# TECHNICAL MEMORANDUM 3-2

## Aquatic Macroinvertebrates
## Downstream of Englebright Dam

Yuba River Development Project

FERC Project No. 2246

April 2013

TECHNICAL MEMORANDUM 3-2

# EXECUTIVE SUMMARY

In 2012, Yuba County Water Agency conducted benthic aquatic macroinvertebrate (BMI) surveys in the Yuba River downstream of the United States Army Corps of Engineer's Englebright Dam.

The surveys were completed in late July 2012. The study took place on the Yuba River at six sites, in representative locations, between Englebright Dam and the Feather River. Due to the unwadeable conditions present in the study area, methods utilized in the collection of BMI and sampling of habitat parameters in this study were derived from two protocols suitable for large unwadeable rivers: the United States Environmental Projection Agency's Environmental Monitoring and Assessment Program and the Large River Bioassessment Protocol.

Physical habitat varied among the sites, with substrate becoming finer from upstream to downstream, and an increase in the percentage of riffle habitat. An estimated 183,682 invertebrates were collected from the six sample sites. A subset of 3,665 invertebrates was randomly sorted from the whole samples representing six aquatic insect orders. BMIs from the families Chironomidae and Baetidae were among the most common observed. In addition, aquatic crustaceans, arachnids, annelids, gastropods, mollusks, nemerteans, and turbellarians were identified. Eighteen common BMI metrics were calculated for each site. Although metric values were not consistently related to distance downstream of a project dam or reservoir, some BMI metrics were correlated with physical habitat characteristics, such as streambed substrate and habitat composition.

Conditions overall were good and no site showed substantial degradation or disturbance, based on BMI metrics. The quality of each site was generally a factor of substrate, channel size and morphology. Overall, Site 6 (RM 23), the site downstream of Englebright Dam, reflected the greatest degree of disturbance relative to the other sites, while Site 2 (RM 11), the site downstream of Daguerre Point Dam, showed the best overall reported matrix scores. There was no upstream to downstream decrease in site condition - overall results showed no upstream to downstream trend.

The study was conducted according to the Federal Energy Regulatory Commission-approved Study 3.2, Aquatic Macroinvertebrates Downstream of Englebright Dam Study, with one variance. The study plan was scheduled to be completed in September 2012. Additional time was required for the BMI samples to be processed and delayed the delivery of the report to October 2012. This does not alter the data or quality of the report in any manner.

The study is complete.

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# AQUATIC MACROINVERTEBRATES DOWNSTREAM OF ENGLEBRIGHT RESERVOIR[1]

Yuba County Water Agency's (YCWA or Licensee) continued operation and maintenance (O&M) of the Yuba River Development Project, Federal Energy Regulatory Commission (FERC or Commission) Project No. 2246 (Project) may potentially have an adverse effect on benthic macroinvertebrate (BMI) assemblages in the Yuba River downstream of the United States Army Corps of Engineers' (USACE) Englebright Dam.[2]

## 1.0 Goals and Objectives

The goal of the study was to characterize BMI assemblages in the Yuba River downstream of Englebright Dam. The objective of the study was to collect BMI and physical data to meet the study goals.

## 2.0 Methods

The study methods consisted of the following three steps: 1) select sampling sites; 2) collect BMI and habitat data; and 3) analyze and report the data. The methods used in each step are described below.

### 2.1 Study Area

This study area was the Yuba River from Englebright Dam to the confluence of the Yuba and Feather rivers. YCWA collected BMI data at six representative sites (Figure 2.1-1; Table 2.1-1). The location, from upstream to downstream for each site, was:

- Site 6 - Downstream of Narrows 2 Powerhouse and upstream of Deer Creek (River Miles [RM] 23.7 to 23.4)
- Site 5 - Near the University of California (U.C.) at Davis Field Station (Timbuctoo Bend) (RMs 20.3 to 20)
- Site 4 - Parks Bar to Long Bar Area (RMs 17.8 to 17.5)

[1] This technical memorandum presents the results for Study 3.2, Aquatic Macroinvertebrates Downstream of Englebright Dam, which was included in YCWA's September 8, 2011 Revised Study Plan for Relicensing of the Yuba River Development Project, and modified and approved by FERC in its September 30, 2011 Study Plan Determination. There were no modifications to Study 3.2 subsequent to FERC's September 30, 2011 Study Determination.

[2] Englebright Dam, which is about 260 feet high and forms Englebright Reservoir, was constructed by the California Debris Commission in 1941. The dam is owned by the United States. When the California Debris Commission was decommissioned in 1986, administration of Englebright Dam and Reservoir was passed to the USACE. The primary purpose of the dam is to trap and contain sediment derived from extensive historic hydraulic mining operations in the Yuba River watershed. Englebright Reservoir is about 9 miles long with a surface area of 815 acres and a gross storage capacity of about 45,000 ac-ft.

- Site 3 - At Hammon Bar (Upstream of USACE's Daguerre Point Dam[3]) (RMs 14.3 to 14.0)
- Site 2 - Downstream of USACE's Daguerre Point Dam (RMs 11.4 to 11.1)
- Site 1 - Near Hallwood Boulevard (RMs 7.5 to 7.2)

3 Daguerre Point Dam, which is about 25 feet high and 575 feet wide, was constructed by the California Debris Commission in 1904. The dam is owned by the United States. When the California Debris Commission was decommissioned in 1986, administration of Daguerre Point Dam was passed to the USACE. The primary purpose of the dam is to trap and contain sediment derived from extensive historic hydraulic mining operations in the Yuba River watershed.

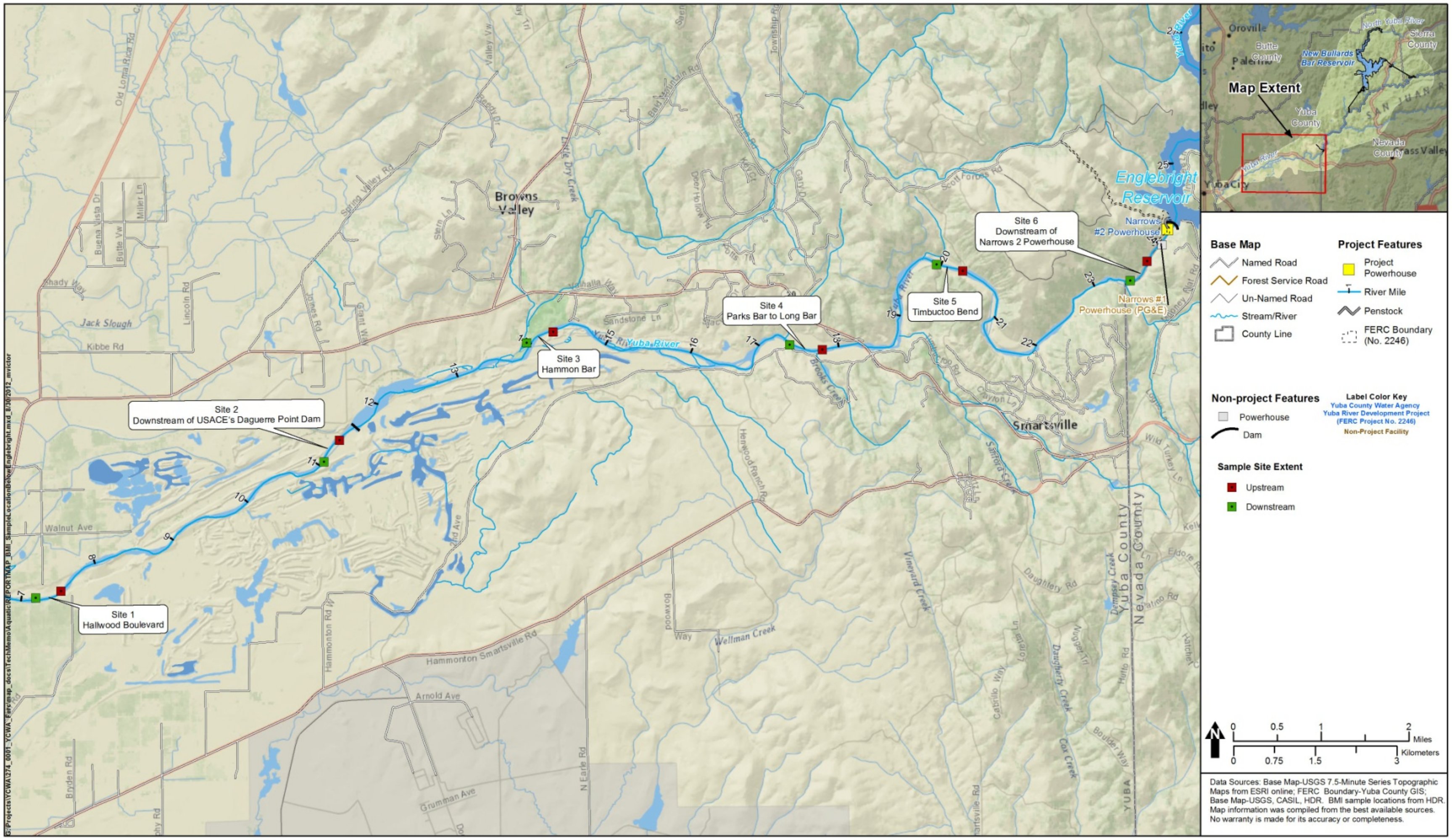


**Figure 2.1-1. Locations of the six BMI sample sites in the Yuba River downstream of Englebright Dam.**

**Table 2.1-1. Sampling and location information for the BMI sampling sites in the Yuba River downstream of Englebright Dam listed in order from upstream to downstream.**

| Site | Sample Date | Elevation (ft) | Gradient (%) | Flow (cfs) | River Mile | |
|---|---|---|---|---|---|---|
| | | | | | Start | End |
| Site 6: Downstream of Narrows 2 Powerhouse | 7/18/2012 | 298 | 1.2 | 2,225 | 23.7 | 23.4 |
| Site 5: Timbuctoo Bend | 7/17/2012 | 239 | 1 | 2,225 | 20.3 | 20.0 |
| Site 4: Parks Bar to Long Bar | 7/16/2012 | 196 | 1 | 2,225 | 17.8 | 17.5 |
| Site 3: Hammon Bar | 7/17/2012 | 150 | 1 | 2,225 | 14.3 | 14.0 |
| Site 2: Downstream of USACE's Daguerre Point Dam | 7/19/2012 | 128 | 1.2 | 1,330 | 11.4 | 11.1 |
| Site 1: Hallwood Boulevard | 7/19/2012 | 71 | 1 | 1,330 | 7.5 | 7.2 |

## 2.2 Data Collection

Generally, the Surface Water Ambient Monitoring Program is used as the standard methodology for BMI assessments in California (SWAMP 2012). However, this method is designed for wadeable streams and is not adapted for unwadeable riverine habitat comprising the majority of habitat in this effort. The United States Environmental Projection Agency (EPA) has developed a method to accommodate unwadeable habitat called the *Environmental Monitoring and Assessment Program– Surface Waters* (Lazorchak et al. 2000). A hybrid to this method is the *Large River Bioassessment Protocol* (LR-BP). Like the *Environmental Monitoring and Assessment Program – Surface Waters*, the LR-BP uses transect and main channel sampling and can be applied in a systematic, unbiased manner for bioassessment. The LR-BP is a combination of semi-quantitative multi-habitat sampling methods applied in a systematic randomized fashion that has been studied for its performance characteristics and variability and was designed to be standardized, quantitative, and user-friendly (Flotemersch et al. 2006). It incorporates proportional multi-habitat sampling and, therefore, should accurately reflect site condition. This method was shown to be responsive to a gradient of disturbance and can be used on a variety of large rivers (Flotemersch et al. 2006). Methods utilized in the collection of BMIs and sampling of habitat parameters in this study was derived from these two protocols.

### 2.2.1 Site Setup

Site lengths were approximately 500 meters (m). The beginning sample point was located at the upstream end of the site and randomly selected within a designated site and marked by Global Positioning System coordinates. Each site had a total of six transects. Transect A was located at the upstream end of the site with the remaining five transects (i.e., designated B through F) at 100 m, 200 m, 300 m, 400 m, and 500 m.

At each transect, a 20 m sample zone (i.e., 10 m on each side of transect) on the chosen bank defined where BMIs were collected. The bank to be sampled was determined by coin toss at the start of the day and all remaining transects were sampled from that bank unless safety concerns or physical attributes (i.e., steep cut-bank or obstructions) prohibited sampling. When the randomly selected bank could not be sampled, the alternate bank was sampled. If a selected bank for a site was deemed not to be representative of both banks (e.g., shallow, sunny and unchanging aspect), then sampling of left and right banks was alternated between transects.

The sampling zone to be sampled extended 10 m into the channel from the water's edge, but did not exceed a depth of 1 m.

### 2.2.2 Macroinvertebrate Collection

Twelve sweeps or kicks, dependent on stagnant or flowing water, each 0.5 m in length were collected within the sample zone using a D-frame net (0.5-millimeter, or mm, mesh). Regardless of the collection method (i.e., sweep or kick), each collection point covered 0.15 square m ($m^2$) of substrate (i.e., net width of 0.3 m and a 0.5 m length of substrate disturbance). Therefore, 12 collection points covered an area of 1.8 $m^2$.

The 12 collection points were proportionately allocated based on available habitat within the 20 m sample zone (e.g., snags, macrophytes and cobble).

Samples from each transect were composited into a single sample for the entire site. Samples were preserved with 95 percent ethanol, and labeled to form a single composite sample for that site. This resulted in each sample containing debris and organisms from six separate zones (total of ~11 $m^2$) that represent the 500 m site.

### 2.2.3 Physical Habitat Characterization and Water Quality

On the day of sampling, water quality measurements were collected once with a handheld water quality meter (Hydrolab Quanta) and included water temperature (degrees Celsius, or °C), conductivity (micro Siemens per centimeter, or µS/cm), and dissolved oxygen (DO).

Physical habitat was characterized over the length of the site and at each transect. Habitat parameters collected were:

- Site-wide parameters collected every 10 m between transects following the thalweg of the stream
  - Thalweg depth
  - Habitat type classification (pool, glide, riffle, rapid, cascade, falls, or dry), presence/absence of backwater and off-channel habitats
  - Dominant substrate classification—visually or using a sounding rod
- Transect parameters collected at each of the six transects
  - Global Positioning System coordinates of the transect
  - Photos from each transect looking upstream and downstream
  - Gradient (clinometer) from one transect to the next
  - Bearing (compass) from one transect to the next
  - Wetted width (laser range finder)
  - Mid channel bar width, if present

  - Bankfull width and height (estimate)
  - Incision height (estimate)
  - Bank Angle (estimate)
  - Riparian canopy cover (densitometer) reading in four directions from the waters edge 1 ft above the water surface
  - Shoreline substrate in the first 1 m above the waterline (estimate dominant and subdominant size class)
  - Estimated diameter, height, and distance from water's edge of largest visible riparian tree and recorded tree species.

- Transect parameters collected within plot that extended 10 m streamward from the water's edge and 10 m upstream and downstream of each transect
  - Measurement of depth and classified dominant and subdominant substrate size class at five systematically-spaced locations within the plot
  - Tally of large woody material (LWM) in plot and in bankfull channel by size and length class
  - Aerial cover class of fish concealment features, including: filamentous algae, aquatic macrophytes, LWM, overhanging vegetation, undercut banks, boulders, artificial structures

- Transect parameters collected within plot that extends 10 m landward from the bankfull margin and 10 m upstream and downstream of each transect
  - Estimated aerial cover class and type of riparian vegetation in canopy, mid-layer, and ground cover
  - Observed and recorded human activities and disturbances and their proximity to the channel

### 2.2.4 Macroinvertebrate Sorting

Each composite sample was rinsed in a standard no. 35 sieve (0.5 mm mesh) and transferred to a tray with twenty, 4-inch-square grids for subsampling, which was performed using a stereomicroscope with magnifications of 10 to 20 times magnification.

Subsamples were transferred from randomly selected grids to Petri dishes where the BMIs were removed indiscriminately with the aid of a stereomicroscope and placed in vials containing 70 percent ethanol and 2 percent glycerol. In cases where BMI abundance exceeded 100 organisms per grid, half grids were delineated to assure that a minimum of three discreet areas within the tray of benthic material were subsampled. At least 500 BMIs were subsampled from a minimum of five grids, or five half grids. The debris from the processed grids was placed in a remnant jar and preserved in 70 percent ethanol for quality control testing.

Subsampled BMIs were subjected to a standard level one taxonomic effort as specified in the *Southwestern Association of Freshwater Invertebrate Taxonomists* (SAFIT 2006). BMIs were identified by a taxonomist approved by the California Department of Fish and Game (CDFG) for USEPA evaluations using standard BMI identification keys (e.g., Stewart and Stark 1993; Merritt and Cummins 1996; Wiggins 1996; Kathman and Brinkhurst 1998; Thorp and Covich 2001) and other appropriate references.

Following BMI processing, the CDFG Aquatic Bioassessment Laboratory (ABL) was contracted to perform an external quality control (QC) review of the sample identification. Twenty percent of the samples collected were randomly selected for QC by the taxonomist and sent to the CDFG ABL.

## 2.3 Data Analysis

### 2.3.1 Aquatic Macroinvertebrates

Richness metrics count a number of unique taxa in a group that are expected to decrease in abundance with increasing disturbance. Composition metrics account for the number of individuals in a taxon or group of sensitive taxa (e.g. Ephemeroptera), relative to the total number of individuals in a sample. The Shannon Diversity Index (SDI) is a measure of both taxa richness and the evenness of taxa composition. Tolerance/Intolerance metrics measure the richness and composition of a sample, in terms of published values of tolerance to disturbance. The California Tolerance Value (CTV) is a weighted average with a scale from 1 to 10, based on taxonomic composition and each taxon's assigned tolerance value. Feeding metrics indicate the presence of certain food resources and the complexity of the overall BMI community.

BMI data for each site were analyzed using the 18 selected metrics identified in the FERC-approved study. In addition, total estimated abundance was calculated. Table 2.3-1 shows the 19 metrics calculated to assess BMI assemblages.

**Table 2.3-1. Biological metrics calculated to assess BMI assemblages.**

| BMI Metrics | Description | Predicted Response to Impairment |
|---|---|---|
| **ABUNDANCE** | | |
| Total Estimated Abundance | Extrapolated value of all the individual taxa in a sample | Decrease |
| **RICHNESS** | | |
| Taxonomic Richness | Total number of individual taxa | Decrease |
| No. EPT Taxa | Number of taxa in the insect orders Ephemeroptera, Plecoptera, and Trichoptera | Decrease |
| No. Ephemeroptera Taxa | Number of mayfly taxa | Decrease |
| No. Plecoptera Taxa | Number of stonefly taxa | Decrease |
| No. Trichoptera Taxa | Number of caddisfly taxa | Decrease |
| No. Coleoptera Taxa | Number of beetle taxa | Decrease |
| **COMPOSITION** | | |
| % EPT | Percent of the composite of mayfly, stonefly, and caddisfly larvae | Decrease |
| % Ephemeroptera | Percent of mayfly nymphs | Decrease |
| Shannon Diversity Index (SDI) | General measure of sample diversity that incorporates richness and evenness | Decrease |

**Table 2.3-1. (continued)**

| BMI Metrics | Description | Predicted Response to Impairment |
|---|---|---|
| **TOLERANCE/INTOLERANCE** | | |
| 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 |
| No. of Intolerant taxa | Taxa richness of those organisms considered to be sensitive to perturbation | Decrease |
| % Tolerant Organisms | Percent of macrobenthos considered to be tolerant of various types of perturbation | Increase |
| % Dominant Taxon | Measures the dominance of the single most abundant taxon. Can be calculated as dominant 2, 3, 4, or 5 taxa | Increase |
| **FEEDING** | | |
| % collector-filterers+collector-gatherers Individuals | Percentage of BMIs within the collector-filterer and collector gatherer functional feeding groups | Increase |
| % Scrapers | Percent of BMIs that graze upon periphyton | Variable |
| **RICHNESS** | | |
| % Non-gastropoda Scrapers | Percentage of BMIs within the scraper functional feeding group excluding gastropod scrapers | Decrease |
| % Predators | Percent of BMIs that prey on living organisms | Decrease |
| % Shredders | Percent of BMIs that shred leaf litter | Decrease |

### 2.3.2 Physical Habitat

The BMI sampling sites were each characterized in terms of water quality and physical habitat conditions. Some raw data from the site and physical habitat transects were reduced into site-wide averages and composition percentages. The following physical habitat variables were reduced to site-wide averages for each site:

- Gradient
- Thalweg depth
- Sample plot depth
- Wetted width
- Bankfull width
- Bankfull height
- Incision height

The following physical habitat variables were reduced to site-wide composition percentages for each site:

- Thalweg substrate types
- Habitat types
- Sample plot substrate types
- Riparian canopy cover

Riparian vegetative cover, large woody material (LWM), human influence, and instream cover data were not reduced to descriptive statistics, but general trends and descriptions were included in this report.

### 2.3.3 Comparison of BMI Metrics to Physical Habitat

BMI metrics were examined for upstream to downstream trends and for correlations with physical habitat features among the sites. Non-parametric (rank-order) Spearman correlation coefficients were calculated for pairwise combinations of BMI metrics and physical habitat variables. Correlation coefficients of 80 percent and higher were further examined for biological relevance. The intent of the correlation analysis was to screen and identify possible relationships for qualitative analysis. Interpretation of the correlation results was limited to a qualitative analysis because of the small sample size and because of the risk of erroneously interpreting spurious correlations. Hypothesis testing with statistical confirmation sampling is beyond the scope of this study.

# 3.0 Results

An estimated 183,682 BMIs were collected from the six sample sites. A subset of 3,665 BMIs was randomly sorted from the whole samples. From this representative subset, aquatic insects from orders Coleoptera, Diptera, Ephemeroptera, Hemiptera, Plecoptera, and Trichoptera were identified. In addition, aquatic crustaceans, arachnids, annelids, gastropods, mollusks, nemerteans, and turbellarians were identified. Overview tables of habitat characteristics (Table 3.0-1) and BMI metrics (Table 3.0-2) are presented below for all six sampled sites. Individual reporting by site is presented following the table. All collected data are available in Attachment 3.2-A and photos of sites are available in Attachment 3.2-B. For ease of reading, referenced figures are presented at the end of the following sections.

**Table 3.0-1. Water quality and habitat characteristics collected at six sites in the Yuba River downstream of Narrows 2 Powerhouse in July 2012.**

| Category | Metric | Site 6 (RM 23) | Site 5 (RM 20) | Site 4 (RM 18) | Site 3 (RM 14) | Site 2 (RM 11) | Site 1 (RM 7) |
|---|---|---|---|---|---|---|---|
| Water Quality | Water Temperature (°C) | 11.7 | 11.8 | 12.5 | 13.1 | 12.5 | 16.8 |
| | Dissolved Oxygen (mg/L) | 11.1 | 10.5 | 10.9 | 10.5 | 10.1 | 9.6 |
| | Specific Conductivity (µS/cm) | 68 | 69 | 69 | 68 | 70 | 72 |
| Site Characteristics | Flow (cfs) | 2,225 | 2,225 | 2,225 | 2,225 | 1,330 | 1,330 |
| | Gradient (%) | 1.2 | 1 | 1 | 1 | 1.2 | 1 |
| | Average Thalweg Depth (cm) | 285 | 128 | 218 | 103 | 80 | 174 |
| | Habitat Composition (% of site) | | | | | | |
| | Pool | 72 | 0 | 46 | 0 | 0 | 0 |
| | Glide | 8 | 78 | 32 | 44 | 68 | 52 |
| | Riffle | 20 | 22 | 22 | 56 | 32 | 48 |
| | Rapid | 0 | 0 | 0 | 0 | 0 | 0 |
| | Dominate Thalweg Substrate Composition (% of site) | | | | | | |
| | Fines | 0 | 0 | 0 | 0 | 0 | 0 |
| | Sand | 0 | 0 | 0 | 0 | 0 | 0 |
| | Gravel | 0 | 12 | 16 | 20 | 60 | 72 |
| | Cobble | 24 | 68 | 68 | 80 | 40 | 26 |
| | Boulder | 76 | 16 | 16 | 0 | 0 | 2 |
| | Bedrock | 0 | 4 | 0 | 0 | 0 | 0 |
| Transect Characteristics | Average Sample Plot Depth (cm) | 80 | 70 | 120 | 50 | 50 | 70 |
| | Average Wetted Width (m) | 53.3 | 53.7 | 55.0 | 78.0 | 59.7 | 59.6 |
| | Average Bankfull Width (m) | 59.4 | 59.9 | 66.5 | 85.0 | 67.2 | 63.9 |
| | Average Bankfull Depth (m) | 0.7 | 0.7 | 0.9 | 0.5 | 0.5 | 0.6 |
| | Average Incision Height (m) | 0 | 1 | 5.1 | 0.2 | 0.9 | 1.6 |
| | Riparian Canopy Cover (%) | 6 | 16 | 35 | 18 | 14 | 33 |
| | No. LWM Pieces (> 0.3 m width and > 5 m length) | 0 | 0 | 0 | 0 | 0 | 2 |

Key:

RM = river mile
°C = Celsius
Mg/L = milligrams/Liter
µm -= micrometers

cm = centimeters
cfs = cubic feet per second
% = percent
m = meter

**Table 3.0-2. BMI metrics from samples collected at six sites in the Yuba River downstream of Narrows 2 Powerhouse in July 2012.**

| BMI Metrics | Site 6 (RM 23) | Site 5 (RM 20) | Site 4 (RM 18) | Site 3 (RM 14) | Site 2 (RM 11) | Site 1 (RM 7) |
|---|---|---|---|---|---|---|
| **ABUNDANCE** | | | | | | |
| Total Estimated Abundance | 7,422 | 22,720 | 23,080 | 15,500 | 82,320 | 32,640 |
| **RICHNESS** | | | | | | |
| Taxonomic Richness | 38 | 35 | 41 | 43 | 34 | 46 |
| No. EPT Taxa | 6 | 11 | 8 | 11 | 7 | 14 |
| No. Ephemeroptera Taxa | 3 | 5 | 4 | 3 | 4 | 7 |
| No. Plecoptera Taxa | 1 | 2 | 2 | 3 | 1 | 2 |
| No. Trichoptera Taxa | 2 | 4 | 2 | 5 | 2 | 5 |
| No. Coleoptera Taxa | 0 | 0 | 0 | 1 | 1 | 1 |
| **COMPOSITION** | | | | | | |
| % EPT | 6.5 | 16.5 | 7.3 | 15.1 | 16.8 | 17.2 |
| % Ephemeroptera | 5.9 | 13.9 | 6.4 | 10.1 | 13.4 | 10.0 |
| Shannon Diversity Index (SDI) | 2.6 | 2.6 | 2.8 | 3.2 | 2.7 | 3.3 |
| **TOLERANCE/INTOLERANCE** | | | | | | |
| California Tolerance Value (CTV) | 6.1 | 6.1 | 5.9 | 5.8 | 5.8 | 5.9 |
| No. of Intolerant taxa | 4 | 6 | 4 | 6 | 5 | 8 |
| % Tolerant Organisms | 10.7 | 6.9 | 2.3 | 3.8 | 3.9 | 12.7 |
| % Dominant Taxon | 22.5 | 25.4 | 18.8 | 13.9 | 29.6 | 12.9 |

**Table 3.0-2. (continued).**

| BMI Metrics | Site 6 (RM 23) | Site 5 (RM 20) | Site 4 (RM 18) | Site 3 (RM 14) | Site 2 (RM 11) | Site 1 (RM 7) |
|---|---|---|---|---|---|---|
| **FEEDING** | | | | | | |
| % Collector-filterer+Collector-gatherer Individuals | 82.6 | 85.2 | 90.9 | 89.7 | 90.8 | 83.1 |
| % Scrapers | 8.3 | 1.1 | 3.3 | 1.2 | 1.0 | 1.8 |
| % Non-gastropoda Scrapers | 0.9 | 0.5 | 2.6 | 0.9 | 0.9 | 1.5 |
| % Predators | 5.3 | 7.2 | 5.1 | 7.3 | 7.0 | 9.8 |
| % Shredders | 0.5 | 0.2 | 0.2 | 0.2 | 0.0 | 1.0 |

## 3.1 Site 6: Downstream of Narrows 2 Powerhouse

### 3.1.1 Physical Habitat

Site 6 (RM 23) was the furthest upstream site on the Yuba River, starting just downstream of the Englebright Dam and Narrows 1 and 2 powerhouses (Figure 2.1-1). The upstream boundary was at the base of a rapid, resulting in glide habitat for the first 40 m. The glide transitioned into a long pool that continued for 310 m. The downstream end of the site consisted of a 100 m riffle and ended with 50 m of pool habitat, just upstream of Deer Creek. The upstream 150 m of the site was confined on both banks with bedrock valley walls, with bedrock, boulders, residual angular gravel/cobble from historical road and dam construction, and some rounded gravel/cobble from recent gravel augmentation projects. The downstream two-thirds of the site had a narrow bar on the north bank with gravel/cobble sediment. The south bank was confined with a bedrock valley wall. Evidence of past mining was observed. The site had an average gradient of 1.2 percent and an average thalweg depth of 285 centimeters (cm) (Table 3.1.1). Water was cold and well oxygenated. Thalweg substrate was predominantly boulder and cobble (Table 3.0-1; Figure 3.1-1).

The BMI sample plots were all located on the north bank. The average sample plot depth was 80 cm, and the average wetted and bankfull widths were 53.3 and 59.4 m, respectively (Table 3.0-1). The channel had an average bankfull height of 0.7 m and was not incised. Canopy cover was low and consisted entirely of understory cover. Tall tree canopy (i.e., >5 m tall) was absent. Understory cover was a mix of deciduous and evergreen woody and non-woody shrubs. The majority of the ground was bare with sparse woody shrubs and grasses in places. No LWM were observed in the sample plots. Algae and aquatic plants were observed in the sample plots, though infrequently. Substrate in the BMI sample plots were primarily composed of boulders and cobble with coarse gravel in the substrate matrix and bedrock in places (Figure 3.1-2).

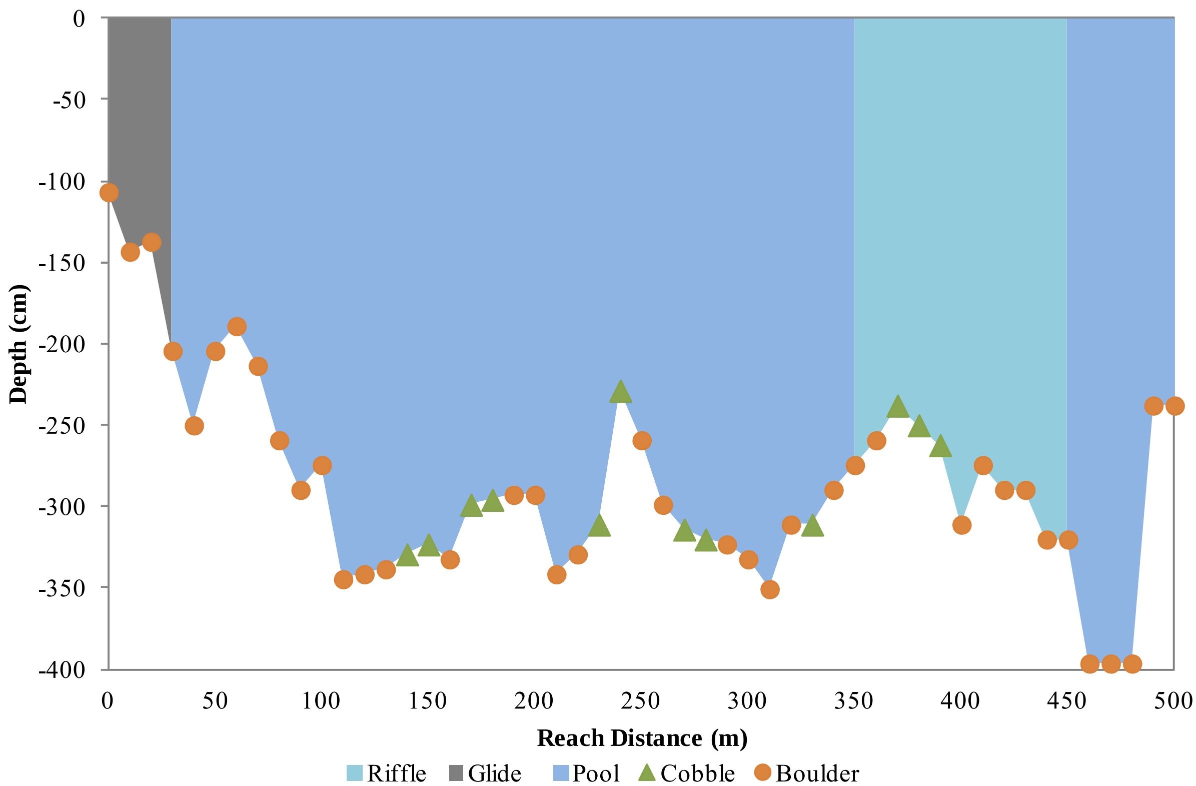


**Figure 3.1-1. Longitudinal profile of Site 6 (RM 23) showing depth, dominant substrate, and habitat type.**

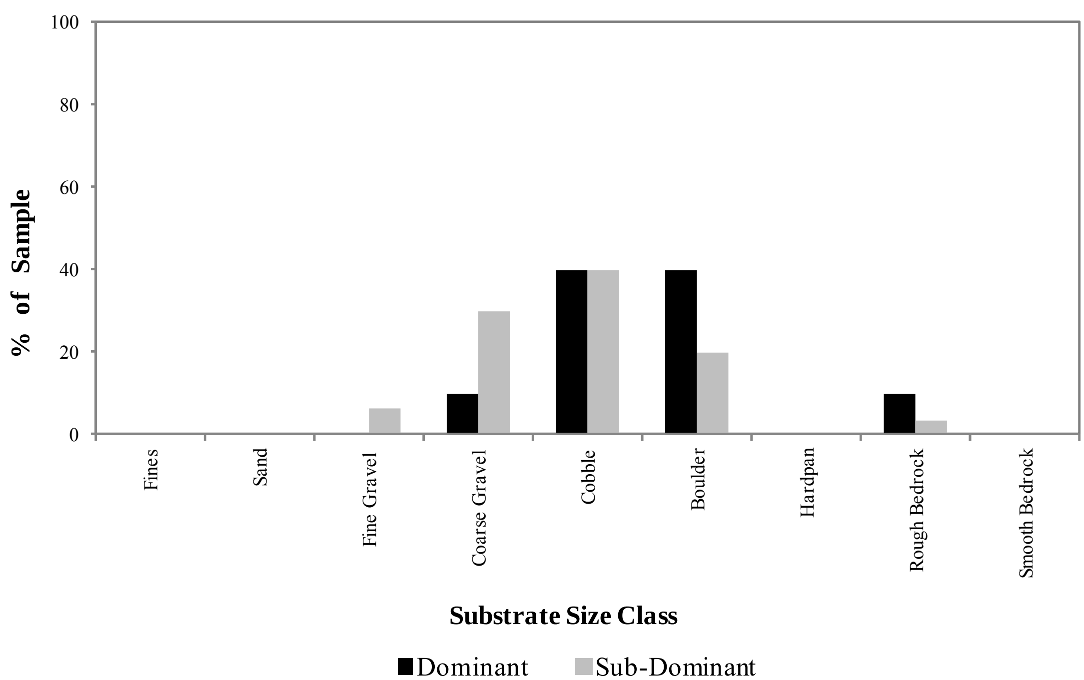


**Figure 3.1-2. Dominant and subdominant substrate size distribution of BMI collection plots at Site 6 (RM 23).**

### 3.1.2 Aquatic Macroinvertebrates

The BMIs were collected from both flowing and stagnant water. Sweep samples were primarily collected in the upstream half of the site, where shallow gravel deposits on bedrock was the predominant shoreline type. In the downstream half of the site, BMIs were collected with kick samples along a gravel and cobble bar with flowing water along the margins.

Thirty-eight BMI taxa were identified, relatively few of which were EPT taxa (Table 3.0-2). The EPT were primarily Ephemeroptera. Only four of the 38 taxa were rated “intolerant” to pollution. On a composition basis, approximately 10.7 percent of the individuals in the sample were rated “tolerant” to pollution. The most abundant taxon (*Paratanytarsus* sp.) accounted for approximately 22.5 percent of the individuals in the sample. Composition of the BMI feeding groups was dominated by collector-filterers and collector-gatherers, indicating the dominance of detritus and suspended particulates as BMI food sources. The relative abundance of scrapers and predators was much lower, but still accounted for a substantial percentage of the sample. The percentage of shredders was very low, indicating the relatively small component of the community that process allochthonous material and coarse particulate organic matter.

## 3.2 Site 5: Timbuctoo Bend

### 3.2.1 Physical Habitat

Site 5 (RM 20) was approximately 4 river miles downstream of Englebright Dam (Figure 2.1-1). This portion of the lower river is confined by bedrock valley walls, but the floodplain and the channel is wider than upstream at Site 6, allowing for gravel bar formation and a limited meander pattern within the corridor. Bedrock outcrops intersected the baseflow channel, creating hydraulic controls.

The first 110 meters of the site was riffle habitat with cobble bars on both sides of the wetted channel. The remaining 390 m was glide habitat. Cobble bars were also present along both banks but the south bank had a bedrock outcrop along the last 100 meters of the site. Human influences were generally absent from this site, although historical mining debris was present. The site had an average gradient of 1.2 percent and an average thalweg depth of 128 cm (Table 3.0-1). Water was cold and well-oxygenated, although the DO was lower than in Site 6. Thalweg substrate was predominantly cobble and transitioned towards a mix of cobble and gravel in the glide (Table 3.0-1; Figure 3.2-1).

Sample plots at Site 5 were all on the south bank. The average sample plot depth was 70 cm, and the average wetted and bankfull widths were 54 and 60 m, respectively (Table 3.1.1). The channel had an average bankfull height of 0.7 m and was nominally incised. Canopy cover was low and consisted primarily of understory, with limited tall tree cover. Large tree canopy cover was generally absent, with only one transect having sparse deciduous cover. Understory consisted of deciduous woody shrubs that had cover ranging from sparse to heavy. The majority of the ground was bare with sparse woody shrubs and grasses in places. LWM was not observed in this site. Algae, aquatic plants, and overhanging vegetation were observed in the sample plots, though infrequently. Substrate in the BMI sample plots were primarily composed of boulders, cobble, and coarse gravel, with coarse gravel, fine gravel, and sand in the substrate matrix (Figure 3.2-2).

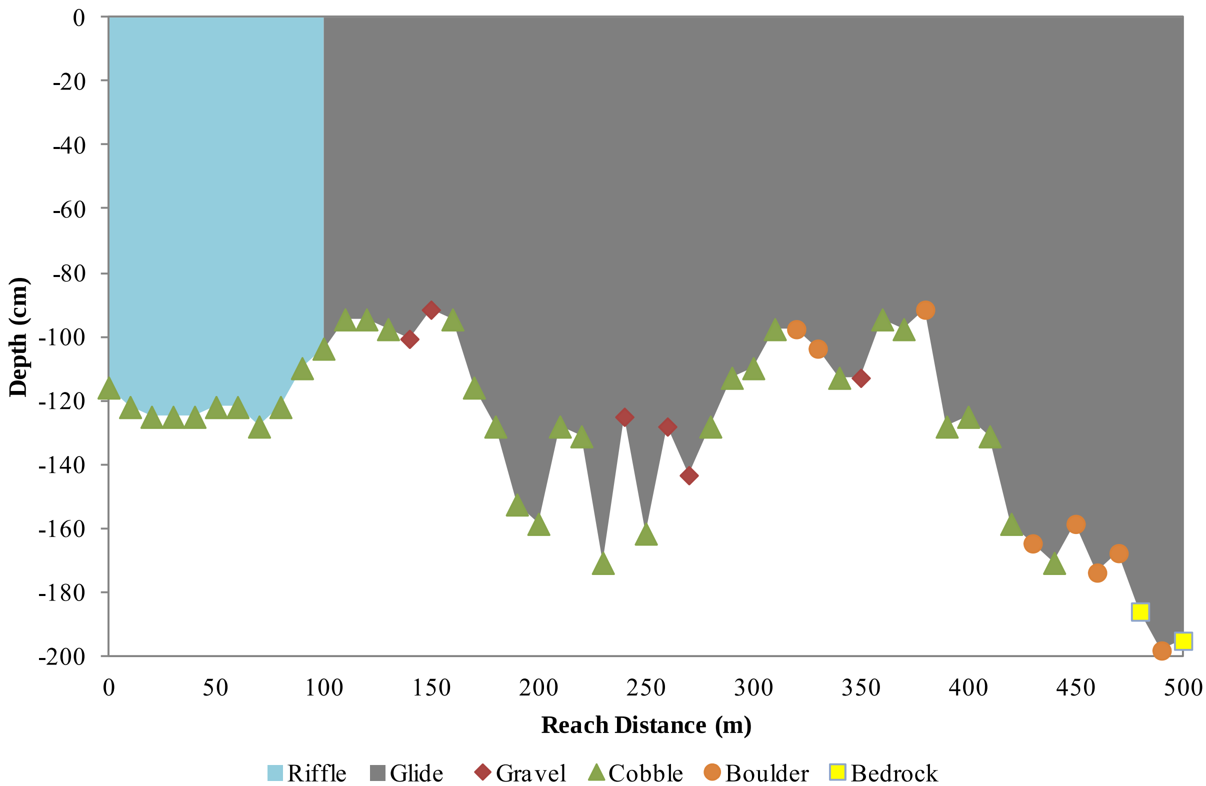


**Figure 3.2-1. Longitudinal profile of Site 5 (RM 20) showing depth, dominant substrate, and habitat type.**

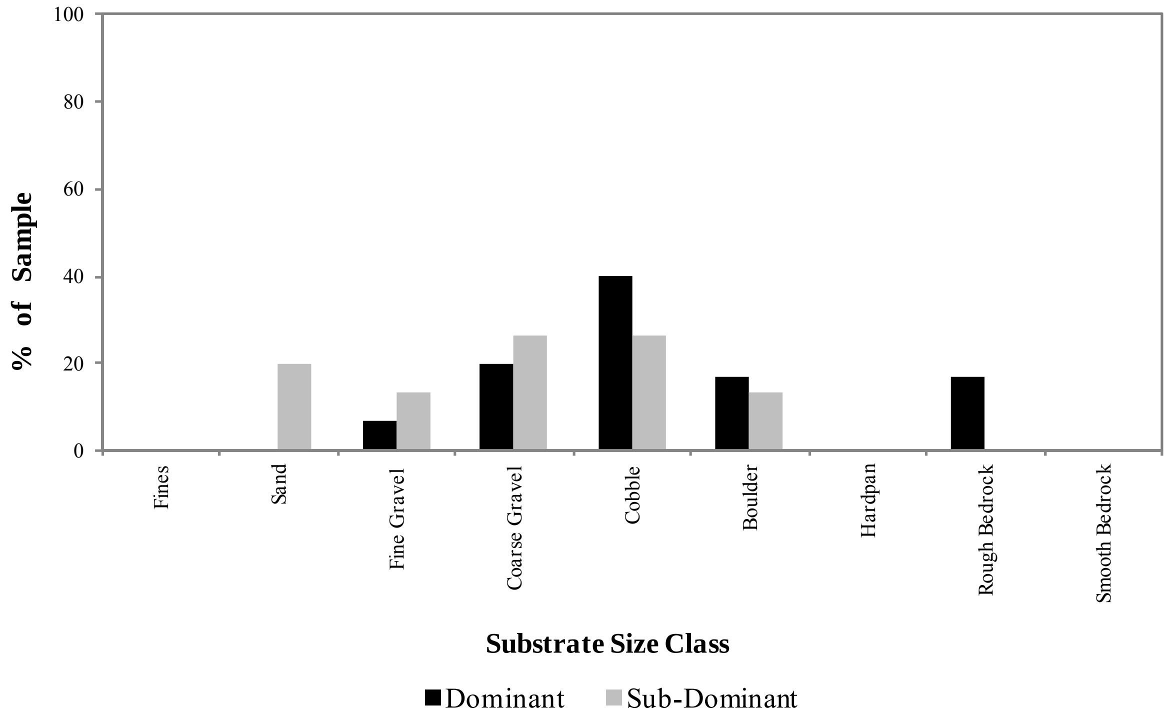


**Figure 3.2-2. Dominant and subdominant substrate size distribution of BMI collection plots at Site 5 (RM 20).**

### 3.2.2 Aquatic Macroinvertebrates

The BMIs were collected from both flowing and stagnant water along most of the site transects. Sweep samples were primarily collected along shallow margins and kick samples were typically collected in deeper water, where water velocity was greater.

Thirty-five BMI taxa were identified including 11 EPT taxa (Table 3.0-2). The EPT taxa were primarily Ephemeroptera. Only six of the 35 taxa were rated "intolerant" to pollution. On a composition basis, approximately 6.9 percent of the individuals in the sample were rated "tolerant" to pollution. The most abundant taxon (*Tanytarsus* sp.) accounted for approximately 25.4 percent of the individuals in the sample. Composition of the BMI feeding groups was dominated by collector-filterers and collector-gatherers, indicating the dominance of detritus and suspended particulates as BMI food sources. The relative abundance of predators was much lower than collector-filterers and collector-gatherers, but still accounted for a substantial percentage of the sample. The percentages of scrapers and shredders were very low, indicating the relatively small component of the community that process periphyton, allochthonous material and coarse particulate organic matter.

## 3.3 Site 4: Parks Bar to Long Bar

### 3.3.1 Physical Habitat

Site 4 (RM 18) was approximately 6 river miles downstream of the Englebright Dam (Figure 2.1-1). Site 4 began as the valley widens after Timbuctoo Bend, downstream of the Highway 20 bridge. Within this site, the average valley width almost doubles from the Timbuctoo Bend site, enabling wider bankfull sedimentary bars, floodplains, islands, and terraces (Wyrick and Pasternack 2012).

The first 110 meters of the site was riffle habitat with a cobble bar on the right bank and a valley wall along the left bank. The remaining 390 m of the site alternates between glide and pool habitat with a cobble bar on the right bank and a valley wall along the left bank. Roads and historical mining debris were visible from the sample plots. Evidence of historical mining and trash were present within some sample plots. The site had an average gradient of 1 percent and an average thalweg depth of 218 cm (Table 3.0-1). Water was cold and well-oxygenated (10.9 mg/L). Both temperature and DO were slightly higher than at Site 5. Thalweg substrate was predominantly cobble with some boulders in the upstream end of the site, transitioning towards a mix of cobble and gravel at the downstream end of the site (Table 3.0-1; Figure 3.3-1).

Sample plots were primarily on the north bank with only two on the south bank. The average sample plot depth was relatively deep compared to other sites (120 cm), and average wetted and bankfull widths were 55 and 67 m, respectively (Table 3.0-1). The channel had an average bankfull height of 0.9 m and was minimally incised. Canopy cover was moderate, resulting from the presence of both large trees and understory vegetation. Coniferous trees provided sparse to moderate cover in places. Understory vegetation had sparse to moderate cover consisting of a mix of evergreen and deciduous woody shrubs. The ground cover was predominately bare, with sparse to very heavy cover of woody shrubs and grasses in places. LWM was not observed. Algae, aquatic plants, small wood, overhanging vegetation, and boulders were also observed in the sample plots, though infrequently. Substrate in the BMI sample plots were primarily composed of cobble, with coarse gravel in the substrate matrix (Figure 3.3-2).

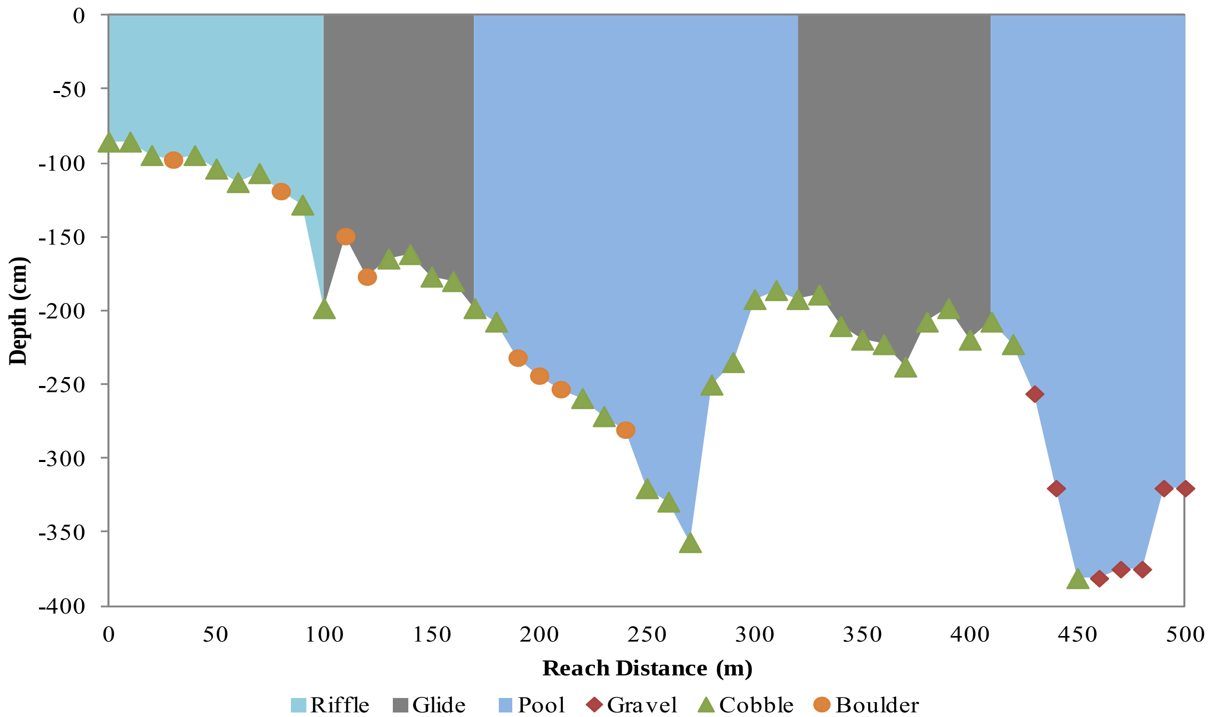


**Figure 3.3-1. Longitudinal profile of Site 4 (RM 18) showing depth, dominant substrate, and habitat type.**

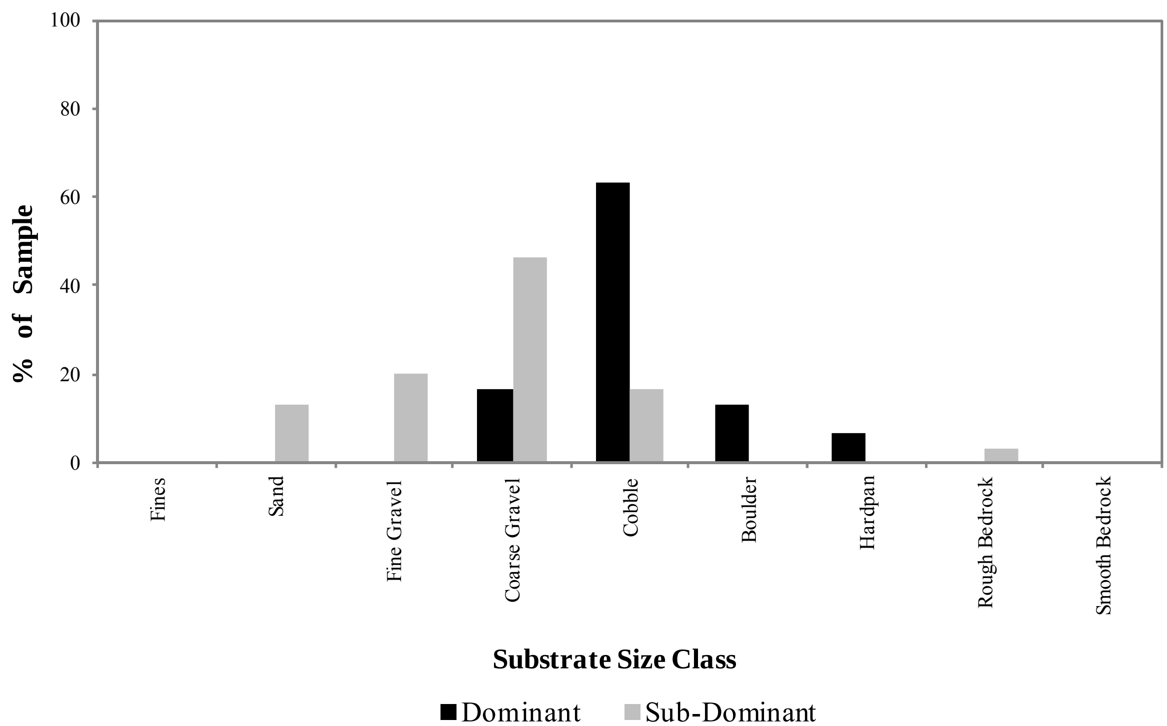


**Figure 3.3-2. Dominant and subdominant substrate size distribution of BMI collection plots at Site 4 (RM 18).**

### 3.3.2 Aquatic Macroinvertebrates

The BMIs were collected from roughly equal proportions of flowing and stagnant water along the site transects. Forty-one BMI taxa were identified including eight EPT taxa (Table 3.0-2). The EPT taxa were primarily Ephemeroptera. Only four of the 42 taxa were rated “intolerant” to pollution. On a composition basis, only 2.3 percent of the individuals in the sample were rated “tolerant” to pollution. The most abundant taxon (*Paratanytarsus* sp.) accounted for approximately 18.8 percent of the individuals in the sample. Composition of the BMI feeding groups was dominated by collector-filterers and collector-gatherers, indicating the dominance of detritus and suspended particulates as BMI food sources. The relative abundance of scrapers and predators was much lower than collector-filterer and collector-gatherers, but still accounted for a substantial percentage of the sample. The percentage of shredders was low, indicating the relatively small component of the community that process allochthonous material and coarse particulate organic matter.

## 3.4 Site 3: Hammon Bar

### 3.4.1 Physical Habitat

Site 3 (RM 14) was approximately 10 river miles downstream of Englebright Dam (Figure 2.1-1). Site 3 had geomorphic characteristics similar to Site 4, with relatively wider bankfull sedimentary bars than Sites 5 and 6, creating floodplains, islands, and terraces. The Yuba Goldfields were proximal to the site and influenced the channel with confinement and erosion. The upstream half (250 m) of the site consisted of a large riffle with a cobble bar on the left bank and a confined right bank. The riffle transitioned into glide habitat for the next 220 m. The last 30 m of the site was riffle habitat in a split-channel. Trash and debris were observed in some of the sample plots and evidence of historical mining was visible throughout the site. The site had an average gradient of 1 percent and an average thalweg depth of 103 cm (Table 3.0-1). Water was cold and well-oxygenated, although the temperature was slightly higher and DO slightly lower than at Site 4. Thalweg substrate was predominantly cobble and gravel with embedded sand (Table 3.0-1; Figure 3.4-1).

The sample plots at Site 3 were primarily on the south bank. The average sample plot depth was 50 cm, and average wetted and bankfull widths were the widest observed at all the sites at 78 and 85 m, respectively (Table 3.0-1). The channel had an average bankfull height of 0.5 m and was nominally-incised. Canopy cover was low, consisting of both trees and understory vegetation. Deciduous canopy cover from trees was present at only one transect. Understory deciduous cover ranged from moderate to very heavy and was present at all but one transect. Ground Cover in the form of woody shrubs ranged from moderate to very heavy with sparse grasses and some bare ground in places. LWM was not observed. Algae, aquatic plants, small wood, overhanging vegetation, and boulders were observed in the sample plots, though infrequently. Substrate in the BMI sample plots were primarily composed of cobble and coarse gravel, with fine gravel in the substrate matrix (Figure 3.4-2).

 

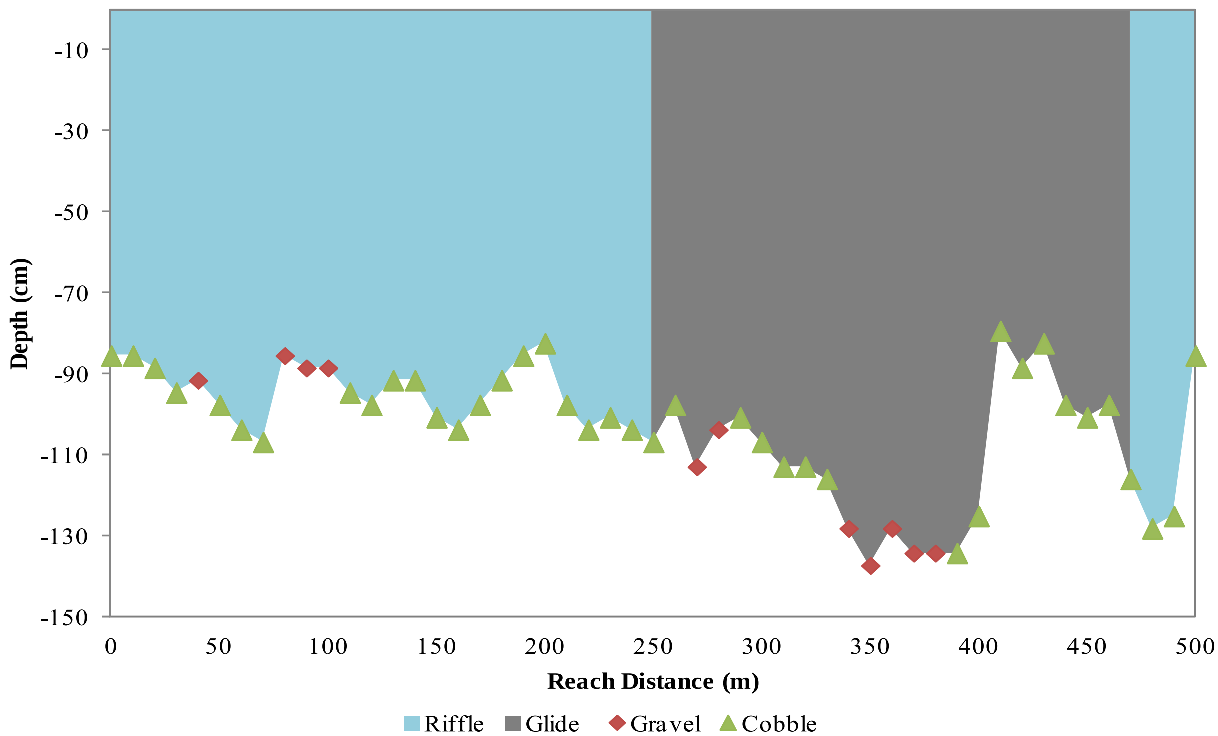


**Figure 3.4-1. Longitudinal profile of Site 3 (RM 14) showing depth, dominant substrate, and habitat type.**

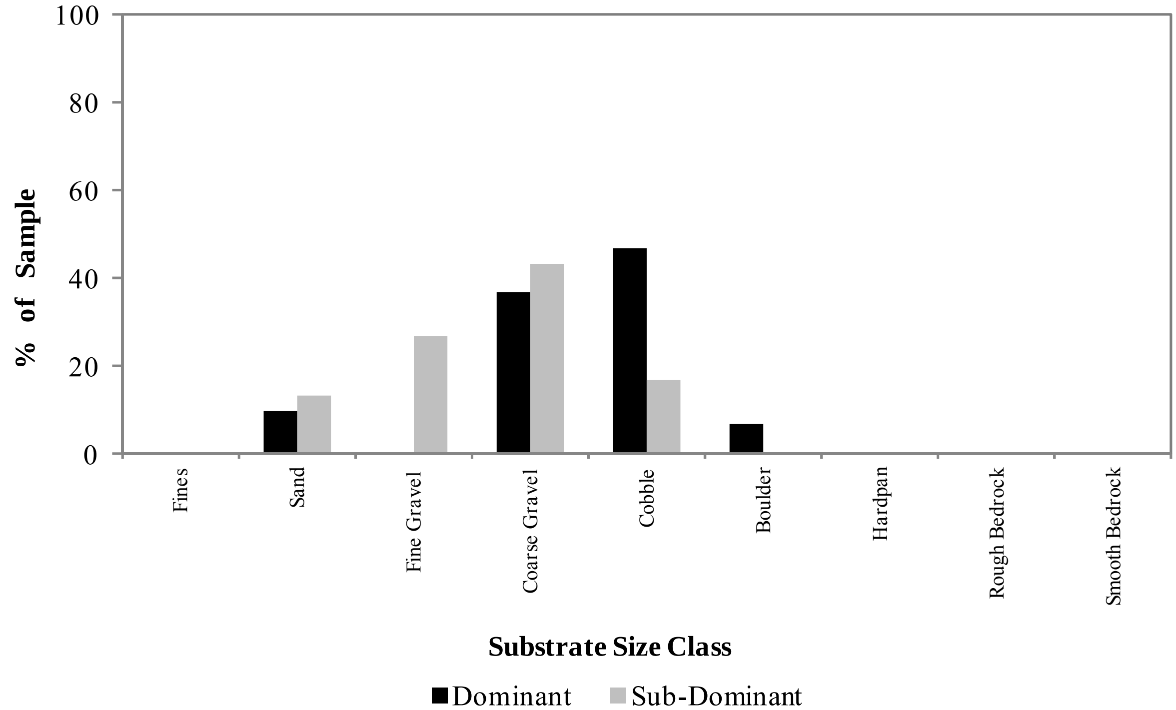


**Figure 3.4-2. Dominant and subdominant substrate size distribution of BMI collection plots at Site 3 (RM 14).**

### 3.4.2 Aquatic Macroinvertebrates

The BMIs were collected exclusively from flowing sample locations along the site transects. Forty-three BMI taxa were identified including 11 EPT taxa (Table 3.0-2). The EPT taxa were primarily Ephemeroptera, but Ephemeroptera accounted for a lower proportion of EPT taxa than at sites 4-6. Only six of the 43 taxa were rated "intolerant" to pollution. On a composition basis, approximately 3.8 percent of the individuals in the sample were rated "tolerant" to pollution. The most abundant taxon (*Tanytarsus* sp.) accounted for approximately 13.9 percent of the individuals in the sample. Composition of the BMI feeding groups was dominated by collector-filterers and collector-gatherers, indicating the dominance of detritus and suspended particulates as BMI food sources. The relative abundance of predators was much lower than collector-filterers and collector-gatherers, but still accounted for a substantial percentage of the sample. The percentages of scrapers and shredders were relatively low, indicating the relatively small component of the community that process periphyton, allochthonous material, and coarse particulate organic matter.

## 3.5 Site 2: Downstream of Daguerre Point Dam

### 3.5.1 Physical Habitat

Site 2 (RM 11) was approximately 13 river miles downstream of Englebright Dam and 0.2 river miles downstream of Daguerre Point Dam (Figure 2.1-1). The wide, alluvial site was characterized by a single-threaded meandering channel, with multiple floodplain flowpaths and backwater ponds. The Yuba Goldfields were proximal to this site, resulting in confinement and erosion. The first third (160 m) of the site was riffle habitat with cobble and gravel bars on both banks. The riffle transitioned into a glide for the remaining 340 m of the site. The site had cobble and gravel bars on both banks with Yuba Goldfield pits, piles, and training levees adjacent to the bars. Other than the presence of historical mining debris, human influences were not present at the site. The site had an average gradient of 1.2 percent and an average thalweg depth of 81 cm (Table 3.0-1). The water was cold and well-oxygenated, but the temperature was slightly warmer and the DO slightly lower than at Site 3. Thalweg substrate was predominantly gravel and cobble (Table 3.0-1; Figure 3.5-1).

The sample plots at Site 2 were entirely on the south bank. The average sample plot depth was 50 cm, and the average wetted and bankfull widths were 60 and 67 m, respectively (Table 3.0-1). The channel had an average bankfull height of 0.5 m and was nominally-incised. Canopy cover was low, consisting of both trees and understory vegetation. Sparse deciduous tree cover was present in some places. Understory deciduous cover ranged from sparse to very heavy. The ground was primarily bare with sparse to very heavy woody shrubs and sparse grasses in places. No LWM was observed in the sample plots. Algae, aquatic plants, small wood, and overhanging vegetation were observed in the sample plots, though on an infrequent basis. Substrate in the BMI sample plots were primarily composed of coarse gravel, with fine gravel in the substrate matrix (Figure 3.5-2).

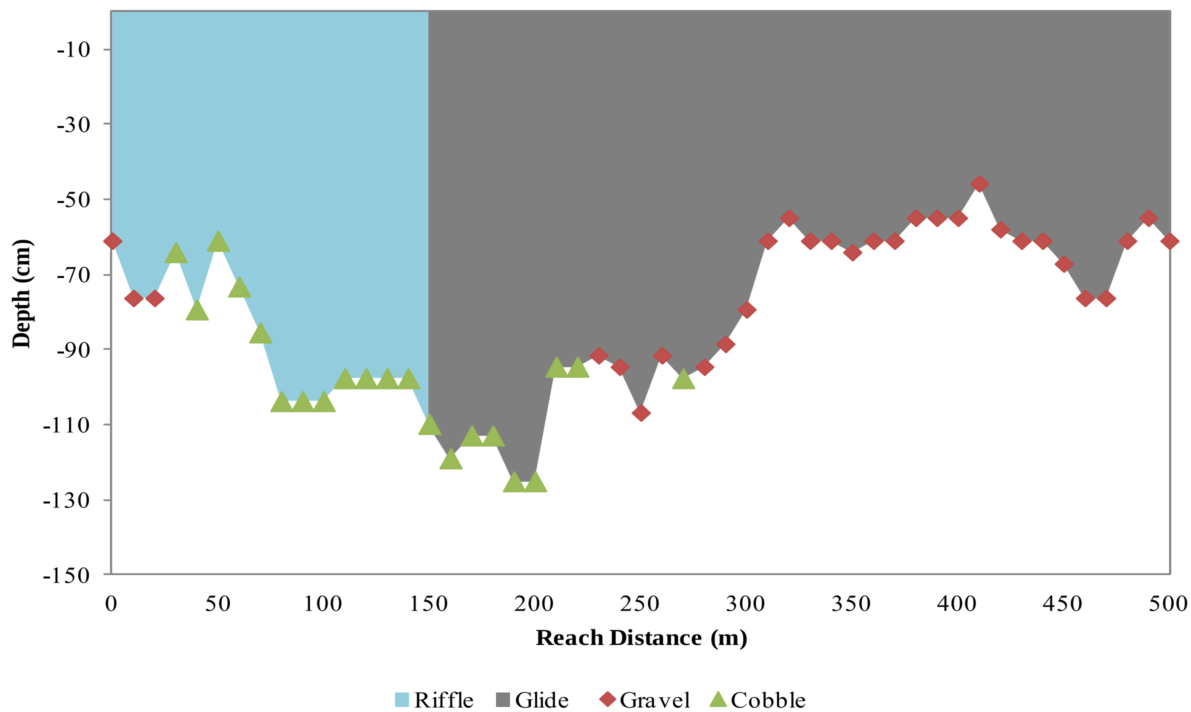


**Figure 3.5-1. Longitudinal profile of Site 2 (RM 11) showing depth, substrate, and habitat type.**

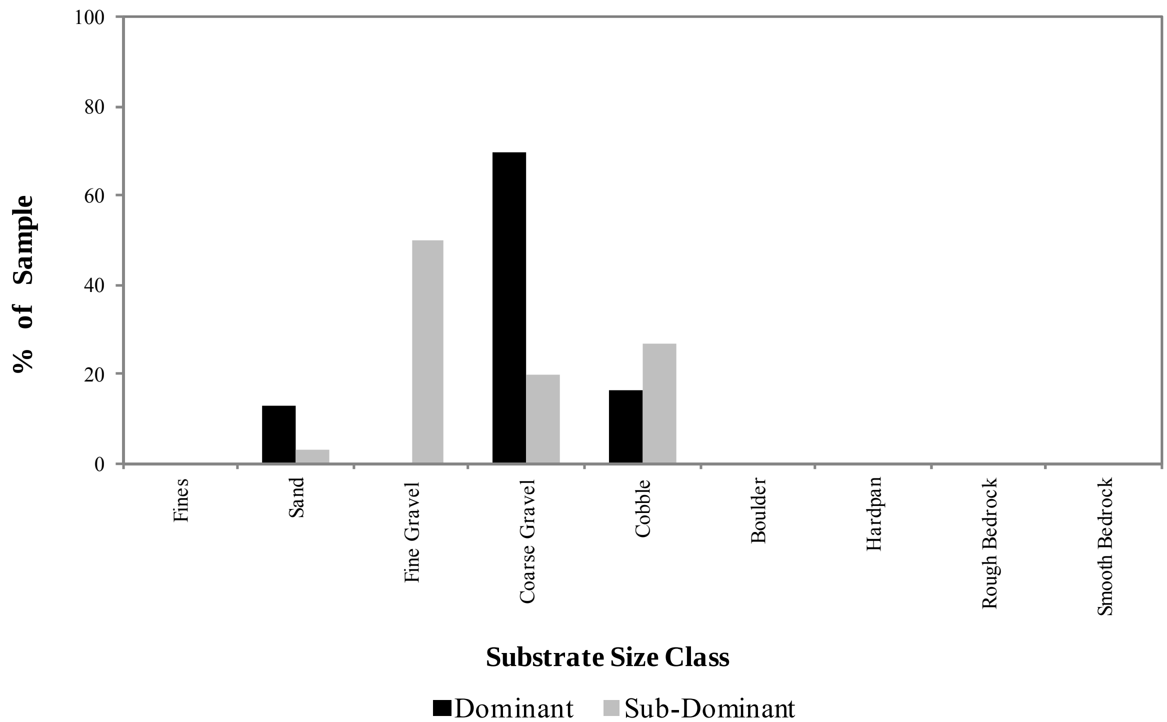


**Figure 3.5-2. Dominant and subdominant substrate size distribution of BMI collection plots at Site 2 (RM 11).**

### 3.5.2 Aquatic Macroinvertebrates

The BMIs were collected exclusively from flowing sample locations along the site transects. Thirty four BMI taxa were identified including seven EPT taxa (Table 3.0-2). The EPT taxa were primarily Ephemeroptera. Only five of the 34 taxa were rated "intolerant" to pollution. On a composition basis, approximately 3.9 percent of the individuals in the sample were rated "tolerant" to pollution. The most abundant taxon (*Tanytarsus* sp.) accounted for approximately 29.6 percent of the individuals in the sample. Composition of the BMI feeding groups was dominated by collector-filterers and collector-gatherers, indicating the dominance of detritus and suspended particulates as BMI food sources. The relative abundance of predators was much lower than collector-filterers and collector-gatherers, but still accounted for a substantial percentage of the sample. The percentage of scrapers was relatively low, and no shredders were identified, indicating the relatively small component of the community that process periphyton, allochthonous material, and coarse particulate organic matter.

## 3.6 Site 1: Hallwood Boulevard

### 3.6.1 Physical Habitat

Site 1 (RM 7) was the most downstream site of the study, approximately 17 river miles downstream of Englebright Dam and 4 river miles downstream of Daguerre Point Dam (Figure 2.1-1). The site was confined by riprap training levees (Wyrick and Pasternack 2012). The first 20 m of the site consisted of the end of a glide. The next 240 m was pool habitat, before transitioning back into a glide for the remaining 240 m. The entire site had a training berm on the south bank and a cobble/gravel bar on the north bank. Human influence was evident, with buildings, roads, pipes, trash, lawn, and crops visible from the site. The site had an average gradient of 1 percent and an average thalweg depth of 174 cm (Table 3.0-1). Water was moderately cool and well-oxygenated, but temperature was much higher and the DO slightly lower than at Site 2. Thalweg substrate was a mix of cobble and gravel in the upstream half of the site and then transitioned to gravel in the downstream half of the site (Table 3.0-1; Figure 3.6.1). Sand was embedded in the gravel and cobble throughout the site.

The sample plots at Site 1 alternated between the left and right banks as a result of differing riparian conditions. The average sample plot depth was 70 cm, and the average wetted and bankfull widths were 60 and 64 m, respectively (Table 3.0-1). The channel had an average bankfull height of 0.6 m and was nominally-incised. Canopy cover was moderate, resulting from the presence of both trees and understory vegetation. The south bank had moderate to very heavy canopy cover consisting of deciduous trees with a moderate understory cover of deciduous trees and shrubs. Ground cover was heavy, with woody shrubs and sparse grasses. The north bank had no canopy cover with moderate deciduous understory cover in places. The ground was primarily bare with some sparse grass in places. Two pieces of LWM were observed. Algae, aquatic plants, small wood, overhanging vegetation, and boulders were also observed in the sample plots, though infrequently. Substrate in the BMI sample plots were primarily composed of coarse gravel, with fine gravel in the substrate matrix (Figure 3.6-2).

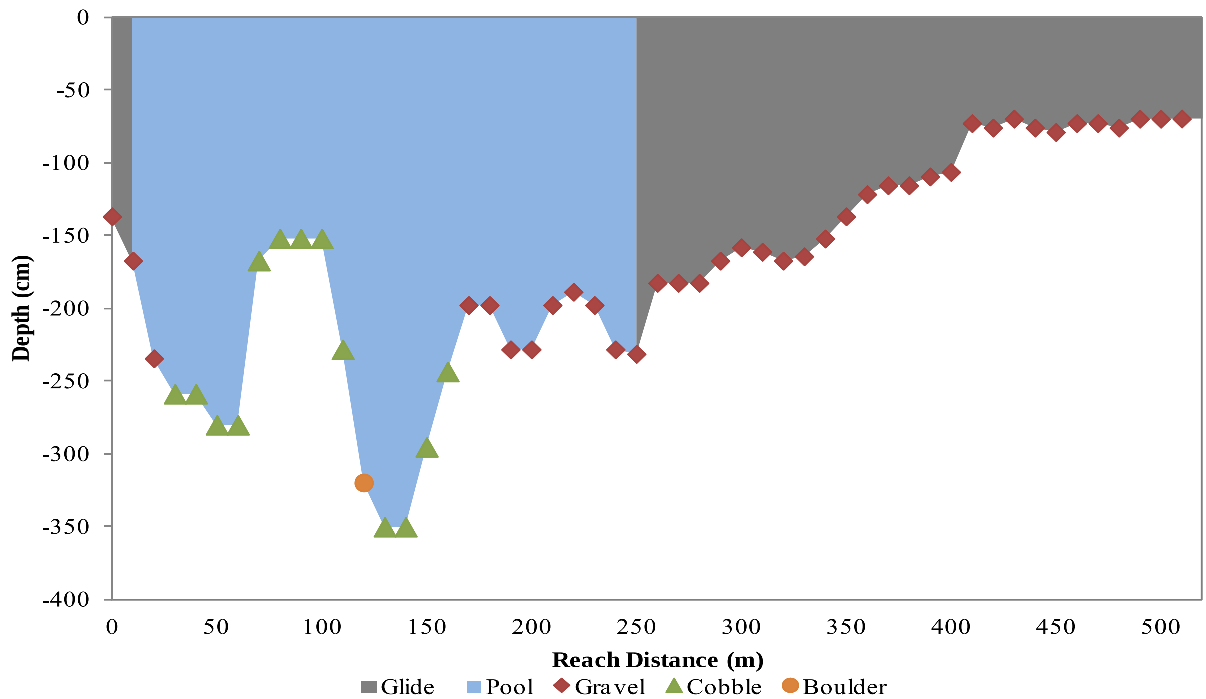


**Figure 3.6-1. Longitudinal profile of Site 1 (RM 7) showing depth, dominant substrate, and habitat type.**

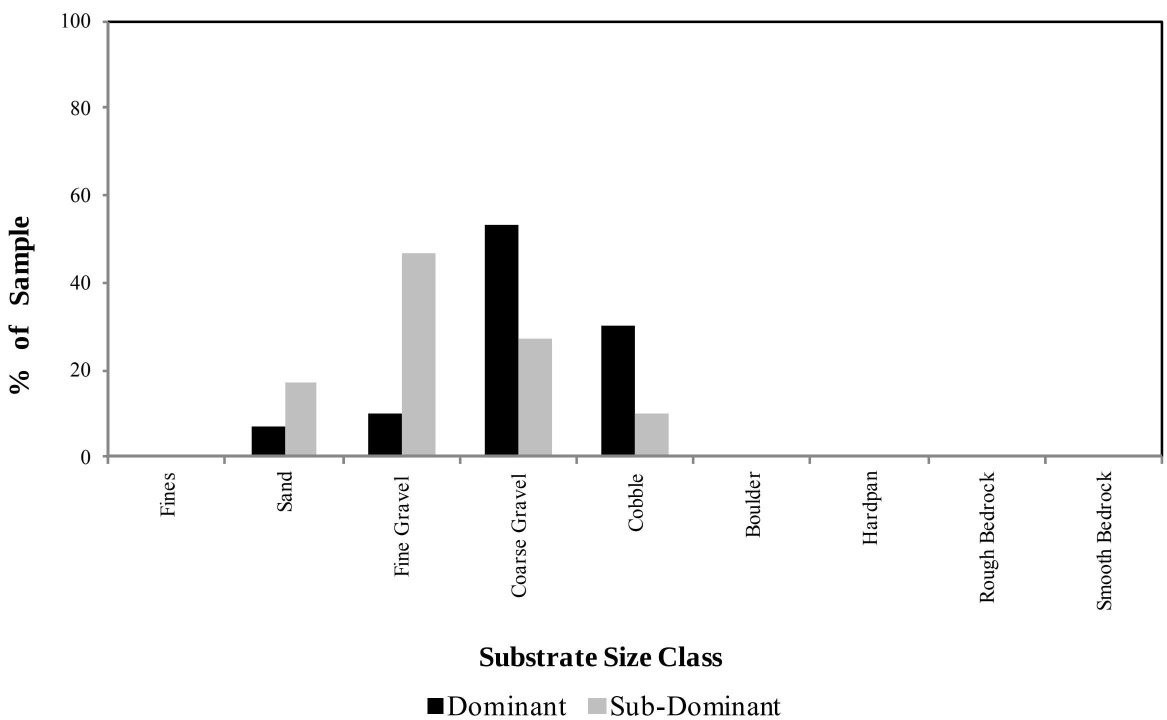


**Figure 3.6-2. Dominant and subdominant substrate size distribution of BMI collection plots at Site 1 (RM 7).**

### 3.6.2 Aquatic Macroinvertebrates

The BMIs were collected from both flowing and stagnant sampling locations along the site transects. Forty-six BMI taxa were identified including 14 EPT taxa (Table 3.0-2). The EPT taxa were primarily Ephemeroptera, and both the proportion and number of Ephemeroptera taxa were higher than at any other site. Only eight of the 46 taxa were rated “intolerant” to pollution. On a composition basis, approximately 12.7 percent of the individuals in the sample were rated “tolerant” to pollution. The most abundant taxon (*Tanytarsus* sp.) accounted for approximately 12.9 percent of the individuals in the sample. Composition of the BMI feeding groups were dominated by collector-filterers and collector-gatherers, indicating the dominance of detritus and suspended particulates as BMI food sources. The relative abundance of predators was much lower than collector-filterers and collector-gatherers, but still accounted for a substantial percentage of the sample. The percentages of scrapers and shredders were relatively low, indicating the relatively small component of the community that processes periphyton, allochthonous material, and coarse particulate organic matter.

## 3.7 Comparison of BMI Metrics to Physical Habitat

Several correlations were identified (Table 3.7-1). Positive correlation coefficients indicate positive associations between the BMI and physical habitat metrics. Negative correlation coefficients indicate negative associations between the BMI and physical habitat metrics. Interpretation of biological relevance is presented in Section 4.1.

**Table 3.7-1. Non-parametric correlations between BMI and physical habitat metrics.**

| BMI Metric | Physical Habitat | Correlation Coefficient (Spearman ρ) |
|---|---|---|
| Abundance | % Boulder (sample plot) | -0.81 |
| | Conductivity | 0.91 |
| EPT Richness | Gradient | -0.84 |
| Ephemeroptera Richness | % Fine Gravel (sample plot) | 0.87 |
| Plecoptera Richness | Gradient | -0.89 |
| Coleoptera Richness | Elevation | -0.88 |
| | Wetted Width | 0.88 |
| | %Boulder (sample plot) | -0.89 |
| | % Coarse Gravel (sample plot) | 0.88 |
| | % Sand (sample plot) | 0.93 |
| | Bankfull Height | -0.88 |
| | % Riffle Habitat | 0.89 |
| % EPT | Conductivity | 0.85 |
| | Dissolved Oxygen | 1.00 |
| | Elevation | -0.83 |
| | Discharge | -0.8 |
| | % Boulder (sample plot) | -0.81 |
| | % Coarse Gravel (sample plot) | 0.89 |
| | % Pool Habitat | 0.85 |
| % Ephemeroptera | % Pool Habitat | -0.85 |
| | % Glide Habitat | 0.94 |
| SDI | Temperature | 0.99 |
| | Elevation | -0.83 |
| | % Riffle Habitat | 0.84 |

**Table 3.7-1. (continued)**

| | | |
|---|---|---|
| CTV | Elevation | 0.83 |
| | Wetted Width | -0.94 |
| | % Boulder (sample plot) | 0.9 |
| | % Coarse Gravel (sample plot) | -0.89 |
| | % Sand (sample plot) | -0.94 |
| | Thalweg Depth | 0.83 |
| | % Riffle Habitat | -0.81 |
| Intolerant Richness | % Pool Habitat | -0.84 |
| % Scrapers | Bankfull Width | 0.89 |
| | Thalweg Depth | 0.94 |
| | % Pool Habitat | 0.85 |
| | % Glide Habitat | -0.89 |

## 3.8 Aquatic Macroinvertebrate Sample QA/QC

In general, the CDFG Aquatic Bioassessment Laboratory QA/QC (CDFG ABL) and laboratory taxonomic determinations for the Aquatic Macroinvertebrates Downstream of Englebright Reservoir were in agreement for the sample (Site 5) randomly selected for taxonomic QA/QC. Most taxonomic discrepancies occurred with chironomidae, differences in taxonomic resolution, and minor count differences (see Attachment 3-2C). The CDFG QA/QC taxonomic verification resulted in a counting discrepancy of 10 individuals, adjusting the total count of invertebrates from 568 individuals to 558. The counting discrepancy is likely a result of species being lost during sorting or transcription error. There was a total of 15 disputed taxa identifications that affected a total of 128 organisms. The majority of these were in the family chironomidae and were the result of a difference in taxonomic precision. Comparison of metrics generated from the CDFG QA/QC taxonomic determinations to the original are presented in Table 3.8-1. Of note, the total estimated abundance shifted due to the counting discrepancy. Taxonomic richness in the QA/QC sample was higher primarily as a result of the difference in taxonomic precision which led to the disputed taxa identifications. The remaining metrics were all relatively similar.

The original results and discussion remain unchanged for the QA/QC'd site, as the CDFG QA/QC did not address every site. This QA/QC's primary purpose was to assess the accuracy and precision of the laboratory analyses, with an independent reviewer (i.e., CDFG), and to describe the potential variance that may be present in site assessment. The CDFG review indicates that potential variance is relatively low.

**Table 3.8-1. Comparison of metrics generated for Site 5 on the Yuba River from the original taxonomic determination and the CDFG QA/QC taxonomic determination.**

| BMI Metrics | Site 5 Original | Site 5 QA/QC |
|---|---|---|
| **ABUNDANCE** | | |
| Total Estimated Abundance | 22,720 | 22,360 |
| **RICHNESS** | | |
| Taxonomic Richness | 35 | 48 |
| No. EPT Taxa | 11 | 12 |
| No. Ephemeroptera Taxa | 5 | 6.0 |
| No. Plecoptera Taxa | 2 | 2.0 |

**Table 3.8-1. (continued)**

| | | |
|---|---|---|
| No. Trichoptera Taxa | 4 | 4.0 |
| **COMPOSITION** | | |
| % EPT | 16.5 | 17.0 |
| Shannon Diversity Index (SDI) | 2.6 | 2.9 |
| **TOLERANCE/INTOLERANCE** | | |
| California Tolerance Value (CTV) | 6.1 | 6.2 |
| % Dominant Taxon | 25.4 | 16 |
| **FEEDING** | | |
| % Collector-filterer+Collector-gatherer Individuals | 85.2 | 81.3 |
| % Scrapers | 1.1 | 1.1 |
| % Predators | 7.2 | 6.4 |
| % Shredders | 0.2 | 0.2 |

# 4.0 Discussion

BMI communities in streams can be highly influenced by a variety of naturally-occurring and human-induced factors, including annual hydrologic cycle, timing and magnitude of spring outflows, streambed substrate composition, channel gradient, bank erosion and sediment deposition, pollution, riparian habitat degradation, instream-mining, and recreational activities. The presence of dams and diversions on streams can substantially affect the supply and mobility of streambed sediment by retention in storage reservoirs and alteration of the magnitude and timing of stream flows. The effect of dams and diversions on stream flows and sediment supplies can significantly affect the abundance and distribution of BMI communities. Rehn (2008) found that BMI-based metrics tend to be lowest immediately downstream of dams and diversions but normally increase with distance below these structures. However, stream characteristics such as substrate type and riparian vegetation composition can affect BMI community metrics, regardless of distance from dams or diversion structures (Bahuguna et al. 2004). The following sections describe the overall composition of the BMI community among all of the sites and associations in BMI community metrics and related physical habitat characteristics for each site.

## 4.1 Site-by-Site Comparisons

### 4.1.1 Water Quality

Water quality was within expected ranges at all sites and did not appear to be a limiting factor to BMI productivity (Table 3.0-1). Conductivity varied little among sites. Water temperature generally increased with distance downstream from Englebright Dam, with a considerable increase occurring between Sites 1 and 2 (RMs 7 and 11). This temperature increase is common as rivers decrease in elevation, widen and are exposed to higher ambient air temperatures. Water diversions near Daguerre Point Dam also reduced in-river flow downstream of the dam. As expected, DO trended downward with increasing distance from Englebright Dam and increasing water temperature.

### 4.1.2 Physical Habitat

Downstream sites generally had more riffle and glide habitat than upstream sites, with an exception being the large proportion of glide habitat at Site 5 (RM 20; Table 3.0-1). This general trend was accompanied by a shift from larger boulder and cobble substrates in upstream sites to cobble and gravel in downstream sites. The shift in habitat and substrate composition is likely a function of geomorphic controls. Sites 6 and 5 (RM 23 and 20) were confined by valley walls and bedrock outcrops. The downstream sites were in a relatively unconfined floodplain, resulting in more diverse habitat types. The shift in sediment distribution was likely related to the change in channel form. This trend may have been compounded in Site 6 (RM 23) by the Englebright Dam serving as a sediment barrier. This effect was likely attenuated downstream, as gravel and cobble supply increased and became more abundant in the bedload.

The riparian zone was not a major determinant in stream reach function, because channel banks were contained by bedrock, cobble bars, or levees. Most riparian vegetation was limited to narrow fringes of understory vegetation (e.g., willows) and sparse deciduous trees. LWM and allochthonous material (i.e., leaf litter) were generally absent in all of the sites. Adjacent land uses were most apparent in the downstream sites (e.g., Yuba Goldfields, agriculture and levees). The Yuba Goldfield berms and constructed levees clearly affected the habitat distribution in the lower river, confining an otherwise anastomosing channel form. However, quantifying this overall effect is beyond the scope of this study.

### 4.1.3 BMI Metrics

Plots of BMI metric values among sites from upstream to downstream were made for each of the 19 calculated metrics and are available in Figure 4.1-1.

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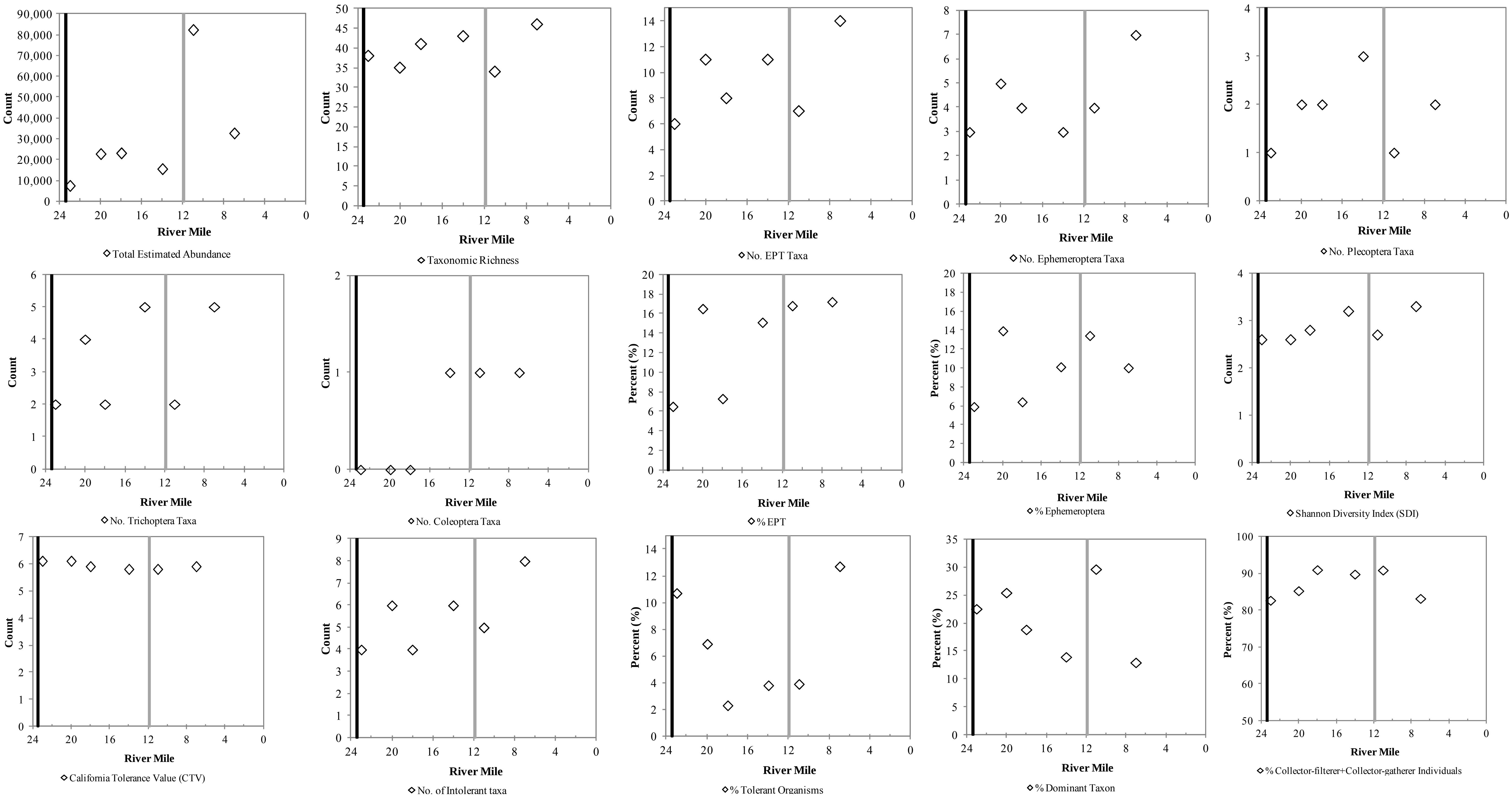


**Figure 4.1-1. Plots of BMI metrics among Site 1 (RM 7) through Site 6 (RM 23). Black line indicates Englebright Dam location and grey line indicates Daguerre Point Dam location.**

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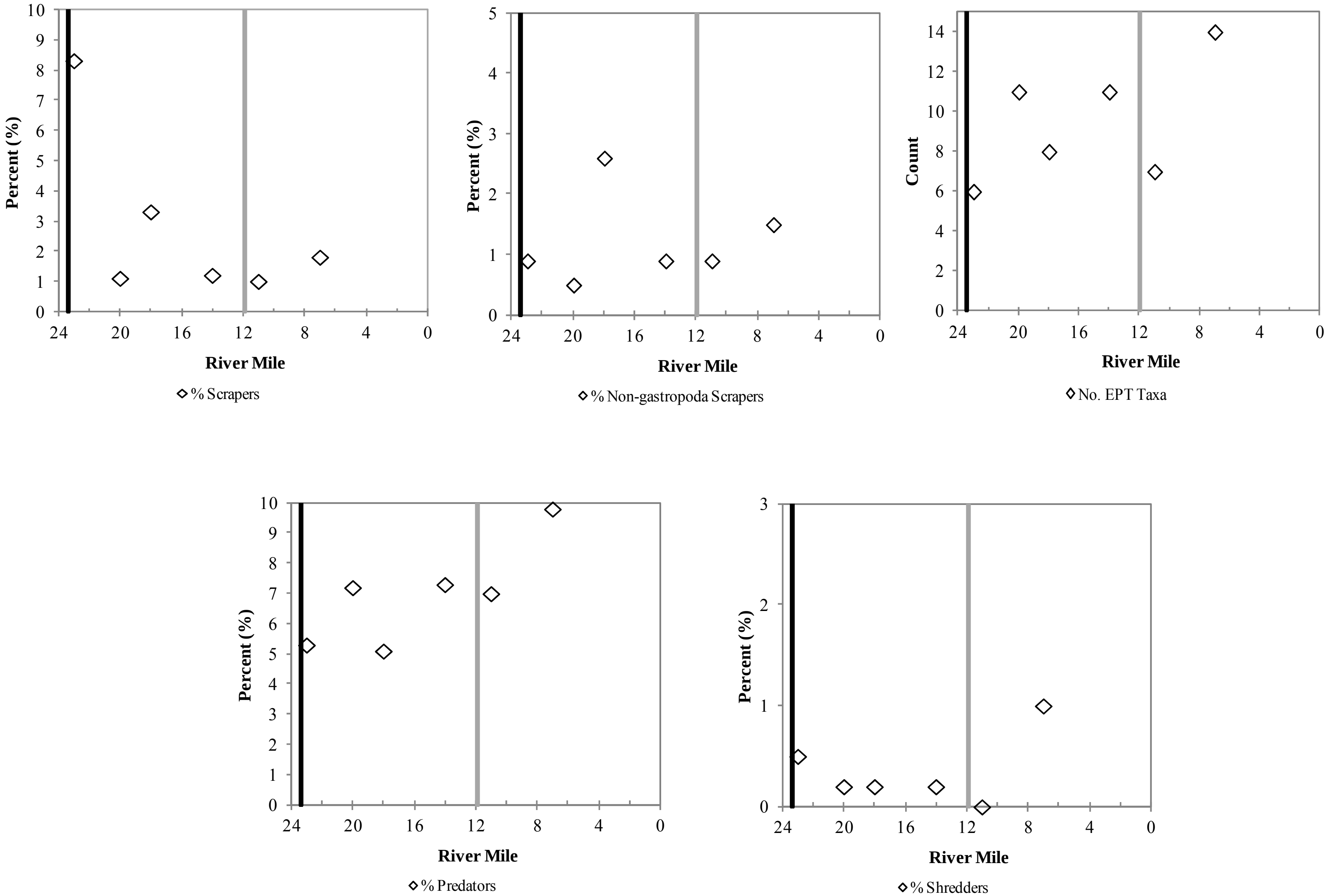


**Figure 4.1-1. (continued)**

#### 4.1.3.1 BMI Abundance

No clear upstream to downstream trend in total estimated BMI abundance and taxa richness was observed, although abundance was highest at sites 1 and 2 (RMs 7 and 11), and was lowest at the most upstream location, Site 6 (RM 23). Abundance at Site 2 (RM 11) was 2.5–11.1 times higher than that of other sites. Variability in site BMI abundance is likely related to the presence of productive benthic habitats with gravel, moving water, and food resources. Conversely, abundance was negatively correlated with the percentage of boulders in the sample plots (ρ= -0.81). Boulders are a less productive substrate type, relative to cobble and gravel. The upstream half of Site 6 (RM 23) had very little gravel with stagnant water on the margins, likely resulting in low overall abundance. The relatively high abundance at Site 2 (RM 11) was likely due to sample plots dominated by gravel and cobble with flowing water. Cobble and coarse gravel have a large amount of surface area and interstitial space available that may favor higher densities of BMIs.

#### 4.1.3.2 BMI Richness

No clear upstream to downstream trend in any of the richness metrics was observed; however. Most richness metrics were highest at Site 1 (RM 7), and most were lowest at Site 6 (RM 23). Site 1 had the highest taxonomic richness of each of the other sites, including the most mayflies (Ephemeroptera) and caddisflies (Trichoptera). Site 2 (RM 11) had the overall lowest taxonomic richness. Taxonomic richness typically increases with habitat complexity, and the number of niche habitats that are sampled. Site 1 (RM 7) had a combination of flowing and stagnant water samples with a range of substrate types (sand to cobble). Ephemeroptera richness was positively correlated with the percentage of fine gravel in the sample plots (ρ= 0.87). These ephemeropteran taxa were almost all collector-gatherers, and would benefit from fine gravel with detrital material in the interstitial spaces.

#### 4.1.3.3 BMI Composition

In general, the BMI communities in all of the sites were dominated by midges (*Chironomidae*), worms (*Oligochaeta*), mayflies (*Baetidae*), and caddisflies (*Hydropsychidae*). Of these, only mayflies (Ephemeroptera) and caddisflies (Trichoptera) are EPT taxa. The percentage of EPT taxa varied little among sites 1, 2, 3, and 5, but was much lower at sites 4 and 6. EPTs are generally associated with riffles and gravel sediments. The EPT distribution was positively correlated with coarse gravel (ρ= 0.89) and negatively associated with pools (ρ= -0.85). The percentage of Ephemeroptera was positively correlated with glide habitat (ρ= 0.94). The Ephemeroptera are almost all collector-gatherers, and would benefit from glide habitat with moderate current, gravel, and deposited detrital material.

Higher SDI values indicate increased BMI diversity. SDI values were positively correlated with riffle habitat (ρ= 0.84) and generally increased as elevation decreased (i.e. increased from upstream to downstream; ρ= -0.83). This increase in diversity could be the result of substrate composition becoming finer (shift from boulders and cobble to cobble, gravel, and sand) or increased channel form complexity. The channel becomes much less confined downstream of

Site 4 (RM 18), with more riffle habitat, and would presumably provide more microhabitat niches for a larger variety of taxa.

#### 4.1.3.4 BMI Tolerance/ Intolerance

No clear upstream to downstream trend in tolerance was observed; however, the number of intolerant taxa was highest, and the percent of individuals from the dominant taxa was lowest, at Site 1 (RM 7). The percent of the population consisting of tolerant individuals was also highest at Site 1. The percent of the most dominant taxon was similar at sites 2, 5, and 6, and much lower at Sites 1, 3, and 4. In all cases, the most dominant taxon was either *Paratanytarsus* sp. (Diptera, Chironomidae) or *Tanytarsus* sp. (Diptera, Chironomidae). These taxa are collector-filterers, and are likely found in benthic habitat with flowing water and particulate organic matter available in the water column, as a food source. The relative dominance of these taxa at sites 2, 5, and 6 could be related to their proximity to impounded water and the production of plankton.

The CTV metric increases in response to impairment. CTV increased with decreasing coarse gravel (ρ= -0.89), sand (ρ= -0.94), and riffle habitat (ρ= -0.81). Coarse gravel and riffle habitat are required for many intolerant BMI taxa.

#### 4.1.3.5 BMI Feeding

Dominant functional feeding groups in the BMI communities in all sites were Collector-Gatherers and Collector-Filterers (range of 83% to 91%). Collector-Gatherers feed on organic matter deposited on and in benthic sediments. This detrital organic matter likely originated from periphyton algae and leaf litter. The Collector-Gatherer feeding strategy was represented by multiple taxonomic groups, including chironomids (Diptera, Chironomidae), baetids (Ephemeroptera, Baetidae), and oligochaetes. Collector-Filterers feed on organic matter suspended in the water column, such as plankton from releases at the upstream reservoirs and from lower river production. The Collector-Filterer feeding strategy was also represented by multiple taxonomic groups, including *Paratanytarsus* sp. (Diptera, Chironomidae), *Tanytarsus* sp. (Diptera, Chironomidae) and *Hydropsyche* sp. (Trichoptera, Hydropsychidae).

Relative abundance of the “scraper” functional feeding group of BMI’s was relatively low (range of 1% to 8%). These BMIs feed off of periphyton and other organic matter attached to the benthic substrate, and are primarily represented by mollusks (Gastropoda), *Glossosoma* sp. (Trichoptera, Glossomatidae), and *Phaenopsectra* sp. (Diptera, Chironomidae). The presence of periphyton on benthic substrate is typical for mid-order and larger rivers with abundant cobble, boulders, and bedrock. The percentage of scrapers increased with bankfull width (ρ= -0.89). Increasing bankfull width allows more light into the wetted channel and increased periphyton production.

The “Shredder” functional feeding group of BMIs process particulate organic matter, such as leaf litter, as a food source. The potential for inputs of coarse and fine particulate organic material is dependent on the vegetative structure of the riparian area. Organic inputs from riparian vegetation become food for stream organisms. A strong indicator of the potential for these riparian inputs is an estimation of canopy cover. Overall canopy cover across all the sites was low (range of 6.1% to 35.0%). The relatively low abundance of canopy cover and expected lack of inputs of coarse particulate matter are concordant with the low relative density of shredder BMIs found across all sites (range of 0% to 1.0%).

Finally, the predator functional feeding group is composed of BMIs that feed on other BMIs. Predators accounted for a significant proportion of the BMI community (range of 5% to 10%), and included genera from the Tanypodinae (Diptera), Empedidae (Diptera), Perlidae (Plecoptera), Perlodidae (Plecoptera), and water mites (Arachnida). The presence of a significant amount of predators indicates trophic complexity in the BMI community. Relative abundance of predators was highest at Site 1 (RM 7), and lowest at sites 6 and 4 (RM 23 and 18).

## 4.2 Comparison with Historical Data

Available historical BMI data for comparison with the study sites were limited to surveys conducted at Parks Bar (Site 4, RM 18) in 2006 and 2007 by the South Yuba River Citizen's League (SYRCL) (G. Reedy, pers. comm.., 2012). The historical BMI sampling sites occurred near YCWA's study sites. However, SYRCL used the California Stream Bioassessment Procedure for sampling, which is adapted to wadeable streams and therefore results and effort are inherently different from that of YCWA's study. Additionally, stream habitat characteristics, which influence BMI community structure, may have changed from 2007 when SYRCL's study was performed to 2012 when YCWA's study was performed. Therefore, a limited and qualitative comparison of available metrics was conducted (Table 4.2-1).

Taxonomic richness was considerably higher in 2012 than in 2006 and 2007 (Table 4.2-1); however, the EPT richness values changed little among years. The difference in overall taxonomic richness could therefore be due to smaller collection areas in 2006 and 2007, and to less effort devoted to identifying distinct taxa in groups such as the chironomids.

The percent composition of EPT taxa was much higher in 2006 than in 2012. This difference can likely be attributed to the different methodology resulting in historical samples being collected from flowing riffles, whereas 2012 samples came from a variety of flowing and stagnant habitats.

Higher SDI values in 2012 than in 2006 and 2007 may be due to the larger sample area and multi-habitat sampling strategy employed, but this is speculative.

The relative abundance of collector-filterer and collector-gatherer BMIs varied little between 2006 and 2012, but the relative abundance of all other feeding groups increased in 2012. The increased percentages of the other feeding groups in YCWA's study were likely a result of sampling multiple habitats.

**Table 4.2-1. BMI metrics from samples collected at Site 1: Hallwood Boulevard (RM 7) on July 19, 2012.**

| BMI Metrics | SYRCL's Data Parks Bar 2006 | SYRCL's Data Parks Bar 2007 | YCWA's Data 2012 |
|---|---|---|---|
| **RICHNESS** | | | |
| Taxonomic Richness | 14 | 22 | 41 |
| No. EPT Taxa | 9 | 14 | 8 |
| No. Ephemeroptera Taxa | 5 | 6 | 4 |
| No. Plecoptera Taxa | 2 | 3 | 2 |
| No. Trichoptera Taxa | 2 | 5 | 2 |
| No. Coleoptera Taxa | 0 | 0 | 0 |
| **COMPOSITION** | | | |
| % EPT | 36.51 | NA | 7.3 |
| Shannon Diversity Index (SDI) | 1.36 | 2.03 | 2.8 |
| **FEEDING** | | | |
| % Collector-filterer+Collector-gatherer Individuals | 95.33 | NA | 90.9 |
| % Scrapers | 1.22 | 2.52 | 3.3 |
| % Non-gastropoda Scrapers | 1.22 | NA | 2.6 |
| % Predators | 1.62 | 4.44 | 5.1 |
| % Shredders | 0 | NA | 0.2 |

# 5.0 Study-Specific Consultation

The FERC-approved study included one study-specific consultation, which is discussed below.

## 5.1 Selection of Sampling Sites

The FERC-approved study states:

> YCWA will select the specific sample site locations, within the specified stream reaches, after consultation with the SWRCB, USFWS, NMFS, CDFG, and Forest Service.

Interested Relicensing Participants attended the site selection event on February 2, 2012. Site locations were collaboratively agreed upon.

# 6.0 Variances from FERC-Approved Study

The study was conducted according to the Federal Energy Regulatory Commission-approved Study 3.2, Aquatic Macroinvertebrates Downstream of Englebright Dam Study, with one variance. The study plan was scheduled to be completed in September 2012. Additional time was required for the BMI samples to be processed and delayed the delivery of the report to October 2012. This does not alter the data or quality of the report in any manner.

# 7.0 Attachments to This Technical Memorandum

This Technical Memorandum includes two attachments:

- Attachment 3-2A Physical Habitat and Taxonomic Data. [1 MS Excel file: 4 MB]
- Attachment 3-2B Representative Photographs. [1 PDFWord file: 5282 MB; 3244 pages formatted to print on 8-½ by 11 inch paper]
- Attachment 3-2C QA/QC Report [1 Adobe pdf file: 72 kB; 18 pages formatted to print double sided on 8 ½ by 11 paper]

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