2000 Benthic Biological Assessment of The Lower Mill River

Hamden / New Haven (CT)

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prepared for:

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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. This 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 supplements and updates a similar 1998 study, but provides a more detailed habitat and macroinvertebrate characterization.

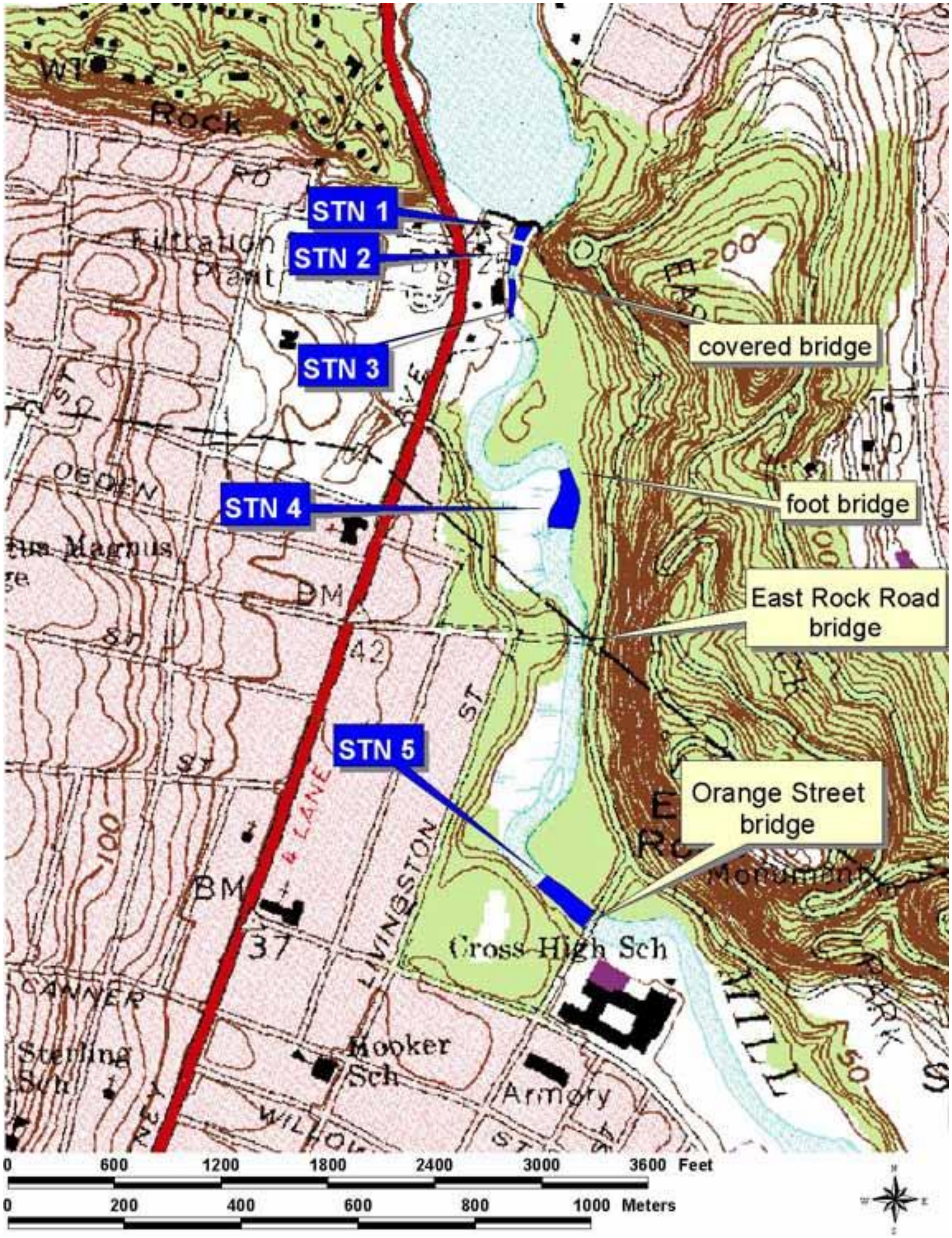
METHODS

General methods followed those applied in the 1998 survey (ENSR 1998). Periphyton and fish surveys were not performed in 2000. Samples were collected in June and August 2000, at the peak of the tidal outflow (low tide). Sampling locations were the same as in the 1998 study. The five sampling locations were located between the Lake Whitney outlet and the Orange Avenue Bridge (Figure 1). Sampling stations were longitudinal stretches, ranging from 85 to 300 ft in length (~25-90 m). Each sampling station was characterized for instream and general habitat and for water quality at representative sites within the stream stretch. A single subsample was used to determine water quality parameters. Macroinvertebrates were collected as duplicate D-frame dip-net samples at each station.

Aquatic habitat was evaluated in a qualitative to semiquantitative way adopting the same framework used in the 1998 study (ENSR 1998). This was a modified version of the USEPA Rapid Bioassessment Protocol (Physical Characterization / Water Quality Assessment) (Plafkin et al. 1989). 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 methodology is commonly used as a multihabitat rapid bioassessment technique (Barbour et al. 1999). Where present, riffle habitats were sampled. Otherwise, run habitats were selected. 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. Subsamples were preserved in 70% ethanol for laboratory analysis. Macroinvertebrates were sorted, identified to the lowest meaningful taxonomic level, and counted. Samples were collected during the period of low tide on both sampling dates (approximately 8:00 AM on 22 June and 12:00 noon on 1 August).

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



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The two subsamples were analyzed separately, but combined into a single sample per station for graphic analysis. Variability among subsamples was slight. Numerical analysis included relative abundance and dominance patterns, species richness, diversity, and evenness. Species richness was expressed as number of taxa (S). Species diversity indices quantify the degree of dominance (or lack thereof) of taxa within a community. When one or a few taxa dominate a community, diversity is low. Species diversity was calculated as the Shannon-Wiener index (H'), which includes both distribution/dominance patterns and number of taxa (i.e, a community with a high number of taxa is more "diverse" than a community with a low number of taxa, all other things being equal). Evenness (Pielou's index J') normalizes H' in relation to number of taxa, and therefore provides the basis for a quantitative diversity comparison between communities with different S values.

RESULTS

Habitat Characterization

Predominant land use (forest and residential) and sources of watershed pollution (storm pipes discharging at several locations between stations 2 and 5) were the same as in the 1998 survey (Table 1). Source of pollution to the Lower Mill River also include four combined sewer overflows (CSOs), one of which is located in study area (East Rock Road). Canopy cover was maximum at station 3 and minimal at station 1, like in 1998. Major shore or bank erosion was not noted in either of the study years.

Flow (as estimated or calculated at the spillway) was greater during the August sampling because of intense precipitation in the 24 hours preceding the sampling. The June 2000 flow was comparable to the April 1998 flow, and may be considered typical for spring to early-summer discharges. Instream flows were not considered low at any time during sampling.

Instream features were variable between sampling locations, and within locations at some stations. Riffle habitats were predominant at the most upstream station (station 1), as expected (Table 1). The upstream stations were also the least susceptible to flow-driven changes in habitat composition, maintaining a high proportion of riffle and/or run habitats. The two downstream stations (stations 4 and 5) exhibited the widest fluctuations in habitat composition from date to date. These stations had run characteristics in 1998, but exhibited a high proportion of pool habitat in 2000. Stations 4 and 5 were also evidently influenced by tidal activity (Table 1), with numerous barnacle shells observed at station 5 and some at station 4.

Table 1. Lower Mill River habitat characterization - June and August 2000. Flow, as estimated at the Lake Whitney outlet, was 138 cfs on June 22 and 184 cfs on August 1. Watershed characteristics did not change from June to August:

	stn 1	stn 2	stn 3	stn 4	stn 5

parameters	22 Jun	1 Aug	22 Jun	1 Aug	22 Jun	1 Aug	22 Jun	1 Aug	22 Jun	1 Aug
length of sampling 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	
local watershed pollution	some potential sources		obvious sources		obvious sources		obvious sources		obvious sources	
canopy cover	open		some shade (<40%)		mod. shade (40-80%)		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	upstream dam		upstream dam		upstream dam		upstream dam		upstream dam	
in-stream features										
general habitat type (%) :										
riffle	100	100	90	90	70	95	-	-	-	-
run	-	-	10	10	30	5	75	40	80	-

pool	-	-	-	-	-	-	25	60	20	100
estimated stream width (ft) :	55	70	55	65	70	100	130	100	110	100
estimated stream depth (ft) :										
riffle	0.8	1.0	0.7	1.0	0.7	0.8	-	-	-	-
run	-	-	1.2	0.8	2.0	0.5	3.0	2.0	3.0	-
pool	-	-	-	-	-	-	4.0	2.0	4.0	2.5
inorganic substrate composition[2]										
bedrock	-	-	-	-	-	-	-	-	-	-
boulder (>256 mm)	10	10	10	10	5	-	5	5	5	5
cobble (64-256 mm)	75	70	70	60	40	40	20	20	15	20
gravel (2-64 mm)	15	20	20	20	40	40	10	5	20	30
sand (0.06-2 mm)	-	-	-	10	15	20	50	55	40	30
silt (0.004-0.006 mm)	-	-	-	-	-	-	15	15	20	15
clay (<0.004 mm)	-	-	-	-	-	-	-	-	-	-
organic substrate composition[2]										
detritus[3]	5	5	5	5	5	10	5	10	15	5
aquatic macrophytes	50	30	30	25	20	20	15	40	10	55
filamentous algae	50	30	25	25	15	traces	5	-	5	-

water lilies	-	-	-	-	-	20	5	-	-	-
clasping-leaf pondweed(4)	-	-	-	-	-	-	-	15	-	50
other pondweeds	-	-	5	-	5	-	5	15	-	5
waterweed	-	-	-	-	-	traces	-	10	5	-
other notable features					tidal influence		tidal influence		tidal influence	

(1) stable = minimal evidence of erosion or bank failure.

(2) % coverage

(3) logs, wood, coarse particulate organic matter

(4) Potamogeton perfoliatus

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Average stream width and depth varied between and within stations (Table 1). As in 1998, stream width and depth depended on flow regime, with enlarged and deeper stream segments at high flow. However, stations 4 and 5 exhibited a narrower and shallower pattern during the August 2000 high flow. Tide influenced stream width and depth at these downstream sites. Decrease in measured flow between the Lake Whitney spillway and downstream sites (ENSR 1998) suggests that some flow may be lost along the downstream pathway as outseepage (groundwater recharge), but available flow data are too limited to make a conclusive determination.

Inorganic substrates were generally larger at the upstream sites (stations 1 and 2), and decreased progressively along the Lower Mill River (Table 1). Fine-grained substrate such as silt was substantial only at the downstream stations (4 and 5). It was not possible to determine the origin of the increased proportion of sand at station 2 in August (high flow).

Quantity of detritus (logs, wood, leaf litter, and other coarse particulate organic matter) did not change appreciably between and within stations, except for station 5, which had more detritus in June (moderate flow) than August (high flow). This and the slight increase in detritus at stations 3 and 4 may be explained by storm events that preceded the August 2000 sampling; leaves and small branches could have entered the stream because of the storms, and were probably better retained at the stations with larger substrate, while being washed away at station 5. Increased water turbulence because of increased flow could also have contributed to an increase in instream detritus by dislodging material already present.

Aquatic macrophytes rarely comprised a large portion of the organic substrate (Table 1). The vast majority (up to 100%) of the living plant material at the upstream sites (stations 1 and 2) was attached filamentous green algae (Chlorophyta: Chlorophyceae). As in 1998, abundance of green algae decreased from the spring to the mid-summer sampling, but the decrease in 2000 was lower than in 1998. The unusually wet summer of 2000 could explain this pattern, with frequent precipitation importing sufficient amounts of water and nutrients to support the algae throughout the summer.

Vascular plants exhibit few adaptations to life in fast flowing waters (Allan 1995). Accordingly, vascular plants in the Lower Mill River were more abundant at the downstream sites, where areas of low or no current were also more abundant. At these sites, vascular plants were more abundant in August than June, following the peak in seasonal growth. All the taxa of vascular plants encountered in the Lower Mill River 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).

Selected water quality parameters were assessed again in 2000 (Table 2). Water quality parameters were comparable in 1998 and 2000.

Table 2. Water quality at the sampling locations, summer 2000:

		station 1	
parameter		22 Jun	1 Aug
water temperature (° C)		21.1	19.8
dissolved oxygen (mg/l)		9.0	9.4
dissolved oxygen (% saturation)		103	108
specific conductivity (m S/cm)		189	194
turbidity (NTU)		3.2	4.4
pH (SU)		7.8	7.6
		station 2	

		22 Jun	1 Aug
water temperature (° C)		21.3	19.7
dissolved oxygen (mg/l)		9.8	9.0
dissolved oxygen (% saturation)		112	100
specific conductivity (m S/cm)		190	192
turbidity (NTU)		3.3	2.8
pH (SU)		7.8	7.6
		station 3	
		22 Jun	1 Aug
water temperature (° C)		21.1	19.7
dissolved oxygen (mg/l)		9.6	9.3
dissolved oxygen (% saturation)		108	103
specific conductivity (m S/cm)		189	194
turbidity (NTU)		3.8	2.7
pH (SU)		7.6	7.6
		station 4	
		22 Jun	1 Aug
water temperature (° C)		21.9	19.7
dissolved oxygen (mg/l)		10.4	8.9
dissolved oxygen (% saturation)		114	99
specific conductivity (m S/cm)		189	194
turbidity (NTU)		3.5	3.1
pH (SU)		7.7	7.6

		station 5	
		22 Jun	1 Aug
water temperature (° C)		23.1	19.7
dissolved oxygen (mg/l)		9.0	9.6
dissolved oxygen (% saturation)		106	107
specific conductivity (m S/cm)		193	197
turbidity (NTU)		3.9	3.3
pH (SU)		7.4	7.6

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The relatively low water temperature recorded in August 2000 was likely due to the high flow and runoff following the storm event that preceded the sample collection, and is considered to be within the normal range. Dissolved oxygen was always within the life supporting range for most lotic fauna. Higher dissolved oxygen values recorded in April 1998 were related to the spring low temperature. The relatively high August 2000 dissolved oxygen values were likely due to the storm-related high flow. Specific conductivity in 2000 was comparable in June and August, and to the 1998 values. On average, conductivity in August 2000 was approximately 35-40% lower than the 1998 August conductivity. Likewise, the August 2000 pH was slightly lower than the August 1998 pH. Higher flow in 2000 was likely responsible for this pattern, with less brackish water entering the Lower Mill stream channel. Turbidity exhibited comparable values at all stations in both 1998 and 2000, with no clear pattern between stations.

Macroinvertebrates

Total invertebrate numbers were substantially higher in 2000 (up to one order of magnitude at some sites) than 1998, but macroinvertebrate assemblage structure and patterns followed those observed in 1998. In general, the three upstream stations (sites 1, 2 and 3) exhibited markedly higher invertebrate density, species richness, and species diversity than the two downstream sites (stations 4 and 5) (Table 3; Figures 2 and 3). This pattern followed closely that observed in 1998. Taxonomic resolution was lower in 1998, but a few taxa did not appear in 2000 (Eubranchiopoda or fairy shrimps, Lepidoptera or moths, Odonata Anisoptera or dragonflies, and Diptera Tipulidae or crane flies). Hydracarina (water mites) were also not observed in 2000, but the generally high flow might have washed these small-bodied organisms downstream.

Hydracarina density in 1998 was very low, with the very few water mites observed only during the low-flow August sampling (ENSR 1998). On the other hand, a few taxa observed in 2000 were not recorded in 1998. These included the Hirudinea (leeches), the Neuropteran *Sysira* (a small-bodied predator specialized on freshwater sponges, collected as a single individual), and the Dipteran *Simulium*. A complete list of the macroinvertebrate taxa, with numbers collected and taxonomic and ecological (feeding) characterization, is presented in Tables 4 and 5.

In general, the macroinvertebrate assemblages observed in 2000 were indicative of degraded conditions, as in 1998 (ENSR 1998). Most of the invertebrate taxa collected were either moderately tolerant or highly tolerant of organic enrichment and other forms of pollution. Most taxa were typical of urban freshwater habitats. Tolerance to salinity for most taxa was not known. Presence of a few strictly freshwater taxa at the downstream sites such as damselfly nymphs (Odonata Zygoptera) in June but not August suggests that tidal influence, as evident from barnacle shells at stations 4 and 5, may be strong enough in summer months that flow from upstream freshwater sources cannot counteract it (at least under current release rates from Lake Whitney).

Table 3. Number of individual macroinvertebrate (by taxa) at each sampling site, June and August 2000. Sampling time is also reported:

	22 June										**1 August**									
	sites										**sites**									
	1		**2**		**3**		**4**		**5**		**1**		**2**		**3**		**4**		**5**	
	A	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
taxon	**12:05**	**11:50**	**12:25**	**12:15**	**12:45**	**12:35**	**13:20**	**13:10**	**14:15**	**14:05**	**8:20**	**8:30**	**9:00**	**8:50**	**9:10**	**9:20**	**9:40**	**9:50**	**10:10**	**10:20**
Hydra	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Dugesia	-	7	51	42	21	22	62	-	-	-	36	289	-	309	-	16	-	-	-	-
Amn.	44	38	24	34	33	45	1	7	-	3	18	19	96	11	36	35	-	-	-	-

limosa																2				
Physa gyrina	-	-	14	1	2	1	-	4	-	1	11	-	24	1	2	2	-	9	-	-
Gyr. parvus	-	1	4	-	2	8	-	-	-	1	8	14	143	4	18	99	1	1	1	-
Gyr. deflectus	2	-	-	-	-	1	-	-	-	-	-	-	3	-	-	-	-	-	-	-
G. circumstr.	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	6	-	-	-	-
Helisoma	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ferr. rivularis	-	-	5	-	1	-	-	-	-	-	-	-	3	-	1	4	-	-	-	-
Sphaeriidae	1	-	4	1	1	3	-	1	-	-	-	-	1	-	1	3	-	1	-	-
Gl. complanata	-	-	-	-	-	-	-	1	-	-	-	3	2	-	1	1	1	-	-	-
Placobdella	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-
Oligochaeta	-	-	-	-	-	-	-	-	11	4	-	-	-	-	-	-	-	-	1	-
Lumbriculidae	1	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Crangonyx	12	68	66	21	13	7	-	2	-	-	83	3	11	8	6	12	-	-	-	-

Gammarus	369	50	185	355	297	326	11	37	-	1	1185	27	1984	327	1180	724	64	95	22	2
Lirceus	12	20	-	-	7	2	-	1	-	-	6	3	3	6	8	-	-	-	-	-
Argia	-	-	-	5	1	-	-	3	2	1	-	-	-	-	-	-	-	-	-	-
Ischnura	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	1	-
Caenis	-	1	-	-	-	-	1	-	-	-	1	-	2	-	2	-	-	-	12	2
Isonychia	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-
Triaenodes	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Ceraclea	-	-	2	2	5	39	-	2	-	-	8	4	16	20	16	19	-	-	-	-
Mystacides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Macrostemum	9	1	9	10	2	1	-	-	-	-	-	1	7	1	7	1	-	-	-	-
Parapsyche	8	5	3	3	2	1	-	3	-	-	9	-	-	-	1	-	1	-	-	-
Psychomia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	-
Orthotrichia	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
Oxyethira	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	1	-	-	-
Sysira	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-

Berosus	-	-	-	3	1	7	1	-	-	-	-	-	1	4	4	3	-	-	-	-
Hemerodromia	-	1	1	24	6	7	-	-	-	-	1	7	14	84	19	4	-	-	-	1
Simulium	32	19	12	24	2	-	-	-	-	-	5	-	6	-	-	-	-	-	-	1
Chironomidae	160	194	164	108	83	190	88	89	40	111	38	12	26	310	186	20	68	34	62	24
TOTAL	**650**	**405**	**544**	**636**	**479**	**642**	**164**	**151**	**56**	**124**	**1410**	**382**	**2347**	**1086**	**1489**	**1267**	**140**	**142**	**102**	**30**

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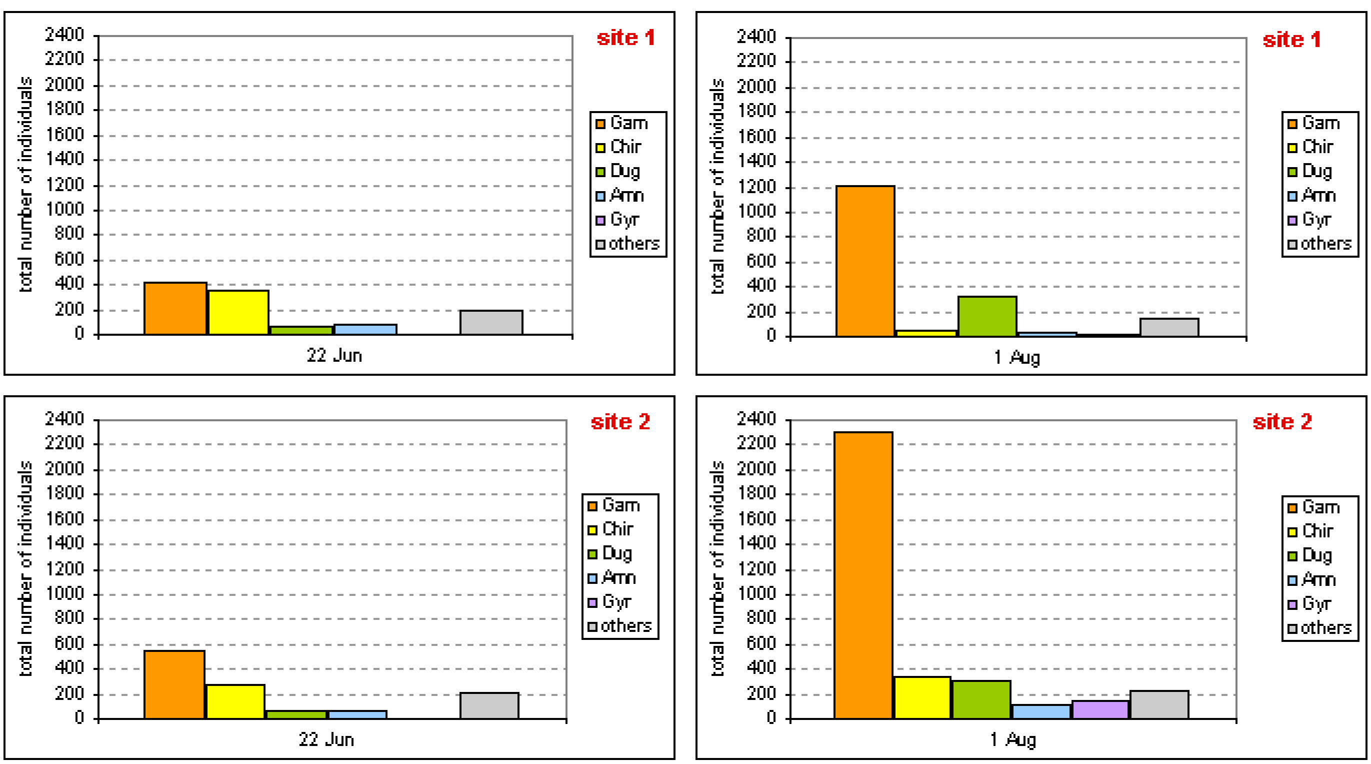
Figure 2. Number of individuals per sampling for selected common taxa in June (left) and August 2000 (right). Gam: *Gammarus* sp.; Chir: Chironomidae; Dug: *Dugesia* sp.; Amn: *Amnicola limosa;* Gyr: *Gyraulus parvus.*



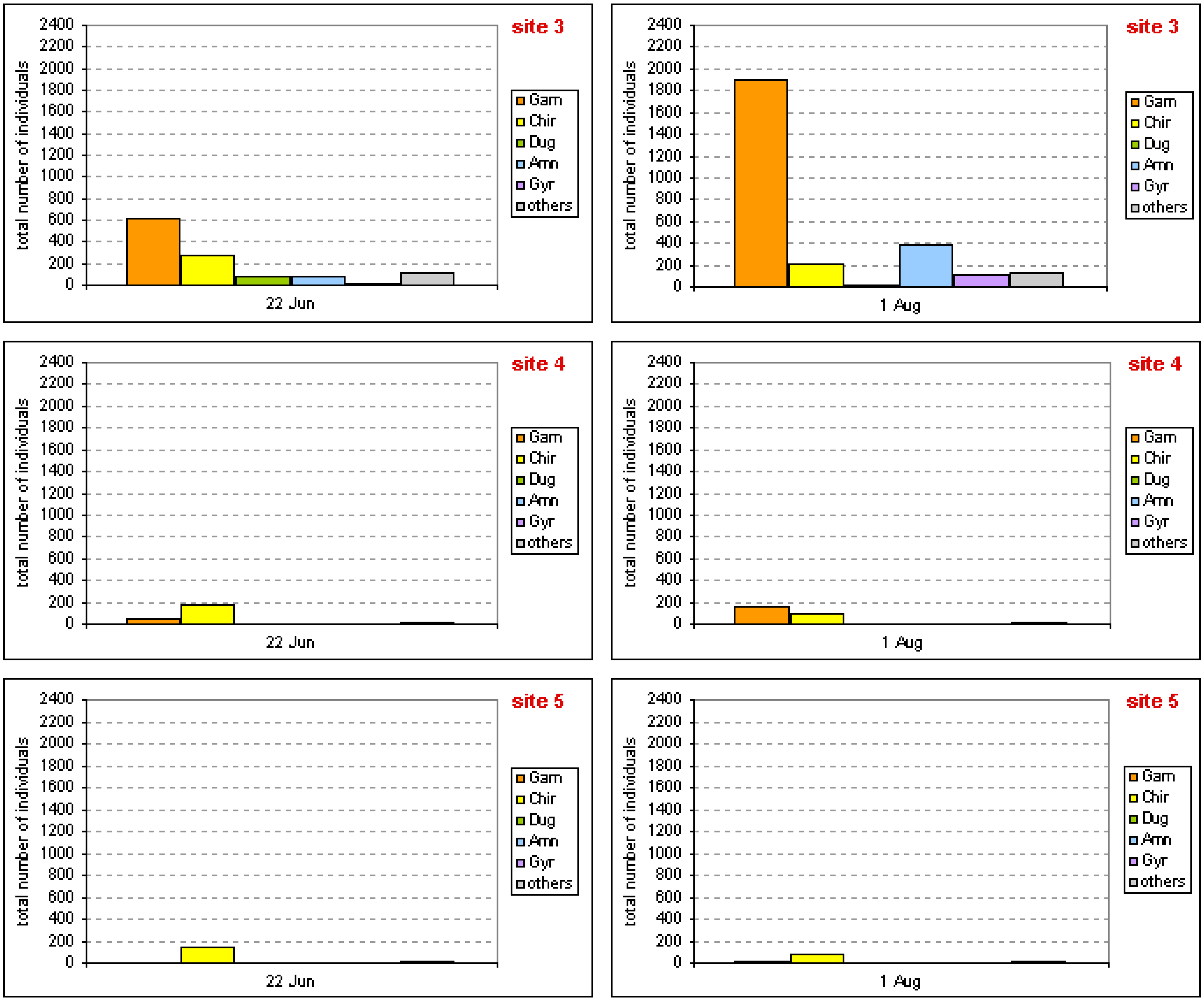


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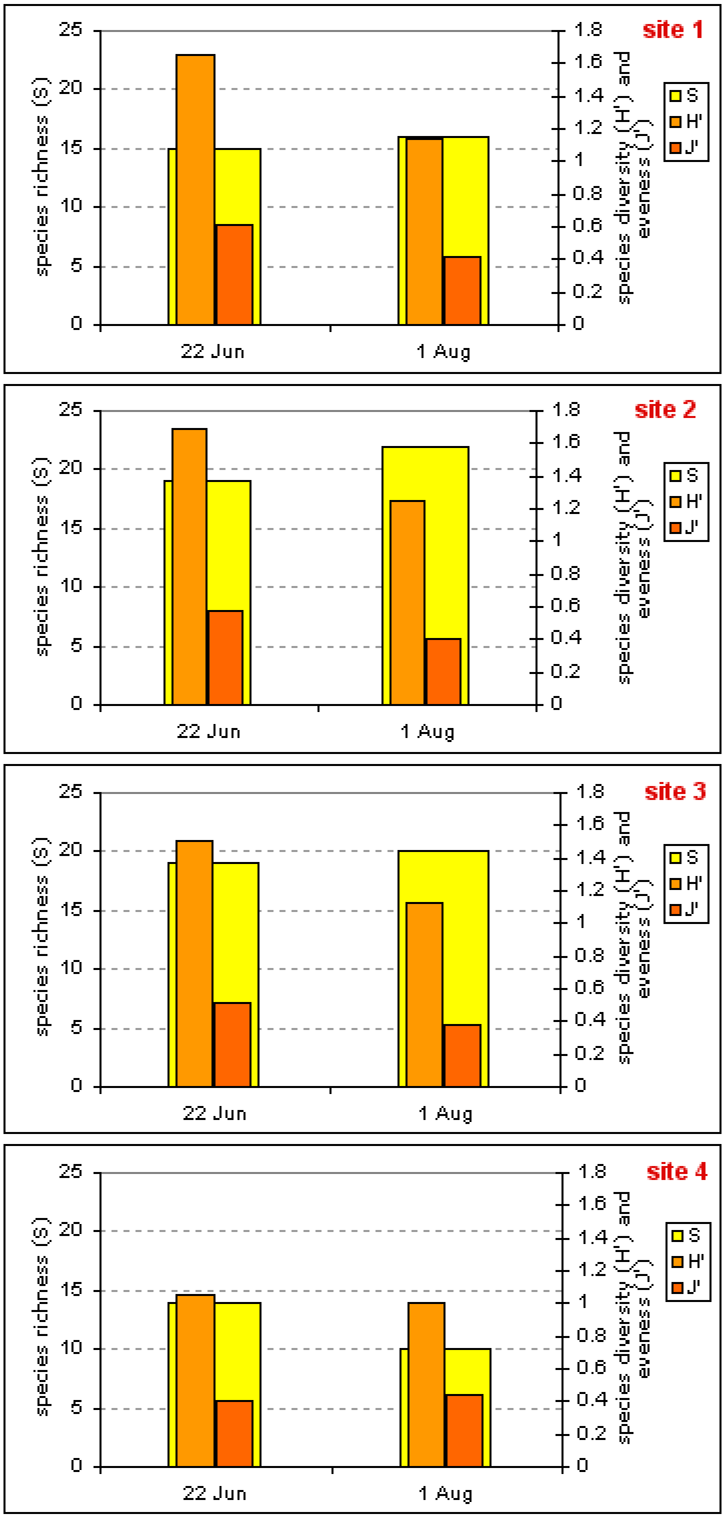
Figure 3. Species richness (*S*), diversity (*H′*) and evenness (*J′*) in June (left) and August 2000 (right).


site 1
site 2
site 3
site 4
species richness (S)
species diversity (H') and eveness (J')
S
H'
J'
22 Jun
1 Aug
0
5
10
15
20
25
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8

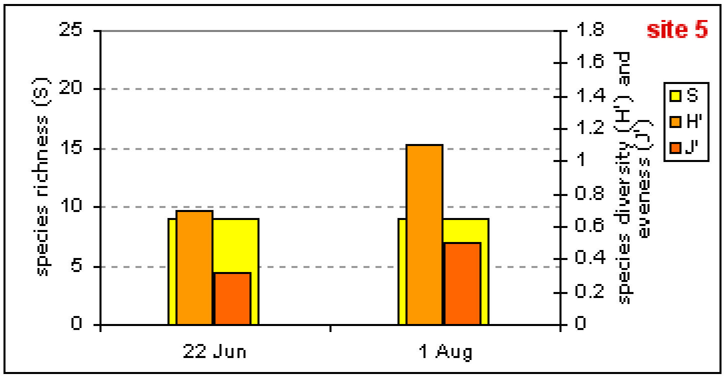


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Table 4. Macroinvertebrate taxonomic characterization:

phylum or subphylum	**class**	**order or subclass**	**family or superfamily**	**taxon**	present on	
					22 Jun	**1 Aug**
Cnidaria	Hydrozoa			*Hydra*		**x**
Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	*Dugesia*	**x**	**x**
Mollusca	Gastropoda	Prosobranchia	Hydrobiidae	*Amnicola limosa*	**x**	**x**
Mollusca	Gastropoda	Pulmonata	Physidae	*Physa gyrina*	**x**	**x**
Mollusca	Gastropoda	Pulmonata	Planorbidae	*Gyraulus parvus*	**x**	**x**
Mollusca	Gastropoda	Pulmonata	Planorbidae	*Gyraulus deflectus*	**x**	**x**
Mollusca	Gastropoda	Pulmonata	Planorbidae	*Gyr. circumstriatus*	**x**	**x**
Mollusca	Gastropoda	Pulmonata	Planorbidae	*Helisoma*	**x**	
Mollusca	Gastropoda	Pulmonata	Ancylidae	*Ferrissia rivularis*	**x**	**x**
Mollusca	Bivalvia		Spheriidae	Sphaeriidae	**x**	**x**
Annelida	Hirudinea	Rhynchobd.	Glossi-phoniidae	*Glossiphonia complanata*	**x**	**x**

Annelida	Hirudinea	Rhynchobd.	Glossiph.	*Placobdella*	**x**	
Annelida	Oligochaeta		Tubificidae?	Oligochaeta	**x**	**x**
Annelida	Oligochaeta		Lumbricul.	Lumbriculidae	**x**	
Crustacea	Malacostraca	Amphipoda	Crangoniyct.	*Crangonyx*	**x**	**x**
Crustacea	Malacostraca	Amphipoda	Gammaridae	*Gammarus*	**x**	**x**
Crustacea	Malacostraca	Asellida	Asellidae	*Lirceus*	**x**	**x**
Uniramia	Insecta	Odonata	Zygoptera	*Argia*	**x**	
Uniramia	Insecta	Odonata	Zygoptera	*Ischnura*		**x**
Uniramia	Insecta	Ephemeropt.	Caenidae	*Caenis*	**x**	**x**
Uniramia	Insecta	Ephemeropt.	Oligoneur.	*Isonychia*		**x**
Uniramia	Insecta	Trichoptera	Leptoceridae	*Triaenodes*	**x**	**x**
Uniramia	Insecta	Trichoptera	Leptoceridae	*Ceraclea*	**x**	**x**
Uniramia	Insecta	Trichoptera	Leptoceridae	*Mystacides*		**x**
Uniramia	Insecta	Trichoptera	Hydropsych.	*Macrostemum*	**x**	**x**
Uniramia	Insecta	Trichoptera	Hydropsych.	*Parapsyche*	**x**	**x**
Uniramia	Insecta	Trichoptera	Psychomiid.	*Psychomia*		**x**
Uniramia	Insecta	Trichoptera	Hydroptilidae	*Orthotrichia*	**x**	
Uniramia	Insecta	Trichoptera	Hydroptilidae	*Oxyethira*		**x**
Uniramia	Insecta	Neuroptera	Sysiridae	*Sysira*		**x**
Uniramia	Insecta	Coleoptera	Hydrophilid.	*Berosus*	**x**	**x**
Uniramia	Insecta	Diptera	Empididae	*Hemerodromia*	**x**	**x**

Uniramia	Insecta	Diptera	Simuliidae	*Simulium*	**x**	**x**
Uniramia	Insecta	Diptera	Chironomid.	Chironomidae	**x**	**x**

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Table 5. Macroinvertebrate ecological (feeding) characterization. Primary (main) and secondary feeding categories are given for facultative predators and generalists (herbivores and/or detritivores). Feeding modality refers to how the animals obtain their food (see note on bottom). Feeding information was obtained mainly from Merritt & Cummins (1996), Thorp & Covich (1991), and ENSR staff personal observations:

taxon	**general**	**primary**	**secondary**	**modality**[(1)]
Hydra	predator			predator
Dugesia	facult. predator	predator	detritivore	predator
Amnicola limosa	generalist	herbivore	detritivore	scraper
Physa gyrina	generalist	herbivore	detritivore	scraper
Gyraulus parvus	generalist	detritivore	herbivore	scraper
Gyraulus deflectus	generalist	detritivore	herbivore	scraper
Gyr. circumstriatus	generalist	detritivore	herbivore	scraper
Helisoma	generalist	detritivore	herbivore	scraper
Ferrissia rivularis	generalist	herbivore	detritivore	scraper
Sphaeriidae	detritivore			filter feeder
Glossiphonia complanata	predator	predator		predator
Placobdella	predator	predator		predator
Oligochaeta	detritivore	detritivore		collector

Lumbriculidae	detritivore	detritivore		collector
Crangonyx	generalist	detritivore	herbivore	shredder
Gammarus	generalist	detritivore	herbivore	shredder
Lirceus	detritivore	detritivore		shredder
Argia	predator	predator		predator
Ischnura	predator	predator		predator
Caenis	detritivore	detritivore		shredder
Isonychia	generalist	detritivore	herbivore	filter feeder
Triaenodes	herbivore	herbivore		shredder
Ceraclea	generalist	herbivore	detritivore	shredder
Mystacides	generalist	herbivore	detritivore	shredder
Macrostemum	generalist	detritivore	herbivore	filter feeder
Parapsyche	generalist	detritivore	herbivore	filter feeder
Psychomia	detritivore	detritivore		collector
Orthotrichia	herbivore	herbivore		shredder
Oxyethira	herbivore	herbivore		scraper
Sysira	predator	predator		predator
Berosus	predator	predator		predator
Hemerodromia	detritivore	detritivore		collector
Simulium	generalist	detritivore	herbivore	filter feeder
Chironomidae	generalist	herbivore	detritivore	shredder

(1)
predator: engulfer and/or piercer
scraper: coarse food scrubbed off substrate
shredder: coarse food cut into smaller particles filter
feeder: suspended particles captured from water
collector: fine food particles gathered from substrate

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In general, however, the differences between the upstream (sites 1 through 3) and downstream stations (sites 4 and 5) may be ascribed to difference in physical habitat. As in 1998, macroinvertebrate assemblages in the upstream stations were more indicative of riffle habitat and coarse substrates, and included several filter-feeding and collector taxa that feed on detritus (e.g., *Simulium* (Diptera Simuliidae) net-spinning caddisflies (Trichoptera Hydropsychidae), *Isonychia* (Ephemeroptera Oligoneuridae)). The downstream macroinvertebrate assemblages were more indicative of slower moving waters with finer substrates (e.g., sand).

At a finer scale, scuds or side-swimmers (Crustacea Amphipoda) dominated at the upstream stations, while midges (Diptera Chironomidae) were relatively more important at the downstream stations (Figure 2). Snails (Mollusca Gastropoda) were represented by several taxa, all tolerant of organic pollution and degraded conditions. Low snail abundance at the downstream sites was likely related to the lack of suitable substrate (aquatic plants, coarse detritus, and especially rocks and cobble supporting growth of attached algae). All these snail taxa can be found in both lentic (lakes) and lotic systems (streams), although the limpet *Ferrissia rivularis* is usually a lotic species. Relatively high snail abundance may explain the presence in 2000 of the leech *Glossiphonia complanata*, a predator somewhat specialized on aquatic snails. Predators (leeches, odonates, beetles) were represented in relatively high numbers, suggesting that food availability in the Lower Mill River is sufficient to support a relatively complex invertebrate food web, even if water quality is suggested as suboptimal by the invertebrate fauna.

CONCLUSIONS

Aquatic habitat quality is primarily a function of physical features and the quantity and quality of water available. The Lower Mill River, from the Lake Whitney dam south, undergoes a transition from a rocky freshwater stream to a sandy tidal system. A cobble and gravel stream bed of moderate slope extends from the dam to a point about 1000 ft (~300 m) downstream, after which the stream bed is considerably sandier and less sloped. Only a short portion of the Lower Mill River is truly freshwater habitat; there are signs of saltwater influence at the footbridge (station 4) and Orange Street bridge (station 5). Freshwater below Lake Whitney comes primarily from Lake Whitney and the largely urbanized drainage area upstream (north) of the dam, with storm water inputs downstream (south) of the dam in New Haven contributing to some extent. As a consequence, the quality of freshwater in the Lower Mill River is not optimal for habitat purposes.

The benthic invertebrate fauna of the Lower Mill River suggests strong differences in habitat among the upstream river reach characterized by stations 1-3 and the downstream area represented by stations 4 and 5. While neither community suggests high quality habitat, the upstream assemblage has a higher density of individuals and greater species richness than the downstream assemblage. Evenness, a measure of the distribution of individuals among species, is only nominally higher for the upstream assemblage and is low relative to other aquatic systems considered to be very healthy. Water quality is undoubtedly influenced by tidal activity in the downstream reach (stations 4 and 5), although the simple water quality variables assessed at low tide in 2000 indicated no major difference among stations. The physical differences in habitat between the defined upstream and downstream reaches within the Lower Mill River appear to be critical determinants of habitat quality and benthic invertebrate community structure.

A study of water quality, most notably salinity or conductivity, in the Lower Mill River over several tidal cycles may allow prediction of tidal effects on habitat under various upstream flow regimes. However, it is apparent that habitat quality in the Lower Mill River will be limited by both physical features (especially substrate conditions) and the quality of freshwater (due to storm water and combined sewer overflow impacts). Alteration of flow associated with reactivation of Lake Whitney as a water supply appears to be only a minor potential influence on the Lower Mill River, based on the data generated in this investigation.

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