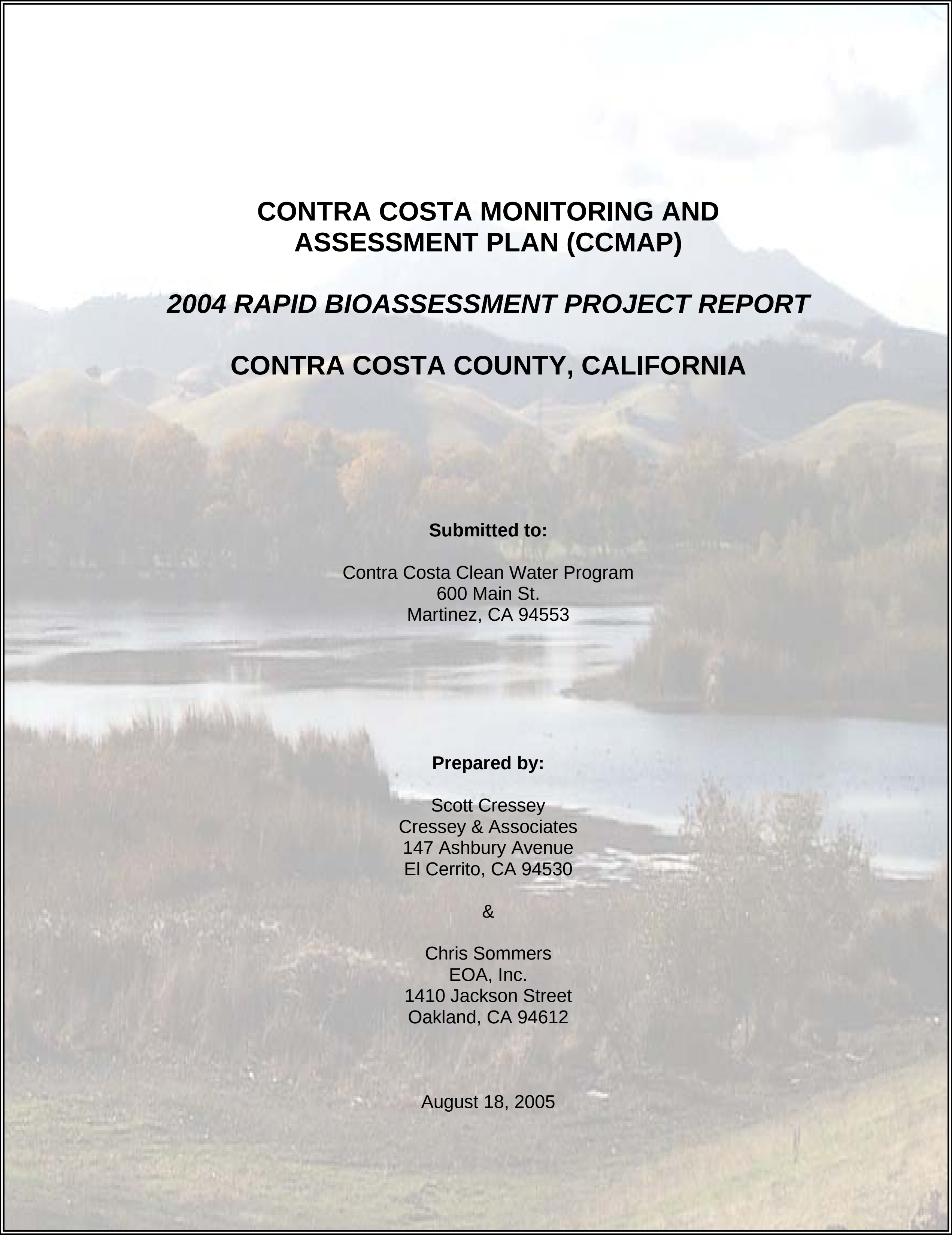

CONTRA COSTA MONITORING AND ASSESSMENT PLAN (CCMAP)

2004 RAPID BIOASSESSMENT PROJECT REPORT

CONTRA COSTA COUNTY, CALIFORNIA

Submitted to:

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Preface

The Contra Costa Clean Water Program (Program) initiated a water quality monitoring and assessment plan (Contra Costa Monitoring and Assessment Plan) within Alhambra Creek, the Program's pilot watershed in 2001. The Program contracted Scott Cressey of Cressey & Associates in 2002, 2003 and 2004 to assist in preparing the work plan for, and ultimately the implementation of, a study to conduct rapid bioassessments on Las Trampas Creek, Refugio Creek, Rodeo Creek, Edwards Creek and Lower Marsh Creek. The California Stream Bioassessment Procedure (CSBP) protocols for Non-point Source Design were followed during all years.

This project was overseen and managed by Chris Sommers (EOA Inc.), Monitoring Program Project Manager for the Program. Mr. Sommers worked closely with Cressey & Associates to apply his expertise bioassessment to study design and data analysis, and was also responsible for the critical review and edits to the draft reports.

Executive Summary

In April 2001, the Contra Costa Clean Water Program (Program) initiated a water quality monitoring and assessment plan within Alhambra Creek, the Program's pilot watershed. The Contra Costa Monitoring and Assessment Plan (CCMAP) is a long-term strategy designed to assess the conditions of watersheds, water bodies, and water quality within Contra Costa County (County). To properly assess the biological integrity of streams and the "health" of watersheds in Contra Costa County, the Program adopted the State of California and Environmental Protection Agency (EPA) recognized California Stream Bioassessment Procedure (CSBP) developed by the California Department of Fish & Game's Water Pollution Control Department. The procedure uses benthic macroinvertebrate (BMI) community assemblages as the primary indicator of water quality and watershed "health".

Building on the successful bioassessments in 2001, 2002 and 2003, the Program continued to assess Contra Costa County water bodies in 2004. BMI sampling was conducted in the previously sampled Las Trampas Creek watershed, and in Refugio Creek, Rodeo Creek, Edwards Creek, Cerrito Creek and Lower/Middle Marsh Creek watersheds in 2004.

A non-random selection of sampling reaches associated with various drainages within the four watersheds resulted in the establishment of: five (5) BMI sampling sites in the Refugio Creek watershed; five (5) sites in the Rodeo Creek watershed; one (1) site in the Edwards Creek watershed; 11 sites in the Lower Marsh Creek watershed; and 12 sites in the Las Trampas Creek watershed. Sampling occurred in March and April 2004. Measurements of electrical conductivity, dissolved oxygen, temperature, and pH were recorded at each site during sampling. Qualitative assessments of physical habitat were also conducted following standard CSBP protocols. Using an established photo point, a photograph was taken of each site at the time of sampling.

Standard CSBP metrics were developed for the BMI sampling results. These metrics were then evaluated using: BMI Ranking Score, Percent Community Similarity, and Percent Dominant Organisms. These data sets led to the following preliminary observations:

<u>Refugio Creek Watershed</u>

- Compared to other watersheds in Contra Costa County, the Refugio Creek watershed has relatively low taxa richness. Throughout Refugio Creek, BMI communities were dominated by short-lived (< 1 year) organisms (i.e., chronomids and blackflies) and organisms that live in fine substrate (i.e., mud), and are moderately tolerant to pollution.

- Although at least 22% of the watershed is currently open space that is generally present in the upper watershed, BMI metrics and ranking scores do not appear to correlate with the degree of urbanization.

<u>Rodeo Creek Watershed</u>

- Compared to other watersheds in Contra Costa County, the Rodeo Creek watershed has relatively moderate to low taxa richness, ranging from 8 to 20 taxa. Similar to Refugio Creek, BMI communities throughout Rodeo Creek were dominated by short-lived (< 1 year) organisms (i.e., chronomids and blackflies) and organisms that live in fine substrate (i.e., mud), and are moderately tolerant to pollution.

- Of the five stations sampled on the mainstem of this creek and one of its intermittent tributaries, the uppermost station (ROD-5) was notable in having one chironomid taxa (orthocladiinae) comprise 86% of all organisms identified. Compared to other Contra Costa sampling stations, this is one of the highest percent dominant taxa recorded.

- ROD-5 had roughly 6-8 inches of newly deposited fine sediment covering most of the margins of the stream channel. Because of the new sediment inputs occurring at this uppermost station, it is suggested that this station continue to be monitored.

- The lowest ranking station on Rodeo Creek is the lowermost station at ROD-1. This is a channelized section of the creek at Viewpointe Road. Being lowest site in the watershed and subject to upstream contributions of urban and suburban runoff, the low ranking of this station is not surprising.
- The unnamed tributary represented by Station ROD-3 drains an open space area with minimal grazing. Although the substrate at this station averages 90% fines, this station still ranked the highest in quality among the five stations sampled on Rodeo Creek.

Edwards Creek Watershed

- Most of Edwards Creek through the city of Crockett is either in a concrete-lined channel or is culverted. Two stations were established on this creek for sampling, but flows at the uppermost station diminished before permission to access the property could be obtained. The lower station, located just downstream of the John Swett High School athletic field, had a good balance of various substrate sizes, but had a relatively low BMI diversity. Future sampling of both ED-1 and the upstream station will allow a comparison of the upper and lower ends of Edwards Creek.

Lower Marsh Creek Watershed

- Results suggest that mine drainage from the Diablo Mercury Mine may continue to effect BMI communities directly downstream. Although the discharge from the mine may not fully explain the reduction in biotic integrity a site directly downstream of the mine drainage, the effects of mine discharge from the Diablo Mercury Mine on water quality degradation and bioaccumulation of mercury in BMI communities have been documented. Therefore, we suggest continuing to monitor this site in future years.

- The lowest biotic integrity for all Marsh Creek sites was identified a short distance below Marsh Creek Reservoir. This impoundment may be discharging sufficient phytoplankton to the creek to cause the abundance of filter-feeding BMIs at this station.

Las Trampas Creek Watershed

- The uppermost site on Las Trampas creek had the highest biotic integrity of any site in the Las Trampas Creek watershed. One explanation may be high substrate complexity at this site.

- The lowest biotic integrity in the watershed was identified at the heavily urbanized sites on Las Trampas Creek.

- Biotic integrity decreased with elevation on Relize Creek.

- The specific conductivity of the water at RZ-3 was 1,310 uS/cm while the rest of the watershed had conductivities between 800 and 910 uS/cm. This measurement may support the theory that a spring enters the creek near or above RZ-3.

- Data collected in 2003 and 2004 appear to illustrate that changes are apparent in the BMI communities between adjacent sites in the Las Trampas Creek watershed. Therefore, it is recommended that the Program consider conducting additional studies in the following subwatershed areas to determine what stressors are causing observed changes in BMI communities from adjacent sites:

    - Land area between sites LT-6 and LT-5 (uppermost watershed); and,

    - Land area between station RZ-3 and RZ-2 (Reliez Creek mid-watershed).

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1.0 INTRODUCTION

In 2000, the Contra Costa Clean Water Program (Program) developed the Contra Costa Monitoring and Assessment Plan (CCMAP) to lead the Program's water quality monitoring and watershed assessment efforts. CCMAP is intended to satisfy the Monitoring Program Provision in each of the Program's Joint Municipal NPDES Permits (Permit). Permit provision C.8. issued by the San Francisco Bay Regional Water Quality Control Board, and Permit provision D.8. issued by the Central Valley Regional Water Quality Control Board. This strategy provides the Program with a working plan, designed to assess and monitor individual watersheds within Contra Costa County over time.

The CCMAP is designed to assess the conditions of water bodies within Contra Costa County (County). The CCMAP's initial goals include:

- Collecting baseline information necessary to identify and reduce and/or eliminate stormwater pollutants in the County;
- Developing a geographical information system (GIS) specifically designed to assess and characterize stormwater quality in the County; and,
- Providing a method to evaluate the effectiveness of control measures and Best Management Practices (BMP's) over time.

The CCMAP entails strategically selecting monitoring stations where physical, biological, and basic chemical data can be collected and analyzed. Field sampling includes conducting rapid bioassessments using benthic macroinvertebrate (BMI) assemblages and physical habitat assessments, to indicate the biological integrity and upstream sub-watershed "health" within a given watershed. Additionally, BMI assemblages, physical habitat assessments, and ambient chemical monitoring, provide a valuable screening device to determine where water quality and watershed health are degraded or have the potential for degradation.

This report discusses the results and findings of CCMAP field activities conducting in Fiscal Year 2003/2004. As background, the following sections provide brief overviews of the field activities conducted in previous years via CCMAP. The objectives of field activities conducted in FY 2003/2004 are also described.

1.1 RECENT CCMAP ACTIVITIES

1.1.1 Fiscal Year 2000/2001

In 2001, Alhambra Creek served as the Program's Pilot Watershed, where CCMAP's assessment methodologies could be evaluated. In May of that year, the BMI assemblages at 10 stations in the Alhambra Creek drainage were sampled using the California Stream Bioassessment Procedure (CSBP). During September 2001, fish communities were sampled at six of these 10 stations. The final report describing the methods and results is titled the *Alhambra Creek Watershed Rapid Bioassessment Pilot Project, Contra Costa County, California*, dated February 12, 2002. The report is on file at the Program's office in Martinez, California and is available upon request.

1.1.2 Fiscal Year 2001/2002

Building on the successful pilot project in Alhambra Creek in 2001, the Program expanded its efforts in 2002. CCMAP related activities for 2002 included a second year of characterizing BMI assemblages in Alhambra Creek, plus sampling the BMI assemblages of Pinole Creek, upper Kellogg Creek, and upper Marsh Creek. Due to the potential harmful effects of sampling on species of special concern (e.g., California red legged frog and steelhead), no fish sampling was conducted in 2002.

The final report for 2002 is titled the *Contra Costa Monitoring and Assessment Plan (CCMAP) 2002 Rapid Bioassessment Project, Contra Costa County,* dated March 17, 2003. This describes the study areas, methods employed for sampling and analysis, results of the BMI sampling effort, provides a data evaluation, and recommends next steps for the Program. The report is on file at the Program's office in Martinez, California and is available upon request.

1.1.3 Fiscal Year 2002/2003

During 2003, CCMAP related activities for Alhambra Creek were reduced to five stations and the BMI sampling conducted by citizen volunteers under the supervision of the County's fisheries consultant, Scott Cressey. A second year of characterizing BMI assemblages in Pinole Creek and upper Marsh Creek watersheds was also conducted. The stations in the upper Kellogg Creek watershed sampled in 2002 were reduced from four to two stations in 2003. These two stations were located on Mallory Creek, a tributary to Kellogg Creek. Additionally, the BMI assemblages of the Las Trampas Creek watershed were sampled for the first time in 2003. Because of the potentially harmful effects of sampling on species of special concern (e.g., California red legged frog and steelhead), no fish sampling was conducted in 2003. The final report, *Contra Costa Monitoring and Assessment Plan (CCMAP) 2003 Rapid Bioassessment Project, Contra Costa County,* dated February 18, 2004, is on file at the Program's office in Martinez, California and is available upon request.

1.2 FISCAL YEAR 2003/2004 STUDY OBJECTIVES

The Fiscal Year 2003/2004 Rapid Bioassessment Project was intended to reach the following specific objectives:

- To begin to characterize the "health" of the watersheds of Refugio Creek, Rodeo Creek, Edwards Creek, lower Marsh Creek, and Las Trampas Creek using BMI assemblages at strategically located sample stations;
- To incorporate "low gradient" BMI sampling protocols into the sampling program where stream gradient was less than 1 %;
- To begin to identify specific land uses and stressors that may be contributing to decreases in biological integrity and watershed "health";
- To prioritize sub-basins within Las Trampas Creek Watershed, allowing direction for future studies to better determine potential stressors to BMIs, including stormwater pollutants;
- To contribute valid data to a Bay-wide data set intended to characterize watershed "health" and possibly create an Index of Biological Integrity (IBI) in the Bay Area.

Figure 1. CCMAP watersheds, Contra Costa County, March - April 2004.

2.0 MATERIALS AND METHODS

2.1 STUDY AREA DESCRIPTION

The following sections provide brief descriptions of the watersheds sampled in Fiscal Year 2003/2004. Descriptions include information on drainage area size, channel characteristics, relevant municipalities, general land uses and the extent of the study area.

2.1.1 Refugio Creek Watershed

The Refugio Creek watershed (4.9 mi^2) is located in western Contra Costa County, within the city limits of Hercules (Figure 2). The watershed landscape is approximately 50 % impervious and the primary land uses are commercial/residential (below Refugio Valley Park); residential (mid-watershed); and open space/grazing (upper watershed). The Refugio Creek channel is approximately 4.4 miles in length, originates at an elevation of 522 feet and flows into San Pablo Bay. Roughly 83 % of the channel banks are currently natural, while 15 % are concrete-lined. Estimated mean daily flow is 4.2 cfs. The Refugio Creek study area consists of the full length of Refugio Creek from the west side of Interstate 80, upstream along Refugio Valley Road to residential housing east of the Hercules Middle/High School.

2.1.2 Rodeo Creek Watershed

The Rodeo Creek watershed (10.4 mi^2) is located in western Contra Costa County and encompasses a portion of the City of Hercules and unincorporated Contra Costa County (Figure 2). The watershed landscape is roughly 20 % impervious and the primary land uses include commercial/residential (lower watershed); golf course and scattered commercial enterprises in the middle reach below Christie Road; and grazing, horse stables, residential, and open space in the upper watershed. The Rodeo Creek channel is approximately 8.2 miles in length and originates at an elevation of 801 feet. Approximately 91 % of the channel banks are currently natural, while 5 % are modified/earthen. Mean daily flow for Rodeo Creek is estimated to be 7.0 cfs. The primary tributaries of the creek (Canada del Cierbo Creek and an unnamed creek) begin in the undeveloped land on the east side of Interstate 80 and have intermittent stream flow. The Rodeo Creek study area consists of the full length of Rodeo Creek mainstem and the unnamed tributary described above..

2.1.3 Edwards Creek Watershed

The Edwards Creek watershed is located in northwestern portion of County within unincorporated Contra Costa County (Figure 2). The primary land uses within the watershed are commercial/residential (lower watershed) and open space/grazing (upper watershed). The Edwards Creek study area includes the full 2.5 miles of Edward Creek, from the Carquinez Strait upstream to its origin at 668 feet elevation.

2.1.4 Lower/Middle Marsh Creek Watershed

With its headwaters in the Morgan Territory (Mt. Diablo foothills) and off the east and southeast flanks of Mt. Diablo, Marsh Creek flows approximately 34 miles before exiting into the San Joaquin River Delta at Big Break (Figure 3). The second largest watershed in the County, the watershed encompasses approximately 94 square miles in eastern Contra Costa County. Tributaries in the upper watershed include Curry Canyon Creek (5.8 mi.), Sycamore Creek (4 mi.) and Briones Creek (13 mi.), which flows into the Marsh Creek Reservoir. Running southeast and easterly off the Mt. Diablo Foothills, tributaries entering the middle portion of the main stem near and in the City of Brentwood include: Dry Creek (5.8 mi.), Sand Creek (18.74 mi.) and Deer Creek (9 mi.). North of the Marsh Creek Reservoir, Marsh Creek runs through the jurisdictions of the City of Brentwood and the City of Oakley. A small portion of the northern section of the watershed lies within the city limits of Antioch.

The Marsh Creek study area includes the middle and lower portions of the watershed, which includes the mainstem of Marsh Creek from its confluence with the Delta to its confluence with Curry Creek

Figure 2. CCMAP sampling stations in Rodeo Creek, Refugio Creek and Edwards Creek watersheds, April 2004.

Figure 3. CCMAP sampling sites in the Marsh Creek watershed, March-April 2004.

(elevation 773 feet) for a total distance of 23.2 miles (Figure 4). The primary tributaries within this length are Sycamore Creek, Briones Valley Creek (entering Marsh Creek Reservoir), Deer Creek, Sand Creek, and Dry Creek. All of these tributaries are typically intermittent, having little to no surface flow during the summer months. Throughout the lower half of the study area there is dense commercial/residential development, constructed in the past 10-15 years on former agricultural lands. The middle portion of the study area consists mostly of ranches and forested park land managed by the East Bay Regional Park District for hiking/horse trails and grazing. The upper section below Curry Creek supports limited residential land use, horse training/boarding stables and forested open space. This upper portion also includes the Diablo Mercury Mine, whose runoff enters the mainstem at Marsh Creek Springs, downstream of our uppermost sampling station.

2.1.5 Las Trampas Creek Watershed

Las Trampas Creek watershed (4.9 mi^2) is located in south central Contra Costa County within the cities of Lafayette, Moraga and Walnut Creek and the unincorporated County (Figure 4). The watershed landscape is made up of roughly 25 % impervious area and the primary land uses include open space and residential areas in the upper watershed; residential areas in the middle portion of the watershed; and commercial/residential areas in the lower watershed. The main water bodies in the Las Trampas Creek watershed are Las Trampas Creek and four primary tributaries, Grizzly Creek, Lafayette Creek, Happy Valley Creek and Reliez Creek. Las Trampas Creek originates on the southern slopes of Las Trampas Peak and flows north and northwest into downtown Lafayette where it turns sharply flows eastward into San Ramon Creek in the City of Walnut Creek for a total length of 12.2 miles. Grizzly Creek originates on the northern slopes of Las Trampas Peak and flows 3.7 miles to enter Las Trampas Creek at Burton Valley. Lafayette Creek (3.5 miles) and Happy Valley Creek (2.9 miles) drain the western and northwestern sides of the town of Lafayette and enter Las Trampas Creek at its sharp bend in downtown Lafayette. The lowermost 0.5 miles of Happy Valley Creek flows through a culvert beneath downtown Lafayette and is assumed to discharge into lower Lafayette Creek a short distance upstream of Las Trampas Creek. Reliez Creek (4.1 miles) drains the Reliez Valley located north of downtown Lafayette and enters Las Trampas Creek midway between downtown Lafayette and San Ramon Creek.

2.1.6 Cerrito Creek Watershed

Cerrito Creek is a 2.5 mile long intermittent stream that serves as the county line between Alameda County to the south and Contra Costa County to the north. It is also the boundary between the cities of Albany and El Cerrito, and between Kensington and Berkeley in its upper reach. The headwaters of Cerrito Creek are just downslope from Summit Reservoir and Arlington Avenue in the Kensington-Berkeley hills. The creek flows west through mostly residential housing to El Cerrito Plaza and commercial buildings west of San Pablo Avenue to enter San Pablo Bay. Approximately 0.6 miles upstream of its mouth at the south side of El Cerrito Plaza, about 800 feet of Cerrito Creek underwent extensive habitat rehabilitation in the summer of 2003. The stream banks were cut back, scalloped, graded, and planted with native vegetation. Rounded large gravel (3-6 inches in diameter) was spread throughout the channel as part of this effort.

2.2 BENTHIC MACROINVERTEBRATE SAMPLING STATIONS

The study consisted of sampling the BMI communities of the Refugio Creek, Rodeo Creek, Edwards Creek, lower Marsh Creek, Las Trampas Creek and Cerrito Creek watersheds to assess biological integrity. The BMI sampling station selection, sample collection, sample processing, and analysis metrics followed California Stream Bioassessment Procedure (CSBP) protocols for Non-point Source Design as described in the December 2003 version of the CSBP Brief for Biological and Physical/Habitat Assessment in Wadeable Streams (California Department of Fish and Game 2003), and a published methods manual (Harrington and Born 2000). A detailed description of these methods is provided below.

Figure 4. CCMAP sampling sites in the Las Trampas Creek watershed, March-April 2004.

2.2.1 Refugio, Rodeo, and Edwards Creek Watersheds

BMI stations were non-randomly selected for Refugio, Rodeo, and Edwards creek reaches where suitable habitat and distinct land use changes were evident. The location of the 2004 BMI sampling stations are described in Table 1 and shown in Figure 2. A second station for Edwards Creek was selected in its upper watershed but was not sampled because permission for access was not received before diminishing flows rendered the station unsuitable for sampling. This station will likely be sampled in the spring 2005. The GPS coordinates and photographs of each station are provided in Appendix A.

2.2.2 Lower Marsh Creek Watershed

BMI sampling during the past two years have included upper Marsh Creek (upstream of Curry Creek) due to the presence of potential reference conditions. In 2004, 11 stations on Marsh Creek downstream of Curry Creek were selected non-randomly and included in the sampling program. The location of the BMI sampling stations on lower Marsh Creek are described in Table 2 and shown in Figure 3. The GPS coordinates taken at the photo points and photographs of these stations can be found in Appendix A.

Table 1. Refugio, Rodeo, and Edwards Creek Watershed benthic macroinvertebrate (BMI) sampling stations and locations. Contra Costa County, March and April 2004.

Sampling Station	Narrative Location	Field Protocol
Refugio Creek:		
RFG-1	Refugio Creek west of Hwy 80	Low Gradient
RFG-2	Refugio Creek above Refugio Valley Park	High Gradient
RFG-3	Refugio Creek above Country Run Road	High Gradient
RFG-4	Refugio Creek at parking area opposite the high school	High Gradient
RFG-5	Refugio Creek between Malibou and Mirimar streets	High Gradient
Rodeo Creek:		
ROD-1	Rodeo Creek at Viewpointe Road	High Gradient
ROD-2	Rodeo Creek below Franklin Canyon Golf Course	High Gradient
ROD-3	Unnamed tributary on north side of Hwy 4 near golf course	High Gradient
ROD-4	North Fork Rodeo Creek above Franklin Canyon Golf Course	High Gradient
ROD-5	Rodeo Creek along upper Christie Road	High Gradient
Edwards Creek:		
ED-1	Edwards Creek behind John Swett High School	High Gradient

Table 2. Lower Marsh Creek Watershed benthic macroinvertebrate (BMI) sampling stations and locations. Contra Costa County, April 2004.

Sampling Station	Narrative Location	Field Protocol
MR-1	Marsh Creek above Laurel Road	Low Gradient
MR-2 [1]	Marsh Creek below Delta Road	Low & High Gradient
MR-3	Marsh Creek above Sunset Road	High Gradient
MR-4	Marsh Creek above Central Avenue	Low Gradient
MR-5	Marsh Creek above Dry Creek	Low Gradient
MR-6	Marsh Creek below Marsh Creek Reservoir	High Gradient
MR-7	Marsh Creek at Round Valley Park	High Gradient
MR-8	Marsh Creek below Sycamore Creek	High Gradient
MR-9	Marsh Creek above Sycamore Creek	High Gradient
MR-10	Marsh Creek at Detention Center	High Gradient
MR-11	Marsh Creek below Curry Creek at Tumbleweed Court	High Gradient

2.2.3 Las Trampas Creek Watershed

Non-random selection of BMI sampling stations was also employed for the Las Trampas Creek watershed. A total of 12 BMI sampling stations were established in the watershed in 2003 and sampled again in 2004. Of the 12 stations, six are located on the Las Trampas mainstem, three are located on Reliez Creek, and one on each of Happy Valley, Lafayette and Grizzly Creeks. The station codes and descriptions for the BMI stations in the Las Trampas Creek drainage are shown below in Table 3. Photographs and GPS coordinates taken at photo points for these stations are provided in Appendix A.

Table 3. Las Trampas Creek Watershed benthic macroinvertebrate (BMI) sampling stations and locations. Contra Costa County, April 2004.

Sampling Station	Narrative Location	Field Protocol
LT-1	Las Trampas Creek below Boulevard Way bridge	High Gradient
LT-2	Las Trampas Creek above Reliez Creek	High Gradient
LT-3	Las Trampas Creek above Lafayette Creek & EBMUD	High Gradient
LT-4	Las Trampas Creek below Grizzly Creek	High Gradient
LT-5	Las Trampas Creek above Grizzly Creek	High Gradient
LT-6	Las Trampas Creek along Bolinger Canyon Road	High Gradient
RZ-1	Reliez Creek below Old Tunnel Road	High Gradient
RZ-2	Reliez Creek along Camino Diablo and below high school	High Gradient
RZ-3	Reliez Creek at 3400 Springhill Road	High Gradient
HV-1	Happy Valley Creek above Rose Lane	High Gradient
LF-1	Lafayette Creek above Fiesta Square	High Gradient
GZ-1	Grizzly Creek above Las Trampas Creek	High Gradient

2.2.4 Cerrito Creek Watershed

An approximately 500-foot section of Cerrito Creek on the south side of El Cerrito Plaza was non-randomly selected in 2002 for a single BMI sampling station to be used for training technicians. Therefore, BMI data exists at this location on Cerrito Creek and documents biotic integrity at this station for two years prior to the rehabilitation of the channel in 2003. In 2004, the Program sampled the same station again to assess the post-rehabilitation conditions. Photographs and GPS coordinates taken at photo points for this station are provided in Appendix A.

2.3 BENTHIC MACROINVERTEBRATE COMMUNITY SAMPLING

The CSBP protocols were modified by California Department of Fish and Game in December 2003. The revised procedures were used during the 2004 BMI sampling. The changes in protocol from previous sampling efforts consisted of the following:

- The stream reach length for each station is no longer defined by a set of five pool-riffle sequences, but rather a discreet length of 300(330?) what did Scott use? feet of stream.
- The total area of benthos sampled at each station has been reduced from 18 ft^2 to 9 ft^2.
- Although three independent samples were collected at each station, one now has the option of compositing the three samples in the laboratory and reducing the total number of BMIs identified at each station from 900 organisms to 500 organisms.
- A new QA/QC procedure has been added that requires the collection of a duplicate set of samples at 10 % of the stations for projects with more than 20 stations.
- Alternative sampling procedures for low gradient stream systems were included.

These revisions were incorporated into the 2004 sampling program, including the compositing samples in the laboratory, identification of 500 organisms, and the collection/identification of duplicate samples for four of the 40 stations sampled (10%).

Additionally, because the lower reaches of some of the streams sampled (primarily lower Marsh Creek) had gradients of less than 1 %, the CSBP's "low gradient" protocol was employed at stations identified in Tables 1-3. A detailed description of this procedure is provided after the following description of the "high gradient" protocols, which were used at stations sampled during previous years.

2.3.1 High Gradient Sampling Protocols

Each BMI station is a 300-foot reach of stream with a gradient equal to or greater than 1 % and containing four or more riffles of sufficient length and width to allow three subsamples per riffle to be taken with a D-frame kick net. A random number table was used to select the three riffles to be sampled in this reach. Within each selected riffle, a transect location for sampling was randomly chosen from the riffle (the upper third of a long riffle). This was accomplished laying a tape measure along the length of the riffle, assigning sequential numbers to each meter or 3-foot length on the tape measure, then using a random number table to select the transect to be sampled in each riffle. Starting with lowermost transect in the downstream riffle, the benthos within a 1 ft^2 area was disturbed upstream of a 1 ft wide, 0.5 mm mesh D-frame kick net. Sampling of the benthos was performed by manually rubbing cobble and boulder substrates followed by 'kicking' the upper layers of substrate to dislodge any remaining invertebrates. Duration of sampling ranged from 60-180 seconds, depending on the amount of boulder and cobble-sized substrates that required rubbing by hand; more and larger substrates required more time to process. Three locations representing the habitats along the transect (usually the two margins and the mid-point) were sampled and combined into a composite sample (representing 6 ft^2 area). This composite sample was transferred into a 500-ml wide-mouth jar containing approximately 200 ml of 95% ethanol. This technique was repeated for each of the three riffles in each monitoring sampling station (reach).

Using a permanent marker, each sample jar was labeled with a station code and transect number, date, and sampler's name. Using a small piece of Rite-in-the Rain paper and a pencil, a second label was prepared and included inside each sample jar. Each sampled BMI station produced three macroinvertebrate samples for processing and identification. The three samples per station would later be composited into one sample at the laboratory.

A total of 90 high gradient BMI samples were collected from 30 stations in five watersheds during the spring 2004 sampling effort. An additional 12 high gradient samples were collected as QA/QC duplicates from four watersheds during this same effort.

2.3.2 Low Gradient Sampling Protocols

Four stations on lower Marsh Creek (MR-1, 2, 4, 5) and one on lower Refugio Creek (RFG-1) had gradients of less than 1 % and were sampled following low gradient protocols for little or no current. At each station, three cross-channel transects covering representative habitats were selected and kick-net samples were taken at the two stream margins and in mid-channel. At each sampling point, the substrate was vigorously disturbed just upstream of the D-frame kick-net for 10 seconds, and then two upward sweeps with the kick-net were made through the disturbed area. The two sweep method was used instead of a "figure eight" motion because the first sweep creates currents that lift organisms and substrate materials off the bottom of the stream where the second sweep can capture it. Three repetitions of the 10 second disturbance followed by the two upward sweeps were made at each of the three points along a transect to comprise one subsample which was then composited in the field to create one sample per transect and three samples per station. All procedures following sample collection were the same as that described above for the high gradient protocols. Marsh Creek station MR-2 had, in addition to its low gradient habitat, a cobble/small boulder check dam that formed a 20-foot length of riffle with a 2 % gradient. To provide a comparison of the two protocols, one set of three samples were taken from the low gradient habitat and a second set of three samples were taken from the high gradient habitat at this station. A total of 15 low gradient samples were collected for a total of 105 high and low gradient samples plus another 12 samples collected as duplicates for QA/QC.

2.4 CHEMICAL AND PHYSICAL HABITAT PARAMETERS

2.4.1 Chemical

Ambient water chemistry was recorded at each station using a Yellow Springs Instruments (YSI 95) dissolved oxygen and temperature meter, Hanna pHep3 pH meter, and Hahn DIST WP4 conductivity meter. Recorded measurements included water temperature, dissolved oxygen, pH, and specific conductance. Stream velocity was determined at each riffle using a Marsh McBirney digital flow meter. An example of the field sheet used to record most of the field data is provided in Appendix B.

2.4.2 Physical Habitat

Physical habitat quality was assessed for each monitoring reach using the U.S. Environmental Protection Agency (EPA) Rapid Bioassessment Protocol (Barbour *et al.* 1999). These subjective habitat quality assessments were recorded for each sampling station during field sampling. Note that the estimate of substrate size % composition addressed only the riffle habitat sampled and not all other instream habitat types (e.g., pools). Therefore, the qualitative substrate composition measurements taken during this study should be used only to characterize riffle substrate at stations sampled, and should not be extrapolated to the entire stream system. The percent fines in riffles are expected to be less than the other instream habitats due to gradient and current velocities. An example of a Physical Habitat Quality Bioassessment Work Sheet is provided in Appendix B.

2.4.3 Photo Documentation

During the 2003 and 2004 BMI samplings of the Las Trampas Creek watershed stations, plus at all new 2004 watersheds, a repeatable photo point was established at each station in a manner to provide a photograph that is representative of the entire reach. The location of the photographer was marked with a 4x4-inch yellow section marker nailed to a nearly tree (or a steel fence post driven into the ground if no trees are nearby). The latitude and longitude of the photographer's position was recorded with a Garmin *E-Trex Vista* GPS unit, and a compass was used to establish a bearing (1 to 360 degrees) between the photographer and the area photographed. Field notes were taken to further describe the photo point and the station (reach) length was recorded. The photograph was taken with a digital camera and included the station identification number and date on a 12x10-inch erasable board held in the foreground of the photograph by an assistant. Photographs and GPS coordinates are included in Appendix A.

2.5 BENTHIC MACROINVERTEBRATE LABORATORY ANALYSIS

Prior to the release of the macroinvertebrate samples to the bioassessment laboratory, a Chain-of-Custody (COC) form was completed. The Chico Research Foundation was contracted to “pick” BMIs from the contents in the sample jars (remove macroinvertebrates from the debris in the sample jar). The bioassessment entomologist subcontracted to identify and analyze (enumeration and developing the metrics) the picked samples was Dr. Richard Borttoff, located in South Lake Tahoe. Dr. Borttoff participates in the California Bioassessment Laboratories Network (CAMLnet) and is approved for CSBP sample analysis by the Water Pollution Control Laboratory, California Department of Fish and Game (CFDG).

At the laboratories of the Chico Research Foundation, the three samples from each station were composited and then rinsed through a No. 35 standard testing sieve (0.5 mm brass mesh) and transferred into a tray marked with twenty, 25cm^2 grids. All detritus was removed from one randomly selected grid at a time and placed in a petri dish for inspection under a stereomicroscope (10x). All macroinvertebrates from the grid were separated from the surrounding detritus and transferred to vials containing 70% ethanol and 5% glycerol. This process was continued until 500 organisms were removed from each station’s composited sample. The material left in from the processed grids was transferred into a jar containing 70% ethanol and labeled as “remnant” material. Any remaining unprocessed material from the tray was transferred back to the original container with 70% ethanol and archived. The picked samples were then delivered to Dr. Borttoff who identified the BMIs to a standard taxonomic level, established by the Aquatic Bioassessment Laboratory, CDFG (typically genus for insects and order or class for non-insects) using standard taxonomic references.

2.6 QUALITY CONTROL AND ASSURANCE

Based on quality assurance results from previous years (2001-2003), Dr. Borttoff has demonstrated a high level of accuracy and precision. Therefore, the Project Team agreed to reduce the percentage of samples selected for quality control analyses from 20% to 10 % for all samples. Thus, during FY 2003/2004, four randomly selected BMI samples were analyzed a second time for discrepancies, which if determined, were reviewed and resolved. Additionally, the sample processing included four duplicate samples for QA/QC purposes. The duplicate samples were collected at stations RFG-4, ROD-5, MR-10, and RZ-3. All macroinvertebrate QA/QC was conducted by the Chico Research Foundation which is a contract laboratory for CDFG’s Water Pollution Control Laboratory. QA/QC results are included in Appendix C.

2.7 METRICS DEVELOPMENT AND ANALYSIS

Enumerated taxonomic lists of the BMIs identified in each sample was generated for all sampling stations and are provided in Appendix C as Table C-1 through C-4. A table of BMI values and means for the biological metrics, as recommended by CDFG, was produced for each sampling station. Twenty standard metrics were calculated for evaluating the BMI data. Descriptions of these metrics are provided in Table 4.

Table 4. Bioassessment metrics used to describe characteristics of the benthic macroinvertebrate (BMI) communities of the Refugio, Rodeo, Edwards, Lower Marsh, Las Trampas and Cerrito Creek watersheds, Contra Costa County.

BMI Metric	Description	Response to Impairment
Richness Measures		
Taxa Richness	Number of individual taxa collected from each sample	decrease
EPT Taxa	Number of taxa in the Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) insect orders collected from each sample	decrease
Composition Measures		
EPT Index	Percent composition of mayfly, stonefly and caddisfly larvae	decrease
Sensitive EPT Index	Percent composition of mayfly, stonefly and caddisfly larvae with tolerance values between 0 and 3	decrease
Percent Dominant Taxa	Percent composition of the single most abundant taxon	increase
Shannon Diversity Index	General measure of sample diversity that incorporates richness and evenness (Shannon and Weaver 1963)	decrease
Tolerance/Intolerance Measures		
Tolerance Value	Value between 0 and 10 weighted for abundance of individuals designated as pollution tolerant (higher values) or intolerant (lower values)	increase
Percent Intolerant Organisms	Percent of organisms in sample that are highly intolerant to impairment as indicated by a tolerance value of 0, 1 or 2	decrease
Percent Tolerant Organisms	Percent of organisms in sample that are highly tolerant to impairment as indicated by a tolerance value of 8, 9 or 10	increase
Functional Feeding Groups (FFG)		
Percent Collectors	Percent of macrobenthos that collect or gather fine particulate matter	increase
Percent Filterers	Percent of macrobenthos that filter fine particulate matter	increase
Percent Grazers	Percent of macrobenthos that graze upon periphyton	variable
Percent Predators	Percent of macrobenthos that feed on other organisms	variable
Percent Shredders	Percent of macrobenthos that shreds coarse particulate matter	decrease
Abundance		
Estimated Abundance	Estimated number of macroinvertebrates in sample calculated by extrapolating from the proportion of organisms in each sample	variable

2.7.1 BMI Ranking Score

Finding a consistent pattern in all metrics can be overwhelming due to the volume of data, and sometimes metrics can provide conflicting results. Consequently, to better assess the biological integrity of a given station, the CDFG recommends integrating six key metrics into a single ranking score for relative comparison to a large regional data set, an Index of Biological Integrity (IBI). Although a large volume of macroinvertebrate data has been collected in the Bay, at this time these data have not been compile and analyzed to the level necessary to develop an IBI. Therefore, single BMI ranking scores are calculated for each station within a given watershed's data set to provide a relative ranking of the various sampling stations within that data set. This process serves as a placeholder for the eventual development of a regional IBI (P. Ode, CDFG, personal communication).

The ranking score approach to evaluating a BMI metrics data set is to normalize and sum the means for six key metrics, and then compare the resulting score between the various sampling stations in a given watershed. The CDFG currently recommends that this approach use the following metrics: Taxonomic Richness, EPT Taxa, Sensitive EPT Index, Shannon Diversity, Percent Intolerant Organisms, and Percent Dominant Taxa. The BMI Ranking scores for each station in each watershed were calculated using the following process:

- Step 1: For each watershed, the mean for each of the six metrics noted above was calculated by averaging the specific metric score for all stations within that watershed. Additionally, on a watershed basis, the Standard Deviation was determined for each of the six metrics.
- Step 2: For each of the six metrics, the metric value for each station was then subtracted from the mean (calculated in step 1), yielding either a positive (greater than the mean) or negative (less than the mean) number for each metric at each station.
- Step 3: For each of the six metrics, the values resulting from Step 2 were then divided by the Standard Deviation for that metric, to create a normalized mean. With the exception of Percent Dominant Taxa, a higher value indicates greater aquatic health. To bring Percent Dominant Taxa into a scale similar to the other five metrics, the absolute value of the normalized mean was used for this metric.
- Step 4: The calculated values for each station now consisted of a normalized mean for each of the six metrics. For the final step, these normalized means were summed to yield one value (a Sum of Normalized Means) for each station. Higher values indicate greater aquatic health.

2.7.2 Species Similarity Analyses

Along with BMI Ranking Score calculations, sampling station similarity analyses were also performed. Station similarity was based on cumulative station totals for each species. Cluster analysis, a multivariate procedure for detecting natural groupings in data, was used to determine species similarity at stations within each watershed. MVSP software (version 3.13c) was used to perform cluster analyses on all station totals. Tables illustrating species similarity between sampling stations are presented for each watershed.

3.0 BENTHIC MACROINVERTEBRATE SAMPLING RESULTS

The BMI species list for each sample collected is provided in Appendix C. The evaluation of these data was conducted by reviewing a series of biological metrics calculated from the BMI sample results. The various metrics can be categorized into four main types:

- Richness Measures (reflects diversity);
- Composition Measures (reflects the relative contribution of individual taxon to the total benthic fauna);
- Tolerance/Intolerance Measures (reflects the relative sensitivity of the community to disturbance); and
- Functional Feeding Groups (shows the balance of feeding strategies in the aquatic assemblage.

A brief description of each metric in these four categories is provided in Table 4.

3.1 REFUGIO CREEK WATERSHED

3.1.1 Metric Results

The metric results for the Refugio Creek watershed BMI data set are presented in Table 5.

<u>Richness</u>

The highest taxa richness (14) occurred at both the furthest downstream (RFG-1) and furthest upstream (RFG-4 and RFG-5) stations. The lowest taxa richness (8) was found at RFG-4. The greatest number of EPT taxa (2) occurred at four stations (RFG-2, 3, 4 and 5) and the least number of EPT taxa (0) were identified at RFG-1.

<u>Composition Measures</u>

Shannon Diversity Index values are affected by taxonomic richness and the distribution of individuals among the species. The Shannon Diversity values may range from 0 to 3.3 (log N), with the higher diversity values being indicative of greater stream health. Of the five stations on Refugio Creek, the highest Shannon Diversity value (1.6) was calculated at RFG-4 and the lowest (0.9) was at RFG-5.

EPT Index scores were low for all stations, ranging from 0% to 2%. Sensitive EPT values were 0% for all stations, meaning there were no sensitive EPT species present.

Another measure of composition characteristics is Percent Dominant Taxon. Unlike the previous metrics, a higher Percent Dominant Taxon indicates a more disturbed environment. Percent Dominant Taxon in Refugio Creek ranged from 34% to 76% with the highest percentage occurring at RFG-5 and the lowest at RFG-4.

<u>Tolerance Measures</u>

No intolerant organisms were identified at the five stations on Refugio Creek. Values for Percent Tolerant Organisms ranged from 0% (RFG-3) to 10% (RFG-4).

<u>Functional Feeding Groups</u>

The functional feeding group Collectors made up the majority of the BMI community in Refugio Creek, ranging from 67% (RFG-4) to 88% (RFG-3). Filterers made up the second largest percentage of organisms at all stations, ranging from 2% to 28%. The highest percentage of Grazers (2%) was identified at RFG-2 and RFG-4.

Table 5. Bioassessment metrics for macroinvertebrate samples, Refugio, Rodeo, and Edwards Creek watersheds, Contra Costa County, March 29 - April 1. 2004

	Refugio Creek Watershed						Rodeo Creek Watershed						Edwards Creek
Metric	**RFG-1**[1]	**RFG-2**	**RFG-3**	**RFG-4**	**RFG-4**[2]	**RFG-5**	**ROD-1**	**ROD-2**	**ROD-3**	**ROD-4**	**ROD-5**	**ROD-5**[2]	**ED-1**
Taxonomic Richness	14	13	8	13	14	14	8	20	20	16	17	23	11
EPT Taxa	0	2	2	1	2	2	1	4	7	1	5	3	2
Ephemeroptera Taxa	0	1	1	1	1	1	1	1	3	1	2	1	1
Plecoptera Taxa	0	0	0	0	0	0	0	1	2	0	1	0	0
Trichoptera Taxa	0	1	1	0	1	1	0	2	2	0	2	2	1
EPT Index	0	1	2	2	1	0	0	3	7	1	3	1	1
Sensitive EPT Index	0	0	0	0	0	0	0	1	4	0	2	1	0
Shannon Diversity	1.5	1.3	1.1	1.6	1.6	0.9	1.1	1.5	1.5	1.5	0.6	1.1	0.9
Tolerance Value	4.9	5.2	5.1	5.3	5.3	5.1	5.2	5.3	5.4	5.7	5.1	5.3	5.1
Percent Intolerant Organisms	0	0	0	0	0	0	0	1	2	0	0	0	0
Percent Tolerant Organisms	3	1	0	10	6	1	0	3	1	8	3	7	5
Percent Hydropsychidae	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent Baetidae	0	1	2	2	1	0	0	1	2	1	1	1	0
Percent Dominant Taxon	47	57	52	48	34	76	47	47	45	47	88	76	66
Percent Collectors	87	79	88	75	67	79	84	65	48	43	91	88	94
Percent Filterers	2	18	11	20	28	17	16	30	46	47	2	4	0
Percent Grazers	2	0	0	0	0	0	0	0	0	0	0	0	5
Percent Predators	1	2	0	2	1	1	0	3	3	8	5	8	0
Percent Shredders	0	0	0	0	0	0	0	1	3	0	1	0	0
Percent Piercer Herbivores	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent Macrophyte Herbivores	0	0	0	0	0	0	0	0	0	0	0	1	0
Percent Omnivores	0	0	0	0	0	0	0	0	0	0	0	0	0
Abundance													
Total Organisms per Sample	9320	20800	27413	13440	19380	46720	37120	8320	11840	5976	2024	1458	15520

[1] This station had a gradient of less than 1% and was sampled using Low Gradient protocols.

[2] The second sample for RFG-4 and ROD-5 are the duplicate samples taken for quality control purposes.

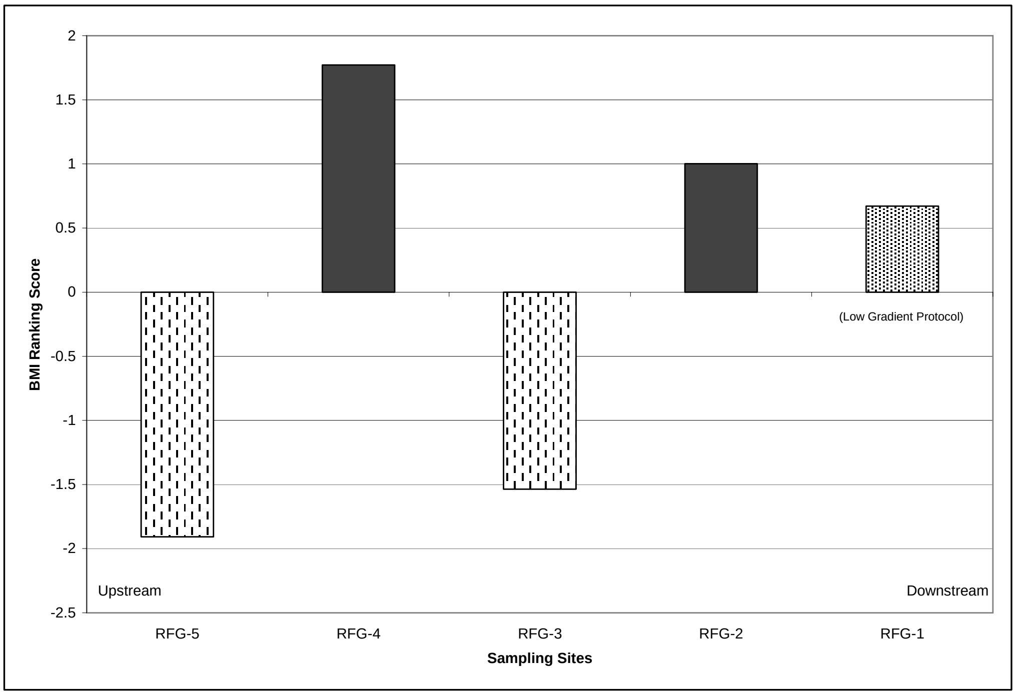
3.1.2 BMI Ranking Scores

As previously noted, BMI Ranking scores were calculated using the following metrics: Taxonomic Richness, EPT Taxa, Sensitive EPT Index, Shannon Diversity, Percent Intolerant Organisms, and Percent Dominant Taxon. This process resulted in a single ranking score for each BMI sampling station. The ranking scores for this data set were developed for comparison between stations only within the Refugio Creek watershed and should not be compared to other data sets.

The BMI Ranking scores for the Refugio Creek watershed are illustrated in Figure 5. Higher values are indicative of greater biotic integrity. However, it is important to remember that a low ranking score is relative only to this particular data set and may not necessarily indicate a severely degraded aquatic environment.

The lowest BMI ranking score (-1.9) for Refugio Creek was calculated for RFG-5, the uppermost station of those sampled. The highest ranking score (1.8) was calculated for RFG-4, approximately 4.4 miles downstream at RFG-5. Site RFG-3 exhibited the second lowest score (-1.5), and is located just 0.4 miles downstream of RFG-4.

Figure 5. Benthic Macroinvertebrate Ranking Scores for Refugio Creek Watershed Sampling Sites, Contra Costa County, April 2004.



3.1.3 Dominant Taxa Composition

To assess the differences and similarities of BMI communities between stations, species abundance data (Appendix C) were used to calculate the five most dominant BMI species for each station. The five dominant species per sampling station and their Tolerance Values (TV) for the Refugio Creek watershed stations are shown in Table 6. The primary differences (change in % dominance) in dominant taxon between adjacent stations in Refugio Creek are shown in Table 7.

In summary, the midge, Orthocladiinae, was the dominant or near dominant organism in all of the Refugio Creek stations, with the highest percentage (76%) occurring at the uppermost station (RFG-5). The lowermost station (RFG-1) had a slightly higher percentage of the midge, Tanytarsini (19%). Oligochaete worms and the black fly, *Simulium* sp., were the second most numerous organism at these stations. Additionally, from the furthest upstream to the furthest downstream station, the change in percent dominant species composition included a 28% reduction in Orthocladiinae and an increase in Oligochaete worms.

Table 6. Dominant macroinvertebrate species for each BMI sampling station, Rodeo, Refugio, and Edwards Creek watershed, Contra Costa County, March and April 2004.

	T.V. [1]	RFG-1	RFG-2	RFG-3	RFG-4	RFG-4 dup	RFG-5	ROD-1	ROD-2	ROD-3	ROD-4	ROD-5	ROD-5 dup	ED-1
ARTHROPODA														
Hexapoda														
Coleoptera (Larvae)														
Dytiscidae														
Agabus sp.	8											3%	6%	
Diptera														
Ceratopogonidae														
Bexxia - Palpomyia sp.	6								1%		5%			
Chironomidae														
Chironomini	6	2%												
Orthocladiinae	5	17%	57%	34%	48%	34%	76%	36%	47%	35%	30%	86%	76%	66%
Tanytarsini	6	19%	3%				1%	1%		4%		1%	6%	
Simuliidae														
Simulium sp.	6		17%	11%	20%	28%	16%	15%	28%	45%	47%	2%	4%	
Ephemeroptera														
Baetidae														
Baetis sp.	5		1%	2%					1%					
Plecoptera														
Nemouridae														
Malenka sp.	2								1%					
Trichoptera														
Sericostomatidae														
Gumaga sp.	3									2%		1%		
Subphylum Crustacea														
Malacostraca														
Amphipoda														
Hyalellidae														
Hyalella sp.	8				10%	5%					7%			
Ostracoda	8	9%			4%	3%	2%							
MOLLUSCA														
Gastropoda														
Physidae														
Physa sp.- Physella sp.	8													5%
ANNELIDA														
Oligochaeta	5	47%	17%	44%	13%	25%	2%	47%	16%	5%	3%		1%	28%
Total Number of Organisms:		466	520	514	504	495	484	464	483	510	498	497	474	485

1 T.V. = Tolerance Value (Low values indicates an intolerance to pollution and high values indicate a high tolerance to pollution.).

Table 7. Change in percent dominant macroinvertebrate taxa between selected Refugio Creek watershed stations, Contra Costa County, March 2004.

Taxa		TV[1]	RFG4-RFG5[2]	RFG3-RFG4	RFG2-RFG3	RFG1-RFG2[3]
Midge:						
	Chironomini	6				2%
	Orthocladiinae	5	-28%	-12%	23%	-40%
	Tanytarsini	6	-1%		3%	16%
Blackflies:						
	Simulium sp.	6	4%	-9%	6%	-17%
Mayflies:						
	Baetis sp.	5		2%	-1%	-1%
Amphipods:						
	Hyalella sp.	8	10%	-10%		
Seed Shrimp:						
	Ostracoda	8	2%	-4%		
Annelid Worms:						
	Oligochaeta	*5*	11%	31%	-27%	30%

[1] TV = Tolerance Value: Values between 0 and 10; higher values = greater pollution tolerance.

[2] The difference in percent dominant organism was calculated by subtracting RFG-5 % from RFG-4 percentages. This shows the change in the dominant organisms in the downstream site compared to the upstream site.

[3] Station RFG-1 was the only site in this watershed sampled using "low gradient protocols".

3.1.4 Species Similarity

A cluster analysis was performed to determine the similarity in species composition at Refugio Creek sampling stations. As illustrated in Table 8, the highest species similarity (82.0%) occurred at stations RFG-2 and RFG-4, while the most dissimilar stations were RFG-1 and RFG-5.

Table 8. BMI community similarity between Refugio Creek watershed stations Contra Costa County, March 2004.

	RFG-1	RFG-2	RFG-3	RFG-4	RFG-4 (Duplicate)	RFG-5
RFG-1	100.0					
RFG-2	40.2	100.0				
RFG-3	63.1	64.6	100.0			
RFG-4	38.1	82.0	60.7	100.0		
RFG-4 (Duplicate)	49.7	73.1	71.4	78.1	100.0	
RFG-5	24.0	80.3	50.5	71.5	57.4	100.0

3.2 RODEO CREEK WATERSHED

The Rodeo Creek watershed BMI data set contains data for five different sampling stations, three on the main stem of Rodeo Creek (ROD-1, ROD-2 and ROD-5), one on the North Fork Rodeo Creek (ROD-4) and one (ROD-3) on a small and likely intermittent tributary entering from the north near the Franklin Canyon Exit from Highway 4. Station ROD-2 (mainstem) is a short distance downstream of the Franklin Canyon golf course and ROD-4 is just upstream of the golf course, although located on the North Fork.

3.2.1 Metric Results

Metric results for the Rodeo Creek watershed are described in this section and the provided in Table 5.

Richness

The highest Taxa Richness (23) occurred in the duplicate sample from the uppermost station (ROD-5). Taxa Richness of the primary sample from ROD-5 was 17. The lowest value for this metric (8) was at the lowermost station on the creek (ROD-1). The remaining stations had Taxa Richness values ranging from 16 to 20.

Composition Measures

Shannon Diversity values may range from 0 to 3.3 (log N), with the higher diversity values being suggestive of greater stream health. The highest Shannon Diversity value (1.5) within this watershed was calculated for three stations (ROD-2, ROD-3 and ROD-4. The lowest diversity value in the watershed (0.6) was found at ROD-5.

The highest EPT Index score (7%) occurred at ROD-3 and the lowest (0%) at ROD-1. The remaining stations had EPT Index scores ranging from 1 to 3 %. Sensitive EPT Index scores were 0 % for ROD-1 and ROD-4, and the highest score for this metric was at ROD-3 with a value of 4 %.

Percent Dominant Taxon is another measure of species composition. However, unlike a majority of other metrics, a higher Dominant Taxon percentage suggests a more impacted environment. Percent Dominant Taxon in the Rodeo Creek watershed ranged from 45 at ROD-3 to 88 at ROD-5. The remaining stations had Percent Dominant Taxon scores were between 40 and 50.

Tolerance Measures

The tributary ROD-3 had a Percent Intolerant Organisms score of 2 %, the highest value in the watershed. All remaining stations had 0% Intolerant Organisms.

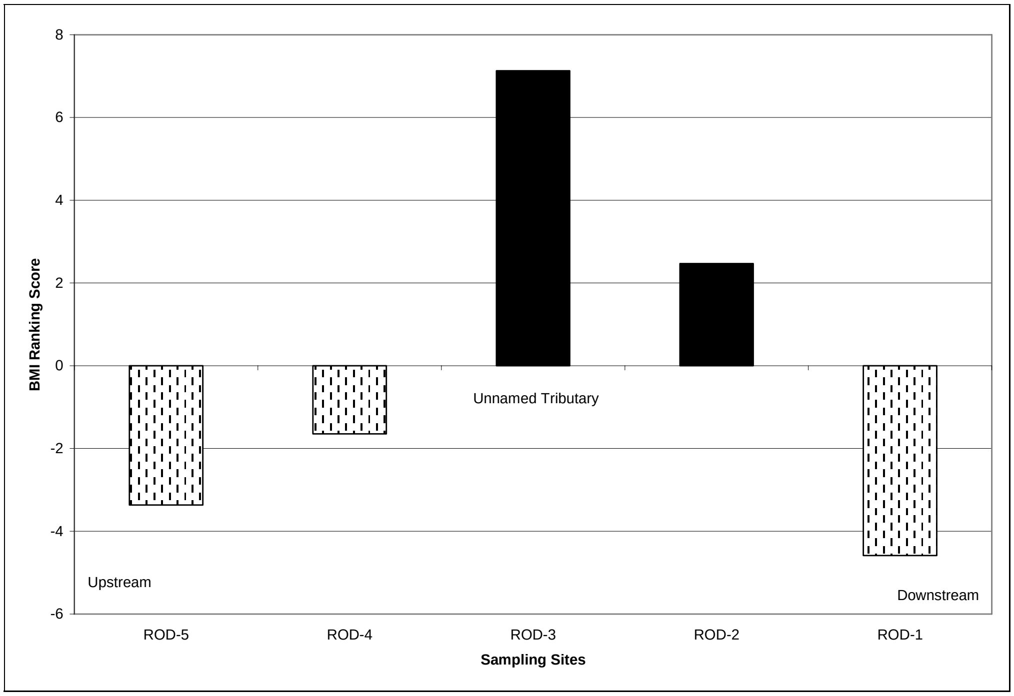
Functional Feeding Groups

The BMI communities at each Rodeo Creek station were dominated by macro-invertebrates in the functional feeding group Collectors. The percent composition of Collectors ranged from 43 % (ROD-3) to 91 % (ROD-5). The feeding group with the next highest percentage of organisms for all stations except ROD-5 was Filterers, ranging from 2 % to 47 %. The uppermost station (ROD-5) had a greater proportion of Predators (8%) than Filterers (5%).

3.2.2 BMI Ranking Scores

The BMI Ranking Scores for the Rodeo Creek watershed data set were developed for comparison between stations only within this watershed and should not be compared to other data sets at this time. Higher values are indicative of greater biotic integrity. The highest ranking score in the Rodeo Creek watershed was at the tributary (ROD-3) with a score of 7.1. The lowest BMI Ranking Score was -4.6 at ROD-1. The BMI Ranking scores for the Rodeo Creek watershed are illustrated in Figure 6.

Figure 6. **Benthic Macroinvertebrate Ranking Scores for Rodeo Creek Watershed Sampling Sites, Contra Costa County, March 29-30, 2004**



3.2.3 Dominant Taxa Composition

The dominant taxa composition of Rodeo Creek are shown in Table 6 and the change in percent composition is provided in Table 9. The BMI community of the five stations in the Rodeo Creek watershed was dominated by the midge, Orthocladiinae, ranging from 30% at ROD-4 to 86% at ROD-5. The black fly (*Simulium* sp.) was the second most prevalent organism and ranged from 2% at ROD-5 to 47% at ROD-4. The remaining stations had 15% to 45% *Simulium* sp. composition. Oligochaeta were low at the upper stations (1%-3%) and gradually increased in the downstream stations until comprising 47% at ROD-1. A high occurrence of watercress in the channelized stream at ROD-1 is a possible factor in the prevalence of Oligochaete worms at this station.

The uppermost station on Rodeo Creek (ROD-5) is heavily impacted with sediment and has the second lowest ranking score (see Figure 6). Compared to the station on the North Fork Rodeo Creek (ROD-4), the BMI community of ROD-5 has less diversity of species (0.9 diversity index value) and 56% more Orthocladiinae. ROD-4 has 45% more *Simulium* sp. than does ROD-5 and 7% more *Hyalella*.

Station ROD-3 is on an unnamed tributary that drains open space land that receives minimal grazing. Comparing this highest ranked station (ROD-3) to the two lowest ranked stations (ROD-5 and ROD-1) shows that ROD-3 has 51% fewer Orthocladiinae and 43% more *Simulium* than ROD-5. Station ROD-3 has 30% more Simulium and 42% fewer Oligochaeta than ROD-1.

Table 9. Change in percent dominant macroinvertebrate taxa between selected Rodeo Creek watershed stations, Contra Costa County, March 2004.

	Taxa	TV [1]	ROD4-ROD5 [2]	ROD3-ROD5	ROD2-ROD4	ROD1-ROD2	ROD1-ROD3
Beetle Larvae:							
	Agabus sp.	8	-3%	-3%			
Biting Midge:							
	Bexxia-Palpomyia sp.	6	5%		-4%	-1%	
Midge:							
	Orthocladiinae	5	-56%	-51%	17%	-11%	1%
	Tanytarsini	6	-1%	3%		1%	-3%
Blackflies:							
	Simulium sp.	6	45%	43%	-19%	-13%	-30%
Mayflies:							
	Baetis sp.	5			1%	-1%	
Stonefly:							
	Malenka sp.	2				-1%	
Caddisfly:							
	Gumaga sp.	3	-1%	1%			-2%
Amphipods:							
	Hyalella sp.	8	7%		-7%		
Annelid Worms:							
	Oligochaeta	*5*	3%	5%	13%	31%	42%

[1] TV = Tolerance Value: Values between 0 and 10; higher values = greater pollution tolerance.

[2] The difference in percent dominant organism was calculated by subtracting ROD-5 percentages from ROD-4 percentages. This shows the change in the dominant organisms in the downstream site compared to the upstream site.

3.2.4 Species Similarity

A cluster analysis was performed to determine the similarity in species composition between Rodeo Creek watershed sampling stations. As illustrated in Table 10, the highest species similarity (84.1%) occurred between stations ROD-3 and ROD-4, while ROD-5 and ROD-4 (36.1) were the most dissimilar.

Table 10. BMI community similarity between Rodeo Creek watershed stations Contra Costa County, March 2004.

	ROD-1	ROD-2	ROD-3	ROD-4	ROD-5	ROD-5 (Duplicate)
ROD-1	100.0					
ROD-2	68.0	100.0				
ROD-3	55.0	73.5	100.0			
ROD-4	50.1	64.4	84.1	100.0		
ROD-5	38.9	51.1	42.3	36.1	100.0	
ROD-5 (Duplicate)	42.2	55.0	47.4	40.5	84.7	100.0

3.3 EDWARDS CREEK WATERSHED

Two stations were established to characterize Edwards Creek, ED-1 behind the John Swett High School and ED-2 in the upper watershed above a concrete-lined section. The Edwards Creek drainage is small, and the upper station could not be sampled for lack of adequate stream flow. Station ED-1 was sampled and the results are presented below.

3.3.1 Metric Results

The metric results for the Edwards Creek watershed BMI data set are provided in Table 6.

Richness

The Taxa Richness at ED-1 was 11, and the EPT Taxa value was 2.

Composition Measures

Shannon Diversity Index values are affected by taxonomic richness and the distribution of individuals among the species. The Shannon Diversity values may range from 0 to 3.3 (log N), with the higher diversity values being indicative of greater stream health. Station ED-1 had a Shannon Diversity value of 0.9.

The station's EPT Index score was 1. The Sensitive EPT value was 0%, meaning there were no sensitive species of mayflies, stoneflies, and caddisflies present.

Another measure of composition characteristics is Percent Dominant Taxon. Unlike the previous metrics, a higher Percent Dominant Taxon indicates a more disturbed environment. Percent Dominant Taxon in lower Edwards Creek was 66%.

Tolerance Measures

Lower Edwards Creek had no Intolerant Organisms (a value of 0%).

Functional Feeding Groups

The functional feeding group, Collectors, made up 94% of the BMI community in lower Edwards Creek. The nest highest feeding group percentage was Grazers which comprised 5% of the BMI community.

3.3.2 BMI Ranking Scores

Because only one station on Edwards Creek was sampled in 2004, there were not sufficient data sets to calculate a BMI ranking score.

3.3.3 Dominant Taxa Composition

The dominant BMI taxa at the single Edwards Creek station are shown in Table 3-2. The midge, Orthocladiinae, comprised 66% of the BMI community and Oligochaeta comprised 28%. There was little diversity in this BMI community (Shannon Diversity Index value of 0.9).

3.3.4 Species Similarity

Because data were only collected for one station on Edwards Creek, a cluster analysis to determine the similarity in species composition between sampling stations was not applicable to evaluating the Edwards Creek BMI data.

3.4 LOWER MARSH CREEK WATERSHED

The lower Marsh Creek watershed BMI data set contains data for 11 different sampling stations, all on the main stem of the creek. High Gradient protocols for BMI sampling was used at the majority of the stations. Stations MR-1, MR-2, MR-4, and MR-5 were sampled using the Low Gradient protocols. Station MR-2 was also sampled in a high gradient section using the High Gradient protocols for comparison with the Low Gradient protocols samples at this station.

3.4.1 Metric Results

Metric results for the lower Marsh Creek watershed are described in this section and the metric results are provided in Table 11.

Richness

Taxa Richness ranged from 11 (MR-3) to 24 (MR-7). Interestingly, within the upper end of the study area, the uppermost station (MR-11) had a Taxa Richness of 21, but the next station downstream (MR-10) only had a value of 12. Downstream of MR-10, Taxa Richness began to increase until peaking at MR-7 (20) which is located at Round Valley Park. The next station downstream (MR-6), which is located below Marsh Creek Reservoir, the Taxa Richness again dropped to 12. Of those stations downstream of MR-6, Taxa Richness values ranged from 11 to 19.

Composition Measures

Shannon Diversity values may range from 0 to 3.3 (log N), with the higher diversity values being suggestive of greater stream health. A Shannon Diversity value of 1.2 below Marsh Creek Reservoir (MR-6) was the lowest for the watershed. A relatively high Shannon Diversity value of 2.0 occurred at two stations, MR-4 and MR-8. Station MR-10, noted above for a lower Taxa Richness value, had a relatively low Shannon Diversity value of 1.3.

Station MR-11 had a very high EPT Index score of 91%. This score dropped to 14% at MR-10 and then increased to 32% at MR-9. Upstream of Marsh Creek Reservoir, Station MR-7 had an EPT Index score of 51% which dropped to 4% below the reservoir. The lowest EPT Index scores (0%) occurred at MR-1, MR-2, MR-4, and MR-5, all samples collected using Low Gradient protocols. The High Gradient protocol sample from MR-2 had an EPT Index score of 2%. The Sensitive EPT Index scores followed a similar pattern with a high of 67% at MR-11, a drop to 6% at MR-10, and low scores of 0% at all stations downstream of MR-6.

Percent Dominant Taxon is another measure of species composition. However, unlike a majority of other metrics, a higher Dominant Taxon percentage suggests a more impacted environment. Percent Dominant Taxon in the middle/lower Marsh Creek watershed ranged from 24% at MR-8 to 64% at MR-10. Station MR-2, sampled with both High and Low Gradient protocols, showed a lower percentage of Dominant Taxon (29%) when the low gradient protocol was used, than when the high gradient protocol was used (62%).

Tolerance Measures

Station MR-11 had a relatively high Percent Intolerant Organisms of 65%. This value dropped significantly to 6% at MR-10. Upstream of Marsh Creek reservoir, intolerant organisms comprised 11% and 23% of the BMI community at MR-7 and MR-8, respectively. Downstream of Marsh Creek Reservoir, the Percent Intolerant Organisms was 1% at MR-6 and 0% at the remaining stations.

Functional Feeding Groups

The BMI communities of the middle/lower Marsh Creek stations show considerable variability in which functional feeding group predominates. Station MR-11 was dominated by Collectors (76%), while MR-10 was dominated by Filterers (60%-64%). Station MR-9 had only slightly more Filterers (45%) than Collectors (40%), and the remaining two stations upstream of Marsh Creek Reservoir were dominated by Collectors. Immediately downstream of the reservoir (MR-6), Filterers dominated (60%) the BMI community as expected below any lake or impoundment where water retention favors the growth of phytoplankton. All other downstream stations were dominated by Collectors. Grazers were the second most prevalent organisms at MR-4 and MR-5 (10%) and less so at MR-1 and MR-2 (low gradient) with 2% and 4%, respectively.

Table 11. Bioassessment metrics for macroinvertebrate samples, lower Marsh Creek watershed, Contra Costa County, April 2004.

	Lower Marsh Creek Watershed Stations												
Metric	**MR-1**[1]	**MR-2**[1]	**MR-2**[2]	**MR-3**	**MR-4**[1]	**MR-5**[1]	**MR-6**	**MR-7**	**MR-8**	**MR-9**	**MR-10**	**MR-10**[3]	**MR-11**
Taxonomic Richness	13	16	14	11	17	19	12	24	20	19	13	12	21
EPT Taxa	1	1	3	3	0	2	3	7	8	9	4	4	11
Ephemeroptera Taxa	0	0	1	2	0	1	2	4	4	3	3	3	6
Plecoptera Taxa	0	0	0	0	0	0	1	1	2	1	1	1	2
Trichoptera Taxa	1	1	2	1	0	1	0	2	2	5	0	0	3
EPT Index	0	0	2	15	0	0	4	51	50	32	14	17	91
Sensitive EPT Index	0	0	0	0	0	0	1	10	24	9	6	6	67
Shannon Diversity	1.6	1.7	1.3	1.6	2.0	1.9	1.2	1.9	2.0	1.8	1.4	1.3	1.8
Tolerance Value	5.7	5.5	5.5	5.0	4.1	5.6	5.6	4.8	4.3	5.3	5.3	5.4	2.5
Percent Intolerant Organisms	0	0	0	0	0	0	1	11	23	8	6	6	65
Percent Tolerant Organisms	3	6	16	1	14	17	0	1	1	5	1	1	1
Percent Hydropsychidae	0	0	0	0	0	0	0	1	1	0	0	0	0
Percent Baetidae	0	0	1	15	0	0	2	40	24	23	8	11	21
Percent Dominant Taxon	34	29	62	33	31	30	60	40	24	44	60	64	48
Percent Collectors	95	91	71	58	52	72	38	68	63	40	21	24	76
Percent Filterers	1	0	11	33	0	1	60	21	24	45	60	64	3
Percent Grazers	2	4	1	1	10	10	0	2	1	5	0	0	3
Percent Predators	2	3	16	0	7	9	1	9	12	7	19	12	17
Percent Shredders	0	0	0	0	0	0	0	0	0	0	0	0	2
Percent Piercer Herbivores	0	0	1	0	0	0	0	0	0	0	0	0	0
Percent Macrophyte Herbivores	0	0	0	0	0	0	0	0	0	2	0	0	0
Percent Omnivores	0	1	1	8	0	0	0	0	0	0	0	0	0
Abundance													
Total Organisms per Sample	5547	3905	8064	10240	3292.3	8940	55328	7875	10080	13813	2954.29	6880	6732

1 These stations had gradients of less than 1% and were sampled using Low Gradient protocols.

2 Station MR-2 was sampled at both low gradient and high gradient sites. This is the sampling using High Gradient protocols.

3 This second sample for MR-10 is the duplicate sample for this watershed and was taken for quality control purposes.

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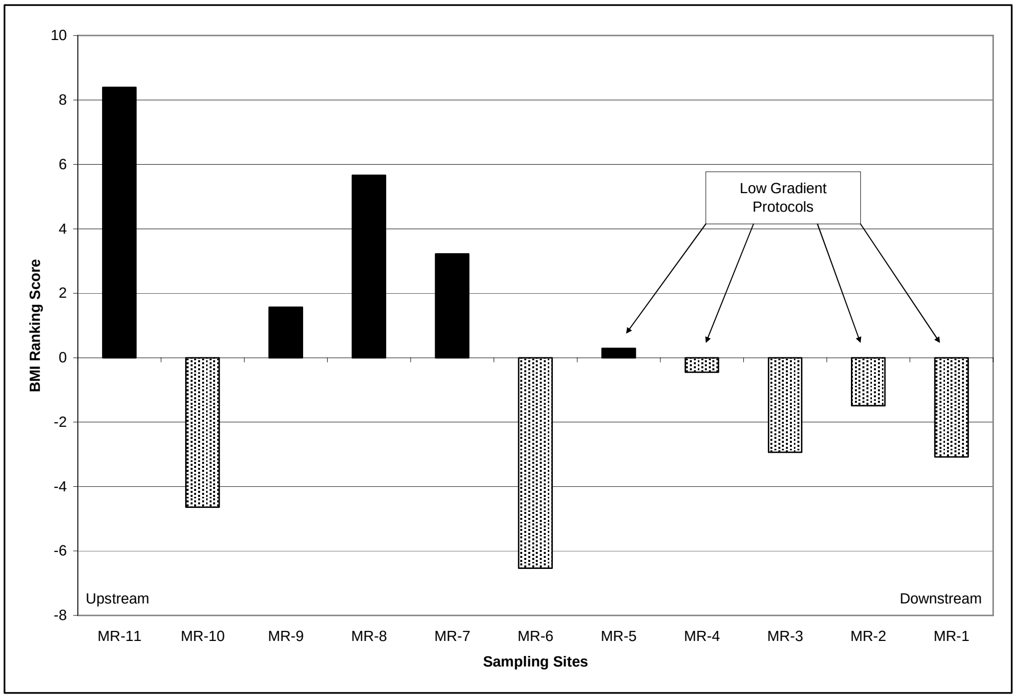
3.4.2 BMI Ranking Scores

The BMI Ranking Scores for the middle/lower Marsh Creek watershed data set were developed for comparison between stations only within this watershed and should not be compared to other data sets at this time. Higher values are indicative of greater watershed health. The BMI Ranking scores for the lower Marsh Creek watershed are illustrated in Figure 7.

The highest ranking score (8.4) in the middle/lower Marsh Creek watershed was at the uppermost station (MR-11), and the next highest score was 5.6 at MR-8. The lowest BMI Ranking Score was -6.5 at MR-6 below Marsh Creek Reservoir, and the second lowest score of -4.6 occurred at MR-10. Station MR-10 was the only station upstream of Marsh Creek Reservoir with a negative BMI ranking score. Downstream of the reservoir all stations except MR-5 (0.3) had negative BMI ranking scores.

Figure 7. Benthic Macroinvertebrate Ranking Scores for Lower Marsh Creek Watershed Sampling Sites, Contra Costa County, April 2004.



3.4.3 Dominant Taxa Composition

Dominant taxa compositions for stations on middle/lower Marsh Creek are presented in Table 12. Changes in the percentages of the most dominant taxa are shown in Table 13.

Station MR-11, the station furthest upstream in the Marsh Creek study area, had the highest ranking score (see Figure 7) and was dominated by species intolerant to pollution. The BMI community at MR-11 was dominated (48%) by Ephemerella sp., a mayfly that is highly sensitive to pollution (tolerance value =1). The second most prevalent organism at this station was the moderately tolerant swimming mayfly, *Baetis* species, which made up 21% of all species identified at this station. The stonefly, *Isoperla* sp. comprised 11% of the community and is also a sensitive species with a Tolerance Value of 2.

In contrast to MR-11, station MR-10 was dominated by *Simulium* sp. (60%) and Planariidae sp. (14%). Sites located in the middle portion of the study area (MR-9 to MR-6) were dominated by Orthocladiinae, *Simulium* sp., *Baetis* mayflies, and Oligochaeta,. The lowermost two stations on Marsh Creek were dominated by the biting black fly, *Bexxia-Palpomyia* sp., Orthocladiinae and Tanytarsini, species.

A comparison of the differences in the BMI community of these two stations (Table 14) shows that, compared to MR-11, MR-10 had 57% more *Simulium* sp., 14% more Oligochaeta, and 7% more Orthocladiinae. It also had 13% fewer Baetis sp. and 11% fewer *Isoperla* stoneflies than occurred at MR-11.

The BMI community showed improvement at the next downstream station (MR-9). A comparison of MR-9 to MR-10 shows the downstream station to have 16% fewer *Simulium*, 14% fewer flatworms, and 5% fewer of the *Ephemerella* mayfly. The downstream station also had 15% more Baetis mayflies, 3% more snails and 8% more Oligochaeta.

Moving downstream, the dominate species from station MR-8 were compared to the upstream station (MR-9). Results indicate that MR-8 had 21% fewer *Simulium* and 7% fewer Orthocladiinae. Station MR-8 also had 18% more *Ephemerella* sp. (pollution intolerant mayfly), 5% more of the sensitive stonefly, Isoperla sp., 5% more flatworms, and 8% more Oligochaeta.

A comparison of the station above Marsh Creek Reservoir (MR-7) to the station directly below (MR-6) shows 38% fewer Baetis mayflies, 9% fewer Ephemerella mayflies and 6% fewer flatworms at the downstream station. Station MR-6 also had 39% more *Simulium*, 9% more Orthocladiinae, and 6% more Oligochaeta than MR-7.

Stations MR-1, 2, 4, and 5 were sampled using low gradient protocols. A comparison of MR-4 with MR-2 shows the downstream station (MR-2) to have had 31% fewer seed shrimp (Ostracoda) and 5% fewer snails. MR-2 also differs in having 22% more Tanytarsini, 14% more Orthocladiinae, 6% more Oligochaeta, and 4% more biting midge than occurred at MR-4.

When compared to MR-2, the lowermost station (MR-1) had 18% more biting midges and 4% more Tanytarsini. It also had 12% less Orthocladiinae and 7% less Oligochaeta than MR-2.

Table 12. Dominant macroinvertebrate species for each BMI sampling station, lower Marsh Creekwatershed, Contra Costa County, April 2004.

	T.V. [1]	MR-1	MR-2	MR-2HG	MR-3	MR-4	MR-5	MR-6	MR-7	MR-8	MR-9	MR-10	MR-10 Duplicate	MR-11
ARTHROPODA														
Hexapoda														
Diptera														
Ceratopogonidae														
Bexxia - Palpomyia sp.	6	34%	16%			12%	15%						6%	
Chironomidae														
Orthocladiinae	5	12%	24%	26%	33%	10%	24%	15%	6%		7%	7%	7%	
Tanytarsini	6	26%	22%					2%						
Simuliidae														
Simulium sp.	6			10%	33%			60%	21%	23%	44%	60%	64%	3%
Ephemeroptera														
Ameletidae														
Ameletus sp.	0													3%
Baetidae														
Baetis sp.	5				14%			2%	40%	24%	23%	8%	11%	21%
Ephemerellidae														
Ephemerella sp.	1								9%	18%		5%	5%	48%
Heptageniidae														
Leucrocuta - Nixe sp.	3													2%
Plecoptera														
Perlodidae														
Isoperla sp.	2									5%				11%
Trichoptera														
Brachycentridae														
Micrasema sp.	1													
Odonata														
Coenagrionidae														
Enallagma sp.	9						7%							
Subphylum Chelicerata														
Arachnoidea														
Acari														
Sperchontidae														
Sperchon sp.	8			14%										
Subphylum Crustacea														
Ostracoda	8					31%	9%							
MOLLUSCA														
Gastropoda														
Hydrobiidae	8										3%			
Physidae														
Physa sp.- Physella sp.	8	2%	4%			9%								
PLATYHELMINTHES														
Turbellaria														
Tricladia														
Planariidae	4			1%					6%	5%		14%		
ANNELIDA														
Oligochaeta	5	23%	29%	7%	9%	23%	30%	17%	11%	16%	8%			
Polychaeta														
Nereidae														
Nereis sp.	9				8%									
Total Number of Organisms:		416	515	504	491	489	447	484	503	504	481	505	500	503

1 T.V. = Tolerance Value (Low values indicates an intolerance to pollution and high values indicate a high tolerance to pollution.).

Table 13. Change in percent dominant macroinvertebrate taxa between selected lower Marsh Creek watershed sites, Contra Costa County, April 2004.

	Taxa	TV [1]	MR10-MR11[2]	MR9-MR10	MR8-MR9	MR6-MR7	MR3-MR6	MR2-MR4	MR1-MR2
Biting Midge:									
	Bexxia-Palpomyia sp.	6						4%	18%
Midge:									
	Orthocladiinae	5	7%	0%	-7%	9%	18%	14%	-12%
	Tanytarsini	6				2%	-2%	22%	4%
Blackflies:									
	Simulium sp.	6	57%	-16%	-21%	39%	-27%		
Mayflies:									
	Ameletus sp.	0	-3%						
	Baetis sp.	5	-13%	15%	1%	-38%	12%		
	Ephemerella sp.	1		-5%	18%	-9%			
Stonefly:									
	Isoperla sp.	2	-11%		5%				
Damselfly:									
	Enallagma sp.	9							
Seed Shrimp:									
	Ostracoda	8						-31%	
Snails:									
	Hydobiidae	8		3%	-3%				
	Physa p.-Physella sp.	8						-5%	-2%
Flatworms:									
	Planariidae	4	14%	-14%	5%	-6%			
Annelid Worms:									
	Oligochaeta	*5*		8%	8%	6%	-8%	6%	-7%
	Polychaeta	9					8%		

[1] TV = Tolerance Value: Values between 0 and 10; higher values = greater pollution tolerance.
[2] The difference in percent dominant organism was calculated by subtracting MR-11 percentages from MR-10 percentages. This shows the change in the dominant organisms in the downstream site compared to the upstream site.

3.4.4 Species Similarity

A cluster analysis was performed to determine the similarity in species composition at middle/lower Marsh Creek watershed sampling stations. As illustrated in Table 14, the highest species similarity occurred between stations MR-7 and MR-8 (76.9%) and between MR-1 and MR-2 (75.4%). Station MR-11 was extremely dissimilar from MR-1, MR-2, MR-4 and MR-5.

Table 14. BMI community similarity between middle/lower Marsh Creek watershed stations Contra Costa County, April 2004.

	MR-1 (Low Gradient)	MR-2 (Low Gradient)	MR-2 (High Gradient)	MR-3	MR-4 (Low Gradient)	MR-5 (Low Gradient)	MR-6	MR-7	MR-8	MR-9	MR-10	MR-10 (Duplicate)	MR-11
MR-1 (Low Gradient)	100.0												
MR-2 (Low Gradient)	75.4	100.0											
MR-2 (High Gradient)	21.7	34.9	100.0										
MR-3	24.0	37.2	53.9	100.0									
MR-4 (Low Gradient)	55.5	57.0	19.5	21.8	100.0								
MR-5 (Low Gradient)	68.2	72.4	11.6	14.3	65.5	100.0							
MR-6	33.1	34.4	34.4	60.9	31.0	23.4	100.0						
MR-7	22.2	20.3	27.4	52.2	21.0	17.1	44.2	100.0					
MR-8	22.6	20.6	24.2	51.1	20.9	20.0	47.2	76.9	100.0				
MR-9	17.8	16.3	28.4	63.8	16.5	11.2	64.5	61.0	62.9	100.0			
MR-10	8.5	7.9	19.9	47.9	7.9	3.0	70.7	47.2	46.7	63.8	100.0		
MR-10 (Duplicate)	9.4	8.5	20.7	51.7	8.5	2.8	71.4	48.2	48.9	67.8	89.6	100.0	
MR-11	2.6	2.8	6.8	18.7	2.4	2.3	8.5	38.8	52.8	31.9	22.9	25.3	100.0

3.5 LAS TRAMPAS CREEK WATERSHED

3.5.1 Metric Results

The 2004 metric results for the Las Trampas Creek watershed are provided in Table 15 and described in this section.

Richness

The highest Taxa Richness in the Las Trampas Creek watershed occurred at LT-6 (42), the Las Trampas Creek station highest in the watershed. The lowest value for this metric (7) was found at LT-2. The highest EPT Taxa value (20) also occurred at LT-6, while the lowest EPT Taxa value (1) was found at LT-1, LT-2, LF-1, GZ-1, and RZ-1.

Composition Measures

The Shannon Diversity values may range from 0 to 3.3 (log N), with the higher diversity values being indicative of increased watershed health. A Shannon Diversity value of 2.9 at LT-6 was the highest within this watershed. Station LT-1, the most downstream Las Trampas Creek station, had the lowest diversity value of 1.0.

EPT Index scores ranged from 9% to 75%, with the highest value occurring at the LT-6 and the lowest value at GZ-1. Sensitive EPT scores were 0% at LT-1, LT-2, LT-3, GZ-1, HV-1, RZ-1, RZ-2, and LF-1. Stations LT-4, LT-5, and RZ-3 had Sensitive EPT scores of 1, and LT-6 was notable with a score of 47.

Another measure of BMI community composition is Percent Dominant Taxon in which a higher percentage indicates a more impacted environment. Percent Dominant Taxon in the Las Trampas Creek watershed ranged from 20% to 71% with the highest percentage (most impacted) occurring at LT-1 and the lowest percentage at LT-6.

Tolerance Measures

The Percent Intolerant Organisms in the Las Trampas Creek drainage ranged from 0% (at all but four stations) to 43% at LT-6. Stations LT-4, LT-5, and RZ-3, all upper watershed stations, had 1% Intolerant Organisms. Values for Percent Tolerant Organisms were highest at GZ-1 (6%), ranged from 1% to 4% in Reliez Creek and the middle and upper watershed stations on Lafayette Creek, and were 0% at LT-1, Lt-2, HV-1, and LF-1. Higher percentages of tolerant organisms are indicative of environmental stress.

Functional Feeding Groups

Collectors dominated the BMI communities of the Las Trampas Creek watershed, making up 40% (LT-6) to 96% (LT-2) of the organisms identified. Excluding Station LT-6, the second most prevalent feeding group was the Filterers which ranged from 3% (LT-3) to 25% at HV-1. Station LT-6 was notable in having a BMI community comprised of 40% Collectors, 2% Filterers, 12% Grazers, 24% Predators, and 22% Shredders. This mixed composition of the functional feeding groups in the BMI community is indicative of healthy environmental conditions.

Table 15. Bioassessment metrics for macroinvertebrate samples, Las Trampas Creek watershed, Contra Costa County, April 2004.

	Las Trampas Creek						Grizzley Creek	Happy Valley Creek	Reliez Creek				Lafayette Creek
Metric	**LT-1**	**LT-2**	**LT-3**	**LT-4**	**LT-5**	**LT-6**	**GZ-1**	**HV-1**	**RZ-1**	**RZ-2**	**RZ-3**	**RZ-3***	**LF-1**
Taxonomic Richness	8	7	10	12	19	42	16	12	14	17	18	17	9
EPT Taxa	1	1	3	3	5	20	1	2	1	3	5	4	1
Ephemeroptera Taxa	1	1	2	2	3	10	1	1	1	1	2	1	1
Plecoptera Taxa	0	0	1	1	2	5	0	0	0	0	2	0	0
Trichoptera Taxa	0	0	0	0	0	5	0	1	0	2	1	3	0
EPT Index	71	31	34	59	51	75	9	14	51	42	31	28	28
Sensitive EPT Index	0	0	0	1	1	47	0	0	0	0	1	1	0
Shannon Diversity	1.0	1.1	1.3	1.2	1.4	2.9	1.7	1.7	1.4	1.6	1.9	1.6	1.5
Tolerance Value	5.1	5.0	5.1	5.1	5.2	3.2	5.4	5.4	5.2	5.2	5.3	5.4	5
Percent Intolerant Organisms	0	0	0	1	1	43	0	0	0	0	1	1	0
Percent Tolerant Organisms	0	0	1	1	2	1	6	0	1	2	4	2	0
Percent Hydropsychidae	0	0	0	0	0	2	0	0	0	0	0	0	0
Percent Baetidae	71	31	34	58	50	18	9	12	51	40	30	27	28
Percent Dominant Taxon	71	55	45	58	50	20	37	27	51	40	30	31	33
Percent Collectors	92	96	95	88	86	40	73	72	87	85	72	62	76
Percent Filterers	7	4	3	10	10	2	23	25	11	8	19	31	23
Percent Grazers	0	0	0	0	0	12	2	0	0	0	0	0	0
Percent Predators	1	0	2	2	4	24	2	1	2	4	8	5	2
Percent Shredders	0	0	0	0	0	22	0	0	0	0	1	1	0
Percent Piercer Herbivores	0	0	0	0	0	0	0	2	0	2	0	0	0
Percent Macrophyte Herbivores	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent Omnivores	0	0	0	0	0	0	0	0	0	0	0	0	0
Abundance													
Total Organisms per Sample	8512	8720	27147	16608	5050	441	5210	2832	1898	1358	1350	3157	3367

* This second sample for RZ-3 is the duplicate sample for this watershed and was taken for quality control purposes.

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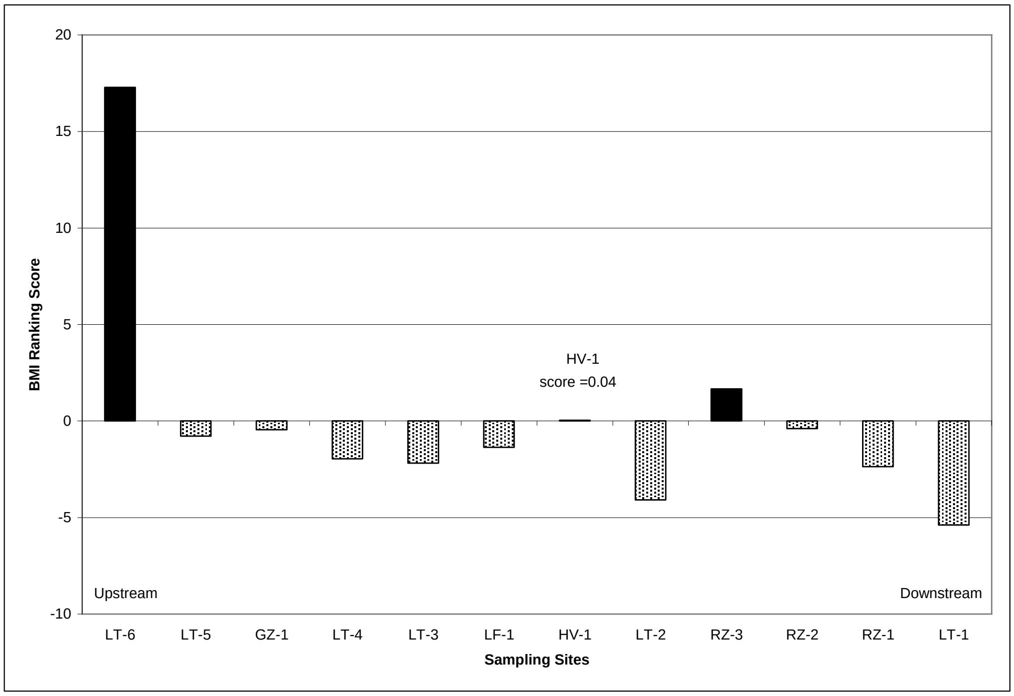
3.5.2 BMI Ranking Scores

As previously noted, the BMI Ranking scores for the Las Trampas Creek watershed data set were developed for comparison between stations only within this watershed and should not be compared to other data sets at this time. The BMI Ranking scores discussed below were calculated for the 2004 data set consisting of the 12 stations.

The BMI Ranking scores for the Las Trampas Creek watershed are illustrated in Figure 8 (higher values are indicative of greater watershed health). In general, the top half of the ranking scores occurred at stations located higher in the watershed. The highest ranking score by far (17.3) was calculated for LT-6, the most upstream station on Las Trampas Creek. In a distant second, RZ-3 scored a BMI Ranking score of 1.7. The lowest ranking value was -5.4 at LT-1, followed by -4.1 at LT-2.

Figure 8. Benthic Macroinvertebrate Ranking Scores for Las Trampas Creek Watershed Sampling Sites, Contra Costa County, April 2004 (higher values are indicative of greater watershed health).



3.5.3 Dominant Taxa Composition

The five dominant species and associated Tolerance Values for the 12 Las Trampas Creek watershed stations are shown in Table 16. Most stations had a BMI community dominated by the chironomid Orthocladiinae, the blackfly *Simulium* sp., the mayfly *Baetis* sp., and/or oligochaete worms. These organisms have Tolerance Values of 5 and 6, indicating a moderate tolerance to pollution and stress. The BMI community at Station LT-6 stands out in being comprised of 20% highly intolerant caddisfly (*Lepidostoma* sp.) and 7% intolerant stonefly (*Kogotus nonus*). The BMI community of LT-6 also had 16% *Baetis* sp. which is a swimming mayfly with a moderate tolerance value of 5.

A comparison of the dominant taxa between adjacent stations on Las Trampas Creek is provided in Table 17. Comparing LT-5 with LT-6 shows the downstream station (LT-5) to have 20% less of the intolerant caddisfly (*Lepidostoma* sp.), 7%less of the intolerant stonefly (*Kogotus nonus*) and 6% less of the highly sensitive mayfly, *Ameletus* sp. The downstream station also had 22% more Orthocladiinae, 9% more *Simulium*, 34% more *Baetis* mayflies and 5% more Oligochaeta.

While Grizzly Creek station GZ-1 ranks similar to LT-5 (see Figure 8), it was notably different in its BMI community in having 41% less Simulium and 41% less Baetis mayflies than LT-5. The Grizzly Creek station also had 32% more Oligochaeta than the upstream station.

The dominant BMI communities of the three stations on Reliez Creek were relatively similar. The most consistent trend was a gradual decline in the percentage of *Baetis* mayflies from the upper watershed to the lower. This same decline associated with a downstream progression is evident in the percentage of Oligochaeta (see Table 17). A notable difference in the BMI community of the uppermost station on Reliez Creek (RZ-3) was the presence of the blind amphipod, *Stygobromus* species. The taxonomist, Dr. Richard Bottorff states that its presence possibly nearby springs.

Table 16. Dominant macroinvertebrate species for each BMI sampling station, Las Trampas Creek watershed, Contra Costa County, April 2004.

		Five Highest Percent Composition by Species at each BMI Station											
Taxa	**T.V.** [1]	**LT-1**	**LT-2**	**LT-3**	**LT-4**	**LT-5**	**LT-6**	**GZ-1**	**HV-1**	**RZ-1**	**RZ-2**	**RZ-3**	**LF-1**
ARTHROPODA													
Hexapoda													
Coleoptera (Larvae)													
Dytiscidae													
Agabus sp.	8				1%								
Diptera													
Ceratopogonidae													
Bexxia - Palpomyia s	6					1%							
Chironomidae													
Orthocladiinae	5	6%	9%	15%	21%	29%	7%	26%	26%	22%	33%	27%	33%
Tanytarsini	6	1%	1%						6%	1%	2%	4%	6%
Simuliidae													
Simulium sp.	6	7%	4%	3%	10%	9%		19%	25%	11%	8%	19%	23%
Ephemeroptera													
Ameletidae													
Ameletus sp.	0						6%						
Baetidae													
Baetis sp.	5	71%	31%	34%	58%	50%	16%	9%	12%	51%	40%	30%	28%
Plecoptera													
Perlodidae													
Kogotus nonus	2						7%						
Trichoptera													
Lepidostomatidae													
Lepidostoma sp.	1						20%						
Subphylum Chelicerata													
Arachnoidea													
Acari													
Sperchontidae													
Sperchon sp.	8			1%						1%			
Subphylum Crustacea													
Malacostraca													
Amphipoda													
Crangonyctidae													
Stygobromus sp.	4											4%	
MOLLUSCA													
Gastropoda													
Bivalvia													
Pelecypoda													
Sphaeriidae													
Pisidium sp.	8							4%					
ANNELIDA													
Oligochaeta	5	14%	55%	45%	8%	5%		37%	27%	12%	9%		9%

[1] T.V. = Tolerance Value (Low values indicates an intolerance to pollution and high values indicate a high tolerance to pollution.).

Table 17. Change in percent dominant macroinvertebrate taxa between selected Las Trampas Creek watershed sites, Contra Costa County, April 2004.

	Taxa	TV [1]	LT5-LT6 [2]	GZ1-LT5	LT4-LT5	LT2-LT3	LF1-LT3	RZ2-RZ3	RZ1-RZ2
Midge:									
	Orthocladiinae	5	22%	-3%	-8%	-6%	18%	6%	-11%
	Tanytarsini	6				1%	6%	-2%	-1%
Blackflies:									
	Simulium sp.	6	9%	-41%	1%	1%	20%	-11%	3%
Mayflies:									
	Ameletus sp.	0	-6%						
	Baetis sp.	5	34%	-41%	8%	-3%	-6%	10%	3%
Stonefly:									
	Kogotus nonus	2	-7%						
Caddisfly:									
	Lepidostoma sp.	1	-20%						
Amphipod:									
	Stygobromus sp.	4						-4%	
Clam:									
	Pisidium sp.	8		4%					
Annelid Worms:									
	Oligochaeta	5	5%	32%	3%	10%	-36%	9%	3%

[1] TV = Tolerance Value: Values between 0 and 10; higher values = greater pollution tolerance.

[2] The difference in percent dominant organism was calculated by subtracting LT-6 percentages from LT-5 percentages. This shows the change in the dominant organisms in the downstream site compared to the upstream site.

3.5.4 Species Similarity

A cluster analysis was performed to determine the similarity in species composition at Las Trampas Creek watershed sampling stations. As illustrated in Table 18, the highest species similarity occurred between stations LT-4 and RZ-1 (90.9%) and between LT-2 and LT-3 (89.1%). Station LT-6 was relatively dissimilar from all other stations.

Table 18. BMI community similarity between Las Trampas Creek watershed stations Contra Costa County, April 2004.

	LT-1	LT-2	LT-3	LT-4	LT-5	LT-6	GZ-1	HV-1	RZ-1	RZ-2	RZ-3	RZ-3 (Duplicate)	LF-1
LT-1	100.0												
LT-2	56.8	100.0											
LT-3	58.8	89.1	100.0										
LT-4	79.8	52.2	60.9	100.0									
LT-5	68.7	49.6	59.3	86.3	100.0								
LT-6	23.9	23.5	25.1	24.9	27.7	100.0							
GZ-1	38.2	59.0	65.2	48.5	49.9	20.0	100.0						
HV-1	41.0	52.3	58.2	51.4	52.7	23.2	83.1	100.0					
RZ-1	78.7	57.5	66.6	90.9	86.6	25.3	55.4	58.1	100.0				
RZ-2	64.4	53.7	62.6	77.5	83.9	25.9	54.9	61.1	82.0	100.0			
RZ-3	48.3	46.5	53.9	66.1	71.9	28.5	60.5	66.7	68.6	74.1	100.0		
RZ-3 (Duplicate)	42.5	40.8	48.1	60.2	68.2	27.6	58.3	69.0	62.7	72.0	83.0	100.0	
LF-1	51.7	49.9	55.8	67.1	71.1	24.8	65.2	76.6	70.4	81.0	83.5	84.8	100.0

3.6 CERRITO CREEK WATERSHED

3.6.1 Metric Results

The data set for Cerrito Creek is different from that of the other watersheds sampled in 2004. A single station has been sampled on this creek annually since 2002 as part of a training exercise. Because this section of Cerrito Creek channel was rehabilitated during the summer of 2003, the collected data became of interest as a means of monitoring the effect of regrading the stream channel and the placement of large gravel substrate in the creek. The 2004 metric results for the Cerrito Creek watershed are provided in Table 19 and described in this section.

Richness

Taxa Richness in this Cerrito Creek station was consistent at values of 14 and 15 prior to the rehabilitation effort in the summer of 2003. Following rehabilitation, the 2004 Taxa Richness dropped to 8. EPT Taxa showed little change over the 3 years with values ranging from 1 to 2.

Composition Measures

The Shannon Diversity values may range from 0 to 3.3 (log N), with the higher diversity values being indicative of increased watershed health. Shannon Diversity values were 1.1 and 1.6 prior to the rehabilitation and 1.0 after the rehabilitation. EPT Index scores were 13 in 2004 compared to 15 in 2003 and 5 in 2002. Sensitive EPT Index scores remained 0 throughout the three years.

Another measure of BMI community composition is Percent Dominant Taxon in which a higher percentage indicates a more impacted environment. Percent Dominant Taxon at this Cerrito Creek station ranged from 46% to 51% during the first two years of sample collection, followed by a score of 70% in 2004.

Tolerance Measures

The Percent Intolerant Organisms in Cerrito Creek was 0 for all three years. Values for Percent Tolerant Organisms were 1% and 2% during the first 2 years and 0% during 2004. Higher percentages of tolerant organisms are indicative of environmental stress.

Functional Feeding Groups

Collectors dominated the BMI communities of this portion of Cerrito Creek, making up 86% (2003), 96% (2002), and 99% (2004) of the organisms identified. The 2002 sample had 3% Predators as the second most abundant feeding group. In 2003, the second most prevalent feeding group was Filterers (9%) followed by Predators (4%). The 2004 sample had 1% Filterers and no other feeding groups represented.

Table 19. Bioassessment metrics for macroinvertebrate samples, Cerrito Creek, Contra Costa County, April 2002, 2003, 2004.

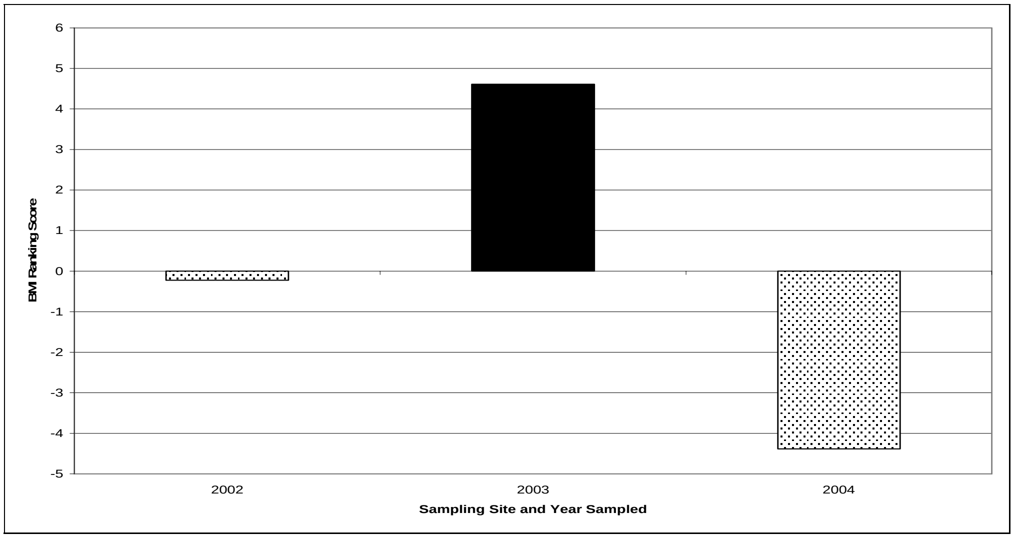
	Cerrito Creek Watershed		
	EC-1		
Metric	**2002**	**2003**	**2004**
Taxonomic Richness	14	15	8
EPT Taxa	1	2	1
Ephemeroptera Taxa	1	1	1
Plecoptera Taxa	0	0	0
Trichoptera Taxa	0	1	0
EPT Index	5	15	13
Sensitive EPT Index	0	0	0
Shannon Diversity	1.1	1.6	1.0
Tolerance Value	5.1	5.3	5.0
Percent Intolerant Organisms	0	0	0
Percent Tolerant Organisms	1	2	0
Percent Hydropsychidae	0	0	0
Percent Baetidae	5	15	13
Percent Dominant Taxon	51	46	70
Percent Collectors	96	86	99
Percent Filterers	0	9	1
Percent Grazers	0	1	0
Percent Predators	3	4	0
Percent Shredders	0	0	0
Percent Piercer Herbivores	0	0	0
Percent Macrophyte Herbivores	0	0	0
Percent Omnivores	0	0	0
Abundance			
Total Organisms per Sample	3997	9740	23360

3.6.2 BMI Ranking Scores

As previously noted, the BMI Ranking scores for the Cerrito Creek data set were developed for comparison between stations only within this watershed and should not be compared to other data sets at this time. The BMI Ranking scores discussed below were calculated for the 2002 through 2004 data set.

The BMI Ranking scores for 3 years of Cerrito Creek BMI data are illustrated in Figure 9 (higher values are indicative of greater watershed health). The highest ranking score (4.6) occurred in 2003, the lowest ranking score (-4.4) occurred in 2004 following the rehabilitation efforts.

Figure 9. **Benthic Macroinvertebrate Ranking Scores for One Site on Cerrito Creek (EC-1), Contra Costa County, April 2002, 2003, 2004.**



3.6.3 Dominant Taxa Composition

During 2002, the Orthocladiinae midge (51%) and Oligochaete worms (38%), both with a Tolerance Value of 5, comprised 89% of the total organisms (Table 20). The 2003 sampling shows a more diverse BMI community with 46% Oligochaeta, 18% Orthocladiinae, 15% *Baetis* mayflies, 9% *Simulium* blackflies and 6% Tanytarsini midge. Following rehabilitation of the stream channel, the 2004 BMI community was heavily dominated by Orthocladiinae (70%), but Oligochaeta had dropped to 14% and Baetis mayflies had dropped slightly to 13%.

Table 21 shows a comparison of the dominant organisms for the 3 years of sampling the Cerrito Creek station. Compared to 2002, the 2003 BMI community had 33% fewer Orthocladiinae, 10% more *Baetis* mayflies, 9% more *Simulium*, and 8% more Oligochaeta. A comparison of the 2004 results to that of 2003 shows the 2004 BMI community to have had 52% more Orthocladiinae and fewer of the other four dominant organisms.

Table 20. Dominant macroinvertebrate species for 3 Years of a BMI sampling station, EC-1 on Cerrito Creek, April 2002, 2003, 2004.

	T.V. [1]	EC-1		
		2002	2003	2004
ARTHROPODA				
Hexapoda				
Diptera				
Chironomidae				
Chironomini	6	2%		
Orthocladiinae	5	51%	18%	70%
Tanypodinae	7	1%		
Tanytarsini	6	1%	6%	1%
Simuliidae				
Simulium sp.	6		9%	1%
Ephemeroptera				
Baetidae				
Baetis sp.	5	5%	15%	13%
ANNELIDA				
Oligochaeta	5	38%	46%	14%
Total Number of Organisms:		494	487	482

1 T.V. = Tolerance Value (Low values indicates an intolerance to pollution and high values indicate a high tolerance to pollution).

Table 21. Change in percent dominant macroinvertebrate taxa between three years of data on one Cerrito Creek site (EC-1), Contra Costa County, April 2002, 2003, 2004.

Taxa		TV [1]	EC-1, 2003-2002[2]	EC-1, 2004-2003	EC-1, 2004-2002
Midge:					
	Chironomini	6	-2%		-2%
	Orthocladiinae	5	-33%	52%	19%
	Tanypodinae	7	-1%		-1%
	Tanytarsini	6	5%	-5%	0%
Blackflies:					
	Simulium sp.	6	9%	-8%	1%
Mayflies:					
	Baetis sp.	5	10%	-2%	8%
Annelid Worms:					
	Oligochaeta	*5*	8%	-32%	-24%

[1] TV = Tolerance Value: Values between 0 and 10; higher values = greater pollution tolerance.

[2] The difference in percent dominant organism was calculated by subtracting 2003 % from 2002 percentages. This shows the change in the dominant organisms in the downstream site compared to the upstream site.

3.7 QUALITY ASSURANCE AND CONTROL

3.7.1 Precision

To assess the precision of field protocols, duplicate BMI samples were collected one site in each of the following four sites, RZ-3, MR-10, RFG-4 and ROD-5. Duplicate samples were compared to samples collected at the same location and variability was assessed to determine if field methods were adequate enough to yield similar results.

Quality assurance analysis indicated that BMI community composition in duplicate samples were very similar (>78% similarity) to samples collected at the same site.

3.7.2 Accuracy

To assess laboratory accuracy, the California Department of Fish and Game Aquatic Bioassessment Laboratory conducted an independent review of the voucher collection for four BMI samples collected in FY 04-05. The CDFG assessment determined that the overall taxonomy was very good and performed in accordance with the California Stream Bioassessment Procedure (CSBP) Level I standards with a few minor exceptions. The resulting changes in taxonomy had no effect on the analytical results. Appendix D contains the QA/QC results for BMI laboratory analyses.

4.0 CHEMICAL AND PHYSICAL HABITAT RESULTS

4.1 REFUGIO CREEK WATERSHED

A summary of the chemical and physical habitat results for the Refugio Creek watershed is included in Table 22. At the time of sampling (March 29-April 1), stream flow in Refugio Creek ranged from 0.1 cfs at its upper end (RFG-5) to 1.6 cfs at its lower end (RFG-1).

Physical habitat quality scores in Refugio Creek ranked “Optimal” at RFG-5 and RFG-2, but “suboptimal” at all other stations with scores ranging from 107 to 149. Sedimentation was notable at the low gradient station (RFG-1) and fines comprised 87% of the substrate. Embeddedness was also highest (53%) at this station, while being 20% to 27% at the other stations. Riffles at the uppermost station (RFG-5) were comprised 85% from rootlets from trees. The predominant substrate in Refugio Creek at stations between the upper and lowermost stations was gravel (37% - 90%).

Refugio Creek gradients ranged from 10% at the uppermost station (RFG-5) to less than 1% at the lowermost station (RFG-1), with most middle stations having a 4% gradient. Canopy shading was relatively high at three of the five Refugio Creek stations (40%-87%) and lowest at RFG-1 (0%) and RFG-3 (10%).

At the time of sampling in late March and early April, water temperatures ranged from 11.3^0 C to 15.1^0 C at the Refugio Creek stations. Specific conductivity was relatively high and ranged from 1,380 uS/cm at RFG-5 to 2,530 uS/cm at the lower stations. The range of pH for the five stations was 7.7 to 8.3, and dissolved oxygen ranged from 9.2 mg/L to 10.6 mg/L.

4.2 RODEO CREEK WATERSHED

A summary of the chemical and physical habitat results for the Rodeo Creek watershed is included in Table 22. At the time of sampling in late March, stream flow in Refugio Creek ranged from 0.05 cfs at its upper end (ROD-5) to 1.0 cfs at its lower end (ROD-1).

Physical habitat quality scores in Rodeo Creek ranked “suboptimal” at ROD-2, -3, and -4, but “marginal” at the upper and lower stations (ROD-1 and Rod-5). These latter two stations had physical habitat quality scores of 85 and 73, respectively. Sedimentation was particularly notable at the uppermost station (ROD-5) where recent silt/sand deposits were 8 inches deep throughout most of the channel. With the exception of ROD-1, located in a channelized area, all other stations had 62% to 90% fines comprising the substrate and a high degree of embeddedness.

Rodeo Creek gradients ranged from 1% (ROD-3, unnamed tributary) to 7% at ROD-4, with most stations having a 2% to 5% gradient. Canopy shading was high at ROD-4 (80%), but less than 50% at all other Rodeo Creek stations.

At the time of sampling in late March, water temperatures ranged from 13.3^0 C to 20.3^0 C at the Rodeo Creek stations. Specific conductivity ranged from 1,230 uS/cm at ROD-3 to 1,920 uS/cm at the lowest station. The range of pH for the five stations was 8.2 to 8.5, and dissolved oxygen ranged from 7.5 mg/L to 12.0 mg/L.

4.3 EDWARDS CREEK WATERSHED

A summary of the chemical and physical habitat results for the single station sampled on Edwards Creek is included in Table 22. At the time of sampling in early April, stream flow in lower Edwards Creek (ED-1) was 0.15 cfs.

The physical habitat quality score for ED-1 ranked “suboptimal” with a score of 141. Sedimentation was not a problem at this location as fines were 3% and embeddedness was 25%. The substrate was nearly evenly divided between gravel, cobble, boulder, and tree rootlets. The creek’s gradient at ED-1 was 7%, and the canopy shading was 70%.

At the time of sampling in early April, the water temperature in Edwards Creek was 13.8^0 C. Specific conductivity was 1,130 uS/cm, pH was 8.4, and dissolved oxygen was 8.6 mg/L.

Table 22. Physical and chemical habitat characteristics at BMI sampling stations, Refugio, Rodeo, and Edwards creeks, March 29-April 1,

	Refugio Creek						Rodeo Creek						Edwards Cr.
Riffle Characteristics	RFG-5	RFG-4	RFG-4 dup	RFG-3	RFG-2	RFG-1	ROD-5	ROD-5 dup	ROD-4	ROD-3	ROD-2	ROD-1	ED-1
Mean Length (ft)	8	6	11	15	9	N.A. [1]	6	4	23	9	9	26	10
Mean Width (ft)	2	5	4	4	3	6	2	2.8	4	1.8	8	6	3
Mean Depth (ft)	0.2	0.2	0.2	0.3	0.3	1.2	0.1	0.1	0.1	0.2	0.1	0.4	0.2
Mean Velocity (ft/sec)	0.9	0.7	1.3	1.3	2.4	0.3	0.6	0.4	0.8	1.2	0.9	1.5	1.0
Subjective Assessments:													
% Canopy	87%	40%	55%	10%	67%	0%	47%	25%	80%	23%	10%	0%	77%
Substrate Complexity	Low	Low	Low	Low	Mod	Low	Low	Low	Low	Low	Low	Mod.	High
% Embeddedness	N.A. [2]	27%	25%	20%	20%	53%	53%	47%	70%	37%	70%	40%	25%
% Fines (< 2 mm)	10%	23%	21%	10%	3%	87%	62%	62%	87%	90%	80%	27%	3%
% Gravel (2-50 mm)	5%	77%	78%	90%	37%	10%	15%	15%	13%	12%	20%	33%	20%
% Cobble (50-256 mm)					7%		63%	24%				30%	23%
% Boulder (>256 mm)												13%	27%
% Bedrock (solid)													
% Rootlets (from trees)	85%				53%	3%							27%
Substrate Consolidation	High	Low	Low	Low	High	Mod.	Low	Low	High	High	Low	Mod.	Mod.
Habitat Quality Score	163	149	149	141	163	107	73	73	103	113	121	85	141
Quantative Assessments:													
% Gradient	10%	1%		4%	4%	< 1%	2%	2%	7%	1%	3%	5%	7%
Streamflow (cfs)	0.10	0.50		0.80	0.80	1.60	0.05	0.05	0.07	0.09	0.50	1.00	0.15
Water Quality Conditions	RFG-5	RFG-4	RFG-4 dup	RFG-3	RFG-2	RFG-1	ROD-5	ROD-5 dup	ROD-4	ROD-3	ROD-2	ROD-1	ED-1
Time of Sampling	0903	1340	1340	1108	916	1100	1222	1222	1500	1315	0900	1516	1330
Water Temperature (^{0}C)	11.3	15.1	15.1	13.7	13.2	15.0	13.8	13.8	20.3	19.2	13.3	18.7	13.8
Specific Conductance (uS/cm)	1380	> 1900	> 1900	2500	2530	2530	1900	1900	1560	1230	1860	1920	1130
pH	8.3	8.3	8.3	8.1	7.7	8.1	8.5	8.5	8.2	8.2	8.2	8.3	8.4
Dissolved Oxygen (mg/L)	9.4	10.6	10.6	9.3	9.8	9.2	10.8	10.8	7.5	8.3	9.8	12.0	8.6

[1] Because Low Gradient protocols were used for this station, riffle length is not applicable (N.A.).

[2] Embeddedness does not apply here because the substrate is a dense clay and wads of rootlets.

4.4 LOWER MARSH CREEK WATERSHED

A summary of the chemical and physical habitat results for the lower Marsh Creek watershed is included in Table 23. At the time of sampling in April, stream flow in lower Marsh Creek ranged from 1.0 cfs to 1.8 cfs above Marsh Creek Reservoir, and 0.3 cfs to 8.0 cfs below the reservoir.

Physical habitat quality scores in lower Marsh Creek ranked “Optimal” at MR-8 (score of 158), “suboptimal” at all other stations from MR-6 upstream to MR-11, and “marginal at all stations downstream of MR-6. Sedimentation was not a noticeable problem at the stations from M-6 upstream. Downstream of M-6, all stations were low gradient with a silt/sand/clay substrate except MR-3, where small boulders and cobble had been placed in 120 feet of the channel to serve as a small drop structure. All stations downstream of MR-5 are located in a channelized streambed.

Lower Marsh Creek gradients upstream of Marsh Creek Reservoir ranged from 3% to 6%, and downstream of the reservoir ranged from less than 1% to 3% at the small boulder drop structures. With the exception of MR-8, located in open pasture, all the stations upstream of the reservoir had 33% to 80% canopy shading. From MR-4 downstream the stations had no canopy shading.

At the time of sampling in April, water temperatures ranged from 14.0^0 C to 21.7^0 C at the Marsh Creek stations. Specific conductivity ranged from 780 uS/cm to 1,490 uS/cm at the lowermost station. The range of pH for the 11 stations was 8.1 to 9.0, and dissolved oxygen ranged from 7.0 mg/L at MR-5 to 11.2 mg/L at MR-6. Extensive growths of filamentous algae in riffles exposed to solar radiation is likely the reason for the high dissolved oxygen levels at this station as it was a sunny day and little turbulence in the riffles to release oxygen produced by plant photosynthesis.

4.5 LAS TRAMPAS CREEK WATERSHED

A summary of the chemical and physical habitat results of the Las Trampas Creek watershed is provided in Table 24. Stream flows in this watershed during the April samplings ranged from 0.5 cfs to 3.3 cfs in the main stem of Las Trampas Creek, 0.3 cfs to 0.8 cfs in Reliez Creek, 0.7 cfs in Lafayette Creek, and 0.2 cfs to 0.4 cfs in Grizzly and Happy Valley creeks. Sampling station gradients in the watershed ranged from 2% to 7% with the highest gradient being at LT-3 and LF-2. Canopy shade was highest (> 80%) at the stations on Grizzly Creek, Happy Valley Creek, and Reliez Creek.

Physical habitat quality scores in the watershed ranged from 107 to 144, which places all of them in the category of “suboptimal”. Embeddedness was generally in the low to mid- 20% with the highest embeddedness (57%) occurring at LT-6. Site LT-6 had the highest percent fines (47%), followed by Happy Valley Creek (30%) and LT-5 (23%). Gravel dominated the substrate composition at all but LT-3 (cobble = 39%) and LF-1 (small boulder = 50%).

Water temperatures in the mainstem of Las Trampas Creek during the early April sampling ranged from 10.0^0 C at LT-6 to 15.8^0 C at LT-2. Tributary stations ranged from 12.2^0 C at RZ-3 to 14.8^0 C at HV-1. Specific conductivity in the watershed was typically between 800 and 910 uS/cm, but RZ-3 on upper Reliez Creek was 1,310 uS/cm. The presence of a blind amphipod at Station RZ-3, plus the unusually high conductivity, indicates that a spring enters the creek at this station or just above it. The pH at all stations sampled in the watershed was between pH of 8.3 and 8.5. The range in dissolved oxygen for all stations was from 9.8 mg/L to 12.4 mg/L.

Table 23. Physical and chemical habitat characteristics at BMI sampling stations, Lower Marsh Creek watershed, April 2004.

	BMI Sampling Stations, Lower Marsh Creek Watershed												
Riffle Characteristics	**MR-11**	**MR-10**	**MR-10 dup**	**MR-9**	**MR-8**	**MR-7**	**MR-6**	**MR-5**	**MR-4**	**MR-3**	**MR-2**	**MR-2HG[2]**	**MR-1**
Mean Length (ft)	6	7	13	10	15	13	12	N.A. [1]	N.A. [1]	30	N.A. [1]	19	N.A. [1]
Mean Width (ft)	9	5	5	8	6	7	8	9	6	11	25	22	25
Mean Depth (ft)	0.1	0.2	0.2	0.3	0.4	0.3	0.2	1.3	1.1	0.6	1.4	0.4	1.6
Mean Velocity (ft/sec)	1.0	1.1	1.5	1.7	1.7	1.1	1.1	< 0.1	< 0.1	0.9	< 0.1	1.4	< 0.1
Subjective Assessments:													
% Canopy	80%	33%	40%	87%	10%	62%	20%	83%	0%	0%	0%	0%	0%
Substrate Complexity	Low	Mod	Mod	High	High	Mod	Mod	Low	Low	Mod	Mod	Mod	Low
% Embeddedness	20%	20%	20%	20%	23%	20%	20%	47%	40%	30%	40%	30%	40%
% Fines (< 2 mm)	18%	10%	7%	3%	5%	5%	2%	65%	60%	25%	50%		40%
% Gravel (2-50 mm)	70%	67%	55%	13%	35%	67%	67%	20%		25%	20%		23%
% Cobble (50-256 mm)	12%	23%	38%	43%	53%	40%	33%	13%	23%	27%	30%	40%	
% Boulder (>256 mm)				40%	7%	5%		3%	17%	22%		60%	37%
% Bedrock (solid)						3%							
Substrate Consolidation	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod
Habitat Quality Score	125	132	132	142	158	148	128	71	69	81	70	70	70
Quantative Assessments:													
% Gradient	3%	3%	3%	6%	5%	3%	3%	< 1%	< 1%	2%	< 1%	3%	< 1%
Streamflow (cfs)	1.2	1.0	1.0	1.4	1.8	1.7	0.7	0.4	0.3	4.2	8.0	8.0	8.0
Water Quality Conditions	**MR-11**	**MR-10**	**MR-10 dup**	**MR-9**	**MR-8**	**MR-7**	**MR-6**	**MR-5**	**MR-4**	**MR-3**	**MR-2**	**MR-2HG[2]**	**MR-1**
Time of Sampling	1029	1011	1011	1303	1236	1455	1616	1437	0925	1052	1253	1253	1434
Water Temperature (^{0}C)	12.7	14.0	14.0	16.1	16.0	19.1	21.7	15.9	13.9	16.9	19.4	19.4	20.7
Specific Conductance (uS/cm)	920	960	960	1020	1090	1180	1050	790	1080	780	1200	1200	1490
pH	8.3	8.1	8.1	8.4	8.3	8.4	9.0	8.4	8.2	8.4	8.3	8.3	8.6
Dissolved Oxygen (mg/L)	10.2	10.3	10.3	9.9	8.2	9.4	11.2	7.0	7.6	8.5	8.8	8.8	10.9

[1] Because Low Gradient protocols were used for this station, riffle length is not applicable (N.A.).

Table 24. Physical and chemical habitat characteristics at BMI sampling stations, Las Trampas Creek watershed, April 2004.

	Las Trampas Creek						Grizzly Creek	Happy Valley Creek	Reliez Creek				Lafayette Creek
Riffle Characteristics	**LT-6**	**LT-5**	**LT-4**	**LT-3**	**LT-2**	**LT-1**	**GZ-1**	**HV-1**	**RZ-3**	**RZ-3 dup.**	**RZ-2**	**RZ-1**	**LF-1**
Mean Length (ft)	10	7	13	11	8	13	7	11	6	33	19	8	10
Mean Width (ft)	4	9	6	7	9	11	3	4	4	5	9	7	9
Mean Depth (ft)	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.3
Mean Velocity (ft/sec)	1.1	1.0	1.3	1.2	1.7	1.3	1.1	1.1	0.8	0.9	1.0	1.0	1.3
Subjective Assessments:													
% Canopy	53%	70%	73%	13%	37%	38%	100%	73%	96%	86%	93%	95%	96%
Substrate Complexity	Low	Low	Low	High	Mod.	Low	High	Low	Mod.	High	Mod.	Low	Mod.
% Embeddedness	57%	20%	30%	20%	22%	20%	25%	32%	20%	22%	23%	22%	22%
% Fines (< 2 mm)	47%	23%	17%	7%	8%	15%	10%	30%	13%	13%	7%	13%	10%
% Gravel (2-50 mm)	53%	77%	83%	30%	50%	85%	57%	67%	80%	37%	63%	63%	27%
% Cobble (50-256 mm)				39%	40%		15%	3%	7%	25%	22%	20%	15%
% Boulder (>256 mm)				23%	2%		5%			25%	3%	7%	50%
% Bedrock (solid)											5%		
% Rootlets (from trees)							13%						
Substrate Consolidation	Low	Low	Low	Mod.	Mod.	Low	Mod.	Low	Mod.	Mod	Mod.	Mod.	Mod.
Habitat Quality Score	118	144	126	118	107	121	147	125	133	133	140	140	104
Quantative Assessments:													
% Gradient	2%	3%	3%	7%	7%	3%	4%	2%	2%	5%	6%	5%	5%
Streamflow (cfs)	0.50	0.70	1.40	1.20	4.80	3.30	0.20	0.40	0.30	0.30	0.60	0.80	0.70
Water Quality Conditions	**LT-6**	**LT-5**	**LT-4**	**LT-3**	**LT-2**	**LT-1**	**GZ-1**	**HV-1**	**RZ-3**	**RZ-3 dup.**	**RZ-2**	**RZ-1**	**LF-1**
Time of Sampling	0928	1434	1104	1158	1420	1222	1252	1610	1000	1000	1253	1436	959
Water Temperature (^{0}C)	10.0	13.7	11.3	14.5	15.8	15.2	13.0	14.8	12.2	12.2	13.4	13.4	12.8
Specific Conductance (uS/cm)	810	880	880	910	850	900	910	850	1310	1310	920	940	800
pH	8.3	8.3	8.3	8.3	8.3	8.4	8.3	8.4	8.5	8.5	8.5	8.4	8.3
Dissolved Oxygen (mg/L)	10.8	12.4	10.2	11.6	12.4	10.4	11.1	10.6	10.4	10.4	9.8	10.6	9.8

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4.6 CERRITO CREEK WATERSHED

A summary of the 3 years of chemical and physical habitat results for the single station sampled on Cerrito Creek is included in Table 24. At the time of sampling, stream flow in Cerrito Creek (EC-1) was 0.10 cfs in 2002, 0.04 cfs in 2003, and 0.06 cfs in 2004.

The physical habitat quality score for EC-1 ranked "marginal" with score of 84 to 85. The 2004 score of 85 reflects that the stream banks had recently been cut and graded and replanted, but that the shrubs hadn't grown sufficiently to provide shade. Sedimentation was not a problem at this location as fines were 20% in 2002, 7% in 2003, and 10% in 2004, plus embeddedness ranged from 12% to 25%. Prior to the rehabilitation, the substrate was 48% to 65% gravel in the riffle habitat. Following the rehabilitation, gravel comprised 87% of the substrate. The creek's gradient at EC-1 was 2% to 4% over the 3-year period. The canopy shading was 29% to 43% prior to the rehabilitation and 0% after the rehabilitation for the reasons noted above.

At the time of the 3 years of sampling, the water temperature in Cerrito Creek ranged from 15.0^{0} C to 16.9^{0}C. Specific conductivity was 750-770 uS/cm, pH was 8.2-8.4, and dissolved oxygen was 9.0-12.0 mg/L.

Table 25. Physical and chemical habitat characteristics at Cerrito Creek BMI sampling station (EC-1), April, 2002, 2003, 2004.

	EC-1		
Riffle Characteristics	**2002**	**2003**	**2004 [1]**
Mean Length (ft)	14	13	9
Mean Width (ft)	3	3	3
Mean Depth (ft)	0.1	0.2	0.1
Mean Velocity (ft/sec)	-	0.7	0.6
Subjective Assessments:			
% Canopy	29%	43%	0%
Substrate Complexity	Mod	High	Low
% Embeddedness	12%	25%	20%
% Fines (< 2 mm)	20%	7%	10%
% Gravel (2-50 mm)	65%	48%	87%
% Cobble (50-256 mm)	15%	23%	3%
% Boulder (>256 mm)		22%	
% Bedrock (solid)			
Substrate Consolidation	Low	Mod	Mod
Habitat Quality Score	84	84	85
Quantative Assessments:			
% Gradient	2%	4%	2%
Streamflow (cfs)	0.10	0.04	0.06
Water Quality Conditions	**2002**	**2003**	**2004 [1]**
Time of Sampling	1600	1500	0931
Water Temperature (^{0}C)	15.0	16.9	15.5
Specific Conductance (uS/cm)	-	750	770
pH	-	8.4	8.2
Dissolved Oxygen (mg/L)	-	9.0	12.0

5.0 DISCUSSION AND CONCLUSIONS

The Contra Costa Clean Water Program (Program) initiated a stream assessment project in Alhambra Creek in spring 2001 as part of the Contra Costa Monitoring and Assessment Plan (CCMAP), a long-term strategy designed to assess the conditions of watersheds, water bodies, and water quality within Contra Costa County (County). The objective of the project was to evaluate the creek's biological integrity (watershed health), using rapid biological assessments, while testing sampling design methodologies. Valuable information was gained from this pilot effort, which led to additional sampling in 2002.

The Program expanded the pilot effort to three additional watersheds (Upper Marsh Creek, Pinole Creek and Upper Kellogg Creek) in 2002, and continued to evolve CCMAP in 2003, where it began assessing the Las Trampas Creek watershed, while supporting citizen volunteers in conducting bioassessments in the Alhambra Creek watershed at stations previously sampled by the Program. In 2004, the Las Trampas Creek watershed was sampled for a second year, and Cerrito Creek was sampled for a third year. All other watersheds sampled in 2004 were new (Refugio, Rodeo, Edwards, and lower Marsh creeks).

The following paragraphs discuss the information collected during the 2004 sampling and compare data collected in 2004 with those collected at the same stations sampled in previous years. Data is compared to determine the biotic integrity at individual sampling stations and for each watershed. In particular, data collected at stations within a single watershed are compared to each other to determine trends within a single watershed. Conclusions were drawn if adequate data is available.

5.1 EFFECTS OF URBANIZATION AND LACK OF REFERENCE CONDITIONS

It has been well documented that the indirect effects (e.g., increased pollutant loading) and direct effects (e.g. increased imperviousness and runoff volume) of urbanization can adversely affect benthic macroinvertebrate communities (Karr and Chu 1999). This is evident in the BMI communities of nearly all creeks in Contra Costa County, where increased urbanization exists. Generally, biological metrics and physical habitat scores decrease moving downstream, indicating lower biological integrity and watershed health in the more urbanized sections watersheds. This trend was generally observed again in 2004, with a few caveats that will be discussed later in this report.

It should be noted that teasing out a specific urban stressor(s) that is adversely affecting biological communities requires a significant amount of complementary chemical water quality data and physical habitat data which is currently unavailable in Contra Costa County. To complicate data interpretation even more, reference conditions for BMIs have not been established for the San Francisco Bay Area. Reference conditions are biotic metric values that would be considered typical for a watershed and allow scientists to compare observed results with expected results and create hypothesis that can be tested to determine the cause or extent of reduced biotic integrity. Until reference conditions are established on a regional basis, investigators must use best professional judgment and empirical methods on a project-by-project basis to evaluate the effects of habitat and/or water quality impacts on benthic fauna.

The following sections provide an interpretation of the 2004 results, and where appropriate results from earlier years, that are based on best professional judgment. Data interpretation is presented on a watershed-by-watershed basis, with the goal of informing the Contra Costa Clean Water Program on potential sub-watershed areas that may be impacting biological communities.

5.2 REFUGIO CREEK WATERSHED

Refugio Creek was sampled for the first time in late March of 2004 at five stations. Compared to other watersheds in Contra Costa County, the Refugio Creek watershed has relatively low taxa richness, ranging from 8-13 taxa. Throughout Refugio Creek, BMI communities were dominated by short-lived (< 1 year) organisms (i.e., chronomids and blackflies) and organisms that live in fine substrate (i.e., mud), and are moderately tolerant to pollution.

Although at least 22% of the watershed is currently open space that is generally present in the upper watershed, BMI metrics and ranking scores do not appear to correlate with the degree of urbanization. Specifically, the uppermost station in the creek is RFG-5, located at the upper end of Refugio Valley Road between Malibou and Miramar streets. As illustrated in Figure 5, RFG-5 ranked the lowest among the five stations in the quality of its BMI community based on six key metrics. One possible explanation is that the riffles sampled at RFG-5 consisted of 85% rootlets from nearby vegetation (see Table 23) which may nave reduced BMI richness and diversity. However, Station RFG-2 had 53% rootlets in its riffles sampled and it ranked the second highest of the five stations. Both stations had high consolidation of riffle substrate and both stations had the highest Physical Habitat Score (163) of the five stations. Because the alternative explanation for the low ranking score of RFG-5 may be one related to water quality, this station should be given particular attention in future studies.

The Low Gradient protocol used to sample Station RFG-1 (gradient of < 1%) appears to have done an adequate job of capturing sufficient numbers of the BMI community. Although dominated by Oligochaete worms, and Orthocladiinae and Tanytarsini midges, diversity and taxa were sufficient to give this station a ranking score of third best among the five stations on Refugio Creek (see Figure 5).

5.3 RODEO CREEK WATERSHED

Rodeo Creek was also sampled for the first time in late March 2004. Compared to other watersheds in Contra Costa County, the Rodeo Creek watershed has relatively moderate to low taxa richness, ranging from 8 to 20 taxa. Similar to Refugio Creek, BMI communities throughout Rodeo Creek were dominated by short-lived (< 1 year) organisms (i.e., chronomids and blackflies) and organisms that live in fine substrate (i.e., mud), and are moderately tolerant to pollution.

Of the five stations sampled on the mainstem of this creek and one of its intermittent tributaries, the uppermost station (ROD-5) was notable in having one chironomid taxa (orthocladiinae) comprise 86% of all organisms identified. Compared to other Contra Costa sampling stations, this is one of the highest percent dominant taxa recorded. This lack of taxa diversity (0.6) is the biggest contributor to its low ranking score (see Figure 6).

Also notable, ROD-5 had roughly 6-8 inches of newly deposited fine sediment covering most of the margins of the stream channel. Two of the riffles sampled here were 80% to 90% fines, but the third riffle sampled was 70% cobble and a slightly steeper gradient. As a result, the average percent fines for this station shown in Table 23 is 62%, less than the percentage of fines at most other stations on the creek. Because of the new sediment inputs occurring at this uppermost station, it is suggested that this station continue to be monitored.

The lowest ranking station on Rodeo Creek is the lowermost station at ROD-1. This is a channelized section of the creek at Viewpointe Road. The riffle habitat sampled was a balanced mix of the primary substrate sizes (see Table 23), and had extensive growths of filamentous algae and watercress. Being lowest site in the watershed and subject to upstream contributions of urban and suburban runoff, the low ranking of this station is not surprising.

The unnamed tributary represented by Station ROD-3 drains an open space area with minimal grazing. Although the substrate at this station averages 90% fines, this station still ranked the highest in quality among the five stations sampled on Rodeo Creek (see Figure 6).

5.4 EDWARDS CREEK WATERSHED

Most of Edwards Creek through the city of Crockett is either in a concrete-lined channel or is culverted. Two stations were established on this creek for sampling, but flows at the uppermost station diminished before permission to access the property could be obtained. The lower station, located just downstream of the John Swett High School athletic field, had a good balance of various substrate sizes, but had a relatively low BMI diversity of 0.9. Future sampling of both ED-1 and the upstream station will allow a comparison of the upper and lower ends of Edwards Creek.

5.5 LOWER MARSH CREEK WATERSHED

In 2002 and 2003, upper Marsh Creek above Curry Creek was sampled in an attempt to establish reference conditions. 2004 was the first time lower Marsh Creek below Curry Creek was sampled as part of this program. The lower Marsh Creek watershed BMI data set contains data for 11 different sampling stations, all on the main stem of the creek. A High Gradient protocol was used for BMI sampling at the majority of the stations. Stations MR-1, MR-2, MR-4, and MR-5 were sampled using the Low Gradient protocols. Station MR-2 was also sampled in a high gradient section using the High Gradient protocols for comparison with the Low Gradient protocols samples at this station.

Stations MR-11 and MR-10 were purposely located above and below the abandoned Diablo Mercury mine to examine the possible effects of mine discharge on BMI communities. Results suggest that mine drainage may continue to effect BMI communities directly downstream. The site above the mine discharge point (MR-11) had moderate taxa richness (21) compared to upstream sites sampled in previous years, and had an extremely high EPT Index (91%), Sensitive EPT Index (67%) and percent intolerant organisms (65%). In comparison, the site directly below the mine discharge point (MR-10) exhibited a significant decrease in all metrics. Although the discharge from the mine may not fully explain the reduction in biotic integrity at MR-10, the effects of mine discharge from the Diablo Mercury Mine on water quality degradation and bioaccumulation of mercury in BMI communities have been documented (Slotten et. al 1996). Therefore, we suggest continuing to monitor this site in future years.

A short distance below Marsh Creek Reservoir, Station MR-6 had the lowest ranking score for Marsh Creek. Like MR-10, this station had a Taxonomic Richness of 12 and 60% of its BMI community was *Simulium* species. The high percentage of the black fly *Simulium* is not unexpected below an impoundment that likely provides a relatively large biomass of phytoplankton that this organism prefers. The similarity in *Simulium* density between MR-10 and MR-6 offers another explanation for the difference between MR-11 and MR-10. The abandoned mine drains into a small impoundment that serves as a stormwater and mine drainage retention basin. This impoundment may be discharging sufficient phytoplankton to the creek to cause the abundance of Simulium at MR-10 and the low ranking score for this station.

The sampling stations lower in the drainage (downstream of MR-6) were dominated by midges (Orthocladiinae and Tanytarsini), Oligochaete worms, and a biting midge, *Bexxia-Palpomyia* species that are typically found in urbanized environments. This latter species was rarely seen upstream of MR-5, but very common at the two lowest stations.

Two polychaete worms, usually indicative of estuarine influence, were found at the three lowest stations on Marsh Creek (MR-1, -2, -3). *Nereis* sp. is fairly common in Delta waters, while *Laonome* sp. is more unusual though it's been collected previously from the Delta and San Joaquin River. *Laonome* sp. is a tube-worm with fan appendages that filter food (Dr. R. Bottorff, pers. com.). In addition to these two polychaetes, other species found here that are indicative of estuarine conditions are *Corbicula* sp. and *Corophium* species.

5.6 LAS TRAMPAS CREEK WATERSHED

5.6.1 Year 2004 Data Set

The 2004 data set for Las Trampas Creek shows that the highest ranking score (17.3) was determined at LT-6, the most upstream station on Las Trampas Creek, followed by the RZ-3 (most upstream station on Reliez Creek) score of 1.7. The lowest ranking value was -5.4 at LT-1, followed by -4.1 at LT-2. In general, the highest ranking scores occur at stations located higher in the watershed (see Figure 8). Station LT-6 was notable in having a substrate that was 47% sand and 53% gravel, yet having the highest number of taxa (42) and the highest diversity (2.9) of any of the stations sampled in Contra Costa County in 2004.

The dominant BMI communities of the three stations on Reliez Creek are relatively similar. The most consistent trend is a gradual decline in the percentage of *Baetis* mayflies from the upper watershed to the lower. This same decline associated with a downstream progression is evident in the percentage of

Oligochaeta (see Table 17). A notable difference in the BMI community of the uppermost station on Reliez Creek (RZ-3) is the presence (4%) of the blind amphipod, *Stygobromus* species. The taxonomist, Dr. Richard Bottorff states that its presence may indicate that the creek is fed by a nearby spring. The specific conductivity of the water at RZ-3 was 1,310 uS/cm while the rest of the watershed had conductivities between 800 and 910 uS/cm. This measurement may support the theory that a spring enters the creek near or above RZ-3.

5.6.2 Year 2004 and 2003 Data Set Comparison

The ranking scores for the combined 2004 and 2003 data sets are illustrated in Figure 10. These ranking scores were constructed using the standard six metrics described earlier and were developed by normalizing the entire 2004 and 2003 data sets so that comparisons can be made.

In both 2003 and 2004, Station LT-6 ranked the highest of any site in the Las Trampas Creek watershed. However, the 2004 sample from this station had a ranking score more than twice that of the 2003 sample. One explanation may be substrate complexity. The substrate of LT-6 in 2003 was 70% fines and 30% gravel, but in 2004 the percentage of fine was reduced to 47% and gravel was increased to 53%.

An overview of Figure 10 shows that virtually all 11 stations sampled on Las Trampas Creek had 2004 rankings similar to that occurring in 2003. The primary difference in the rankings is that, with the exception of LT-1 and LF-1, each of the stations showed improvement in 2004 over that found in 2003. Even though LT-1 and LF-1 scored lower in 2004 than in 2003, the difference was relatively small.

5.7 CERRITO CREEK WATERSHED

5.7.1 Year 2004 Data Set

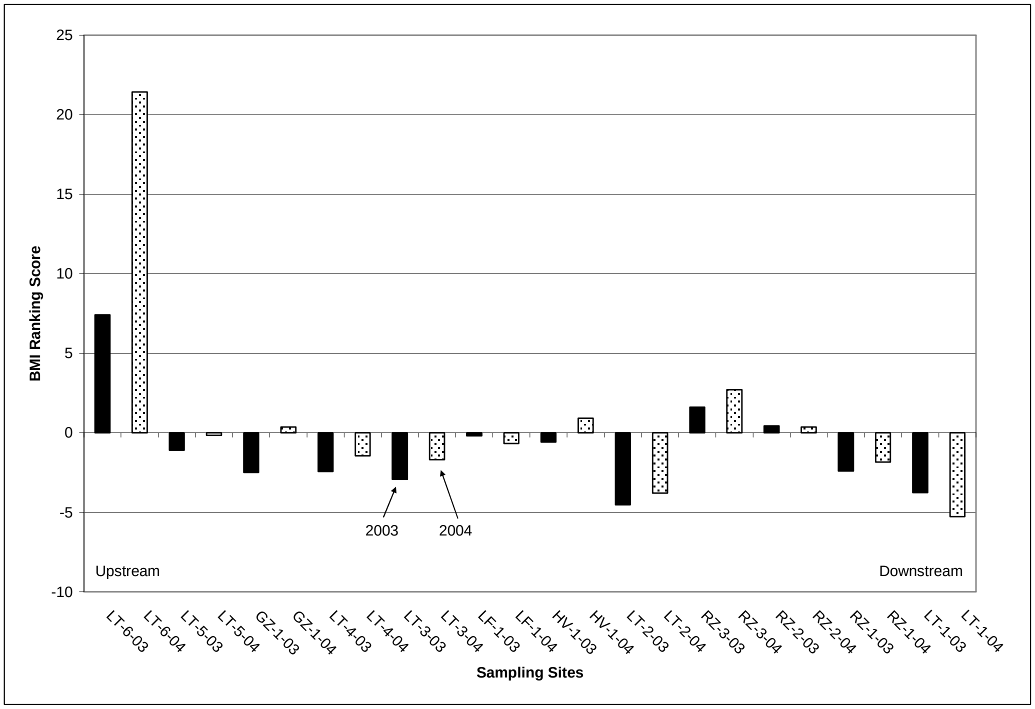
The Cerrito Creek data set is different from that of the other watersheds in that a single station has been sampled on this creek annually since 2002 as part of a training exercise. Because this section of Cerrito Creek channel was rehabilitated during the summer of 2003, the collected data became of interest as a means of monitoring the effect of regrading the stream channel and the placement of large gravel substrate in the creek. The 2004 data set for Cerrito Creek is notable for having a low (8) Taxonomic Richness and diversity (1.0).

5.7.2 Year 2004, 2003, and 2002 Data Set Comparison

As illustrated previously in Figure 9, the highest ranking score for the combined data sets occurred in 2003 prior to the stream rehabilitation. The lowest ranking score was calculated from the 2004 data set, which was collected during the first spring following the rehabilitation effort.

One explanation for the lower ranking score in 2004 following the rehabilitation effort is the redistribution of the rounded gravel substrate during winter and spring storm events during January through March of 2004. During the summer of 2003, the substrate materials were spread relatively evenly throughout the rehabilitated stream with the knowledge that winter storm events would redistribute the gravels to their appropriate locations based on the hydraulic dynamics of the channel. Whenever rounded substrate materials are dramatically shifted about the stream channel, the aquatic macroinvertebrates attached to the rocks or occupying the crevices between the rocks may be displaced and drift downstream. It generally takes about 3 months for the BMI community to recolonize the substrate and become reestablished to previous levels of density after flows that disrupt the substrate. If a storm event caused significant movement of these large gravels within 60 days prior to the early April 2004 sampling of the creek, the samples could reflect a recovering BMI population.

Figure 10. Benthic Macroinvertebrate Ranking Scores for Las Trampas Creek Watershed Sampling Sites, April 2003 and 2004.



5.8 PRIORITIZATION OF SUB-WATERSHEDS

5.8.1 Refugio, Rodeo, Edwards and Lower Marsh Creek Watersheds

As previously described, significant differences in BMI ranking scores, metrics, and species composition were observed between adjacent stations on Refugio Creek, Rodeo Creek, Lower Marsh Creek and Las Trampas Creek watersheds. Each watershed is scheduled to be sampled again during spring 2005. Therefore, we recommend that the prioritization of sub-watersheds and the development of hypothesis be deferred until 2005 data collections are completed and data is analyzed. These data will enable more informed hypotheses to be developed to address the potential causes of differences observed in BMI communities.

5.8.2 Las Trampas Creek Watershed

Data collected in 2003 and 2004 appear to illustrate that changes are apparent in the BMI communities between adjacent sites in the Las Trampas Creek watershed. In the 2003 report, the Program recommended that the following sub-watershed areas be preliminarily considered high priority, where the Program could conduct additional studies to determine why there are significant differences in BMI communities from adjacent sites:

- ***Sub-watershed Area A***: Land area above station LT-5 (uppermost watershed),
- ***Sub-watershed Area D***: Land area between station RZ-3 and RZ-2 (Reliez Creek mid-watershed).

Given that the 2004 data are for Las Trampas Creek watershed are consistent with those collected in 2004, we continue to suggest that if the Program conducts follow-up studies in the Las Trampas creek watershed, it should hold these areas as the highest priority.

6.0 RECOMMENDED NEXT STEPS

Using the data collected from the 2001 through2004, the following are recommendations for next steps in implementing CCMAP and future bioassessments in Contra Costa County watersheds:

- Actively support volunteers in conducting a bioassessment in the Alhambra Creek, Pinole Creek, Wildcat Creek, Mt. Diablo Creek, Kirker Creek, and San Pablo Creek watersheds in spring 2005 and 2006, with a goal of collecting data to better assess the biological integrity of Contra Costa County watersheds;

- Conduct a second bioassessment in the Rodeo Creek, Refugio Creek, Edwards Creek and Lower Marsh Creek watersheds in spring 2005 to better assess biological integrity and develop a revised list of high-priority sub-watersheds;

- Conduct bioassessments in Grayson/Murderers Creek watershed in spring 2005 to begin assessing the biological integrity of these creeks and their tributaries; and,

- Actively participate in developing a regional Index of Biological Integrity (IBI) through the Bay Area Macroinvertebrate Bioassessment Information (BAMBI) Network, providing a framework for watershed assessment priorities and resource allocation in the future;

7.0 REFERENCES

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Appendix – A

Sampling Site Lat/Long Coordinates
&
Site Photographs

Appendix – B

Sample Data Collection Forms

(On CD-ROM Only)

Appendix – C

2004 BMI Species Lists
&
2004 BMI Metrics

(On CD-ROM Only)

Appendix – D

Quality Assurance and Control Results

(On CD-ROM Only)