condition based on eight subcategories: in-stream habitat, vegetative protection, bank erosion, floodplain connection, vegetated buffer width, floodplain vegetation, floodplain habitat, and floodplain encroachment. Each subcategory was given a score on a 20-point scale (in general, a score of zero to 5 is designated as poor condition, 6 to 10 is marginal, 11 to 15 is suboptimal and 16 to 20 is optimal). The subcategory scores were summed to give a total reach score ranging from zero to 160.

The USA protocol was also used to identify eight potential creek impacts: channel modification, erosion, utilities, outfalls, creek crossings, trash/debris, recreation sites, and miscellaneous features. The location, extent and general characteristics of each impact were documented.

Findings

Reach Level Assessment

In the larger study watersheds (i.e., Atherton and Redwood Creek), overall creek condition scores generally increased in the upstream direction with decreasing urbanization. The scores were largely driven by improved instream habitat and increased buffer widths and floodplain connection in the upper parts of the larger watersheds. In the smaller study watersheds (i.e., Burlingame, Sanchez, Easton and Mills Creek), overall creek condition was generally marginal or suboptimal in all reaches due to extensive urbanization throughout the watershed. Impacts were typically associated with low buffer widths (e.g., homes constructed very close to the creek) or highly impacted riparian corridor due to culverting beneath roads and driveways and extensive channel armoring, often to protect the backyards of residential properties.

Channel Modification

Construction of bank revetments along homes and yards was the most common type of channel modification observed. Culverted sections of creek, typically below roads or driveways, were also common. Some of the channel modifications identified appeared to be failing and/or causing erosion. Older revetments were especially vulnerable to scour and undercutting by increased peak flows associated with urbanization.

Erosion

The majority of erosion observed was in the form of bank scour, especially at meander bends and revetments. Bank failure was also common, especially the failure of steep banks within highly incised channels. Channel incision in the study watersheds generally appeared to be associated with historical land use changes and may no longer be active (i.e., the watersheds have likely been developed for a long enough period of time for the channel to have adjusted to change in the hydrograph and reached a new equilibrium). The channel bed in many of the reaches appeared to be clay, which is relatively resistant to erosion. In some cases grade control structures appeared to further stabilize the channel bed.

Utilities

In most cases, utilities in the study watersheds did not appear to have much impact on the creeks. The majority of utilities observed consisted of small pipes crossing over the creek high above the channel bed without any apparent impact on the creek. In some cases, utilities were located near the channel bed and were associated with bank erosion, apparently during high flow events. In areas that had major utilities such as a San Francisco Public Utilities Commission water supply pipeline, grade control structures and bank armoring had often been constructed to protect the facility.

Outfalls

The assessments were carried out during the dry season and few dry weather flows were observed. Only a small fraction of the outfalls with discharge showed any indications of illicit discharge (e.g., discoloration, odor). All suspicious discharges were reported to a municipal illicit discharge coordinator. Some outfall pipes were associated with erosion, either immediately downstream from the outfall or head cuts perpendicular to the creek.

Creek Crossings

The most common type of creek crossing observed was road crossings. Other types of crossings identified include houses, yards and driveways. In addition to habitat alteration impacts, creek crossings can potentially impact upstream passage for fish. The study watersheds are not expected to support anadromous fish (e.g., steelhead); however, native warm water fish, primarily stickleback, were observed in several reaches. These fish need to migrate to search for spawning habitat and refuge during summer low flow conditions. Conversely, creek crossings can be beneficial by serving as grade controls. When the bottoms of creek crossings are hardened, creek bed erosion may be prevented from migrating upstream.

Trash/Debris

Trash is deposited in creeks through several possible means including illegal dumping and/or littering at the site, windborne transport from adjacent land uses, and waterborne transport from upstream sources. Littering and illegal dumping are typically problematic when urban creeks are adjacent to areas that receive high vehicle and/or foot traffic (e.g., shopping centers) or locations with good public access (e.g., parks and schools). The study area was predominately comprised of residential land uses west of major transportation corridors, such as El Camino Real or Alameda de las Pulgas. As a result, littering or dumping in creeks occurred in only a limited number of locations.

Trash impacts in the study area were often associated with the dumping of yard waste into creek channels behind residential properties. Impacted sites also included areas where trash accumulated due to obstructions in the channel, such as dense vegetation or utilities. Other impacted sites occurred where creeks passed through parks or vacant lands that were in close proximity to schools. SMCWPPP (2008a) describes the application of an additional protocol, the Urban Rapid Trash Assessment (URTA), which was used to further characterize selected locations in the study watersheds with relatively high levels of trash.

Recreation

Evidence of recreation in the study watersheds was limited to two sites located within one creek reach in a public park (Stulsaft Park in Redwood City). Both of these sites had rope swings over the creek with excellent public access. However, the potential for water contact recreation appeared limited at the time of the assessment due to low flow conditions and the lack of deep-water pools.

Potential Uses of USA Data

Data generated through USA surveys can address multiple stormwater program monitoring-related objectives. USA survey uses include establishing baseline data, identifying the types and locations of potential impacts to water quality, identifying potential beneficial uses to protect and threats to such uses, and refining monitoring program objectives and design. USA survey data can assist stormwater programs to better understand creek conditions and threats to water quality upstream and downstream of existing monitoring sites, thereby assisting in the interpretation of existing monitoring data and the identification of appropriate stormwater BMPs and potential restoration activities. The Program, in collaboration with the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP), recently prepared a guidance document for municipal stormwater programs and other interested agencies on the potential uses of the USA based on recent experience in the Bay Area (SCVURPPP and SMCWPPP 2008).

Many of the impacts observed during the Program's USA surveys are associated with efforts by individual private property owners to control bank instability on their properties. Education and outreach could help landowners understand the impacts of such actions on creeks and potentially lead to the use of better practices in the future. The Program is currently exploring developing an outreach and support program similar to the Urban Creeks Council's Stream Management Program for Landowners (SMPL). This program is funded by the Contra Costa Clean Water Program and provides free advice about creek care to Contra Costa County property owners. The data from the Program's USA surveys could assist San Mateo County property owners to target and optimize creek management and restoration efforts initiated through this type of creek management program. However, a funding source to implement a program similar to SMPL in San Mateo County has not been identified. SMCWPPP (2008b) has prepared a memo that further discusses the SMPL program and the potential development of a creek management program in San Mateo County.

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GLOSSARY

Anadromous fish - Migratory species that are born in freshwater, live mostly in estuaries and ocean water, and return to freshwater to spawn.

Bank - The sloping ground that borders a creek and confines the water in the natural channel except during certain high flow conditions.

Bank Failure - The collapse or slippage of a large mass of bank material (often from the top of bank to the toe) into a creek.

Bank toe - The break in slope at the foot of a creek bank where the bank meets the bed.

Base flow - The sustained low flow of a creek during dry weather, usually a result of groundwater inflow into the creek channel.

Bed - The bottom of a creek channel.

Channelize - To straighten and often deepen a creek channel to allow conveyance of greater water velocities and volumes, often performed for flood control purposes.

Discharge - The volume of fluid passing a point per unit of time (e.g., cubic feet per second, million gallons per day, gallons per minute).

Diversion - A turning aside or alteration of the natural course of a flow of water, normally to physically leave the natural channel.

Down cutting - see incision.

Ecosystem - A community of organisms considered together with their habitat and environment.

Erosion - The process whereby materials are loosened, dissolved, or worn away and simultaneously moved from one place to another.

Flood plain - A relatively flat area of land bordering a creek channel that is inundated at times of high water.

Grade control structure - A weir, dam, sill, drop structure, artificially hardened bottom or other structure(s) used to control erosion in a creek channel with a steep grade or where the slope has been destabilized.

Habitat - The part of the physical environment in which a plant or animal lives.

Headwaters - The source and upper part of a creek.

Head cut - The upstream movement of a waterfall or a locally steep channel bottom due to the erosion caused by rapidly flowing water.

Imperviousness - The percentage of the ground surface that is impermeable to water and prevents infiltration.

Incision - G process that deepens the channel of a stream or valley by removing material from the stream's bed or the valley's floor

Load - Material such as sediment that is entrained by creeks, reported as weight of material transported during a specified time period (e.g., kg per year).

Pool - A small part of a creek reach with little velocity, commonly with deeper water than the surrounding areas.

Reach - A continuous section of a creek between two specified landmarks.

Revetment - A facing of wood, stone, concrete, or any other material used to support a creek embankment.

Riparian - Pertaining to or situated on the bank of a natural body of flowing water such as a creek or river.

Runoff - Rainfall that becomes a surface flow rather than infiltrating or absorbing into the ground.

Scour - Erosion by flowing water and sediment of a creek channel; results in removal of mud, silt, and sand on the outside curve of a creek bank and/or the bed material of a creek channel.

Sediment - Particles suspended in water or settled that were derived from geological or biological materials and are transported by creek flow or other natural process.

Substrate - The materials on the surface beneath a waterbody; these materials often provide habitat for aquatic organisms.

Tributary - A river or creek flowing into a larger river, creek or lake.

Watershed (of a creek) - An area of land that drains into a creek.

**Unified Stream Assessment
in Seven Watersheds in
San Mateo County, California**

1.0 INTRODUCTION

The San Mateo Countywide Water Pollution Prevention Program (Program) conducts Watershed Assessment and Monitoring (WAM) component activities in compliance with its municipal stormwater NPDES permit. A current emphasis is collecting screening-level biological, physical and chemical water quality data from creeks in representative urban watersheds in San Mateo County. These creeks are generally receiving waters for urban runoff discharges from municipal storm drain systems. The Program collects environmental indicator data (e.g., via creek walks, bioassessments and water column toxicity testing) to help evaluate current creek health and water quality conditions. These data also help establish a baseline for future evaluations of long-term trends and thereby inform the Program's efforts to improve the effectiveness of its Best Management Practices (BMPs) to prevent or reduce stormwater runoff impacts.

During fall 2007, the Program performed creek walks in seven watersheds in San Mateo County that drain to San Francisco Bay. This report documents the methods and results. The creek walks were conducted using the Unified Stream Assessment (USA) protocol. The USA is a rapid assessment tool used to collect data on instream and riparian habitat conditions and identify possible influencing factors and opportunities for improvement. Overall reach condition (e.g., bank stability, instream and riparian habitat, floodplain connectivity) is qualitatively assessed. In addition, individual impacts such as creek crossings, utilities, outfalls, areas with erosion, channel modifications and trash are documented.

The Program conducted similar USA creek walks in six other San Mateo County watersheds during fall 2006 (SMCWPPP 2007a). The USA has also been used to evaluate several San Francisco Bay Area creeks in other counties, including Calabazas and Saratoga creeks in Santa Clara County and Martin Canyon and Ward Creeks in Alameda County.

2.0 STUDY AREA

The study area was comprised of urban creek reaches in seven San Mateo County watersheds (Figure 1):

- Atherton Creek Watershed
- Redwood Creek Watershed
- Burlingame Creek Watershed
- Sanchez Creek Watershed
- Easton Creek Watershed
- Mills Creek Watershed
- Millbrae Creek Watershed

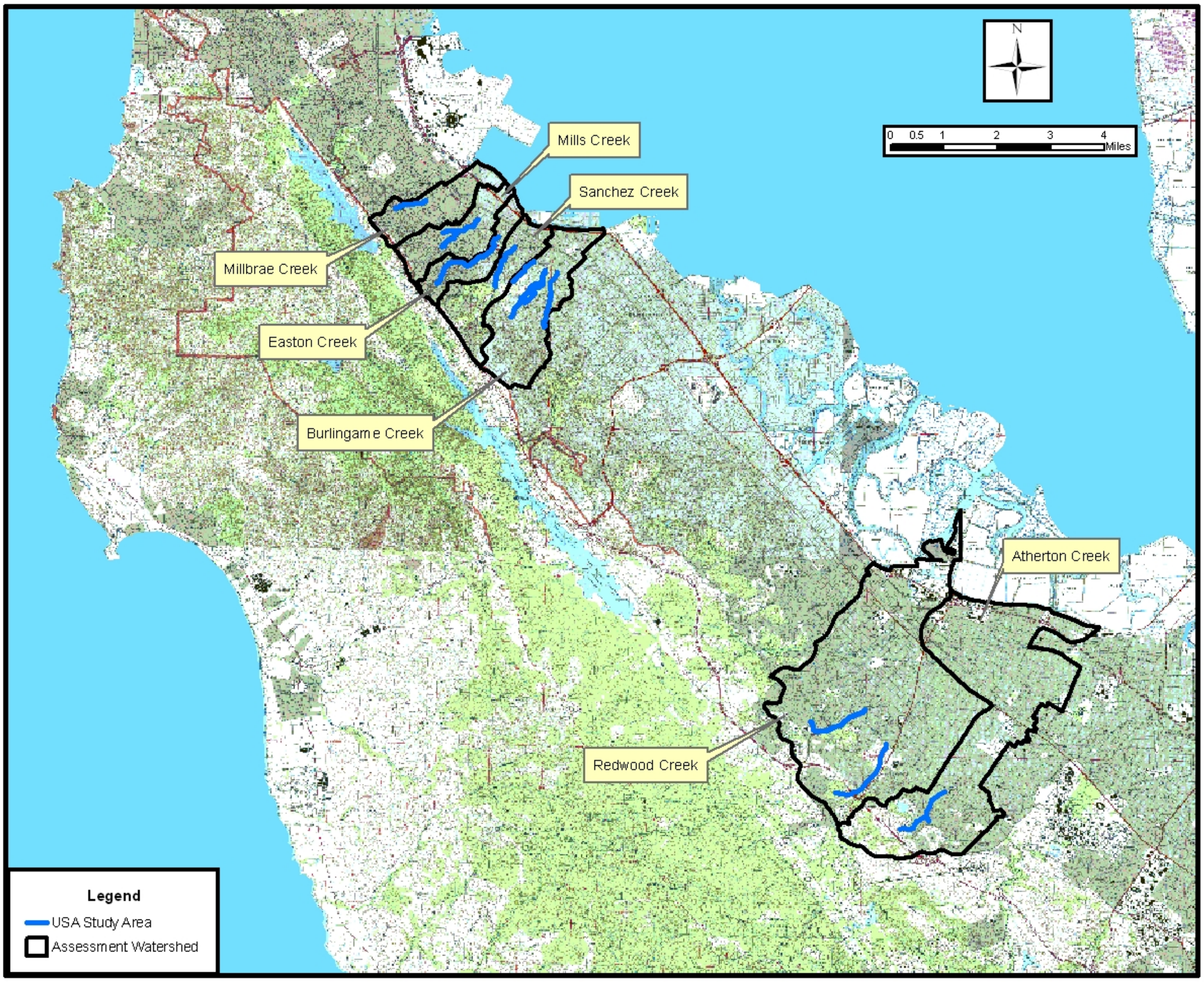

Figure 1. Seven study watersheds in San Mateo County.

The study watersheds drain into San Francisco Bay and range in size from 1.1 – 11.8 square miles (Table 1). Redwood and Atherton Creeks are the two largest study watersheds and are located in the southern portion of San Mateo County. Burlingame, Sanchez, Easton, Mills and Millbrae Creek watersheds are smaller, similar in size and grouped together in the northern portion of the county.

Table 1. Study watershed area and channel characteristics.[1]

Watershed	Area (square miles)	Length (miles)			
		Natural[2] creek	Engineered[3]	Underground[4] culvert or storm drain	Total
Atherton Creek	8.9	3.61	4.67	22.44	30.72
Redwood Creek	11.8	8.42	4.04	25.02	37.49
Burlingame Creek	3.1	5.92	0.47	4.88	11.27
Sanchez Creek	1.8	3.32	0.78	2.92	7.03
Easton Creek	1.1	1.68	0.73	1.29	3.70
Mills Creek	1.6	1.66	0.73	2.30	4.68
Millbrae Creek	1.5	0.74	0.99	3.37	5.11

[1] Generated from data developed by WLA (2007).
[2] Creek channels designated natural are located in their historical location and have not been significantly modified.
[3] Engineered channels include both natural creeks significantly reinforced by concrete or rock, and artificial channels, ditches, and canals not coincident with a historical creek location.
[4] Culverts and storm drains that are 24-inches or greater in diameter.

2.1 Atherton Creek Watershed

The Atherton Creek watershed drains 8.9 square miles and the channel is highly modified (Table 1). Jurisdictions with the watershed are Atherton, Redwood City, Menlo Park, Woodside and San Mateo County. The creek flows in its historical position from its headwaters just west of Interstate 280 to Alameda de las Pulgas. Further downstream, the creek is highly modified and flows through a concrete channel to El Camino Real and then a combination of concrete channel and culvert to San Francisco Bay. There are several small tributary creeks that drain into Atherton Creek above Alameda de las Pulgas, but further downstream the drainage network is comprised of underground culverts or storm drains.

2.2 Redwood Creek Watershed

The Redwood Creek watershed is located directly north of the Atherton Creek watershed and drains 11.8 square miles. Parts of Redwood City, Woodside and San Mateo County are located within this watershed. The Redwood Creek drainage network is highly modified (Table 1). The creek is relatively unmodified and flows in its historical location from its headwaters just west of Interstate 280 to the east end of the Menlo

County Club golf course at Alameda de las Pulgas. Further downstream, the creek flows through a concrete channel to El Camino Real and then through an underground culvert to San Francisco Bay. Arroyo Ojo de Agua is the largest tributary and flows approximately 4.2 miles from it headwaters above Stulsaft Park to its confluence with Redwood Creek in downtown Redwood City. Similar to Redwood Creek, Arroyo Ojo de Agua is relatively unmodified upstream of Alameda de las Pulgas and hardened or culverted downstream of this road.

2.3 Burlingame Creek Watershed

Burlingame Creek watershed drains an area of 3.1 square miles within the jurisdictions of Hillsborough, Burlingame and small portion of the City of San Mateo. The creek has two major tributaries, Terrace and Ralston Creeks, which converge near a Caltrain crossing and further downstream enter an engineered channel. The creek eventually flows into San Francisco Bay near Coyote Point. All three channels are relatively unmodified upstream of El Camino Real; these sections total 3.3 miles in length (Table 1). Below the road, the channel is culverted or hardened down to the Bay. The upper portion of Terrace Creek flows through the Burlingame Country Club golf course.

2.4 Sanchez Creek Watershed

The Sanchez Creek watershed is located directly north of the Burlingame Creek watershed and drains 1.8 square miles. The watershed is entirely within the jurisdictions of Hillsborough and Burlingame. The channel is relatively unmodified for about 3.3 miles (Table 1) upstream of El Camino Real and culverted downstream to its confluence with the Burlingame Lagoon. The creek has one small tributary that flows to the north of the Burlingame Country Club golf course and empties into Sanchez Creek downstream of Redington Road.

2.5 Easton Creek Watershed

The jurisdictions within the Easton Creek watershed are Hillsborough, Burlingame and San Mateo County. Draining an area of 1.1 square miles, this is the smallest of the study watersheds. The creek forks into two small branches near the headwaters. Similar to neighboring creeks, the channel upstream of El Camino Real is relatively unmodified and about 1.7 miles in length (Table 1). Further downstream, the creek flows into a culvert down to the Caltrain crossing and then continues as an engineered canal to the Bay.

2.6 Mills Creek Watershed

The Mills Creek watershed drains 1.6 square miles and is located in Burlingame and San Mateo County. The creek is relatively unmodified upstream of El Camino Real and approximately 1.7 miles in length (Table 1). The creek has a major tributary that is culverted in the upper portion (i.e., above Martinez Drive) and then is relatively unmodified down to the confluence with the mainstem. The upper portion of the mainstem flows through Mills Canyon park. Downstream of El Camino Real, the creek becomes an engineered channel down to Shoreline Park and the Bay.

2.7 Millbrae Creek Watershed

The Millbrae Creek watershed drains 1.5 square miles and is located in Millbrae and Burlingame. The creek is culverted or hardened except for a 0.7-mile section upstream of Ashton Avenue.

3.0 METHODS

Instream habitat and riparian corridor conditions were evaluated during fall 2007 (before the rainy season) using the USA protocol. This creek walk protocol was developed and extensively tested by the Center for Watershed Protection (CWP 2005). The USA uses visual observations made during a continuous walk of the creek corridor to rapidly evaluate and systematically identify conditions, problems and opportunities for improvement within the urban creek corridor.

The USA protocol includes delineating the creek corridor into survey reaches. Each reach represents a relatively uniform set of conditions within the creek corridor. Factors that contribute to delineating a reach include land use in the immediate vicinity, elevation, creek order, access, and total length. In this study reaches were typically less than one mile long, began and ended at major creek crossings or grade changes, and reflected the general condition of the area adjacent to the creek.[1] Tributaries were generally treated as separate reaches unless they were considered too small to assess. Creek sections that were inaccessible (due to factors such as culverts or vegetation) and/or that had little apparent urban influence were not assessed.

A single overall assessment was conducted for each reach. The reach level assessment qualitatively evaluated characteristics such as base flow, dominant substrate, water clarity, biota, shading, and active channel dynamics. In addition, each reach was ranked for overall creek condition and overall buffer and floodplain condition based on eight subcategories: instream habitat, vegetative protection, bank erosion, floodplain connection, vegetated buffer width, floodplain vegetation, floodplain habitat, and floodplain encroachment. Each subcategory was given a score on a 20-point scale (in general, a score of zero to 5 is designated as poor condition, 6 to 10 is marginal, 11 to 15 is suboptimal and 16 to 20 is optimal). The subcategory scores were summed to give a total reach score ranging from zero to 160.

The USA protocol was also used to identify the locations and general characteristics of eight specific creek impacts (Table 2): erosion, channel modification, outfalls, creek crossings, trash/debris, recreation sites, utilities and miscellaneous features. Notable impacts occurring within each reach were recorded on separate field forms for each impact.

As a follow-up to this study and the previous USA creek walks conducted in fall 2006 (SMCWPPP 2007a), an additional protocol, the Urban Rapid Trash Assessment (URTA), was used to further characterize trash at selected trash/debris USA impact sites in the study watersheds with relatively high amounts of trash (SMCWPPP 2007b and 2008a).

For the purposes of this study, a few adjustments were made to the standard USA protocol. To increase efficiency in the field, streamlined versions of several impact

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[1] If the land use immediately surrounding the creek corridor changed from, for example, high density residential to protected forested open space, generally a new reach would be delineated at that point.

forms were used when less detailed data were needed. These versions are designed to provide an inventory of features that may have minor impacts on the creek resources, but are not deemed to require immediate attention. In addition, *impacted buffer* was not assessed given the high degree of urbanization in the study watersheds. Finally, a new impact assessment category was added to the protocol to evaluate the potential use of creeks for recreation. This study also added the use of a hip chain, in addition to a Global Positioning System (GPS) unit, to identify the location and extent of impacts within each reach. The hip chain had two benefits: 1) when the GPS unit failed to receive satellite information, location information could still be collected, and 2) it allowed for the collection of data at a finer spatial resolution.

Table 2. USA data types collected in the field. Adapted from CWP (2005).

ASSESSMENT FORM	FEATURES ASSESSED	INFORMATION COLLECTED (IN ADDITION TO GPS AND PHOTOGRAPHS)
Outfalls	All discharge pipes or channels. Water diversion pipes are also included in this category.	Basic type (private, municipal storm drain[2]), source, and condition. Characteristics of any discharge (e.g., approximate flow rate, discoloration, odor) are recorded. The presence of diversion pipes and whether they are pumping water is also noted.
Bank Erosion	Bank scour, bank and slope failure, head cuts, incision, and widening.	Location, any threat to property and basic bank measurements.
Utilities	Leaking or exposed utilities causing water quality, habitat, or channel stability problems.	Type, condition, location, and discharge characteristics associated with leaks, if present.
Channel Modification	Channelized, concrete or reinforced sections of creek.	Type of modification, length of creek impacted, condition of the modification.
Recreation[3]	Areas where there is evidence of people using the creek for recreation.	Evidence of access, evidence of recreational activity (e.g., rope swing over the creek).
Creek Crossings	All man-made or natural structures that cross the creek, such as roads, buildings, railroads, or dams.	Type of crossing and characteristics (e.g., hardened bottom, height, width), dimensions, relevant information if suspected fish barrier (i.e., 6-inch or greater water drop, or less than ½-inch water depth during normal flow).
Trash and Debris	Areas with relatively high amounts of trash and debris.	Amount, type and source of trash and land use type.
Miscellaneous	High quality areas or unusual features impacting the creek that do not fit under the other impact categories.	
Reach Level Assessment	Overall characteristics of each reach. Tracks locations of impacts.	Base flow, dominant substrate, water clarity, biota, shading, and active channel dynamics. Includes ranking of overall instream and floodplain habitat conditions.

[2]Municipal storm drains were generally assumed to be any pipe with a diameter greater than six inches, except for pipes that obviously originated from a private property.
[3]The original USA protocol does not include this impact. This study added recreation sites to the protocol to document potential recreational beneficial uses of the creek.

4.0 RESULTS

Thirty-seven reaches within 13 creek miles were assessed during this study. The following sections summarize the results of the assessments for each of the watersheds. Electronic files containing the complete study datasets are available upon request.

4.1 Atherton Creek Watershed

4.1.1 Reach Delineation

The USA was conducted in a continuous section of Atherton Creek between Alameda de las Pulgas and Valley Road, just downstream of Interstate 280. Areas not included in the study were the section of creek downstream of Alameda de las Pulgas, which is a continuously hardened channel down to San Francisco Bay, and a creek segment above Valley Road that flows through a privately owned horse boarding facility. The study area was approximately 1.5 miles in length and was delineated into five reaches (Table 3 and Figure 2). Reaches A1 – A3 are part of the mainstem and A4 and A5 were lower sections of tributaries; upper sections of these tributaries were culverts under homes. Reach A3 was downstream of a horse boarding facility and reaches A4 and A5 were downstream of a golf course. All five reaches flow through low-density residential land use within the City of Atherton.

Table 3. Reaches delineated in the Atherton Creek watershed.

Reach	Creek	Geographic Extent	Length (ft)	Reach description
A1	Atherton Creek	Alameda de las Pulgas to Reservoir Rd.	4,052	Channel bed continuously hardened; bank erosion where banks are not hardened; deeply incised with limited connected flood plain; stagnant pools along margin of creek.
A2	Atherton Creek	Reservoir Rd. to tributary confluence near Valley Rd.	2,093	Active channel incision with eroding banks; incision decreasing upstream; grade control structure protecting water supply pipeline; stagnant pools throughout reach.
A3	Atherton Creek	Confluence to Valley Rd (below horse ranch).	1,050	Channel deeply incised with eroding banks and stagnant water; channel dry above Valley Rd. at horse ranch.
A4	Tributary to Atherton Creek	Tributary confluence at Walsh Rd. and Meadow Ln. to culvert.	680	Tributary with natural channel runs along Meadow Lane; banks well vegetated; downstream horse boarding facility.
A5	Tributary to Atherton Creek	Tributary confluence to culvert at Valley Rd.	88	Tributary with modified channel and bank erosion below Valley Rd; downstream golf course.

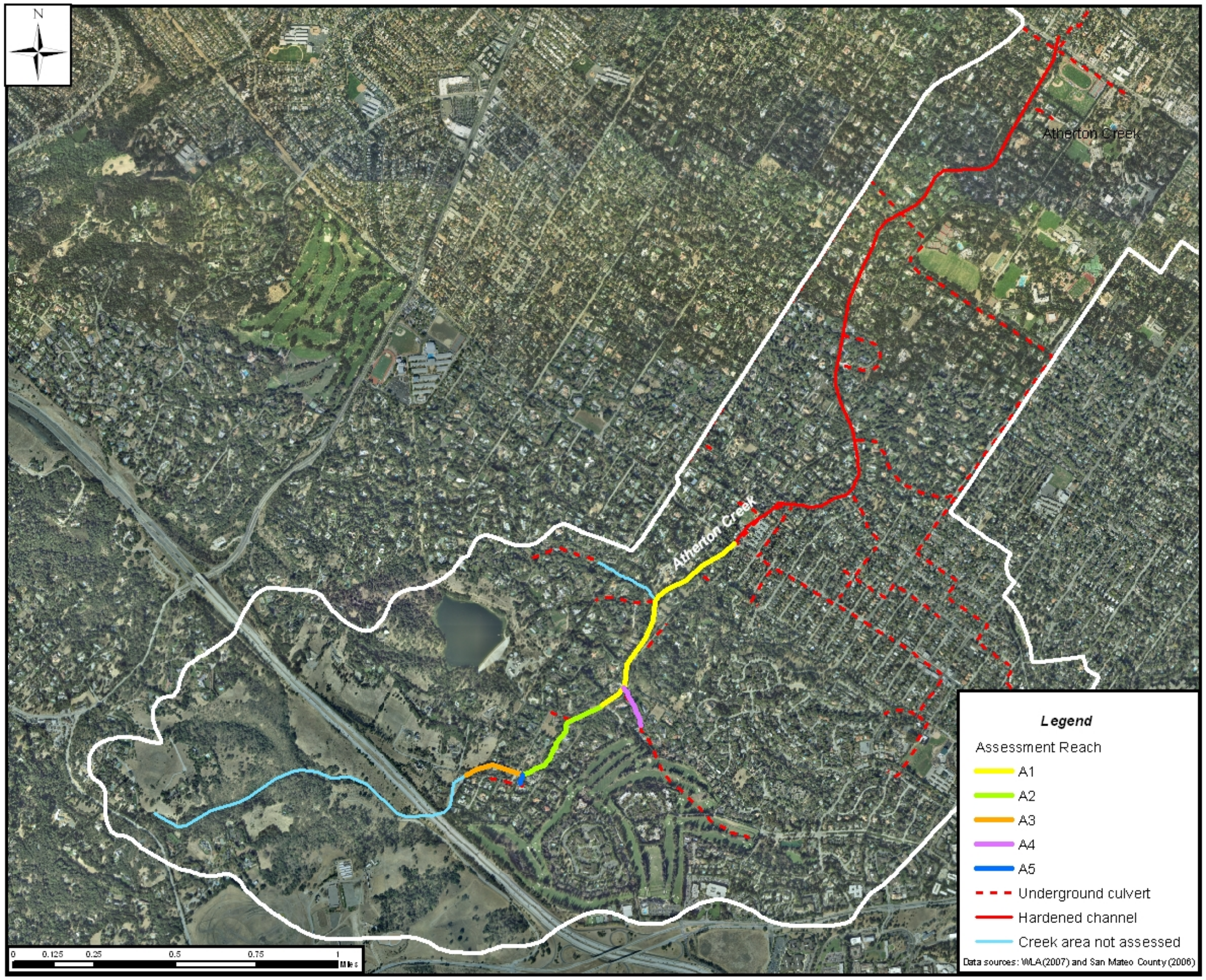


Figure 2. Creek reaches assessed in the Atherton Creek watershed.

4.1.2 Reach Assessment

Silt or clay was the dominant substrate observed in all of the reaches, with the exception of Reach A1, which had a predominantly concrete bed. Incised channel and active bank scour and failure were consistently observed throughout the mainstem reaches (Figure 3). Sediment deposition on the channel bed was also evident throughout the reaches except in Reach A1.

Figure 3. Bank erosion occurring on unprotected banks in Atherton Creek.

All five reaches had consistently wetted channel; however, the three mainstem reaches (A1 – A3) consisted of primarily stagnant pools. The channel bed consisted of fine substrate that released a sulfur-like odor when disturbed, which may be an indication of the presence of anaerobic microorganisms. The water in the channel was typically brown or black in color and turbid. Fish were observed in one pool in the upper end of Reach A1, including several large carp and school of smaller fish, possibly native stickleback. The reaches were estimated to have 50% - 75% canopy cover.

Total reach assessment scores for the mainstem reaches ranged from 31 to 39 out of a possible score of 160. Tributary reaches A4 and A5 had higher scores of 116 and 48, respectively (Table 4 and Figure 4).

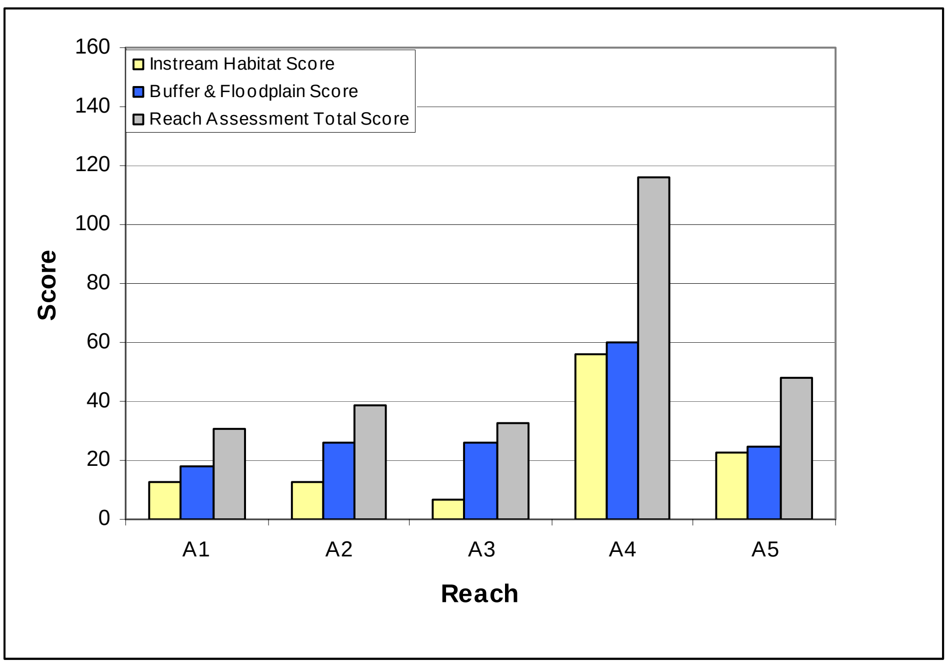
Poor instream habitat condition resulted from homogenous habitat with low complexity, frequent bank erosion, limited vegetative cover on banks and no or limited flood plain connection. Poor riparian buffer condition was caused by limited floodplain habitat and encroachment (primarily from bank armoring); however, buffer width scores were moderate due to large distances between residential structures and the top of the bank.

Table 4. Reach assessment scores in the Atherton Creek watershed.

	A1	A2	A3	A4	A5
Overall Reach Condition					
Instream Habitat	0	2	1	8	2
Vegetative Protection: LB	1	2	1	8	3
Vegetative Protection: RB	1	2	1	8	3
Bank Erosion: LB	3	2	1	8	4
Bank Erosion: RB	3	2	1	8	4
Floodplain Connection	5	3	2	16	7
Subtotal	***13***	***13***	***7***	***56***	***23***
Overall Buffer and Floodplain Condition					
Vegetated Buffer Width: LB	8	7	4	7	3
Vegetated Buffer Width: RB	8	7	5	7	4
Floodplain Vegetation	0	4	4	15	8
Floodplain Habitat	0	4	4	15	6
Floodplain Encroachment: LB	1	2	4	8	2
Floodplain Encroachment: RB	1	2	5	8	2
Subtotal	***18***	***26***	***26***	***60***	***25***
Total	***31***	***39***	***33***	***116***	***48***

LB – Left Bank, RB – Right Bank.

Figure 4. Reach assessment scores in Atherton Creek watershed.



4.1.3 Impact Assessment

The type and location of impacts documented in Atherton Creek are shown in Figure 5. Summary information on the impacts is shown by reach in Table 5.

Table 5. Summary of impacts in the Atherton Creek watershed.

	A1	A2	A3	A4	A5
Total Length of Reach	4,052	2,093	1,050	680	88
Channel Modification (ft)					
Culverted	172	0	20	50	0
Armored bed or bank	3,020	853	373	5	43
Total length modified	3,192	853	393	55	43
Percent of reach modified	79	41	37	8	49
Total number of drop structures	0	1	1	1	1
Erosion					
Total length eroded (ft)	2,795	1,510	554	0	45
Percent of reach eroded	69	72	53	0	51
Outfalls and tributaries					
> 6 inches	11	4	1	4	1
$\leq$ 6 inches	2	2	0	0	0
Tributary confluence	3	2	0	0	0
Diversion pipe	0	0	0	0	0
Creek crossings					
Road	3	0	0	1	0
Driveway/house	2	0	2	0	0
Utilities	5	3	2	0	0
Trash sites	0	1	0	0	0
Recreation sites	0	0	0	0	0

Atherton Creek is highly modified, with about 4,536 feet of armored bed and/or banks, equaling about 57% of the total length assessed. Reach A1 had the greatest proportion of modified channel (79%) primarily due to a continuous length of hardened channel bed from Alameda de las Pulgas to Reservoir Road. Reaches A2, A3 and A5 were also significantly modified, with 41%, 37% and 49% of the total reach length modified, respectively. Bank revetments were typically constructed of sacrete walls (i.e., stacked bags of hardened concrete). A concrete drop structure was documented in each reach except Reach A1. Reach A2 had the largest drop structure; this grade control structure protects a water supply pipeline that crosses the creek immediately above it (Figure 6).

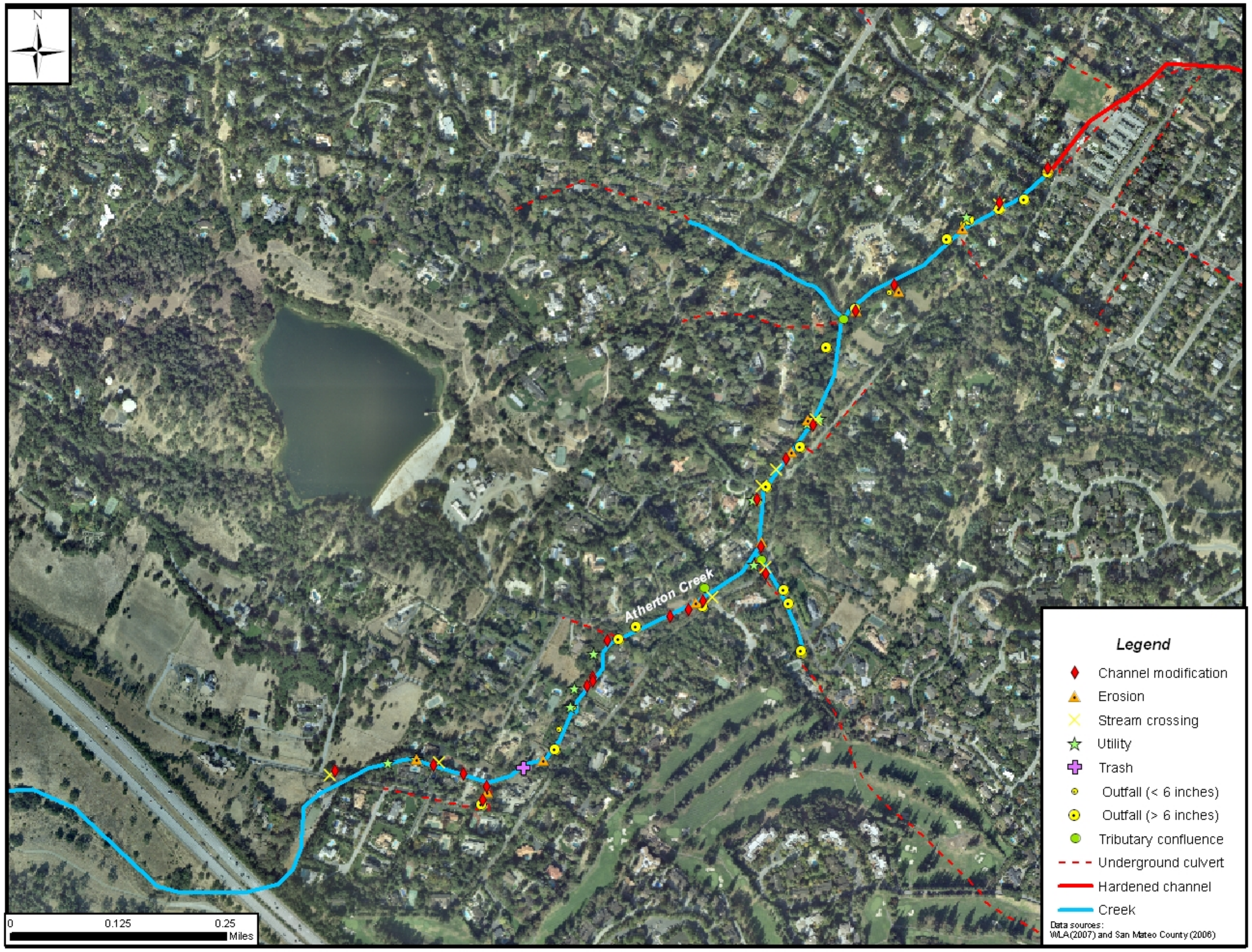


Figure 5. Impacts in the Atherton Creek watershed.

Bank erosion was pervasive in all the reaches, ranging from 51 to 72% of the total reach length, with the exception of Reach A4, which had no erosion impacts (Table 5). Erosion impacts were predominately associated with bank scour and failure due to steep and un-vegetated banks and highly incised channel. Bank scour was frequent at meander bends and adjacent to bank revetment structures. Channel incision was estimated between 4 to 6 feet in depth, with the deepest incision occurring in Reach A2. A 4-foot deep head cut was observed in Reach A2, which indicates that the channel may still be actively incising. Channel incision was greatly reduced upstream of the grade control structure (Figure 6) in Reach A2.

Figure 6. Grade control structure protecting a water supply pipeline in Atherton Creek.

A total of 25 outfalls were documented in all five reaches, with about 85% of the total being larger than 6 inches in diameter. There were four tributary confluences; two of the tributaries were assessed (reaches A4 and A5). There was one outfall discharge that was reported to a municipal illicit discharge coordinator. An outfall in Reach A1 was observed to discharge a high volume of turbid water onto an unprotected bank causing fine sediment deposition in the channel. The source of the discharge appeared to be a private residence that was draining a pool or water fountain. The remaining outfalls had either no flow (30% of total) or no unusual odors or colors in the discharge. Bank erosion was documented at two outfalls located in Reach A1 and A2.

Eight creek crossings were observed in this watershed, five of which were in Reach A1 (Table 5). Six of the crossings were culverts and the remaining two consisted of hardened banks under a bridge. Crossings were a combination of roads and private driveways. None of the crossings had vertical drops that would appear to impede fish passage. There were 10 utilities documented in the watershed, consisting of 1” – 10” diameter pipes crossing over the channel. None of the utilities appeared to cause bank erosion or otherwise impact the creek.

There was only one trash site observed in this watershed, located at the upper end of Reach A2. At this site plastic and Styrofoam debris accumulated in a stagnant pool that formed upstream of vegetation growing in the creek.

Recreation sites were not observed in this watershed.

4.2 Redwood Creek watershed

4.2.1 Reach Delineation

The USA was conducted in a continuous section of Redwood Creek between Alameda de las Pulgas and 0.25 mile upstream of Interstate 280 and in Arroyo Ojo de Agua, a tributary to Redwood Creek, between Alameda de las Pulgas and Bret Harte Road. The sections of both creeks downstream of Alameda de las Pulgas were not assessed due to highly modified channel (i.e., continuously hardened or culverted to the Bay). The section of Redwood Creek above the study area had relatively natural channel and was not assessed due to the lack of apparent impacts from urbanization.

The study area was approximately 2.4 miles in total length and was delineated into seven reaches (Table 6). Reaches RW1 – RW4 are located in Redwood Creek and reaches OA1 – OA3 are located in Arroyo Ojo de Agua (Figure 7). A golf course surrounds Reach RW1. RW2 – RW4 flow through low-density residential areas. Reach OA1 is in an area of high-density residential land use, reach OA2 is in Stulsaft City Park and reach OA3 flows through undeveloped vacant land.

Table 6. Reaches delineated in the Redwood Creek watershed.

Reach	Creek	Geographic Extent	Length (ft)	Notes
RW1	Redwood Creek	Alameda de las Pulgas to bridge at Menlo Country Club entrance.	2,989	Deeply incised channel with eroding banks; heavy sediment deposition; open canopy, lack of bank vegetation; entirely within golf course; channel bed and banks littered with golf balls.
RW2	Redwood Creek	Menlo Country Club to outfall at power station.	2,790	Incised channel with eroding banks; banks somewhat stabilized by riparian vegetation; minimal buffer to residential land use.
RW3	Redwood Creek	Outfall at power station to upstream end of I-280 culvert.	1,367	Channel is highly modified in upper section adjacent to power station (i.e., armored) and Interstate 280 (culvert); lower portion of reach is relatively natural; trash below I-280.
RW4	Redwood Creek	Upstream end of I-280 culvert to end of development.	1,266	Bank erosion at meander bends and along private roadway; sediment deposition below tributary confluence; naturally vegetated banks.
OA1	Arroyo Ojo de Agua	Alameda de las Pulgas to eastern end of Stulsaft Park.	1,413	Highly modified channel (i.e., bank hardening); water diversions very common; supports native fish community.
OA2	Arroyo Ojo de Agua	Downstream end of Stulsaft Park to culvert at end of Chatham Court.	2,906	Bank erosion throughout city park; series of grade control structures, possibly for historic road crossings; high public use impacting vegetation on banks.
OA3	Arroyo Ojo de Agua	Upper end of culvert at Farm Hill Road to Bret Harte Drive.	933	Upper portion is relatively natural and unmodified; lower portion is culverted and hardened; channel has steep gradient that is protected with dense riparian vegetation.

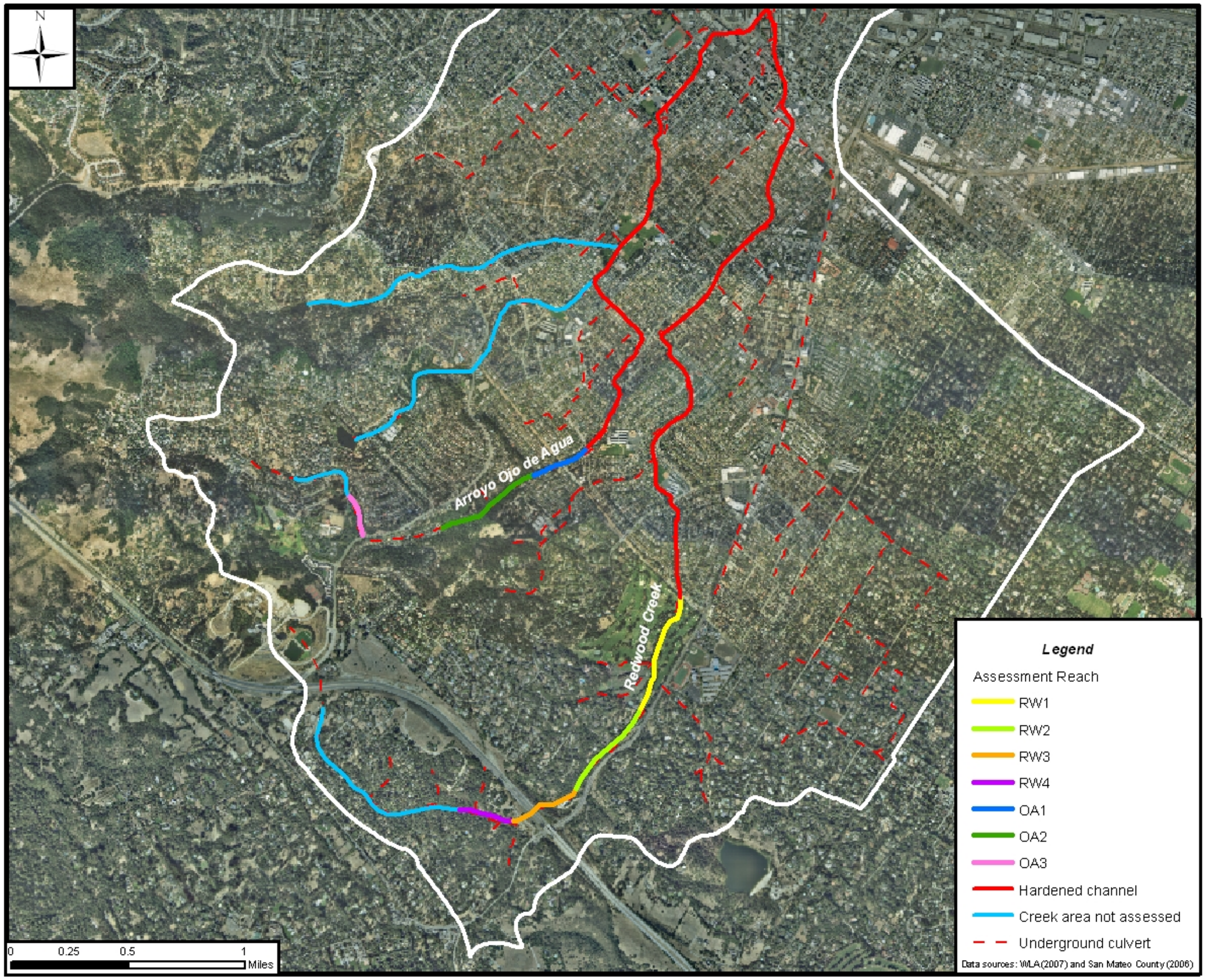


Figure 7. Creek reaches assessed in the Redwood Creek watershed.

4.2.2 Reach Assessment

The dominant substrate was sand or gravel in the study reaches in Redwood Creek and gravel or cobble in the reaches in Arroyo Ojo de Agua. Active bank scour, bank failure and fine sediment deposition were the active channel dynamics observed in Redwood Creek below I-280 and the portion of Arroyo Ojo de Agua within Stulstaft Park.

All seven reaches had consistently wetted channel, although Redwood Creek was typically stagnant with a black mud substrate in some locations that released a sulfur-like odor when disturbed, which may be an indication of the presence of anaerobic microorganisms. No fish were observed in Redwood Creek. Arroyo Ojo de Agua had clear flowing water that supported a native fish community up through Stulsaft Park (e.g., 2-3 species of fish were observed in one pool in Reach OA1). Canopy cover was good (>75% shaded) in all reaches, except for Reach RW1 in the golf course (about 50% shaded). Both attached and floating algae were observed in RW1.

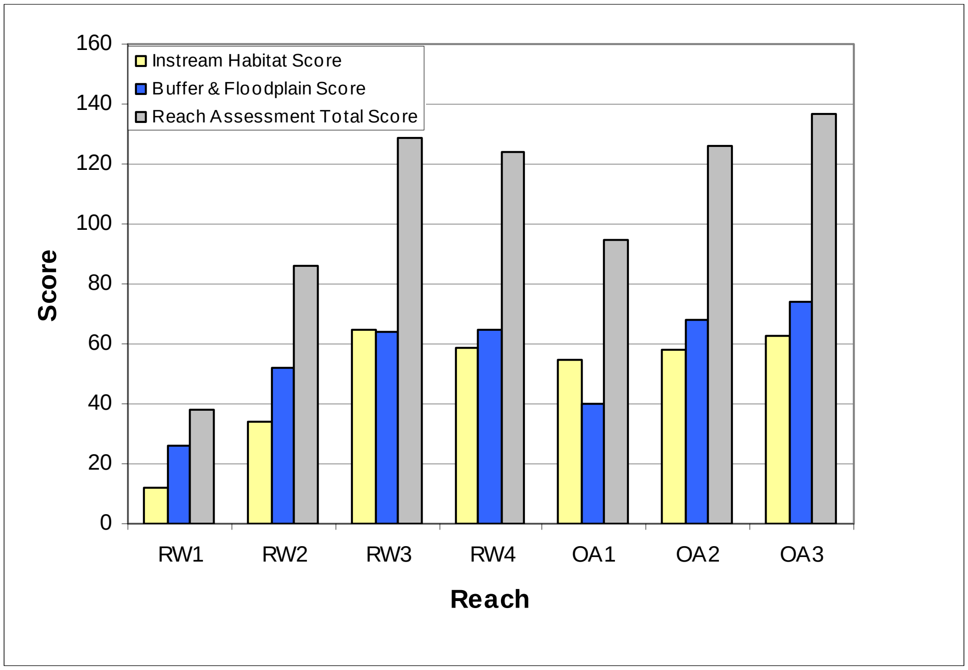
Total reach assessment scores ranged from 38 to 129 for Redwood Creek and 95 to 137 for Arroyo Ojo de Agua, with scores increasing in the upstream direction (Table 7 and Figure 8).

Table 7. Reach assessment scores in the Redwood Creek watershed.

	RW1	RW2	RW3	RW4	OA1	OA2	OA3
Overall Reach Condition							
Instream Habitat	4	9	12	11	12	15	15
Vegetative Protection: LB	2	4	9	8	6	9	8
Vegetative Protection: RB	2	4	9	8	6	8	8
Bank Erosion: LB	1	3	9	8	9	5	8
Bank Erosion: RB	1	3	9	8	9	5	8
Floodplain Connection	2	11	17	16	13	16	16
Subtotal	***12***	***34***	***65***	***59***	***55***	***58***	***63***
Overall Buffer and Floodplain Condition							
Vegetated Buffer Width: LB	3	7	9	9	4	10	10
Vegetated Buffer Width: RB	3	7	9	8	4	10	10
Floodplain Vegetation	7	12	16	16	11	16	18
Floodplain Habitat	7	12	16	16	11	16	18
Floodplain Encroachment: LB	3	7	7	8	5	8	9
Floodplain Encroachment: RB	3	7	7	8	5	8	9
Subtotal	***26***	***52***	***64***	***65***	***40***	***68***	***74***
Total	***38***	***86***	***129***	***124***	***95***	***126***	***137***

LB – Left Bank, RB – Right Bank.

Figure 8. Reach assessment scores in the Redwood Creek watershed.



4.2.3 Impact Assessment

The type and location of impacts observed in Redwood Creek are shown in Figure 9. Summary information on the impacts is shown by reach in Table 8.

The upper section of Redwood Creek (i.e., above Alameda de las Pulgas) was moderately modified, with about 3,900 feet of armored or culverted channel, equaling about 29% of the total length assessed. Reaches RW3 and OA1 had the greatest proportion of modified channel, 72% and 64%, respectively. Channel modification in Reach RW3 consisted of a long culverted section under Interstate 280 with armored bed and banks downstream of the culvert. Channel armoring in Reach OA1 was primarily sacrete and concrete walls constructed to protect private homes and yards. In addition, there were nine concrete drop structures observed in this watershed.

The most extensive bank erosion occurred in reaches RW1, RW2 and OA2, ranging from 75 – 92% of the total reach length. These reaches were also the least modified. Erosion impacts were predominately associated with bank scour and failure due to highly incised channel with steep and un-vegetated banks. Channel incision was estimated between 6 to 8 feet in depth in Reaches RW1 and RW2. Old landslide scars were observed at two locations in Stulstaft Park (Reach OA2).

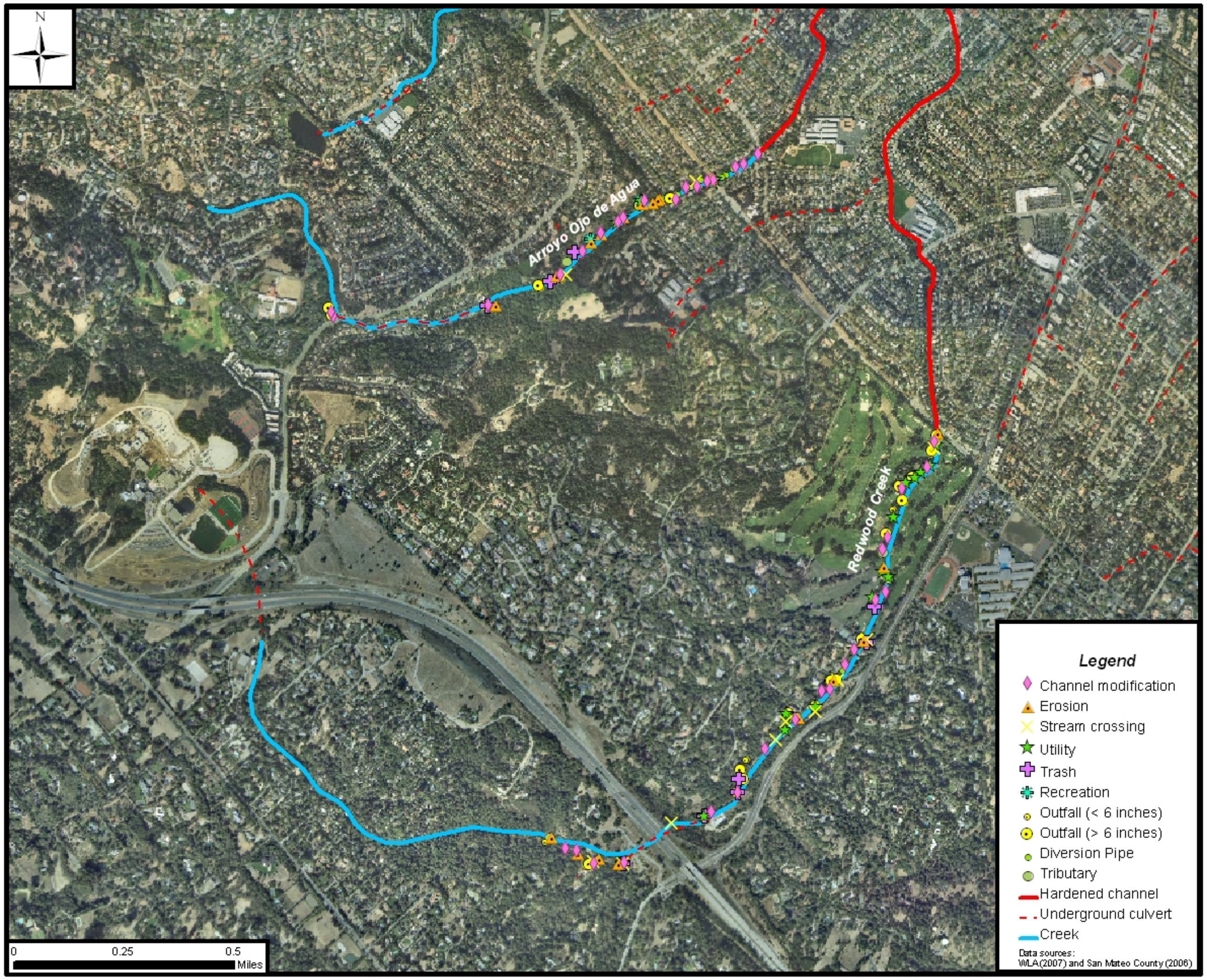


Figure 9. Impacts in the Redwood Creek watershed.

Table 8. Summary of impacts in the Redwood Creek watershed.

	RW1	RW2	RW3	RW4	OA1	OA2	OA3
Total Length of Reach	2,989	2,790	1,367	1,266	1,413	2,906	933
Channel Modification (ft)							
Culverted	217	301	715	0	63	37	177
Armored bed or bank	462	225	265	143	845	367	83
Total length modified	679	526	980	143	908	404	260
Percent of reach modified	23	19	72	11	64	14	28
Total drop structures	2	3	0	0	1	3	0
Erosion							
Total length eroded (ft)	2,757	2,480	0	395	52	2,184	0
Percent of reach eroded	92	89	0	31	4	75	0
Outfalls and tributaries							
> 6 inches	6	9	0	2	1	4	2
≤ 6 inches	1	2	0	1	0	0	0
Tributary confluence	2	0	0	2	0	2	0
Diversion pipe	1	2	0	0	12	0	0
Creek crossings							
Road	2	1	1	2	1	1	0
Driveway/house	0	3	0	0	0	0	0
Utilities	9	5	1	1	2	3	0
Trash sites	2	2	1	1	0	3	0
Recreation sites	0	0	0	0	0	2	0

A total of 28 outfalls were documented in the watershed, with about 85% of the total larger than 6 inches in diameter. There were also six tributary confluences, none of which was assessed due to small size. There were 15 diversion pipes (1-2 inches in diameter) observed in the watershed; 12 were in Reach OA1. The remaining outfalls had either no flow (67% total) or trickle flow (30%) with no unusual odors or colors in the discharge. One storm drain outfall located in Reach RW1 was damaged and its discharge was causing bank erosion (Figure 10). The discharge from another outfall in Reach RW1 was tinted green and turbid and caused reduced water clarity in the creek. This discharge was reported to the municipal illicit discharge coordinator.

Figure 10. Damaged outfall causing bank erosion in Redwood Creek.

There were 11 road crossings observed in this watershed, four of which were in Reach RW2. Eight of the crossings were modified, seven with culverts and one with concrete blocks. Road crossings in Reaches OA1 and OA2 had 1-2 vertical drops and shallow flow through the culvert, both conditions potentially impeding upstream passage of native fishes. There was a deep pool with large school of fish observed below the culvert in OA1 (Figure 11).

Figure 11. Culvert that may impede upstream fish passage In Arroyo Ojo de Agua.

There were 21 utilities observed in this watershed, with nine occurring in Reach RW1. Most of these utilities consisted of pipes crossing over the channel without any apparent impact to the creek; however, some pipes were located directly in the channel and causing erosion. There was a leaky pipe originating from the top of the bank in Reach RW2 that was suspected to be a broken water pipe. The resultant flow was causing bank erosion and sedimentation into the channel. This impact was reported to municipal staff.

There were nine trash sites identified in this watershed, with six occurring in Redwood Creek. One site in RW1 was located at the downstream end of a golf course; golf balls were observed scattered throughout the channel. Another site in RW3 contained a high accumulation of litter (e.g., plastic and Styrofoam) that was trapped in vegetation just below Interstate 280. There were three trash sites with litter in Reach OA2 in Stulsaft Park.

There were two potential recreation sites documented in Stulsaft Park (Reach OA2). These sites both had rope swings over the channel. At the time of the assessment there were no pools at either of these sites and the depth of water was less than six inches. There was good public access to the creek with trails along the banks that crossed the creek in several locations. There were also several picnic areas close to creek.

Two large patches of *Arrundo donax* in Stulsaft Park were identified as a miscellaneous impact within Ojo de Agua (Figure 12). *Arrundo* is a non-native plant that has invaded creeks in San Francisco Bay region. The plant typically grows directly within the channel, and once fully established, can dramatically change channel dynamics.

4.3 Burlingame Creek Watershed

4.3.1 Reach Delineation

Figure 12. Invasive plant species *Arrundo donax* growing in Arroyo Ojo de Agua.

The USA was conducted in Burlingame Creek, Ralston Creek and Terrace Creek, all of which are located within the Burlingame Creek watershed. The study area included continuous creek channels upstream of El Camino Real and Occidental Road. Downstream of the assessment area, the creeks have been culverted continuously to the Bay. Burlingame Creek was not assessed upstream of Hillsborough Road due to an apparent lack of urban impacts to the channel. Ralston Creek and a tributary were assessed in the upstream direction until no longer accessible due to impassable culverts. Terrace Creek was assessed upstream to a golf course, where the creek channel was modified into a ditch.

The study area was approximately 3.8 miles in total length and was delineated into eleven reaches (Table 9 and Figure 13). Reaches B1 - B3 were delineated in Burlingame Creek, which flows through a low-density residential area. Reaches T1 – T2 were delineated in Terrace Creek, within low-density residential land use and directly below and adjacent to golf course. Reaches R1 – R4 were delineated in Ralston Creek within low-density residential land use and adjacent to a high school. Reaches R5 – R6 were delineated in a tributary to Ralston Creek within low-density residential land use.

4.3.2 Reach Assessment

The dominant substrate was sand in the Terrace Creek and Ralston Creek reaches and gravel in the Burlingame Creek reaches. Channelization, bank scour and fine sediment deposition were the active channel dynamics observed for the majority of reaches. Active bank failure was also observed in the upper reaches of Burlingame and Ralston Creeks. The most commonly noted impact to reaches was extensive bank hardening and culverting.

All of the study reaches were flowing at the time of the assessment indicating that perennial flow is likely, with the exception of T1, which was dry. The native fish threespine stickleback was observed in all three reaches of Burlingame Creek and the lower reach of the tributary to Ralston Creek (R5). One salamander was also observed in reach B1. Canopy cover was generally moderate (50 - 75% shaded), except for the upper reaches in Burlingame and Terrace Creeks, which had more cover (> 75% shaded).

Total reach assessment scores ranged from 37 to 102, with Reaches R2 and B3 receiving the lowest and highest scores, respectively (Table 10). Reaches in Terrace and Ralston Creek had little variation in assessment scores, ranging from 37 – 65 (Figure 14). These reaches all had narrow buffer widths, impacted flood plain and poor habitat conditions. Reach assessment scores in Burlingame Creek generally increased with elevation.

Table 9. Reaches delineated in the Burlingame Creek watershed.

Reach	Creek	Geographic Extent	Length (ft)	Notes
B1	Burlingame Creek	El Camino Real to Barroilet Rd.	2,323	Continuously hardened banks on both sides and long culvert sections below roadways; bank scour at bends or failing revetments; narrow riparian buffer area; increasing sinuosity above Occidental Rd.
B2	Burlingame Creek	Barroilet Rd. to storm drain outfall near Bromfield Rd.	1,695	Bank armoring at meander bends; bank scour typically above or below revetments; more flood plain connection; moderate riparian buffer width with structures impacting flood plain.
B3	Burlingame Creek	Storm drain outfall to Hillsborough Rd.	2,714	Bank armoring at meander bends; bank scour typically above or below revetments; few connections to flood plain; moderate riparian buffer width with structures impacting flood plain; fine sediment deposition in pools.
T1	Terrace Creek	El Camino Real to Sharon Dr.	1,755	Below Newell Road the creek is channelized and hardened; poorly vegetated and narrow buffer; above Newell the creek is less modified, but entrenched with eroding banks (in Redwood Grove).
T2	Terrace Creek	Sharon Rd. to Eucalyptus Rd.	1,305	Continuously hardened or culverted; buffer impacted by road (Brookvale) and homes; reach ends at golf course.
R1	Ralston Creek	Occidental to tributary confluence near Pepper Rd.	1,445	Continuously hardened or culverted; buffer significantly impacted by homes; banks covered in ivy, limited canopy cover.
R2	Ralston Creek	Tributary confluence to Hillsborough Rd.	1,012	Continuously hardened or culverted; buffer significantly impacted by homes and roadway; banks covered in ivy, limited canopy cover.
R3	Ralston Creek	Hillsborough Rd. to Ralston Rd.	2,044	Channel incision and sediment deposition in lower end; channelized and culverted in upper end; buffer significantly impacted by homes and roadway; banks covered in ivy; limited canopy cover.
R4	Ralston Creek	Ralston Rd. to Homer Place	2,225	Channelized and culverted; incised and eroding in sections not modified; buffer impacted by homes (right bank) and roadway (left bank); riparian vegetation predominantly non-native plants and trees.
R5	Tributary to Ralston Creek	Confluence to Hillsborough Rd.	1,762	Channelized, hardened and culverted; buffer impacted by homes and roadway; riparian vegetation is mostly non-native plants and trees.
R6	Tributary to Ralston Creek	Hillsborough Rd. to Eucalyptus Rd.	1,588	Channel incised with steep banks, bank erosion common where channel was not hardened or culverted; buffer widths greater than previous reach, but flood plain impacted by structures.

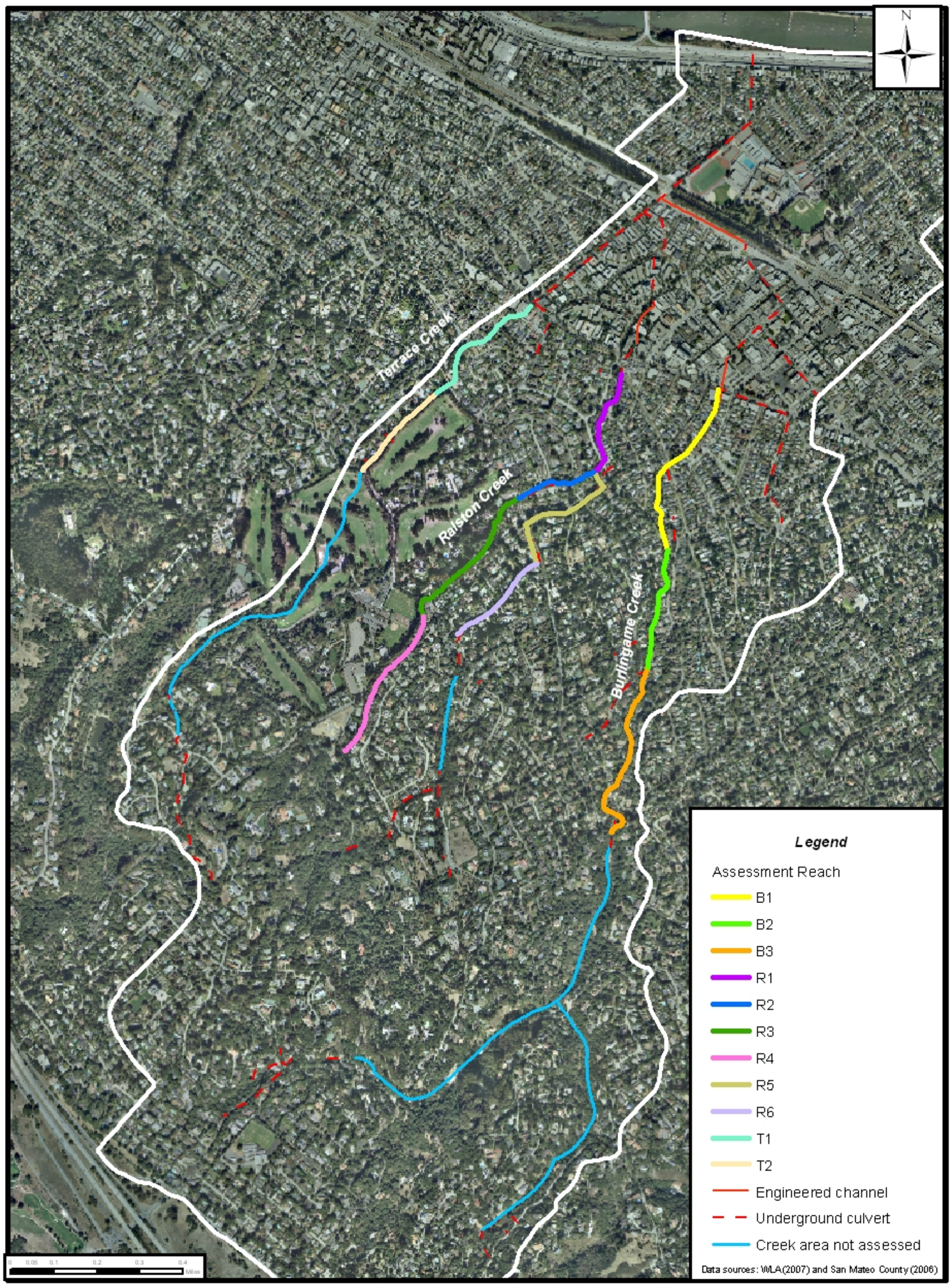


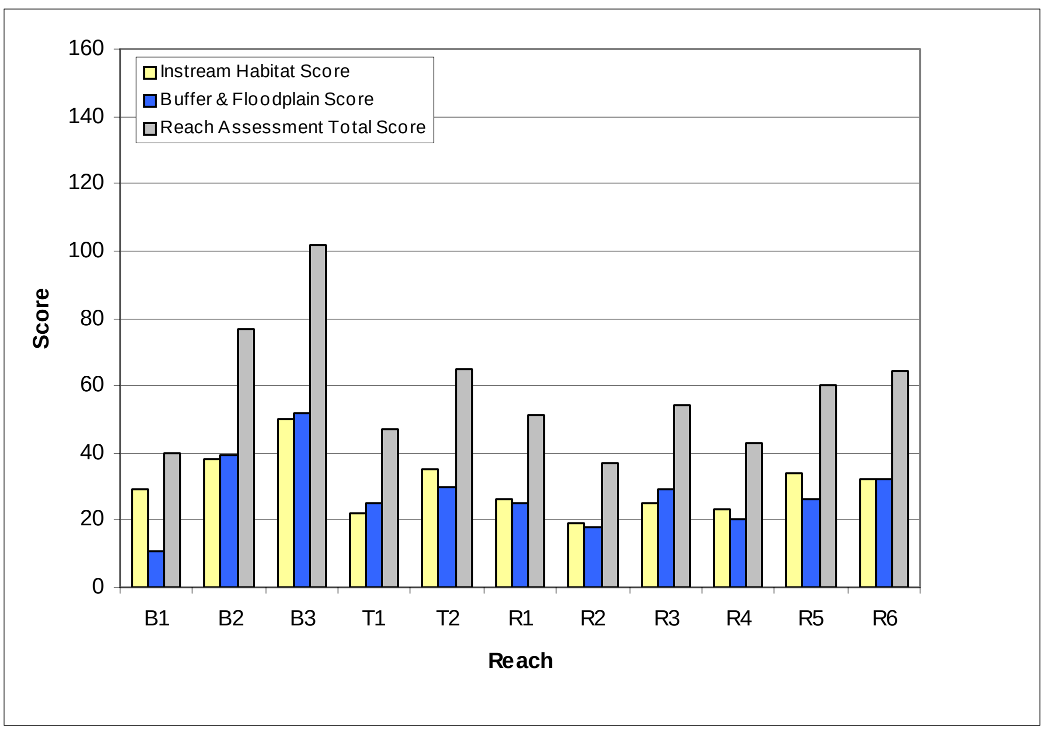
Figure 13. Creek reaches assessed in Burlingame Creek watershed.

Table 10. Reach assessment scores in the Burlingame Creek watershed.

	B1	B2	B3	T1	T2	R1	R2	R3	R4	R5	R6
Overall Reach Condition											
Instream Habitat	5	8	10	2	3	3	1	2	3	5	8
Vegetative Protection: LB	2	5	6	3	5	3	2	2	3	2	3
Vegetative Protection: RB	2	5	6	3	5	3	2	2	2	3	3
Bank Erosion: LB	7	3	7	4	7	4	3	5	4	6	4
Bank Erosion: RB	6	3	6	4	7	6	3	5	4	8	4
Floodplain Connection	7	14	15	6	8	7	8	9	7	10	10
Subtotal	***29***	***38***	***50***	***22***	***35***	***26***	***19***	***25***	***23***	***34***	***32***
Overall Buffer and Floodplain Condition											
Vegetated Buffer Width: LB	2	5	7	3	4	3	3	5	4	4	5
Vegetated Buffer Width: RB	2	5	7	3	3	3	3	5	2	4	5
Floodplain Vegetation	3	10	12	6	8	6	4	6	3	6	8
Floodplain Habitat	2	9	12	5	7	6	4	5	3	6	6
Floodplain Encroachment: LB	1	5	7	4	4	4	2	4	5	3	4
Floodplain Encroachment: RB	1	5	7	4	4	3	2	4	3	3	4
Subtotal	***11***	***39***	***52***	***25***	***30***	***25***	***18***	***29***	***20***	***26***	***32***
Total	***40***	***77***	***102***	***47***	***65***	***51***	***37***	***54***	***43***	***60***	***64***

LB – Left Bank, RB – Right Bank.

Figure 14. Reach assessment scores in Burlingame Creek watershed.



4.3.3 Impact Assessment

The type and location of impacts documented in Burlingame Creek are shown in Figure 15. Summary information on the impacts is shown by reach in Table 11.

Table 11. Summary of impacts in the Burlingame Creek watershed.

	B1	B2	B3	T1	T2	R1	R2	R3	R4	R5	R6
Total Length of Reach	2,323	1,695	2,714	1,755	1,305	1,445	1,012	2,044	2,225	1,762	1,588
Channel Modification											
Culverted	565	87	85	560	820	235	366	373	584	909	304
Armored bed or bank	1,624	1,075	1,422	650	267	453	387	356	498	786	300
Total length modified (ft)	2,189	1,162	1,507	1,210	1,087	688	753	729	1,082	1,695	604
Percent reach modified	94	69	56	69	83	48	74	36	49	96	38
Total drop structures	1	3	5	1	0	0	0	5	4	2	2
Erosion											
Total length eroded (ft)	111	379	386	520	35	170	100	284	949	127	467
Percent of reach eroded	5	22	14	30	3	12	10	14	43	7	29
Outfalls and tributaries											
> 6 inches	0	1	3	3	2	3	1	4	3	2	0
≤ 6 inches	2	0	0	2	1	2	2	1	8	0	1
Tributary confluence	0	0	0	0	0	1	0	0	0	0	0
Diversion pipe	1	0	0	0	0	0	0	0	0	0	0
Creek crossings											
Road	3	2	1	3	1	1	1	2	0	4	2
Driveway/house	0	1	1	0	2	5	2	5	0	4	2
Utilities	0	3	8	0	3	2	3	6	4	1	0
Trash sites	0	0	0	2	0	0	0	1	1	0	0
Recreation sites	0	0	0	0	0	0	0	0	0	0	0

The assessment reaches were highly modified, with about 12,706 feet of armored or culverted channel, equaling about 64% of the total length assessed. Reaches R5 and B1 had the greatest proportion of modified channel, 96% and 94%, respectively. The lowest proportion of modification (36%) occurred in Reach R3. About 40% of the total modified length was culverted sections of creek. Over 500 feet of culvert built under yards of private residences occurred in Reach R4, accounting for over 50% of the total reach length (Figure 16).

Figure 16. One of several culverts built under residences along Ralston creek.

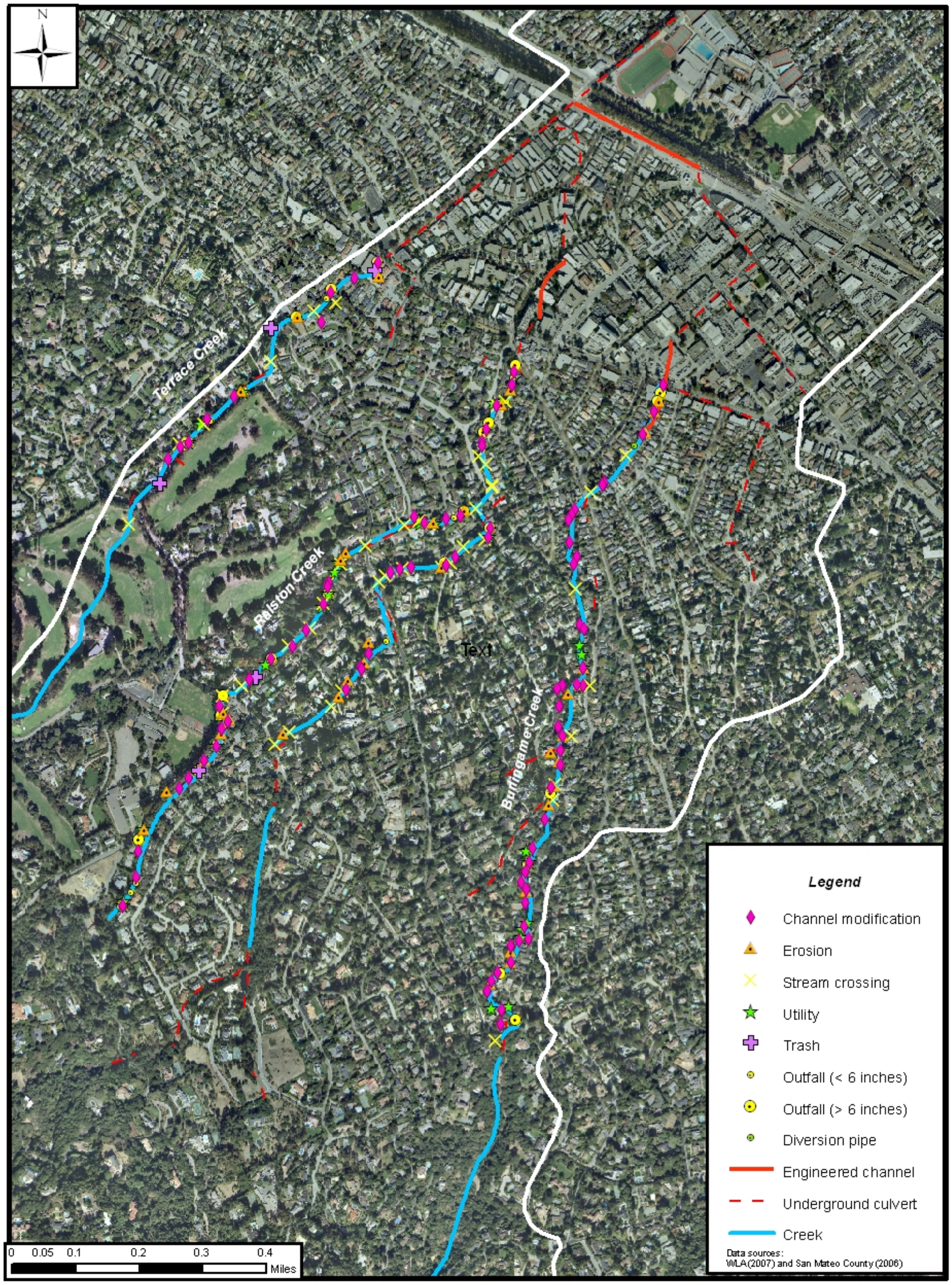


Figure 15. Impacts in the Burlingame Creek watershed.

Channel armoring materials observed throughout this watershed were primarily concrete and rock walls constructed to protect private homes and yards. In addition, there were 23 concrete drop structures observed in this watershed, occurring primarily in Ralston Creek (13) and Burlingame Creek (9).

A total of 3,548 feet of bank erosion was documented in this watershed, equaling about 18% of the total length of creek that was assessed. The highest proportion of erosion occurred in Reaches R4 and T1, 43% and 30%, respectively. Erosion impacts were predominately associated with bank scour at failing revetments and bank failure due to highly incised channel with steep and un-vegetated banks. Channel incision was most extensive in Reaches R4, R6 and T1 and was estimated between 2 to 4 feet in depth. One site in Reach B3 had both bank erosion along a meander bend and unprotected, loose soils on the hillside above the channel (Figure 17). There were newly constructed homes at the top of the hill resulting in potential surface erosion from exposed soil down to the creek.

Figure 17. Surface erosion below construction site along Burlingame Creek.

A total of 41 outfalls were observed in this watershed, with about 50% of the total being larger than 6 inches in diameter. Illicit discharges were not observed during the assessment. Approximately 70% of the outfalls had no flow, 17% trickle flow, and 12% moderate flow. Bank erosion was observed below an energy dissipater of an outfall in Reach R4.

There were 42 road crossings observed in this watershed, with 22 crossings associated with homes, driveways or yards and 20 crossings associated with roadways. Culverts and bank armoring were associated with 28 and 11 creek crossings, respectively. The longest creek crossings occurred under a combination of roadway and adjacent homes in Reaches R5 (540 feet), R2 (366 feet) and T1 (360 feet). There were 30 utilities observed in this watershed, with 15 occurring in Ralston Creek. Most of these utilities consisted of pipes crossing over the channel without any apparent impact to the creek.

There were four trash sites observed in this watershed, with two sites occurring in Terrace Creek and two sites in Ralston Creek. One of the trash sites occurred in Reach T1 where trash accumulated in a concrete channel above El Camino Real. Sources appeared to be a combination of accumulation from upstream locations and wind blown trash from a dumpster located next to the creek. Another trash site in Reach R3 had a 6'-8' high and 100-foot long pile of yard waste dumped along the creek bank (Figure 18). The remaining sites were associated with littering from a high school (Reach R4) and discarding yard waste behind a residence (R3).

Figure 18. Large pile of yard waste along creek bank in Ralston Creek.

4.4 Sanchez Creek watershed

4.4.1 Reach Delineation

The USA was conducted in Sanchez Creek between El Camino Real and Skyfarm Road. A small section of a tributary to Sanchez Creek below Skyfarm Road was also assessed. The creek below El Camino Real was not assessed due to continuous culverting down to San Francisco Bay. The upper reaches of Sanchez Creek and an unnamed tributary above Skyfarm Road were not assessed because they were inaccessible. Based on orthophotographic maps (SMC 2006) these reaches appear to have limited urban impacts to the riparian corridor.

The study area was approximately 1.2 miles in total length and was delineated into five reaches (Table 12 and Figure 19). Reaches S1 – S4 were delineated in Sanchez Creek and flow through high-density (Reach S1) and moderate density (Reaches S2 - S4) residential land uses. Reach S5 is the lower section of an unnamed tributary to Sanchez Creek and flows through a moderate density residential area, just below a golf course.

Table 12. Reaches delineated in the Sanchez Creek watershed.

Reach	Creek	Geographic Extent	Length (ft)	Notes
S1	Sanchez	El Camino Real to Bernal Ave.	1,710	Channelized with continuously hardened banks; limited erosion; narrow riparian buffer width with structures impacting flood plain; culvert failing below utility pipe.
S2	Sanchez	Bernal Ave. to creek crossing (i.e., culvert under house) near Geri Lane bridge.	2,070	Channel with increasing sinuosity; eroding at bends or steep banks that are not armored; moderate buffer widths and flood plain access.
S3	Sanchez	Creek crossing downstream of Geri Lane bridge to tributary confluence.	950	Channel mostly armored; channelized in sections; narrow riparian buffer and flood plain access impacted by structures.
S4	Sanchez	Tributary confluence to private driveway at end of Redington Rd.	785	Lower section of reach relatively unmodified; moderate buffer width and flood plain access; upper section culverted below homes.
S5	Tributary to Sanchez Creek	Tributary confluence to Skyfarm Dr. near golf course.	1,045	Lower section of reach is armored with steep drop; short section below Redington Rd. culvert is low gradient channel with wide flood plain and dense riparian vegetation; above Redington Rd. the channel is culverted below roads and homes.

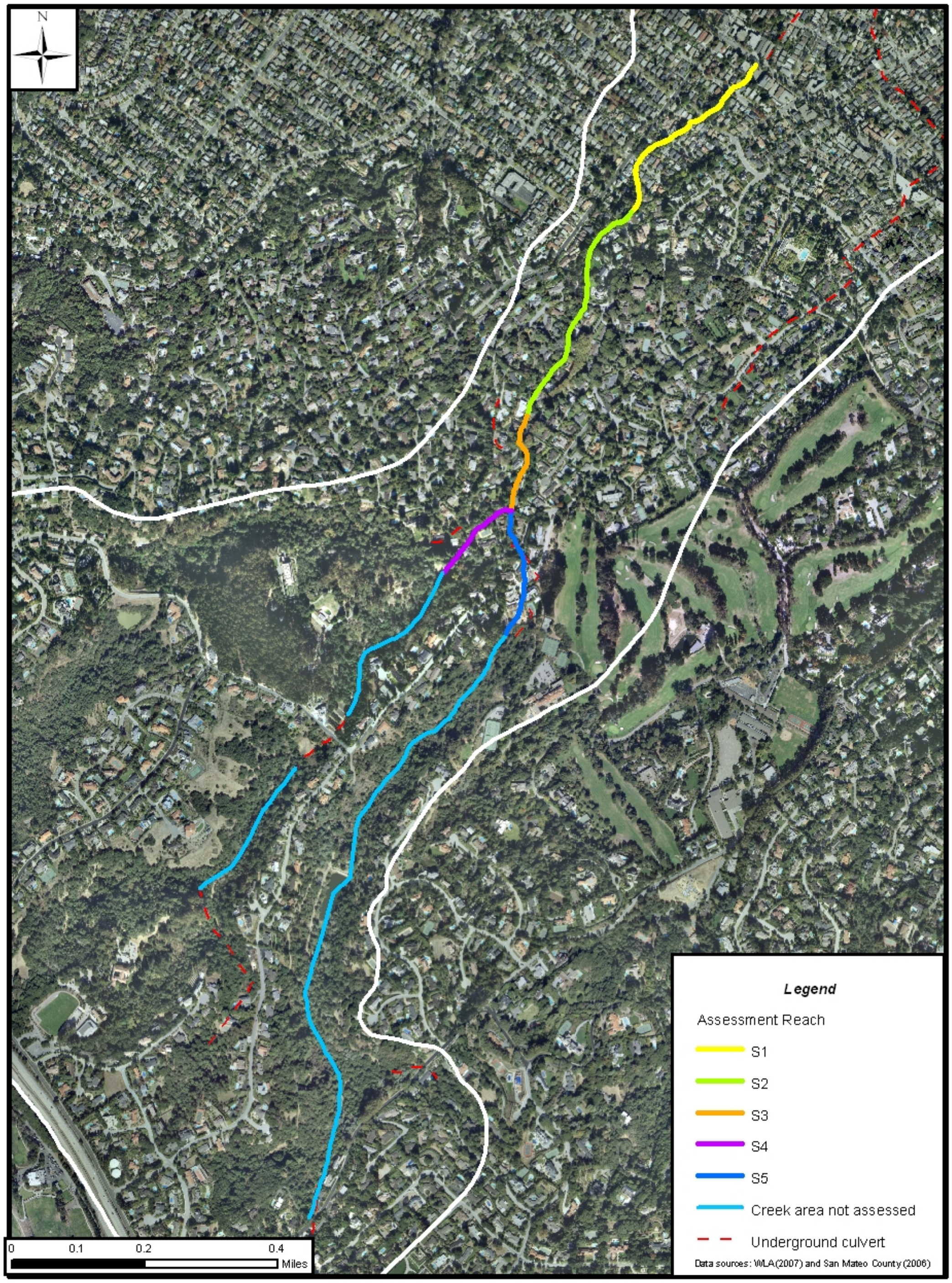


Figure 19. Creek reaches assessed in Sanchez Creek watershed.

4.4.2 Reach Assessment

The dominant substrate was sand in Reaches S1 and S5 and gravel or cobble in the remaining reaches. Channelization was noted in all reaches except for Reach S2. Bank scour and failure was the active channel dynamics observed in Reaches S2 and S3. Sediment deposition was observed in Reaches S4 and S5. The impacts most commonly observed were extensive bank hardening and culverts.

Reaches S1 – S3 were flowing at the time of the assessment indicating that perennial flow is likely with the exception of a short section of S1 that was dry. The upper two reaches were dry except at pool type habitats. Water clarity was good for all reaches with flow. No fish or other aquatic vertebrates were observed during the assessment. Canopy cover was good ($\geq$ 75% shaded) in Reaches S2 and S3 and moderate (50-75% shaded) in other reaches.

Total reach assessment scores ranged from 39 to 98 (Table 13 and Figure 20).[4] Reach S1 had the lowest total score (39) in the watershed and Reach S2 had the highest total score (98). Reach S2 had a relatively low amount of channel modification and relatively high access to the flood plain.

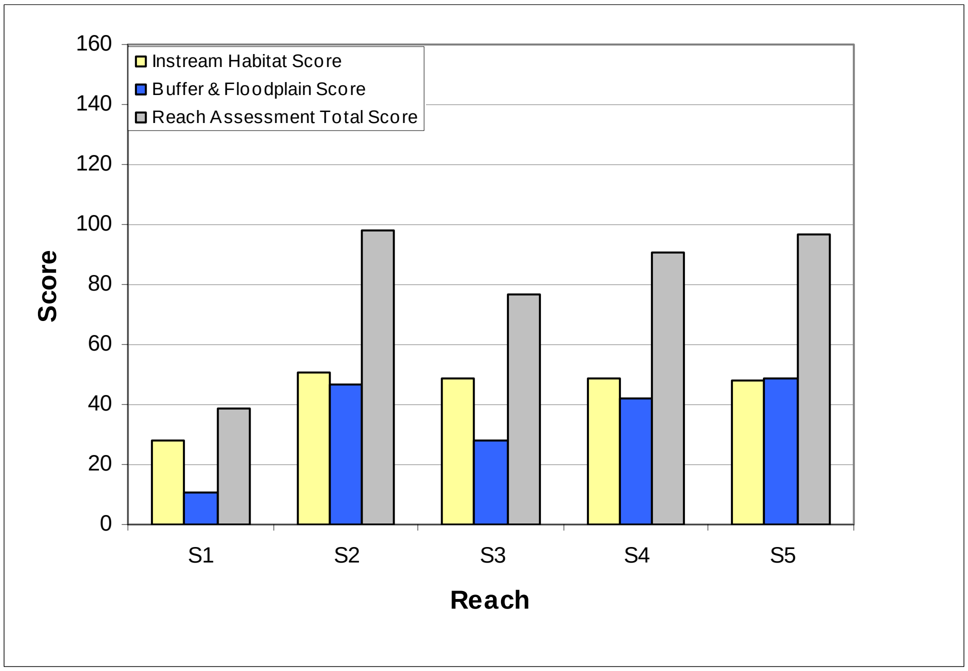
Table 13. Reach assessment scores in the Sanchez Creek watershed.

	S1	S2	S3	S4	S5
Overall Reach Condition					
Instream Habitat	2	14	10	9	2
Vegetative Protection: LB	1	6	6	5	7
Vegetative Protection: RB	1	6	6	5	8
Bank Erosion: LB	8	5	8	9	9
Bank Erosion: RB	9	5	7	9	9
Floodplain Connection	7	15	12	12	13
Subtotal	***28***	***51***	***49***	***49***	***48***
Overall Buffer and Floodplain Condition					
Vegetated Buffer Width: LB	2	6	4	6	7
Vegetated Buffer Width: RB	2	6	4	6	8
Floodplain Vegetation	3	12	7	8	11
Floodplain Habitat	2	11	7	6	11
Floodplain Encroachment: LB	1	6	3	8	6
Floodplain Encroachment: RB	1	6	3	8	6
Subtotal	***11***	***47***	***28***	***42***	***52***
Total	***39***	***98***	***77***	***91***	***97***

LB – Left Bank, RB – Right Bank.

[4]Only the un-culverted sections of Reaches R4 and R5 were assessed, resulting in higher scores than if the culverts had been taken into account.

Figure 20. Reach assessment scores in Sanchez Creek watershed.



4.4.3 Impact Assessment

The types and locations of impacts documented in the Sanchez Creek watershed are shown in Figure 21. Summary information on the impacts is shown by reach in Table 14.

The study reaches in this watershed were highly modified, with about 4,761 feet of armored or culverted channel, equaling about 73% of the total length assessed. The proportion of modified channel ranged from 44% - 99%. Reaches S1 and S5 were almost entirely modified at 99% and 91%, respectively. Reach S2 had the lowest proportion of modification (44%) in the watershed. About 46% of the total modified length was culverted. A culvert in Reach S1 that conveyed the creek under a large utility pipe appeared to be failing (Figure 22).

Figure 21. Impacts in the Sanchez Creek watershed.

The amount of erosion in this watershed was relatively limited (183 feet total), with the highest amount occurring in Reach S2 (136 feet). This reach also had the least amount of channel modification. Erosion impacts were predominately associated with bank scour at failing revetments and meander bends. There were some cases of bank failure at sites with unprotected steep banks (10-15 feet in height).

Figure 22. Potentially failing culvert built under utility pipe and house in Sanchez Creek.

Table 14. Summary of impacts in the Sanchez Creek watershed.

	S1	S2	S3	S4	S5
Total Length of Reach	1,710	2,070	950	785	1,045
Channel Modification (ft)					
Culverted	0	253	696	500	770
Armored bed or bank	1,685	657	20	0	180
Total length modified	1,685	910	716	500	950
Percent of reach modified	99	44	75	64	91
Total drop structures	0	1	0	0	1
Erosion					
Total length eroded (ft)	30	136	17	0	0
Percent of reach eroded	2	7	2	0	0
Outfalls and tributaries					
> 6 inches	0	4	2	0	0
≤ 6 inches	0	3	0	0	0
Tributary confluence	0	0	1	0	0
Diversion pipe	0	0	0	0	0
Creek crossings					
Road	5	1	1	0	1
Driveway/house	0	1	0	1	0
Utilities	3	1	3	1	0
Trash sites	0	1	2	1	0
Recreation sites	0	0	0	0	0

Nine outfalls were observed in this watershed, six of which had diameters larger than 6 inches (Table 14). Five of the outfalls had no flow, three had trickle flow, and one had substantial flow. The outfall with substantial flow was in Reach S2 and the discharge, which included leaves, suds and trash subsided after a short period of time (Figure 23). Only one tributary confluence that was eventually assessed (Reach S5).

Ten creek crossings were observed in this watershed; eight were roads and two were homes, driveways or yards. Five of the road crossings were in Reach S1. Eight utilities were observed in this watershed, most of which were pipes crossing over the channel without any apparent impact to the creek. Four trash sites were identified in this watershed, all consisting of yard waste dumped behind private residences.

Figure 23. Outfall in Sanchez Creek with discharge containing leaves, suds and trash.

4.5 Easton Creek Watershed

4.5.1 Reach Delineation

The USA was conducted in Easton Creek between El Camino Real and the confluence of two forks at Canyon Road. The creek below El Camino Real was not assessed because it is continuously culverted down to San Francisco Bay. The two forks were not assessed due to their small size and high density of vegetation, making access very difficult. The study area was approximately 1.9 miles in length and was delineated into four reaches (Table 15 and Figure 24). The study reaches are surrounded by high and moderate-density residential land uses.

Table 15. Reaches delineated in the Easton Creek watershed.

Reach	Creek	Geographic Extent	Length (ft)	Notes
E1	Easton Creek	El Camino Real Rd. to Jackling Dr.	2,303	Channelized and banks continuously hardened or culverted; incised with steep banks; no flood plain access; fish in pools.
E2	Easton Creek	Jackling Dr. to Summit Dr.	3,953	Channel bed and banks armored; grade control structures protecting sewer line within the channel; erosion at bends; fine sediment deposition on bed; flowing water is turbid.
E3	Easton Creek	Summit to Canyon Rd. east of La Cuesta Rd.	2,354	Channel bed and banks armored or culverted; homes and road impacting channel; erosion at failing revetment or banks with steep walls; fish disappear at upper end where gradient increases.
E4	Easton Creek	Canyon Rd. to confluence of forks east of Tiara Court.	1,641	Channel hardened; homes and road impacting channel; erosion in upper section of reach; flowing water is turbid; source is from reach above at confluence of forks.

4.5.2 Reach Assessment

The dominant substrate was gravel in Reaches E1 and E2 and cobble in upstream reaches E3 and E4. The most commonly observed impact in this watershed was extensive bank hardening and encroachment of homes and roadways into the riparian buffer. Channelization and sediment deposition were observed in all of the reaches. Bank scour was an active channel dynamic observed in all reaches except E1. Other notable impacts included structures (e.g., for grade control) to protect a sewer line within the creek channel in Reach E2 (Figure 25).

Figure 25. Sewer pipeline in the channel of Easton Creek.

All of the reaches in this watershed were flowing at the time of the assessment indicating that perennial flow is likely. Turbid water was observed in Reach E4. The turbid water appeared to come from the South Fork culvert. The confluence is under the garage and driveway of a house. The property owner indicated the culvert was damaged and needs replacement.

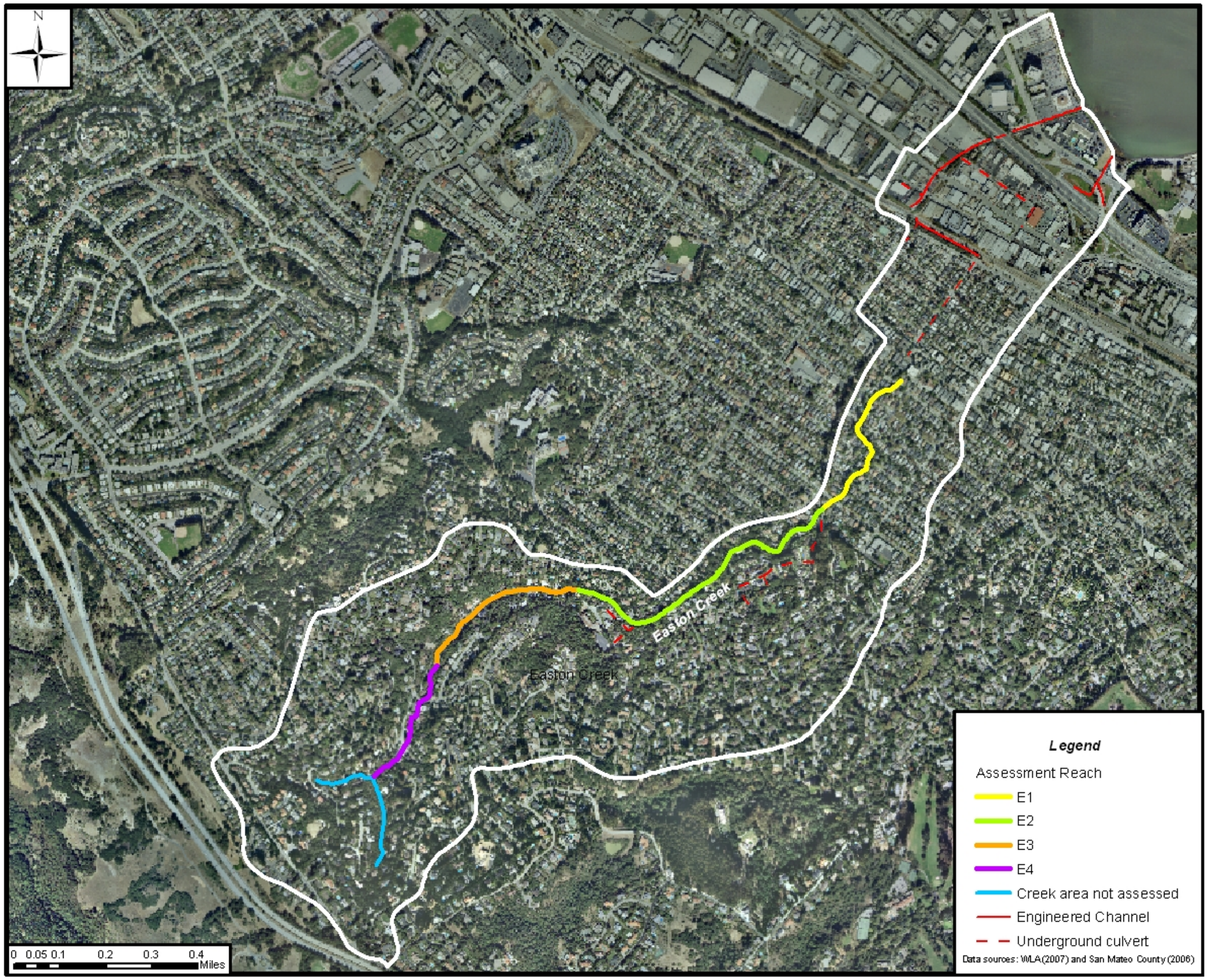


Figure 24. Creek reaches assessed in the Easton Creek watershed.

A native fish community (stickleback) was observed continuously from El Camino Real to a point in Reach E3 where the channel gradient increased. Salamanders were also observed in Reach E3. Canopy cover was good (≥ 75% shaded) in all of the reaches with the exception of Reach E1, which had moderate cover (50-75% shaded).

Total reach assessment scores ranged from 51 to 85 (Table 16). Reach E1 had the lowest score (51) and Reach E3 had the highest score (85). Reach assessment scores were generally low due to narrow riparian buffer and impacted flood plain due to encroachment from homes, roads and utilities. Floodplain and habitat condition improved upstream of Reach E1 (Figure 26). In the upper section of Reach E2 the channel created an S-shape meander, changing flow direction 180 degrees in a broad flood plain.

Table 16. Reach assessment scores in the Easton Creek watershed.

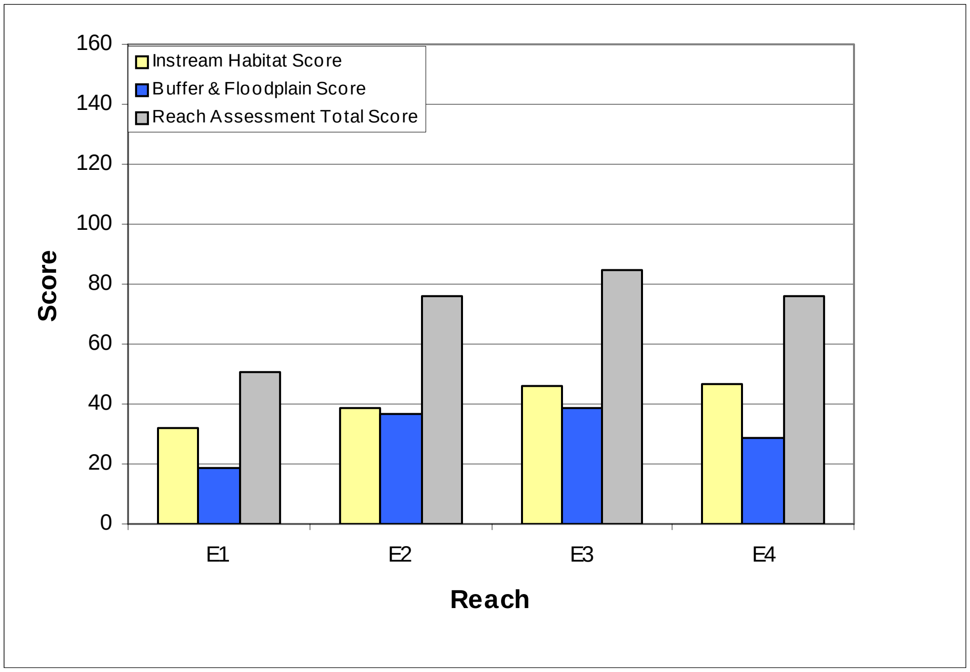
	E1	E2	E3	E4
Overall Reach Condition				
Instream Habitat	5	8	10	7
Vegetative Protection: LB	2	5	8	6
Vegetative Protection: RB	2	5	8	7
Bank Erosion: LB	8	4	4	7
Bank Erosion: RB	8	4	4	7
Floodplain Connection	7	13	12	13
Subtotal	***32***	***39***	***46***	***47***
Overall Buffer and Floodplain Condition				
Vegetated Buffer Width: LB	3	5	5	3
Vegetated Buffer Width: RB	3	5	4	4
Floodplain Vegetation	5	10	11	9
Floodplain Habitat	4	11	13	9
Floodplain Encroachment: LB	2	3	3	2
Floodplain Encroachment: RB	2	3	3	2
Subtotal	***19***	***37***	***39***	***29***
Total	***51***	***76***	***85***	***76***

LB – Left Bank, RB – Right Bank.

4.5.3 Impact Assessment

The type and location of impacts observed in Easton Creek are shown in Figure 27. Summary information on the impacts is shown by reach in Table 17.

Figure 26. Reach assessment scores in Easton Creek watershed.



The assessment reaches were highly modified, with about 7,013 feet of armored or culverted channel, equaling about 68% of the total length assessed. The proportion of modified channel in each reach ranged from 50% - 99%, with Reach E1 being almost entirely modified at 99%. About 28% of the total modified length was culverted sections of creek running below roads and houses (Figure 28). Channel armoring materials in this watershed were mainly concrete or rock walls on banks and concrete on channel beds to protect private homes and utilities. There were eleven drop structures in this watershed, nine of which were in Reaches E2 and E3.

Figure 28. Concrete culvert constructed under a home on Easton Creek.

About 2,100 feet of erosion was observed in this watershed. Reach E2 had the greatest total length (1,126 feet) and proportion (28%) of erosion. This reach also had the least amount of channel modification. Erosion impacts predominately consisted of bank scour at failing revetments and meander bends. Surface erosion on a bank from a leaking pipe was observed in Reach E2.

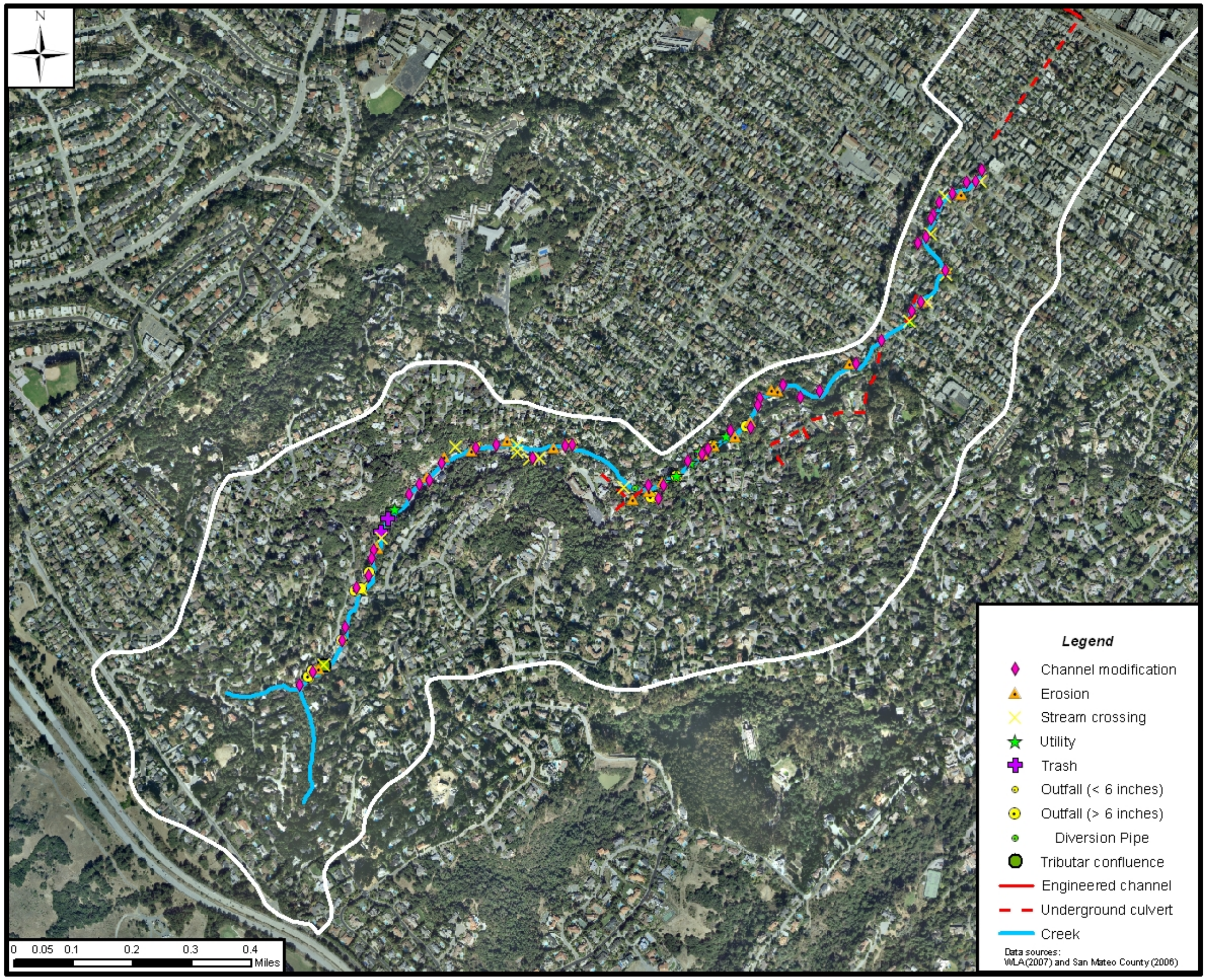


Figure 27. Impacts in the Easton Creek watershed.

Table 17. Summary of impacts in the Easton Creek watershed.

	E1	E2	E3	E4
Total Length of Reach	2,303	3,953	2,354	1,641
Channel Modification (ft)				
Culverted	778	670	289	285
Armored bed or bank	1,497	1,965	886	643
Total length modified	2,275	2,635	1,175	928
Percent of reach modified	99	67	50	57
Total number drop structures	1	5	4	1
Erosion				
Total length eroded (ft)	107	1,126	487	357
Percent of reach eroded	5	28	21	22
Outfalls and tributaries				
> 6 inches	0	7	2	7
≤ 6 inches	1	0	1	0
Tributary confluence	0	1	0	1
Diversion pipe	1	0	0	0
Creek crossings				
Road	6	1	3	2
Driveway/house	0	0	3	0
Utilities	1	7	1	0
Trash sites	0	1	2	0
Recreation sites	0	0	0	0

A total of 18 outfalls were observed in this watershed, with 16 outfalls larger than 6 inches in diameter (Table 17). Nine of the outfalls had no flow, three had trickle flow, and six had moderate or substantial flow. There were two illicit discharges observed; one in Reach E2 and the other in E3. The first discharge was an unidentified leaking pipe that was causing erosion on the bank and sedimentation in the channel in Reach E2. The incident in Reach E3 involved a discharge from a leaky pipe below a private residence (the creek flows under the home); the owner was immediately notified by field staff (Figure 29). There were two tributary confluences observed, including one in Reach E2 that originated from an artesian spring on an adjacent property and was conveyed to the creek via a PVC pipe.

Figure 29. Discharge from leaky pipe under home in Easton Creek.

There were 15 creek crossings documented in this watershed, 12 of which were roads; the remaining three were homes, driveways or yards (several of the impacts identified as channel modifications were also under homes). There were six road crossings in Reach E1. The longest creek crossing occurred in Reach E2, which was a 650-foot long culvert that passed under homes and two roads.


Figure 30. Sewer pipe and access port constructed in the channel of Easton Creek.

There were nine utilities observed in this watershed, seven of which were in Reach E2. A 6" - 8" diameter sewer pipe was constructed along the entire channel of Reach E2. There were several structures for sewer access that were typically constructed in the channel or on the banks (Figure 30) and smaller lateral lines running up the banks to private homes.

There were three trash sites identified in the watershed. At two of the sites small amounts of plastic bottles, rubber balls and Styrofoam were accumulating in the channel. At the third site yard waste was dumped on the top of the bank at a private residence.

4.6 Mills Creek watershed

4.6.1 Reach delineation

The USA was conducted in Mills Creek between El Camino Real and the upper end of Mills Canyon Park and in a tributary to Mills Creek up to a culvert below Martinez Drive. The creek was not assessed below El Camino Real due to continuous culverting down to San Francisco Bay. The creek was also not assessed above Mills Canyon Park due to an apparent lack of urban impacts.

The study area was approximately 1.3 miles in total length and was delineated into three reaches (Table 18 and Figure 31). High-density residential land use surrounded the study area, with portions of the creek adjacent to schools, office buildings, urban parks and undeveloped open space (Reach M2).

Table 18. Reaches delineated in the Mills Creek watershed.

Reach	Creek	Geographic Extent	Length (ft)	Notes
M1	Mills Creek	El Camino Real to tributary confluence.	2,760	Lower section of channel continuously hardened or culverted; moderately incised channel with bank erosion at bends or failing revetments; minimal native vegetation protecting banks; large accumulation of trash above SFPUC pipeline at El Camino Real.
M2	Mills Creek	Tributary confluence to upper end of Mills Canyon Park.	2,641	Extensive bank erosion at bends; channel incised with steep eroding banks; moderately wide buffer with some encroachment on the flood plain by structures protecting yards.
M3	Tributary to Mills Creek	Tributary confluence to culvert below Martinez Dr.	1,635	Extensive bank erosion at bends; channel incised with steep eroding banks; moderately wide buffer with some encroachment on the flood plain by structures protecting yards; turbid water and trash noted in the upper portion of reach; litter and dumping site near school.

4.6.2 Reach Assessment

The dominant substrate observed was sand in Reach M1 and gravel in Reaches M2 and M3. Bank scour was an active channel dynamic observed in all of the reaches. Bank failure was observed in the upper two reaches where channel incision had led to steep banks. Sediment deposition was observed in all of the reaches.

All of the study reaches were flowing at the time of the assessment indicating that perennial flow is likely. Good water clarity was observed throughout this watershed, with the exception of the upper section of Reach M3, where turbidity and trash were observed below an outfall that drains the upper watershed. Fish were not observed in this watershed. Good canopy cover ($\geq$ 75% shaded) was observed throughout most of the watershed.

Total reach assessment scores ranged from 77 to 97 (Table 19), with Reaches M3 and M2 having the lowest and highest scores, respectively. Overall creek condition was impacted by widespread erosion, especially in the upper two reaches which often lacked sufficient vegetation to protect the creek banks.

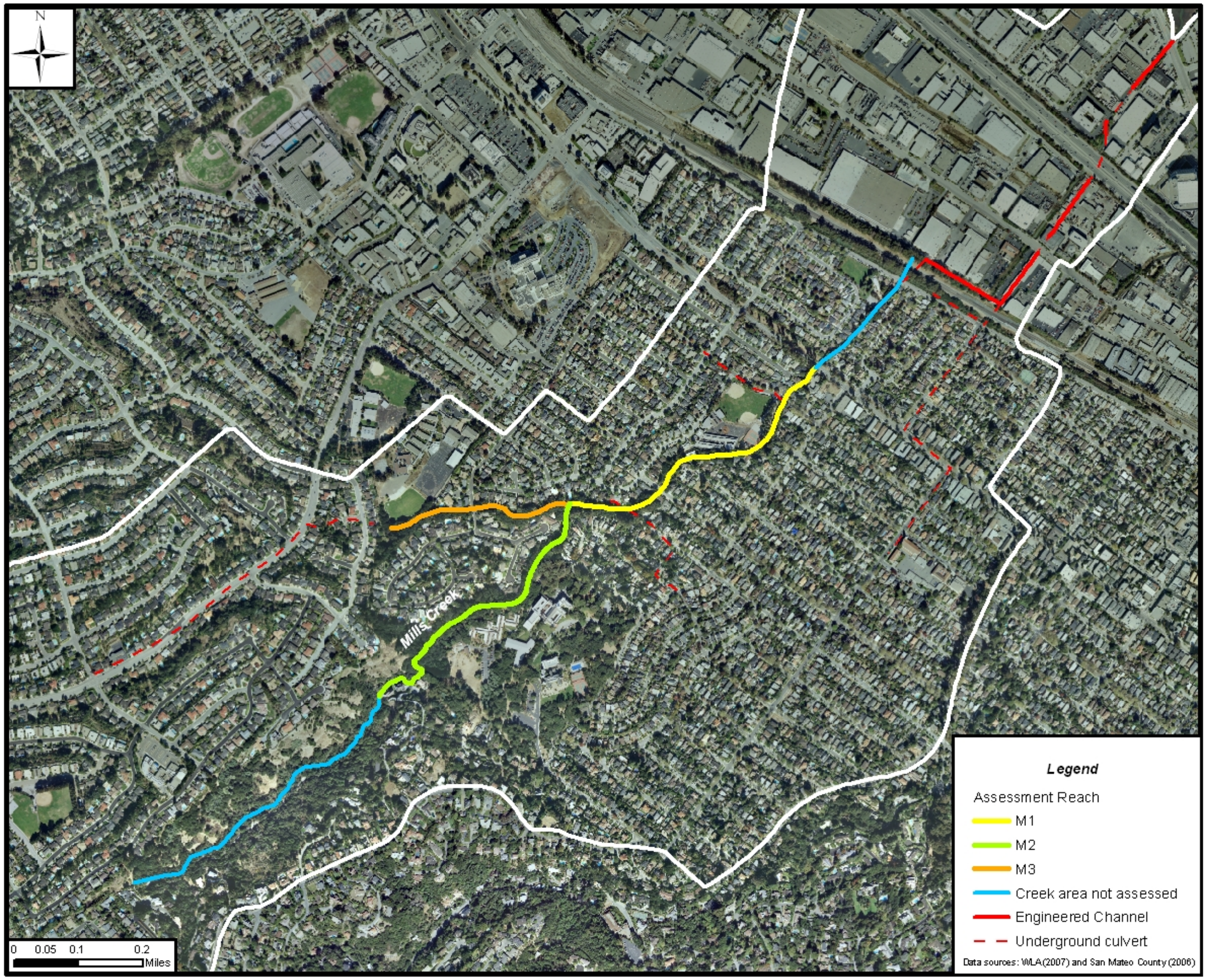


Figure 31. Creek reaches assessed in the Mills Creek watershed.

Table 19. Reach assessment scores in the Mills Creek watershed.

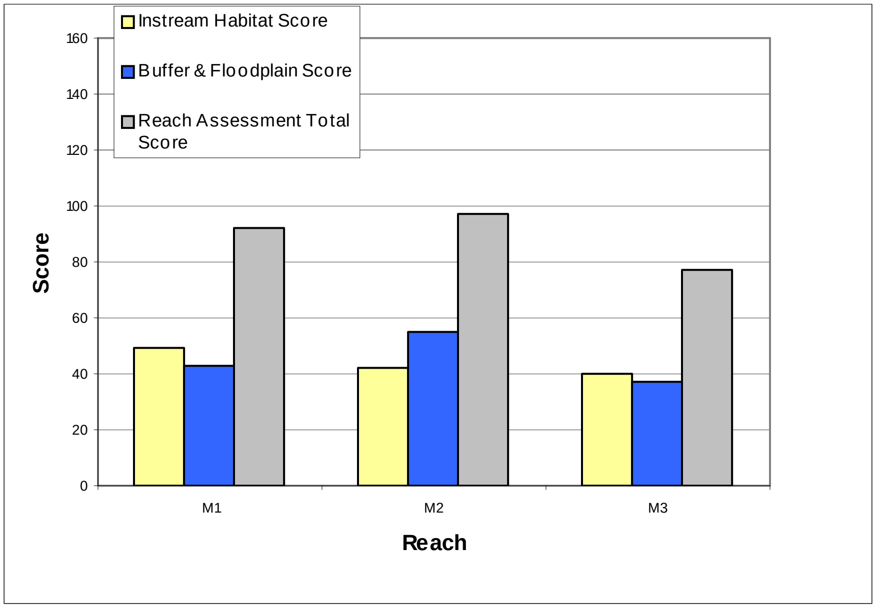
	M1	M2	M3
Overall Reach Condition			
Instream Habitat	7	9	7
Vegetative Protection: LB	6	6	6
Vegetative Protection: RB	6	5	6
Bank Erosion: LB	7	5	5
Bank Erosion: RB	8	4	5
Floodplain Connection	15	13	11
Subtotal	***49***	***42***	***40***
Overall Buffer and Floodplain Condition			
Vegetated Buffer Width: LB	6	7	5
Vegetated Buffer Width: RB	6	7	6
Floodplain Vegetation	10	13	6
Floodplain Habitat	11	12	7
Floodplain Encroachment: LB	5	8	6
Floodplain Encroachment: RB	5	8	7
Subtotal	***43***	***55***	***37***
Total	***92***	***97***	***77***

LB – Left Bank, RB – Right Bank.

English ivy was the dominant riparian ground cover throughout the watershed (Figure 32). Reaches M1 and M2 had higher reach assessment scores due to better overall flood plain condition (i.e., connectivity and habitat) (Figure 33).

Figure 32. Ivy covered banks at tributary confluence in Mills Creek.

Figure 33. Reach assessment scores in the Mills Creek watershed.



4.6.3 Impact Assessment

The type and location of impacts observed in the Mills Creek watershed are shown in Figure 34. Summary information on the impacts is shown by reach in Table 20.

The assessment reaches were highly modified, with about 2,700 feet of armored or culverted channel, equaling about 39% of the total length assessed. The proportion of modified channel in the study reaches ranged from 26% - 57%, with Reach M1 having the greatest amount of modified channel. About 25% of the total modified length was culverted sections of creek under roads and homes. The longest culvert (485 feet) was in the lower portion of Reach M1. Channel armoring materials in this watershed typically consisted of concrete or wood walls on the banks and concrete on the channel bed to protect private homes and yards. There were three concrete drop structures in the watershed, ranging from 4 to 10 feet in height.

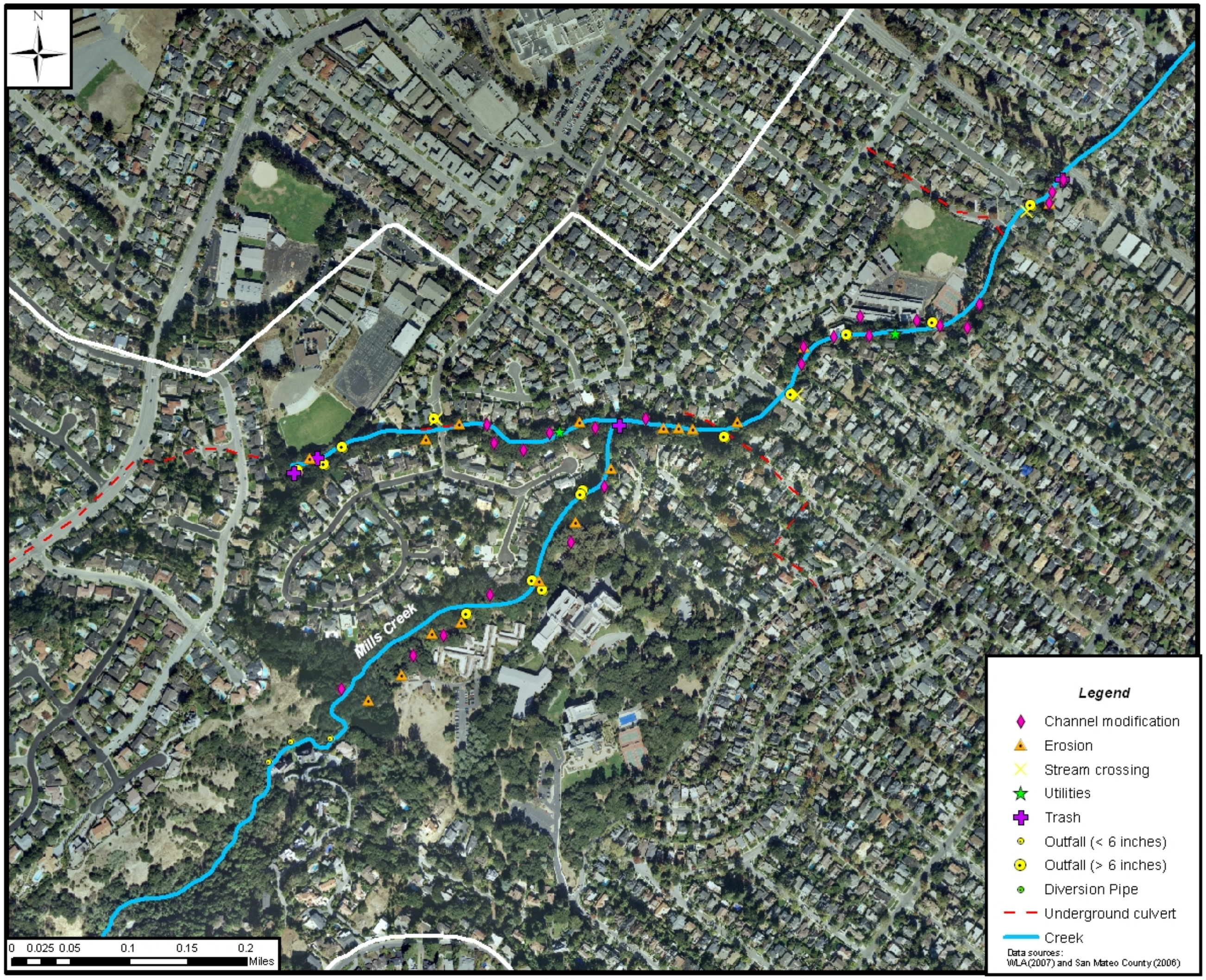


Figure 34. Impacts in the Mills Creek watershed.

There was about 2,500 feet of erosion observed in this watershed. Reaches M2 and M3 had the greatest proportion of erosion with 49% and 58% of their channels eroded, respectively. Erosion impacts typically consisted of bank scour at failing revetments, downstream culverts and meander bends. The upper portion of Reach M2 within Mills Canyon Park had widespread erosion due to an incised channel with steep banks (Figure 35).

Figure 35. Bank erosion below footpath of park in Mills Creek.

Table 20. Summary of impacts in the Mills Creek watershed.

	M1	M2	M3
Total Length of Reach	2,760	2,641	1,635
Channel Modification (ft)			
Culverted	595	0	94
Armored bed or bank	975	676	375
Total length modified	1,570	676	469
Percent of reach modified	57	26	29
Total drop structures	2	0	1
Erosion			
Total length eroded (ft)	246	1,298	951
Percent of reach eroded	9	49	58
Outfalls and tributaries			
> 6 inches	5	5	4
≤ 6 inches	0	3	2
Tributary confluence	1	0	0
Diversion pipe	1	0	0
Creek crossings			
Road	2	0	1
Driveway/house	0	0	0
Utilities	1	0	1
Trash sites	2	0	2
Recreation sites	0	0	0

A total of 19 outfalls were observed in this watershed, with 14 outfalls larger than 6 inches in diameter (Table 20). Thirteen of the outfalls had no flow, four had trickle flow, and two had moderate or substantial flow. One outfall with substantial flow, located at the upper end of Reach M3, had a turbid discharge that was reported to the municipal illicit discharge coordinator. There were two outfalls at this location and the smaller pipe was discharging turbid water and staining the structure red (Figure 36). A diversion pipe was observed in Reach M1.

Figure 36. Outfall with turbid discharge and red staining in Mills Creek.

There were three creek crossings observed in this watershed, all of which were roads. The longest creek crossing, which was in the lower section of Reach M1, was a 485-foot long culvert that passed under several homes, one road and part of a public park. Two of the crossings had drop structures, four and eight feet in height. Only two utilities were observed in this watershed.

Three trash sites were identified in this watershed, two sites in Reach M1 and one site in Reach M3. One site was located at the bottom end of Reach M1 at the upstream side of a San Francisco Public Utilities Commission pipeline below El Camino Real Bridge (Figure 37). The pipe was constructed about two feet from bottom of the channel and the creek flowed under it. A large trash raft, consisting of rubber balls, plastic bottles and Styrofoam, was trapped immediately upstream of the pipe. The other trash site in Reach M1 consisted of yard waste dumped onto the creek bank behind a private residence.

Figure 37. Floating trash trapped by a SFPUC pipeline in Mills Creek.

The third trash site was located at the upper end of Reach M3, downstream of the culvert draining the main channel. This site was located near a middle school and had limited public access due to a locked gate. The site consisted of plastic bottles, bags and Styrofoam accumulating from upstream sources and large items (plywood, shopping carts and a garbage can) that indicated illegal dumping. Trash bags and a tarp were also observed at the top of the bank near the gate.

4.7 Millbrae Creek watershed

4.7.1 Reach delineation

The USA was conducted in Millbrae Creek from an outfall near the Palm Avenue and Millbrae Avenue intersection to a point on the creek adjacent to the west end of Via Canon Road. The creek was not assessed below Palm Avenue because that section was continuously culverted to the Bay. The creek was also not assessed above Via Canon Road due to its very small size and an apparent lack of any urban impacts. The study area was approximately 0.7 miles in total length and was delineated into two reaches (Table 21 and Figure 38). The study area was surrounded by high and moderate-density residential land use, with some pockets of urban vacant and park uses.

Table 21. Reaches delineated in the Millbrae Creek watershed.

Reach	Creek	Geographic Extent	Length (ft)	Notes
MB1	Millbrae Creek	Palm Ave. and Millbrae Ave. intersection to Ashton Rd.	940	Lower section runs through a park and has incised channel and eroding banks; armored banks in middle portion adjacent to homes; upper section of reach culverted under a home and road; channel bed was dry.
MB2	Millbrae Creek	Ashton Rd. to west end of Via Canon Rd.	2,655	Sections of armored channel protecting homes or yards; erosion typically at bends; bank vegetation is primarily ivy; channel was generally dry in the lower reach and had trickle flow or was dry except some pools in the upper reach.

4.7.2 Reach Assessment

The dominant substrate was sand in Reach MB1 and gravel in Reach MB2. Bank scour and failure were active channel dynamics observed in both reaches. The channel was generally dry in the lower reach and had trickle flow or was dry except some pools in the upper reach. Fish were not observed in this watershed. Good canopy cover ($\geq$ 75% shaded) was observed in both reaches.

The total reach assessment score for Reach MB1 (47) was much lower than Reach MB2 (99) (Table 22). The score in the lower reach reflected poor habitat quality, low buffer widths and the floodplain being impacted by roads and homes. Increased habitat quality, flood plain connection and buffer widths and less floodplain encroachment contributed to the higher score for the upper reach (Figure 39).

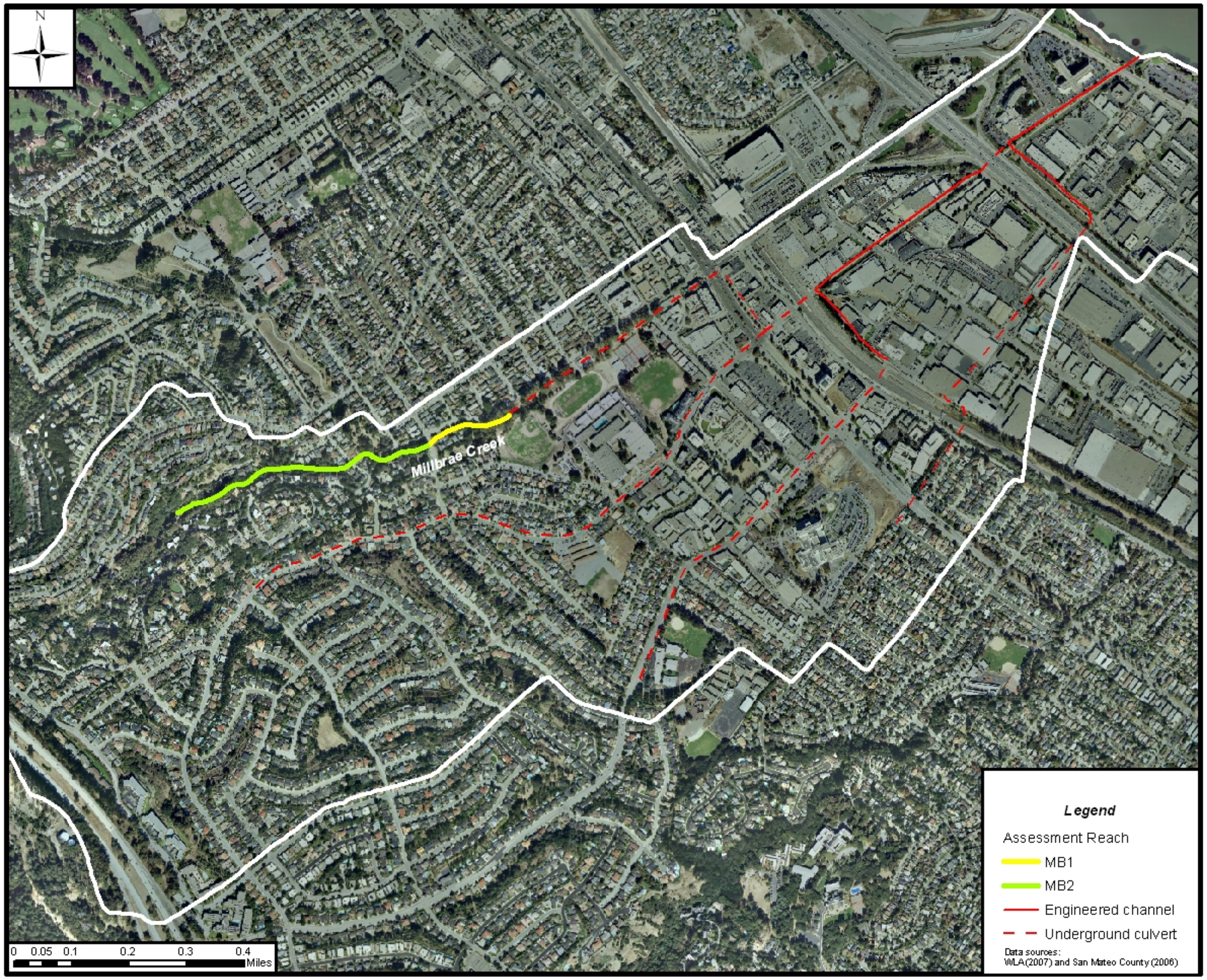


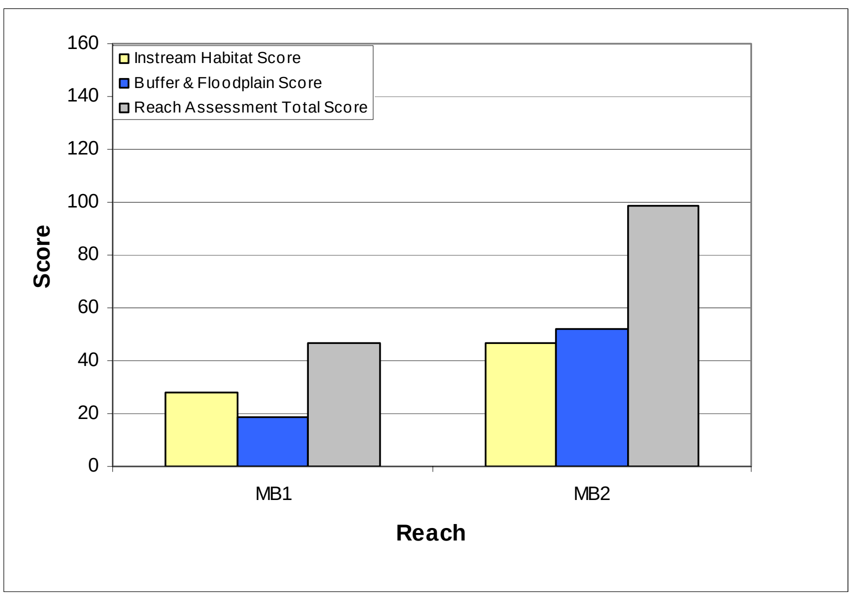
Figure 38. Creek reaches assessed in the Millbrae Creek watershed.

Table 22. Reach assessment scores for Millbrae Creek watershed.

	MB1	MB2
Overall Reach Condition		
Instream Habitat	4	9
Vegetative Protection: LB	1	5
Vegetative Protection: RB	2	5
Bank Erosion: LB	6	8
Bank Erosion: RB	7	8
Floodplain Connection	8	12
Subtotal	***28***	***47***
Overall Buffer and Floodplain Condition		
Vegetated Buffer Width: LB	1	6
Vegetated Buffer Width: RB	3	7
Floodplain Vegetation	6	14
Floodplain Habitat	5	12
Floodplain Encroachment: LB	1	6
Floodplain Encroachment: RB	3	7
Subtotal	***19***	***52***
Total	***47***	***99***

LB – Left Bank, RB – Right Bank.

Figure 39. Reach assessment scores in Millbrae Creek watershed.



4.7.3 Impact Assessment

The type and location of impacts observed in Millbrae Creek are shown in Figure 40. Summary information on the impacts is shown by reach in Table 23.

Table 23. Summary of impacts in the Millbrae Creek watershed.

	MB1	MB2
Total Length of Reach	940	2,655
Channel Modification (ft)		
Culverted	372	180
Armored bed or bank	282	518
Total length modified	654	698
Percent of reach modified	70	26
Total number drop structures	1	3
Erosion		
Total length eroded (ft)	125	105
Percent of reach eroded	13	4
Outfalls and tributaries		
> 6 inches	1	5
≤ 6 inches	0	7
Tributary confluence	0	1
Diversion pipe	0	0
Creek crossings		
Road	1	2
Driveway/house	1	0
Utility	0	1
Utilities	0	10
Trash sites	1	2
Recreation sites	0	0

The assessment reaches were highly modified and had about 1,350 feet of armored or culverted channel, equaling about 38% of the total length assessed. The proportion of modified channel in the study reaches was 70% in Reach M1 and 26% in Reach M2. About 41% of the total modified length in the watershed was culverted sections of creek under roads and homes. Channel armoring materials in this watershed typically consisted of concrete or wood walls on the banks and concrete on the channel bed to protect private homes and yards. Four concrete drop structures were observed in this watershed (Table 23).

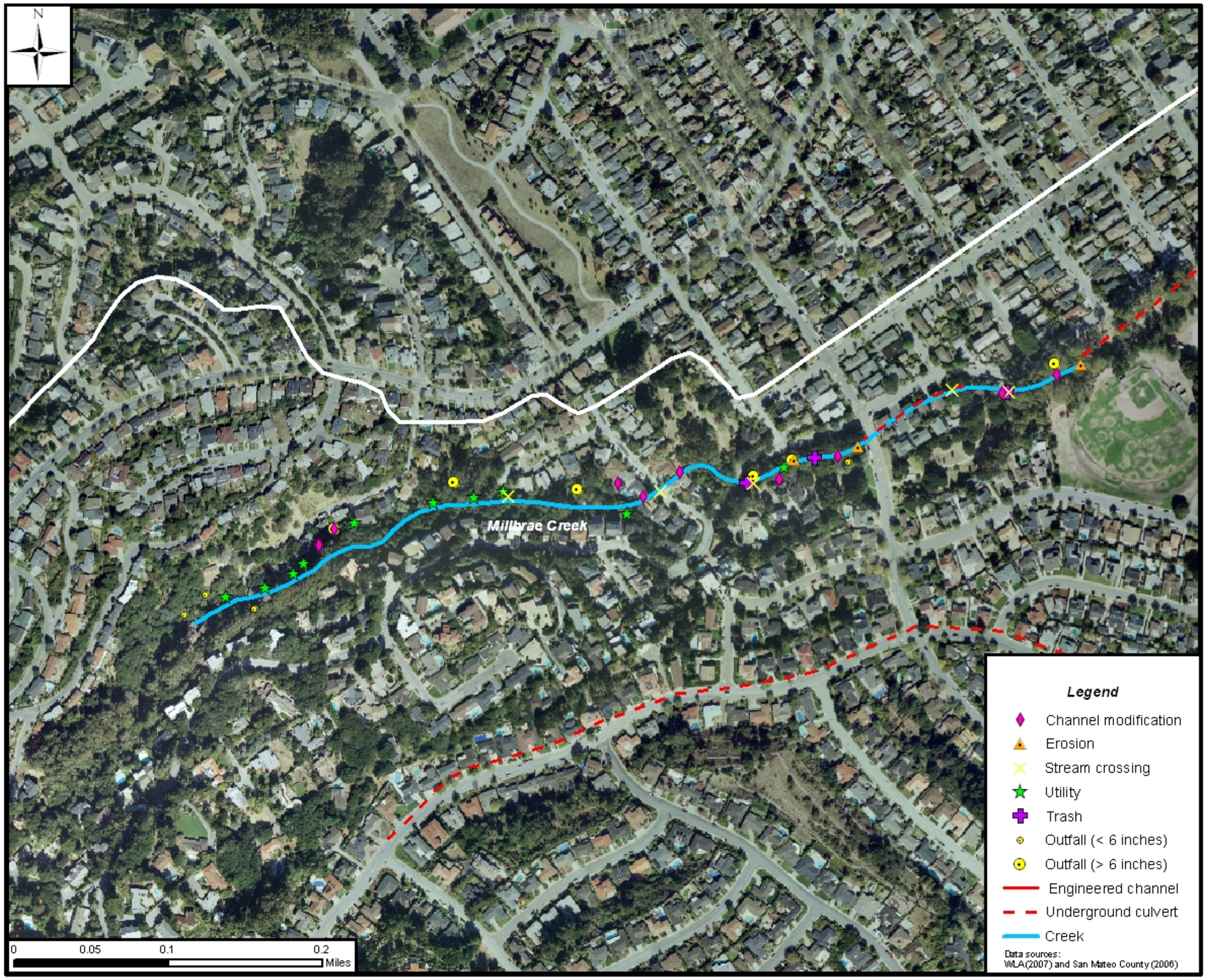


Figure 40. Impacts in the Millbrae Creek watershed.

About 230 feet of channel with erosion was observed in this watershed, with 13% and 4% of the channel eroded in Reach MB1 and MB2, respectively. Erosion was most commonly observed at meander bends (Figure 41) and parts of the channel with steep, unprotected banks.

Figure 41. Bank erosion at a meander bend in Millbrae Creek.

A total of 13 outfalls were documented in this watershed, with all but one occurring in Reach MB2 (Table 23). More than 50% of the outfalls were smaller than 6-inches in diameter. Ten of the outfalls had no flow and three had trickle flow; no water quality problems were apparent. At least four of the outfalls were associated with bank erosion.

Five creek crossings were observed in this watershed. Three crossings were roads, one was a house and driveway, and the remaining crossing was where the creek passed under utility pipes. The longest crossing, a 350-foot long culvert that passed under both a house and road, was in the lower section of Reach M1. Ten utilities were observed in the watershed, all in Reach MB2.

Figure 42. Litter in Millbrae Creek in Reach MB2.

Three trash sites were identified during the assessment, one in Reach MB1 and two in MB2. One site was located at the bottom end of Reach MB1 at a park near a high school. This site contained primarily litter, but also has some larger items (e.g., carpet) indicating dumping from an adjacent roadway. The lower trash site in Reach MB2 was located where the creek flows through a vacant area above Ashton Road. This site primarily contained cigarette waste, food wrappers and beverage containers (Figure 42).

4.8 Comparison of study watersheds

4.8.1 Reach condition

The upper two reaches of Redwood Creek and Arroyo Ojo de Agua had the highest total reach condition scores in the study watersheds and were the only reaches in the optimal category (120 – 160 range) (Figure 43). The score for the upper reach of Atherton Creek was just below the threshold for optimal ranking. The Redwood and Atherton Creek watersheds were the largest watersheds in this study and showed a general trend of increasing reach assessment scores with increasing elevation. There were no apparent trends by watershed or elevation for the reach scores in the five smaller study watersheds.

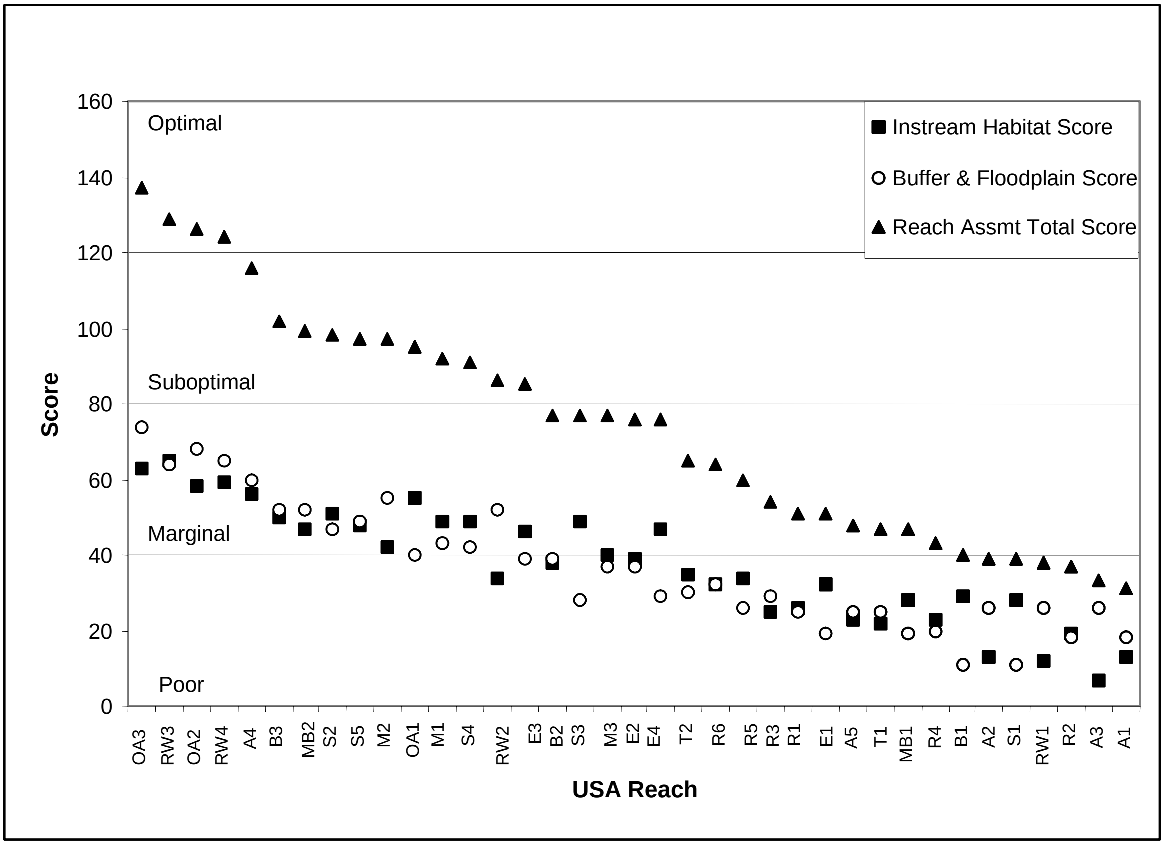


Figure 43. Ranked assessment scores for the 37 study reaches.

4.8.2 Fish community distribution documented during USA

The native fish communities observed during this study are shown in Figure 44. Fish were documented in nine reaches of four creeks: Arroyo Ojo de Agua, Burlingame Creek, Easton Creek and a tributary to Ralston Creek. The fish observed were largely native stickleback, however two to three species of fish were observed in the lowest reach of Arroyo Ojo de Agua. The total reach assessment scores ranged for these reaches ranged from 40 to 126. Stickleback are very tolerant of warm water and low dissolved oxygen, so it is not surprising they were observed in highly impacted reaches with poor habitat and water quality. Fish passage impediments may play an important role in limiting overall range of native fish communities. Anadromous fish (e.g., steelhead) were not observed during this study.

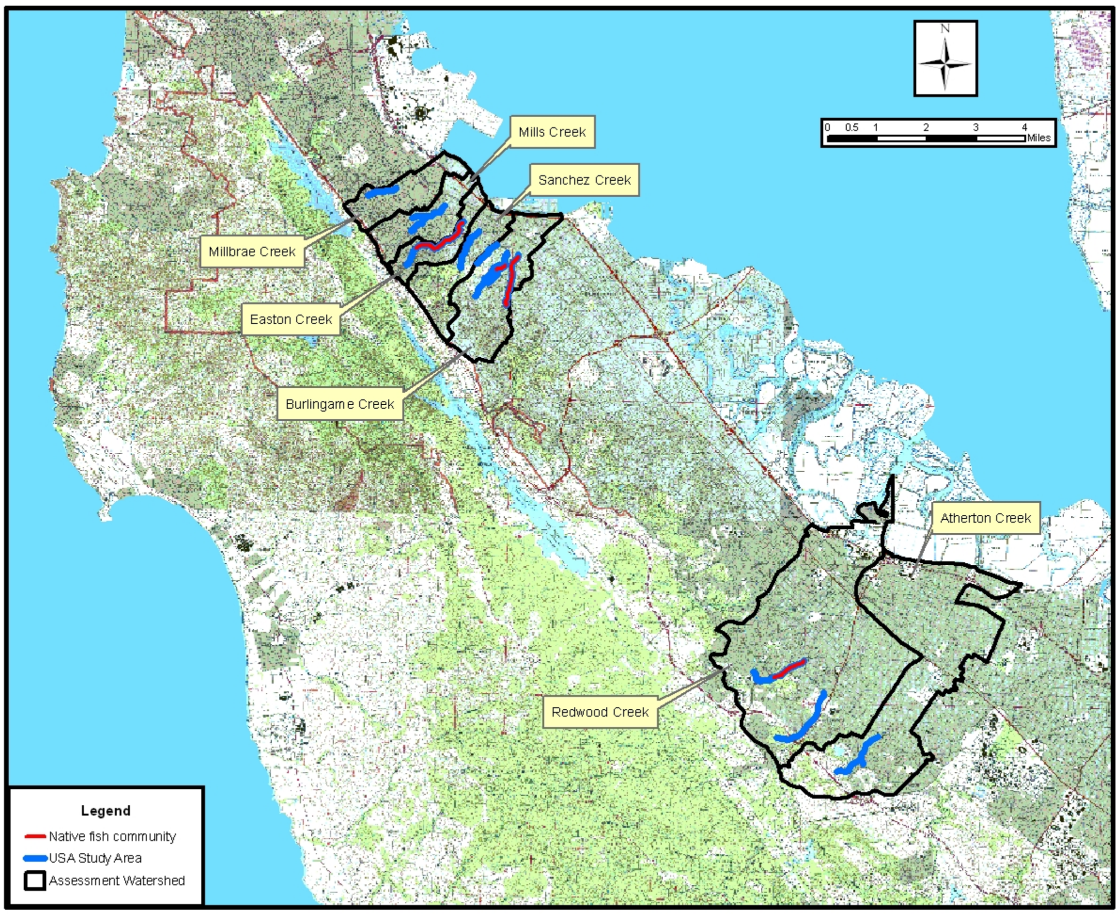


Figure 44. Native fish community distribution in reaches assessed during the USA.

5.0 DISCUSSION

Natural creek corridors are dynamic ecosystems. Over time, equilibrium is reached among slope, channel dimensions, discharge, and sediment load (Riley 1998). The creek channel evolves to balance the energy from the flow of water and the need to transport sediment. Under equilibrium conditions, creek banks and channel morphology are relatively stable. This equilibrium is disturbed when urbanization changes the land cover and other surface characteristics of the watershed. Urbanization increases imperviousness and diverts much of the surface drainage into storm drain systems. This results in changes in the volume and timing of water delivered to creeks, and the amount and type of material conveyed to creeks (Walsh et al. 2005). Additionally, urbanization typically reduces the width of the riparian corridor, which reduces the space in which the creek can migrate laterally.

In response to urbanization, creek channels adjust their widths, depths, gradients and meanders. Typically, urbanization results in accelerated bank erosion and wider and deeper channels. As channels deepen, they can become entrenched and disconnected from their floodplains. As a result, the energy of the water flow concentrates within the channel, as it cannot dissipate on the floodplain. Bed erosion can destabilize creek banks by making their slopes too steep and undermining the bank toe. The combination of increased energy within the channel and reduced bank stability often leads to rapid bank erosion (Riley 1998).

Reach Level Assessment

The creek impacts observed during this study were documented individually; however, cumulative affects along entire reaches are common in urban creeks. For example, when the creek bank is hardened at various locations along a reach, the creek may lose its ability to adjust to changes in the hydrograph via, for example, increases in channel sinuosity and length, which in turn reduce the velocity and erosive power of the flow. The channel bed may incise to the point that floodplains are disconnected from the creek. This reduces the establishment and survival of riparian vegetation and decreases the overall integrity of the creek ecosystem. The reach assessment scoring methodology used in this study is designed to capture these related interactions.

In the larger study watersheds (i.e., Atherton and Redwood Creek), overall creek condition scores generally increased in the upstream direction with decreasing urbanization. The scores were largely driven by improved instream habitat and increased buffer widths and floodplain connection in the upper parts of the larger watersheds. In the smaller study watersheds (i.e., Burlingame, Sanchez, Easton and Mills Creek), overall creek condition was generally marginal or suboptimal in all reaches due to extensive urbanization throughout the watershed. Impacts were typically associated with low buffer widths (e.g., homes constructed very close to the creek) or highly impacted riparian corridor due to culverting beneath roads and driveways and extensive channel armoring, often to protect the backyards of residential properties.

Channel Modification

Creek-side landowners often try to control erosion and stabilize creek banks by hardening the portion of the bank on their property. In the study creeks, such channel modification was mostly in the form of bank revetments. In some cases, property owners constructed culverts to convey water under their homes or backyards. In general, the design of channel modifications observed during the assessment did not account for the overall geomorphic equilibrium of an entire reach. As a result, hardening of the channel at one location was often associated with instability farther downstream. In addition, many of the channel modifications appeared to be failing and/or causing erosion. Older revetments were especially vulnerable to scour and undercutting by increased peak flows associated with urbanization.

Erosion

The majority of erosion observed was in the form of bank scour, especially at meander bends and revetments. Bank failure was also common, especially of steep banks within highly incised channels. Non-native vegetation growing along the banks was pervasive, resulting in reduced protection from erosion. Channel incision in the study watersheds generally appeared to be associated with historical land use changes and may no longer be active (i.e., the watersheds have likely been developed for a long enough period of time for the channel to have adjusted to the change in the hydrograph and reached a new equilibrium). In many of the reaches the channel bed appeared to be clay, which is relatively resistant to erosion. In some cases grade control structures appeared to further stabilize the channel bed.

Utilities

Impacts on the study creeks due to utilities were limited. The majority of utilities consisted of small pipes crossing over the creek high above the channel bed. In some cases, utilities were located near the channel bed and were associated with bank erosion, apparently during high flow events. In areas that had major utilities, such as a San Francisco Public Utilities Commission water supply pipeline, grade control structures and bank armoring had been constructed to protect the facility. The largest impact from a utility was observed in Easton Creek, where a sewer pipeline was constructed along the creek bed for an entire reach. Numerous grade control structures and bank revetments had been constructed to protect this sewer line.

Outfalls

The assessments were carried out during the dry season and few dry weather flows were observed. For those outfalls with discharge, few had discoloration, odor, or other indications of illicit discharge, but those outfalls with a suspicious discharge were reported to a municipal illicit discharge coordinator. Some of the outfall pipes appeared to cause erosion, either immediately downstream from the outfall or head cuts perpendicular to the creek.

Creek Crossings

The most common type of creek crossing observed was road crossings. Other types of crossings identified include houses, yards, driveways and utilities. In addition to habitat alteration impacts, creek crossings can potentially impact upstream passage for fish. The study watersheds are not expected to support anadromous fish (e.g., steelhead); however, native warm water fish, such as stickleback, were observed in several reaches. These fish need to migrate to search for spawning habitat and refuge during summer low flow conditions. Conversely, creek crossings can be beneficial by serving as grade controls. When the bottoms of creek crossings are hardened, creek bed erosion may be prevented from migrating upstream.

Trash/Debris

Trash is deposited in creeks through several possible means including illegal dumping, littering, windborne transport and waterborne transport from upstream sources. Littering and illegal dumping in urban creeks are typically problematic in areas that receive high vehicle and foot traffic (e.g., shopping centers) or locations with good public access (e.g., parks and schools). The USA study area was predominately in residential land uses west of major transportation corridors, such as El Camino Real or Alameda de las Pulgas. As a result, litter or dumping in creeks was limited to a few locations.

Trash impacts in the study area were often associated with the dumping of yard waste into creek channels behind residential properties. Impacted sites also included areas where trash accumulated due to obstructions in the channel, such as dense vegetation or utilities. Other impacted sites occurred where creeks passed through parks or vacant lands that were in close proximity to schools. SMCWPPP (2008a) describes application of the URTA protocol, which was used to further characterize selected locations in the study watersheds with relatively high levels of trash.

Recreation

Evidence of recreation in the study watersheds was limited to two sites located within one creek reach in a public park (Stulsaft Park in Redwood City). Both of these sites had rope swings over the creek with excellent public access. However, the potential for water contact recreation appeared limited at the time of the assessment due to low flow conditions and the lack of deep-water pools.

6.0 POTENTIAL USES OF USA DATA

Data generated through USA surveys can address multiple stormwater program monitoring-related objectives. USA survey uses include establishing baseline data, identifying the types and locations of potential impacts to water quality, identifying potential beneficial uses to protect and threats to such uses, and refining monitoring program objectives and design (e.g., parameters and sampling locations). USA survey data can assist stormwater programs to better understand creek conditions and threats to water quality upstream and downstream of existing monitoring sites, thereby assisting in the interpretation of existing monitoring data (e.g., benthic macroinvertebrate bioassessments), and the identification of appropriate stormwater BMPs and potential restoration activities. The Program, in collaboration with the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP), recently prepared a guidance document for municipal stormwater programs and other interested agencies on the potential uses of the USA based on recent experience in the Bay Area (SCVURPPP and SMCWPPP 2008). This document further discusses potential uses of USA data and includes several case studies.

Many of the impacts observed during the Program's USA surveys are associated with efforts by individual private property owners to control bank instability on their properties. Education and outreach could help landowners understand the impacts of such actions on creeks and potentially lead to the use of better practices in the future. The Program is currently exploring developing an outreach and support program similar to the Urban Creeks Council's (www.urbancreeks.org) Stream Management Program for Landowners (SMPL). This program is funded by the Contra Costa Clean Water Program and provides free advice about creek care to Contra Costa County property owners. Services include free site visits and consultations on creek restoration techniques and associated permitting, including addressing issues such as bank failure, erosion, and flooding. The data from the Program's USA surveys could assist San Mateo County property owners to target and optimize creek management and restoration efforts initiated through this type of creek management program. However, a funding source to implement a program similar to SMPL in San Mateo County has not been identified. SMCWPPP (2008b) has prepared a memo that further discusses the SMPL program and the potential development of a creek management program in San Mateo County.

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