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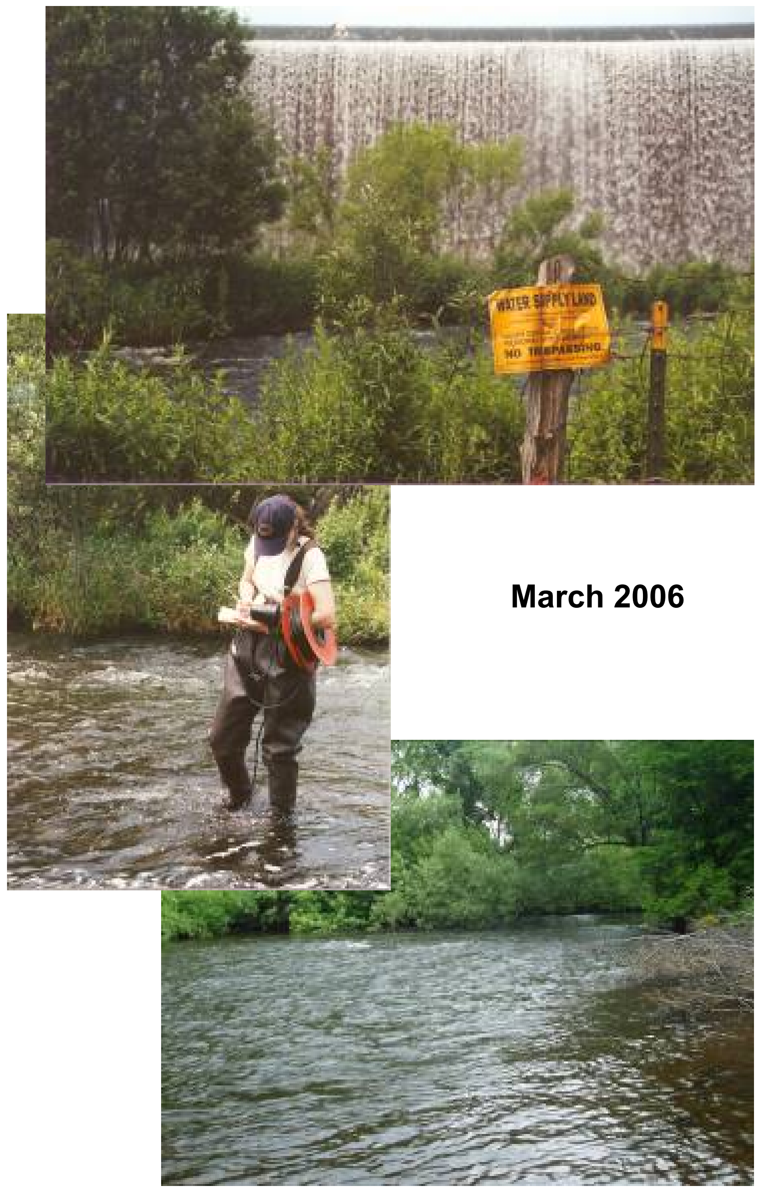
2005 BENTHIC BIOLOGICAL ASSESSMENT OF THE LOWER MILL RIVER, HAMDEN / NEW HAVEN (CT)

prepared for :

South Central Connecticut
Regional Water Authority
90 Sargent Drive
New Haven CT 06511



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prepared by :

ENSR | AECOM

11 Phelps Way, P.O. Box 506
Willington, CT 06279-0506

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INTRODUCTION

The purpose of this study is to provide baseline information for future management decisions in conjunction with possible alterations to present stream flows in the Mill River downstream of Lake Whitney. The study provides quantitative and qualitative information about general habitat characteristics and benthic macroinvertebrate community structure at five locations along the lower Mill River in Hamden and New Haven, CT. This study summarizes survey results from 2005. In April 2005 the new water treatment facility which draws water from Lake Whitney went online, and this study represents the first year of post-operational data collection. However, the water treatment facility was operating mostly in a testing mode in 2005, and withdrawals were generally near the low end of the expected range. It is intended that a review of all data collected in 2005 and future operational years will be conducted to evaluate any potential impacts to Mill River from the water withdrawal in Lake Whitney. Ultimately, pre-operation data will be compared to post-operation data. This investigation facilitates that analysis.

METHODS

General methods were consistent with previous years, beginning in 2000. Samples were collected in June and August 2005, at the peak of the tidal outflow (low tide). Sampling locations (Figure 1) were the same as previous years. Sampling stations were longitudinal stretches, ranging from 85 to 300 ft in length (~25-90 m). Each sampling station was characterized for general habitat and instream water quality at representative sites. A single sample per site was used to determine water quality features on the day of sampling. Flow values were daily means from SCCRWA flow records from the Whitney Dam.

Aquatic habitat was evaluated in a qualitative to semi-quantitative way. This was a modified version of the USEPA Rapid Bioassessment Protocol (Physical Characterization / Water Quality Assessment) (Barbour et al. 1999). Aquatic habitat characterization included features such as surrounding land use, canopy cover, flow, and substrate composition for each sampling station. Water quality was assessed in a quantitative way with in situ determinations of water temperature, dissolved oxygen content, conductivity, turbidity, and pH at each sampling station.

Timed (two minutes) D-frame dip-net sampling was used to collect macroinvertebrates. This method is commonly used as a multi-habitat rapid bioassessment technique (Barbour et al. 1999). Riffle habitats were sampled, although at higher flows some of these areas could be characterized as run habitats. Macroinvertebrates were captured in the net by dislodging the substrate up to 1 ft (0.3 m) upstream of the dip-net. Two subsamples per sampling station were collected. Each subsample consisted of a two-minute collection, itself comprised of four 30-second collection efforts at four nearby locations within the site. Subsamples were preserved in 70% ethanol for laboratory analysis. Macroinvertebrates were sorted, identified to the lowest practical taxonomic level, and counted. Samples were collected during the period of low tide on both sampling dates.

In 2005, Chironomidae samples from August 2003 and August 2005, representing wet and dry periods respectively, were identified to species to further facilitate water quality analysis. Although the main focus of this monitoring program is on the impacts of changing flows, flow can affect water quality, and pollution tolerance of individual species varies within the Chironomidae family. The analysis and discussion are attached in Appendix A of this report.

The two macroinvertebrate subsamples were analyzed separately, but combined into a single sample per station for data analysis. Variability among subsamples was evident, as is expected for such samples, but was not striking. Numerical analysis included relative abundance and dominance patterns on taxonomic and feeding group bases, species richness and diversity. Species richness was expressed as number of taxa (S). Species diversity quantifies the degree of dominance (or lack thereof) of taxa within a community; it measures the distribution of individuals among taxa present. When one or a few taxa dominate a community, diversity is low. Species diversity was calculated as the Shannon-Wiener index (H'), but this measure is affected by the number of taxa present. Evenness was therefore also applied, putting diversity on a scale of 0 to 1.0, with 1.0 representing the most even distribution of individuals among the number of taxa present. Mathematical descriptions of the indices can be found in Zar (1984).

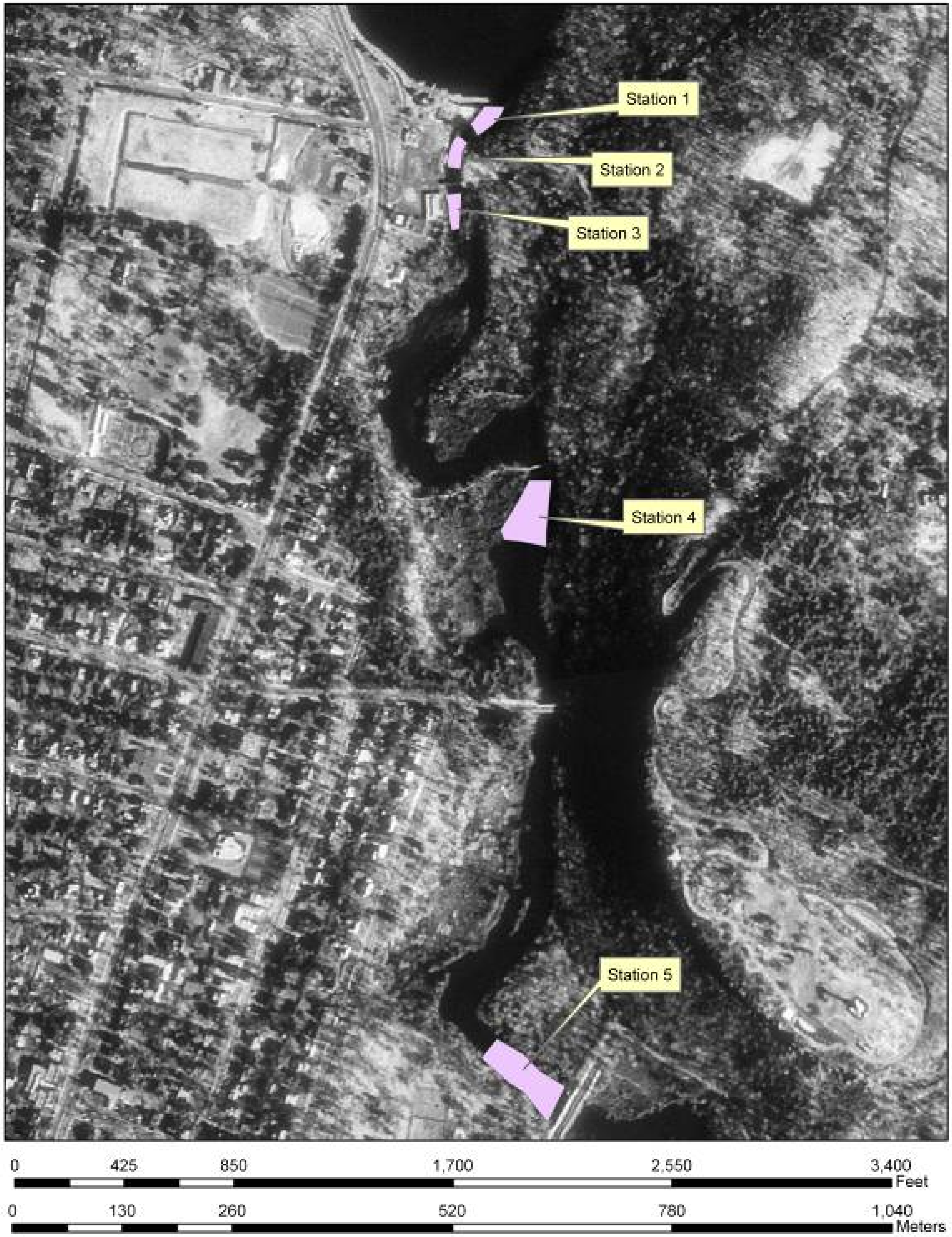

Figure 1. Locations of the five sampling stations along the Lower Mill River in Hamden (stations 1-4) and New Haven (station 5).

RESULTS

Habitat Characterization

Predominant land use (forest and residential) and sources of pollution (storm pipes discharging at several locations between stations 2 and 5) were the same in 2005 as in all previous surveys (Table 1). Sources of pollution to the lower Mill River include combined sewer overflows (CSOs), one of which is located in the study area (East Rock Road). CSOs can have strong but intermittent water quality impacts in the tidal areas of the river. Canopy cover was maximum at station 3 and minimum at station 1. Major shore or bank erosion was not observed.

Flow is measured by the SCCRWA at the spillway of Lake Whitney. Flows on the day of the survey are not necessarily an indication of antecedent conditions, however, and SCCRWA flow records were consulted to categorize the hydrological conditions for two and a half months before each sampling. In 2005 the spring flows were larger than the summer flows (Table 2), as expected. Based on factors such as tidal influence and watershed hydrologic characteristics, a wide range of flow conditions might be anticipated at any given time within the study area. Tidal influences are apparent at stations 3, 4 and 5, while variation in flow from Lake Whitney is the more dominant current influence at stations 1-2. However, while water level changes with tide are evident at station 3, saltwater does not intrude this far upstream.

The abundance and distribution of aquatic vegetation was similar to pre-operational years. The amount of filamentous algae and rooted aquatic plants varied among sampling locations in 2005 and is likely a function of varied flow. The abundance of aquatic macrophytes generally decreased in the downstream direction. Stations 4 and 5 were influenced by tidal activity involving saltwater intrusion, as indicated by the presence of intertidal organisms.

Average stream depth and width were similar to previous years. Tide influenced stream depth at the downstream sites, with slight water level changes observed during data collection at stations 4 and 5. However, as sampling at those sites was conducted under low tide conditions, observed fluctuations were minor in comparison with possible changes over the tidal cycle.

Inorganic substrates were generally coarser at the upstream sites (Stations 1 and 2) and progressively decreased in mean particle size in the downstream direction (Table 1). Fine-grained substrate such as silt was observed only at the most downstream stations (i.e., 4 and 5). Data from previous years suggest particle transport is occurring during large storm events, but the amount of transport has not been examined.

Detritus (e.g., logs, wood, leaf litter) was present at relatively low levels, indicating periodic flushing as would be expected in this large watershed. Most stations had similar percentages of detritus. Stations 4 and 5 had the greatest amount of detritus, but the relative amount was minimal in comparison with inorganic substrates. However, general amounts of detritus, both fine and coarse, appeared to be sufficient to support abundant populations of macroinvertebrates at all stations.

Vegetation levels in 2005 were similar to those in previous pre-operation survey years. Our experiences from previous years is that species tolerant of high flow such as attached moss and filamentous green algae (Chlorophyta: Chlorophyceae) comprised the majority of the vegetation at the upstream stations (1 and 2), but presence of rooted macrophytes (mostly narrow-leaved pondweeds) was noted in the upstream area during some samplings. Filamentous algal abundance increased in spring in response to decreasing flows, but tended to decline during summer despite lower flows, possibly as a function of lower light as the tree canopy developed, and possibly related to lower nutrient inputs or availability at lower flows. These same patterns were observed in 2005.

Waterlilies (*Nymphaea* sp., a freshwater species that prefers slow-flowing to lentic waters) were observed at the downstream stations. All the taxa of vascular plants encountered in the lower Mill River in 2005 were common taxa, tolerant of conditions such as low light, high nutrients, and salinity gradients (Crow and Hellquist 1980). Total plant coverage at the sites was within the typical ranges observed for temperate lotic systems (Allan 1995).

In general, habitat structure was suitable for macroinvertebrates at all stations in 2005. Substrate structural complexity (i.e., spatial heterogeneity) provides a diverse habitat for invertebrates, creating "niches" dominated by different food resources and hence varied invertebrate species, and/or providing crevices that protect invertebrates from predation or dislodgement by strong currents (Hixon & Menge 1991; Allan 1995). Macrophytes also contribute to increased spatial heterogeneity by providing a substrate rich in food resources (epiphytic algae and detritus covering the plants) (Diehl & Kornijów 1998). Physical substrate (cobble and gravel substrate) and/or macrophyte cover was sufficient to potentially support a rich and diverse macroinvertebrate community at all stations, although the quality of that habitat was not as high at stations 4 and 5 as at stations 1-3.

Selected water quality parameters were assessed in 2005 (Table 3). Assessed water quality in 2005 was similar to previous years with the exception of salinity. Water temperature in 2005 was within the range from previous years. Water temperature in June was higher than in August, which is not typical. Dissolved oxygen was always within the life-supporting range for most lotic fauna (Table 3), although August levels were on the lower end of observed conditions during previous years. In August 2005, the salinity levels at Stations 4 and 5 were the highest observed since monitoring began in 2000, with bottom salinity at Station 5 measuring 14 ppt in August.

Decreasing oxygen levels with increasing tidal influence were observed in a separate study (CH2MHill 2001), but not in the 2005 data. However, dissolved oxygen measurements during macroinvertebrate sampling took place during daylight hours when concentrations are positively influenced by algal photosynthesis.

Specific conductivity was comparable between stations 1, 2 and 3, but was considerably higher at stations 4 and 5. Saltwater influence from the recent tide was undoubtedly responsible and was likely due to greater saltwater intrusion under lower flows. There is evidence of saltwater intrusion at lower flows, extending upstream of Station 4 (CH2MHILL 2001).

Turbidity varied among stations and dates to some degree, but was generally low to moderate at the time of sampling. Very high turbidity is known from the Mill River system upstream of Lake Whitney, but the lake acts as a detention basin and minimizes downstream transport of particles much of the time. The pH of most samples was slightly basic to basic (Table 3). Higher pH values might be attributed to increased algal influence. Even so, pH remained within the life-compatible 4.5 – 9.5 range for most aquatic biota (Wetzel 2001b).

Table 1. - Lower Mill River habitat characterization. Data are for the June and August sampling events in 2005.

	Stn 1		Stn 2		Stn 3		Stn 4		Stn 5	
Parameters	**Jun**	**Aug**	**Jun**	**Aug**	**Jun**	**Aug**	**Jun**	**Aug**	**Jun**	**Aug**
Length of Segment	85 ft (26 m)		150 ft (46 m)		300 ft (91 m)		300 ft (91 m)		300 ft (91 m)	
Watershed/Bank Features										
predominant surrounding land use	forest/residential		forest/residential		forest/residential		forest/residential		forest/residential	
canopy cover	open		some shade (<40%)		mod. Shade (30-80%)		some shade (<40%)		some shade (<40%)	
dominant riparian vegetation	shrubs		shrubs		trees		trees/shrubs		trees	
bank stability (1)	stable		stable		stable		stable		stable	
other notable features	near dam		near dam		downstream of dam		tidal influence		tidal influence	
In-stream Features										
general habitat type (%)										
riffle	100	100	90	95	70	85	-	-	-	-
run	-	-	10	5	30	15	70	30	90	60
pool	-	-	-		-	-	30	70	10	40
estimated stream width (ft):	80	35	40	30	90	80	120	90	110	80
estimated stream depth (ft):										
riffle	1.4	0.5	1.5	1.2	0.6	0.3	-	-	-	-
run	-	-	0.8	1.0	0.8	0.5	3.0	2.0	3.5	2.0
pool	-	-	-	-	-	-	3.5	3.0	4.0	4.0
inorganic substrate composition(2)										
bedrock	-	-	-	-	-	-	-	-	-	-
boulder (>256 mm)	10	5	10	5	0	5	5	5	5	5
cobble (64-256 mm)	75	70	70	65	30	20	10	10	10	10
gravel (2-64 mm)	15	15	20	20	55	55	30	30	30	25
sand (0.06-2 mm)	-	-	-	10	15	25	45	40	40	40
silt (0.004-0.006 mm)	-	-	-	-	-	-	10	15	15	20
clay (<0.004 mm)	-	-	-	-	-	-	-	-	-	-
organic substrate composition(2)										
detritus(3)	0	5	5	5	5	10	15	10	10	10
aquatic macrophytes (total)	50	50	80	50	40	50	20	45	50	40
filamentous algae	100	100	40	20	80	60	20	20	40	20
water lilies (*Nymphaea, Nuphar*)	-	-	-	-	-	15	25	50	-	-
pondweeds (*Potamogeton spp*) (4)	-	-	60	80	10	20	30	25	50	70
moss	-	-				-		-		
waterweed (*Elodea canadensis*)	-	-			10	5	25	5	10	10
tidal influence	No	No	No	No	No	No	Yes	Yes	Yes	Yes

(1) stable = minimal evidence of erosion or bank failure
(2) percent coverage
(3) logs, wood, coarse particulate organic matter
(4) *Potamogeton richardsonii* at stn 5 and narrow-leaved species at the other stations.

Table 2. - Average flows at the Lake Whitney dam in spring (April 1-June 15) and summer (June 16-August 30) for 2005.

Season/Year	Flow (mgd)
Spring 2005	101
Summer 2005	30

Table 3. Water quality ranges at the sampling locations.

	Station 1			
Parameter	**Jun**		**Aug**	
water temperature (°C)	25.6		23.8	
dissolved oxygen (mg/L)	8.1		8.0	
dissolved oxygen (% saturation)	99.5		95.8	
specific conductivity (µS/cm)	271		286	
turbidity (NTU)	1.4		1.9	
pH (SU)	8.5		8.0	
	Station 2			
	Jun		**Aug**	
water temperature (°C)	26.2		24.0	
dissolved oxygen (mg/L)	7.4		7.9	
dissolved oxygen (% saturation)	90.8		94.3	
specific conductivity (µS/cm)	271		287	
turbidity (NTU)	2.2		1.9	
pH (SU)	8.2		7.9	
	Station 3			
	Jun		**Aug**	
water temperature (°C)	26.2		24.5	
dissolved oxygen (mg/L)	8.3		8.2	
dissolved oxygen (% saturation)	103		98.4	
specific conductivity (µS/cm)	271		286	
turbidity (NTU)	1.8		1.8	
pH (SU)	8.5		7.8	
	Station 4			
	Jun		**Aug**	
	Bottom	**Surface**	**Bottom**	**Surface**
water temperature (°C)		26.8	26.5	22.8
dissolved oxygen (mg/L)		9.8	6.8	4.8
dissolved oxygen (% saturation)		122	90.4	56
specific conductivity (µS/cm)		268	17100	2070
turbidity (NTU)		2.2		2.0
pH (SU)		8.6	7.1	7.2
Salinity (ppt)			10.0	1.1
	Station 5			
	Jun		**Aug**	
	Bottom	**Surface**	**Bottom**	**Surface**
water temperature (°C)		26.4	25.9	24.9
dissolved oxygen (mg/L)		9.2	7.7	7.4
dissolved oxygen (% saturation)		111.3	100.8	91.9
specific conductivity (µS/cm)		468	24100	10390
turbidity (NTU)		2.11		4.8
pH (SU)		8.5	7.4	7.5
Salinity (ppt)			14.4	5.6

Macroinvertebrates

This investigation focused on the invertebrate community as an indicator of conditions downstream of Lake Whitney. Invertebrates have long been used as indicators of environmental quality, and will reflect water quantity effects to the extent that water quantity affects water quality (e.g., dilution, runoff). In the extremes, water quantity can also affect invertebrates by altering the substrate (scouring or drying/oxidation), through dislodgment of biota with downstream transport, and through reduced available habitat under dry conditions. Most effects of water quantity are indirect, however, necessitating a considerable data base to allow an analysis that accounts for other potentially influential factors. An initial survey of the Mill River downstream of Lake Whitney was conducted in 1998, from which it was determined that invertebrates might provide suitable indication of the impact of changing flow as a consequence of the re-activation of Lake Whitney as a water supply.

2005 raw data for benthic macroinvertebrates has been analyzed in several ways relevant to questions of flow impacts. Total benthic macroinvertebrate abundance in 2005 (Figure 2) varied considerably within and among stations. The obvious conclusion for 2005 as well as previous years, supported visually, is that invertebrates are more abundant at stations 1-3 than at stations 4-5. There are both physical and chemical habitat changes between stations 3 and 4 that are more likely to be responsible for this difference than any variation in flow. The primary influence is tidal, with slower water velocities, changing direction of flow, and oscillating salinity at stations 4 and 5.

Taxonomically, the assemblage of invertebrates in the Mill River downstream of Lake Whitney exhibits variable richness (Table 3), with between 6 and 17 taxa identified at each station for both sampling occasions in 2005. The findings in 2005 are comparable to previous years where the number of taxa present at each station varied between 6 and 28.

A cumulative look at the abundance of invertebrates within the more common taxa encountered between 2000-2004 (Figure 4), indicates that the two most common taxa (the Amphipod *Gammarus* and the midge family Chironomidae) are by far the most abundant, each more than five times more abundant overall than the next most abundant taxon (the caddisfly *Macrostemum*). The 15 most abundant taxa are shown in Figure 4, with the next 10 most abundant lumped together and the remaining 56 taxa lumped into yet another category for graphic comparison. 2005 data are similar to the pooled abundance data from previous years (Figure 5), but differences between the top five most abundant taxa do exist. In 2005, Nais communis (oligochete worm) and Unidentified Empididae (dance fly) are in the top five taxa by abundance (Figure 5), however, neither are present in the top 15 from the cumulative 2000-2004 data (Figure 4). One important note is that two taxa in the family Empididae are in the top 15 for the cumulative data, so there have been relatively high numbers from this predatory family in previous years.

The common taxa observed in any one year were also encountered in the other years. In 2005, two new taxa were collected, Donacia (leaf beetles) and Neophylax (caddisfly). In previous years we found that less common taxa were not consistently observed over time or space. Rare taxa tend to be patchily distributed, and patchiness may be exacerbated by spatial habitat heterogeneity. Therefore, absence of such rare taxa in some samples or years may not mean that the taxa were not present in the lower Mill River system.

An alternative way to evaluate the macroinvertebrate data is to organize them by feeding groups. These groups have ecological meaning in terms of food resources and energy flow, and may be affected by flow insofar as flow affects food delivery from upstream, the growth of periphyton, and the accumulation of organic detritus. 2005 feeding group data varied between stations and among sampling dates (Figures 6-10). Stations 1-3 were dominated by collectors and filter feeders, while stations 4 and 5 showed less of a pattern. Increased predator abundance was apparent in the August sample at stations 1 and 2.

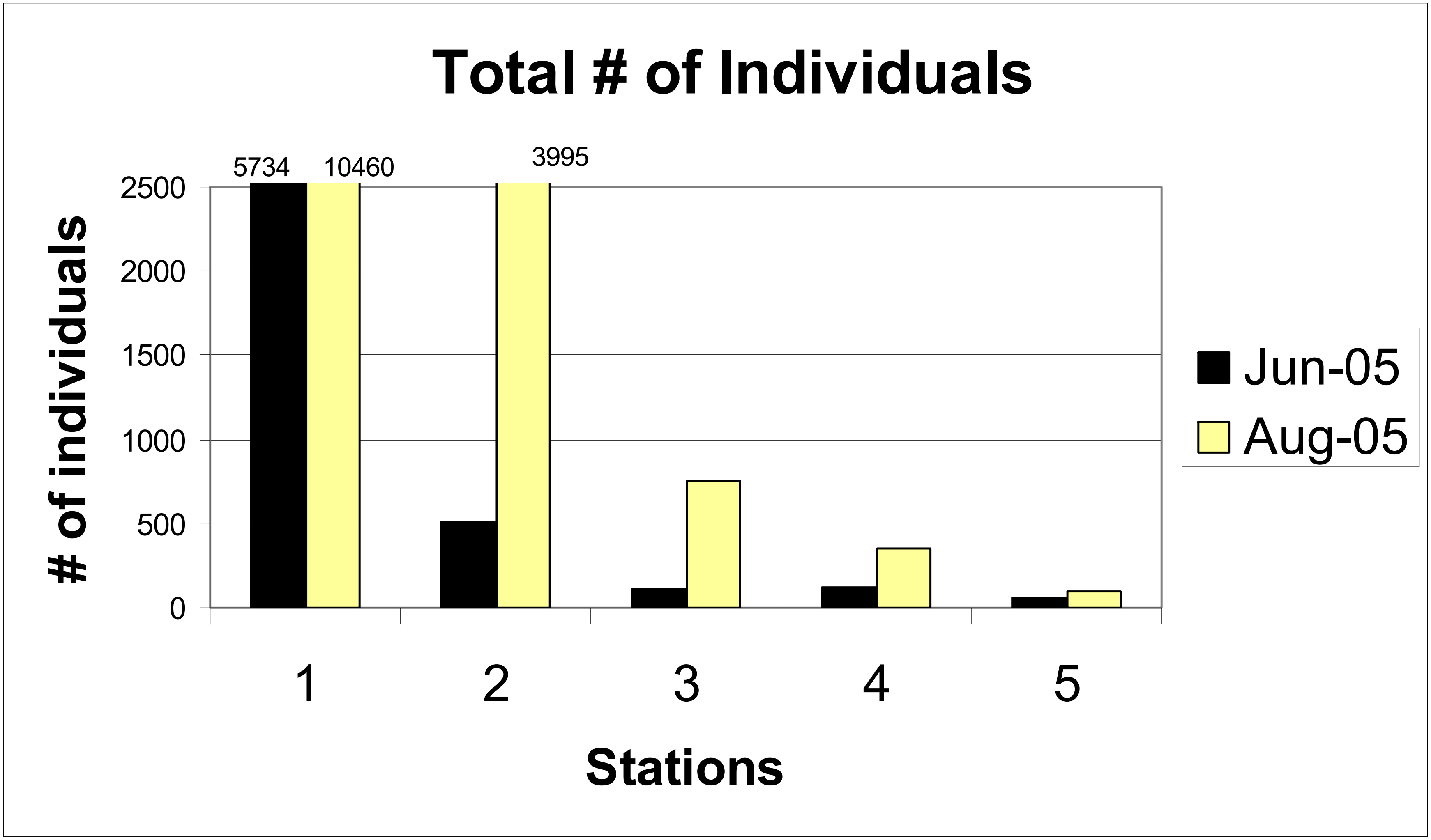

Figure 2. 2005 benthic macroinvertebrate abundance over space and time in the Mill River, downstream of Lake Whitney.

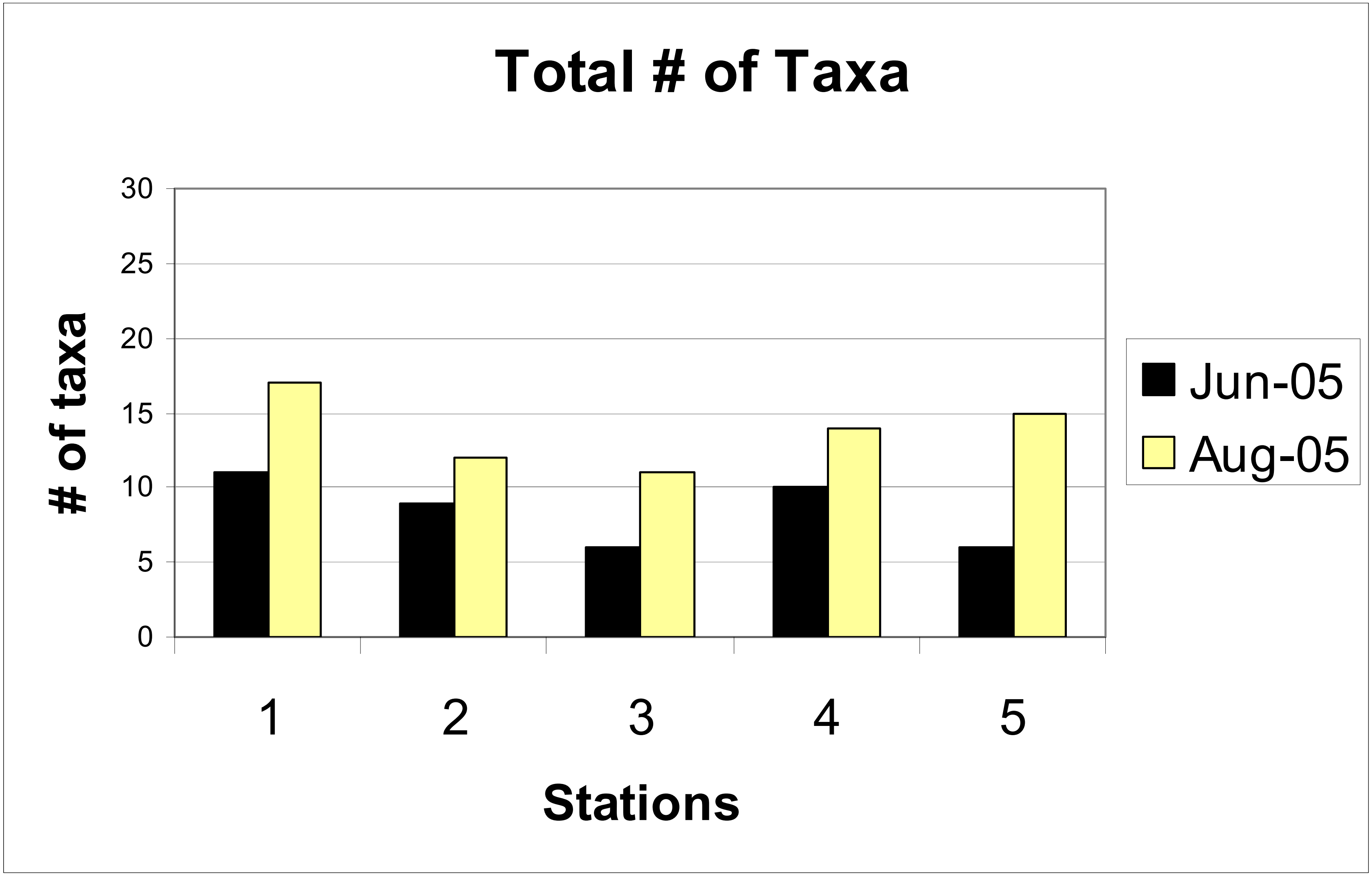

Figure 3. 2005 benthic macroinvertebrate taxa abundance over space and time in the Mill River, downstream of Lake Whitney.

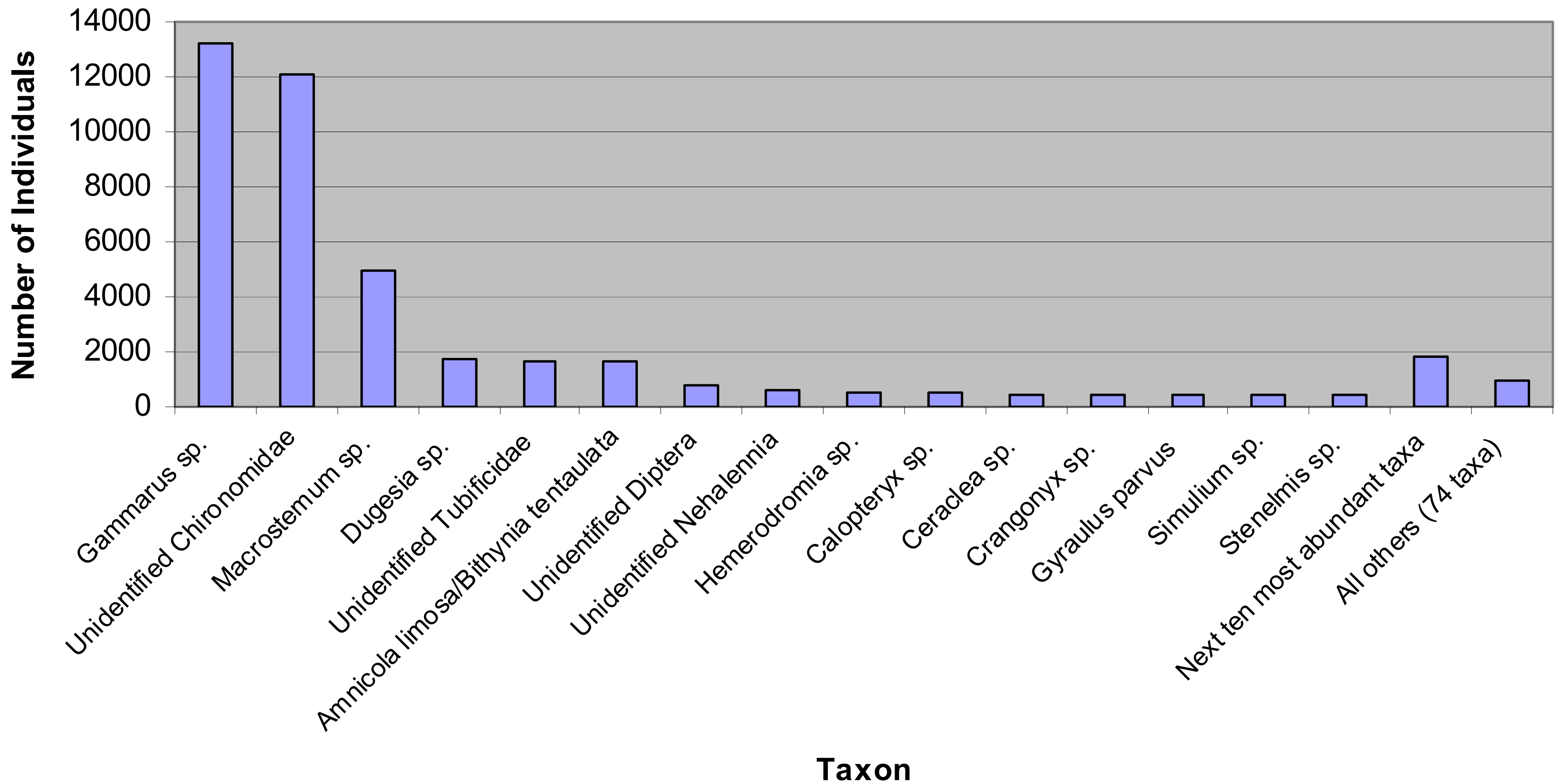

Figure 4. Pooled invertebrate abundance data for 2000-2004 in the Mill River, downstream of Lake Whitney. The 15 most abundant invertebrate taxa are graphed, after which the next 10 most abundant are grouped and the remaining individuals are grouped (74 taxa).

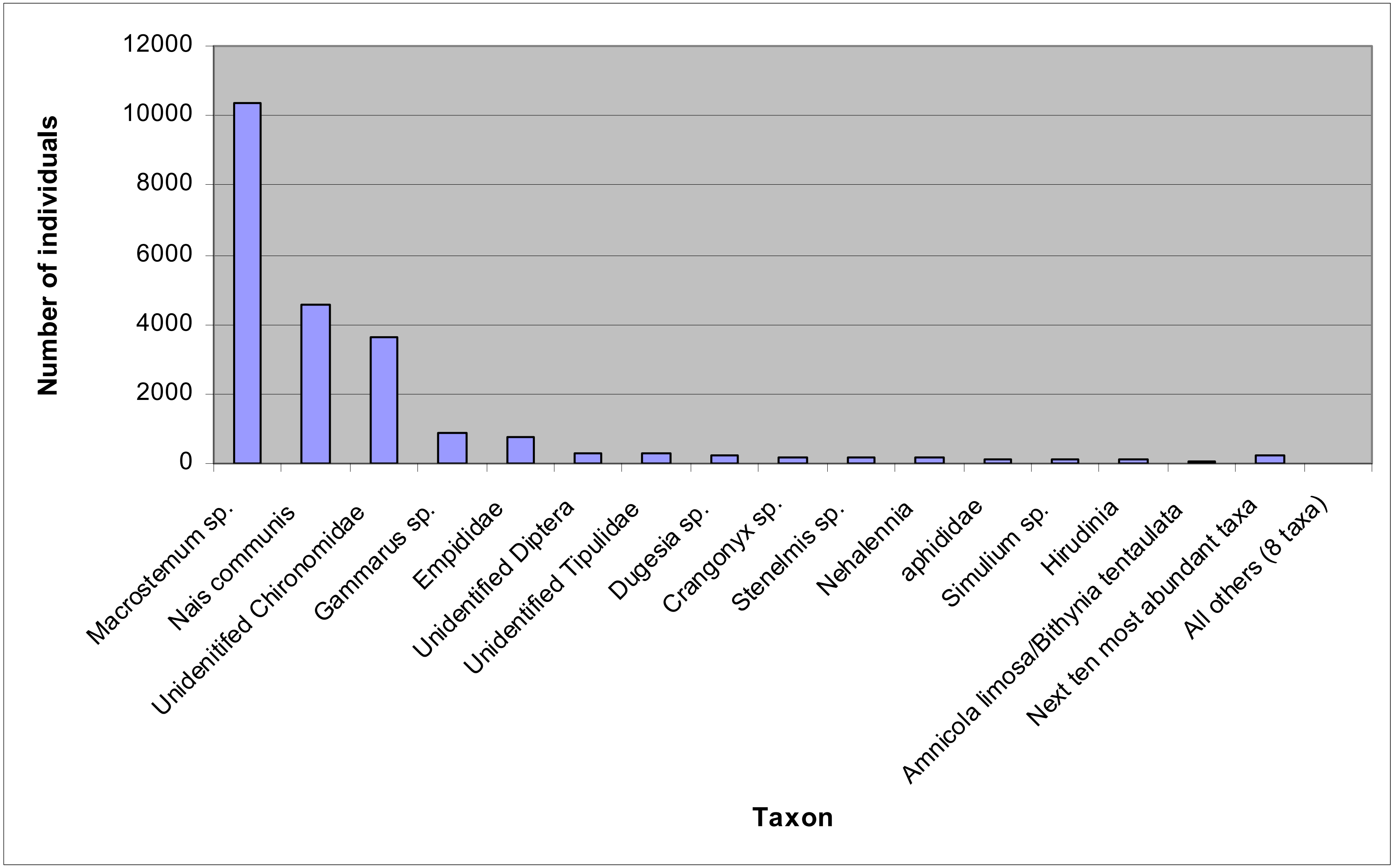

Figure 5. Pooled invertebrate abundance data for 2005 in the Mill River, downstream of Lake Whitney. The 15 most abundant invertebrate taxa are graphed, after which the next 10 most abundant are grouped and the remaining individuals are group (8 taxa).

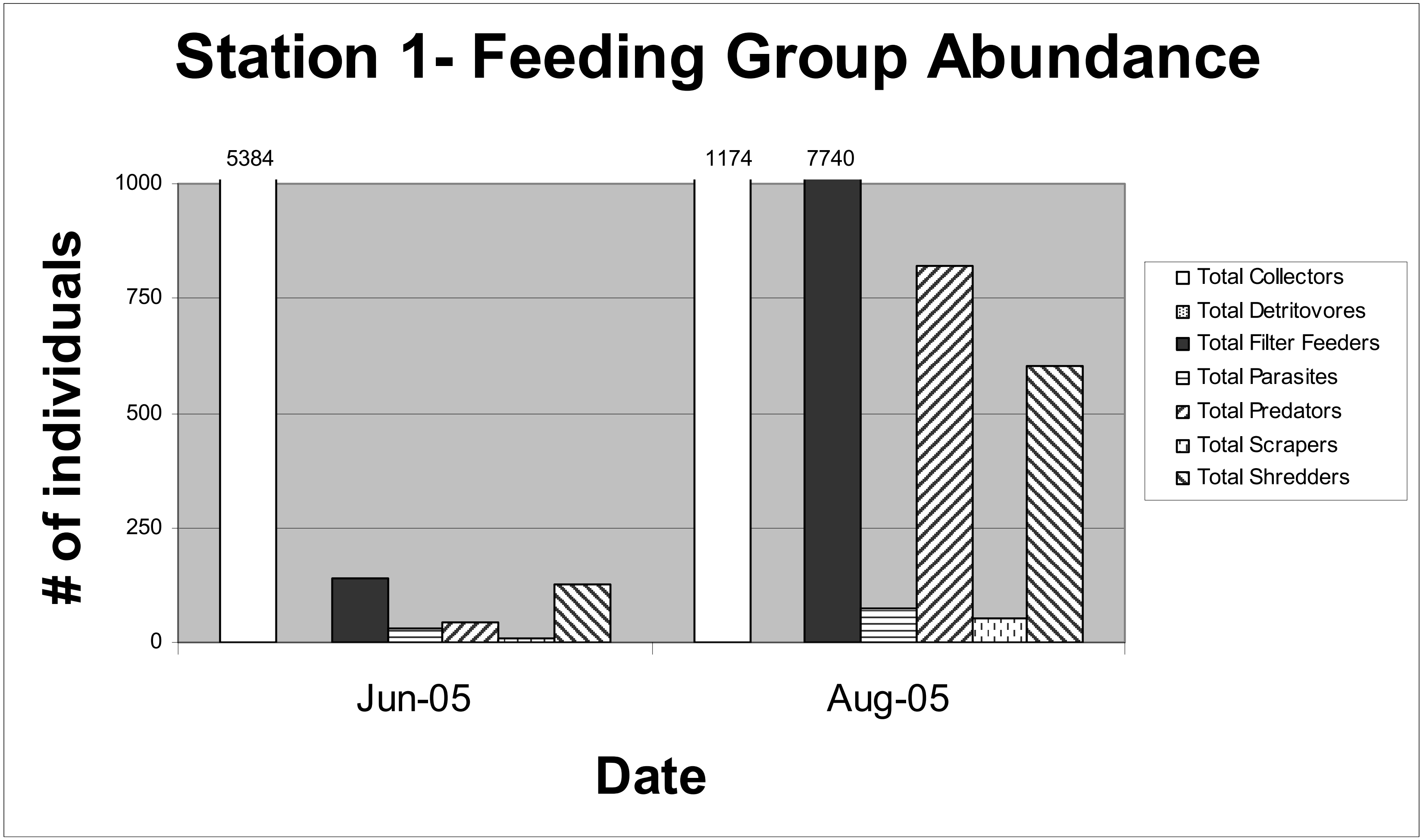

Figure 6. Feeding group presence at Station 1 in 2005.

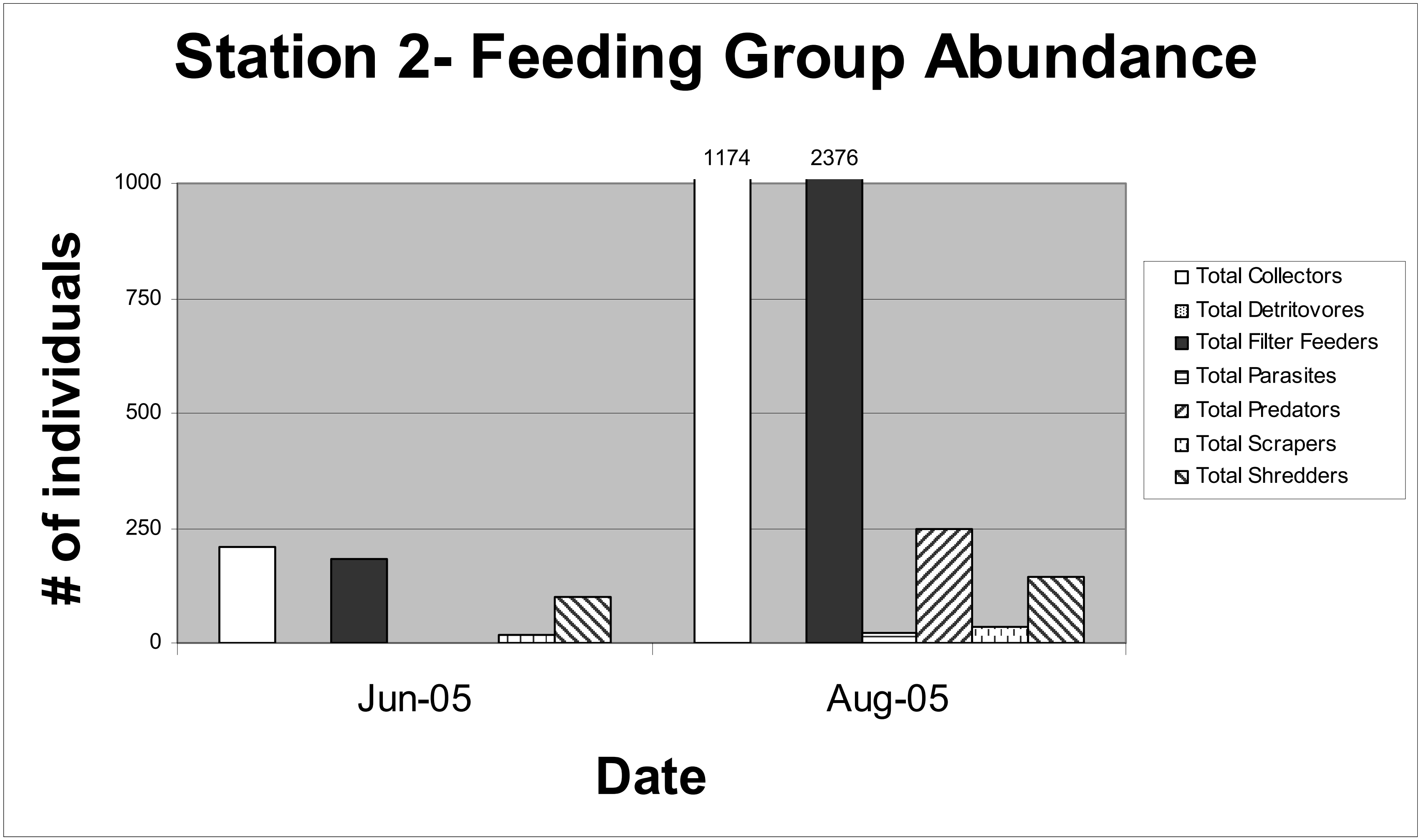

Figure 7. Feeding group presence at Station 2 in 2005.

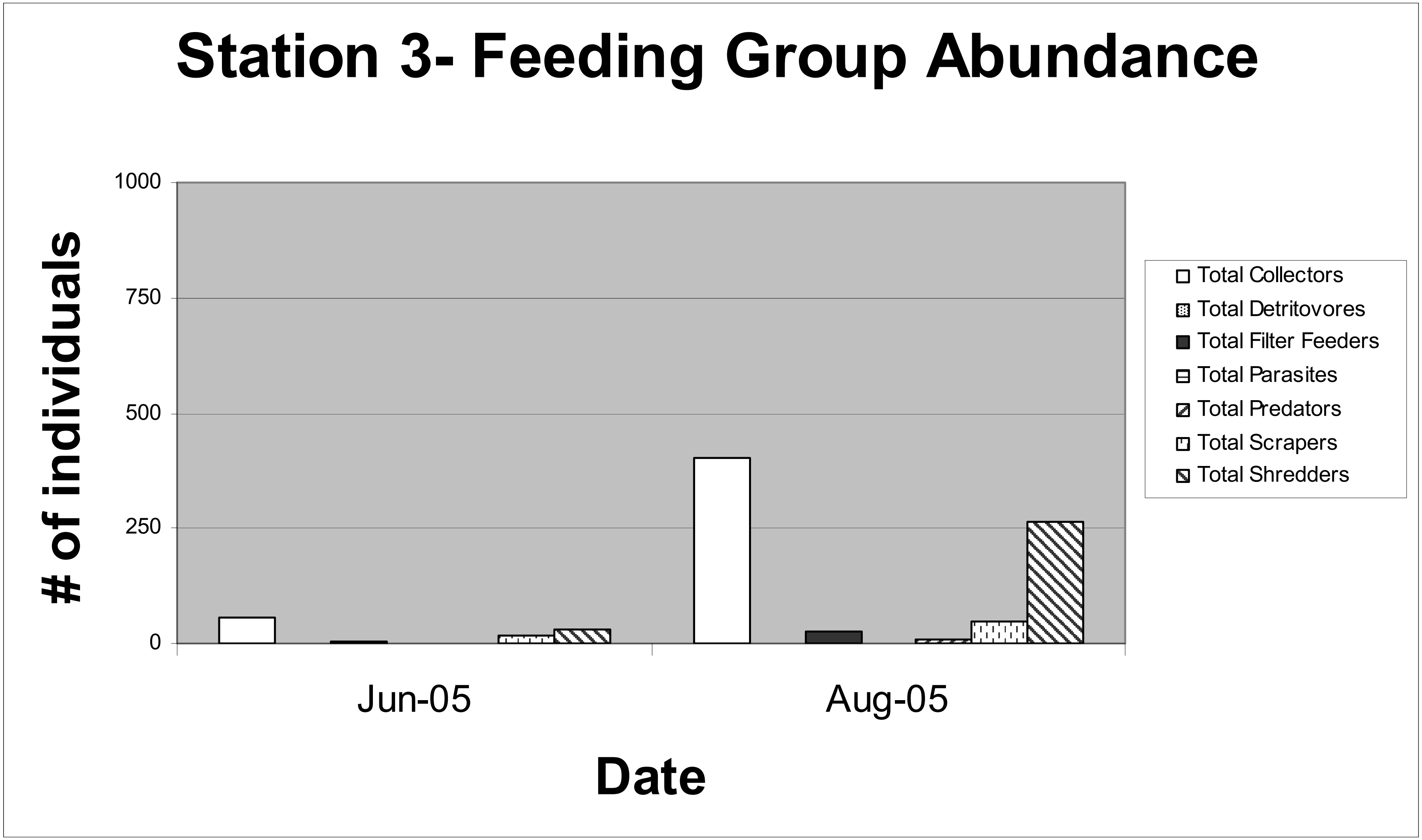

Figure 8. Feeding group presence at Station 3 in 2005.

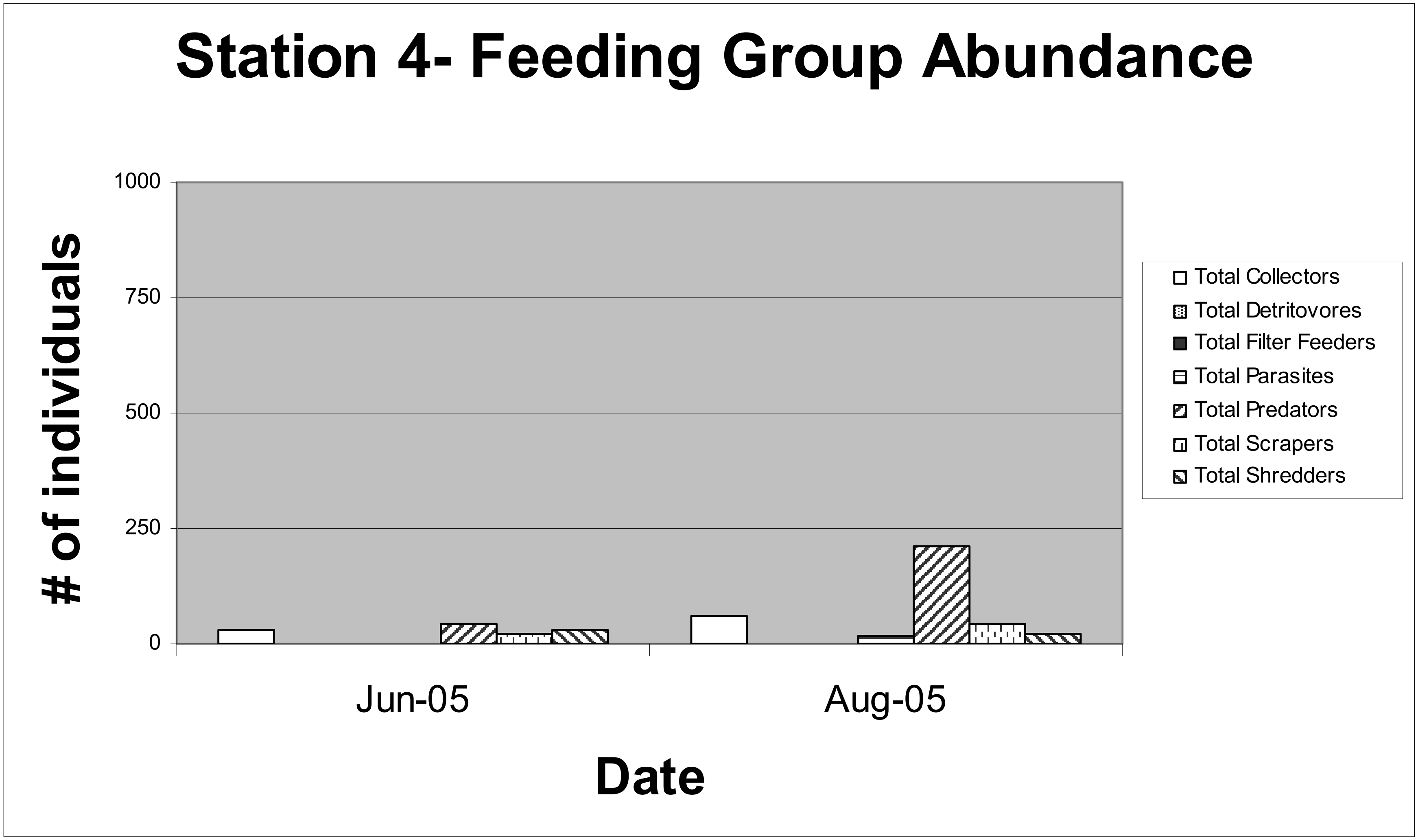

Figure 9. Feeding group presence at Station 4 in 2005.

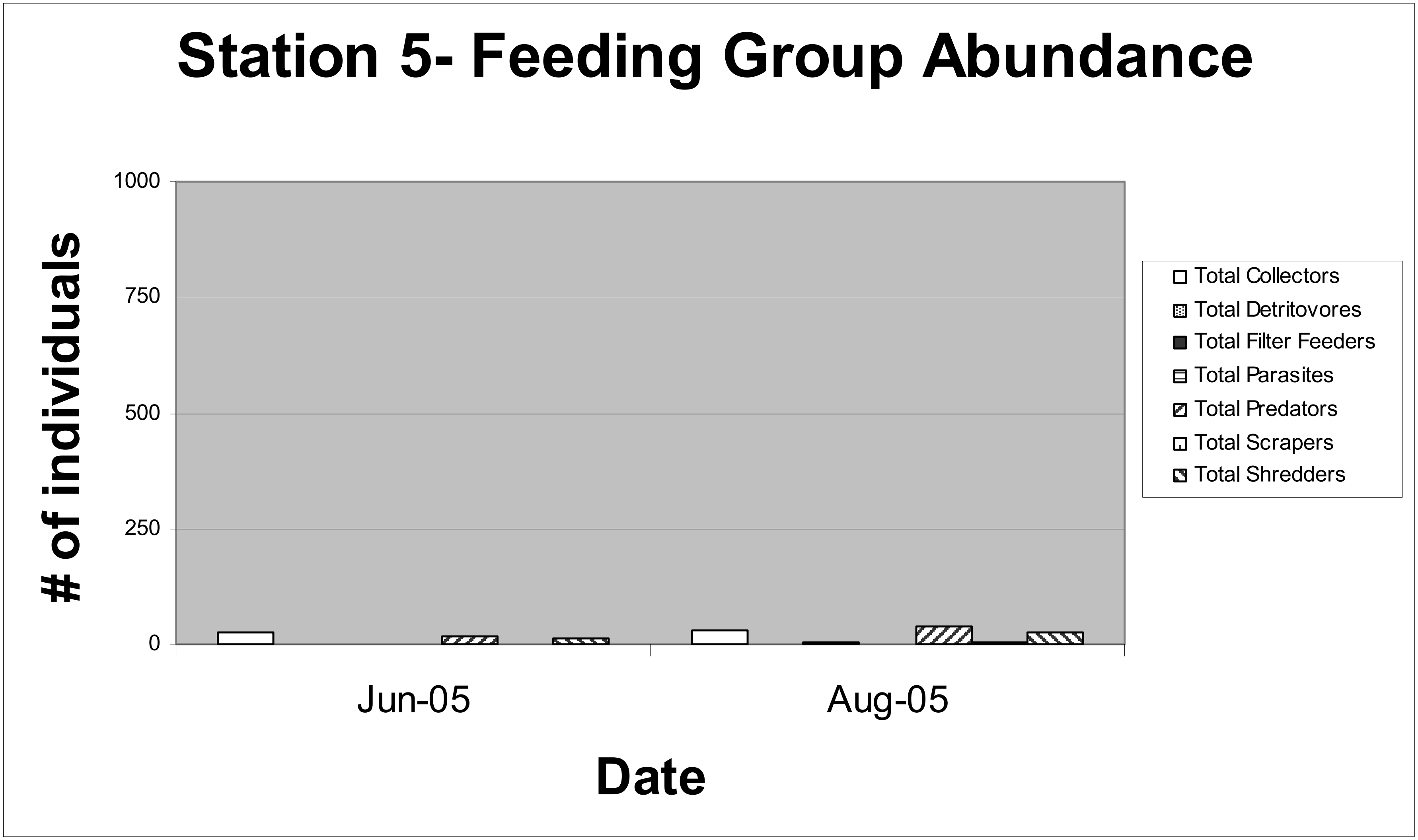

Figure 10. Feeding group presence at Station 5 in 2005.

DISCUSSION

Differences in macroinvertebrate taxonomic composition between the upstream (stations 1 through 3) and downstream stations (stations 4 and 5) may be ascribed mostly to differences in physical habitat and salinity exposure. Taxa that can tolerate influxes of marine water were found only at stations 4 and 5, including shrimp and crabs. Freshwater invertebrate tolerance to salinity is not well known, but some of the taxa found in the lower Mill River during previous years (e.g., scuds, damselflies, chironomid midges, beetles, and pulmonate snails) are found in relatively high numbers in moderately saline lakes (Colburn 1988; Alcocer et al. 1998).

Summer flow in 2005 calculated as the average flow 10 weeks prior to sampling was the lowest since sampling began. These low flows correspond with the lowest June through September precipitation levels measured at the Whitney precipitation gauge (9.3 inches) since 1984, more than 5 inches below the 95 year average of 14.9 inches. Salinity levels at stations 4 and 5 were higher than we've seen in any previous sampling year. In fact, bottom salinity at station 5 reached nearly 20 ppt in 2005 (CH2MHILL 2005). The flow pattern was not related to withdrawals from Lake Whitney, although there was one short test period for maximum withdrawal.

In 2005 we witnessed the largest numbers of invertebrates since the inception of the study program (Figure 11). By far, stations 1 and 2 had the largest total number of individuals (Figure 2). The number of invertebrates in August was higher than June for all stations. Station 1 had over 5000 invertebrates in June and over 10,000 in August. The likely reason for this increase is the availability of new habitat. In 2004, the lake drawdown for maintenance resulted in the addition of new rock substrate to station 1. Sampling in 2004 showed that the total numbers and diversity of invertebrates was increasing after the addition of the new substrate. This pattern of increasing recruitment to the new substrate is the most probable explanation for the high numbers in 2005.

Analysis of the feeding groups at each station indicates a potential response by predators between June and August at station 1 due to an abundance of prey items (Figure 6). Collectors were the dominant feeding group in June for stations 1-3. In August, stations 1 and 2 experienced a shift, and filter feeders were the dominant feeding group, comprised almost entirely of the filter feeding caddisfly *Macrostemum sp* (Figure 7). The first appearance of *Macrostemum* in the study area in great numbers (>500) occurred in 2003, and has increased in 2004 and 2005. Despite the general increasing pattern between years, there is no discernible pattern between months or stations.

In general, the macroinvertebrate assemblages observed in the Mill River were indicative of moderately healthy stream communities. The taxa collected at the five stations located along the Mill River may be commonly found in a range of environments (e.g., worms, scuds, prosobranch snails, caddisflies, mayflies). Most taxa found were typical of urban freshwater habitats (Walsh et al. 2001), where water quality impacts are common. Midges (Diptera Chironomidae) and worms (Oligochaeta, *Nais communis*), which were dominant invertebrates, can be found in a variety of freshwater habitats (Wetzel 2001c), but their dominance in a community is often regarded as a sign of degraded conditions. However, the most common invertebrate in 2005, *Macrostemum sp*. is less tolerant of pollution. The data show decreased numbers of Macrostemum in the downstream direction, indicating less favorable habitat or water quality conditions. Water quality data are generally similar at all stations, so habitat changes and increased salinity are the likely cause for the decline.

This study represents the first year of post-operational macroinvertebrate data related to the withdrawal of water in Lake Whitney. As such, although we have attempted to make comparisons, not enough data have been collected to facilitate longer term comparisons among sites or within sites over time as they relate to the activation of the water treatment facility. Initial impressions from these data should be tempered with the larger data set that will be generated over the course of the planned study.

As noted in the summary report for the 2000-2004 pre-operational monitoring program, changes in the invertebrate community over time may be a consequence of many environmental factors, including the desiccation of the stream during the dry summer months, changes in water quality, altered food abundance and quality, and predation effects. Flow is only one factor, and is likely to have more indirect effects at low levels. Variability in flow, inducing instability, may also be a potent factor in structuring the benthic macroinvertebrate community of the lower Mill River, and is linked to water quality issues (including dilution of contaminants from upstream and salinity from downstream), altered physical habitat, and available food resources.

Reduced flow may decrease invertebrate density and diversity (Gørtz 1998; Brunke et al. 2001), but flow interacts closely with the physical structure of the habitat. Streams with relatively low flow but high degree of habitat heterogeneity (coarse detritus, rocks, submerged vegetation) may still support high invertebrate density, taxonomic richness and diversity (Brunke et al. 2001). Increased vegetation cover may be expected at lower flow regimes, thus counterbalancing (at least in part) the potentially negative effects of decreased flow by increasing substrate heterogeneity. Relatively rapid response of invertebrate communities suggests that recovery will occur within months after a drought period.

Effects of increased salinity on the lower Mill River invertebrate assemblages are difficult to predict, but would seem likely to be more severe than minor changes in flow. Reduced freshwater flow could increase salinity effects. Most of the taxa found in this survey may withstand small increases in salinity, with invertebrate communities shaped more by physical habitat characteristics than those fluctuations in salinity (Alcocer et al. 1998). However, effects of possible tide-related bursts in salinity, exacerbated by lower flow or removal of tide gates, could shift the community to a taxa-poor, low-diversity assemblage dominated by high salinity tolerant taxa (Wolfram et al. 1999). The current community at stations 4 and 5, where salinity exposure is periodically high, already exhibit this condition to a large extent. The upstream portion of the lower Mill River (stations 1 through 3) appears unlikely to be significantly affected by tide-driven salinity bursts, because of its higher elevation.

As discussed in Appendix A, this monitoring program will be modified beginning in 2006. At Stations 1 through 4, Chironomids will be identified to a minimum of genus level in order to assess the variability among Chironomid types in responding to hydrologic changes. Station 5, where water quality is influenced more so by tidal changes and urban stormwater impacts than flows from Lake Whitney, will be dropped from the monitoring program.

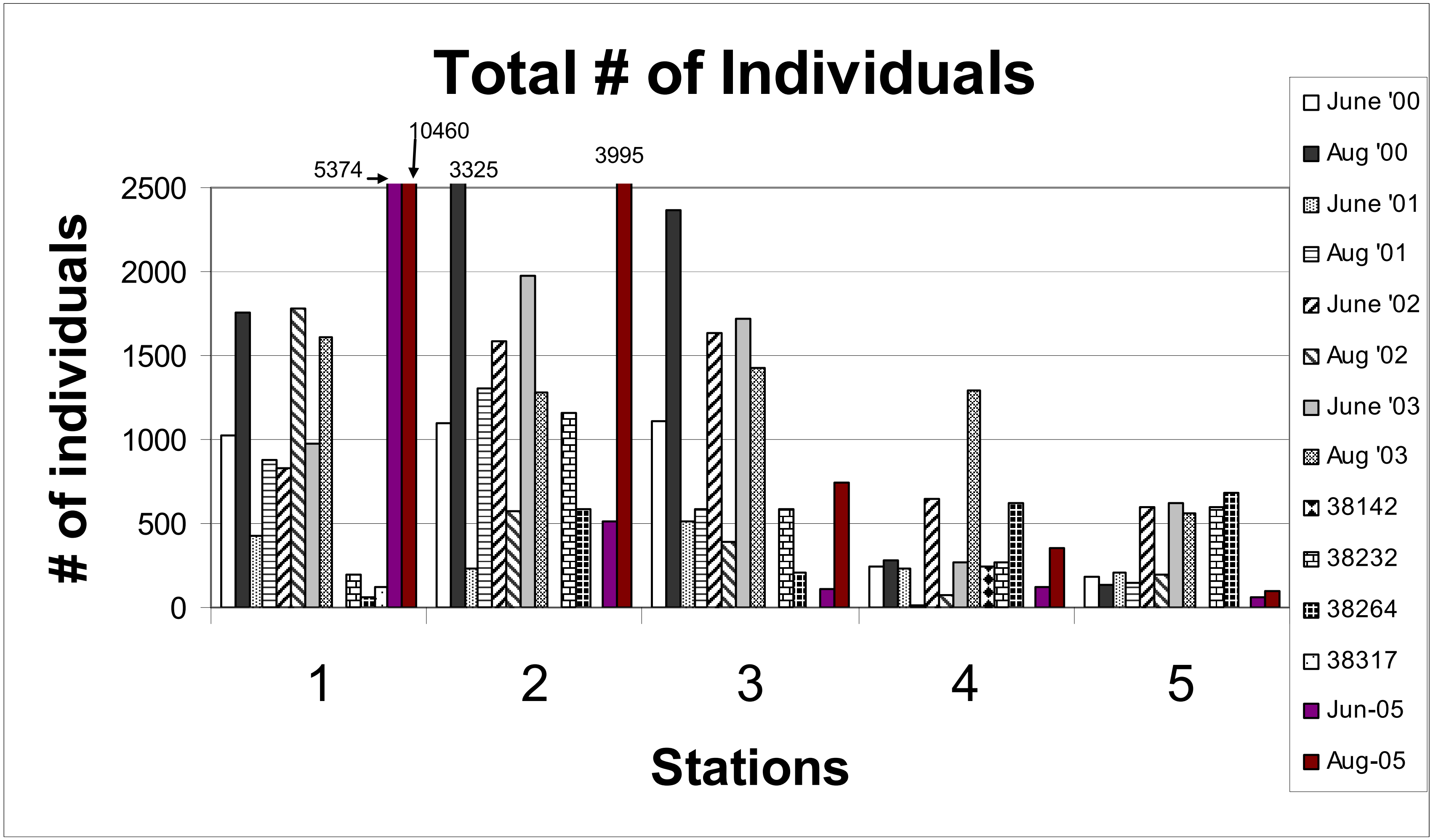

Figure 11. Total number of invertebrates over space and time in the Mill River, downstream of Lake Whitney for all years.

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APPENDIX A

2005 Chironomid Taxonomic Study Summary

2005 Lower Mill River Chironomid Taxonomic Study

Analysis of Mill River chironomids from samples collected at stations 2 and 4 during August of 2003 and August of 2005 was conducted to assess variability in responses to hydrologic changes among subclassifications of chironomids beyond family level. The stations were selected as representative of the two discernible reaches of the Mill River, the upstream portion minimally affected by tides and saltwater intrusion and the affected downstream portion. The dates were selected as representative of periods of high summer flow (2003) and low summer flow (2005), a variable of strong interest in this aquatic system. Up to 50 head capsules were separated from chironomid bodies and mounted in oil for viewing at 100 to 400X magnification with phase contrast optics. Only station 4 in August of 2005 had a limited number of chironomids; only 16 specimens were available for viewing. Identifications followed Simpson and Bode, 1980, a standard reference for this group, developed in New York State.

The results presented in the accompanying table demonstrate relatively low taxonomic richness and fairly consistent composition across years and flow regimes. There were a total of eight (8) taxa identified, all but one to the species level, representing four sub-families of the Chironomidae. The most common stream chironomid encountered in extensive NY collections (*Polypedilum convictum*) was most abundant in the Mill River at stations 2 and 4, followed by another very common and widespread chironomid (*Cricotopus trifascia*). The ecological indications of virtually all encountered species were of minimal water quality preference (found in a wide range of chemical conditions), high tolerance for elevated nutrients and organic matter (eutrophic conditions), and wide tolerance of current speed with a general preference for moderate to high velocities.

Table 1. Results of Chironomid Analysis (data as percent of individuals viewed).

	Station 2		Station 4		
Taxon	Aug-03	Aug-05	Aug-03	Aug-05	Ecological Notes
Chironominae					
Chironomini					
Polypedilum convictum	45.7	65.8	59.6	31.3	Most common stream Chironomid, no WQ preference, prefers moderate current, high suspended particles for food
Dicrotendipes neomodestus	2.2	0.0	14.9	25.0	Common, tolerant of high nutrients and organic compounds.
Chironomus riparius	0.0	2.6	0.0	0.0	Tolerates wide range of current and WQ
Tanytarsini					
Paratanytarsus sp.	4.3	2.6	4.3	12.5	No WQ preference
Rheotanytarsus exiguus	2.2	7.9	6.4	18.8	Wide WQ tolerance, prefers moderate current, high particulate content
Orthocladiinae					
Cricotopus trifascia	39.1	18.4	10.6	6.3	No water quality preference, prefers high current
Cricotopus intersectus	6.5	2.6	0.0	0.0	Tolerant of high nutrients, low DO, prefers slower current
Tanypodinae					
Ablabesmyia mallochi	0.0	0.0	4.3	6.3	Wide range of WQ and current speed
Total	100	100	100	100	

The ecological indications of the chironomid species present in the Mill River downstream of the Lake Whitney dam are entirely consistent with observed conditions over the last five years. If a knowledgeable benthic invertebrate ecologist constructed a list of species likely to be found downstream of Lake Whitney in the Mill River, all species actually encountered would be on that list, which would emphasize filter feeders tolerant of a wide range of water quality and flow conditions.

Identifying the chironomids to the species level to determine the ecological indications of the existing community was useful for verifying the assumption that chironomids in the Mill River are pollution and flow tolerant forms, given the range of known flows and water quality conditions. The community contains mostly the same taxa and shifts in relative abundance were not extreme over a very wide range of flows.

Based on discussions among members of the Whitney Environmental Study Team, the macroinvertebrate sampling program will be modified beginning in 2006. At Stations 1 through 4, Chironomids will be identified to a minimum of genus level in order assess the variability among Chironomid types in responding to hydrologic changes. Station 5, where water quality is influenced more so by tidal influences and urban stormwater impacts than flows from Lake Whitney, will be dropped from the monitoring program.

APPENDIX B

2005 Benthic Macroinvertebrate Data

					13-Jun-05					23-Aug-05				
					Stations					Stations				
					1	2	3	4	5	1	2	3	4	5
Class	Order	Family	Genus/Species	Feeding Group										
Annelida	Hirudinea	Glossiphoniidae	Glossiphonia complanata	Parasite										
Annelida	Hirudinea	Glossiphoniidae	Placobdella sp.	Parasite										
Annelida	Hirudinea		Hirudinia	Parasite	30					53	10			
Annelida	Oligochaeta	Lumbriculidae	Unidentified Lumbriculidae	Collector										
Annelida	Oligochaeta	Naididae	Nais communis	Collector	4127	55		17		367	7	13		
Annelida	Oligochaeta	Oligochaeta	Unidentified Oligochaeta	Collector						20				
Annelida	Oligochaeta	Tubificidae	Limnodrilus hoffmeisteri	Collector										
Annelida	Oligochaeta	Tubificidae	Unidentified Tubificidae	Collector										
Annelida	Polychaeta	Ampherididae	Unidentified Ampherididae	Detritivore										
Annelida	Polychaeta	Capitellidae	Heteromastus filiformis	Detritivore										
Annelida	Polychaeta	Spionidae	Marenzellaria viridis	Filter Feeder										
Annelida	Polychaeta	Spionidae	Polydora sp.	Detritivore										
Arachnida	Trombidiformes	Lebertiidae	Lebertia sp.	Predator								1	3	
Arachnoidea	Hydracarina	Arrenuridae	Unidentified Arrenuridae	Parasite				2					3	
Bivalvia	Veneorida	Pisidiidae	Pisidium sp.	Filter Feeder										
Branchiopoda	Cladocera		cladocera	Collector										
Crustacea	Amphipoda	Corophiidae	Corophium sp. (juvenile)	Filter Feeder										
Crustacea	Amphipoda	Crangonyctidae	Crangonyx sp.	Shredder	77	18				67				
Crustacea	Amphipoda	Gammaridae	Gammarus sp.	Shredder	50	82	30	30	12	247	137	264	15	14
Crustacea	Cumacea	Nannasticidae	Almyracuma proximoculi	Shredder										
Crustacea	Decapoda	Palaemonidae	Paleomonetes vulgaris	Shredder										8
Crustacea	Decapoda	Palaemonidae	Paleomonetes paludosus	Shredder										
Crustacea	Decapoda	Portunidae	Carcinus maenus	Shredder										1
Crustacea	Isopoda	Asellidae	Caecidotea communis	Collector										
Crustacea	Isopoda	Asellidae	Lirceus/Acellus sp. (communis)	Shredder										
Hydrozoa	Hydroida	Hydridae	Hydra sp.	Predator										
Insecta	Coleoptera	Brachyceridae	Brachycerus sp.	Collector					2			1		
Insecta	Coleoptera	Chrysomelidae	Donacia	Shredder									7	2
Insecta	Coleoptera	Coleoptera	Unidentified Coleoptera	Predator										
Insecta	Coleoptera	Curculionidae	Unidentifed Curculionidae	Shredder										
Insecta	Coleoptera	Dryopidae	Helichus sp.	Predator										
Insecta	Coleoptera	Elmidae	Stenelmis sp.	Scraper	10	16	18	3		20	24	48	20	1
Insecta	Coleoptera	Haliplidae	Peltodytes	Shredder										
Insecta	Coleoptera	Hydrophilidae	Berosus sp.	Predator		2		2		20			3	1
Insecta	Coleoptera	Psephenidae	Unidentified Psephenidae	Predator										
Insecta	Diptera	Atrichopogon	Atrichopogon	Predator	10			3						1
Insecta	Diptera	Ceratopognidae	Unidentified Ceratopognidae	Predator										
Insecta	Diptera	Chironomidae	Unidenitifed Chironomidae	Collector	1130	139	35	14	22	747	1087	385	48	23
Insecta	Diptera	Diptera	Unidentified Diptera	Collector	127	15	21			40	80	4	7	1
Insecta	Diptera	Empididae	Empididae	Predator						533	227			
Insecta	Diptera	Empididae	Hemerodromia sp.	Filter Feeder										
Insecta	Diptera	Simuliidae	Simulium sp.	Filter Feeder	50	39				33				
Insecta	Diptera	Tabanidae	tabanidae	Predator	33									
Insecta	Diptera	Tachinidae	Ceracia	Parasite										
Insecta	Diptera	Tipulidae	Unidentified Tipulidae	Shredder						287	7	1		
Insecta	Ephemeroptera	Baetidae	Baetis sp	Collector					2				6	6
Insecta	Ephemeroptera	Caenidae	Caenis sp.	Collector										
Insecta	Ephemeroptera	Ephemerellidae	Unidentified Ephemerellidae	Collector										
Insecta	Ephemeroptera	Heptageniidae	Stenonema sp.	Scraper										
Insecta	Ephemeroptera	Oligoneuridae	Isonychia sp.	Collector										
Insecta	Hemiptera	Aphididae	aphididae	Predator									133	
Insecta	Hemiptera	Hemiptera	Unidentified Hemiptera	Predator										
Insecta	Heteroptera	Gerridae	Unidentified Gerridae	Predator										
Insecta	Heteroptera	Gerridae	Rheumatobates sp.	Predator										1
Insecta	Heteroptera	Mesoveliidae	Mesovelia sp.	Predator										
Insecta	Heteroptera	Veliidae	Microvelia	Predator										
Insecta	Neuroptera	Sisyridae	Sisyira sp.	Predator										
Insecta	Odonata	Calopterygidae	Calopteryx spp	Predator										
Insecta	Odonata	Coenagrionidae	Argia sp.	Predator										
Insecta	Odonata	Coenagrionidae	Ischnura/Enallagma sp.	Predator										
Insecta	Odonata	Coenagrionidae	Nehalennia	Predator				36	16				73	34
Insecta	Odonata	Cordulegastridae	Epitheca	Predator										
Insecta	Odonata	Corduliidae	Didymops sp.	Predator										
Insecta	Odonata	Corduliidae	Somatochlora sp.	Predator										
Insecta	Odonata		Anisoptera (juvenile)	Predator										
Insecta	Odonata		zygoptera fragments	Predator										
Insecta	Trichoptera	Brachycentridae	Brachycentrus sp.	Filter Feeder										
Insecta	Trichoptera	Brachycentridae	Micrasema sp.	Filter Feeder										
Insecta	Trichoptera	Glossosomatidae	Glossosoma	Scraper										
Insecta	Trichoptera	Hydropsychidae	Hydropsyche sp.	Filter Feeder										
Insecta	Trichoptera	Hydropsychidae	Macrostemum sp.	Filter Feeder	90	145	3			7707	2376	24		3
Insecta	Trichoptera	Hydropsychidae	Parapsyche sp.	Filter Feeder										
Insecta	Trichoptera	Hydroptilidae	Agraylea sp.	Parasite						20	10	1	13	
Insecta	Trichoptera	Hydroptilidae	Orthotrichia sp.	Predator										
Insecta	Trichoptera	Hydroptilidae	Oxyethira sp.	Predator										
Insecta	Trichoptera	Leptoceridae	Ceraclea sp.	Collector										
Insecta	Trichoptera	Leptoceridae	Mystacides sp.	Collector										
Insecta	Trichoptera	Leptoceridae	Triaenodes sp.	Shredder										
Insecta	Trichoptera	Limnephilidae	Rossiana sp.	Scraper										
Insecta	Trichoptera	Limnephilidae	Unidentified Limnephilidae	Scraper										
Insecta	Trichoptera	Philopotamidae	Chimarra spp	Filter Feeder										
Insecta	Trichoptera	Psychomyiidae	Psychomyia sp.	Collector										
Insecta	Trichoptera	Uenoidae	Neophylax	Shredder										1
Malacostraca	Amphipoda	Hyalellidae	Hyalella azteca	Collector										
Malacostraca	Decapoda	Cambaridae	Orconectes limosus	Shredder										
Malacostraca	Decapoda	Cambaridae	Unidentified Cambaridae	Shredder			1		2					
Maxillopoda	Sessilia	Balanidae	Balanus improvisus	Filter Feeder										
Mollusca	Bivalvia	Sphaeriidae	Unidentified Sphaeriidae	Scraper										
Mollusca	Gastropoda	Ancylidae	Ferrissia rivularis	Scraper										
Mollusca	Gastropoda	Gastropoda	Unidentified Gastropoda	Scraper										
Mollusca	Gastropoda	Hydrobiidae	Amnicola limosa/Bithynia tentaulata	Scraper						33			13	
Mollusca	Gastropoda	Hydrobiidae	Pomatiopsis sp.	Scraper										
Mollusca	Gastropoda	Lymnaeidae	Lymnaea columella	Scraper										
Mollusca	Gastropoda	Physidae	Physa sp.	Scraper				3					8	3
Mollusca	Gastropoda	Planorbidae	Gyraulus circumstriatus	Scraper										
Mollusca	Gastropoda	Planorbidae	Gyraulus deflectus	Scraper										
Mollusca	Gastropoda	Planorbidae	Gyraulus parvus	Scraper										
Mollusca	Gastropoda	Planorbidae	Helisoma sp.	Scraper				15			10			
Mollusca	Gastropoda	Pleuroceridae	Pleurocera sp.	Scraper										
Mollusca	Gastropoda	Valvatidae	Valvata tricarinata	Scraper										
Nemertea	Nemertea	Nemertea	Unidentified Nemertea	Predator						33				
Turbellaria	Tricladida	Dugesiidae	Dugesia sp.	Predator						233	20	7		
				Total Individuals	5734	511	108	125	56	10460	3995	749	352	100
				Total Taxa	11	9	6	10	6	17	12	11	14	15