Final Report
July, 2001

Characterization of Benthic Communities and Physical Habitat in an Agricultural and Urban Stream in California's Central Valley

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ABSTRACT

The primary goal of this study was to characterize physical habitat and benthic communities in a representative urban (Arcade Creek) and agricultural (Orestimba Creek) stream in California's Central Valley. Both of these streams have been listed as impaired water bodies (303d list) by the State of California due to the presence of the organophosphate (OP) insecticides chlorpyrifos and diazinon. A secondary goal of this study was to compare the presence of OP-sensitive benthic species in these streams with available OP toxicity and exposure data to determine if these benthic species are present. Habitat requirements and to a lesser degree sampling gear limitations were considered in this comparison.

Based on 10 instream and riparian physical habitat metrics, total physical habitat scores in Arcade Creek ranged from 59 to 135 (maximum possible total score is 200). All metrics were highly variable among Arcade Creek sites except channel flow. Channel alteration showed a significant increase between the downstream and upstream sites while bank stability showed a significant decrease from downstream to upstream. Orestimba Creek physical habitat scores ranged from 74 to 158; less variability was reported for the habitat metrics in this stream when compared with Arcade Creek. Channel flow showed a significant decrease between the downstream and upstream sites; bank stability increased from downstream to upstream. Total physical habitat scores were generally higher for Orestimba Creek than Arcade Creek.

Approximately 8,200 individuals from 60 benthic taxa were collected from 10 Arcade Creek sites with Chironomidae and Oligochaetes comprising 92% of the total individuals collected. Chironomidae can be either tolerant or sensitive to environmental degradation depending on the species. Oligochaetes are generally considered tolerant taxa. Taxa richness was somewhat variable by site and ranged from 14 to 30. There was no apparent spatial trend in benthic taxa among the

Arcade Creek sites although the lowest abundance generally occurred at the downstream site. The % tolerant taxa were dominant at the downstream site. Collectors, benthos that collect or gather fine particulate matter and usually dominate in stressed environments, were the dominant feeding guild for benthic taxa collected in Arcade Creek.

Approximately 5,400 individuals from 98 taxa were collected from 10 Orestimba Creek sites with Oligochaetes and Chironomids the most dominant comprising 63% of the total taxa. Taxa richness was variable among sites ranging from 19 to 52. Abundance was generally greater at the upstream sites. At the most upstream site, the % dominant and % tolerant taxa were lowest and mayflies and caddisflies were more dominant. As reported above for Arcade Creek, collectors were the dominant feeding guild. The following benthic metrics were higher in Orestimba Creek when compared to Arcade Creek: abundance, percent filterers, percent grazers, percent predators, Shannon Diversity and richness.

Bank stability was reported to be the most important physical habitat metric influencing various benthic metrics in both streams. Bank vegetation and frequency of bends/riffles were also reported to be important physical habitat metrics influencing the various benthic metrics.

A qualitative comparison of OP-sensitive benthic species in both creeks based on single-species toxicity data was limited due to lack of data. Cladocerans (daphniidae), an OP-sensitive taxa of benthic macroinvertebrates, were found in either low numbers (Arcade Creek) or were absent (Orestimba Creek). Unsuitable habitat was considered the primary factor responsible for these results although, the use of standardized sampling gear with somewhat low efficiency for collecting cladocerans was also a possible factor. The amphipod, *Gammarus lacustris*, which is sensitive to chlorpyrifos at environmentally realistic concentrations, was the 8^{th} most dominant taxa found in Orestimba Creek. However, this species was not collected in Arcade Creek.

ACKNOWLEDGEMENTS

We would like to thank Dow AgroSciences for supporting this study. Special appreciation is extended to our project officer, Dr. Nick Poletika, for helpful suggestions on the study design. Jeff DeBerardinis is acknowledged for assisting with the field work. Dr. Elgin Perry is acknowledged for conducting the statistical analysis. Jim Harrington of California Department of Fish and Game is acknowledged for directing the identification of benthic species. We would also like to thank the following landowners for allowing access to their property near Orestimba Creek: Mr. Glen Crow, Mr Norman Crow, Mr Marvin Kaminska, Mr A. George, Mr. Peters and Mr. DePaul.

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Appendix C - Number of lowest identified taxa by transect and combined transects including tolerance values (TV) and feeding guilds for Orestimba Creek sites. Tolerance values for taxa range from 1 to 10 with 10 the most tolerant value. Feeding guilds are defined as follows: c = collector; f = filterer; g = grazer; p = producer and s = shredder.

INTRODUCTION

Intense agricultural and urban development in California's Central Valley has modified many of the natural lotic systems in this area (May and Brown, 2000). The changing landscape coupled with various other anthropogenic factors has created stressful conditions for resident aquatic biological communities. Foe (1995) postulated that the following factors may have contributed to the decline of aquatic resources in California's Central Valley: water diversion, changes in basin hydrology, loss of habitat, introduction of exotic species and contaminants (e. g. organophosphate insecticides). Moyle et al. (1992) reported that activities such as diking, dredging, filling of wetlands and significant diversion of freshwater flows for irrigated agriculture and urban use have altered fish habitat and resulted in adverse impacts on fish populations.

In recent years, assessments of benthic invertebrate assemblages and physical habitat have been initiated in wadeable streams in California's Central Valley (Brown and May, 2000; Jim Harrington, personal communication). These efforts are valuable for determining the status of aquatic biological communities across large spatial scales and landuse types (agricultural and urban). Information on the status of resident biological communities is particularly useful for determining impaired water bodies, developing Total Maximum Daily Loads (TMDLs), and measuring success of voluntary or regulatory actions.

The primary goal of this study was to characterize physical habitat and benthic communities in a representative agricultural and urban stream in California's Central Valley. Both of these streams have been listed as impaired water bodies (303 d list) due to the presence of diazinon and chlorpyrifos (www.swrcb.ca.gov). The benthic community data was therefore interpreted in the context of recent ecological risk assessments for the organophosphate (OP) insecticides chlorpyrifos and diazinon which have identified OP-sensitive benthic species.

METHODS

Site Selection

The two second to third order wadeable streams sampled during this study were Arcade Creek (Figure 1) and Orestimba Creek (Figure 2). Arcade Creek is located within the city of Sacramento in Sacramento County, California and is a tributary of the Sacramento River watershed. This creek is approximately 17 miles long from its confluence with the Natomas Main Drainage Canal to the upper-most study site. Arcade Creek is highly urbanized and consists of residential, commercial and light industry land use types.

Orestimba Creek is located in Stanislaus County and is a tributary of the San Joaquin River watershed. The stations sampled in this stream covered approximately 13 stream miles from the upstream sample site to the confluence with the San Joaquin River. Agriculture is the predominate land use type in Orestimba Creek.

Ten sample sites were selected in each stream using a stratified random design with approximate equal spacing among sample sites (Table 1; Figures 1 and 2). Initial site visits were conducted in April of 2000 but due to heavy rainfall and high water conditions exact locations could not be determined. In May of 2000, exact sample stations were determined in each stream and landowner contacts were made to access the sample sites for the late spring sampling.

Physical Habitat Assessments

Physical habitat was evaluated at each site concurrently with benthic collections and water quality evaluations. The physical habitat evaluation methods followed protocols described in Harrington (1999) and Harrington and Born (2000). The physical habitat metrics used for this study are based on nationally standardized protocols described in Barbour et al. (1999). A total of 10 continuous metrics scored on a 0-20 scale were evaluated (Appendix A). Other non-continuous metrics including percent canopy, % gradient, and substrate composition that were also measured are described in Appendix A.

Benthic Macroinvertebrate Sampling

Benthic macroinvertebrates were collected in the late spring of 2000 from three replicate samples at 10 stations in both Arcade and Orestimba Creeks. The sample site selections and sampling procedures were conducted in accordance with methods described in Harrington (1999) and Harrington and Born (2000). Sampling reaches were equally spaced along the stream starting at the confluence. Within each of these sample reaches, a riffle was located (if possible) for the collection of benthic macroinvertebrates. A tape measure was placed along the riffle and potential sampling transects were located at each meter interval of the tape. Using a random numbers table, three transects were randomly selected for sampling from among those available within the riffle. Benthic samples were then taken using a standard D-net with 0.5 mm mesh starting with the most downstream portion of the riffle. A 1x2 foot section of the riffle immediately upstream of the net was disturbed to a depth of 4-6 inches to dislodge and collect the benthic macroinvertebrates. Large rocks and woody debris were scrubbed and leaves were examined to dislodge organisms clinging to these substrates. Within each of the randomly chosen transects three replicate samples were collected to reflect the structure and complexity of the habitat within the transect. If habitat complexity was lacking, samples were taken near the side margins and thalweg of the transect and the procedures described above were followed. All samples were preserved with 95% ethanol.

Due to the physical nature of these agricultural and urban streams, it was often difficult to locate a substantial number of riffles to sample. In various cases, there was only a single section of riffle available within a selected reach to sample and in some instances there were no riffles present. In cases where riffles were lacking, alternative sampling methods for non-riffle areas were used as outlined in Harrington and Born (2000). This involved sampling the best available 1x2 foot sections of habitat throughout the reach using the same procedures described above. Nine 1x2 foot sections were randomly selected for sampling. Groups of three 1x2 foot sections were composited for each replicate for a total of three replicates per site.

Taxonomy of Benthic Macroinvertebrates

The goal of this study was to identify all benthic samples to the species level if possible. Species level identifications will be particularly useful if and when Indices of Biotic Integrity (IBIs) are developed for wadeable streams in California's Central Valley. For taxa such as oligochaetes and chironomids, family and genus level, respectively, were the lowest level of identification possible.

The benthic macroinvertebrate subsampling (resulting in a maximum of 300 individuals) and identifications were supervised by Angie Montalvo of California's Department of Fish and Game (CDFG) in Rancho Cordova, California. The benthic macroinvertebrate samples were subsampled and sorted by personnel at the CDFG Laboratory located at Chico State University campus. Level 3 identifications (species level identifications) followed protocols outlined in Harrington and Born (2000). Mr. Dan Pickard of CDFG conducted the taxonomic identifications. Slide preparations and mounting for species such as midges and oligochaetes followed protocols from the United States Geological Survey National Quality Control Laboratory described in Moulton et al. 2000.

Water Quality Measurements

The following water quality parameters were measured at each stream site using procedures described in Kazyak (1997): temperature, pH, specific conductivity, dissolved oxygen, and turbidity.

Statistical Analysis

Principal components analysis (PCA) was used to determine the relationship among the various physical habitat metrics to identify groups of metrics that covary. Spatial trends (upstream to downstream) of both physical habitat and benthic metrics within each stream were examined using Spearmans Rank Correlation Coefficients and significance levels. The relationship among physical habitat and benthic metrics was also determined by using Spearmans Rank Correlation Analysis. The Wilcoxon Rank-Sum Test was used to compare habitat and benthic metrics between Arcade and Orestimba Creeks.

RESULTS

Physical Habitat

Arcade Creek

The physical habitat scores in Arcade Creek ranged from 59 to 135 for the ten metrics that were scored on a 0 to 20 scale (Table 2). With the exception of channel flow, all the other metrics were highly variable across the ten stations within Arcade Creek. For example, epifaunal substrate ranged from 3 to 16, sediment deposition ranged from 2 to 18 and riparian width ranged from 0 to 18. The site with the lowest total physical habitat score (ARC7) had particularly low scores for epifaunal substrate, embeddedness, sediment deposition, bank stability and riparian vegetation. In contrast, the site with the highest physical habitat score (ARC2) had higher scores for the these four metrics.

Other descriptive physical habitat metrics that were not scored on a 0 - 20 scale are presented in Table 3. These metrics are not scored on a 0 to 20 scale because some are bimodal (too much or too little canopy can be advantageous) and others are just descriptive. The percent canopy for the 10 Arcade Creek sites ranged from 2% at the downstream site (ARC1) to 100% approximately 3 miles upstream at site ARC3. Gradient was relatively consistent at all sites (1%) with the exception of ARC6 (2%). The percent fines for substrate percentages ranged from 98% (ARC1) to 5% at ARC2.

Orestimba Creek

Orestimba Creek physical habitat scores for the 10 metrics that were scored on a 0 to 20 scale ranged from 74 to 158 (Table 2). These 10 metrics were generally less variable at the Orestimba Creek sites when compared with sites in Arcade Creek. The lowest total habitat score (74) was reported for the downstream site (ORE1) near the confluence of Orestimba Creek and the

San Joaquin River (see Figure 2). This site had particularly low scores for embeddedness, sediment deposition, bank stability, and riparian vegetation. The highest total habitat score (158) was reported at ORE5. The following metrics were reasonably high at this site: epifaunal substrate, velocity/depth/diversity, sediment deposition, frequency of bends, and riparian vegetation. Other descriptive habitat metrics for the 10 Orestimba Creek sites in Table 3 showed that % canopy ranged from 0 to 68%, % gradient was consistently 1%, and % fines ranged from 15 to 85%.

Summary Statistical Analysis for Both Creeks

Principal Components Analysis (PCA) was used to determine the relationship among habitat metrics and identify metrics that covary (ie. increase or decrease together). The 10 habitat metrics that were scored on a 0 to 20 scale had three eigenvalues that were greater than 1 (Table 4). The significance of this finding is that 10 habitat metrics contain three important factors which explained 75% of the variance in the data set. After identifying the three most important factors, the next step is to determine which metrics are important to each factor as presented in Table 5. Epifaunal substrate, embeddedness, sediment deposition, and bend-riffle frequency were heavily loaded on the first factor. These metrics were actual instream habitat measurements (not riparian metrics). Velocity/depth was somewhat split between factor one and three. Factor 2 was composed of the following riparian metrics: bank stability, bank vegetation, and riparian buffer zone. Velocity/depth and channel alteration were significant metrics for Factor 3.

The correlations among the instream habitat metrics in Factor 1 and the riparian metrics in Factor 2 are logical as these grouping of metrics measure similar attributes in the stream environment. The velocity/depth and channel alteration metrics that load heavily on Factor 3 are both hydrological type stream characteristics; therefore, a relationship between these metrics is not surprising.

Correlations among raw physical habitat metrics grouped by factors identified by PCA showed that channel alteration had a very low correlation with the total habitat score (Table 6). Riparian buffer zone and channel flow status had correlations of 0.40 and 0.41, respectively, with the final physical habitat scores. All other metrics had correlations of 0.60 ($p < 0.05$) or greater with the final physical habitat scores.

The correlation matrix in Table 7 showed significant correlations among stream characteristics that were not scored on a 0 to 20 scale (ie. width, depth) and those metrics that were scored. It is not surprising that embeddedness, velocity/depth, and sediment deposition were associated with stream velocity. A negative association was reported between bank stability and canopy.

Spearman Rank Test for spatial trends (downstream to upstream) of habitat metrics showed a significant increase for channel alteration between the most downstream site in Arcade Creek (ARC 1) and the most upstream site (ARC 10) (Table 8). Bank stability showed a significant decrease between ARC 1 and ARC 10. In Orestimba Creek, channel flow showed a significant decrease between ORE 1 and ORE 10 due to the absence of upstream irrigated agriculture. Bank stability showed a significant increase between the downstream and upstream site in Orestimba Creek. The bank stability result for the agricultural stream is in sharp contrast to that reported above for the urban stream.

A comparison of habitat metrics and total scores for each creek showed that Orestimba Creek had a slightly higher scores for individual metrics when compared with Arcade Creek (Table 9). This difference among the various metrics is not considered to be significant based on the variability among metrics in each creek. However, the total physical habitat score was higher ($p=0.06$) for Orestimba Creek.

Benthic Macroinvertebrates

Arcade Creek

Approximately 8,200 individuals from 60 taxa were collected from the 10 Arcade Creek sites (Table 10, Appendix B). The two most abundant taxa of benthic macroinvertebrates , Chironomidae and Oligochaeta, comprised 92% of the total individuals collected (Table 10). The chironomid, *Rheocricotopus sp*, accounted for 40% of the total individuals collected in Arcade Creek. Chironomids can be either tolerant or sensitive to environmental degradation depending on the species (Stribling et al., 1998). Oligochaetes are generally found in stressful environments (Harrington and Born, 2000). Pollution-sensitive species such as Trichoptera (Caddisflies) and Plecoptera (Stoneflies) were collected in low numbers in this stream.

Total taxa richness ranged from 14 at upstream site ARC 10 to 30 at the ARC 9 just below the most upstream site (Figure 3). Taxa richness was somewhat variable among transects at each site (Figure 3). In most cases, the number of individuals per transect at each site was similar (Figure 4). There was no apparent widespread spatial trend in benthic abundance by station location although the lowest abundance was reported at the most downstream site. Total number of individuals per site with all replicates combined ranged from 690 to 889 with lowest total number of individuals reported at the most downstream site (ARC1).

Various benthic metrics summarized by site in Table 11 showed the following: the % dominant taxa were consistent among sites; EPT taxa (mayflies, caddisflies and stoneflies) metrics were not useful discriminators because these taxa were rare; and the % tolerant taxa were generally higher at the downstream sites (ARC 1 and 2). Collectors, macrobenthos that collect or gather fine particulate matter, were the dominant feeding guild for the various benthic taxa collected in Arcade Creek (Table 11). This functional feeding guild is usually dominant in stressed aquatic environments

(Harrington and Born, 2000). The ARC 4 site had the lowest % collectors and the higher percent of shredders (macrobenthos that shreds coarse particulate matter). Shredders are typically found in non-stressed environments (Harrington and Born, 2000).

Orestimba Creek

Approximately 5,400 individuals from 98 taxa were collected from 10 sites in Orestimba Creek (Table 12; Appendix C). Oligochaetes and Chironomids were the two most dominant taxa comprising 63% of the total species. As discussed above, Oligochaetes are generally found in stressful environments while Chironomids can be either sensitive or tolerant depending on the species. Pollution-sensitive species such as Trichoptera (caddisflies) and Ephemeroptera (mayflies) were also collected in low numbers in this creek, primarily at the upstream site (ORE 10).

Total taxa richness ranged from 19 at ORE 7 to 52 at the most upstream site ORE 10 (Figure 5). Richness was variable among the transects. The number of individuals per transect at each site was somewhat variable for approximately half the sites (Figure 6). Benthic abundance was generally greater at the three upstream sites (ORE 8, 9 and 10) with the lowest abundance reported at ORE 7. The total number of individuals per site with all transects combined ranged from 149 to 983.

Benthic metrics for the Orestimba Creek sites are summarized in Table 13. The following benthic metrics at ORE 10 were particularly noteworthy when compared with the other sites: the % dominant taxa were lowest; EPT taxa (mayflies and caddisflies) were more dominant; and the % of tolerant taxa collected were lowest. Collectors, a feeding guild that dominates in stressed environments, were the dominant feeding group for the various benthic taxa collected in Orestimba Creek. The lowest % collectors were reported at ORE 10.

Approximately two thirds of the individual macroinvertebrates collected from Orestimba Creek were non-insects (generally tolerant of water pollution as reported in Harrington and Born,

2000) (Appendix C). The non-insects were more dominant in Orestimba Creek than in Arcade Creek as reported above. Amphipods, which are considered sensitive to organophosphate insecticides such as diazinon (Giddings et al. 2000) and chlorpyrifos (Giesy et al. 1999), were the 8th most dominant taxa in Orestimba Creek.

Summary Statistical Analysis for Both Creeks

Spearmans Rank Correlation Analysis showed no spatial trends (downstream to upstream) for the various benthic metrics in Arcade Creek (Table 14). For Orestimba Creek, abundance and percent shredders showed a significant increase between ORE 1 (downstream site) and ORE 10 (upstream site). Percent collectors, percent tolerant taxa and tolerance values showed a significant decrease from ORE 1 to ORE 10 (Table 14).

A comparison of benthic metrics between Arcade and Orestimba Creek showed that the following metrics were higher ($p < 0.05$) in Orestimba Creek: abundance, percent filterers, percent grazers, percent predators, Shannon Diversity and taxonomic richness (Table 15). Percent collectors were greater in Arcade Creek (Table 15).

Relationship of Physical Habitat and Benthos

Spearmans Rank Correlation Analysis showed that bank stability was the most important physical habitat metric influencing the various benthic metrics (Table 16). Bank stability was significant and positively correlated with EPT Index (%), EPT taxa, % dominant taxa, % grazers, % shredders, Shannon Diversity and Trichoptera taxa. Bank vegetation was positively correlated with EPT Index (%), % grazers and Trichoptera taxa but negatively correlated with % dominant taxa. Bends/Riffle frequency was positively correlated with EPT Index (%), EPT taxa and Trichoptera taxa. The velocity/depth metric was positively correlated with % filterers and negatively correlated with % collectors. Riparian buffer zone was positively correlated with %

grazers. The total physical habitat scores were positively correlated with the presence of Trichoptera taxa.

Water Quality

Arcade Creek

Various water quality conditions such as temperature and conductivity were reasonably consistent at all 10 sample sites in Arcade Creek (Table 1). Parameters such as pH (7.5 to 8.8), dissolved oxygen (6.7 to 10.9 mg/L) and turbidity (5 to 35 NTU) showed some variability but there was no apparent spatial pattern.

Orestimba Creek

Temperature, conductivity and pH were fairly consistent among all 10 sites in Orestimba Creek (Table 1). Dissolved oxygen varied from 6.7 mg/L at the most downstream site (ORE 1) to 13 mg/L at the most upstream site (ORE 10). Oxygen consumption is likely higher at ORE sites 1-9 due to the mix of non-point source contaminants coming from cultivated agricultural fields. Turbidity was much lower at the upstream site (ORE 10) when compared with the nine downstream sites. The lower turbidity at this upstream site likely occurs because there is no suspended sediment coming from eroded soil in irrigated agricultural fields (sites ORE 1-9). Parameters such as conductivity, pH and turbidity were generally higher at all sites in this agricultural stream when compared with Arcade Creek (an urban stream).

DISCUSSION

Physical Habitat

The presence of altered habitat structure is considered one of the major stressors of aquatic systems (Karr et al., 1986). Degraded physical habitat in streams can sometimes hinder investigations on the effects of toxic chemicals or other water quality related stressors. Rankin (1995) has reported that there is a small but still significant risk of reporting a water quality related impact when one does not exist (false positive) when habitat assessments are insufficient or absent. Physical habitat evaluations are not intended to replace biological assessments but rather to add an additional line of evidence about the status of lotic systems when conducted in concert with biological assessments. Evaluation of physical habitat in both agricultural and urban streams in California's Central Valley is particularly important due to the intensive development and landscape modifications in these areas.

The limited number of sample sites and stream types in the present study hinders an extensive discussion of these physical habitat data across large spatial scales. One key finding is that the physical habitat in Orestimba Creek (agricultural stream) was generally of higher quality than reported for Arcade Creek (urban stream). Various metrics such as epifaunal substrate, embeddedness, velocity/depth and bank vegetation were generally higher across all sites in Orestimba Creek. The number of benthic taxa (species richness) in Orestimba Creek was also higher than in Arcade Creek. This supports the positive relationship between physical habitat and benthic communities that has been reported in other freshwater stream studies (Hall et al., 2000).

An exact historical comparison of total physical habitat scores (maximum of 200) for Arcade Creek (59 to 135) and Orestimba Creek (74 to158) is not possible because historical physical habitat data for California's Central Valley streams has not been summarized in a published format.

However, based on best professional judgement from other physical habitat assessments in the area, the range of physical habitat scores reported for the two streams in our study is generally considered low (Peter Ode, California Department of Fish and Game, personal communication).

Presence of OP-Sensitive Species

One of the goals of this study was to compare the presence of benthic macroinvertebrates in Arcade and Orestimba Creeks with available organophosphate (OP) single-species toxicity data. The intent of this comparison is to determine if OP-sensitive benthic species are present in these streams. In order to conduct a valid comparison, the following issues must be addressed: (1) Are the OP-sensitive benthic species determined from single species toxicity tests expected to be found in these systems based on their habitat requirements? and (2) Are the sampling techniques used in our study (D-net sampling with 0.5mm mesh) appropriate for collecting all OP-sensitive benthic species (ie. cladocerans)? Ranges of chlorpyrifos and diazinon concentrations presented in Table 17 have been reported during high use periods in recent years in both Arcade (Tomko, 1999) and Orestimba Creek (Poletika and Robb, 1998). These exposure data are used in a comparative analysis with the OP toxicity data presented below.

Chlorpyrifos acute toxicity data were available for 11 different taxa collected in either Arcade or Orestimba Creek during our study (Table 18). The most sensitive taxa to chlorpyrifos that could be affected at environmentally realistic concentrations in either creek (concentrations < 2,282 ng/L based on the highest concentration in either creek) were *Chironomus sp.* (LC50 = 70 ng/L), *Gammarus lacustris* (LC50 = 110 ng/L), *Neomysis mercedis* (LC50 = 140 -160 ng/L) and Daphnidae (LC50 = 210 ng/L) . Only one *Chironomus sp.* was collected in Orestimba Creek and none were collected in Arcade Creek; therefore, this OP-sensitive genus is considered rare for both of these streams. *G. lacustris* are predicted to be sensitive to chlorpyrifos based on single species toxicity tests and the effect concentrations are environmentally realistic. However, this scud was the 8th most dominant species in Orestimba Creek and it appears that the sampling gear used for this OP-sensitive species was efficient. *G. lacustris* was not collected in Arcade Creek. *N. mercedis* was rare in both creeks as only one specimen was collected at the mouth of Orestimba Creek near the San Joaquin River. Failure to collect *N. mercedis* was likely related to the use of stream bioassessment sampling gear and unsuitable habitat. *N. mercedis* is found throughout the Delta but is most abundant in the entrapment zone (Obrebski et al., 1992). Daphniidae (cladocerans) were collected in very low numbers in Arcade Creek and were not collected at any sites in Orestimba Creek. The primary reason for collecting low numbers is that cladocerans prefer lentic environments such as ponds and lakes rather than lotic environments such as streams and creeks (Pennack, 1989). The sampling gear used for collection of benthic macroinvertebrates in lotic habitats (D net with .5 mm mesh) is also somewhat inefficient for cladocerans. Five of the seven other chlorpyrifos tolerant taxa in Table 18 were found in both creeks. Only *Hydropsyche* (caddisfly) were found in Arcade Creek; *Caenis sp.* (mayfly) was only found in Orestimba Creek.

Diazinon acute toxicity data were available for seven different taxa collected in either Arcade or Orestimba Creek during our study (Table 19). The most sensitive taxa to diazinon that could be affected at environmentally realistic concentrations in either creek (concentrations < 29,371 ng/L based on the highest value in either creek) were: daphniids (LC50 = 780 to 1,020 ng/L); *Neomysis mercedis* (LC50 = 4,150 ng/L); and *Baetis tricaudatus* (LC50 = 24,000 ng/L). Daphniids (cladocerans) and mysids were likely collected in low numbers or not at all in either creek due to the unsuitable habitat and to a lesser degree the use of stream bioassessment sampling gear. The mayfly *B. tricaudatus* was collected in low numbers in Orestimba Creek. Of the remaining four taxa in Table 19, *Physa/Physella* (gastropods) and undetermined tubificidae were found in both creeks.

G. lacustris and *Helisoma anceps* (gastropods) were only found in Orestimba Creek.

Historical Comparisons of Benthic Data

Historical comparisons of our data with other benthic data from Arcade and Orestimba Creeks were limited. Previous macroinvertebrate data collected from 1996-1999 near our ARC 2 and 3 sites showed that Chironomids and Oligochaetes were the two most dominant taxa (Larry Walker and Associates, personal communication). As presented previously in the results section, we reported similar dominant benthic taxa based on our 2000 sampling in Arcade Creek. In 1993, the U. S Geological Survey collected benthic macroinvertebrates at one site in Orestimba Creek that was approximately half way between our stations ORE 2 and ORE 3 (Larry Brown, personal communication). Dominant taxa reported by these investigators were mayflies, oligochaetes and gastropods. The dominant taxa we reported in Orestimba Creek (particularly at ORE 2 and 3) were oligochaetes and chironomids. Mayflies were not collected during our 2000 sampling at these two sites and gastropods were collected in very low numbers. Due to the seven year time period between the two sampling events, it is difficult to explain possible factors contributing to the differences in dominant taxa.

Regulatory and Ecological Implications

Both Arcade and Orestimba Creeks are classified by the State of California as impaired water bodies (303(d) list) due to the presence of chlorpyrifos and diazinon (www.swrcb.ca.gov). These water bodies were listed as impaired based on either OP concentrations exceeding a threshold (narrative water quality criteria) or toxicity reported from single species toxicity tests. The status of resident biological communities was not considered when these water bodies were classified as impaired because these data were not available. The benthic community data generated from this study is therefore useful for providing another line of evidence for determining the biological condition of these creeks.

Benthic communities in both Arcade and Orestimba Creeks were generally comprised of tolerant species such as Oligochaetes and Chironomids. Dominance by tolerant species is expected in these streams due to fluctuating flow conditions. Historical data from permanent gaging stations near ORE 10 (USGS) and ORE 8 (CA DWR) show that in most years Orestimba Creek is ephemeral in the reach with no commercial agriculture but generally has continuous low flow (in non-drought years) in most of the lower reach which receives irrigation return water (Poletika and Robb, 1998). Despite the presence of ephemeral flow conditions, the most dominant species in Arcade Creek (*Rheocricotopus sp*. which comprises 40% of the individuals collected) is considered to have a somewhat moderate rating to environmental stressors (Harrington and Born, 2000). An amphipod species (*G. lacustris*) with a moderate to sensitive tolerance rating to general environmental stressors, but highly sensitive to chlorpyrifos, was also fairly dominant in Orestimba Creek.

The key issues to address with the benthic community data from these streams data are: (1) What are the biological (benthic) expectations for this urban and agricultural stream? and (2) Do these streams meet these biological expectations and are they impaired based on the status of resident benthic communities? Unfortunately, an urban and agricultural reference stream is not available for these two watersheds to compare benthic communities for each stream. Therefore, the traditional approach often used to interpret the status of benthic communities is not feasible. The presence of 60 benthic taxa in Arcade Creek and 98 benthic taxa in Orestimba Creek implies that these creeks are fairly robust, considering their ephemeral environments, but without a clear definition of benthic community expectations it is unknown if these water bodies are truely impaired. Extensive spatial and temporal assessments of benthic communities in concert with physical habitat assessments are needed in agricultural and urban streams of California's Central

Valley in order to develop a range of benthic community taxa assemblages by strata (land use types and stream orders) and identify potential reference sites.

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Table 1. Sample site names, coordinates and water quality parameters measured during late spring 2000 in Arcade and Orestimba Creeks.

Site	Latitude	Longitude	Water Temperature (C)	Specific Conductivity μmhos/L	pH	Dissolved Oxygen mg/L	Turbidity NTU
ARC 1	38 37 30	121 27 20	25.6	251	7.45	7.85	14.3
ARC 2	38 37 49	121 24 59	24.8	257	7.66	9.24	8.7
ARC 3	38 38 28	121 22 56	21.4	296	7.58	6.8	10
ARC 4	38 38 38	121 21 00	20.2	302	7.86	8.95	18.3
ARC 5	38 39 37	121 20 10	20.8	298	8.04	9.25	28
ARC 6	38 41 00	121 19 31	22.8	342	8.31	10.3	35
ARC 7	38 41 15	121 41 15	26.2	228	8.81	10.9	5
ARC 8	38 41 02	121 17 28	18.6	173	7.61	7.58	6.2
ARC 9	38 41 03	121 16 33	19.2	322	7.74	6.65	5.1
ARC 10	38 41 17	121 15 53	23.1	365	7.7	9	4.4
ORE 1	37 25 10	121 00 09	21.5	754	8.01	6.7	115
ORE 2	37 25 12	121 00 21	22.5	744	8.23	8.18	158
ORE 3	37 24 47	121 00 59	23	739	8.18	7.45	156
ORE 4	37 24 19	121 01 28	21.4	683	8.01	7.83	107
ORE 5	37 23 54	121 02 02	22	654	8.1	8.1	107
ORE 6	37 23 21	121 02 34	22.9	644	8.25	8.9	131
ORE 7	37 22 59	121 03 00	29.5	620	8.48	8.9	153
ORE 8	37 22 37	121 03 31	22.9	840	8.21	8.15	80
ORE 9	37 21 53	121 03 45	27.7	857	8.4	7.81	213
ORE 10	37 19 08	121 07 18	27.4	878	8.37	13	0.51

Table 2. Scoring of individual physical habitat metrics (0-20 scale) and final habitat score (maximum of 200) for the 10 sites in both Arcade and Orestimba Creeks.

Site	Epifaunal Substrate	Embedd.	Velocity Depth Divers.	Sediment Deposit.	Channel Flow Status	Channel Alter.	Bends/Riffle Frequency	L. Bank Stability	R. Bank Stability	L. Bank Veget. Protect.	R. Bank Veget. Protect.	L. Bank Riparian Zone	R. Bank Riparian Zone	Total
ARC 1	3	1	3	2	8	13	2	9	9	7	7	9	9	82
ARC 2	16	15	9	17	16	2	17	10	10	7	7	6	3	135
ARC 3	15	9	9	5	15	1	10	2	2	1	1	0	0	70
ARC 4	6	17	14	18	16	15	12	2	2	4	4	6	6	122
ARC 5	8	10	12	15	16	17	11	8	5	9	7	9	5	132
ARC 6	10	9	13	11	15	11	15	4	4	3	3	6	6	110
ARC 7	2	3	6	4	8	16	6	1	1	2	2	4	4	59
ARC 8	3	6	9	17	14	17	5	4	7	2	5	7	2	98
ARC 9	8	4	14	9	15	17	11	2	2	2	2	8	2	96
ARC 10	10	13	9	16	15	18	12	1	1	2	2	3	3	105
ORE 1	6	4	7	4	16	18	5	1	1	2	2	5	3	74
ORE 2	10	13	10	5	15	18	17	1	1	2	2	5	5	104
ORE 3	14	14	10	15	19	15	18	7	7	6	6	3	3	137
ORE 4	15	14	17	16	15	15	10	5	5	4	4	4	5	129
ORE 5	17	13	19	15	15	15	18	7	6	9	8	8	8	158
ORE 6	10	11	13	10	15	14	8	8	8	9	8	6	4	124
ORE 7	8	13	12	14	11	15	10	4	5	6	9	3	6	116
ORE 8	13	11	10	14	10	13	15	7	9	7	7	6	6	128
ORE 9	14	14	10	14	15	15	10	9	9	8	8	7	8	141
ORE 10	10	7	13	12	9	19	16	7	7	3	3	3	3	112

Table 3. Physical habitat characteristics for Arcade and Orestimba Creek that were not scored on a 0-20 scale.

Site	Canopy Cover %	Gradient %	Fines %	Gravel %	Cobble %	Boulder %	Bedrock %
			Substrate Percentages				
ARC 1	2	1	98	2	0	0	0
ARC 2	35	1	5	10	35	50	0
ARC 3	100	1	43	15	42	0	0
ARC 4	51	1	15	15	0	0	70
ARC 5	54	1	20	10	20	0	50
ARC 6	63	2	39	60	1	0	0
ARC 7	43	1	85	15	0	0	0
ARC 8	42	1	14	25	1	0	60
ARC 9	61	1	60	39	1	0	0
ARC 10	82	1	50	50	0	0	0
ORE 1	10	1	85	15	0	0	0
ORE 2	61	1	40	60	0	0	0
ORE 3	29	1	30	70	0	0	0
ORE 4	60	1	45	45	10	0	0
ORE 5	68	1	15	75	10	0	0
ORE 6	8	1	40	60	0	0	0
ORE 7	77	1	35	60	5	0	0
ORE 8	0	1	47	48	5	0	0
ORE 9	16	1	50	45	5	0	0
ORE 10	0	1	45	50	5	0	0

Table 4. Eigenvalues and proportion of variance explained for the correlation matrix of the ten habitat metrics.

	Eigenvalue	Proportion	Cumulative
PRIN1	3.864	0.386	0.386
PRIN2	2.207	0.221	0.607
PRIN3	1.429	0.143	0.750
PRIN4	0.712	0.071	0.821
PRIN5	0.575	0.058	0.879
PRIN6	0.425	0.043	0.921
PRIN7	0.342	0.034	0.956
PRIN8	0.251	0.025	0.981
PRIN9	0.133	0.013	0.994
PRIN10	0.061	0.006	1.000

Table 5. Eigenvectors for the three dominant factors of the correlation matrix of habitat metrics.

Metric	Factor 1	Factor 2	Factor 3
EPI SUB	0.419*	-0.122	-0.290
EMBEDDED	0.440*	-0.112	0.061
SED DEP	0.387*	0.039	0.246
BENRIFF	0.381*	-0.187	0.007
BANKSTAB	0.224	0.507*	-0.290
BANKVEG	0.261	0.535*	-0.057
RIPBUFF	0.052	0.544*	0.257
VEL DPTH	0.344+	-0.094	0.382*
CHAN ALT	-0.122	0.079	0.739*
CH FLOW	0.287	-0.287	0.074

* coefficients >= 0.35 for each factor
+ 0.30 < coefficients < 0.35 for each factor

Table 6. Correlation matrix for raw physical habitat metrics grouped by factors identified by the PCA. In the body of the table, the correlation coefficients are paired with the p-value for the null hypotheses that the correlation is 0.0.

	EPI SUB	EMBEDD	SED DEP	BENRIFF	BANKSTAB	BANKVEG	RIPBUFF	VEL DEPTH	CHAN ALT	CH FLOW	TOTAL
EPI SUB	1.000	0.649	0.378	0.699	0.347	0.285	0.139	0.501	-0.451	0.448	0.645
	0.0	0.002	0.101	0.001	0.134	0.223	0.559	0.025	0.046	0.048	0.002
EMBEDD	0.649	1.000	0.705	0.632	0.163	0.340	0.023	0.509	-0.171	0.542	0.747
	0.002	0.0	0.001	0.003	0.494	0.142	0.924	0.022	0.471	0.014	0.001
SED DEP	0.378	0.705	1.000	0.440	0.330	0.379	0.080	0.543	0.040	0.389	0.762
	0.100	0.001	0.0	0.052	0.155	0.099	0.736	0.013	0.868	0.090	0.0001
BENRIFF	0.699	0.632	0.440	1.000	0.135	0.110	0.096	0.518	-0.128	0.358	0.629
	0.001	0.003	0.052	0.0	0.570	0.643	0.688	0.019	0.589	0.121	0.003
BANKSTAB	0.347	0.163	0.330	0.135	1.000	0.812	0.447	0.023	-0.251	0.102	0.596
	0.134	0.494	0.155	0.570	0.0	0.0001	0.048	0.923	0.286	0.668	0.006
BANKVEG	0.285	0.340	0.379	0.110	0.812	1.000	0.624	0.190	-0.073	0.007	0.712
	0.223	0.142	0.099	0.643	0.0001	0.0	0.003	0.422	0.758	0.976	0.0004
RIPBUFF	-0.139	-0.023	0.080	0.096	0.447	0.624	1.000	0.106	0.256	0.160	0.404
	0.559	0.924	0.736	0.688	0.048	0.003	0.0	0.658	0.276	0.500	0.077
VEL DEPTH	0.501	0.509	0.543	0.518	0.023	0.190	0.106	1.000	0.141	0.356	0.646
	0.025	0.022	0.013	0.019	0.923	0.422	0.658	0.0	0.552	0.123	0.002
CHAN ALT	-0.451	-0.171	0.040	0.128	0.251	0.073	0.256	0.141	1.000	0.127	0.316
	0.046	0.471	0.868	0.589	0.286	0.758	0.276	0.552	0.0	0.594	0.895
CH FLOW	0.448	0.542	0.389	0.358	-0.102	0.007	0.160	0.356	-0.127	1.000	0.408
	0.048	0.014	0.090	0.121	0.668	0.976	0.500	0.123	0.594	0.0	0.074

Table 7. Correlation matrix for stream width, depth, velocity and canopy measurements against raw physical habitat metrics. In the body of the table, the top entry is the correlation coefficient and the bottom entry is the p-value for that correlation coefficient.

Metric	WIDTH	DEPTH	VELOC	CANOPY
EPI SUB	0.086	0.219	0.259	0.187
	0.717	0.353	0.269	0.431
EMBEDDED	-0.111	0.067	0.632	0.276
	0.642	0.778	0.003	0.239
VEL DPTH	-0.111	0.171	0.516	0.319
	0.641	0.470	0.020	0.171
SED DEP	-0.440	-0.184	0.532	0.127
	0.052	0.438	0.016	0.593
CH FLOW	0.109	0.217	0.172	0.324
	0.647	0.359	0.469	0.164
CHAN ALT	-0.152	0.071	0.053	-0.228
	0.522	0.765	0.825	0.334
BENRIFF	-0.059	-0.107	0.275	0.179
	0.805	0.653	0.242	0.450
BANKSTAB	-0.154	-0.110	0.140	-0.569
	0.516	0.643	0.557	0.009
BANKVEG	-0.140	-0.033	0.436	-0.352
	0.5578	0.889	0.054	0.129

Table 8. Spearman Rank Correlation Coefficients and significance levels for upstream-downstream trend in the physical habitat metrics and the total physical habitat index.

Metric	Arcade	Orestimba
EPI SUB	-0.159 0.661	0.105 0.774
EMBEDDED	0.073 0.841	-0.056 0.878
VEL DPTH	0.282 0.429	0.295 0.408
SED DEP	0.152 0.675	0.154 0.671
CH FLOW	-0.172 0.635	-0.782 0.008
CHAN ALT	0.791 0.006	-0.221 0.540
BENRIFF	0.043 0.907	0.006 0.987
BANKSTAB	-0.640 0.046	0.703 0.023
BANKVEG	-0.492 0.148	0.445 0.197
RIPBUFF	-0.360 0.307	0.202 0.576
TOTAL	-0.139 0.701	0.261 0.467

Table 9. Mean scores for each metric and the total for each creek with the p-value for comparing the means based on the Wilcoxon Rank-Sum Test.

	Mean for each creek		Wilcoxon test
Metric	Arcade	Orestimba	p-value
EPI SUB	8.10	11.70	0.1005
EMBEDDED	8.70	11.40	0.2094
VEL DPTH	9.80	12.10	0.1943
SED DEP	11.40	11.90	0.7613
CH FLOW	13.80	14.00	1.0000
CHAN ALT	12.70	15.70	0.5135
BENRIFF	10.10	12.70	0.3818
BANKSTAB	8.60	11.40	0.3814
BANKVEG	7.90	11.30	0.1466
RIPBUFF	9.80	10.10	1.0000
TOTAL	100.90	122.30	0.0640

Table 10. Total taxon abundance for benthic macroinvertebrates in Arcade Creek

Lowest Taxa	Total N	Total %	Cumulative %
Rheocricotopus sp.	3306	40.22	40.22
Naididae	1428	17.37	57.60
Undetermined Tubificidae	1402	17.06	74.66
Eukiefferiella sp.	738	8.98	83.64
Cricotopus sp.	664	8.08	91.71
Physa/ Physella	75	0.91	92.63
Simulium sp.	69	0.84	93.47
Dicrotendipes sp.	64	0.78	94.25
Megadrile	56	0.68	94.93
Undetermined Sphaeriidae	50	0.61	95.53
Corbicula fluminea	45	0.55	96.08
Undetermined Erpobdellidae	34	0.41	96.50
Pisidium sp.	25	0.30	96.80
Undetermined Orthocladiinae	21	0.26	97.06
Polypedilum sp.	18	0.22	97.27
Erpobdella punctata	17	0.21	97.48
Cricotopus trifascia gp.	15	0.18	97.66
Menetus opercularis	14	0.17	97.83
Undetermined Coenagrionidae	13	0.16	97.99
Limnophyes sp.	12	0.15	98.14
Ferrissia rivularis	11	0.13	98.27
Phaenopsectra sp.	11	0.13	98.41
Cricotopus bicinctus gp.	10	0.12	98.53
Daphniidae	10	0.12	98.65
Undetermined Simulidae	10	0.12	98.77

Table 10. - continued

Lowest Taxa	Total N	Total %	Cumulative %
Argia sp.	9	0.11	98.88
Hydropsyche californica	9	0.11	98.99
Cryptochironomus sp.	7	0.09	99.08
Nematoda	7	0.09	99.16
Fossaria sp.	6	0.07	99.23
Microtendipes sp.	5	0.06	99.28
Paratanytarsus sp.	5	0.06	99.36
Dugesia tigrina	4	0.05	99.40
Limonia sp.	4	0.05	99.45
Bezzia/ Palpomyia	3	0.04	99.49
Corynoneura sp.	3	0.04	99.53
Gyraulus parvus	3	0.04	99.56
Hydra sp.	3	0.04	99.60
Hydroptila sp.	3	0.04	99.63
Parachironomus sp.	3	0.04	99.57
Undetermined Ancylidae	3	0.04	99.71
Cyclopidae	2	0.02	99.73
Cyprididae	2	0.02	99.76
Ephydridae	2	0.02	99.78
Ischnura sp.	2	0.02	99.81
Undetermined Lymnaeidae	2	0.02	99.83
Argia vivida	1	0.01	99.84
Branchiura sowerbyi	1	0.01	99.85
Enallagma sp.	1	0.01	99.87
Helophorus sp.	1	0.01	99.88
Macropelopiini	1	0.01	99.89

Table 10. - continued

Lowest Taxa	**Total N**	**Total %**	**Cumulative %**
Odontomyia sp.	1	0.01	99.90
Pericoma/ Telmatoscopus	1	0.01	99.91
Planorbula sp.	1	0.01	99.93
Pseudochironomus sp.	1	0.01	99.94
Thienemanniella sp.	1	0.01	99.95
Tipula sp.	1	0.01	99.96
Undetermined Hemiptera	1	0.01	99.98
Undetermined Tanytarsini	1	0.01	99.99
Undetermined Tipulidae	1	0.01	100

Table 11. Benthic metrics by transect (including the means) for the 10 Arcade Creek sites

	ARC 1					ARC 2					ARC 3					ARC 4					ARC 5				
Transect Number:	T1	T2	T3	Mean	CV	T1	T2	T3	Mean	CV	T1	T2	T3	Mean	CV	T1	T2	T3	Mean	CV	T1	T2	T3	Mean	CV
Taxonomic Richness	20	15	12	16	26	12	13	11	12	8	10	17	14	14	26	14	11	14	13	13	10	18	11	13	34
Cumulative Taxa				26					19					23					23					23	
Percent Dominant Taxon	52	43	50	48	10	44	51	55	50	11	70	49	63	61	18	41	40	52	45	15	48	45	54	49	9
Ephemeroptera Taxa	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-
Plecoptera Taxa	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-
Trichoptera Taxa	0	0	0	0	-	2	0	1	1	100	0	0	0	0	-	1	1	1	1	0	0	1	0	0	173
EPT Taxa	0	0	0	0	-	2	0	1	1	100	0	0	0	0	-	1	1	1	1	0	0	1	0	0	173
Cumulative EPT Taxa				0					2					0					1					1	
EPT Index (%)	0	0	0	0	-	1	0	0	0	100	0	0	0	0	-	1	0	0	1	83	0	1	0	0	173
Sensitive EPT Index (%)	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-
Shannon Diversity	1.8	1.8	1.7	1.7	3	1.5	1.5	1.1	1.3	18	1.1	1.6	1.3	1.3	17	1.5	1.4	1.4	1.4	2	1.4	1.7	1.4	1.5	12
Tolerance Value	8.2	7.7	8.2	8.0	4	7.7	7.4	7.2	7.4	3	6.5	7.0	6.6	6.7	4	6.9	7.0	6.8	6.9	2	7.8	7.0	7.0	7.3	7
Percent Intolerant Taxa (0-2)	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-
Percent Tolerant Taxa (8-10)	78	69	78	75	7	72	61	59	64	11	21	43	27	31	36	26	29	23	26	10	69	43	40	51	31
Percent Collectors	81	77	76	78	4	94	88	94	92	4	91	91	89	90	1	52	56	75	61	21	97	90	94	94	4
Percent Filterers	0	2	3	2	81	1	0	0	1	85	7	4	7	6	34	5	3	1	3	76	0	4	1	2	135
Percent Grazers	4	4	10	6	61	1	0	1	1	100	1	3	0	1	99	2	0	0	1	96	0	2	1	1	63
Percent Predators	5	2	1	3	87	0	1	1	1	103	0	2	2	1	88	0	0	2	1	127	0	2	0	1	138
Percent Shredders	10	15	10	12	25	4	10	4	6	61	0	1	1	1	46	41	41	22	35	32	2	2	4	3	40
Abundance (#/ sample)	467	670	183	440	56	6549	5562	27508	13206	94	1239	1242	1025	1169	11	746	704	427	626	28	1336	830	815	994	30

Table 11. - continued

Transect Number:	ARC 6 T1	T2	T3	Mean	CV	ARC 7 T1	T2	T3	Mean	CV	ARC 8 T1	T2	T3	Mean	CV	ARC 9 T1	T2	T3	Mean	CV	ARC 10 T1	T2	T3	Mean	CV
Taxonomic Richness	13	8	13	11	25	11	11	13	12	10	16	14	10	13	23	16	15	18	16	9	8	10	11	10	16
Cumulative Taxa				20					19					19					30					14	
Percent Dominant Taxon	51	43	48	48	9	52	61	54	56	9	21	58	48	43	45	58	57	66	60	8	68	50	55	58	16
Ephemeroptera Taxa	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-
Plecoptera Taxa	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-
Trichoptera Taxa	0	0	0	0	-	0	0	1	0	173	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-
EPT Taxa	0	0	0	0	-	0	0	1	0	173	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-
Cumulative EPT Taxa				0					1					0					0					0	
EPT Index (%)	0	0	0	0	-	0	0	0	0	173	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-
Sensitive EPT Index (%)	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-
Shannon Diversity	1.5	1.2	1.4	1.4	9	1.5	1.3	1.4	1.4	4	2.3	1.5	1.5	1.8	25	1.4	1.5	1.3	1.4	4	1.0	1.4	1.4	1.2	16
Tolerance Value	7.0	7.2	7.0	7.1	1	6.8	6.8	6.8	6.8	0	7.7	8.4	8.1	8.1	4	6.9	7.0	6.8	6.9	2	6.7	7.2	6.9	6.9	3
Percent Intolerant Taxa (0-2)	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-
Percent Tolerant Taxa (8-10)	43	55	47	48	12	30	32	33	32	4	62	84	75	74	15	37	40	28	35	17	31	49	41	40	22
Percent Collectors	93	99	98	97	3	81	92	87	87	6	51	86	84	74	27	92	86	84	87	5	99	96	98	98	2
Percent Filterers	2	0	1	1	100	0	4	0	2	134	4	2	0	2	112	3	11	11	8	53	0	3	2	2	82
Percent Grazers	0	0	1	0	173	0	0	0	0	173	13	2	0	5	129	1	1	2	1	58	0	0	0	0	-
Percent Predators	0	0	0	0	87	2	0	1	1	115	11	1	2	5	115	1	0	0	0	44	0	0	0	0	87
Percent Shredders	4	0	1	2	125	16	4	11	11	55	21	9	13	15	42	3	1	3	2	35	0	0	0	0	7
Abundance (#/ sample)	1102	3798	617	1839	93	1474	179	1953	1202	76	584	1404	3674	1887	85	1200	432	731	788	49	2991	1801	537	1776	69

Table 12. Total taxon abundance for benthic macroinvertebrates in Orestimba Creek

Lowest Taxa	Total N	Total %	Cumulative %
Naididae	1586	29.35	29.35
Undetermined Tubificidae	550	10.18	39.53
Cricotopus bicinctus gp.	474	8.77	48.30
Cricotopus sp.	358	6.62	54.92
Prostoma sp.	213	3.94	58.86
Undetermined Oligochaeta	201	3.72	62.58
Physa/ Physella	183	3.39	65.97
Gammarus lacustris	152	2.81	68.78
Megadrile	137	2.54	71.32
Corbicula fluminea	122	2.26	73.58
Nematoda	107	1.98	75.56
Pseudochironomus sp.	107	1.98	77.54
Torrenticola/ Psuedotorrenticola	92	1.70	79.24
Rheotanytarsus sp.	89	1.65	80.88
Fallceon quilleri	85	1.57	82.46
Corynoneura sp.	64	1.18	83.64
Dicrotendipes sp.	64	1.18	84.83
Hydra sp.	57	1.05	85.88
Sperchon/ Sperchonopsis	48	0.89	86.77
Eukiefferiella sp.	41	0.76	87.53
Undetermined Erpobdellidae	41	0.76	88.29
Dugesia tigrina	38	0.70	88.99
Simulium sp.	34	0.63	89.62
Enchytraeidae	32	0.59	90.21
Fossaria sp.	30	0.56	90.77

Table 12. - continued

Lowest Taxa	Total N	Total %	Cumulative %
Undetermined Orthocladiinae	29	0.54	91.30
Manayunkia speciosa	27	0.50	91.80
Hemerodromia sp.	26	0.48	92.28
Paratanytarsus sp.	22	0.41	92.69
Parachironomus sp.	20	0.37	93.06
Thienemanniella sp.	20	0.37	93.43
Cyprididae	19	0.35	93.78
Rheocricotopus sp.	19	0.35	94.13
Centroptilum/ Procloeon	18	0.33	94.47
Cricotopus trifascia gp.	17	0.31	94.78
Oxyethira sp.	16	0.30	95.08
Undetermined Tipulidae	14	0.26	95.34
Baetis tricaudatus	13	0.24	95.58
Hydroptila sp.	13	0.24	95.82
Tricorythodes sp.	13	0.24	96.06
Bezzia/ Palpomyia	12	0.22	96.28
Nanocladius sp.	12	0.22	96.50
Tanytarsus sp.	11	0.20	96.71
Undetermined Hydrophilidae	11	0.20	96.91
Corisella decolor	10	0.19	97.09
Polypedilum sp.	10	0.19	97.28
Cricotopus/ Orthocladius	9	0.17	97.45
Odontomyia sp.	9	0.17	97.61
Hexatoma sp.	7	0.13	97.74
Peltodytes sp.	7	0.13	97.87
Branchiura sowerbyi	6	0.11	97.98

Table 12. - continued

Lowest Taxa	Total N	Total %	Cumulative %
Erioptera sp.	6	0.11	98.09
Caecidota occidentalis	5	0.09	98.19
Caenis sp.	5	0.09	98.28
Enochrus sp.	5	0.09	98.37
Erpobdella punctata	5	0.09	98.46
Eudistylia vancouveri	5	0.09	98.56
Hedriodiscus/ Odontomyia	5	0.09	98.65
Nebrioporus/ Stictotarsus	5	0.09	98.74
Planorbula sp.	5	0.09	98.83
Undetermined Empididae	5	0.09	98.93
Menetus opercularis	4	0.07	99.00
Micropsectra sp.	4	0.07	99.07
Acentrella sp.	3	0.06	99.13
Cyclopidae	3	0.06	99.19
Gyraulus parvus	3	0.06	99.24
Helisoma anceps	3	0.06	99.30
Undetermined Hemiptera	3	0.06	99.35
Acentrella insignificans	2	0.04	99.39
Euparyphus sp.	2	0.04	99.43
Hygrobatidae	2	0.04	99.46
Temoridae	2	0.04	99.50
Undetermined Coleoptera	2	0.04	99.54
Ambrysus mormon	1	0.02	99.56
Chironomus sp.	1	0.02	99.57
Cladotanytarsini sp.	1	0.02	99.59
Glyptotendipes sp.	1	0.02	99.61

Table 12. - continued

Lowest Taxa	Total N	Total %	Cumulative %
Hydrobiidae	1	0.02	99.63
Lebertia/ Scutolebertia	1	0.02	99.65
Leucrocuta sp.	1	0.02	99.67
Libellulidae	1	0.02	99.69
Limnophyes sp.	1	0.02	99.70
Limonia sp.	1	0.02	99.72
Microtendipes sp.	1	0.02	99.74
Neomysis mercedis	1	0.02	99.76
Odontomesa sp.	1	0.02	99.78
Oreodytes sp.	1	0.02	99.80
Paracymus sp.	1	0.02	99.81
Parametriocnemus sp.	1	0.02	99.83
Pentaneura sp.	1	0.02	99.85
Pentaneurini	1	0.02	99.87
Pericoma/ Telmatoscopus	1	0.02	99.89
Phaenopsectra sp.	1	0.02	99.91
Sigara vallis	1	0.02	99.93
Tropisternus sp.	1	0.02	99.94
Undetermined Lymnaeidae	1	0.02	99.96
Undetermined Planorbidae	1	0.02	99.98
Undetermined Tanytarsini	1	0.02	100
	5404		

Table 13. Benthic metrics by transect (including the means) for the 10 Orestimba Creek sites.

	ORE 1					ORE 2					ORE 3					ORE 4					ORE 5				
Transect Number:	T1	T2	T3	Mean	CV	T1	T2	T3	Mean	CV	T1	T2	T3	Mean	CV	T1	T2	T3	Mean	CV	T1	T2	T3	Mean	CV
Taxonomic Richness	19	13	10	14	33	9	14	20	14	38	16	16	22	18	19	23	15	22	20	22	14	19	11	15	28
Cumulative Taxa	-	-	-	27		-	-	-	25					25					25					23	
Percent Dominant Taxon	52	46	71	56	24	81	32	42	52	50	38	35	71	48	41	61	40	46	49	21	50	27	29	35	36
Ephemeroptera Taxa	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-
Plecoptera Taxa	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-
Trichoptera Taxa	0	0	0	0	-	0	0	0	0	-	1	0	1	1	87	0	0	0	0	-	0	1	1	1	87
EPT Taxa	0	0	0	0	-	0	0	0	0	-	1	0	1	1	87	0	0	0	0	-	0	1	1	1	87
Cumulative EPT Taxa				0					0					0					0					1	
EPT Index (%)	0	0	0	0	-	0	0	0	0	-	1	0	0	1	124	0	0	0	0	-	0	1	1	1	88
Sensitive EPT Index (%)	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-
Shannon Diversity	1.7	1.5	1.1	1.4	20	0.8	2.0	2.0	1.6	42	1.9	2.1	1.4	1.8	22	1.8	2.0	2.1	2.0	8	1.8	2.4	1.9	2.0	15
Tolerance Value	7.7	8.5	8.0	8.1	5	8.8	7.7	7.9	8.1	7	6.9	7.3	7.1	7.1	3	7.6	6.4	7.0	7.0	8	6.9	7.1	6.3	6.8	6
Percent Intolerant Taxa (0-2)	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-
Percent Tolerant Taxa (8-10)	80	90	89	87	6	93	75	78	82	12	53	58	76	63	19	77	54	63	65	17	65	65	43	57	22
Percent Collectors	85	91	92	90	4	92	83	86	87	5	81	77	86	81	5	83	61	68	71	15	79	66	64	70	12
Percent Filterers	3	3	0	2	88	5	6	2	5	40	11	14	1	9	74	5	17	13	12	50	6	17	25	16	58
Percent Grazers	1	1	0	1	93	0	2	3	2	94	1	1	0	1	56	2	6	9	5	67	10	5	1	5	77
Percent Predators	9	4	5	6	41	1	9	7	6	73	7	3	10	7	47	4	14	8	9	58	5	5	1	4	57
Percent Shredders	2	0	3	2	90	1	0	1	1	87	0	5	2	2	97	7	2	2	4	71	0	6	8	5	88
Abundance (#/ sample)	143	90	101	111	25	91	53	164	103	55	73	88	305	155	84	132	181	229	181	27	62	94	75	77	21

Table 13. - continued

Transect Number:	ORE 6 T1	ORE 6 T2	ORE 6 T3	ORE 6 Mean	ORE 6 CV	ORE 7 T1	ORE 7 T2	ORE 7 T3	ORE 7 Mean	ORE 7 CV	ORE 8 T1	ORE 8 T2	ORE 8 T3	ORE 8 Mean	ORE 8 CV	ORE 9 T1	ORE 9 T2	ORE 9 T3	ORE 9 Mean	ORE 9 CV	ORE 10 T1	ORE 10 T2	ORE 10 T3	ORE 10 Mean	ORE 10 CV
Taxonomic Richness	17	20	16	18	12	5	3	18	9	94	19	18	19	19	3	13	13	9	12	20	36	38	33	36	7
Cumulative Taxa				23					19					28					22					52	
Percent Dominant Taxon	28	27	50	35	38	67	92	37	65	42	26	37	40	34	23	50	34	70	52	34	19	13	15	16	21
Ephemeroptera Taxa	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	6	7	5	6	17
Plecoptera Taxa	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-
Trichoptera Taxa	1	1	0	1	87	0	0	0	0	-	1	1	0	1	87	0	0	0	0	-	1	1	0	1	87
EPT Taxa	1	1	0	1	87	0	0	0	0	-	1	1	0	1	87	0	0	0	0	-	7	8	5	7	23
Cumulative EPT Taxa				1					0					1					0					9	
EPT Index (%)	1	2	0	1	92	0	0	0	0	-	1	0	0	0	101	0	0	0	0	-	16	16	22	18	18
Sensitive EPT Index (%)	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	7	4	2	4	62
Shannon Diversity	2.2	2.1	1.6	2.0	15	1.1	0.3	1.9	1.1	73	2.1	1.9	2.1	2.0	5	1.6	1.9	1.1	1.5	25	2.9	2.9	2.9	2.9	2
Tolerance Value	6.4	6.5	6.9	6.6	4	5.3	4.4	5.5	5.1	12	6.0	6.8	6.8	6.5	7	8.4	7.3	5.3	7.0	22	6.0	6.0	5.7	5.9	2
Percent Intolerant Taxa (0-2)	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	5	1	3	3	59
Percent Tolerant Taxa (8-10)	19	37	56	37	49	24	8	39	24	67	20	43	55	40	45	85	74	14	57	66	22	15	7	15	50
Percent Collectors	70	61	82	71	15	76	92	86	85	10	75	71	66	71	6	78	71	79	76	6	63	58	53	58	8
Percent Filterers	3	2	1	2	57	14	4	2	7	99	2	6	2	3	64	0	0	1	0	43	10	16	21	16	34
Percent Grazers	2	3	0	2	76	0	4	1	2	124	1	2	9	4	110	11	20	11	14	37	3	1	2	2	51
Percent Predators	2	8	10	7	59	10	0	9	6	87	2	5	9	5	63	7	4	4	5	25	16	18	17	17	7
Percent Shredders	22	26	7	18	56	0	0	2	1	173	20	16	14	17	19	4	5	5	5	15	8	7	7	7	13
Abundance (#/ sample)	88	386	1968	814	124	21	26	102	50	91	759	1411	3974	2048	83	537	467	730	578	24	5168	4916	7926	6003	28

Table 14. Spearman Rank Correlation Coefficients and significance levels for upstream-downstream trend in the benthic metrics.

Metric	Creek	
	Arcade	Orestimba
Abundance (#/ sample)	0.2485	0.5636
	0.4888	0.0897
EPT Index (%)	-0.4179	0.4152
	0.2295	0.2383
EPT Taxa	-0.3578	0.4221
	0.3100	0.2243
Ephemeroptera Taxa	.	0.5222
	.	0.1215
Percent Collectors	0.2364	-0.6261
	0.5109	0.0528
Percent Dominant Taxon	0.1515	-0.5030
	0.6761	0.1383
Percent Filterers	0.2147	0.0122
	0.5513	0.9734
Percent Grazers	-0.3669	0.5601
	0.2969	0.0922
Percent Intolerant Taxa (0-2)	.	0.5222
	.	0.1215
Percent Predators	-0.4247	0.0365
	0.2212	0.9203
Percent Shredders	-0.3212	0.5976
	0.3655	0.0681
Percent Tolerant Taxa (8-10)	-0.2000	-0.8572
	0.5796	0.0015

Table 14. - continued

Metric	Creek: Arcade	Creek: Orestimba
Plecoptera Taxa	.	.
	.	.
Sensitive EPT Index (%)	.	0.5222
	.	0.1215
Shannon Diversity	-0.1951	0.3903
	0.5890	0.2645
Taxonomic Richness	-0.2796	0.1879
	0.4339	0.6032
Tolerance Value	-0.1702	-0.7903
	0.6383	0.0065
Trichoptera Taxa	-0.3578	0.3133
	0.3100	0.3780

Table 15. Mean scores for each metric and the total for each creek with the p-value for comparing the means based on the Wilcoxon Rank-Sum Test.

Metric	Mean for each Creek		
	Arcade	Orestimba	p-value
Abundance (#/ sample)	2392.67	1012.00	0.0376
EPT Index (%)	0.10	2.03	0.2278
EPT Taxa	0.27	0.93	0.5887
Ephemeroptera Taxa	0.00	0.60	0.3681
Percent Collectors	85.70	75.83	0.0311
Percent Dominant Taxon	51.57	44.20	0.3256
Percent Filterers	2.70	7.07	0.0337
Percent Grazers	1.63	3.73	0.0525
Percent Intolerant Taxa (0-2)	0.00	0.30	0.3681
Percent Predators	1.20	7.10	0.0002
Percent Shredders	8.43	6.07	0.9095
Percent Tolerant Taxa (8-10)	47.50	52.57	0.6230
Plecoptera Taxa	0.00	0.00	1.0000
Sensitive EPT Index (%)	0.00	0.43	0.3681
Shannon Diversity	1.46	1.84	0.0139
Taxonomic Richness	12.97	17.33	0.0492
Tolerance Value	7.21	6.82	0.3071
Trichoptera Taxa	0.27	0.33	0.7068

Table 16. Spearman Rank Correlation Analysis of benthic metrics vs. habitat metrics. For each benthic metric, there are two rows. The first row shows the Spearman Correlation Coefficient and the second row shows the p-value for the correlation coefficient.

	Habitat Metric										
Benthic Metric	BANKSTAB	BANKVEG	BENRIFF	CHANALT	CHFLOW	EMBEDDED	EPISUB	RIPBUFF	SEDDEP	TOTAL	VELDPTH
MET01	0.2120	-0.1907	0.0643	-0.1346	-0.1996	-0.1899	-0.0023	-0.2169	0.1949	-0.1203	-0.2103
Abundance (#/sample)	0.3696	0.4205	0.7877	0.5716	0.3989	0.4225	0.9924	0.3583	0.4103	0.6134	0.3734
MET02	0.5116	0.5322	0.5104	-0.0723	0.2071	0.2919	0.3222	0.1145	0.3249	0.5861	0.4210
EPT Index (%)	0.0211	0.0157	0.0215	0.7619	0.3809	0.2117	0.1660	0.6307	0.1621	0.0066	0.0645
MET03	0.4174	0.3739	0.5062	-0.0993	0.1656	0.3119	0.2166	0.0042	0.3433	0.4725	0.2670
EPT Taxa	0.0671	0.1044	0.0228	0.6770	0.4854	0.1807	0.3590	0.9861	0.1384	0.0354	0.2551
MET04	0.1602	-0.1206	0.2202	0.3844	-0.3143	-0.1802	0.0201	-0.3010	-0.0600	-0.0199	0.1808
Ephemeroptera Taxa	0.4998	0.6124	0.3510	0.0943	0.1772	0.4471	0.9330	0.1972	0.8018	0.9337	0.4455
MET05	-0.3639	-0.3927	-0.0310	-0.0161	0.3058	-0.1737	-0.0650	-0.2219	-0.1968	-0.3212	-0.4281
Percent Collectors	0.1148	0.0868	0.8967	0.9464	0.1898	0.4638	0.7854	0.3470	0.4056	0.1674	0.0597
MET06	-0.5373	-0.4592	-0.2686	0.1136	0.1129	-0.0727	-0.1167	-0.3342	-0.2837	-0.4235	-0.3483
Percent Dominant Taxon	0.0146	0.0417	0.2521	0.6335	0.6356	0.7608	0.6242	0.1498	0.2254	0.0628	0.1324
MET07	-0.1196	-0.0530	0.3203	0.2160	-0.0465	0.0843	0.2726	-0.2264	0.0527	0.1147	0.5471
Percent Filterers	0.6154	0.8244	0.1686	0.3604	0.8457	0.7239	0.2449	0.3371	0.8255	0.6302	0.0126
MET08	0.5385	0.4729	-0.1808	-0.1008	-0.3984	0.0160	0.2118	0.4537	-0.0110	0.2859	0.2147
Percent Grazers	0.0143	0.0352	0.4457	0.6725	0.0819	0.9467	0.3701	0.0445	0.9632	0.2217	0.3634
MET09	0.1602	-0.1206	0.2202	0.3844	-0.3143	-0.1802	0.0201	-0.3010	0.0600	-0.0199	0.1808
Percent Intolerant Taxa	0.4998	0.6124	0.3510	0.0943	0.1772	0.4471	0.9330	0.1972	0.8018	0.9337	0.4455

Table 16. - continued

	Habitat Metric										
Benthic Metric	BANKSTAB	BANKVEG	BENRIFF	CHANALT	CHFLOW	EMBEDDED	EPISUB	RIPBUFF	SEDDEP	TOTAL	VELDPTH
MET10	0.2652	0.2361	-0.0588	0.1560	-0.1532	0.1096	0.1771	-0.2250	-0.1049	0.2140	0.1347
Percent Predators	0.2585	0.3163	0.8056	0.5115	0.5191	0.6455	0.4551	0.3402	0.6600	0.3649	0.5712
MET11	0.5230	0.4415	-0.1828	-0.2158	-0.2449	-0.0326	-0.2099	0.3783	0.1867	0.1885	0.0811
Percent Shredders	0.0180	0.0513	0.4405	0.3608	0.2979	0.8914	0.3744	0.1000	0.4307	0.4262	0.7340
MET12	0.1113	0.0540	-0.0961	0.0719	0.2693	0.0117	0.0574	0.2155	-0.0151	0.0730	-0.3301
Percent Tolerant Taxa	0.6403	0.8212	0.6869	0.7632	0.2508	0.9608	0.8101	0.3616	0.9496	0.7598	0.1553
MET13	.	.	.	.	.	.	.	.	.	.	.
Plecoptera Taxa	.	.	.	.	.	.	.	.	.	.	.
MET14	0.1602	-0.1206	0.2202	0.3844	-0.3143	-0.1802	0.0201	-0.3010	-0.0600	-0.0199	0.1808
Sensitive EPT Index (%)	0.4998	0.6124	0.3510	0.0943	0.1772	0.4471	0.9330	0.1972	0.8018	0.9337	0.4455
MET15	0.4830	0.3980	0.1614	0.1195	-0.1642	-0.0030	0.2051	0.2640	0.0450	0.3886	0.3183
Shannon Diversity	0.0310	0.0822	0.4967	0.6159	0.4892	0.9899	0.3857	0.2608	0.8506	0.0904	0.1715
MET16	0.3057	0.0643	0.1442	0.0551	-0.0741	-0.1113	0.2350	-0.0247	-0.1357	0.1264	0.2960
Taxonomic Richness	0.1900	0.7878	0.5441	0.8175	0.7562	0.6403	0.3186	0.9178	0.5684	0.5954	0.2051
MET17	-0.0625	-0.1608	-0.1030	0.1779	0.3784	-0.0428	-0.1951	0.1408	0.0314	-0.1061	-0.4001
Tolerance Value	0.7935	0.4981	0.6658	0.4530	0.0999	0.8578	0.4099	0.5538	0.8956	0.6562	0.0805
MET18	0.4160	0.4209	0.5006	-0.1906	0.2469	0.3815	0.2340	0.0646	0.3875	0.5104	0.2515
Trichoptera Taxa	0.0681	0.0646	0.0246	0.4208	0.2940	0.0969	0.3207	0.7868	0.0914	0.0215	0.2849

Table 17. Range of chlorpyrifos and diazinon concentrations measured historically in Orestimba and Arcade Creeks.

OP Insecticide	Location	Range Conc (ng/L)	Years	Reference
Chlorpyrifos	Orestimba Creek	0 - 2,282	1996/97	Poletika and Robb, 1998
Chlorpyrifos	Arcade Creek	4 - 100	1993-99	Tomko, 1999
Diazinon	Orestimba Creek	0 - 29,371	1996/97	Poletika and Robb, 1998
Diazinon	Arcade Creek	50 - 1,380	1993-99	Tomko, 1999

Table 18. Comparison of resident benthic species by site in Arcade and Orestimba Creek with acute chlorpyrifos toxicity data from Giesy et al. 1999.

Species	Collection Site	Abundance	EC or LC50 Values (μg/L)
Dugesia tigrina	ORE 3	15	2.0-4.3[A]
Dugesia tigrina	ORE 4	4	2.0-4.3[A]
Dugesia tigrina	ORE 5	1	2.0-4.3[A]
Dugesia tigrina	ORE 6	4	2.0-4.3[A]
Dugesia tigrina	ORE 7	3	2.0-4.3[A]
Dugesia tigrina	ORE 8	7	2.0-4.3[A]
Dugesia tigrina	ORE 9	4	2.0-4.3[A]
Dugesia tigrina	ARC 4	1	2.0-4.3[A]
Dugesia tigrina	ARC 8	1	2.0-4.3[A]
Dugesia tigrina	ARC 9	1	2.0-4.3[A]
Dugesia tigrina	ARC 10	1	2.0-4.3[A]
Gammarus lacustris	ORE 4	1	0.11[B]
Gammarus lacustris	ORE 5	1	0.11[B]
Gammarus lacustris	ORE 6	20	0.11[B]
Gammarus lacustris	ORE 7	76	0.11[B]
Gammarus lacustris	ORE 8	54	0.11[B]
Daphniidae	ARC 1	9	0.21[C]
Daphniidae	ARC 2	1	0.21[C]
Neomysis mercedis	ORE 1	1	0.14-0.16
Simulium sp.	ORE 2	1	27[D]
Simulium sp.	ORE 10	33	27[D]
Simulium sp.	ARC 3	44	27[D]
Simulium sp.	ARC 4	13	27[D]
Simulium sp.	ARC 5	8	27[D]
Simulium sp.	ARC 6	2	27[D]

Table 18. - continued

Simulium sp.	ARC 9	2	27[D]
Hydropsyche californica	ARC 2	1	30.6[E]
Hydropsyche californica	ARC 4	6	30.6[E]
Hydropsyche californica	ARC 5	2	30.6[E]
Paratanytarsus sp.	ORE 1	2	<1.6
Paratanytarsus sp.	ORE 2	4	<1.6
Paratanytarsus sp.	ORE 3	4	<1.6
Paratanytarsus sp.	ORE 6	4	<1.6
Paratanytarsus sp.	ORE 8	4	<1.6
Paratanytarsus sp.	ORE 10	3	<1.6
Paratanytarsus sp.	ARC 1	4	<1.6
Paratanytarsus sp.	ARC 9	1	<1.6
Caenis sp.	ORE 10	5	>3[F]
Chironomus sp.	ORE 10	1	0.07[G]
Cricotopus sp.	ORE 1	1	3.5-9.0
Cricotopus sp.	ORE 2	3	3.5-9.0
Cricotopus sp.	ORE 3	6	3.5-9.0
Cricotopus sp.	ORE 4	10	3.5-9.0
Cricotopus sp.	ORE 5	11	3.5-9.0
Cricotopus sp.	ORE 6	108	3.5-9.0
Cricotopus sp.	ORE 7	2	3.5-9.0
Cricotopus sp.	ORE 8	144	3.5-9.0
Cricotopus sp.	ORE 9	25	3.5-9.0
Cricotopus sp.	ORE 10	48	3.5-9.0
Cricotopus sp.	ARC 1	77	3.5-9.0
Cricotopus sp.	ARC 2	37	3.5-9.0
Cricotopus sp.	ARC 3	2	3.5-9.0
Cricotopus sp.	ARC 4	287	3.5-9.0

Table 18. - continued

Cricotopus sp.	ARC 5	18	3.5-9.0
Cricotopus sp.	ARC 6	14	3.5-9.0
Cricotopus sp.	ARC 7	87	3.5-9.0
Cricotopus sp.	ARC 8	128	3.5-9.0
Cricotopus sp.	ARC 9	12	3.5-9.0
Cricotopus sp.	ARC 10	2	3.5-9.0
Dicrotendipes sp.	ORE 1	2	7-40[H]
Dicrotendipes sp.	ORE 2	3	7-40[H]
Dicrotendipes sp.	ORE 3	1	7-40[H]
Dicrotendipes sp.	ORE 4	1	7-40[H]
Dicrotendipes sp.	ORE 6	3	7-40[H]
Dicrotendipes sp.	ORE 8	6	7-40[H]
Dicrotendipes sp.	ORE 9	1	7-40[H]
Dicrotendipes sp.	ORE 10	47	7-40[H]
Dicrotendipes sp.	ARC 1	40	7-40[H]
Dicrotendipes sp.	ARC 2	8	7-40[H]
Dicrotendipes sp.	ARC 3	1	7-40[H]
Dicrotendipes sp.	ARC 4	1	7-40[H]
Dicrotendipes sp.	ARC 6	2	7-40[H]
Dicrotendipes sp.	ARC 7	6	7-40[H]
Dicrotendipes sp.	ARC 8	4	7-40[H]
Dicrotendipes sp.	ARC 9	2	7-40[H]

[A] Listed toxicity value was for *Dugesia dorotocephala*.
[B] 2 values listed for this species, used conservative value, other value = 0.76 µg/L.
[C] Several genera listed, toxicity value used was for *Daphnia pulex*.
[D] Listed toxicity value was for *Simulium vitattum*.
[E] Listed toxicity value was for *Hydropsyche/Cheumatopsyche sp.*
[F] Listed toxicity value was for *Caenis horaria*.
[G] Listed toxicity value was for *Chironomus tentans*.
[H] Listed toxicity value was for *Dicrotendipes californicus*.

Table 19. Comparison of resident benthic species by site in Arcade and Orestimba Creek with acute diazinon toxicity data from Giddings et al. 2000.

Species	Collection Site	Abundance	EC or LC50 Values (µg/L)
Gammarus lacustris	ORE 4	1	184
Gammarus lacustris	ORE 5	1	184
Gammarus lacustris	ORE 6	20	184
Gammarus lacustris	ORE 7	76	184
Gammarus lacustris	ORE 8	54	184
Daphniidae	ARC 1	9	0.78[A]
Daphniidae	ARC 2	1	0.78[A]
Daphniidae	ARC 1	9	1.02[B]
Daphniidae	ARC 2	1	1.02[B]
Neomysis mercedis	ORE 1	1	4.15
Baetis tricaudatus	ORE 10	13	24[C]
Physa/ Physella	ORE 1	1	48[D]
Physa/ Physella	ORE 2	4	48[D]
Physa/ Physella	ORE 3	1	48[D]
Physa/ Physella	ORE 4	7	48[D]
Physa/ Physella	ORE 5	5	48[D]
Physa/ Physella	ORE 6	6	48[D]
Physa/ Physella	ORE 7	1	48[D]
Physa/ Physella	ORE 8	42	48[D]
Physa/ Physella	ORE 9	116	48[D]
Physa/ Physella	ARC 1	34	48[D]
Physa/ Physella	ARC 3	2	48[D]
Physa/ Physella	ARC 4	2	48[D]
Physa/ Physella	ARC 5	1	48[D]
Physa/ Physella	ARC 8	34	48[D]
Physa/ Physella	ARC 9	2	48[D]

Table 19. - continued

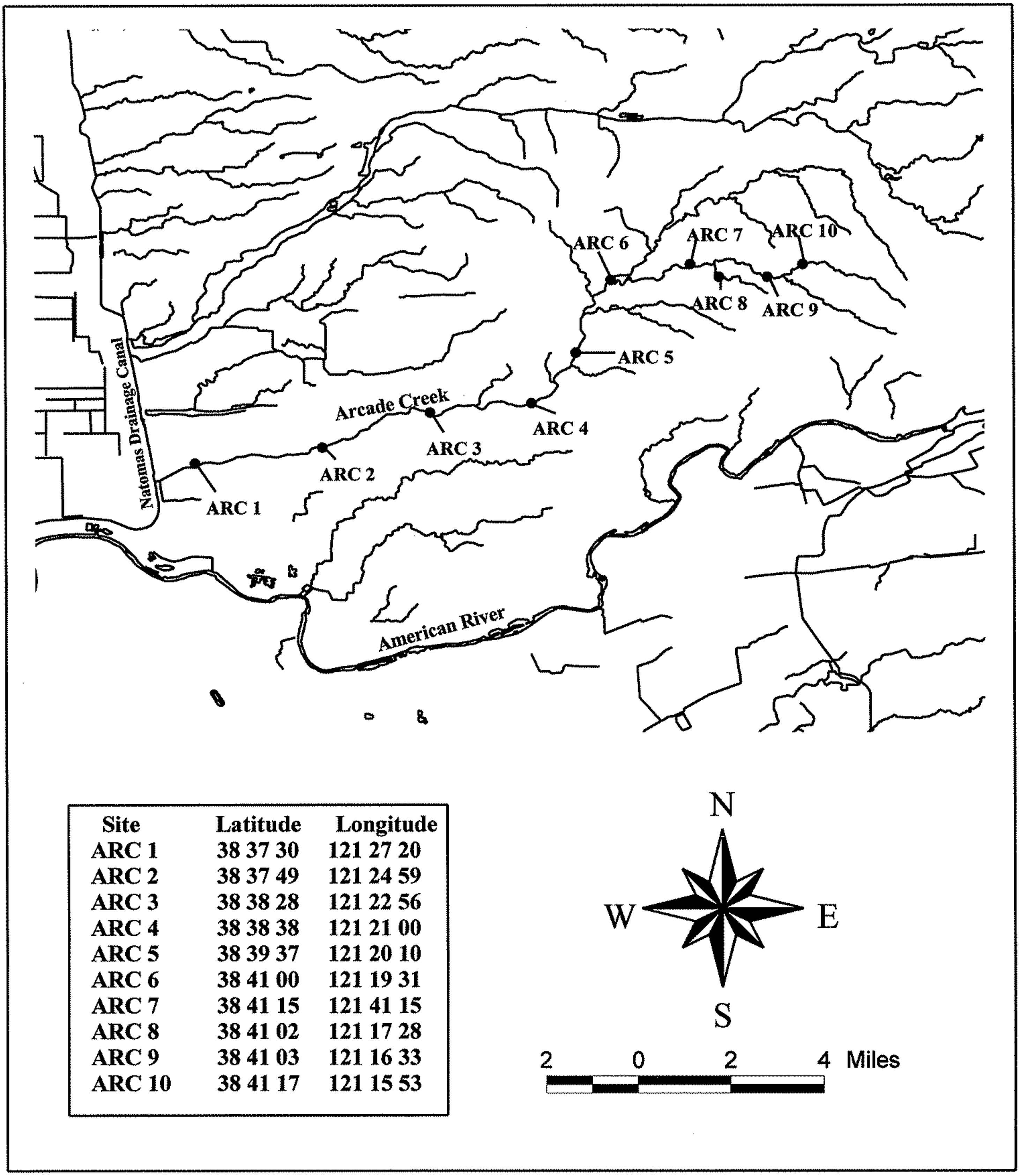
Physa/ Physella	ORE 1	1	4800[E]
Physa/ Physella	ORE 2	4	4800[E]
Physa/ Physella	ORE 3	1	4800[E]
Physa/ Physella	ORE 4	7	4800[E]
Physa/ Physella	ORE 5	5	4800[E]
Physa/ Physella	ORE 6	6	4800[E]
Physa/ Physella	ORE 7	1	4800[E]
Physa/ Physella	ORE 8	42	4800[E]
Physa/ Physella	ORE 9	116	4800[E]
Physa/ Physella	ARC 1	34	4800[E]
Physa/ Physella	ARC 3	2	4800[E]
Physa/ Physella	ARC 4	2	4800[E]
Physa/ Physella	ARC 5	1	4800[E]
Physa/ Physella	ARC 8	34	4800[E]
Physa/ Physella	ARC 9	2	4800[E]
Helisoma anceps	ORE 10	3	528[F]
Undetermined Tubificidae	ORE 1	85	3160[G]
Undetermined Tubificidae	ORE 2	128	3160[G]
Undetermined Tubificidae	ORE 3	9	3160[G]
Undetermined Tubificidae	ORE 4	17	3160[G]
Undetermined Tubificidae	ORE 5	20	3160[G]
Undetermined Tubificidae	ORE 6	13	3160[G]
Undetermined Tubificidae	ORE 7	4	3160[G]
Undetermined Tubificidae	ORE 8	25	3160[G]
Undetermined Tubificidae	ORE 9	249	3160[G]
Undetermined Tubificidae	ARC 1	265	3160[G]
Undetermined Tubificidae	ARC 2	82	3160[G]
Undetermined Tubificidae	ARC 3	62	3160[G]

Table 19. - continued

Undetermined Tubificidae	ARC 4	42	3160[G]
Undetermined Tubificidae	ARC 5	229	3160[G]
Undetermined Tubificidae	ARC 6	67	3160[G]
Undetermined Tubificidae	ARC 7	39	3160[G]
Undetermined Tubificidae	ARC 8	381	3160[G]
Undetermined Tubificidae	ARC 9	118	3160[G]
Undetermined Tubificidae	ARC 10	117	3160[G]

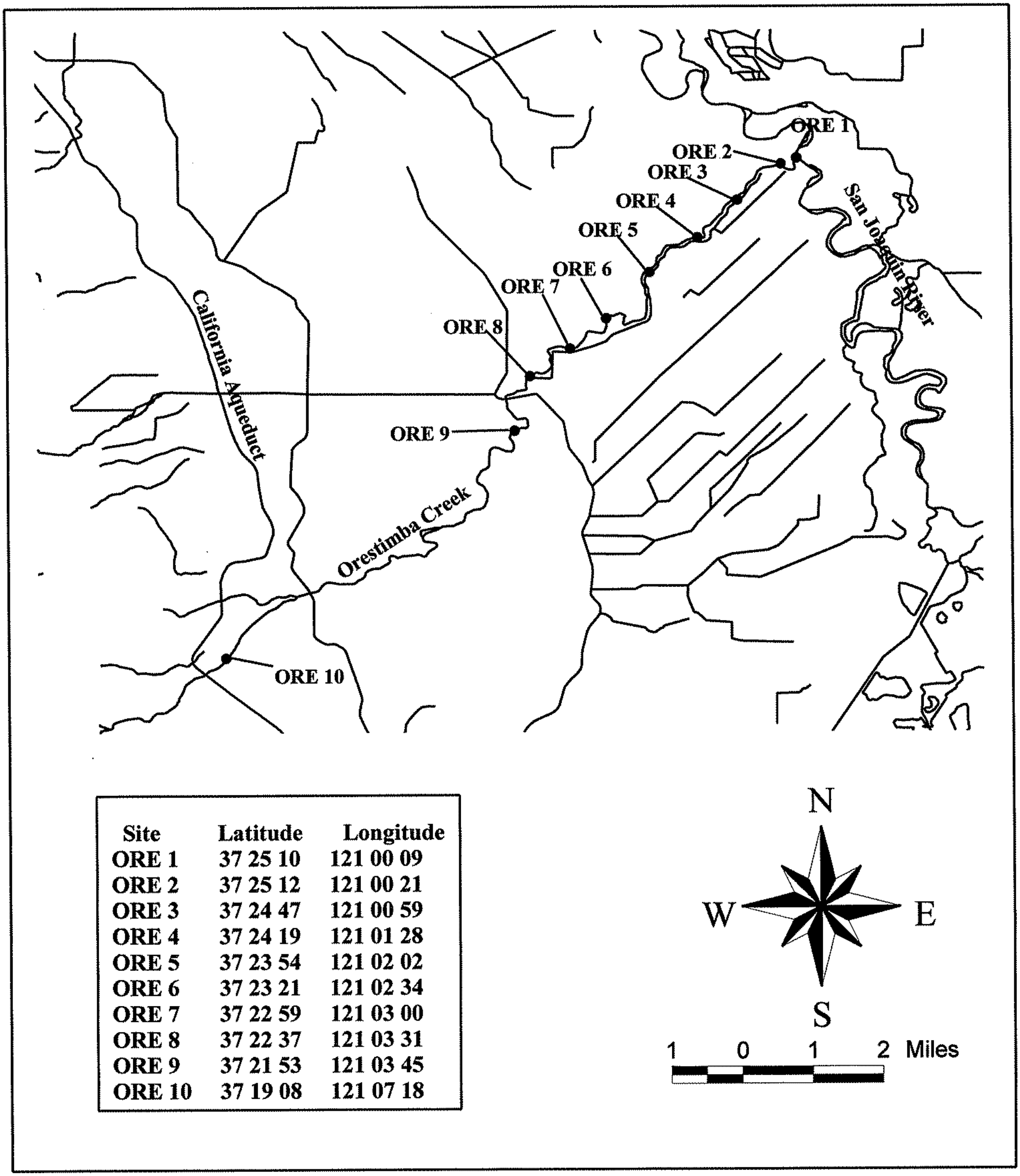
[A] Listed toxicity value was for *Daphnia pulex.*
[B] Listed toxicity value was for *Daphnia magna.*
[C] Listed toxicity value was for *Baetis intermedius.*
[D] Listed toxicity value was for *Physa gyrina.*
[E] Listed toxicity value was for *Physa acuta.*
[F] Listed toxicity value was for *Helisoma trivolvis.*
[G] Listed toxicity value was for *Tubifex* species.

Figure 1. Arcade Creek sample sites



Site	Latitude	Longitude
ARC 1	38 37 30	121 27 20
ARC 2	38 37 49	121 24 59
ARC 3	38 38 28	121 22 56
ARC 4	38 38 38	121 21 00
ARC 5	38 39 37	121 20 10
ARC 6	38 41 00	121 19 31
ARC 7	38 41 15	121 41 15
ARC 8	38 41 02	121 17 28
ARC 9	38 41 03	121 16 33
ARC 10	38 41 17	121 15 53

Figure 2. Orestimba Creek sample sites.



Site	Latitude	Longitude
ORE 1	37 25 10	121 00 09
ORE 2	37 25 12	121 00 21
ORE 3	37 24 47	121 00 59
ORE 4	37 24 19	121 01 28
ORE 5	37 23 54	121 02 02
ORE 6	37 23 21	121 02 34
ORE 7	37 22 59	121 03 00
ORE 8	37 22 37	121 03 31
ORE 9	37 21 53	121 03 45
ORE 10	37 19 08	121 07 18

Figure 3. Macroinvertebrate richness for each transect and site total for the 10 Arcade Creek sites.

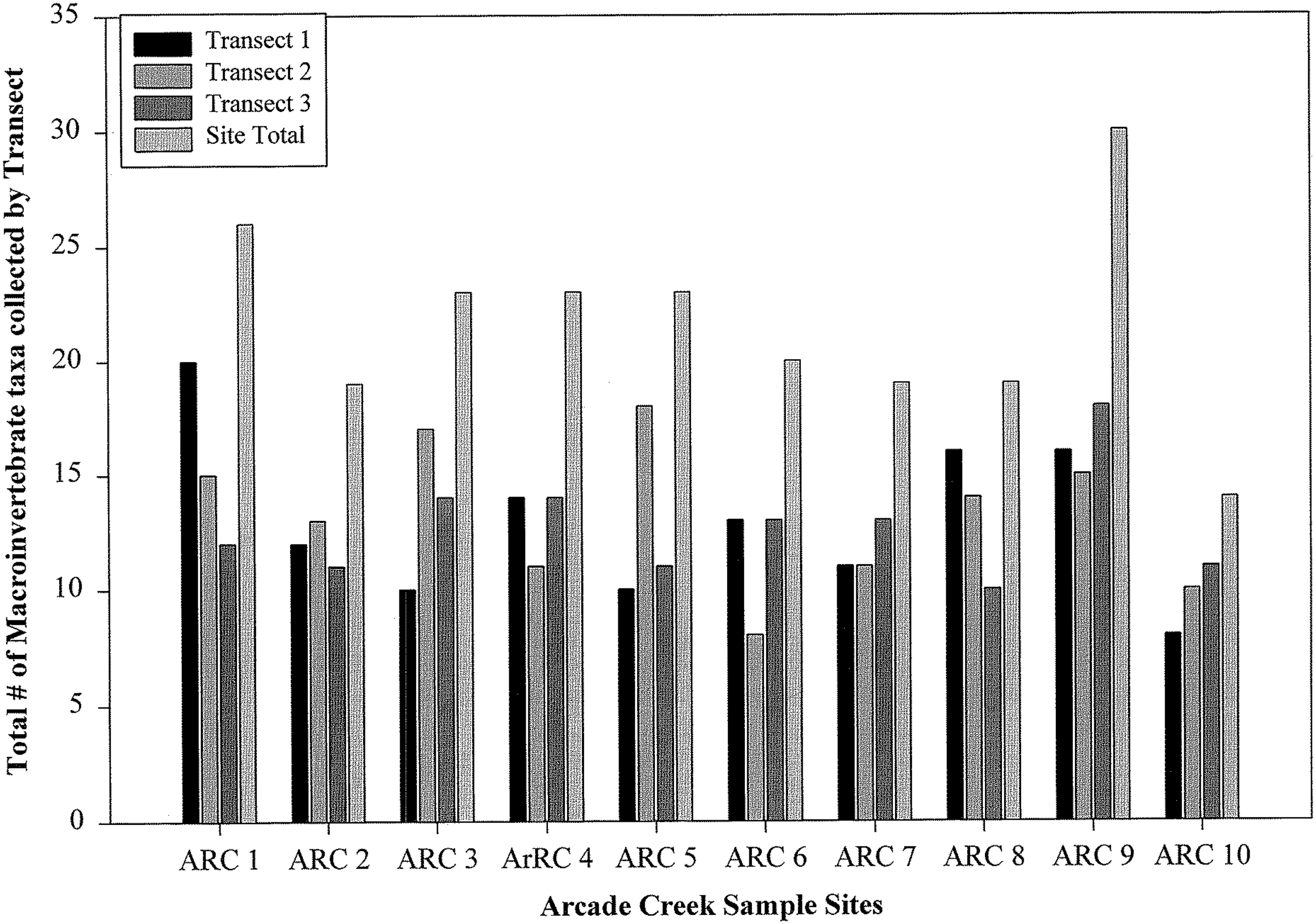


Figure 4. Macroinvertebrate abundance for each transect and site total for the 10 Arcade Creek sites.

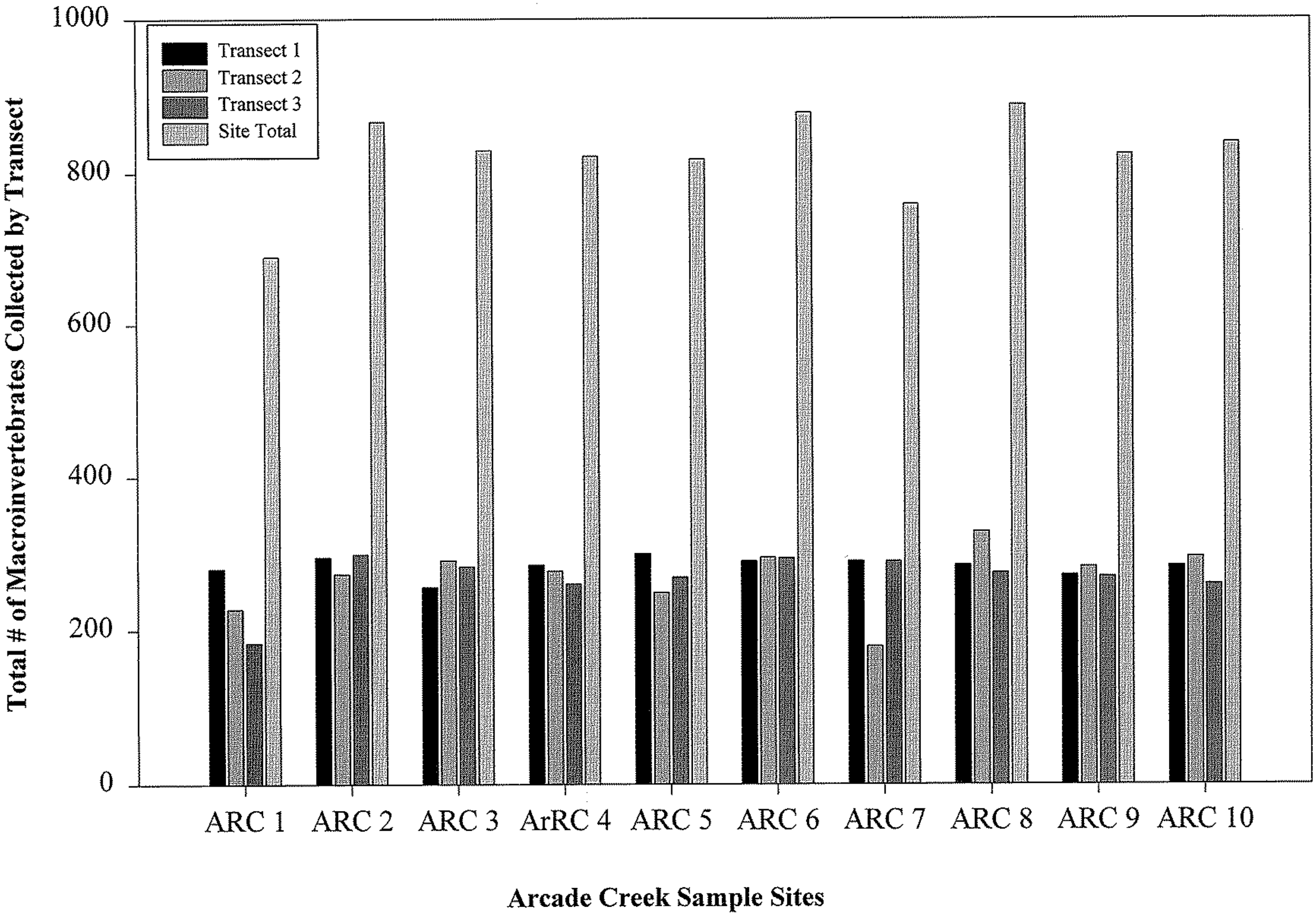


Figure 5. Macroinvertebrate richness for each transect and site total for the 10 Orestimba Creek sites.

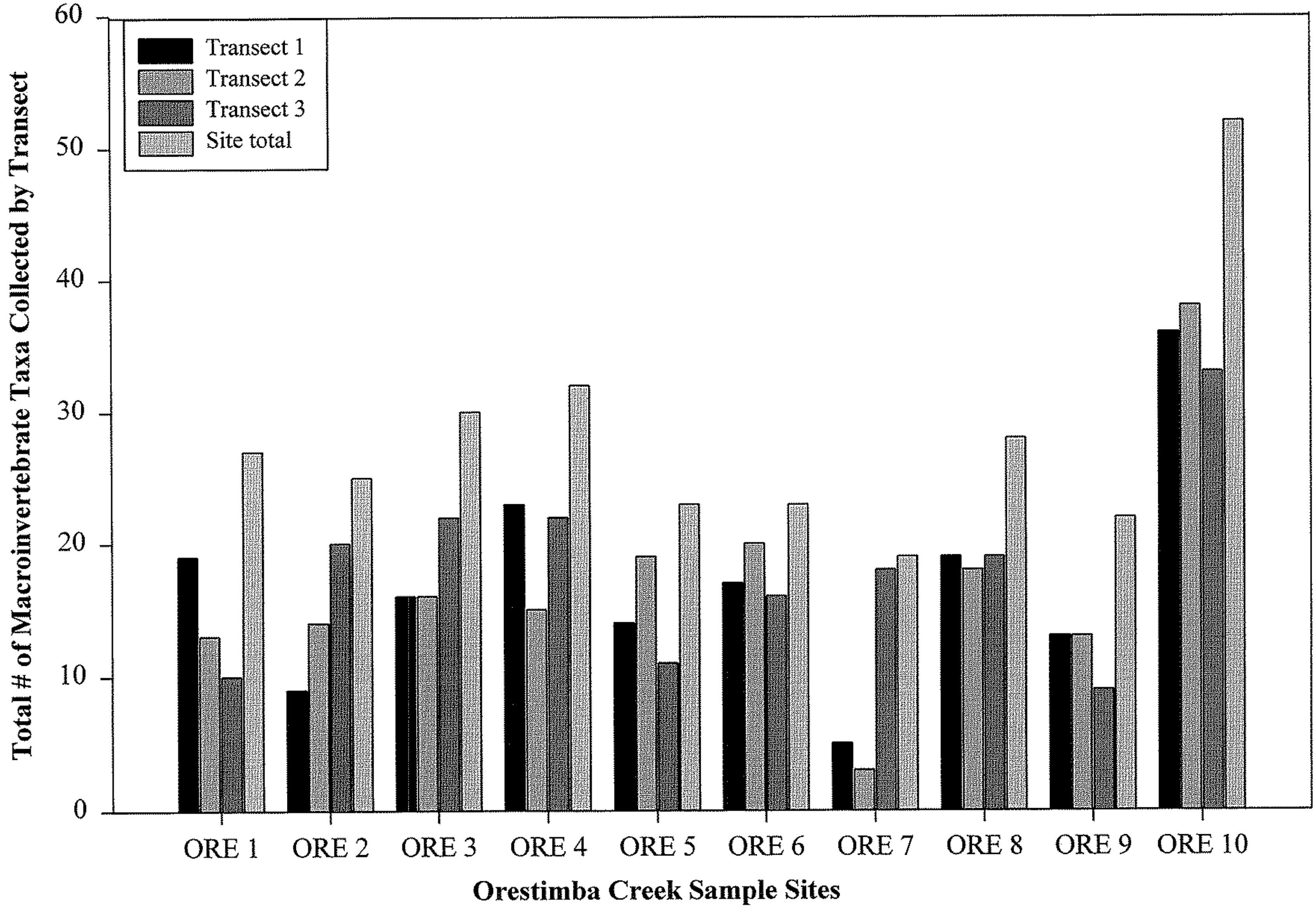
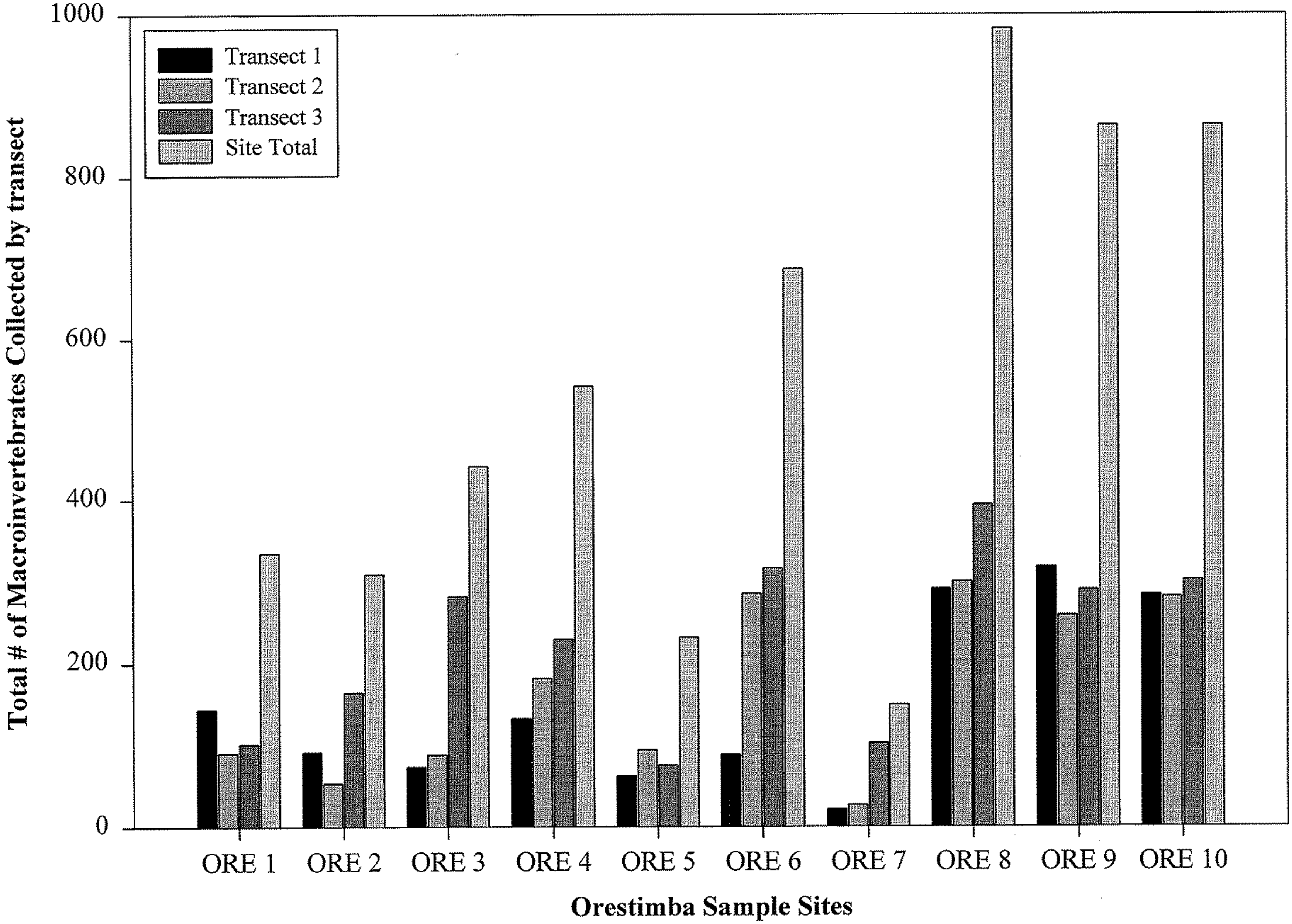


Figure 6. Macroinvertebrate abundance for each transect and site total for the 10 Orestimba Creek sites.



Appendix A

California bioassessment worksheets icluding specific descriptions of the various physical habitat metrics.

CALIFORNIA 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: ____________

Bioassessment Laboratory Information:

____
____
____
____
____

SEND A COPY OF THIS FORM TO:
DFG/ WPCL
2005 Nimbus Road
Rancho Cordova, CA 95670
(916) 358-2858
website: www.dfg.ca.gov/cabw/cabwhome.html

RIFFLE/ REACH CHARACTERISTICS

Point Source Sampling Design

Riffle Length: ____
- Transect 1: ____
- Transect 2: ____
- Transect 3: ____

(record Physical/ Habitat Characteristics in Riffle 1 column)

Non-Point Source Sampling Design

Reach Length: ____
Physical Habitat Quality Score: ____

Physical/ Habitat Characteristics

	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:			

CALIFORNIA STREAM BIOASSESSMENT PROCEDURE
CHAIN OF CUSTODY (COC) RECORD

Project Name: ______________________ Date/ Time: ____________________

Watershed Name:______________________ Boiassessment Lab: ____________________

Sample Number	Lab Number	Sample Date	Sample Description

Sampled by: (sign and date)	Relinquished by: (sign and date)	Received by: (sign and date)
Received by: (sign and date)	Received by: (sign and date)	Received by: (sign and date)

Address of Sampler:

____
____
____
____

Address of Project Advisor:

____
____
____
____

BIOLOGICAL METRICS USED TO DESCRIBE BENTHIC MACROINVERTEBRATE (BMI) SAMPLES COLLECTED FOLLOWING THE CALIFORNIA STREAM BIOASSESSMENT PROCEDURE (CSBP)

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

PHYSICAL HABITAT QUALITY
(California Stream Bioassessment Procedure)

Watershed/ Stream: ____________________ Date/ Time: ____________________

Company/ Agency: ____________________ Sample ID Number: ____________________

Site Description: ____________________

Circle the appropriate score for all 20 habitat parameters. Record the total score on the front page of the CBW.

Parameters to be evaluated within the sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; most favorable is a mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	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 0-25% 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 more than 75% surrounded by fine sediment.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/ Depth Regimes *(deep<0.5 m, slow<0.3 m/s)*	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow).	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat 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 islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	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 base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water 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

Parameters to be evaluated in an area longer than the sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
	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 width of the stream <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 the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream 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 of >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 (score each bank) Note: determine left of right side by facing downstream	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zones covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank 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 centimeters or less in average stubble height.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities haveimpacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Appendix B

Number of lowest identified taxa by transect and combined transects including tolerance values (TV) and feeding guilds for Arcade Creek sites. Tolerance values for taxa range from 1 to 10 with 10 the most tolerant value. Feeding guilds are defined as follows: c = collector; f = filterer; g = grazer; p = producer and s = shredder.

Arcade 1

Lowest Taxa	T1
Undetermined Tubificidae	146
Naididae	40
Cricotopus sp.	24
Rheocricotopus sp.	14
Undetermined Coenagrionida	12
Dicrotendipes sp.	11
Daphniidae	8
Physa/ Physella	8
Cricotopus bicinctus gp.	3
Polypedilum sp.	2
Ephydridae	2
Cyclopidae	2
Phaenopsectra sp.	1
Pseudochironomus sp.	1
Corynoneura sp.	1
Cricotopus trifascia gp.	1
Ischnura sp.	1
Fossaria sp.	1
Corbicula fluminea	1
Nematoda	1
	280

Lowest Taxa	T2
Naididae	98
Cricotopus sp.	34
Rheocricotopus sp.	29
Undetermined Tubificidae	28
Dicrotendipes sp.	14
Physa/ Physella	9
Cryptochironomus sp.	3
Cricotopus bicinctus gp.	3
Corbicula fluminea	3
Paratanytarsus sp.	1
Corynoneura sp.	1
Undetermined Erpobdellida	1
Ischnura sp.	1
Undetermined Orthocladiina	1
Megadrile	1
	227

Lowest Taxa	T3
Undetermined Tubificidae	91
Cricotopus sp.	19
Physa/ Physella	17
Dicrotendipes sp.	15
Rheocricotopus sp.	15
Naididae	15
Paratanytarsus sp.	3
Corbicula fluminea	3
Megadrile	2
Phaenopsectra sp.	1
Enallagma sp.	1
Daphniidae	1
	183

Lowest Taxa	TV	FFG	Total
Undetermined Tubificidae	9	c	265
Naididae	8	c	153
Cricotopus sp.	7	s	77
Rheocricotopus sp.	6	c	58
Dicrotendipes sp.	8	c	40
Physa/ Physella	8	g	34
Undetermined Coenagrionida	7	p	12
Daphniidae	8	c	9
Corbicula fluminea	10	f	7
Cricotopus bicinctus gp.	7	c	6
Paratanytarsus sp.	6	f	4
Cryptochironomus sp.	8	p	3
Megadrile	5	c	3
Phaenopsectra sp.	7	g	2
Polypedilum sp.	6	s	2
Corynoneura sp.	7	c	2
Ephydridae	6	c	2
Ischnura sp.	9	p	2
Cyclopidae	8	c	2
Pseudochironomus sp.	6	c	1
Cricotopus trifascia gp.	7	s	1
Undetermined Orthocladiinae	5	c	1
Enallagma sp.	9	p	1
Fossaria sp.	6	g	1
Nematoda	5	p	1
Undetermined Erpobdellidae	8	p	1
			690

Arcade 2

Lowest Taxa	T1
Naididae	131
Undetermined Tubificidae	67
Rheocricotopus sp.	61
Eukiefferiella sp.	12
Cricotopus sp.	9
Dicrotendipes sp.	3
Undetermined Simulidae	3
Ferrissia rivularis	3
Cricotopus trifascia gp.	2
Undetermined Orthocladiinae	2
Hydropsyche californica	1
Hydroptila sp.	1
	295

Lowest Taxa	T2
Naididae	138
Rheocricotopus sp.	73
Cricotopus sp.	18
Undetermined Tubificidae	14
Cricotopus trifascia gp.	10
Eukiefferiella sp.	10
Bezzia/ Palpomyia	3
Dicrotendipes sp.	2
Cryptochironomus sp.	1
Cricotopus bicinctus gp.	1
Undetermined Orthocladiina	1
Undetermined Simulidae	1
Daphniidae	1
	273

Lowest Taxa	T3
Naididae	165
Rheocricotopus sp.	109
Cricotopus sp.	10
Eukiefferiella sp.	4
Dicrotendipes sp.	3
Parachironomus sp.	2
Cricotopus trifascia gp.	2
Hydroptila sp.	1
Undetermined Ancylidae	1
Corbicula fluminea	1
Undetermined Tubificidae	1
	299

Lowest Taxa	TV	FFG	Total
Naididae	8	c	434
Rheocricotopus sp.	6	c	243
Undetermined Tubificidae	9	c	82
Cricotopus sp.	7	s	37
Eukiefferiella sp.	8	c	26
Cricotopus trifascia gp.	7	s	14
Dicrotendipes sp.	8	c	8
Undetermined Simulidae	6	f	4
Bezzia/ Palpomyia	6	p	3
Undetermined Orthocladiinae	5	c	3
Ferrissia rivularis	6	g	3
Parachironomus sp.	10	p	2
Hydroptila sp.	6	g	2
Cryptochironomus sp.	8	p	1
Cricotopus bicinctus gp.	7	c	1
Hydropsyche californica	4	f	1
Daphniidae	8	c	1
Undetermined Ancylidae	6	g	1
Corbicula fluminea	10	f	1
			867

Arcade 3

Lowest Taxa	T1
Rheocricotopus sp.	180
Eukiefferiella sp.	26
Naididae	19
Simulium sp.	15
Undetermined Tubificidae	8
Undetermined Simulidae	4
Polypedilum sp.	1
Limnophyes sp.	1
Physa/ Physella	1
Menetus opercularis	1
	256

Lowest Taxa	T2
Rheocricotopus sp.	142
Naididae	72
Undetermined Tubificidae	32
Eukiefferiella sp.	14
Simulium sp.	9
Undetermined Erpobdellida	4
Polypedilum sp.	3
Menetus opercularis	3
Megadrile	3
Ferrissia rivularis	2
Parachironomus sp.	1
Phaenopsectra sp.	1
Undetermined Tanytarsini	1
Hydra sp.	1
Fossaria sp.	1
Physa/ Physella	1
Branchiura sowerbyi	1
	291

Lowest Taxa	T3
Rheocricotopus sp.	179
Eukiefferiella sp.	33
Undetermined Tubificidae	22
Simulium sp.	20
Naididae	15
Undetermined Erpobdellid	5
Cricotopus sp.	2
Dicrotendipes sp.	1
Polypedilum sp.	1
Corynoneura sp.	1
Hydra sp.	1
Ferrissia rivularis	1
Erpobdella punctata	1
Megadrile	1
	283

Lowest Taxa	TV	FFG	Total
Rheocricotopus sp.	6	c	501
Naididae	8	c	106
Eukiefferiella sp.	8	c	73
Undetermined Tubificidae	9	c	62
Simulium sp.	6	f	44
Undetermined Erpobdellidae	8	p	9
Polypedilum sp.	6	s	5
Undetermined Simulidae	6	f	4
Menetus opercularis	7	g	4
Megadrile	5	c	4
Ferrissia rivularis	6	g	3
Cricotopus sp.	7	s	2
Hydra sp.	5	f	2
Physa/ Physella	8	g	2
Dicrotendipes sp.	8	c	1
Parachironomus sp.	10	p	1
Phaenopsectra sp.	7	g	1
Undetermined Tanytarsini	6	f	1
Corynoneura sp.	7	c	1
Limnophyes sp.	8	c	1
Fossaria sp.	6	g	1
Erpobdella punctata	8	p	1
Branchiura sowerbyi	9	c	1
			830

Arcade 4

Lowest Taxa	T1	Lowest Taxa	T2	Lowest Taxa	T3
Cricotopus sp.	118	*Cricotopus sp.*	112	*Rheocricotopus sp.*	136
Rheocricotopus sp.	75	*Rheocricotopus sp.*	75	*Cricotopus sp.*	57
Eukiefferiella sp.	66	*Eukiefferiella sp.*	64	*Eukiefferiella sp.*	27
Simulium sp.	7	Undetermined Tubificidae	12	Undetermined Tubificidae	26
Hydropsyche californica	4	*Simulium sp.*	6	Naididae	5
Undetermined Tubificidae	4	*Polypedilum sp.*	2	Undetermined Orthocladii	1
Undetermined Simulidae	2	Naididae	2	*Argia vivida*	1
Ferrissia rivularis	2	*Cryptochironomus sp.*	1	*Hydropsyche californica*	1
Naididae	2	*Hydropsyche californica*	1	*Physa/ Physella*	1
Dicrotendipes sp.	1	*Menetus opercularis*	1	*Pisidium sp.*	1
Hydra sp.	1	Megadrile	1	Nematoda	1
Physa/ Physella	1		277	*Dugesia tigrina*	1
Gyraulus parvus	1			*Erpobdella punctata*	1
Menetus opercularis	1			Megadrile	1
	285				260

Lowest Taxa	TV	FFG	Total
Cricotopus sp.	7	s	287
Rheocricotopus sp.	6	c	286
Eukiefferiella sp.	8	c	157
Undetermined Tubificidae	9	c	42
Simulium sp.	6	f	13
Naididae	8	c	9
Hydropsyche californica	4	f	6
Polypedilum sp.	6	s	2
Undetermined Simulidae	6	f	2
Ferrissia rivularis	6	g	2
Physa/ Physella	8	g	2
Menetus opercularis	7	g	2
Megadrile	5	c	2
Cryptochironomus sp.	8	p	1
Dicrotendipes sp.	8	c	1
Undetermined Orthocladiinae	5	c	1
Argia vivida	7	p	1
Hydra sp.	5	f	1
Gyraulus parvus	8	g	1
Pisidium sp.	8	f	1
Nematoda	5	p	1
Dugesia tigrina	4	p	1
Erpobdella punctata	8	p	1
			822

Arcade 5

Lowest Taxa	T1
Undetermined Tubificidae	143
Rheocricotopus sp.	73
Naididae	40
Eukiefferiella sp.	22
Megadrile	12
Cricotopus sp.	5
Polypedilum sp.	2
Cryptochironomus sp.	1
Limnophyes sp.	1
Physa/ Physella	1
	300

Lowest Taxa	T2
Rheocricotopus sp.	113
Undetermined Tubificidae	55
Eukiefferiella sp.	25
Naididae	23
Simulium sp.	6
Megadrile	5
Undetermined Orthocladiina	4
Phaenopsectra sp.	3
Cricotopus sp.	3
Hydropsyche californica	2
Erpobdella punctata	2
Undetermined Erpobdellida	2
Microtendipes sp.	1
Polypedilum sp.	1
Undetermined Tipulidae	1
Ferrissia rivularis	1
Undetermined Sphaeriidae	1
Nematoda	1
	249

Lowest Taxa	T3
Rheocricotopus sp.	145
Naididae	44
Eukiefferiella sp.	32
Undetermined Tubificidae	31
Cricotopus sp.	10
Simulium sp.	2
Phaenopsectra sp.	1
Limnophyes sp.	1
Limonia sp.	1
Ferrissia rivularis	1
Menetus opercularis	1
	269

Lowest Taxa	TV	FFG	Total
Rheocricotopus sp.	6	c	331
Undetermined Tubificidae	9	c	229
Naididae	8	c	107
Eukiefferiella sp.	8	c	79
Cricotopus sp.	7	s	18
Megadrile	5	c	17
Simulium sp.	6	f	8
Phaenopsectra sp.	7	g	4
Undetermined Orthocladiinae	5	c	4
Polypedilum sp.	6	s	3
Limnophyes sp.	8	c	2
Hydropsyche californica	4	f	2
Ferrissia rivularis	6	g	2
Erpobdella punctata	8	p	2
Undetermined Erpobdellidae	8	p	2
Cryptochironomus sp.	8	p	1
Microtendipes sp.	6	f	1
Limonia sp.	6	s	1
Undetermined Tipulidae	3	s	1
Physa/ Physella	8	g	1
Menetus opercularis	7	g	1
Undetermined Sphaeriidae	8	f	1
Nematoda	5	p	1
			818

Arcade 6

Lowest Taxa	T1
Rheocricotopus sp.	149
Naididae	55
Eukiefferiella sp.	37
Undetermined Tubificidae	26
Cricotopus sp.	12
Corbicula fluminea	4
Dicrotendipes sp.	1
Microtendipes sp.	1
Polypedilum sp.	1
Limnophyes sp.	1
Thienemanniella sp.	1
Undetermined Sphaeriidae	1
Erpobdella punctata	1
	290

Lowest Taxa	T2
Rheocricotopus sp.	127
Naididae	116
Undetermined Tubificidae	25
Eukiefferiella sp.	20
Undetermined Orthocladiina	4
Polypedilum sp.	1
Nematoda	1
Megadrile	1
	295

Lowest Taxa	T3
Rheocricotopus sp.	142
Naididae	69
Eukiefferiella sp.	51
Undetermined Tubificidae	16
Undetermined Orthocladii	4
Phaenopsectra sp.	2
Cricotopus sp.	2
Simulium sp.	2
Megadrile	2
Dicrotendipes sp.	1
Microtendipes sp.	1
Cricotopus bicinctus gp.	1
Cyprididae	1
	294

Lowest Taxa	TV	FFG	Total
Rheocricotopus sp.	6	c	418
Naididae	8	c	240
Eukiefferiella sp.	8	c	108
Undetermined Tubificidae	9	c	67
Cricotopus sp.	7	s	14
Undetermined Orthocladiinae	5	c	8
Corbicula fluminea	10	f	4
Megadrile	5	c	3
Dicrotendipes sp.	8	c	2
Microtendipes sp.	6	f	2
Phaenopsectra sp.	7	g	2
Polypedilum sp.	6	s	2
Simulium sp.	6	f	2
Cricotopus bicinctus gp.	7	c	1
Limnophyes sp.	8	c	1
Thienemanniella sp.	6	c	1
Cyprididae	8	c	1
Undetermined Sphaeriidae	8	f	1
Nematoda	5	p	1
Erpobdella punctata	8	p	1
			879

Arcade 7

Lowest Taxa	T1	Lowest Taxa	T2	Lowest Taxa	T3
Rheocricotopus sp.	151	*Rheocricotopus sp.*	110	*Rheocricotopus sp.*	158
Cricotopus sp.	47	*Eukiefferiella sp.*	27	Naididae	60
Eukiefferiella sp.	44	Naididae	14	*Cricotopus sp.*	33
Naididae	18	Undetermined Tubificidae	10	*Eukiefferiella sp.*	16
Undetermined Tubificidae	17	*Cricotopus sp.*	7	Undetermined Tubificidae	12
Undetermined Erpobdellidae	5	*Pisidium sp.*	3	*Dicrotendipes sp.*	3
Dicrotendipes sp.	3	*Corbicula fluminea*	2	*Limnophyes sp.*	2
Undetermined Orthocladiinae	2	Undetermined Sphaeriidae	2	*Microtendipes sp.*	1
Pisidium sp.	1	Megadrile	2	*Cricotopus bicinctus* gp.	1
Nematoda	1	*Polypedilum sp.*	1	Undetermined Orthocladii	1
Megadrile	1	*Cricotopus bicinctus* gp.	1	*Hydroptila sp.*	1
	290		179	*Erpobdella punctata*	1
				Undetermined Erpobdellid	1
					290

Lowest Taxa	TV	FFG	Total
Rheocricotopus sp.	6	c	419
Naididae	8	c	92
Cricotopus sp.	7	s	87
Eukiefferiella sp.	8	c	87
Undetermined Tubificidae	9	c	39
Dicrotendipes sp.	8	c	6
Undetermined Erpobdellidae	8	p	6
Pisidium sp.	8	f	4
Undetermined Orthocladiinae	5	c	3
Megadrile	5	c	3
Cricotopus bicinctus gp.	7	c	2
Limnophyes sp.	8	c	2
Corbicula fluminea	10	f	2
Undetermined Sphaeriidae	8	f	2
Microtendipes sp.	6	f	1
Polypedilum sp.	6	s	1
Hydroptila sp.	6	g	1
Nematoda	5	p	1
Erpobdella punctata	8	p	1
			759

Arcade 8

Lowest Taxa	T1	Lowest Taxa	T2	Lowest Taxa	T3
Cricotopus sp.	61	Undetermined Tubificidae	192	Undetermined Tubificidae	133
Undetermined Tubificidae	56	Naididae	42	*Cricotopus sp.*	36
Naididae	47	*Cricotopus sp.*	31	*Eukiefferiella sp.*	35
Physa/ Physella	27	*Eukiefferiella sp.*	27	Naididae	32
Rheocricotopus sp.	23	*Rheocricotopus sp.*	14	*Rheocricotopus sp.*	30
Eukiefferiella sp.	14	*Physa/ Physella*	7	*Erpobdella punctata*	4
Undetermined Erpobdellidae	14	*Dicrotendipes sp.*	4	Megadrile	2
Argia sp.	8	Undetermined Sphaeriidae	3	*Argia sp.*	1
Undetermined Sphaeriidae	7	Megadrile	3	Undetermined Ancylidae	1
Erpobdella punctata	7	*Pisidium sp.*	2	Undetermined Erpobdellid	1
Menetus opercularis	6	Undetermined Coenagrionid	1		275
Pisidium sp.	5	*Fossaria sp.*	1		
Megadrile	5	*Dugesia tigrina*	1		
Fossaria sp.	3	Undetermined Erpobdellida	1		
Undetermined Ancylidae	1		329		
Undetermined Hemiptera	1				
	285				

Lowest Taxa	TV	FFG	Total
Undetermined Tubificidae	9	c	381
Cricotopus sp.	7	s	128
Naididae	8	c	121
Eukiefferiella sp.	8	c	76
Rheocricotopus sp.	6	c	67
Physa/ Physella	8	g	34
Undetermined Erpobdellidae	8	p	16
Erpobdella punctata	8	p	11
Undetermined Sphaeriidae	8	f	10
Megadrile	5	c	10
Argia sp.	7	p	9
Pisidium sp.	8	f	7
Menetus opercularis	7	g	6
Dicrotendipes sp.	8	c	4
Fossaria sp.	6	g	4
Undetermined Ancylidae	6	g	2
Undetermined Hemiptera	10	p	1
Undetermined Coenagrionida	7	p	1
Dugesia tigrina	4	p	1
			889

Arcade 9

Lowest Taxa	T1
Rheocricotopus sp.	157
Undetermined Tubificidae	44
Eukiefferiella sp.	34
Naididae	11
Undetermined Sphaeriidae	8
Cricotopus sp.	5
Megadrile	3
Polypedilum sp.	2
Cryptochironomus sp.	1
Paratanytarsus sp.	1
Limnophyes sp.	1
Undetermined Orthocladiinae	1
Limonia sp.	1
Gyraulus parvus	1
Menetus opercularis	1
Nematoda	1
	272

Lowest Taxa	T2
Rheocricotopus sp.	162
Undetermined Tubificidae	43
Eukiefferiella sp.	35
Corbicula fluminea	13
Undetermined Sphaeriidae	9
Pisidium sp.	7
Dicrotendipes sp.	2
Cricotopus sp.	2
Simulium sp.	2
Limonia sp.	2
Physa/ Physella	2
Phaenopsectra sp.	1
Odontomyia sp.	1
Dugesia tigrina	1
Naididae	1
	283

Lowest Taxa	T3
Rheocricotopus sp.	178
Undetermined Tubificidae	31
Corbicula fluminea	18
Eukiefferiella sp.	13
Undetermined Sphaeriidae	10
Cricotopus sp.	5
Undetermined Lymnaeida	2
Pisidium sp.	2
Megadrile	2
Helophorus sp.	1
Phaenopsectra sp.	1
Polypedilum sp.	1
Macropelopiini	1
Pericoma/ Telmatoscopus	1
Ferrissia rivularis	1
Gyraulus parvus	1
Planorbula sp.	1
Naididae	1
	270

Lowest Taxa	TV	FFG	Total
Rheocricotopus sp.	6	c	497
Undetermined Tubificidae	9	c	118
Eukiefferiella sp.	8	c	82
Corbicula fluminea	10	f	31
Undetermined Sphaeriidae	8	f	27
Naididae	8	c	13
Cricotopus sp.	7	s	12
Pisidium sp.	8	f	9
Megadrile	5	c	5
Polypedilum sp.	6	s	3
Limonia sp.	6	s	3
Dicrotendipes sp.	8	c	2
Phaenopsectra sp.	7	g	2
Simulium sp.	6	f	2
Undetermined Lymnaeidae	6	g	2
Physa/ Physella	8	g	2
Gyraulus parvus	8	g	2
Helophorus sp.		s	1
Cryptochironomus sp.	8	p	1
Paratanytarsus sp.	6	f	1
Limnophyes sp.	8	c	1
Undetermined Orthocladiinae	5	c	1
Macropelopiini	6	p	1
Pericoma/ Telmatoscopus	4	c	1
Odontomyia sp.	5	c	1
Ferrissia rivularis	6	g	1
Menetus opercularis	7	g	1
Planorbula sp.	7	g	1
Nematoda	5	p	1
Dugesia tigrina	4	p	1
			825

Arcade 10

Lowest Taxa	T1	Lowest Taxa	T2	Lowest Taxa	T3
Rheocricotopus sp.	194	*Rheocricotopus sp.*	148	*Rheocricotopus sp.*	144
Naididae	46	Naididae	60	Naididae	47
Undetermined Tubificidae	22	Undetermined Tubificidae	55	Undetermined Tubificidae	40
Eukiefferiella sp.	17	*Eukiefferiella sp.*	21	*Eukiefferiella sp.*	12
Limnophyes sp.	2	Undetermined Sphaeriidae	6	Megadrile	7
Cricotopus sp.	1	*Pisidium sp.*	2	*Limnophyes sp.*	3
Pisidium sp.	1	*Microtendipes sp.*	1	Undetermined Sphaeriidae	3
Megadrile	1	*Cricotopus sp.*	1	*Tipula sp.*	1
	284	*Dugesia tigrina*	1	Cyprididae	1
		Megadrile	1	*Pisidium sp.*	1
			296	Nematoda	1
					260

Lowest Taxa	TV	FFG	Total
Rheocricotopus sp.	6	c	486
Naididae	8	c	153
Undetermined Tubificidae	9	c	117
Eukiefferiella sp.	8	c	50
Undetermined Sphaeriidae	8	f	9
Megadrile	5	c	9
Limnophyes sp.	8	c	5
Pisidium sp.	8	f	4
Cricotopus sp.	7	s	2
Microtendipes sp.	6	f	1
Tipula sp.	4	s	1
Cyprididae	8	c	1
Nematoda	5	p	1
Dugesia tigrina	4	p	1
			840

Appendix C

Number of lowest identified taxa by transect and combined transects including tolerance values (TV) and feeding guilds for Orestimba Creek sites. Tolerance values for taxa range from 1 to 10 with 10 the most tolerant value. Feeding guilds are defined as follows: c = collector; f = filterer; g = grazer; p = producer and s = shredder.

Orestimba 1

Lowest Taxa	T1	Lowest Taxa	T2	Lowest Taxa	T3
Naididae	75	Undetermined Tubificidae	41	Naididae	72
Undetermined Tubificidae	33	Naididae	29	Undetermined Tubificidae	11
Hemerodromia sp.	6	*Cricotopus bicinctus* gp.	7	Enchytraeidae	6
Cricotopus bicinctus gp.	3	*Corbicula fluminea*	3	*Polypedilum sp.*	3
Rheocricotopus sp.	3	*Dicrotendipes sp.*	2	*Hemerodromia sp.*	3
Enchytraeidae	3	*Hemerodromia sp.*	1	*Cricotopus bicinctus* gp.	2
Paratanytarsus sp.	2	*Corisella decolor*	1	*Micropsectra sp.*	1
Nanocladius sp.	2	Undetermined Hemiptera	1	Undetermined Empididae	1
Thienemanniella sp.	2	*Lebertia/ Scutolebertia*	1	*Corisella decolor*	1
Undetermined Empididae	2	*Cyclopidae*	1	*Manayunkia speciosa*	1
Corbicula fluminea	2	*Physa/ Physella*	1		101
Nematoda	2	Enchytraeidae	1		
Prostoma sp.	2	*Branchiura sowerbyi*	1		
Parachironomus sp.	1		90		
Phaenopsectra sp.	1				
Cricotopus sp.	1				
Corisella decolor	1				
Neomysis mercedis	1				
Manayunkia speciosa	1				
	143				

Lowest Taxa	TV	FFG	TOTAL
Naididae	8	c	176
Undetermined Tubificidae	9	c	85
Cricotopus bicinctus gp.	7	c	12
Hemerodromia sp.	6	p	10
Enchytraeidae	10	c	10
Corbicula fluminea	10	f	5
Polypedilum sp.	6	s	3
Rheocricotopus sp.	6	c	3
Undetermined Empididae	6	p	3
Corisella decolor	10	p	3
Dicrotendipes sp.	8	c	2
Paratanytarsus sp.	6	f	2
Nanocladius sp.	3	s	2
Thienemanniella sp.	6	c	2
Nematoda	5	p	2
Manayunkia speciosa		c	2
Prostoma sp.		c	2
Parachironomus sp.	10	p	1
Phaenopsectra sp.	7	g	1
Micropsectra sp.	7	c	1
Cricotopus sp.	7	s	1
Undetermined Hemiptera	10	p	1
Lebertia/ Scutolebertia	5	p	1
Cyclopidae	8	c	1
Neomysis mercedis		p	1
Physa/ Physella	8	g	1
Branchiura sowerbyi	9	c	1
			334

Orestimba 2

Lowest Taxa	T1	Lowest Taxa	T2	Lowest Taxa	T3
Undetermined Tubificidae	74	Undetermined Tubificidae	17	Naididae	69
Corbicula fluminea	5	Naididae	16	Undetermined Tubificidae	37
Naididae	4	Nematoda	3	*Eukiefferiella sp.*	9
Megadrile	3	*Cricotopus bicinctus* gp.	2	*Hemerodromia sp.*	8
Cricotopus bicinctus gp.	1	*Thienemanniella sp.*	2	*Cricotopus bicinctus* gp.	7
Cricotopus sp.	1	*Hemerodromia sp.*	2	*Thienemanniella sp.*	6
Eukiefferiella sp.	1	*Corbicula fluminea*	2	Enchytraeidae	6
Thienemanniella sp.	1	*Branchiura sowerbyi*	2	*Dicrotendipes sp.*	3
Undetermined Hemiptera	1	*Prostoma sp.*	2	*Paratanytarsus sp.*	3
	91	*Paratanytarsus sp.*	1	*Physa/ Physella*	3
		Cyclopidae	1	*Cricotopus sp.*	2
		Physa/ Physella	1	*Rheocricotopus sp.*	2
		Enchytraeidae	1	Megadrile	2
		Megadrile	1	Undetermined Empididae	1
			53	*Simulium sp.*	1
				Sperchon/ Sperchonopsis	1
				Fossaria sp.	1
				Planorbula sp.	1
				Nematoda	1
				Undetermined Erpobdellidae	1
					164

Lowest Taxa	TV	FFG	Totals
Undetermined Tubificidae	9	c	128
Naididae	8	c	89
Cricotopus bicinctus gp.	7	c	10
Eukiefferiella sp.	8	c	10
Hemerodromia sp.	6	p	10
Thienemanniella sp.	6	c	9
Corbicula fluminea	10	f	7
Enchytraeidae	10	c	7
Megadrile	5	c	6
Paratanytarsus sp.	6	f	4
Physa/ Physella	8	g	4
Nematoda	5	p	4
Dicrotendipes sp.	8	c	3
Cricotopus sp.	7	s	3
Rheocricotopus sp.	6	c	2
Branchiura sowerbyi	9	c	2
Prostoma sp.		c	2
Undetermined Empididae	6	p	1
Simulium sp.	6	f	1
Undetermined Hemiptera	10	p	1
Sperchon/ Sperchonopsis	5	p	1
Cyclopidae	8	c	1
Fossaria sp.	6	g	1
Planorbula sp.	7	g	1
Undetermined Erpobdellid	8	p	1
			308

Orestimba 3

Lowest Taxa	T1
Naididae	28
Megadrile	19
Corbicula fluminea	6
Cricotopus bicinctus gp.	4
Eukiefferiella sp.	3
Hemerodromia sp.	2
Sperchon/ Sperchonopsis	2
Dicrotendipes sp.	1
Micropsectra sp.	1
Paratanytarsus sp.	1
Undetermined Tanytarsini	1
Thienemanniella sp.	1
Undetermined Empididae	1
Hydroptila sp.	1
Undetermined Tubificidae	1
Prostoma sp.	1
	73

Lowest Taxa	T2
Naididae	31
Cricotopus bicinctus gp.	16
Megadrile	8
Corbicula fluminea	7
Undetermined Tubificidae	6
Paratanytarsus sp.	3
Prostoma sp.	3
Parachironomus sp.	2
Polypedilum sp.	2
Cricotopus/ Orthocladius	2
Eukiefferiella sp.	2
Hydra sp.	2
Sperchon/ Sperchonopsis	1
Temoridae	1
Physa/ Physella	1
Branchiura sowerbyi	1
	88

Lowest Taxa	T3
Naididae	200
Dugesia tigrina	15
Cricotopus bicinctus gp.	9
Manayunkia speciosa	8
Prostoma sp.	8
Cricotopus sp.	6
Eukiefferiella sp.	6
Sperchon/ Sperchonopsis	6
Thienemanniella sp.	4
Parachironomus sp.	2
Hemerodromia sp.	2
Corbicula fluminea	2
Nematoda	2
Undetermined Tubificidae	2
Megadrile	2
Paratanytarsus sp.	1
Nanocladius sp.	1
Parametriocnemus sp.	1
Hydroptila sp.	1
Hydra sp.	1
Enchytraeidae	1
Branchiura sowerbyi	1
	281

Lowest Taxa	TV	FFG	Total
Naididae	8	c	259
Cricotopus bicinctus gp.	7	c	29
Megadrile	5	c	29
Corbicula fluminea	10	f	15
Dugesia tigrina	4	p	15
Prostoma sp.		c	12
Eukiefferiella sp.	8	c	11
Sperchon/ Sperchonopsis	5	p	9
Undetermined Tubificidae	9	c	9
Manayunkia speciosa		c	8
Cricotopus sp.	7	s	6
Paratanytarsus sp.	6	f	5
Thienemanniella sp.	6	c	5
Parachironomus sp.	10	p	4
Hemerodromia sp.	6	p	4
Hydra sp.	5	f	3
Polypedilum sp.	6	s	2
Cricotopus/ Orthocladius	7	s	2
Hydroptila sp.	6	g	2
Nematoda	5	p	2
Branchiura sowerbyi	9	c	2
Dicrotendipes sp.	8	c	1
Micropsectra sp.	7	c	1
Undetermined Tanytarsini	6	f	1
Nanocladius sp.	3	s	1
Parametriocnemus sp.	5	c	1
Undetermined Empididae	6	p	1
Temoridae	8	c	1
Physa/ Physella	8	g	1
Enchytraeidae	10	c	1
			442

Orestimba 4

Lowest Taxa	T1
Naididae	80
Eukiefferiella sp.	6
Corbicula fluminea	6
Cricotopus bicinctus gp.	5
Rheocricotopus sp.	5
Cricotopus sp.	4
Polypedilum sp.	3
Undetermined Tubificidae	3
Micropsectra sp.	2
Sperchon/ Sperchonopsis	2
Physa/ Physella	2
Enchytraeidae	2
Prostoma sp.	2
Limnophyes sp.	1
Nanocladius sp.	1
Thienemanniella sp.	1
Hemerodromia sp.	1
Pericoma/ Telmatoscopus	1
Limonia sp.	1
Sigara vallis	1
Hydra sp.	1
Nematoda	1
Megadrile	1
	132

Lowest Taxa	T2
Naididae	73
Nematoda	23
Prostoma sp.	17
Hydra sp.	15
Corbicula fluminea	15
Megadrile	11
Fossaria sp.	9
Undetermined Tubificidae	4
Nanocladius sp.	3
Enchytraeidae	3
Cricotopus bicinctus gp.	2
Physa/ Physella	2
Dugesia tigrina	2
Cricotopus sp.	1
Branchiura sowerbyi	1
	181

Lowest Taxa	T3
Naididae	106
Corbicula fluminea	18
Fossaria sp.	17
Megadrile	17
Hydra sp.	11
Nematoda	11
Undetermined Tubificidae	10
Cricotopus bicinctus gp.	6
Cricotopus sp.	5
Manayunkia speciosa	4
Prostoma sp.	4
Eukiefferiella sp.	3
Physa/ Physella	3
Eudistylia vancouveri	3
Sperchon/ Sperchonopsis	2
Dugesia tigrina	2
Undetermined Erpobdellidae	2
Dicrotendipes sp.	1
Parachironomus sp.	1
Hemerodromia sp.	1
Gammarus lacustris	1
Enchytraeidae	1
	229

Lowest Taxa	TV	FFG	Total
Naididae	8	c	259
Corbicula fluminea	10	f	39
Nematoda	5	p	35
Megadrile	5	c	29
Hydra sp.	5	f	27
Fossaria sp.	6	g	26
Prostoma sp.		c	23
Undetermined Tubificidae	9	c	17
Cricotopus bicinctus gp.	7	c	13
Cricotopus sp.	7	s	10
Eukiefferiella sp.	8	c	9
Physa/ Physella	8	g	7
Enchytraeidae	10	c	6
Rheocricotopus sp.	6	c	5
Nanocladius sp.	3	s	4
Sperchon/ Sperchonopsis	5	p	4
Dugesia tigrina	4	p	4
Manayunkia speciosa		c	4
Polypedilum sp.	6	s	3
Eudistylia vancouveri		c	3
Micropsectra sp.	7	c	2
Hemerodromia sp.	6	p	2
Undetermined Erpobdellid	8	p	2
Dicrotendipes sp.	8	c	1
Parachironomus sp.	10	p	1
Limnophyes sp.	8	c	1
Thienemanniella sp.	6	c	1
Pericoma/ Telmatoscopus	4	c	1
Limonia sp.	6	s	1
Sigara vallis	10	p	1
Gammarus lacustris	4	c	1
Branchiura sowerbyi	9	c	1
			542

Orestimba 5

Lowest Taxa	T1
Naididae	31
Megadrile	9
Cricotopus bicinctus gp.	3
Physa/ Physella	3
Menetus opercularis	3
Corbicula fluminea	3
Manayunkia speciosa	2
Prostoma sp.	2
Parachironomus sp.	1
Eukiefferiella sp.	1
Sperchon/ Sperchonopsis	1
Hydra sp.	1
Dugesia tigrina	1
Undetermined Tubificidae	1
	62

Lowest Taxa	T2
Naididae	25
Corbicula fluminea	14
Undetermined Tubificidae	13
Prostoma sp.	7
Megadrile	6
Cricotopus sp.	5
Corisella decolor	4
Cricotopus bicinctus gp.	3
Eukiefferiella sp.	3
Manayunkia speciosa	3
Hydra sp.	2
Physa/ Physella	2
Nanocladius sp.	1
Thienemanniella sp.	1
Hydroptila sp.	1
Gammarus lacustris	1
Undetermined Lymnaeidae	1
Menetus opercularis	1
Nematoda	1
	94

Lowest Taxa	T3
Megadrile	22
Corbicula fluminea	19
Prostoma sp.	12
Cricotopus sp.	6
Undetermined Tubificidae	6
Eukiefferiella sp.	4
Naididae	2
Cricotopus bicinctus gp.	1
Hydroptila sp.	1
Sperchon/ Sperchonopsis	1
Enchytraeidae	1
	75

Lowest Taxa	TV	FFG	Total
Naididae	8	c	58
Megadrile	5	c	37
Corbicula fluminea	10	f	36
Prostoma sp.		c	21
Undetermined Tubificidae	9	c	20
Cricotopus sp.	7	s	11
Eukiefferiella sp.	8	c	8
Cricotopus bicinctus gp.	7	c	7
Physa/ Physella	8	g	5
Manayunkia speciosa		c	5
Corisella decolor	10	p	4
Menetus opercularis	7	g	4
Hydra sp.	5	f	3
Hydroptila sp.	6	g	2
Sperchon/ Sperchonopsis	5	p	2
Parachironomus sp.	10	p	1
Nanocladius sp.	3	s	1
Thienemanniella sp.	6	c	1
Gammarus lacustris	4	c	1
Undetermined Lymnaeidae	6	g	1
Nematoda	5	p	1
Dugesia tigrina	4	p	1
Enchytraeidae	10	c	1
			231

Orestimba 6

Lowest Taxa	T1	Lowest Taxa	T2	Lowest Taxa	T3
Cricotopus bicinctus gp.	25	Naididae	76	Naididae	159
Cricotopus sp.	17	*Cricotopus sp.*	71	*Cricotopus bicinctus* gp.	63
Gammarus lacustris	14	*Cricotopus bicinctus* gp.	45	*Prostoma sp.*	24
Undetermined Tubificidae	7	*Prostoma sp.*	31	*Cricotopus sp.*	20
Megadrile	5	Undetermined Erpobdellidae	10	Nematode	18
Naididae	4	*Hydroptila sp.*	5	Undetermined Erpobdellidae	11
Corbicula fluminea	3	*Corbicula fluminea*	5	*Paratanytarsus sp.*	3
Prostoma sp.	3	Nematod	5	Megadrile	3
Sperchon/ Sperchonopsis	2	*Gammarus lacustris*	4	*Eukiefferiella sp.*	2
Dicrotendipes sp.	1	*Physa/ Physella*	4	*Sperchon/ Sperchonopsis*	2
Cricotopus/ Orthocladius	1	*Dugesia tigrina*	4	*Gammarus lacustris*	2
Nanocladius sp.	1	Enchytraeidae	4	*Caecidota occidentalis*	2
Undetermined Orthocladiinae	1	Undetermined Tubificidae	4	Enchytraeidae	2
Hydroptila sp.	1	Megadrile	4	Undetermined Tubificidae	2
Caecidota occidentalis	1	*Cricotopus/ Orthocladius*	3	*Nanocladius sp.*	1
Physa/ Physella	1	*Sperchon/ Sperchonopsis*	3	*Physa/ Physella*	1
Enchytraeidae	1	*Dicrotendipes sp.*	2		315
	88	*Caecidota occidentalis*	2		
		Paratanytarsus sp.	1		
		Manayunkia speciosa	1		
			284		

Lowest Taxa	TV	FFG	Total
Naididae	8	c	239
Cricotopus bicinctus gp.	7	c	133
Cricotopus sp.	7	s	108
Prostoma sp.		c	58
Nematod	5	p	23
Undetermined Erpobdellid	8	p	21
Gammarus lacustris	4	c	20
Undetermined Tubificidae	9	c	13
Megadrile	5	c	12
Corbicula fluminea	10	f	8
Sperchon/ Sperchonopsis	5	p	7
Enchytraeidae	10	c	7
Hydroptila sp.	6	g	6
Physa/ Physella	8	g	6
Caecidota occidentalis	6	c	5
Paratanytarsus sp.	6	f	4
Cricotopus/ Orthocladius	7	s	4
Dugesia tigrina	4	p	4
Dicrotendipes sp.	8	c	3
Eukiefferiella sp.	8	c	2
Nanocladius sp.	3	s	2
Undetermined Orthocladiin	5	c	1
Manayunkia speciosa		c	1
			687

Orestimba 7

Lowest Taxa	T1
Gammarus lacustris	14
Corbicula fluminea	3
Naididae	2
Nematoda	1
Dugesia tigrina	1
	21

Lowest Taxa	T2
Gammarus lacustris	24
Physa/ Physella	1
Corbicula fluminea	1
	26

Lowest Taxa	T3
Gammarus lacustris	38
Naididae	30
Prostoma sp.	7
Undetermined Tubificidae	4
Cricotopus bicinctus gp.	3
Nematoda	3
Cricotopus sp.	2
Sperchon/ Sperchonopsis	2
Corbicula fluminea	2
Dugesia tigrina	2
Manayunkia speciosa	2
Eukiefferiella sp.	1
Undetermined Erpobdellidae	1
Temoridae	1
Fossaria sp.	1
Undetermined Hemiptera	1
Megadrile	1
Eudistylia vancouveri	1
	102

Lowest Taxa	TV	FFG	Total
Gammarus lacustris	4	c	76
Naididae	8	c	32
Prostoma sp.		c	7
Corbicula fluminea	10	f	6
Nematoda	5	p	4
Undetermined Tubificidae	9	c	4
Cricotopus bicinctus gp.	7	c	3
Dugesia tigrina	4	p	3
Cricotopus sp.	7	s	2
Sperchon/ Sperchonopsis	5	p	2
Manayunkia speciosa		c	2
Eukiefferiella sp.	8	c	1
Undetermined Hemiptera	10	p	1
Temoridae	8	c	1
Fossaria sp.	6	g	1
Physa/ Physella	8	g	1
Undetermined Erpobdellid	8	p	1
Megadrile	5	c	1
Eudistylia vancouveri		c	1
			149

Orestimba 8

Lowest Taxa	T1	Lowest Taxa	T2	Lowest Taxa	T3
Cricotopus bicinctus gp.	74	Naididae	111	Naididae	158
Gammarus lacustris	52	*Cricotopus bicinctus* gp.	71	*Cricotopus bicinctus* gp.	51
Cricotopus sp.	51	*Cricotopus sp.*	44	*Cricotopus sp.*	49
Naididae	49	*Prostoma sp.*	19	*Physa/ Physella*	37
Prostoma sp.	24	*Hydra sp.*	16	*Prostoma sp.*	23
Rheocricotopus sp.	9	Undetermined Tubificidae	8	Nematoda	13
Megadrile	5	Nematoda	6	Undetermined Tubificidae	13
Cricotopus trifascia gp.	4	*Sperchon/ Sperchonopsis*	5	*Sperchon/ Sperchonopsis*	11
Undetermined Tubificidae	4	*Physa/ Physella*	4	*Hydra sp.*	8
Paratanytarsus sp.	3	*Dicrotendipes sp.*	3	*Cricotopus trifascia* gp.	5
Cricotopus/ Orthocladius	3	*Cricotopus trifascia* gp.	3	Undetermined Erpobdellidae	5
Corisella decolor	2	*Dugesia tigrina*	2	*Manayunkia speciosa*	5
Hydroptila sp.	2	Undetermined Erpobdellidae	2	*Dugesia tigrina*	4
Sperchon/ Sperchonopsis	2	*Polypedilum sp.*	1	*Dicrotendipes sp.*	3
Corbicula fluminea	2	*Paratanytarsus sp.*	1	*Erioptera sp.*	3
Microtendipes sp.	1	*Corisella decolor*	1	*Gammarus lacustris*	2
Physa/ Physella	1	*Hydroptila sp.*	1	*Erpobdella punctata*	2
Dugesia tigrina	1	Hydrobiidae	1	Megadrile	1
Undetermined Erpobdellidae	1		299	*Eudistylia vancouveri*	1
	290				394

Lowest Taxa	TV	FFG	Total
Naididae	8	c	318
Cricotopus bicinctus gp.	7	c	196
Cricotopus sp.	7	s	144
Prostoma sp.		c	66
Gammarus lacustris	4	c	54
Physa/ Physella	8	g	42
Undetermined Tubificidae	9	c	25
Hydra sp.	5	f	24
Nematoda	5	p	19
Sperchon/ Sperchonopsis	5	p	18
Cricotopus trifascia gp.	7	s	12
Rheocricotopus sp.	6	c	9
Undetermined Erpobdellid	8	p	8
Dugesia tigrina	4	p	7
Dicrotendipes sp.	8	c	6
Megadrile	5	c	6
Manayunkia speciosa		c	5
Paratanytarsus sp.	6	f	4
Cricotopus/ Orthocladius	7	s	3
Erioptera sp.	3	c	3
Corisella decolor	10	p	3
Hydroptila sp.	6	g	3
Corbicula fluminea	10	f	2
Erpobdella punctata	8	p	2
Microtendipes sp.	6	f	1
Polypedilum sp.	6	s	1
Hydrobiidae		g	1
Eudistylia vancouveri		c	1
			983

Orestimba 9

Lowest Taxa	T1	Lowest Taxa	T2	Lowest Taxa	T3
Undetermined Tubificidae	160	Undetermined Tubificidae	89	Undetermined Oligochaeta	201
Naididae	56	*Physa/ Physella*	50	*Physa/ Physella*	31
Physa/ Physella	35	Naididae	48	Undetermined Orthocladiinae	26
Cricotopus bicinctus gp.	27	*Prostoma sp.*	20	Undetermined Tipulidae	14
Parachironomus sp.	13	Megadrile	17	Undetermined Erpobdellidae	7
Cricotopus sp.	12	*Cricotopus sp.*	13	Nematoda	5
Nematoda	5	Nematoda	7	Undetermined Coleoptera	2
Erpobdella punctata	3	*Cricotopus bicinctus* gp.	5	*Corbicula fluminea*	2
Prostoma sp.	2	*Erioptera sp.*	3	*Dugesia tigrina*	1
Paracymus sp.	1	*Dugesia tigrina*	3		289
Dicrotendipes sp.	1	*Gyraulus parvus*	1		
Odontomesa sp.	1	*Corbicula fluminea*	1		
Corbicula fluminea	1	Undetermined Erpobdellidae	1		
	317		258		

Lowest Taxa	TV	FFG	Total
Undetermined Tubificidae	9	c	249
Undetermined Oligochaeta	5	c	201
Physa/ Physella	8	g	116
Naididae	8	c	104
Cricotopus bicinctus gp.	7	c	32
Undetermined Orthocladiin	5	c	26
Cricotopus sp.	7	s	25
Prostoma sp.		c	22
Nematoda	5	p	17
Megadrile	5	c	17
Undetermined Tipulidae	3	s	14
Parachironomus sp.	10	p	13
Undetermined Erpobdellid	8	p	8
Corbicula fluminea	10	f	4
Dugesia tigrina	4	p	4
Erioptera sp.	3	c	3
Erpobdella punctata	8	p	3
Undetermined Coleoptera			2
Paracymus sp.	5	c	1
Dicrotendipes sp.	8	c	1
Odontomesa sp.	4	c	1
Gyraulus parvus	8	g	1
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Orestimba 10

Lowest Taxa	T1
Pseudochironomus sp.	54
Dicrotendipes sp.	28
Torrenticola/ Psuedotorrenticola	28
Rheotanytarsus sp.	23
Naididae	23
Fallceon quilleri	19
Cricotopus sp.	18
Cricotopus bicinctus gp.	12
Centroptilum/ Procloeon	9
Oxyethira sp.	9
Cyprididae	8
Bezzia/ Palpomyia	6
Peltodytes sp.	4
Tanytarsus sp.	4
Corynoneura sp.	4
Hexatoma sp.	4
Tricorythodes sp.	4
Helisoma anceps	3
Undetermined Hydrophilidae	2
Paratanytarsus sp.	2
Odontomyia sp.	2
Caenis sp.	2
Fossaria sp.	2
Nebrioporus/ Stictotarsus	1
Enochrus sp.	1
Glyptotendipes sp.	1
Nanocladius sp.	1
Thienemanniella sp.	1
Pentaneura sp.	1
Euparyphus sp.	1
Hedriodiscus/ Odontomyia	1
Baetis tricaudatus	1
Leucrocuta sp.	1
Hygrobatidae	1
Gyraulus parvus	1
Planorbula sp.	1
	283

Lowest Taxa	T2
Pseudochironomus sp.	36
Torrenticola/ Psuedotorrenticola	36
Rheotanytarsus sp.	32
Fallceon quilleri	22
Corynoneura sp.	20
Naididae	19
Cricotopus bicinctus gp.	16
Cricotopus sp.	14
Dicrotendipes sp.	13
Cyprididae	8
Oxyethira sp.	7
Simulium sp.	6
Tanytarsus sp.	5
Tricorythodes sp.	5
Bezzia/ Palpomyia	4
Centroptilum/ Procloeon	4
Undetermined Hydrophilidae	3
Caenis sp.	3
Planorbula sp.	3
Cricotopus trifascia gp.	2
Odontomyia sp.	2
Acentrella insignificans	2
Baetis tricaudatus	2
Sperchon/ Sperchonopsis	2
Oreodytes sp.	1
Peltodytes sp.	1
Enochrus sp.	1
Chironomus sp.	1
Polypedilum sp.	1
Cladotanytarsini sp.	1
Paratanytarsus sp.	1
Nanocladius sp.	1
Undetermined Orthocladiinae	1
Pentaneurini	1
Ambrysus mormon	1
Acentrella sp.	1
Hygrobatidae	1
Cyclopidae	1
	280

Lowest Taxa	T3
Fallceon quilleri	44
Corynoneura sp.	40
Rheotanytarsus sp.	34
Torrenticola/ Psuedotorrenticola	28
Simulium sp.	27
Pseudochironomus sp.	17
Cricotopus sp.	16
Cricotopus bicinctus gp.	11
Baetis tricaudatus	10
Naididae	10
Undetermined Hydrophilidae	6
Dicrotendipes sp.	6
Odontomyia sp.	5
Centroptilum/ Procloeon	5
Nebrioporus/ Stictotarsus	4
Hedriodiscus/ Odontomyia	4
Tricorythodes sp.	4
Enochrus sp.	3
Cricotopus trifascia gp.	3
Hexatoma sp.	3
Sperchon/ Sperchonopsis	3
Cyprididae	3
Peltodytes sp.	2
Bezzia/ Palpomyia	2
Tanytarsus sp.	2
Acentrella sp.	2
Tropisternus sp.	1
Thienemanniella sp.	1
Undetermined Orthocladiinae	1
Euparyphus sp.	1
Libellulidae	1
Gyraulus parvus	1
Undetermined Planorbidae	1
	301

Lowest Taxa	TV	FFG	Total
Pseudochironomus sp.	6	c	107
Torrenticola/ Psuedotorren	5	p	92
Rheotanytarsus sp.	6	f	89
Fallceon quilleri	4	c	85
Corynoneura sp.	7	c	64
Naididae	8	c	52
Cricotopus sp.	7	s	48
Dicrotendipes sp.	8	c	47
Cricotopus bicinctus gp.	7	c	39
Simulium sp.	6	f	33
Cyprididae	8	c	19
Centroptilum/ Procloeon	2	c	18
Oxyethira sp.	3	c	16
Baetis tricaudatus	5	c	13
Tricorythodes sp.	5	c	13
Bezzia/ Palpomyia	6	p	12
Undetermined Hydrophilid	5	p	11
Tanytarsus sp.	6	f	11
Odontomyia sp.	5	c	9
Peltodytes sp.	5	s	7
Hexatoma sp.	2	p	7
Nebrioporus/ Stictotarsus	5	p	5
Enochrus sp.	5	p	5
Cricotopus trifascia gp.	7	s	5
Hedriodiscus/ Odontomyia	5	g	5
Caenis sp.	7	c	5
Sperchon/ Sperchonopsis	5	p	5
Planorbula sp.	7	g	4
Paratanytarsus sp.	6	f	3
Acentrella sp.	4	c	3
Helisoma anceps	7	g	3
Nanocladius sp.	3	s	2
Thienemanniella sp.	6	c	2
Undetermined Orthocladiin	5	c	2
Euparyphus sp.	8	c	2
Acentrella insignificans	4	c	2
Hygrobatidae	5	p	2
Fossaria sp.	6	g	2
Gyraulus parvus	8	g	2
Oreodytes sp.	5	p	1
Tropisternus sp.	5	p	1
Chironomus sp.	10	c	1
Glyptotendipes sp.	10	s	1
Polypedilum sp.	6	s	1
Cladotanytarsini sp.	6	f	1
Pentaneura sp.	6	p	1
Pentaneurini	6	p	1
Ambrysus mormon	5	p	1
Libellulidae	9	p	1
Leucrocuta sp.	1	g	1
Cyclopidae	8	c	1
Undetermined Planorbidae	7	g	1
			864