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Along Sausal Creek: An Assessment of Vegetation, Habitat, and Morphology of an Adopted Urban Creek

Abstract

Since the 1990s, local creek groups organized around habitat restoration and monitoring have coalesced into a growing force in the urban watershed movement that is creating new ways of engaging and reshaping the urban environment. Despite a growth in recent volunteer activities and funding allocation to these volunteer groups, little has been done to assess the biological and social outcomes of this volunteer creek stewardship.

The Friends of Sausal Creek (FoSC) in Oakland, California is one of the most active volunteer groups in Alameda County monitoring and restoring riparian habitat along an adopted creek. From 2000 to 2001, a creek restoration project was designed by Wolfe Mason Associates, Inc. (WMA) and carried out for a reach of Sausal Creek in Dimond Canyon under FoSC's guidance and stewardship.

This paper approaches the study of Sausal Creek in two parts to determine the overall health of that reach of the creek. The first aspect of this study was to determine the success of the volunteer riparian habitat plantings along the left bank of Sausal Creek in Dimond Canyon. We used a quadrat sampling method to determine percent cover, species composition, and species diversity. The second aspect of this study was to compare the Dimond Canyon site with upper watershed sites.

Our findings suggest that the Dimond Canyon restoration site provides better habitat than the pre-project conditions but the habitat remains slightly more impaired than the upper watershed sites. The restoration plantings appear to be successful in that a greater percentages of native plant cover and a greater species diversity exist than pre-restoration site conditions. The Dimond Canyon site has the characteristics of a healthy stream, although the upper watershed has relatively higher habitat quality. These results, while not entirely conclusive, suggest that 1) FoSC's continued contribution in improving riparian habitat along the creek is significant and that 2) the Dimond Canyon site is achieving some of the goals of the WMA restoration.

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1. Introduction

In Alameda County, California, a growing local movement is creating new ways of engaging and reshaping the urban environment through volunteer involvement with creek restoration, water quality monitoring, plant propagation, and wildlife monitoring. Since the 1990s, local creek groups organized around restoration and monitoring have coalesced into a growing force in the urban watershed movement. The Friends of Sausal Creek (FoSC), in particular, has been one of the most active volunteer groups in the county, monitoring and restoring riparian habitat along their adopted creek. Despite recent volunteer activities and funding allocation to these volunteer groups, little has been done to assess the biological and social outcomes of this volunteer creek stewardship. This paper attempts to characterize, assess, and document the conditions of an urban creek adopted by a volunteer group by examining vegetation and channel forms along Sausal Creek in Dimond Canyon (a seemingly popular site for studies by previous graduate students), and compare these characteristics with those of the upper watershed, located in the relatively undeveloped Joaquin Miller Park.

Sausal Creek is a perennial creek that flows east to west through the center of Oakland. The 1,075 hectares of the watershed are primarily located in the Glenview, Dimond and Fruitvale districts of the city. Approximately 80,000 Oakland residents live in the watershed, with the majority living in the dense, urbanized Fruitvale area (FoSC website 2002). The Dimond Canyon reach has been subjected to many engineering attempts to prevent erosion.[1]

Since the flooding of Sausal Creek in the Dimond Canyon area in 1995, the creek has received a lot of attention from the local community with the most recent FoSC efforts focused on native plantings, erosion control, bank stabilization, the removal of invasive plants and monitoring water quality and benthic macroinvertebrates. Wolfe Mason Associates, Inc.

[1] In the 1930s and 1940s, the Works Progress Administration poured concrete into the stream bed in an effort to contain its flow and prevent erosion in Dimond Canyon (Owens-Viani 1998). An concrete flume was also poured onto one of the slopes in the area (Owens-Viani 1998).

(WMA) designed a restoration project in 2000 (WMA 2000) in a 597-linear foot section of Dimond Canyon Park, beginning at about 825 feet upstream of El Centro Avenue. The riparian area in this section, and extending south to El Centro Avenue, was re-vegetated by volunteers between December 2001 and March 2002. The FoSC installed approximately 20,000 plants in the restoration area in Dimond Canyon. We referenced both the WMA restoration plan, and a follow-up draft report on a vegetation survey performed at the creek by the FoSC, during our research.

2. Study Purpose

The objective of our study was to evaluate 1) how successful the restoration has been, specifically the re-vegetation portion of the restoration project completed by volunteers, and 2) how the habitat quality of the area of the creek in which restoration activities took place compares to the upper, less disturbed areas of the creek.

3. Methods

To answer the first part of our study, i.e. the success of the volunteer plantings in Dimond Canyon, we surveyed the vegetation at that site. To answer the second part of our research question, i.e. how the habitat at the Dimond Canyon reach compared with the upper, less disturbed areas of the creek, we conducted habitat assessments of the in-stream and riparian cover, as well as measured channel slope, cross-sections, and, except for the reach with no water, benthic macroinvertebrates. Where possible and appropriate, we compared our results with previous studies of Sausal Creek, completed both prior to the restoration by WMA and FoSC in 2000 and 2001, and after this restoration.

3.1 Description of Study Sites

We sought sites that were either exactly the same, or were in areas near, sites studied previously by restoration planners, the FoSC, and students at UC Berkeley. Our main study site along Sausal Creek is located in Dimond Canyon (herein referred to as the Dimond Canyon site), south of Dimond Canyon Park and north of El Centro Avenue (Figure 1, Site Location Map). We originally intended to examine only one upstream site, along Palo Seco Creek in Joaquin Miller Park, as the "baseline," relatively undisturbed site showing high habitat quality. We selected our upstream site (herein referred to as the upper Palo Seco site) in approximately the same area as one of the sites studied in a previous student paper (Lacan et al. 1999). This upstream site was dry, however, and we selected an additional upstream site with water, approximately one mile downstream along Palo Seco Creek from the first site, where two branches of Palo Seco Creek converge (herein referred to as the Palo Seco confluence site).

We reviewed and referenced several previous reports on Sausal Creek during our study. Refer to the map in Appendix A for locations of previous and existing study sites. Refer to Table A-1 in the same Appendix to see a summary of prior studies relevant to this study and a summary of some of the restoration objectives and goals in the *Sausal Creek Restoration in Dimond Park* WMA restoration plan.

For each site, we studied a 100-foot section of the creek; for the Dimond Canyon site, we also recorded some measurements for a longer (640-foot) section.

3.2 Vegetation Survey: Dimond Canyon Site

To determine the success of the volunteer plantings, we first*reviewe* d the history of native and invasive vegetation at the site to determine which species were planted during the restoration and which species existed prior to the restoration. To *assess* the success of this project, we used the quadrat sampling method outlined in the restoration plan by WMA (WMA 2000). The quadrat method was used by FoSC to characterize the vegetation at the restoration site in Dimond Canyon (Paulsell 2003). Our vegetation survey performed at the Dimond Canyon site drew on both of these documents, and attempted to replicate most closely the methodology presented in the FoSC document.

We surveyed a 100-foot section of the left bank of the creek above El Centro Avenue since the volunteer plantings were only done on that side of the bank. The right bank was covered with cape ivy and Himalayan blackberry.

After determining the lack of significant longitudinal vegetation zones along the left bank, we laid a baseline down the path along this 100-foot section and placed six transects down to the creek at every 20 feet. Following the methods described in the FoSC draft document, we placed a wooden frame quadrat one square meter in size at the midpoint of each transect. At each quadrat, we estimated the percent of the area covered by each species and the percent of bare ground. "Bare" ground, for the purposes of our study, meant ground area not covered by live plants, but included ground covered by dead plants, wood chips, logs, and rocks. We also counted all the plants growing within the quadrat. Since plants may overlap, the results of the percent coverage determination can equal more than 100 percent.[2] Plant cover that overlapped from plants growing outside the quadrat was included in our coverage statistics.[3] No trees were rooted in any of our quadrats, so we did not include tree cover (overstory) in our calculation of coverage, but confined ourselves to an assessment of understory vegetation.

[2] Estimating plant cover is subjective, so different observers may get very different results; some studies have found that the margin of error is about 20 percent (Paulsell 2003).
[3] Plants may overlap the quadrat from outside the frame, so a plant may contribute to percent cover but not be included in the second calculation (the count of plants growing within the frame).

We also compiled a list of all plant species identified in our site area, as shown in Table B-1 in Appendix B.

3.3 Habitat Quality Assessment (EPA Rapid Bioassessment Protocol)

To evaluate the overall habitat conditions for each of our three sites, we used the US EPA's Rapid Bioassessment Protocols for habitat assessment. Application of this method can help determine if a stream is supporting or not supporting a designated aquatic life use. Application of this method can also help determine in what way, if any, stream habitat is impaired, and which stream features contribute to or detract from overall habitat quality. Features assessed included the presence and frequency of pools, riffles, and runs; the amount of apparent sediment deposition; and bank stability.

3.4 Creek Channel Physical Characteristics

We measured longitudinal profiles and cross-sections for each of our three study sites. For details of our surveying methods, refer to Appendix C. For the two upstream sites in Joaquin Miller Park, we measured a longitudinal profile of approximately 100 feet for each site. For the Dimond Canyon site, we estimated elevation at 220 feet, from the Oakland West USGS Quad map. For this site, we determined a longitudinal profile of approximately 640 feet, starting from the bridge and culvert at El Centro Avenue and measuring northwards. The location at which we surveyed our cross-section at the upstream sites was approximately at the mid-point of the 100-foot sections; at the Dimond Canyon site, we located our cross-section at approximately the halfway point of a 100-foot section in the middle of the 640-foot section. See Figures 2, 3 and 4 for these longitudinal profiles and cross-sections. For each site, we mapped channel and vegetation characteristics, and for the Dimond Canyon site and the confluence site, we mapped instream features such as pools, runs, and riffles (see Figures 5, 6 and 7) and measured flow rates. We did not map pools, runs and riffles for the upper Palo Seco site because it was dry.

At the Dimond Canyon site and the Palo Seco confluence site, we measured flow rates using the "orange peel" method. We did not measure flow rates at the upper Palo Seco Creek site because there was no water present. For the channel flow measurements, we measured velocity in feet per second, and then adjusted our result by a factor of 0.8 to reflect the expected difference between surface velocity and average column velocity. This number was then multiplied by an estimate (in square feet) of the cross-sectional area of flowing water. The flow rate was then calculated from these measurements.

3.5 Channel Grain Size and Instream Habitat

The pebble count method is used to characterize the stream substrate by measuring the variability of particle size in the substrate (Kondolf 1997; Flosi et al. 1998: Q18). At each site we did a pebble count of the channel bed, using the pebble count method described by Kondolf (1997). We randomly selected 100 pebbles throughout each 100-foot reach and recorded their sizes in grain size classes, ranking pebbles according to the lower end of the spectrum for each class size. The sampler averted her eyes and moved her finger downward towards the creek bed until a pebble was encountered. Each pebble was measured on the middle axis, as specified by the method. The cumulative percent composition for each reach was then graphed and the mean diameter, D50, was used to describe the mean bed material.

3.6 Water Quality: Benthic Macroinvertebrates

At the wet sites (Dimond Canyon and the Palo Seco confluence site), we collected a sample of 100 benthic macroinvertebrates, following the EPA's Rapid Bioassessment Protocol (Barbour et. al. 1999) to assess the health and water quality of each stream section. The upstream Palo Seco site was dry, and we did not collect benthic macroinvertebrates at this site. At the two sites with water running in the stream bed, we focused our sampling efforts primarily on the riffle sections, which provide more habitat for benthic macroinvertebrates (Barbour et. al. 1999). We used our feet for the "kick method" of disturbing the substrate and rocks. We held a net downstream after rocks and sediment were disturbed, to collect the macroinvertebrates. The contents of the net were then emptied into a bucket with stream water from the site. We then sifted through the contents for the benthic macroinvertebrates and identified each macroinvertebrate according to order on site, preserving unknown specimens in 70 percent ethanol solution for later identification in the lab.

4.0 Results and Discussion

In evaluating our results, we assessed whether conditions at the Dimond Canyon site indicate, either directly or indirectly, that the restoration designed by WMA has achieved some measure of success since implementation.

4.1 Comparison of Dimond Canyon Volunteer Restoration and Results of Vegetation Survey

Prior to the volunteer plantings, FoSC assessed the existing conditions of the riparian vegetation (FoSC 2003).[4] The pre-project conditions indicated that *Equisetum spp.*, the only native species recorded at the site, represented less than one percent cover while the remainder

[4] FoSC used a different methodology to assess existing conditions than to assess success of the riparian plantings. For existing conditions, FoSC estimated percent cover characteristics by using 15 quadrats. Each quadrat was 8.5 ft^2.

of the project site consisted of bare ground (18.75 percent cover), Algerian ivy (33 percent cover), Himalayan blackberry (20 percent cover), and other less prevalent invasive species. The post-planting vegetation assessment (reported in draft form) by the FoSC indicated that the cover for the riparian area of the site consisted of approximately 45 percent bare ground, 41 percent native species, and 14 percent invasive species.

The species which appeared in our quadrats are listed in Table 1, below.

Table 1. Plant Species Appearing in Quadrats

Common Name	Scientific Name	Native/Invasive	Number of Plants	Percent Cover
Annual grass (Fescue/*Festuca californica*?)		unk	1	0.17
Arroyo willow	*Salix lasiolepis*	N	2	0.67
Unk aster (Aster radulinus?)[a]		unk	1	0.17
Mustard	*Brassica sp.*	I	1	0.17
Bull thistle	*Cirsium vulgare*	I	1	0.17
California blackberry	*Rubus vitifolius*	N	3	0.56
Cape ivy	*Delairea odorata*	I	0	0.17
Coyote bush	*Baccharis pilularis*	N	3	10.5
Horsetail	*Equisetum spp.*	N	47	19.95
Himalayan blackberry	*Rubus discolor*	I	7	18.17
Coast live oak	*Quercus agrifolia*	N	1	0.17
Mugwort	*Artemisia douglasiana*	N	1	0.17
Common nightshade	Solanum americanum	N	8	4.72
Ribes spp.[a]	*Ribes spp.*	N	4	0.67
Unk sticky weed (Coast tarweed/*Madia sativa*?)[a]		unk	7	7.22
Yarrow	*Achillea millefolium*	N	1	0.17

NOTES
Unk = Unknown
[a] = Some species difficult to identify outside of blooming season

Table 2 provides a summary of the percent native species, percent invasive species, and percent bare ground represented by all of our quadrat sampling sites, and compares these results with previous results.

Table 2. Percent Cover in Vegetation Sampling Quadrats

Composition	Percent Cover		
	Pre-restoration Results[a]	FoSC Results 2003[b]	Study Results
Native Species	<1.00	41.07	37.56
Invasive Species	81.24	13.67	18.67
Unknown	NA	0.70	7.72
Bare Ground	18.75	44.47	32.17
Total	**~100.00**	**99.91**	**96.11**

[a] = As reported by FOSC 2003
[b] = Results for riparian area

We used the Simpson Diversity Index to measure diversity within the native plant populations. The formula is:

$$\text{Diversity} = \sum(n/N)^2$$

where n is the total number of individuals of a particular species, and N is the total number of individuals of all species. The proportion of one species relative to the total number of plants is calculated, and that number is squared, for all plant species counted in the quadrat. The sum of squared percentages for all plants yields the diversity value. With this index, 0 represents infinite diversity and a value of 1.0 represents no diversity; a lower value indicates greater diversity. Our diversity statistic only includes native plant cover. Our results are presented in Table 3, below.

Table 3: Diversity Index Values, Riparian Area, Sausal Creek Site

	Number of Native Species	Number of Native Plants	Diversity
Study Results	*9*	*70*	*0.47*
FOSC 2003 Results	*42*	*965*	*0.23*

The results of our survey may show an increasing proportion of invasive species in the project area compared to the results from the previous survey conducted by FoSC. Compared with the pre-restoration cover calculations that showed a percent cover for native species of less than one percent, however, our results did show that native species were much more strongly represented at the site. The percent bare ground we measured was greater than that for pre-restoration conditions, but this is not an unusual result for a relatively recently completed restoration project.

In comparing our results with the results from the draft report by FoSC, we show a much lower value for the Simpson's diversity index – the value of the index calculated by FoSC yielded a value of 0.23. Our calculations may indicate that native plant species diversity at the site has significantly decreased since the previous data was collected. This conclusion would be consistent with our determination that invasive species have become more abundant at the site since the previous study.

Although our results may indicate that invasive plant species are increasing in cover at the site, and native plants are decreasing both in terms of cover and diversity compared to the results from the previous FoSC study, these results are for a relatively small area along a 100-foot section of the creek. The previous study took place in a much larger area, and more samples were taken. Although we increased the number of quadrats per area sampled and believe that our results are adequate in describing the characteristics of vegetation at the site, the accuracy of our results would probably have been improved if the sampling effort took place over a larger area, with a higher number of quadrats, as for the previous FoSC study. In addition, seasonal variations (we conducted our survey in October; the FoSC conducted theirs in May) may have resulted in fewer native plants at the site, making it seem as though invasive species are significantly increasing in abundance.

The original goals and objectives in the WMA plan for restoration of native riparian vegetation at the site including creating a vegetative buffer between the trail and the stream, and reducing the population of invasive vegetation to less than 10 percent cover over the total area of the site. Our vegetation survey showed that a vegetative buffer does exist at the site between the trail and the stream; our measured percent cover of invasives in our study area of about 19 percent, however, is still higher than the 10 percent goal in the WMA plan. The successful establishment of native vegetation at the site, such that the existing percent cover for natives is approximately 38 percent, however, is still a considerable achievement, and indicates excellent progress towards the goals of the WMA plan, given that the pre-restoration percent cover for native species was less than one.

4.2 Habitat Quality: EPA Rapid Bioassessment Protocol

Some representative results of our habitat assessment, as well as a summary of the overall assessment for each site are discussed below and presented in Table 4, below.

Table 4: Representative Results of Habitat Assessments[a] for Each Creek Study Site

	Site		
Habitat Parameter	Upper Palo Seco	Palo Seco Confluence	Dimond Canyon
Water Quality Observed	Good	Good	Good
Primary Inorganic Substrate Type	Cobble, gravel	Boulder	Gravel
Pool Variability	NA	Poor	Poor
Sediment Deposition	NA	Low	Moderate/low
Bank Stability (right and left)	Good/Marginal	Good	Good
Vegetative Protection	Excellent	Excellent	Moderate/Good
Tree Canopy Cover	Shaded	Partly Open	Partly Shaded
TOTAL HABITAT SCORE	0.625[b]	0.645	0.640

a = Based on in-field physical characterization/water quality habitat assessment using the EPA Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers
b = Does not include individual scores for pool substrate characterization and pool variability, which both received a score of zero.

The table shows that, in general, habitat quality across all three sites was relatively good. Certain habitat features, such as low or nonexistent pool depth and variability, were consistent across all three sites. In general, the upstream sites had slightly higher habitat quality than the Dimond Canyon site – the total habitat quality score for the upper Palo Seco site was 0.625, and the total score for the Palo Seco confluence site was 0.645, whereas the total score for the Dimond Canyon site was 0.640. These slight differences in overall habitat quality scores may or may not be significant, given the inherent variability in this measurement method.

Field sheets, which show each stream feature studied and scores for each of the three sites, are also included in Appendix D.

4.3 Comparison of Dimond Canyon Site with Upstream Sites

4.3.a. Upper Palo Seco Creek. This site is located in the upper portion of Palo Seco Creek, in Joaquin Miller Park, upstream of any culverts or stormdrains. This site is dry this time of year, and was dry on the day of our site visit; we were, however, able to collect all data but the flow rate and benthic macroinvertebrate data. (Following the rains in early November, however, some water was observed above ground just downstream of the section we examined.) This creek ran through an area populated by redwoods, and through a canyon bounded on both sides by steep banks. Trees identified at this site included Coast redwoods, California bay, and white alders. The tree canopy was closed, shading this reach of the creek.

Compared to the Sausal Creek site in Dimond Canyon, the creek bed for the upper Palo Seco site was broad, and its slope was more steep (Figure 2). The bed contained large and embedded pebbles. We observed the effects of sediment deposition. The creek bed appeared to meander somewhat. Following some of the rain in early November, we observed some redwood debris collecting at particular areas along the creek.

4.2.b. Palo Seco Creek Confluence Site. The site at which the two branches of Palo Seco Creek converged showed a clearer riffle-run and step-pool sequence, with a drop in elevation of the creek bed that was the most pronounced of the three sites.

4.3.c. Dimond Canyon Site. The Dimond Canyon site is located in a canyon with steep slopes and a fairly open tree canopy. The zone of riparian vegetation on the left bank is characterized by diverse native plantings installed by the FoSC volunteers and invasive vegetation. Vegetation on the right bank is characterized by thick growths of Algerian ivy and Himalayan blackberry and some trees, many of which are becoming overpowered by the vine plants. Charbonneau and Resh (1992) note that previously culverted urban streams tend to lack a natural pattern of riffles and pools; that, in fact, they tend to have shallow pools because of sediment deposition. The 100-foot reach we selected did meander but did not show a significant natural pattern of pools and riffles. We did not observe any gullies or signs of significant erosion along this reach.

4.3.d. Channel Flow Measurements. The calculated flow rates for the two sites with water, the Palo Seco confluence site and the Dimond Canyon site, are shown below in Table 5. The flow rate for the Dimond Canyon site was somewhat faster than the Confluence site, although the adjusted velocity for the Palo Seco confluence site was greater than for the Dimond Canyon site.

Table 5: Flow Measurements

Study Site	Adjusted Velocity (ft/s)	Cross-sectional Area of Flowing Water (ft^2)	Flow Rate (cfs)
Palo Seco Creek Upstream	No water		
Palo Seco Creek Confluence	9.76	0.6	5.86
Sausal Creek Dimond Canyon	8.56	1.2	7.70

Measurement method was the floating object method. Adjusted velocity was the average of 10 measurements taken, adjusted by a factor of 0.8.

4.4 Channel Grain Size and Instream Habitat

A chart displaying the results of our pebble count is included in Appendix E. The D50 or mean diameter is 43.93, 46.88, and 25.86 for the upper Palo Seco, Palo Seco confluence, and Dimond Canyon sites, respectively, as shown in Table 6 below. The median for the two upstream sites, i.e. the class size that 50 percent of the pebbles fall into is 22.6. For the Dimond Canyon site, the median class size is 11.30. Looking at the graphs, the Palo Seco confluence site had the largest number of class sizes. The Palo Seco confluence site had a similar median but a different mean when studied in 1999 by Lacan et. al., as shown below in Table 7.

Table 6: Pebble Count Results

	Palo Seco	Confluence	Dimond Canyon
Mean	43.93	46.88	25.86
Median	22.60	22.60	11.30

Table 7: Comparison of 1999 Pebble Count Results at the Same Location

	Palo Seco (Upstream) Site (1999 Lacan et. al. Study)	Palo Seco Confluence Site (2003 Study)
Mean	9.65	43.93
Median	20.36	22.60

4.5 Water Quality: Benthic Macroinvertebrates

The results of our benthic macroinvertebrate studies are presented below in Tables 8 and 9.

Table 8: Number Benthic Macroinvertebrates Collected at Each Site

Order	Palo Seco Confluence Site	Dimond Canyon Site
Plecoptera	17	10
Ephemeroptera	31	19
Hemoptera	3	
Trichoptera	7	
Diptera	15	35
Coleoptera	5	5
Odonata	5	
Megaloptera	2	
Planaria	0	33
Oligochaetes	15	4
Gastropods	3	11
Crustacea	0	18
TOTAL	**103**	**135**

Table 9: Percent Benthic Macroinvertebrate Orders Represented at Each Site

Order	Palo Seco Confluence Site	Dimond Canyon Site	Percent Difference
Plecoptera	16.50	7.41	9.10%
Ephemeroptera	30.10	14.07	16.02%
Hemoptera	2.91	0.00	2.91%
Trichoptera	6.80	0.00	6.80%
Diptera	14.56	25.93	-11.36%
Coleoptera	4.85	3.70	1.15%
Odonata	4.85	0.00	4.85%
Megaloptera	1.94	0.00	1.94%
Planaria	0.00	24.44	-24.44%
Oligochaetes	14.56	2.96	11.60%
Gastropods	2.91	8.15	-5.24%
Crustacea	0.00	13.33	-13.33%
TOTAL	**100**	**100**	

Charbonneau and Resh (1992) note that more families of benthic macroinvertebrates exist upstream than downstream. The orders downstream would be assumed to be less sensitive to pollution since greater urbanization and runoff would cause the water to be more polluted (Charbonneau and Resh 1992). Although the order classification is a rough way, at best, to indicate and compare water quality, some comparison between the sites can be made. The Palo Seco confluence site had more than twice as many stoneflies (*Plecoptera*) as the Dimond Canyon site, which was to be expected since *Plecoptera* are more sensitive to pollution. Likewise, although the confluence site had 0.0 percent scuds (*Crustacea*), the Dimond Canyon site had 13.33 percent scuds – scuds are more tolerant to pollution (California Streamside Biosurvey September 2001). Results of the benthic macroinvertebrate study at the Dimond Canyon site, however, show that this area is still fairly unpolluted, and the ecosystem fairly healthy.

5.0 Conclusions and Recommendations

This research directly measures the success of the volunteer restoration plantings by comparing the results of an on-site vegetation survey with the goals and objectives from the WMA plan (refer to Appendix A). This study also indirectly measures many of the specific restoration objectives in the WMA plan by using specific parameters , i.e. habitat quality, channel form (especially the presence of a clear pool and riffle sequence), bank stability, water quality, and native riparian vegetation.

Using several criteria to characterize the channel condition and to evaluate the performance of the Sausal Creek in Dimond Canyon volunteer restoration project (in-stream and riparian habitat, vegetation cover, and geomorphological characteristics), we concluded 1) native plant percent cover and overall riparian plant diversity has increased since the restoration activities took place at the site, 2) the lack of erosion along the creek banks and the meandering creek form suggest that incising has stopped; and 3) the lack of a clear pool-riffle pattern along our study reach in Dimond Canyon suggests that it may yet be too early to see a developed pool-riffle at the site, since the WMA restoration project is only two and a half years old. Alternatively, this lack of a clear pool-riffle sequence may be because the creek may have experienced some sediment deposition, possibly from a site upstream where a great deal of vegetation was removed to reduce fuel load, leaving bare ground. Future studies might help determine whether sediment deposition has taken place in this area of the creek.

Although an urban creek can never be considered an undisturbed, pristine habitat, the section of Sausal Creek in Dimond Canyon that we studied seems to have shown an improvement in channel conditions and an improvement in riparian habitat since the restoration project. Future studies of this site as this relatively new restoration project ages will also help evaluate the success of this project.

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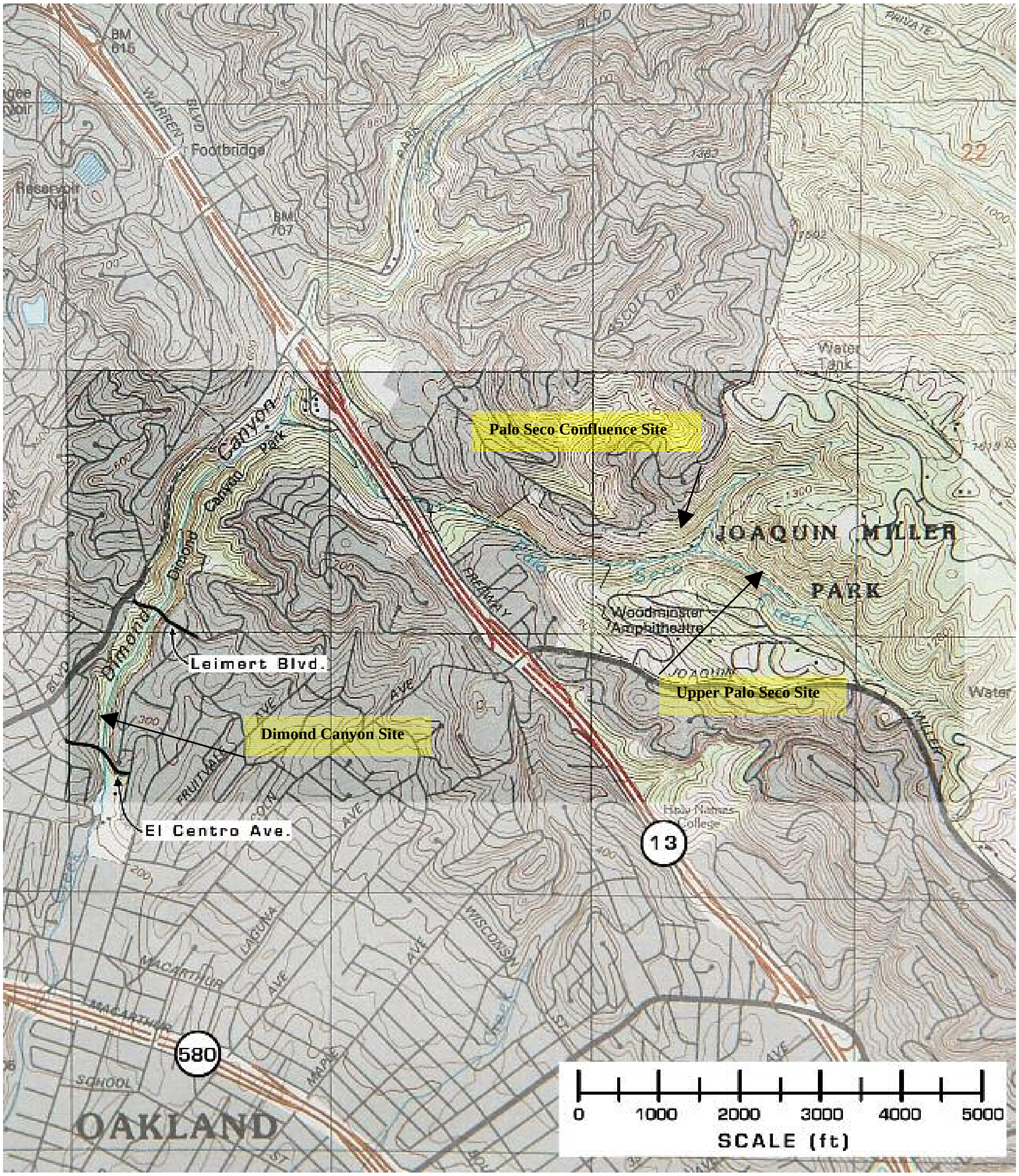


Figure 1: Site Location Map

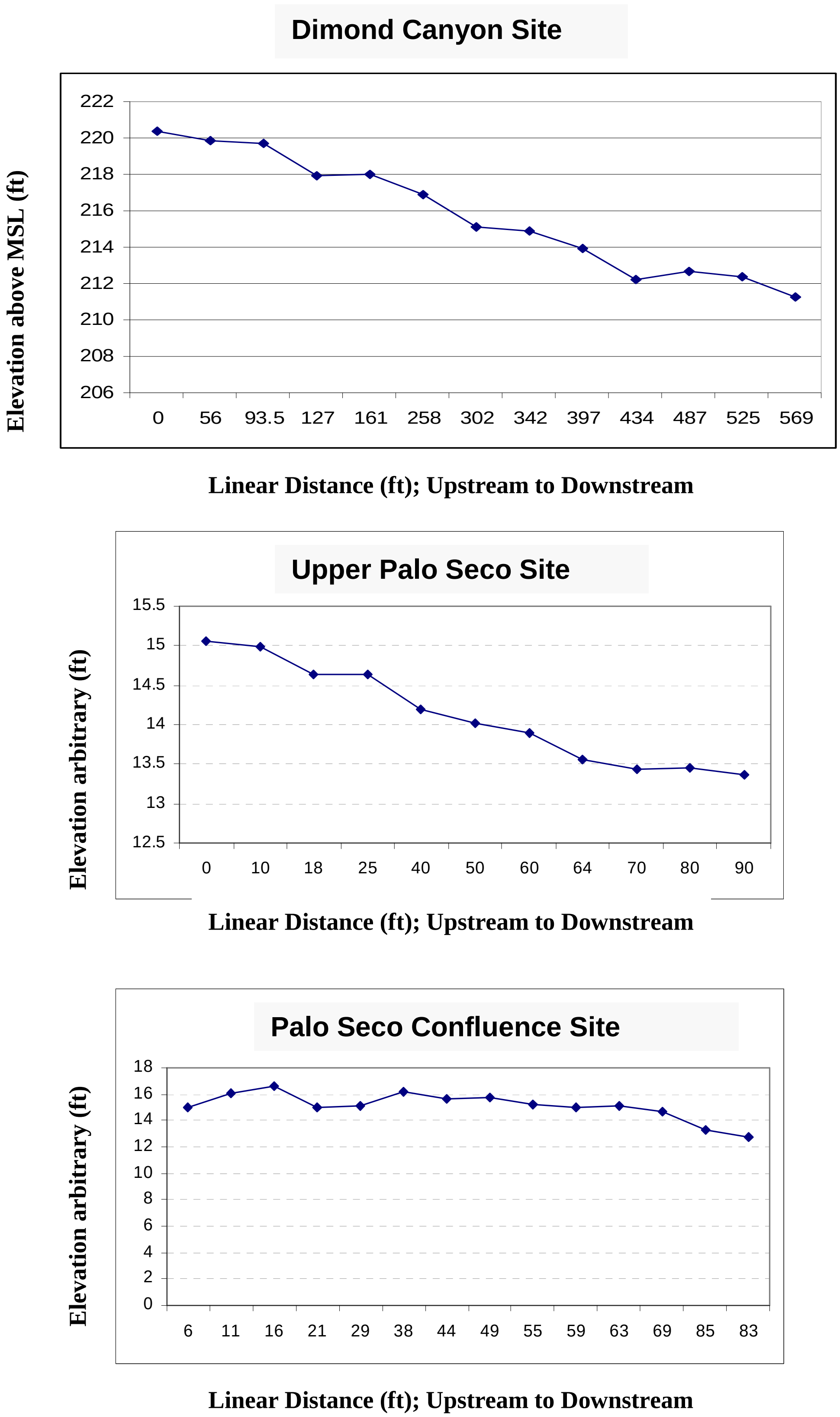
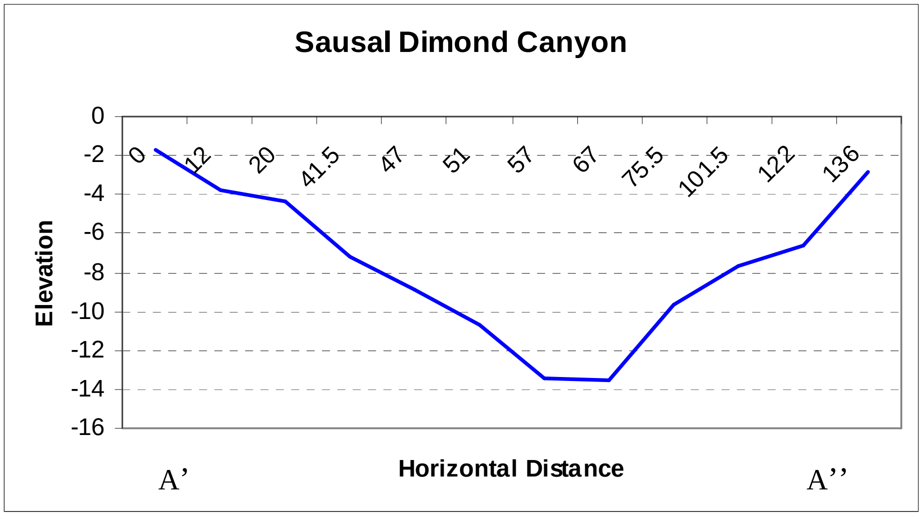
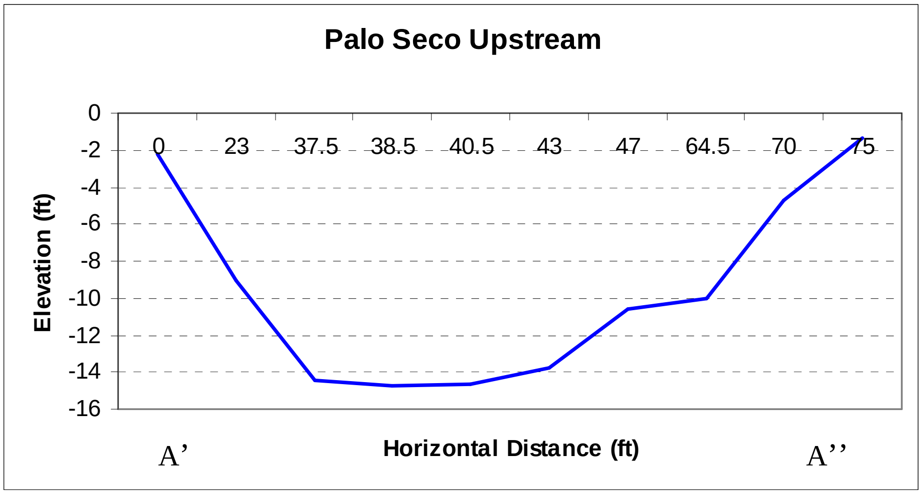


Figure 2: Longitudinal Profiles of Study Sites at Dimond Canyon, Upper Palo Seco Creek, and Palo Seco Creek Confluence





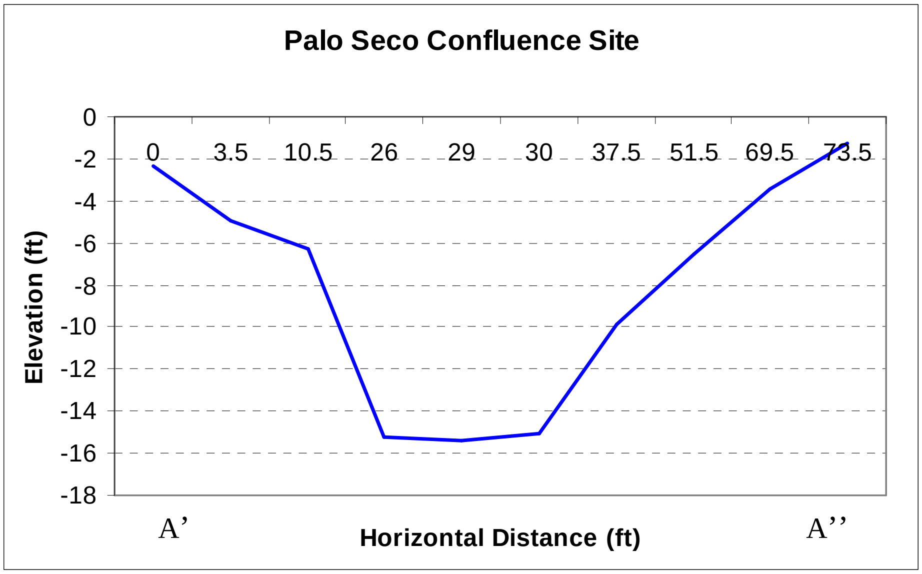


Figure 3: Cross-Sections of Study Sites at Dimond Canyon, Upper Palo Seco Creek, and Palo Seco Creek Confluence

Figure 4: Map of Long Profile of Sausal Creek Site, Dimond Canyon

Figure 5: Map of Study Site at Sausal Creek, Dimond Canyon

Figure 6: Map of Study Site at Upper Palo Seco Creek, Joaquin Miller Park

Figure 7: Map of Study Site at Palo Seco Creek Confluence Site, Joaquin Miller Park

8a. Culvert at El Centro Avenue (View downstream, to the South) *8b. View Upstream from Culvert (to the North)*

8c. View Downstream

8d. Ivy on Right Bank

Figure 8. Site Pictures, Sausal Creek, Dimond Canyon


9a. Pool


9b. Stream Channel, Riparian Vegetation


9c. Path and Restored Riparian Vegetation, Left Bank


9d. Riparian Vegetation

Figure 9. Site Pictures, Sausal Creek, Dimond Canyon

10a. View from Bridge Upstream (to the East)

10b. View Upstream from Location of Cross-Section

10c. View Downstream (to the West)

10d. View Downstream at Location of Cross-Section

Figure 10. Site Pictures, Upper Palo Seco Creek Site

11a. Looking downstream from path above

11b. Looking downstream

11c. Shallow pool

11c. Boulders and riffle/run

Figure 11: Site Photos, Palo Seco Confluence Site

Appendix A: Summary of Previous Studies and Reports, Sausal Creek in Dimond Canyon

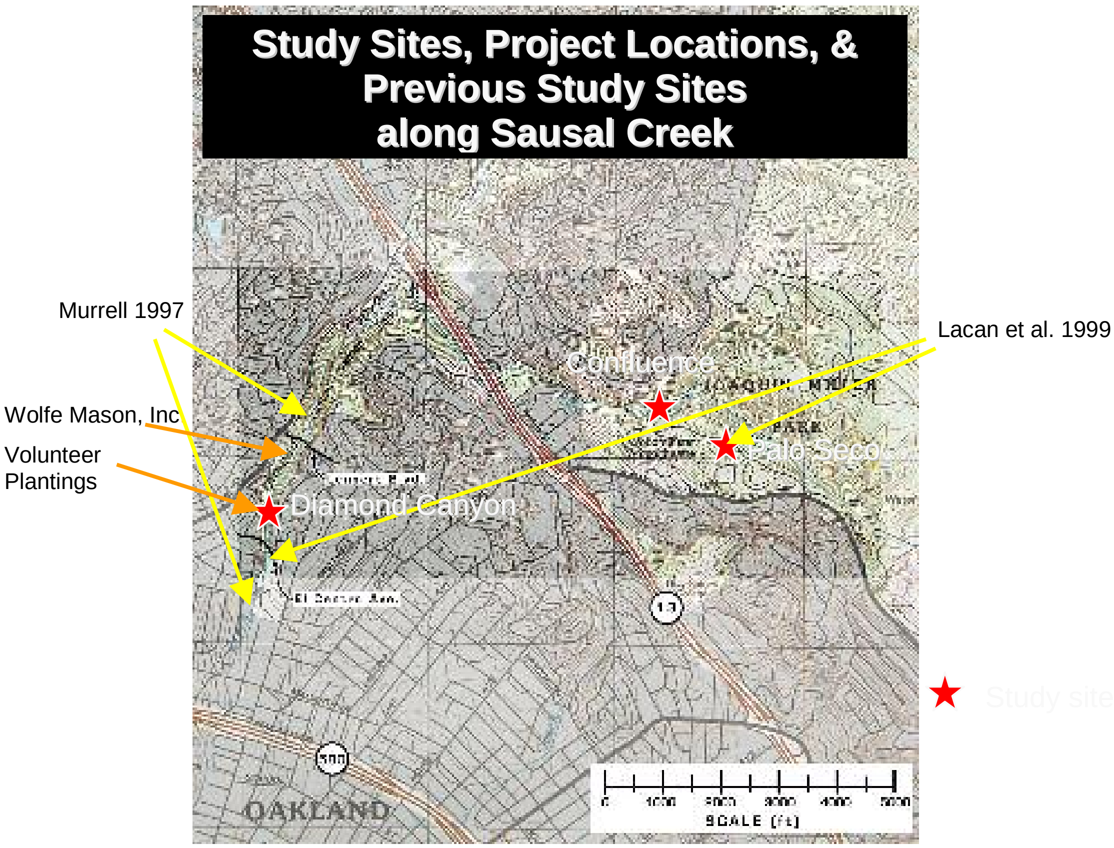


Table A-1. Summary of Previous Studies of Sausal Creek

Date	Report
1997	Diana Murrell, "Comparing More and Less Developed Portions of an Urban Stream: Upper and Lower Reaches of Sausal Creek, Oakland, California"
	Areas Studied: Upper reach: wooded portion of Dimond Canyon Park/1,500 feet from a culvert below the confluence of Shepherd Creek and Palo Seco Creek Middle reach: developed eastern end of Dimond Canyon Park/300 feet from the Wellington Street entrance to a culvert Lower reach: higher-density residential-commercial area/from the top of bank at the end of Blossom Street
	Findings/Conclusions: "Hydrologic problems include incision, bank erosion, undercutting of concrete bed liners, and side-cutting of upstream drop structures. Biotic problems include increasing presence of exotic species as one moves downstream, and a dearth of wildlife due in part to leaky sewer lines upstream. The major aesthetic problem, trash, ranges from snack wrappers and large metal objects to toxic household wastes downstream." (p. 7)
1999	Igor Lacan, Bill Eisenstein, and Mike Soules, "Hydrological and Ecological Assessment of Sausal Creek: Physical Setting, Habitat Quality, and Benthic Diversity in an Urbanized Watershed"
	Areas Studied: First site: Joaquin Miller Park/Second-growth redwood grove along Palo Seco Creek Second site: Dimond Canyon Park/downstream of the confluence of Palo Seco Creek and the more urbanized Shephard Creek Third site: Hickory Court/250 feet downstream from major culvert
	Findings/Conclusions: "The comparison between these sites showed that the increase in relative levels of urbanization as one moves downstream is associated with a clear decline in the diversity and integrity of the benthic macroinvertebrate community…we conclude that the increased speed and volume of runoff resulting from urbanization, evidenced in the channel survey data, is a major factor in this ecological deterioration." (Abstract)
2003	Karen Paulsell (for the FoSC), "Sausal Creek Revegetation Project Understory Monitoring" (DRAFT)
	Areas Studied: The restoration area in Dimond Canyon approximately 1,400 feet long (varying in width), starting at El Centro Avenue and running northward along the east side of the creek
	Findings/Conclusions: "Overall, the FoSC revegetation effort is doing very well at restoring plant cover. The understory has gone 'from 0 to 50' percent cover in the 18 months from the initial planting to the date the survey was performed." (p. 13)

Goals of WMA Restoration Plan

The WMA plan for the restoration of a portion of Sausal Creek in Dimond Canyon was implemented between 2000 and 2002. Some of the initial objectives and goals of the WMA Restoration Plan for the Dimond Canyon site included the following (WMA 2000):

- Habitat improvement. The restored channel would establish riffle/pool sequences that provide habitat for aquatic wildlife. In addition to shading the creek, native (watershed-specific) riparian revegetation efforts would increase overall plant species diversity, which in turn increases wildlife habitat and foraging potential.
- Sediment transport re-establishment. The restored channel would provide improved sediment transport throughout the restoration reach and to healthy reaches directly downstream. Over time this would directly benefit structural elements of the creek such as gravel bars which are important habitat for insects and other aquatic wildlife.
- Long-term bank stability. By addressing the on-going conflicts between the creek and trail alignment through site and resource analysis, planning and design, the restoration will alleviate erosion and water quality issues along the restoration reach and downstream.
- Improved water quality. Native riparian buffer zone planting would act as a filter, reducing runoff to the creek from the trail and valley slopes. Rock falls would increase oxygenation of water.

- The WMA plan also includes two objectives specific to the establishment of native riparian vegetation at the site:
- Reduce the population of invasive non-native vegetation so that no mature individuals remain following project completion and the future total cover of seedlings reaching maturity is less than 10 percent of the total area of the site, and
- Create a vegetative buffer between the trail and stream in order to minimize disturbance to the riparian corridor.

Appendix B: Plant Species Information

Table B-1: Plant Species Identified At Dimond Canyon Site

Common Name	Scientific Name
Native Species	
Box elder	*Acer negundo var. californicum*
California bay	*Umbellularia californica*
California blackberry	*Rubus ursinus*
California fescue	*Festuca californica*
California fuschia	*Epilobium canum ssp. canum*
Carex Sedge	*Carex sp.*
Common rush	*Juncus sp.*
Coffee berry	*Rhamnus californica*
Creek dogwood	*Cornus sericea ssp. sericea*
Gumweed	*Grindelia hirsutula var. hirsutula*
Morning glory	*Calystegia purpurata ssp. purpurata*
Mugwort	*Artemisia douglasiana*
Ninebark	*Physocarpus capitatus*
Red alder	*Alnus rubra*
Red willow	*Salix laevigata*
Sticky monkeyflower	*Mimulus aurantiacus*
White alder	*Alnus rhombifolia*
Invasive/Nonnative Species	
Acacia	*Acacia spp.*
Anise	*Pimipnella anisum*
American elm	*Ulmus Americana*
Mustard	*Brassica sp.*
Bull thistle	*Cirsium vulgare*
Cape ivy	*Senecio mikanioides*
English ivy	*Hedera helix*
Mallow	*Malva nicaeensis*
Unknown	
Aster	*Aster spp.*
Five finger fern	*Adiantum aleuticum*
Lady fern	*Athyrium filix-femina*
Nettle	
Teasel	

Appendix C: Surveying Methods

<u>Distance from Instrument</u> - This calculation yields the horizontal distance between the surveyor's level and the surveyed location. The distance from the instrument is simply calculated by subtracting the low stadia intercept from the high. Each hundredth foot on the rod represents, when viewed through the level, one fool of horizontal distance. For instance, a high stadia intercept of 15.5 and a low stadia intercept of 14 measures a horizontal distance from the instrument of 150 feet.

<u>Instrument Height</u> - The instrument height was measured by shooting a point of known elevation, then adding the value of the middle stadia intercept viewed with the rod on the point of known elevation. The plane observed through the leveled surveying instrument is a fixed distance above this known elevation.

<u>Benchmark Elevation</u> - The center of the northern edge of the bridge was selected as the project benchmark, as it could be identified on the USGS topographic map with relative certainty. The approximate elevation of this project benchmark was taken from the USGS base map. Three temporary benchmarks, or turning points, were used during the creek survey. At least two of these points were shot from each station to ensure accurate calculation of turning point elevation. All turning points were related to the concrete bridge project benchmark.

For example, from the topographic map, the project benchmark (the point on the bridge) was determined to be 150 feet above mean sea level (msl). The instrument elevation at Station C was therefore 155 feet above msl, as the middle stadia intercept when shooting the bridge from this station was 5. The elevation of Temporary Benchmarks 2 and 3 were calculated to be 147.3 and 146 feet above msl, by subtracting the stadia elevation recorded at each of these two points from the calculated instrument height (155).

The process was repeated at each successive survey station. One of the two previously surveyed benchmarks was assumed to be at the elevation surveyed from the previous station. The other benchmark was shot from the new station and this elevation re-calculated for quality assurance. If the re-calculated elevation was the same as the elevation measured relative to the project benchmark at the previous station a successful turn was confirmed.

Appendix D: Habitat Quality EPA Rapid Bioassessment Protocol Field Sheets

Appendix E: Pebble Count Results: Class Size Distribution Chart