Biological Assessment of Belmont Creek and Comparison with Existing San Mateo County Data

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SUMMARY

The San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) conducted biological assessments in the spring season of 2006 and 2007 to help evaluate general creek health and physical habitat quality in the Belmont Creek watershed. The assessment was conducted using protocols outlined in the California Stream Bioassessment Procedure (CSBP), which is a standardized procedure for characterizing benthic macroinvertebrate (BMI) assemblages in wadeable streams. BMIs are often used to monitor water quality and overall creek health because their abundance, taxonomic diversity and community structure are highly responsive to changes in their aquatic environment.

The five creek locations selected for the assessment spanned 250 feet in elevation and two ecological subregions with varying levels of urbanized land uses. The three sites furthest downstream are characterized as deeply incised creek channel with varying levels of channel modification and bank stability and a narrow riparian corridor surrounded by residential and commercial land use. The two sites furthest upstream are characterized as relatively natural channels with highly eroded banks and drainage areas primarily containing open space, residential and public land uses.

The fieldwork consisted of collecting three BMI samples per site during each of two spring bioassessment episodes and documenting characteristics of instream and riparian habitat. The BMI samples were processed in the laboratory by compositing the three samples collected at each site, subsampling 500 BMIs from each composite and identifying the subsampled organisms to a standard taxonomic level. Biological metrics, which are numeric measurements of biotic assemblage quality, were used to describe characteristics of the BMI assemblages. Several metrics were integrated into a composite metric score for assessing BMI assemblage quality at the Belmont Creek sites. In addition, existing BMI data, collected during previous bioassessments conducted in other San Mateo County locations (San Pedro, San Mateo and Cordilleras Creek watersheds), were compared to the Belmont Creek data to provide additional perspective on the relative quality of selected creek sites within the county.

Belmont Creek BMI assemblages were characterized as moderately pollutant tolerant with low richness and diversity at all sampling sites and for both assessment years. BMI taxa sampled from the sites are considered short-lived, requiring less than one year to complete their life cycles. Consequently, the abundance of short-lived BMIs suggests that Belmont Creek was intermittent (i.e., dried out during the dry season) during the water years in which the sampling was conducted.

The countywide assessment revealed a wide range of BMI assemblage quality but most of the variation was restricted to the San Mateo and San Pedro Creek watersheds. Site elevation and corresponding changes in downstream land use likely contributed to this variation. In contrast, the Belmont and Cordilleras Creek watersheds showed consistently low BMI assemblage quality across sites irrespective of changes in elevation or downstream land use. One factor that may contribute to this pattern is the possibility of intermittent flow regimes in the latter watersheds.

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1.0 INTRODUCTION

The San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) conducted biological assessments in the spring season of 2006 and 2007 to help evaluate general creek health and physical habitat quality in the Belmont Creek watershed. Monitoring activities included conducting rapid benthic macroinvertebrate (BMI) bioassessments and physical habitat assessments at five locations in Belmont Creek. This report documents the results of the two-year bioassessment and includes a comparison of all sites assessed to-date in San Mateo County using composite metric scores.

BMIs are an essential component of the food web in aquatic habitats. They cycle nutrients in their aquatic environment by feeding on algae and organic detritus and by preying on a wide range of small organisms. They are an important food resource for fishes, amphibians, reptiles, birds and mammals. Because of BMI abundance, taxonomic diversity and range of response to changes in their aquatic environment, they are commonly the resident biota used to monitor the quality of water resources throughout the United States (Davis et al. 1996). Justifications for their use as indicators of water and habitat quality have been described by Hutchinson (1993), Karr and Chu (1999), Resh and Jackson (1993), Rosenburg and Resh (1993) and others. Additional advantages of BMI-based biological assessment include long holding times for preserved samples and the establishment of BMI voucher collections. Voucher collections, which are archived BMIs, provide verification of work product and can be used as a resource for local watershed groups and professional taxonomists.

1.1 Study Objectives

The objectives of the bioassessment were to:

- Assess biological integrity and overall "health" of the Belmont Creek watershed based upon BMI assemblages at selected creek locations and

- Contribute data to a Bay Area-wide data set that is being used to develop a regional Index of Biological Integrity (IBI).

1.2 Study Area Description

The Belmont Creek watershed drains about 3.0 square miles (Figure 1). Jurisdictions within the watershed are predominately the City of Belmont, with small areas within unincorporated San Mateo County and the Town of San Carlos. The creek originates along the east facing slope of Pulgas Ridge and flows east for approximately 3.2 miles until it discharges into Steinberger Slough, which is tributary to San Francisco Bay.

The upper 1.0 mile of Belmont Creek is largely unmodified, with the exception of an earthen dam that was built in the 1800s to create Water Dog Lake. The creek then flows for about 0.5 mile through an underground culvert to a point just east of Alameda de las Pulgas. The creek continues flowing an additional mile through open modified channel down to another culverted section west of El Camino Real. Downstream of this culvert, the creek flows through channelized earthen channel and is tidally influenced.

Land use patterns in the watershed are typical for the Bay-side of San Mateo County. The upper watershed area is predominately a city park managed as an open space preserve, with some residential and commercial land uses along the ridge tops. The middle portion of the watershed is comprised mainly of residential and commercial land uses. The lower portion of the creek upstream of El Camino Real flows through park and public institutional land use. A small portion of the creek downstream of El Camino Real flows through primarily industrial land uses. The overall watershed imperviousness is approximately 42 percent with 26 percent of the creek channel unmodified (STOPPP 2002).

2.0 METHODS

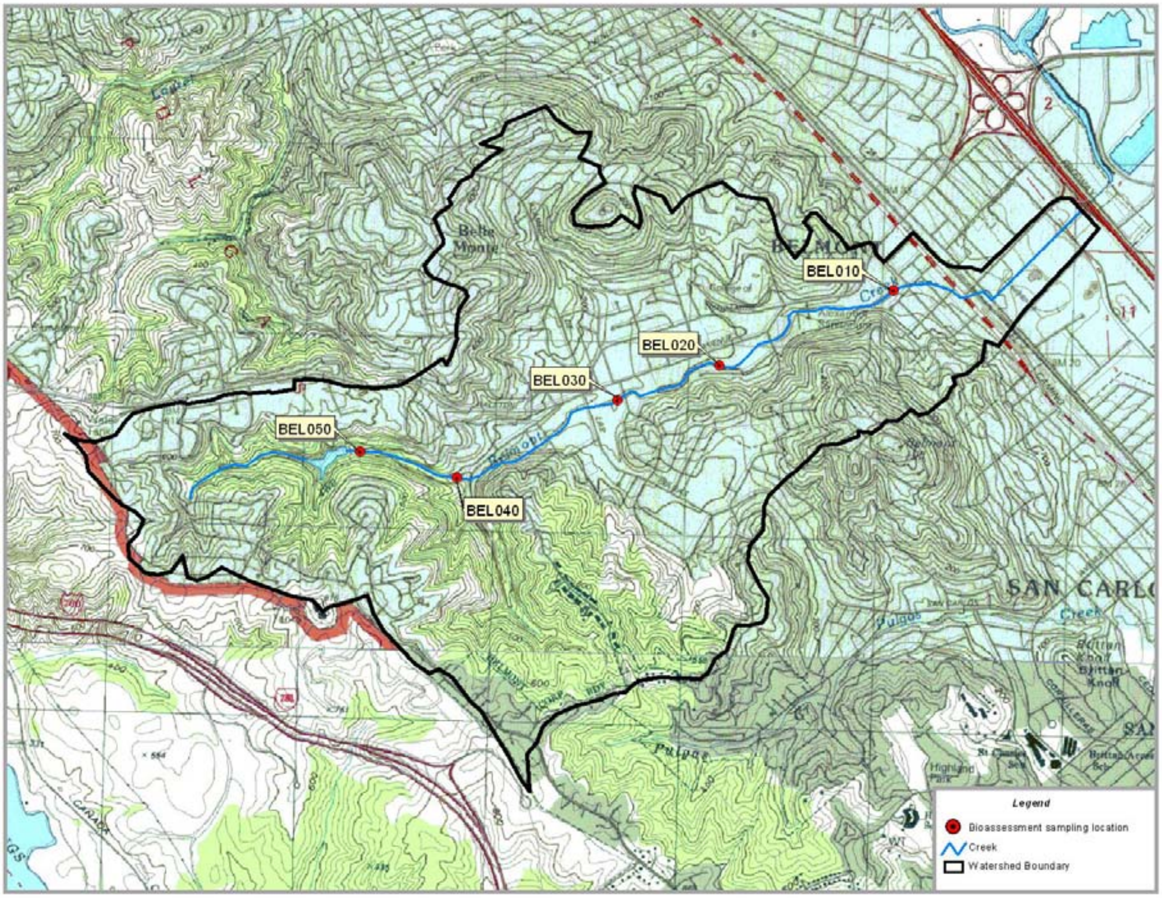
2.1 Site Selection

Bioassessments were conducted at the same five creek locations in the Belmont Creek watershed during both years of the monitoring program. The monitoring sites represent a range of ecoregion subsections, elevations, stream gradients, channel characteristics and land use (Table 1 and Figure 1). Ecoregion information in Table 1 was obtained from the National Hierarchical Framework of Ecological Units GIS database (Bailey 1995). Elevation and channel slope were obtained from USGS 7.5 minute Topographic Maps. Land use information was obtained from Association for Bay Area Governments (ABAG) 2000 Land Use GIS database. Creek channel condition was identified from existing channel survey information (STOPPP 2002, SMCWPPP 2007).

Table 1. Site location descriptions for the Belmont Creek biological assessment.

Sampling Station ID	SWAMP ID	Site Elevation (FT)	Creek Reach Location Description	Predominant Land Use	Ecological Subsection	Channel Slope (%)	Creek Channel Condition
B-1	BEL-010	50	Upstream 6th Av Bridge Crossing	Commercial and public (Park)	Santa Clara Valley	1.1	Armored channel (gabion); deeply incised
B-2	BEL-020	85	Escondido upstream Chula Vista	Residential	Leeward Hills	1.1	Modified channel; eroding banks; deeply incised;
B-3	BEL-030	120	Downstream Maywood Bridge Crossing	Commercial and Residential	Leeward Hills	2.0	Modified channel; moderately incised (bedrock control)
B-4	BEL-040	200	Upstream culvert at Live Oak Way (off Carlmont Dr)	Open space and residential	Leeward Hills	2.9	Natural channel; eroding banks
B-5	BEL-050	300	Downstream overflow bypass for Water Dog Lake	Open space and public (park)	Leeward Hills	6.2	Natural channel

Figure 1. Belmont Creek biological assessment site locations.



2.2 Field and Laboratory Methods

The following sections summarize the field and laboratory methods used for the bioassessment study.

2.2.1 Benthic Macroinvertebrate Field Sampling

Program staff collected benthic samples, measured water quality constituents, and conducted physical habitat assessments during May 2006 and April 2007. Benthic sampling and habitat assessment were conducted using methods outlined in the California Stream Bioassessment Procedure (CSBP) December 2003 revision (http://www.dfg.ca.gov/cabw/csbp_2003.pdf). The CSBP was developed by Harrington (1999) and the CDFG for assessing biotic integrity in wadeable streams. The non-point source portion of the CSBP was applied to this assessment for documenting and describing BMI assemblages and physical habitat within the selected sites.

Benthic sampling was conducted following the CSBP protocols for high gradient streams. Each study site consisted of a 100-meter reach of the channel with at least 3 riffle habitats, each greater than 1 meter wide and 1 meter long. If more than three riffles occurred within the reach, 3 riffles were randomly selected using a random number table. When a selected riffle was of sufficient length and width, a transect location for sampling was randomly chosen from the upper third of the riffle. This was accomplished by laying a tape measure along the length of the upper third 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 the downstream riffle, the benthos within a 1 ft^2 area was disturbed upstream of a 1 ft (0.305 m) wide, 0.02 in. (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. Samples were collected at three locations representing the habitats along each transect (usually the two margins and the mid-point). The samples were combined into a composite sample in the field (representing a 3 ft^2 area) and transferred into a 1000-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 (site).

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 benthic samples, which were composited at the laboratory prior to subsampling and identification of organisms. Composite samples were collected from five stations in the Belmont Creek watershed during both the May 2006 and April 2007 sampling efforts.

2.2.2 Benthic Macroinvertebrate Laboratory Processing

At the laboratory, the three samples collected at each site were composited, rinsed in a standard No. 35 sieve (0.02 in; 0.5 mm) and transferred to a tray with twenty 4 in^2 (26 cm^2) grids for subsampling. Benthic material in the subsampling tray was transferred from randomly selected grids (or half grids if BMI abundance was >150 per grid) to Petri dishes where the BMIs were removed systematically with the aid of a stereomicroscope and placed in vials containing 70% ethanol, 28% water and 2% glycerol. At least 500 BMIs were subsampled from a minimum of three grids. If there were more BMIs remaining in the last grid after 500 were archived, then the remaining BMIs ("extras") were tallied and archived in a separate vial. This was done to assure a reasonably accurate estimate of BMI abundance based on the portion of benthos in the tray that was subsampled. These "extra" BMIs were not included in the taxonomic lists and metric calculations.

Subsampled BMIs were identified using taxonomic keys (Merritt and Cummins 1996; Stewart and Stark 1993; Thorp and Covich 2001 and Wiggins 1996) and unpublished references. The subsampled BMIs identified from each sample were archived in labeled vials with a mixture of 70% ethanol, 28% water and 2% glycerol. A standard taxonomic effort was used as specified in the California Aquatic Macroinvertebrate Laboratory Network (CAMLnet) short list of taxonomic effort, January 2003 revision. Exceptions were made for some immature organisms and organisms in poor condition. Other exceptions included: 1) the identification of midges to subfamily/tribe and 3) a tolerance value of 6 was applied to all Oligochaeta (Adams 2004).

2.2.3 Chemical and Physical Habitat Parameters

Ambient water quality parameters (dissolved oxygen, temperature, pH and conductivity) were recorded at each site using a Yellow Springs Instruments (YSI) 556 Multi-Probe System. Creek velocity was determined at each riffle using a Global Water FP101 flow meter. An example of the field sheet used to record most of the field data is provided in Appendix A.

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 qualitative habitat assessments were recorded for each sampling station during field sampling. Note that the estimate of substrate size percent composition addressed only the riffle habitat sampled and not all other instream habitat types (e.g., pools). Therefore, qualitative and quantitative substrate composition measurements taken during this study should only be used to characterize riffle substrate at stations sampled, and should not be extrapolated to the entire creek 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 A.

Photographs of the BMI sampling sites were taken with a digital camera. Field notes were taken to describe the photo point. Photographs are included in Appendix B.

2.3 Data Quality Assessment Methods

Quality Assurance/Quality Control (QA/QC) activities associated with the field data collection and laboratory analyses are described below. The major goals for these QA/QC procedures are to facilitate collecting representative, comparable, accurate and precise data, to the extent possible under the given limitations.

Duplicate samples were collected at 10% of the total number of sites (n=1) during this monitoring effort to evaluate precision of field sampling methods. In addition one processed BMI sample from the voucher collection was submitted to the Aquatic Bioassessment Laboratory (ABL) for independent assessment of taxonomic accuracy, enumeration of organisms and conformance to standard taxonomic level.

2.4 Bioassessment Data Analysis

2.4.1 Macroinvertebrate Metrics

BMI taxa and the numbers of individuals comprising each taxonomic group were entered into a Microsoft Access® database. A taxonomic list and a table of the five most numerically abundant (dominant) taxa for each site were generated using Microsoft Excel®.

Biological metrics (numerical attributes of biotic assemblages) suggested by the CDFG including those used for the development of regional indices of biotic integrity (Ode and others 2005) were generated using Excel® and are described in Appendix C. Tolerance values and functional feeding group designations were obtained from the CAMLnet short list of taxonomic effort, January 2003 revision.

The various metrics can be categorized into five main types:

- Richness Measures (reflects the total number of distinct taxa);
- Composition Measures (reflects the distribution of individuals among taxonomic groups and includes measures of diversity);
- Tolerance/Intolerance Measures (reflects the relative sensitivity of the assemblage to disturbance);
- Functional Feeding Groups (shows the balance of feeding strategies in the aquatic assemblage);
- Abundance (estimate of the total number of organisms in sample)

2.4.2 Composite Metric Score

Finding a consistent pattern in all metrics is overwhelming due to the plethora of data, and individual metrics can yield conflicting results. Consequently, to better assess the biological integrity of a given site, several metrics are typically integrated into a single ranking score for identifying relative spatial and temporal trends for large regional data sets. A regional data set is necessary to develop an Index of Biological Integrity (IBI). At this time an IBI for the San

Francisco Bay Area is under development but is not yet complete. Therefore, BMI composite metric scores were calculated for each site within a watershed or several watersheds to provide a relative ranking of the various sampling stations. This process serves as a placeholder until regional IBI development is complete (P. Ode, CDFG, personal communication).

The composite metric score approach to evaluating BMI metric data is to normalize and sum the means for selected metrics, and then compare the resulting score between the various sampling sites. Typically, metrics should be responsive (high signal-to-noise ratios) and should measure distinct attributes of the BMI assemblage while minimizing redundancy. The metrics used for the scores were EPT richness, Coleoptera richness, predator richness, percent intolerant individuals, percent collector individuals, percent non-insect taxa and percent tolerant taxa. Several of these metrics have been used for previous Bay Area assessments and all of the metrics were used in the development of an IBI for coastal southern California (Ode and others 1995).

Sites that score high in this integrative index have better than average scores for most or all of the metrics, while sites that score low have poorer scores for most or all of the component metrics. Average ranking sites either have average scores for the component metrics or have a combination of high and low scores.

The formula for computing the composite metric scores is as follows:

$$\text{Composite Metric Score} = \sum \pm(\mathbf{x}_i - x_i)/\text{sem}_i$$

where: $\mathbf{x}_i$ = sample value for the i-th metric; x_i = overall mean for the i-th metric; sem_i = standard error of the mean for the i-th metric; ±: a plus sign denotes a metric that decreases with response to impairment (e.g., EPT richness) while a minus sign denotes a metric that increases with response to impairment (e.g., percent collectors).

2.4.3 Countywide Site Comparisons

Composite metric scores were also calculated for bioassessment data collected by the Program from other watersheds in San Mateo County between 2002 and 2007 (San Pedro, San Mateo and Cordilleras Creek watersheds). These data also included bioassessment data collected for SWAMP by the California Department of Fish and Game (CDFG) in San Mateo Creek during spring 2003. Prior to generation of composite metric scores, data derived from the previous CSBP version were standardized for compatibility with the current 2003 protocol. The standardization included the resampling (shuffle without replacement) of cumulative site totals consisting of 900 organism subsamples to samples consisting of 500 organism subsamples. This was accomplished with the use of an Excel add-in software program (Resampling Stats for Excel version 3.1). Standardization was performed on all San Pedro Creek watershed BMI samples collected in the years 2002 and 2003.

In addition, regression analyses were used to evaluate relationships between habitat and BMI assemblage quality as a function of composite metric scores at sites throughout the county. Selected habitat constituents used for regression analyses included weighted mean substratum size, percent canopy cover, and elevation. Mean substratum particle size was assessed using substrate composition estimated visually at each sampling transect using a modified Wentworth (1922) scale: boulder (phi –10), cobble (phi –8), gravel (phi –6) and sand (phi -1). The phi values ($-\log_2$) were weighted by percent substrate composition at each location where benthic samples were collected. Bedrock was excluded from the weighted mean because a phi value cannot be calculated for bedrock. Bedrock represented a small portion of the substrate: 14% of the data points contained bedrock and of these only two had bedrock percentages greater than 10%.

These habitat constituents were selected because they were assessed within the parameters of the current protocols and they are known to potentially influence BMI assemblages. Transient habitat variables (e.g., velocity and depth) were not evaluated because they change within relatively short temporal scales.

3.0 RESULTS

3.1 Macroinvertebrate Metrics

Complete metric results for the Belmont Creek BMI data set are provided in Table 2. Note that the metrics listed in Table 2 were based on a level I standard taxonomic effort with the exception of chironomid taxa, which were identified to subfamily/tribe instead of family.

Richness and Composition Measures

Total taxonomic richness values ranged from 6 at site BEL-020 (year 2006) to 14 at site BEL-040 (year 2007). EPT taxa ranged from 1 to 2 throughout the creek system and there were no Coleoptera taxa in the subsamples. Predator richness ranged from 1 at sites BEL-020 (2006) and BEL-030 (year 2006) to 5 at site BEL-050 (year 2007). EPT Index metric values ranged from 0.4% at site BEL-030 (year 2007) to 37% at site BEL-020 (year 2006). There were no sensitive EPT taxa in the subsamples. Shannon Diversity values ranged from 1.1 at site BEL-030 (year 2006) to 1.7 at sites BEL-040 and BEL-050 (year 2007). Percent dominant taxon values ranged from 32 at site BEL-050 (year 2007) to 59 at site BEL-030 (year 2007). Non-insect taxa values ranged from 13% at site BEL-030 (year 2006) to 36% at three sites.

Tolerance Measures

Weighted mean tolerance values ranged from 5.1 to 5.6 on a scale from 0 to 10 (see Appendix C for description of tolerance metrics). There were no intolerant organisms sampled from the sites and the percentage of tolerant organisms was less than two percent. The percentage of tolerant taxa ranged from 0 at three sites to 27 at two sites.

Functional Feeding Groups

Functional feeding groups (FFGs) were not evenly distributed across all sites (Figure 2): collectors comprised over 90% of the FFGs at all sites for both years. However, there were consistent increases in the percentage of collector-filterers in year 2007, which was due exclusively to increases in black fly populations. There was a concomitant decrease in segmented worms (collector-gatherers) at all sites in 2007 but no or negligible differences between years for other dominant collector-gatherers including baetid mayflies and orthoclad midges. Predators comprised less than eight percent of the FFGs but were represented by several taxa including tanypod midges, flatworms, damselflies and biting midges. Scrapers, shredders and “other” FFGs were poorly represented at the sites, where they were either not present or comprised less than two percent of the FFGs.

Abundance

Median BMI abundance (individuals per m^2) for the Belmont Creek samples in year 2006 was 6,460 and ranged from 3,350 to 17,900. Median BMI abundance for the Belmont Creek samples in year 2007 was 4,430 and ranged from 2,630 to 14,500.

Table 2. Biological metric values for benthic macroinvertebrate assemblages sampled from Belmont Creek, San Mateo County.

	BEL-010		BEL-020			BEL-030		BEL-040		BEL-050	
Metrics	2006	2007	2006	2007	2007dup	2006	2007	2006	2007	2006	2007
Richness:											
Taxonomic	9	11	6	11	11	8	12	8	14	7	12
EPT*	2	2	1	2	2	1	1	1	2	1	2
Ephemeroptera	1	1	1	1	1	1	1	1	1	1	1
Plecoptera	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	1	1	0	1	1	0	0	0	1	0	1
Coleoptera*	0	0	0	0	0	0	0	0	0	0	0
Predator*	2	3	1	2	4	1	3	3	4	2	5
Composition:											
EPT Index (%)	23	24	37	16	22	9.4	0.4	15	26	10	10
Sensitive EPT Index (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shannon Diversity	1.2	1.4	1.3	1.4	1.5	1.1	1.2	1.4	1.7	1.3	1.7
Dominant Taxon (%)	53	45	37	44	46	56	59	39	34	41	32
Non-insect Taxa (%)*	33	36	33	27	36	13	25	25	36	43	33
Tolerance:											
Tolerance Value	5.6	5.5	5.3	5.5	5.5	5.3	5.1	5.6	5.5	5.5	5.4
Intolerant Organisms (%)*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tolerant Organisms (%)	0.2	0.8	0.0	0.6	0.8	0.0	0.2	0.0	1.6	0.2	0.4
Tolerant Taxa (%)*	11	27	0.0	27	18	0.0	8.3	0.0	21	14	8.3
Functional Feeding Groups:											
Collector-Gatherers (%)*	96	53	95	53	48	97	87	86	58	85	66
Collector-Filterers (%)*	3.4	45	4.7	44	46	2.6	10	12	34	13	29
Scrapers (%)	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.8	0.0	0.0
Predators (%)	0.4	1.2	0.2	2.0	5.7	0.2	2.0	1.8	7.0	1.8	4.3
Shredders (%)	0.0	0.0	0.0	0.0	0.0	0.2	1.2	0.0	0.0	0.0	0.0
Other (%)	0.0	1.2	0.0	0.4	0.2	0.0	0.4	0.0	0.8	0.0	0.4
Estimated Abundance:											
Composite Sample (9 ft^2)	5400	12160	15000	7500	7500	5900	2200	2800	2500	3000	3700
#/ft^2	600	1351	1667	833	833	656	244	311	278	333	411
#/m^2	6459	14545	17943	8971	8971	7057	2632	3349	2990	3589	4426

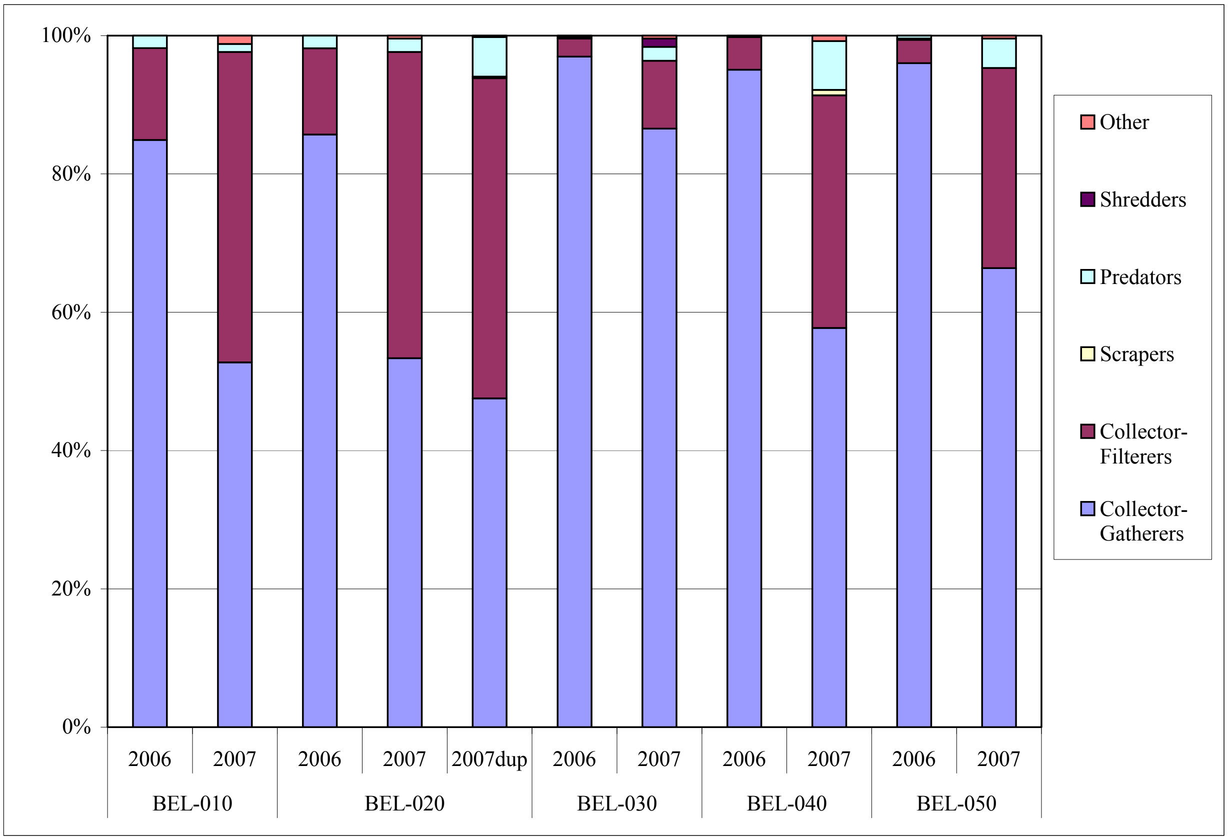


Figure 2. Macroinvertebrate functional feeding groups for Belmont Creek sites sampled in the spring season of 2006 and 2007, San Mateo County.

3.2 Composite Metric Scores

Composite metric scores for the Belmont Creek sites show indistinct trends of BMI assemblage quality across sites and years of sampling except possible higher scores for the two upper elevation sites in year 2007 (Figure 3). Note that the scale of composite metric scores was adjusted to be consistent with the scale of composite metric scores for all sites assessed in San Mateo Creeks since 2002 (see section 3.6).

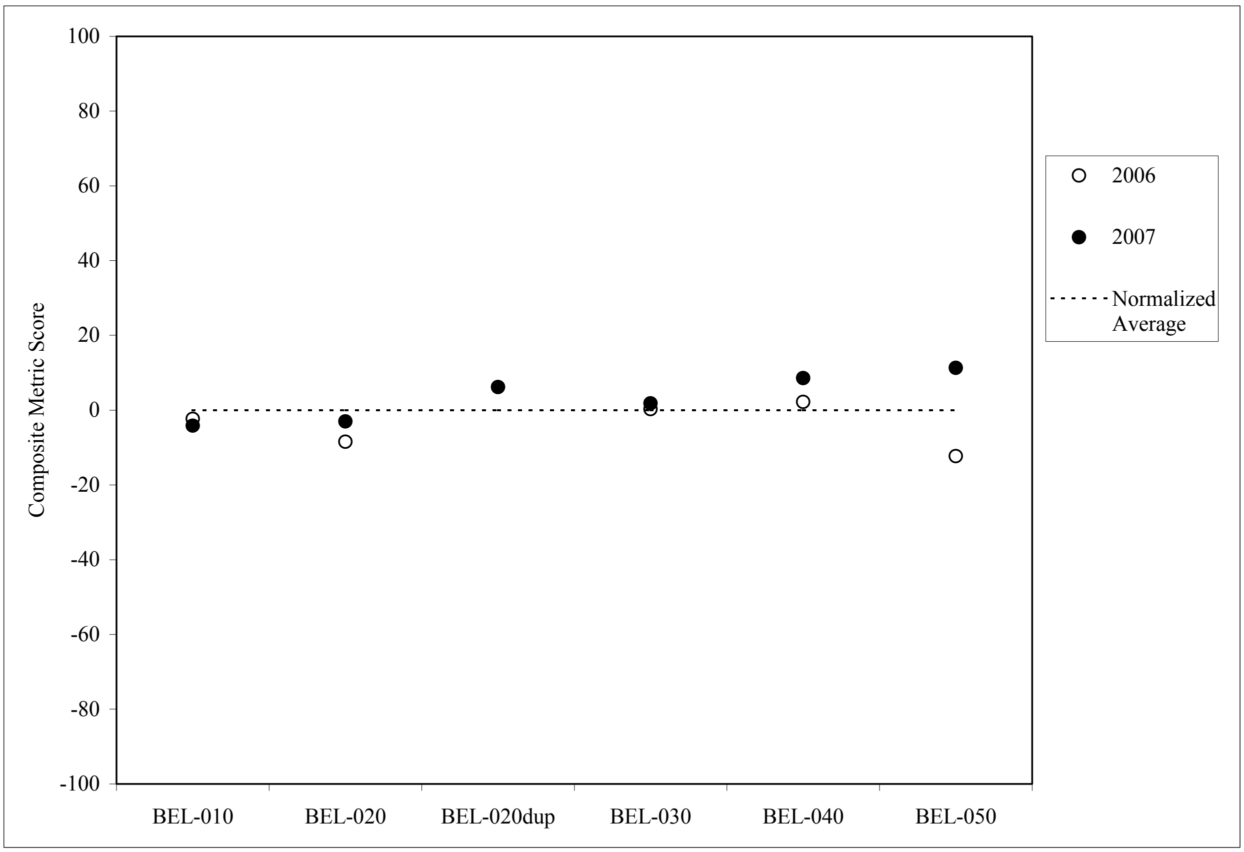


Figure 3. Composite metric scores for Belmont Creek sites sampled in the spring season of 2006 and 2007, San Mateo County.

3.3 Taxonomic Composition

Of the 11 samples collected in 2006 and 2007 from Belmont Creek, including the duplicate, 5,521 BMIs were processed comprising 25 distinct taxa. Table 3 shows the five most numerically abundant (dominant) taxa at each site based on the modified level 1 standard taxonomic effort. A complete taxonomic list including California Tolerance Value (CTV) and functional feeding group (FFG) designations is presented in Appendix D.

Three numerically dominant taxa were common to all sites for both years (Table 3). These taxa included orthoclad midges (Orthocladiinae), black flies (*Simulium*) and segmented worms (Oligochaeta). Baetid mayfly individuals (*Baetis*) were numerically dominant at all sites for both years except site BEL-030 where only two individuals were sampled in year 2007. Year 2007 average relative abundance of *Simulium* was seven times higher than year 2006 but annual average relative abundance of *Baetis* was identical (19%) for both years. Average annual abundance of Orthocladiinae individuals was similar for both years (30% in year 2007 and 36% in year 2006). Average annual Oligochaete relative abundance was three times higher in year 2006 when compared to 2007.

Table 3. Numerically dominant benthic macroinvertebrate taxa and their percent contribution by site for Belmont Creek, San Mateo County.

Year	Site	Numerically Dominant Taxa 1	2	3	4	5
2007	BEL-010	*Simulium* 45%	*Baetis* 22%	Orthocladiinae 22%	Oligochaeta 7%	*Hydroptila* 1%
	BEL-020	*Simulium* 44%	Orthocladiinae 29%	*Baetis* 16%	Oligochaeta 7%	Planariidae 2%
	BEL-020dup	*Simulium* 46%	*Baetis* 22%	Orthocladiinae 16%	Oligochaeta 9%	Planariidae 5%
	BEL-030	Orthocladiinae 59%	Oligochaeta 26%	*Simulium* 10%	*Limonia* 1%	Cyclorrhaphous/ Brachycera 1%
	BEL-040	*Simulium* 34%	*Baetis* 26%	Orthocladiinae 22%	Oligochaeta 8%	*Argia* 5%
	BEL-050	Orthocladiinae 32%	*Simulium* 29%	Oligochaeta 16%	*Baetis* 10%	Tanytarsini 9%
2006	BEL-010	Oligochaeta 53%	*Baetis* 22%	Orthocladiinae 20%	*Simulium* 3%	Tanytarsini 1%
	BEL-020	*Baetis* 37%	Orthocladiinae 33%	Oligochaeta 25%	*Simulium* 5%	Tanytarsini 1%
	BEL-030	Orthocladiinae 56%	Oligochaeta 31%	*Baetis* 9%	*Simulium* 3%	Chironomini 1%
	BEL-040	Oligochaeta 39%	Orthocladiinae 30%	*Baetis* 15%	*Simulium* 12%	Tanytarsini 1%
	BEL-050	Orthocladiinae 41%	Oligochaeta 34%	*Simulium* 13%	*Baetis* 10%	Planariidae 2%

3.4 Quality Control

Results of ABL's independent review of one Belmont Creek sample from the voucher collection from year 2006 indicated no major taxonomic or enumeration discrepancies with one exception (Appendix E). The ABL taxonomist obtained a lower naidid worm count than the original taxonomist. The source of discrepancy was due to fragmented and/or poorly preserved worms. ABL taxonomists count only worms with an intact head while the original taxonomist included some fragmented worms in the final count. Since some naidid worm species are known to reproduce asexually by "budding" it is not unreasonable to conclude that the precise number of viable naidid worms lies between the two counts. A sample collected in 2007 from Belmont Creek is currently being evaluated by the ABL.

3.5 Habitat and Water Quality Assessment

Habitat assessment results are summarized by site in Table 4; transect scale habitat and supplemental site scale habitat assessment data are presented in Appendix F. Sites were moderately (38%) to densely (92%) canopied with intact to highly impaired riparian zones generally increasing in quality with increasing site elevation (Table 4; Appendix F). Riffle substrate composition consisted of gravel (dominant) and cobble (subdominant) with moderate embeddedness. Channel slopes at the sites ranged from 1.1 % to 6.2 % and increased with increasing site elevation.

Site scale habitat scores ranged from 96 at site BEL-030 (year 2006) to 139 at site BEL-050 (year 2007). According to Barbour et al. (1999) the total habitat scores for sites BEL-010 and BEL-030 in year 2006 would imply marginal habitat and suboptimal habitat in year 2007; scores for all other sites for both years would imply suboptimal habitat. For reference, scores of 50 or less would imply poor habitat, scores between >50 and 100 would imply marginal habitat, scores between >100 and 150 would imply suboptimal habitat, and scores greater than 150 would imply optimal habitat.

Water temperature measured at the time of benthic sample collections ranged from 11.3º C to 15.3º C, specific conductance ranged from 690 µS/cm to 1660 µS/cm, pH ranged from 7.8 to 8.1 and dissolved oxygen ranged from 7.0 mg/l to 13.0 mg/l. The later dates of water temperature measurements in year 2006 probably contributed to the annual difference.

Table 4. Physical habitat and water quality constituents documented for Belmont Creek, San Mateo County. Riffle characteristics and subjective assessment data are site mean values.

	BEL-010		BEL-020		BEL-030		BEL-040		BEL-050	
Riffle Characteristics	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**
Mean Length (ft)	8.7	9.0	15	15	6.7	6.7	10	6.7	7.7	9.3
Mean Width (ft)	8.0	6.2	8.0	10.2	3.7	3.7	3.3	1.2	2.2	2.3
Mean Depth (ft)	0.3	0.4	0.2	0.3	0.3	0.3	0.2	0.1	0.1	0.1
Mean Velocity (ft/sec)	2.1	0.9	2.3	0.7	4.1	0.9	1.2	NR	NR	NR
Subjective Assessment										
% Canopy	42	72	58	70	40	67	90	90	92	87
Substrate Complexity (1-10)	6	7	3	3	2	2	4	3	6	5
Embeddedness (1-10)	5	6	5	5	4	7	6	6	3	4
% Fines (<2 mm)	8	8	15	8	12	5	13	17	13	13
% Gravel (2-50 mm)	38	37	43	55	53	57	40	60	48	53
% Cobble (50-256 mm)	28	35	40	35	8	17	45	23	28	18
% Boulder (>256 mm)	25	20	2	2	15	7	2	0	10	15
% Bedrock (soild)	0	0	0	0	12	15	0	0	0	0
Substrate Consolidation	med	med	low	low	low	low	med	med	med	high
Reach Characteristics										
Total Length (ft)	110	205	138	240	122	166	98	118	105	172
% Gradient	1.1	1.1	1.1	1.1	2.0	2.0	2.9	2.9	6.2	6.2
Habitat Quality Score	97	105	101	116	96	136	138	132	116	139
Water Quality Conditions										
Date	5/5/06	4/4/07	5/5/06	4/4/07	5/4/06	4/4/07	5/4/06	4/6/07	5/4/06	4/6/07
Time of Sampling	9:00	9:50	10:30	12:00	14:00	14:30	10:15	11:00	12:00	9:45
Water Temperature (º C)	13.5	11.3	13.5	12.1	14.6	13.8	14.1	11.9	15.3	12.0
Specific Conductance (µS/cm)	1350	1380	1460	1150	1530	1660	798	833	789	690
pH	7.9	7.9	7.9	8.0	8.0	8.0	8.1	7.8	7.8	7.8
Dissolved Oxygen (mg/l)	13.0	10.3	12.3	10.4	11.5	9.2	11.4	7.8	9.6	7.0

3.6 Countywide Assessment

Composite metric scores for all bioassessment sites sampled in San Mateo County between 2002 and 2007 are shown in Figure 4. The plot shows a wide range of scores with most (78%) clustered in the average or below average range. Several sites in the San Pedro and San Mateo watersheds scored in the high range, representing 18% of all sites. One site (SPC-020) scored in a low-intermediate range for two consecutive years. Also, site scores for both San Pedro and San Mateo creek systems increased with increasing elevation and were more variable than sites within the Cordilleras and Belmont creek systems.

While site elevation contributed to some of the variation in composite metric scores (R^2=0.32), substrate size and canopy cover had no or negligible effect on scores (Figure 5, a-c). This strongly suggests that factors other than elevation, substrate size and canopy cover contributed to the variation in composite metric scores.

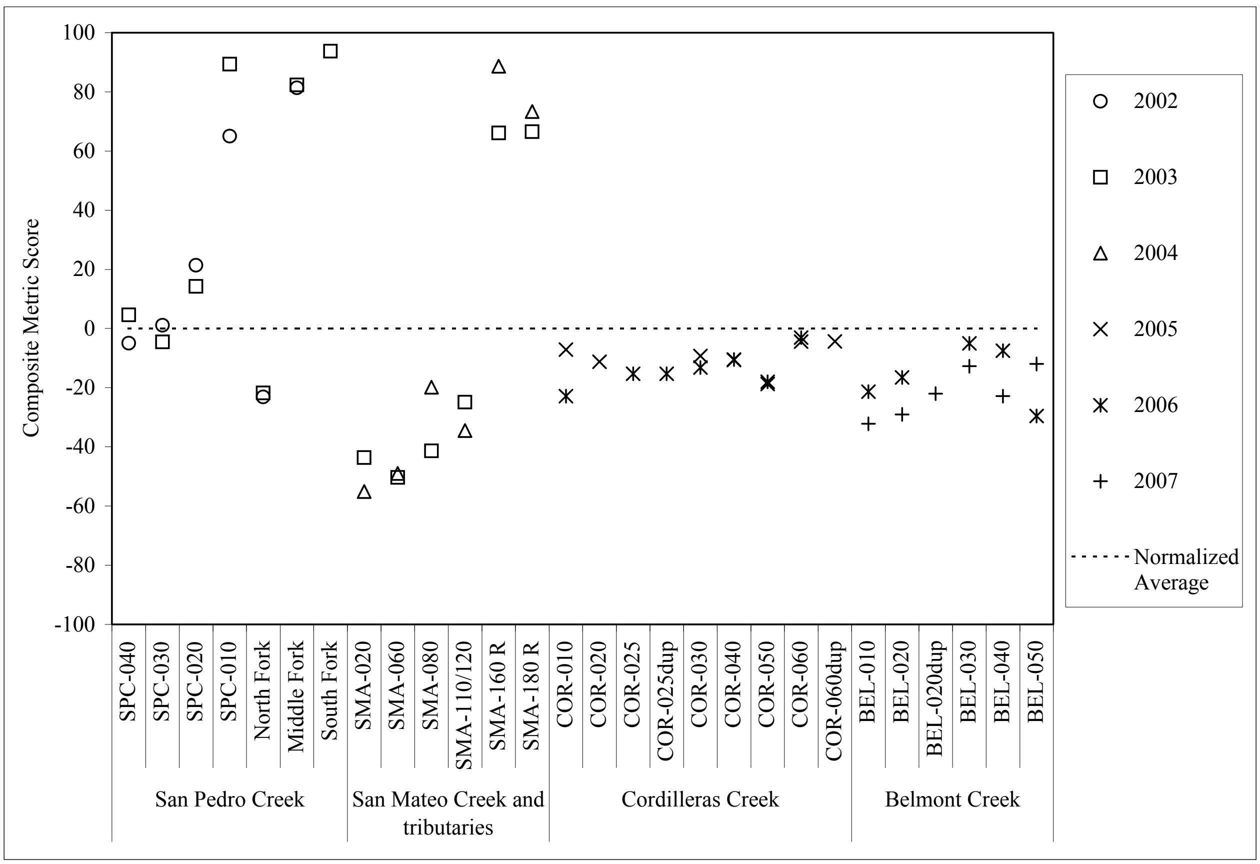


Figure 4. Composite metric scores for all sites sampled in the spring season from 2002 to 2007 in San Mateo County.

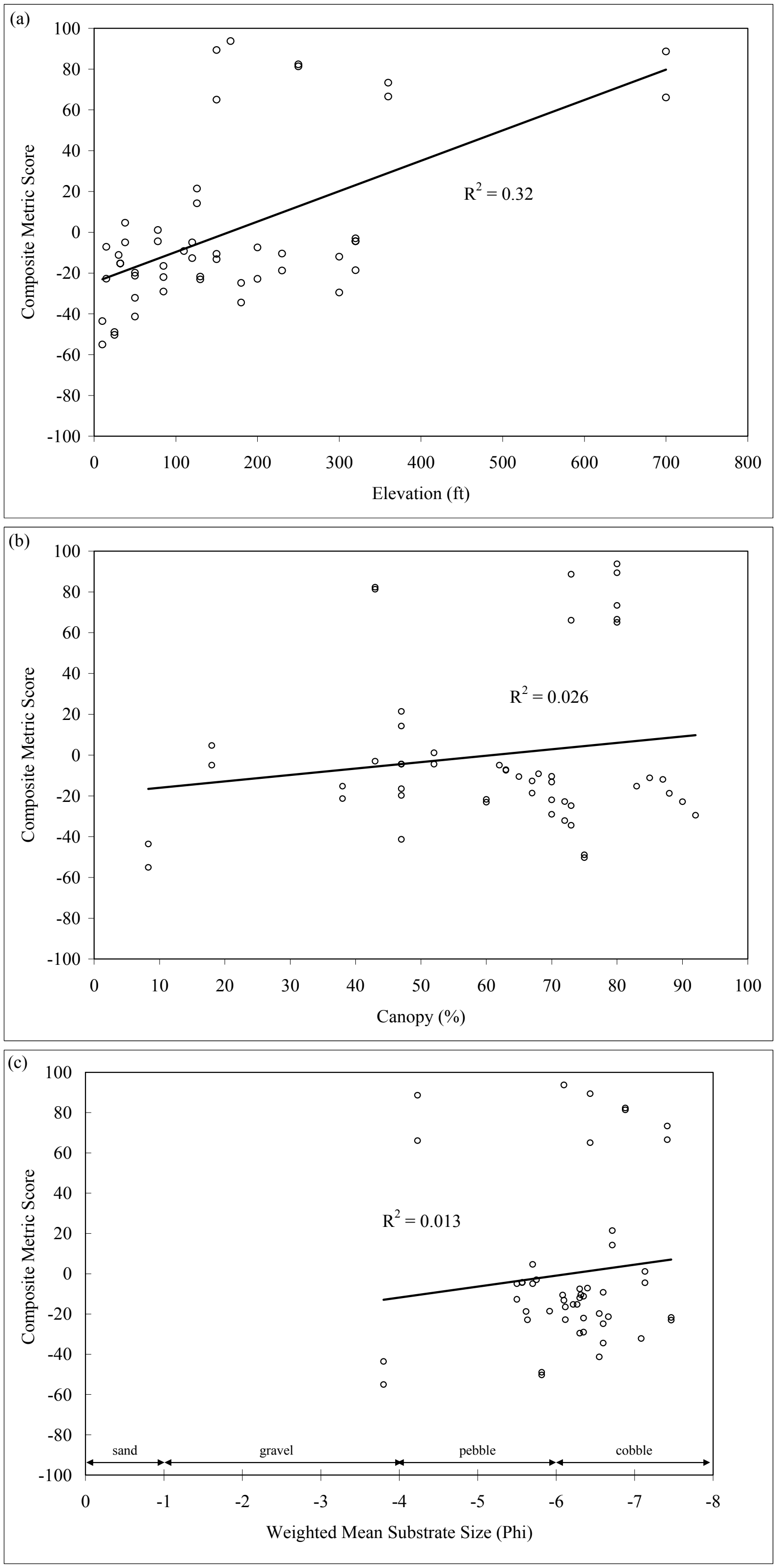


Figure 5. Plots of elevation (a), canopy cover (b) and weighted mean substrate size (c) versus composite metric scores for all sites sampled in the spring season from 2002 to 2007 in San Mateo County.

4.0 DISCUSSION

4.1 Evaluating Influences on Benthic Fauna

Since reference conditions have not been established in creeks within the San Francisco Bay region it is difficult to know what range of biotic metric values would be considered typical for a given region. IBIs have been developed for both south and north coastal regions of California, but reference conditions used to develop those IBIs may not be applicable to watersheds in the San Francisco Bay region. 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 effects of habitat and/or water quality impairment on benthic fauna.

The composite metric score, used for this assessment, is one method for evaluating relative site quality as a function of BMI assemblage quality. However, there are limitations of the composite metric scores. One limitation is that scores cannot be used out of the context of the group of sites being compared. Second, some of the metrics used in the composite metric score measure related attributes of the BMI assemblage, which may contribute to amplified responses. This latter limitation was potentially minimized by incorporating metrics developed for streams in the coastal southern California region where metrics were screened for covariance: if a metric had high correlation with another metric, then the metric with the higher signal-to-noise ratio was selected for the suite of metrics used in the development of the IBI metrics (Ode and others 1995).

It should be noted that the metrics used for this assessment are widely used (Karr and Chu 1999, Ode and others 2005, Rehn and others in review) but are not necessarily the most responsive to stressors affecting creeks in the San Francisco Bay region. Additional BMI and associated habitat data representing a range of conditions including reference conditions for multiple years with a range of water year types would be required for conducting a comprehensive metric analysis. A regional database of BMI and various levels of habitat data are being developed through the Bay Area Macroinvertebrate Bioassessment Network (BAMBI), which will serve to consolidate information for development of a regional IBI. SMCWPPP is providing in-kind assistance to BAMBI's ongoing development of a regional IBI. The comprehensive comparison of all sites assessed to-date for San Mateo County show a wide range of BMI response, which should help with the advancement of IBI development including the establishment of reference condition.

4.2 Effects of Urbanization

Factors contributing to creeks with productive and diverse benthic fauna include mixtures of loosely consolidated coarse substrate, a natural hydrograph, allochthonous inputs and good water quality. These conditions become altered in urban areas where upstream impervious landscape surfaces affect the natural hydrograph and interfere with the production and transport of allocthonous material (Williams and Feltmate 1992, Schueler 1995, and Karr and Chu 1999). While bank sloughing is a natural phenomenon of stream systems, urban creeks are characterized as having higher peak discharges, which contribute to increases in bank instability, increasing channel cross-sectional area and sediment discharge (Trimble 1997). Excessive sediment input occludes interstitial space and thereby decreases the variation of area within the substrate for insect colonization, particularly the

EPT insect orders (Allan 1995, Waters 1995). Often, a shift in benthic fauna occurs with increases in sedimentation resulting in increases in burrowing forms such as chironomids and oligochaetes (Waters 1995). Furthermore, altered hydrographs may affect benthic fauna such as uni/ semi-voltine (long-lived) taxa that are dependent on cyclic thermal cues for their development (Allan 1995, Ward and Stanford 1979). Benthic fauna of urban creeks may also be affected by constituents that may be found in storm water runoff such as petroleum hydrocarbons, fine sediment, pesticides, fertilizers and detergents (Schueler 1987).

Belmont Creek sites had low BMI richness and diversity and pollutant-intolerant taxa were absent for two consecutive spring season sampling events. Furthermore, the BMIs sampled from the Belmont sites are generally considered short-lived, requiring less than one year to complete their life cycles. These attributes of the BMI assemblage were similar across sites for both years despite variation in land use ranging from commercial/residential to open space. Consequently, the relatively low BMI assemblage quality may be a function of the creek's intermittent flow regime rather than urbanization. Creek depth and velocity were observed to be minimal at the upper elevation sites, which lends further support to the seasonal flow condition of Belmont Creek.

The countywide assessment revealed a wide range of BMI assemblage quality but most of the variation was restricted to the San Mateo and San Pedro Creek watersheds. Site elevation and corresponding changes in downstream land use likely contributed to this variation. In contrast, the Belmont and Cordilleras Creek watersheds showed consistently low BMI assemblage quality across sites irrespective of changes in elevation or downstream land use. One factor that may contribute to this pattern is the possibility of intermittent flow regimes in the latter watersheds.

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APPENDIX A

Field data sheets used for documenting site characteristics during biological assessments

CALIFORNIA STREAM BIOASSESSMENT WORKSHEET

WATERSHED/ STREAM: ____________________

DATE/ TIME: ____________________

COMPANY/ AGENCY: ____________________

SAMPLE ID#: ____________________

SITE DESCRIPTION: ____________________

SAMPLING CREW

____

____

SITE INFORMATION

GPS Coordinates

Latitude: ____________

Longitude: ____________

Elevation: ____________

Ecoregion: ____________

COMMENTS:

____

____

____

____

CHEMICAL CHARACTERISTICS

Water Temperature: ________

Specific Conductance: ________

pH: ________

Dissolved Oxygen: ________

SITE PHOTOGRAPHS

RIFFLE/ REACH CHARACTERISTICS

Point Source Sampling Design

Riffle Length: _____

Transcect 1: _____

Transect 2: _____

Transect 3: _____

(Record Physical Habitat Characterization in riffle 1 column)

Non-Point Source Sampling Design

Reach Length: _____

Physical Habitat Quality Score: _____

Physical / Habitat Characteristics

Units: ________

	Riffle 1	Riffle 2	Riffle 3
Riffle Length:	_____	_____	_____
Transect Location:	_____	_____	_____
Avg. Riffle Width:	_____	_____	_____
Avg. Riffle Depth:	_____	_____	_____
Riffle Velocity:	_____	_____	_____
% Canopy Cover:	_____	_____	_____
Substrate Complexity:	_____	_____	_____
Embeddedness:	_____	_____	_____
Substrate Composition:			
Fines (<0.1"):	_____	_____	_____
Gravel (0.1-2"):	_____	_____	_____
Cobble (2-10"):	_____	_____	_____
Boulder (>10"):	_____	_____	_____
Bedrock (solid):	_____	_____	_____
Substrate Consolidation:	_____	_____	_____
Percent Gradient:	_____	_____	_____

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate sand: <0.08" gravel: 0.08-2.5" sm cobble: 2.5-5" lg cobble: 5-10" boulder: >10"	Small and large cobble comprises >70% of substrate. Range of substrate types present from sand to boulder but sand, gravel and/or boulder comprise <30% of substrate. Substrate provides ample and variably sized interstitial space.	Small and large cobble ranges from 40 to 70%. Range of substrate types more limited or present from sand to boulder but amount of sand, gravel and/or boulder accounts for >30-60% of substrate.	Small and large cobble comprises between 20-40% of available substrate. Substrate complexity and ranges of interstitial space limited. Sand, gravel and/or boulder accounts for 60-80% of substrate.	Substrate with little complexity and interstitial space; substrate >90% silt, sand, boulder, bedrock or rip-rap; or, channel is impervious due to concrete or asphalt lining
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble and boulder particles are 25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble and boulder particles are >75% surrounded by fine sediment. May be completely covered.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/ Depth Regime	All four velocity depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow).	Only 3 of 4 of the regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of 4 of the regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep)
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of point bars just above or below riffle. Less than 5% of the bottom of riffle affected by fine sediment.	Some new increases in bar formation just above or below riffle. 5 - 30% of the bottom of the riffle affected by fine sediment.	Moderate deposition of new gravel, sand or fine sediment on bars just above or below riffle. 50-80% of the bottom of the riffle affected by fine sediment.	Heavy deposition of new gravel, sand or fine sediment on bars just above or below riffle. >80% of the bottom of the riffle affected by fine sediment.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches both banks; wetted channel width is equal to bankfull width.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel; or most of channel substrate is exposed.	Very little water present in channel and mostly present as standing pools.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

6. Channel Alteration	No channel alteration; no dredging, levees, rip-rap, gabion structures or bridge abutments	Some channelization present, usually in areas of bridge abutments; evidence of past channelization from dredging	Channelization extensive; embankments or shoring structures present on both banks and 40 to 80% of riffle channelized and disrupted.	Banks shored with gabion or cement; entire riffle affected by channelization.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent: ratio of distance between riffles divided by stream width <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by stream width is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by stream width is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio >25.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability	Both banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of banks adjacent to riffle and just upstream affected.	Banks moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of banks adjacent to riffle and just upstream affected.	Banks moderately unstable; 30-60% of banks adjacent to riffle and just upstream affected.	Unstable banks; 60-80% of banks adjacent to riffle and just upstream affected having Araw@ areas and erosional scars.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
9. Bank Vegetation	Optimal	Suboptimal	Marginal	Poor
	More than 90% of the streambank surfaces adjacent to and near riffle covered by native vegetation including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption by livestock grazing or mowing not evident.	70 - 90% of the streambank surfaces adjacent to and near riffle covered by native vegetation including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption by livestock grazing or mowing not evident.	50-70% of the stream bank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 cm or less in average stubble height.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
10. Riparian Zone Width	Optimal	Suboptimal	Marginal	Poor
	Width of riparian zone >18 m; human activities (eg. Parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 m; human activities have impacted zone only minimally.	Width of riparian zone 6-12 m; human activities have impacted zone substantially.	Width of riparian zone <6 m; little or no riparian zone due to human activities
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

APPENDIX B

Photographs of Belmont Creek sampling sites

Site BEL010 – Belmont Creek upstream of footbridge upstream 6th Ave culvert.

Site BEL020 – Belmont Creek north of Escondido Way.

Site BEL030 – Belmont Creek downstream Maywood Dr.

Site BEL040 – Belmont Creek upstream of Carlmont Dr culvert.

Site BEL050 – Belmont Creek downstream Water Dog Lake.

APPENDIX C

Metrics used to describe characteristics of benthic macroinvertebrate assemblages

BMI Metric	Description	Response to Impairment
Richness Measures		
1. Taxonomic	Total number of distinct taxa.	Decrease
2. EPT*	Number of taxa in the orders Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly).	Decrease
3. Ephemeroptera	Number of mayfly taxa.	Decrease
4. Plecoptera	Number of stonefly taxa.	Decrease
5. Trichoptera	Number of caddisfly taxa.	Decrease
6. Coleoptera*	Number of beetle taxa.	Decrease
7. Predator*	Number of taxa they prey on living organisms.	Decrease
Composition Measures		
8. EPT Index (%)	Percent composition of mayfly, stonefly and caddisfly individuals.	Decrease
9. Sensitive EPT Index (%)	Percent composition of mayfly, stonefly and caddisfly individuals with tolerance values less than 4.	Decrease
10. Shannon Diversity Index	General measure of sample diversity that incorporates richness and evenness.	Decrease
11. Dominant Taxon (%)	The highest percentage of organisms represented by one taxon.	Increase
12. Non-insect Taxa (%)*	Percentage of non-insect taxa.	Increase
Tolerance/Intolerance Measures		
13. California Tolerance Value (CTV)	CTVs between 0 and 10 weighted for abundance of individuals designated as pollution tolerant (higher values) and intolerant (lower values).	Increase
14. Intolerant Organisms (%)*	Percentage of organisms that are highly intolerant to water and/ or habitat quality impairment as indicated by CTVs of 0, 1 or 2.	Decrease
15. Intolerant Taxa (%)	Percentage of taxa that are highly intolerant to water and/ or habitat quality impairment as indicated by CTVs of 0, 1 or 2	Decrease
16. Tolerant Organisms (%)	Percentage of organisms that are highly tolerant to water and/ or habitat quality impairment as indicated by CTVs of 8, 9 or 10.	Increase
17. Tolerant Taxa (%)	Percentage of taxa that are highly tolerant to water and/ or habitat quality impairment as indicated by CTVs of 8, 9 or 10.	Increase
Functional Feeding Groups (FFG)		
18. % Collector-gatherers (cg)*	Percent of macroinvertebrates that collect or gather material.	Increase
19. % Collector-filterers (cf)*	Percent of macroinvertebrates that filter suspended material from the water column.	Increase
20. % Scrapers (sc)	Percent of macroinvertebrates that graze upon periphyton.	Variable
21. % Predators (p)	Percent of macroinvertebrates that prey on living organisms.	Decrease
22. % Shredders (sh)	Percent of macroinvertebrates that shred leaf litter.	Decrease
23. % Others (ot)	Percent of macroinvertebrates that occupy an FFG not described above.	Variable
Other		
24. Abundance	Estimate of the number of BMIs in a sample based on the proportion of BMIs subsampled.	Variable

*** metrics used for composite metric scores**

APPENDIX D

Taxonomic list of benthic macroinvertebrates sampled from Belmont Creek, spring season 2006 and 2007

Taxonomic list of benthic macroinvertebrtates sampled from Belmont Creek in spring 2006 and 2007.

Phylum Class Order Family Final ID	CTV*	FFG**	2006					2007					
			BEL-010	BEL-020	BEL-030	BEL-040	BEL-050	BEL-010	BEL-020	BEL-020dup	BEL-030	BEL-040	BEL-050
Arthropoda													
Insecta													
Diptera													
Cyclorrhaphous/Brachycera	6										4	3	
Ceratopogonidae													
Bezzia/ Palpomyia	6	p											1
Dasyhelea	6	cg									1		
Chironomidae													
Chironomini	6	cg			3								
Orthocladiinae	5	cg	99	166	279	148	206	112	148	80	294	114	156
Tanypodinae	7	p				2				1		7	7
Tanytarsini	6	cg	3	4	2	7	1	5	6	3	4	4	44
Psychodidae													
Psychoda	10	cg							1				
Simuliidae													
Simulium	6	cf	17	24	13	62	67	227	223	227	49	172	143
Stratiomyidae													
Caloparyphus/Euparyphus	8	cg						2	1			1	
Tipulidae													
Limonia	6	sh			1						6		
Tipula	4	om									2		
Ephemeroptera													
Baetidae													
Baetis	5	cg	114	186	47	77	49	113	79	108	2	131	48
Odonata													
Coenagrionidae													
Argia	7	p	1		1	5		3	2	1	2	23	1
Trichoptera													
Hydroptilidae													
Hydroptila	6	ph	1					6	2	1		4	2
Arachnoidea													
Acari													
Acari	5	p											1
Sperchontidae													
Sperchon	8	p						1					
Ostracoda													
Ostracoda	8	cg						1			1	4	2
Annelida													
Hirudinea													
Pharyngobdellida													
Erpobdellidae													
Erpobdellidae	8	p					1						
Oligochaeta													
Oligochaeta	6	cg	270	128	152	193	172	34	35	42	130	41	78

Phylum Class Order Family Final ID	CTV*	FFG**	2006					2007					
			BEL-010	BEL-020	BEL-030	BEL-040	BEL-050	BEL-010	BEL-020	BEL-020dup	BEL-030	BEL-040	BEL-050
Molluska													
Bivalvia													
Pelecypoda													
Sphaeriidae													
Sphaeriidae	8	cf							1				
Gastropoda													
Pulmonata													
Physidae													
Physa/ Physella	8	sc	1							1		3	
Planorbidae													
Menetus	7	sc										1	
Nemertea													
Enopa													
Tertastemmatidae													
Prostoma	8	p								3			
Platyhelminthes													
Turbellaria													
Tricladida													
Planariidae													
Planariidae	4	p	1	1		2	8	2	8	23	4	3	11
Macroinvertebrates subsampled:			507	509	498	496	504	506	506	490	499	511	494

* California Tolerance Value

** Functional Feeding Group:
collector-gatherer (cg); collector-filterer (cf); scraper (sc); predator (p); shredder (sh)
Note: omnivore (om) and piercer herbivore (ph) placed into other (ot) category for metric calculations

APPENDIX E

Quality control results for the Belmont Creek biological assessment project

Comparative Taxonomic Listing of all Submitted Samples

Samples submitted by Bioassessment Services for Project: Bay Area 2006

Report prepared by Brady Richards, CDFG ABL-Chico, 7/21/2006

Taxonomist	Sample no.	Vial no.	Original ID	Original Count	Stage	ABL Count	ABL ID
	BAS-2315						
		1	Argia	1		1	Argia
		2	Baetis	114		114	Baetis
		3	Hydroptila	1	L	1	Hydroptila
		4	Naididae	270		211	Naididae
		5	Orthocladiinae	99	L	99	Orthocladiinae
		6	Physa/Physella	1	L	1	Physa/Physella
		7	Planariidae	1		1	Planariidae
		8	Simulium	17	L	17	Simulium
		9	Tanytarsini	3	L	3	Tanytarsini

APPENDIX F

Habitat data collected for the Belmont Creek biological assessment project

Riffle scale habitat assessments for Belmont Creek, spring season 2006 and 2007.

	2006														
	BEL-010			**BEL-020**			**BEL-030**			**BEL-040**			**BEL-050**		
Riffle Characteristics	R1	R2	R3	R1	R2	R3	R1	R2	R3	R1	R2	R3	R1	R2	R3
Length (ft)	8	9	9	23	11	11	8	5	7	9	9	12	6	9	8
Width (ft)	7.0	7.7	9.2	6.0	8.0	10	4.5	2.5	4.2	3.0	3.0	4.0	2.0	2.5	2.0
Depth (ft)	0.3	0.3	0.4	0.3	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Velocity (ft/sec)	2.4	2.0	1.8	2.3	2.4	2.2	4.9	4.0	3.3	0.9	NR	1.5	NR	NR	NR
Subjective Assessment															
% Canopy	10	75	40	50	50	75	60	50	10	90	90	90	90	95	90
Substrate Complexity (1-10)	6	6	6	3	3	3	3	2	1	3	5	3	6	6	5
Embeddedness (1-10)	6	5	5	5	5	5	3	7	3	6	6	5	3	3	3
% Fines (<2 mm)	10	5	10	15	15	15	10	10	15	15	10	15	15	15	10
% Gravel (2-50 mm)	40	45	30	45	40	45	65	30	65	40	30	50	50	45	50
% Cobble (50-256 mm)	25	30	30	40	45	35	5	10	10	45	60	30	25	30	30
% Boulder (>256 mm)	25	20	30	0	0	5	15	25	5	0	0	5	10	10	10
% Bedrock (solid)	0	0	0	0	0	0	5	25	5	0	0	0	0	0	0
Substrate Consolidation	med	med	med	low	low	low	low	high	low	med	med	low	med	med	med

	2007														
	BEL-010			**BEL-020**			**BEL-030**			**BEL-040**			**BEL-050**		
Riffle Characteristics	R1	R2	R3	R1	R2	R3	R1	R2	R3	R1	R2	R3	R1	R2	R3
Length (ft)	7	11	9	8	22	14	6	7	7	6	8	6	6	10	12
Width (ft)	4	5.5	9	5.5	14	11	3	4.5	3.5	1	1.5	1	2	2	3
Depth (ft)	0.35	0.39	0.4	0.3	0.2	0.3	0.2	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1
Velocity (ft/sec)	0.9	0.85	0.8	0.75	0.77	0.48	0.75	0.56	1.28	NR	NR	NR	NR	NR	NR
Subjective Assessment															
% Canopy	80	75	60	60	70	80	95	85	20	90	90	90	75	90	95
Substrate Complexity (1-10)	7	7	7	3	3	4	1	3	2	3	4	2	6	5	5
Embeddedness (1-10)	7	5	5	4	5	6	7	7	6	5	5	7	4	4	4
% Fines (<2 mm)	5	10	10	5	10	10	5	5	5	15	15	20	10	15	15
% Gravel (2-50 mm)	40	30	40	60	60	45	55	45	70	60	50	70	50	55	55
% Cobble (50-256 mm)	40	40	25	35	30	40	10	20	20	25	35	10	20	15	20
% Boulder (>256 mm)	15	20	25	0	0	5	0	20	0	0	0	0	20	15	10
% Bedrock (solid)	0	0	0	0	0	0	30	10	5	0	0	0	0	0	0
Substrate Consolidation	med	high	med	low	low	low	low	high	low	med	med	low	high	high	high

Site scale habitat data

	BEL-010		**BEL-020**		**BEL-030**		**BEL-040**		**BEL-050**	
Habitat Parameter	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**
Epifaunal Substrate/ Available Cover	10	10	10	15	6	11	16	16	10	15
Embeddedness	10	12	10	12	6	15	12	10	6	9
Velocity/Depth Regime	13	13	16	16	16	14	15	15	10	11
Sediment Deposition	6	14	6	10	3	16	7	7	7	14
Channel Flow Status	15	15	15	12	12	15	15	8	8	6
Channel Alteration	2	1	13	15	13	16	18	19	17	16
Frequency of Riffles	16	18	15	18	18	18	18	19	18	19
Bank Stability	16	15	3	4	8	16	7	4	4	11
Vegetative Protection	4	4	5	7	8	11	18	18	18	18
Riparian Vegetative Zone Width	5	3	8	7	6	4	12	16	18	20
Total Score	**97**	**105**	**101**	**116**	**96**	**136**	**138**	**132**	**116**	**139**