Technical Memorandum CN 342.3

NARRAGANSETT BAY/MOUNT HOPE BAY WATERSHED
2009 BENTHIC MACROINVERTEBRATE BIOASSESSMENT

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Watershed Planning Program
Worcester, MA

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INTRODUCTION

Biological monitoring is a useful means of detecting anthropogenic impacts to the aquatic community. Resident biota (e.g., benthic macroinvertebrates, fish, periphyton) in a water body are natural monitors of environmental quality and can reveal the effects of episodic and cumulative pollution and habitat alteration (Barbour et al. 1995, Plafkin et al. 1989).

As part of the Massachusetts Department of Environmental Protection/Division of Watershed Management's (MassDEP/DWM) 2009 Narragansett Bay/Mount Hope Bay Watershed assessment, aquatic benthic macroinvertebrate biomonitoring was conducted to evaluate the biological health of selected stream reaches to determine their status with respect to the support of the *Aquatic Life* use, as designated in the *Massachusetts Surface Water Quality Standards* (SWQS) (MassDEP 2006). These assessments form the basis for reporting and listing waters pursuant to sections 305(b) and 303(d) of the Clean Water Act (CWA). A total of three stations on three named streams were sampled to investigate the effects of potential point and nonpoint sources of pollution—both historical and current—on the aquatic invertebrate populations throughout the watershed. The 2009 sampling location descriptions, along with station identification numbers, and sampling dates are presented in Table 1.

To provide information for making *Aquatic Life* use-support determinations, macroinvertebrate communities present at biomonitoring stations in the Narragansett Bay/Mount Hope Bay Watershed were compared with the community occurring at a watershed reference station. The West Branch Palmer River (B0777) was selected for this purpose. This site exhibited the lowest percentage of watershed impervious cover of the stations sampled in 2009.

METHODS

Macroinvertebrate Sampling - RBPIII

Macroinvertebrate sampling activities employed for the 2009 Narragansett Bay/Mount Hope Bay Watershed survey were conducted in accordance with the Sampling & Analysis Plan (SAP) for the Narragansett Bay/Mount Hope Bay Watershed (MassDEP 2009). The sampling procedures are described in Nuzzo (2003), and are based on US EPA Rapid Bioassessment Protocols (RBPs) for wadeable streams and rivers (Plafkin et al. 1989). The macroinvertebrate collection procedure utilized kick-sampling, a method of sampling benthic organisms by kicking or disturbing bottom sediments and catching the dislodged organisms in a net as the current carries them downstream. Sampling was conducted by MassDEP/DWM biologists throughout a 100 m reach, in riffle/run areas with fast currents and rocky (cobble, pebble, and gravel) substrates—generally the most productive habitats, supporting the most diverse communities in the stream system. Ten kicks in squares approximately 0.46 m x 0.46 m were composited for a total sample area of about 2 m^2. Samples were labeled and preserved in the field with denatured 95% ethanol, then brought to the MassDEP/DWM lab for further processing.

Table 1. List of biomonitoring stations sampled during the 2009 Narragansett Bay / Mount Hope Bay watershed survey, including station and unique identification numbers, drainage areas, sampling site descriptions, and sampling dates.

Stream Name	Unique ID	Latitude Longitude	Sampling Site Description	Sampling Date
West Branch Palmer River[R]	B0777	41.860199 -71.256372	Approximately 500 meters downstream from Danforth Street, Rehoboth, MA	9-SEP-2009
Cole River	B0778	41.77576 -71.198691	Approximately 40 meters upstream of Hortonville Road, Swansea, MA	8-SEP-2009
Rocky Run	B0779	41.789099 -71.239038	Approximately 90 meters upstream of Martin Street, Rehoboth, MA	8-SEP-2009

[R] 2009 Reference Site

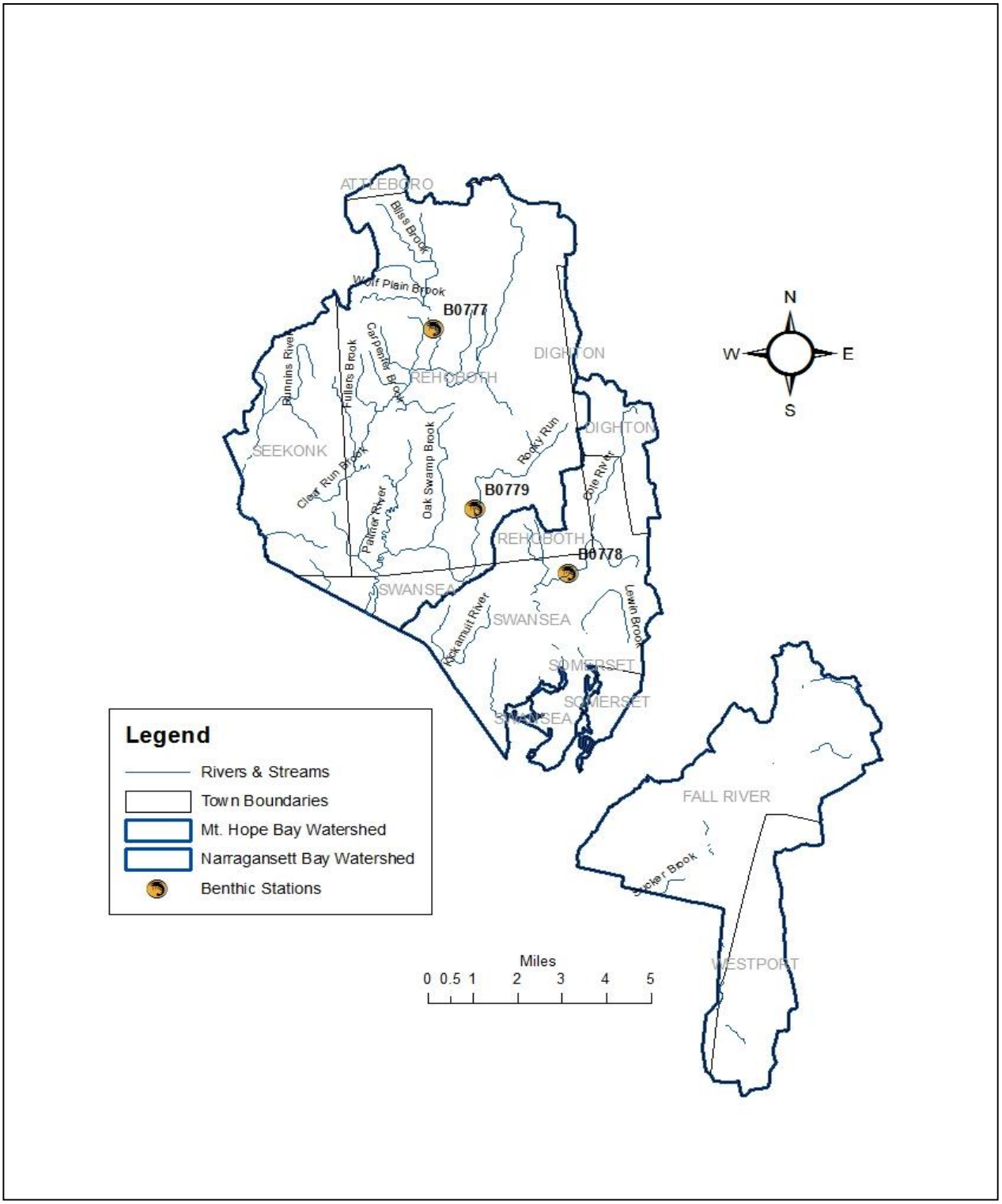

Figure 1. Geographic locations of benthic macroinvertebrate sampling locations during the 2009 Narragansett Bay/Mount Hope Bay Watershed surveys

Macroinvertebrate Sample Processing and Data Analysis

The macroinvertebrate sample processing and analysis procedures employed for the 2009 Narragansett Bay/Mount Hope Bay Watershed biomonitoring samples are described in the standard operating procedures (Nuzzo 2003). Macroinvertebrate sample processing entailed distributing whole samples in pans, randomly selecting grids within the pans, and sorting specimens from the other materials in the sample until approximately 100 organisms (±10%) were extracted. Specimens were identified to genus or species as allowed by available keys, specimen condition, and specimen maturity.

Based on the taxonomy, various community, population, and functional parameters, or "metrics", were calculated which allow measurement of important aspects of the biological integrity of the macroinvertebrate community. This integrated approach provides more assurance of a valid assessment because a variety of biological parameters are evaluated, and the deficiency of any one metric should not invalidate the entire approach (Plafkin et al. 1989). Taxonomic data were analyzed using a modification of Rapid Bioassessment Protocol III (RBP III) metrics and scores (Plafkin et al. 1989). The modifications were: substitution of "reference site affinity" (RSA) for the Community Loss Index and elimination of the shredder/total ratio (no separate leaf-pack material was collected). The reference site affinity metric is a modification of Percent Model Affinity (Novak and Bode 1992). Instead of using the model's percentages for Oligochaeta, Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, Chironomidae, and "other," these percentages were taken from the reference site data. The RSA score is then calculated as:

$$100 - \Sigma (\delta \times 0.5)$$

where δ is the difference between the reference percentage and the sample percentage for each taxonomic grouping. RSA percentages convert to RBP III scores as follows: 0 points for <35%; 2 points in the range from 35 to 49%; 4 points for 50 to 64%; and 6 points if ≥65%. The entire suite of metrics used for the analysis was:

- Richness—the total number of different species present in the subsample plus those detected from a "large/rare" search of the whole sample (those taxa missed in subsampling);

- HBI—Hilsenhoff Biotic Index (Hilsenhoff 1982, 1987), as modified in Nuzzo (2003); the HBI is the sum of the products of each taxon's abundance and its corresponding pollution tolerance value, divided by the total count in the subsample;

- EPT—sum of richness among the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) as determined from the specimens in the subsample plus those detected in a "large/rare" search of the whole sample; these orders tend to be dominated by species generally considered to be pollution sensitive;

- EPT/Chiro—ratio of total abundance among EPT taxa to total abundance among Chironomidae taxa;

- SC/FC—ratio of the proportion of sample that is represented by individuals that predominantly feed by scraping to those that are primarily filter-feeders;

- % Dominant—most abundant taxon as a percent of the assemblage; >20% is generally considered hyperdominant and indicative of a stressor impact;

- RSA—reference site affinity (described above).

Metric values for each station were scored based on comparability to the reference station, and scores were totaled. The percent comparability of total metric scores for each study site to those for the selected "least-impacted" reference station yielded an impairment score for each site. RBP III analysis separates sites into

four categories: “non-impaired”, “slightly impaired”, “moderately impaired”, and “severely impaired”. Each impairment category corresponds to a specific *Aquatic Life* use-support determination used in the CWA Section 305(b) water quality reporting process—non-impaired and slightly impaired benthic invertebrate communities are generally indicative of conditions supporting the *Aquatic Life* use, whereas water bodies exhibiting moderately or severely impaired communities are generally assessed as “non-support.”

Habitat Assessment

Habitat qualities were scored for each sampling reach using the assessment procedure in Plafkin et al. (1989), as modified in Barbour et al. (1999). An evaluation of physical and biological habitat quality is critical to any assessment of ecological integrity (Karr et al. 1986; Plafkin et al. 1989). Habitat assessment supports understanding of the relationship between physical habitat quality and biological conditions, identifies obvious constraints on the attainable potential of a site, assists in the selection of appropriate sampling stations, and provides basic information for interpreting biosurvey results (US EPA 1995). The matrix used to assess habitat quality is based on key physical characteristics of the water body and the immediate riverfront area. Most parameters evaluated are instream physical attributes that are potential sources of limitation to the aquatic biota (Plafkin et al. 1989). The ten habitat parameters are as follows: instream cover, epifaunal substrate, embeddedness, sediment deposition, channel alteration, velocity/depth combinations, channel flow status, right and left bank vegetative protection, right and left bank stability, right and left bank riparian vegetative zone width. Habitat parameters are scored, totaled, and compared to the reference station to infer the extent to which the condition of the habitat, rather than water quality effects, may account for differences in macroinvertebrate community structure at the study sites.

RESULTS AND CONCLUSIONS

A taxonomic list of the macroinvertebrate organisms collected at each sampling station during the 2009 biomonitoring survey is provided in Appendix 2. Included in the list are total organism counts, the functional feeding group designation (FFG) for each macroinvertebrate taxon, and the tolerance value (TV) of each taxon. Table 3 presents summaries of the habitat and RBP III macroinvertebrate data analyses for the 2009 Narragansett Bay/Mount Hope Bay Watershed Benthic sites. Included for each sampling site are the habitat comparability to the reference condition, biological metric calculations, metric scores, and impairment designations.

Rocky Run (B0779) was determined to be non-impaired. Cole River (B0778), although receiving slight reductions in scoring of the Taxa Richness and Scraper/Filterer metrics, still registered as non-impaired. The benthic communities collected at these stations indicate that the *Aquatic Life Use* designation is supported. Habitat conditions between the examined stations were also comparable. In summary, the three stations examined in 2009 were all determined to be non-impaired. As such, they all support their *Aquatic Life* use designations.

Table 2. Habitat Measures for the 2009 Narragansett Bay/Mount Hope Bay Watershed Benthic Macroinvertebrate Sites; USGS StreamStats (USGS 2012), MassDEP Human Disturbance Index (HDI) (Meek 2013), MassDEP Benthic Habitat Assessment Scores.

Site Name	West Branch Palmer River	Cole River	Rocky Run
Site Number	B0777	B0778	B0779
Watershed Area (mi^2)	6.84	7.76	5.37
Stream Length (mi)	18.1	12.6	8.62
# NPDES Discharges	0	0	0
Stream Density	2.65	1.62	1.61
% Impervious Cover	6.0	8.7	6.4
% Agriculture	11	10.8	9.1
HDI Score	3	3	3.5
Habitat Score	161	177	164

Table 3. Summary of RBP III analysis of macroinvertebrate communities sampled in the Narragansett Bay/Mount Hope Bay Watershed on 8 and 9 September 2009. Shown are the habitat analysis, calculated metric values, metric scores (in italics) based on comparability to the reference station (West Branch Palmer River – B0777), and the corresponding assessment designation for each biomonitoring station. Complete habitat evaluations are presented in Appendix 1. Refer to Table 1 for a listing and description of sampling stations.

SAMPLING STATION	B0777		B0778		B0779	
STREAM	West Branch Palmer River		Cole River		Rocky Run	
HABITAT SCORE	161		177		164	
HABITAT % of REFERENCE	--		110%		102%	
HABITAT COMPARABILITY	--		Comparable		Comparable	
TAXA RICHNESS	28	*6*	18	*4*	31	*6*
BIOTIC INDEX	4.03	*6*	4.38	*6*	4.09	*6*
EPT INDEX	7	*6*	7	*6*	10	*6*
EPT/CHIRONOMIDAE	1.14	*6*	1.44	*6*	2.19	*6*
SCRAPER/FILTERER	0.97	*6*	0.38	*4*	1.50	*6*
REFERENCE AFFINITY	100%	*6*	70%	*6*	72%	*6*
% DOMINANT TAXON	13%	*6*	20%	*6*	16%	*6*
TOTAL METRIC SCORE	*42*		*38*		*42*	
BIOLOGICAL CONDITION -DEGREE IMPAIRED	**REFERENCE**		**NON-IMPAIRED**		**NON-IMPAIRED**	

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Appendix 1. Habitat assessment summary for biomonitoring stations sampled during the 2009 Narragansett Bay/Mount Hope Bay Watershed survey. For instream parameters, scores ranging from 16-20 = optimal; 11-15 = suboptimal; 6-10 = marginal; 0-5 = poor. For riparian parameters, scores ranging from 9-10 = optimal; 6-8 = suboptimal; 3-5 = marginal; 0-2 = poor. Maximum habitat score for any site = 200. Refer to Table 1 for a listing and description of sampling stations.

STATION		West Branch Palmer River	Cole River	Rocky Run
Station Code		**B0777**	**B0778**	**B0779**
INSTREAM PARAMETERS (range is 0-20)				
INSTREAM COVER		16	16	17
EPIFAUNAL SUBSTRATE		14	18	15
EMBEDDEDNESS		16	18	16
CHANNEL ALTERATION		20	20	17
SEDIMENT DEPOSITION		14	18	16
VELOCITY-DEPTH COMBINATIONS		11	9	10
CHANNEL FLOW STATUS		14	18	15
RIPARIAN ZONE PARAMETERS (range is 0-10 for each bank)				
BANK VEGETATIVE PROTECTION	left	10	10	10
	right	10	10	10
BANK STABILITY	left	8	10	9
	right	8	10	9
RIPARIAN VEGATIVE ZONE WIDTH	left	10	10	10
	right	10	10	10
TOTAL SCORE		**161**	**177**	**164**

Appendix 2. Taxa list and counts, functional feeding groups (FFG), and tolerance values (TV) for macroinvertebrates collected from stream sites during the 2009 Narragansett Bay/Mount Hope Bay Watershed survey from 8 to 9 September 2009. Refer to Table 1 for a listing and description of sampling stations.

TAXON		FFG[1]	TV[2]	STATIONS		
				West Branch Palmer River	Cole River	Rocky Run
				B0777	B0778	B0779
Pisidiidae	*Pisidium sp.*	FC	6	1		
Naididae	*Vejdovskyella comata*	GC	4			1
Tubificidae	*Tubificidae*	GC	10			1
Gammaridae	*Gammarus sp.*	GC	6		4	
Lebertiidae	*Lebertia sp.*	PR	6		1	
Sperchonidae	*Sperchonopsis sp.*	PR	6	1		
Baetidae	*Baetis flavistriga*	GC	4	2		
Ephemerellidae	*Eurylophella sp.*	GC	2		8	4
Heptageniidae	*Maccaffertium sp.*	SC	3	3		17
Heptageniidae	*Maccaffertium modestum*	SC	1	5	3	9
Leptophlebiidae	*Habrophlebia vibrans*	GC	4		8	3
Leptophlebiidae	*Paraleptophlebia sp.*	GC	1	8	10	8
Calopterygidae	*Calopteryx sp.*	PR	6	1		
Gomphidae	*Gomphidae*	PR	5			2
Perlidae	*Acroneuria sp.*	PR	0	1		
Corydalidae	*Nigronia serricornis*	PR	0		2	2
Calamoceratidae	*Heteroplectron americanum*	SH	5			1
Hydropsychidae	*Cheumatopsyche sp.*	FC	5	6	10	5
Hydropsychidae	*Hydropsyche betteni*	FC	7	7	3	1
Leptoceridae	*Leptoceridae*	PR	4			1
Leptoceridae	*Oecetis sp.*	PR	5			2
Philopotamidae	*Chimarra aterrima*	FC	4	1	10	7
Polycentropodidae	*Polycentropus sp.*	PR	6			1
Elmidae	*Elmidae*	SC	4	1		
Elmidae	*Microcylloepus pusillus*	GC	3	1		
Elmidae	*Optioservus sp.*	SC	4	6		
Elmidae	*Oulimnius latiusculus*	SC	4	3		2
Elmidae	*Promoresia tardella*	SC	2	4	2	1
Elmidae	*Stenelmis sp.*	SC	5	1	4	2
Psephenidae	*Psephenus herricki*	SC	4	5		2
Ceratopogonidae	*Probezzia sp.*	PR	6			1
Chironomidae	*Polypedilum aviceps*	SH	4	12	11	1
Chironomidae	*Stictochironomus sp.*	GC	9			2
Chironomidae	*Tribelos sp.*	GC	7		1	
Chironomidae	*Micropsectra sp.*	GC	7	3	20	4
Chironomidae	*Rheotanytarsus exiguus gr.*	FC	6		1	
Chironomidae	*Rheotanytarsus pellucidus*	FC	5			1
Chironomidae	*Stempellinella sp.*	GC	2			1
Chironomidae	*Tanytarsus sp.*	FC	6			5

Chironomidae	*Corynoneura sp.*	GC	4	4		
Chironomidae	*Eukiefferiella devonica gr.*	GC	4	1		
Chironomidae	*Parachaetocladius sp.*	GC	2	2		
Chironomidae	*Parametriocnemus sp.*	GC	5	4		
Chironomidae	*Rheocricotopus sp.*	GC	6	1		
Chironomidae	*Thienemanniella sp.*	GC	6	1		
Chironomidae	*Tvetenia vitracies*	GC	5			4
Chironomidae	*Labrundinia sp.*	PR	6			2
Chironomidae	*Thienemannimyia gr.*	PR	6	1	3	2
Chironomidae	*Zavrelimyia sp.*	PR	8			5
Empididae	*Hemerodromia sp.*	PR	6		1	2
Simuliidae	*Simulium sp.*	FC	5	14		3
Tipulidae	*Dicranota sp.*	PR	3	7		
Tipulidae	*Tipula sp.*	SH	6	1		
TOTAL				**108**	**102**	**105**

[1]Functional Feeding Group (FFG) lists the primary feeding habit of each species and follows the abbreviations: SH-Shredder; GC-Gathering Collector; FC-Filtering Collector; SC-Scraper; PR-Predator.

[2]Tolerance Value (TV) is an assigned value used in the calculation of the Biotic Index. Tolerance values range from 0 for organisms very intolerant of organic wastes to 10 for very tolerant organisms.

[3] Reference station