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SHAWSHEEN RIVER WATERSHED
2005 BENTHIC MACROINVERTEBRATE BIOASSESSMENT

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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 (Plafkin et al. 1989, Barbour et al. 1995). Biological surveys and assessments are the primary approaches to biomonitoring.

As part of the Massachusetts Department of Environmental Protection/Division of Watershed Management's (MassDEP/DWM) 2005 Shawsheen River Watershed assessments, aquatic benthic macroinvertebrate biomonitoring was conducted to evaluate the biological health of both the mainstem and various tributaries within the watershed. A total of six biomonitoring stations were sampled to investigate the effects of various nonpoint and point source stressors—both historical and current—on the aquatic communities of the watershed. Some of the 2005 biomonitoring stations had never been assessed by MassDEP, while others were most recently sampled in 2000 (Maietta 2001; MassDEP 2003). Table 1 presents the sampling locations, along with station identification numbers and sampling dates.

To provide additional information necessary for making basin-wide aquatic life use-support determinations required by Section 305(b) of the Clean Water Act, all Shawsheen River watershed macroinvertebrate biomonitoring stations were compared to a regional reference station most representative of "least disturbed" conditions in the watershed. Use of a regional reference station is particularly useful in assessing nonpoint source pollution and nutrient/BOD loadings originating from multiple and/or unknown sources in a watershed, as well as nonpoint source pollution impacts (e.g., physical habitat degradation) at sites suspected as chemically-impacted from known point source stressors (Hughes 1989). The regional reference station (SR01) was established in the Shawsheen River at a site unaffected by point sources of water pollution, and assumed [based on historical water quality data (MassDEP 2003), topographic map examinations, and field reconnaissance] to be minimally impacted (relative to other portions of the watershed) by nonpoint sources.

During "year 1" of its "5-year basin cycle", problem areas within the Shawsheen River watershed were better defined through such processes as coordination with appropriate groups (Shawsheen River Watershed Association, MassDEP/DWM, MassDEP/NERO), assessing existing data, conducting site visits, and reviewing NPDES and water withdrawal permits. Following these activities, the 2005 biomonitoring plan was formulated and included well defined study objectives. Table 2 includes a summary of the perceived problems/issues addressed during the 2005 Shawsheen River watershed biomonitoring survey.

The main objectives of biomonitoring in the Shawsheen River watershed were: (a) to determine the biological health of rivers/streams within the watershed by conducting assessments based on biological (aquatic macroinvertebrates) communities; and (b) to identify problem stream segments so that efforts can be focused on developing or modifying NPDES and/or Water Management Act permits, stormwater management, and control of other nonpoint source pollution. Specific tasks were:

1. Conduct benthic macroinvertebrate sampling and habitat assessments at locations throughout the Shawsheen River watershed;

2. Based upon the macroinvertebrate data, identify river segments within the watershed with potential point/nonpoint source pollution problems; and

3. Using the benthic macroinvertebrate data and supporting water chemistry and field/habitat data:

    - Assess the types of water quality and/or water quantity problems that are present, and if possible, make recommendations for remedial actions or additional monitoring and assessment.

- Provide macroinvertebrate and habitat data to MassDEP/DWM's Environmental Monitoring and Assessment Program for assessments of aquatic life use-support status required by Section 305(b) of the Federal Clean Water Act (CWA).
- Provide macroinvertebrate and habitat data for other informational needs of Massachusetts regulatory and resource agencies.

Table 1. List of biomonitoring stations sampled during the 2005 Shawsheen River watershed survey, including station identification number, drainage area, station description, and sampling date. Stations are listed hydrologically (from upstream-most drainage in the watershed to downstream-most).

Station ID	Drainage area (mi^2)	Shawsheen River Watershed Site description	Sampling Date
SH00	7.2	Shawsheen River, downstream from Rtes. 4/225, Bedford	26 July 2005
EB02	5.88	Elm Brook, downstream from Rtes. 4/225, Bedford	26 July 2005
CB01A	5.2	Content Brook, upstream from Whipple Rd., Billerica	26 July 2005
SR01	46.2	Shawsheen River, downstream from Mill St., Tewksbury	26 July 2005
SH09	69.0	Shawsheen River, downstream from Central St., Andover	27 July 2005
RB01A	~1.4	Rogers Brook, upstream from confluence with Shawsheen River, Andover	27 July 2005

Table 2. List of perceived problems addressed during the 2005 Shawsheen River watershed biomonitoring survey.

Shawsheen River Watershed Stations	Issues/Problems
SH00	'impaired" for *Aquatic Life Use*[1]; stormwater from Hanscom Field--industrial/commercial site stormwater discharge (permitted), municipal separate storm sewer systems[1,2,4]; flow alteration[2]; habitat alterations[1,3], organic enrichment/low DO, pathogens[1,3,5]; urban runoff
EB02	'impaired" for *Aquatic Life Use*[1]; stormwater from Hanscom Field--industrial/commercial site stormwater discharge (permitted)[1,2,4]; flow alteration[2]; habitat alterations, turbidity, pathogens[1,3,5]; urban runoff
CB01A	"not assessed" for *Aquatic Life Use*[1]; legacy pollutants (Superfund site) via Middlesex Canal[1]; industrial discharge (permitted)[1]; upstream impoundment effects (Long Pond)[3]; urban runoff
SR01	"not assessed" for *Aquatic Life Use*[1]; organic enrichment/low DO[3], pathogens[1,3,5]; urban runoff
SH09	"not assessed" for *Aquatic Life Use*[1]; organic enrichment/low DO, pathogens[1,3,5]; upstream impoundment effects (Fosters Pond)[3]; urban runoff
RB01A	"not assessed" for *Aquatic Life Use*[1]; habitat alterations (culverted/channelized), pathogens[5], turbidity[1,3]; impoundment effects (Fosters Pond)[3]; urban runoff

[1](MassDEP 2003); [2](MassDEP 2003a); [3](MassDEP 2007); [4](MassDEP 2008); [5](MassDEP 2002)

WATERSHED DESCRIPTION

The Shawsheen River watershed is located in northeastern Massachusetts where it is bordered by the Merrimack, Ipswich, Boston Harbor, Charles and Concord watersheds (Figure 1). The watershed includes 60.1 miles of named streams and encompasses 78 square miles of drainage area. Approximately 4.5% of the watershed area is covered by wetland or open water. Fosters Pond (135 acres) in Andover/Wilmington and Ames Pond (82 acres) in Tewksbury are the two largest of the 18 ponds, which comprise a total of 438 acres, in the watershed.

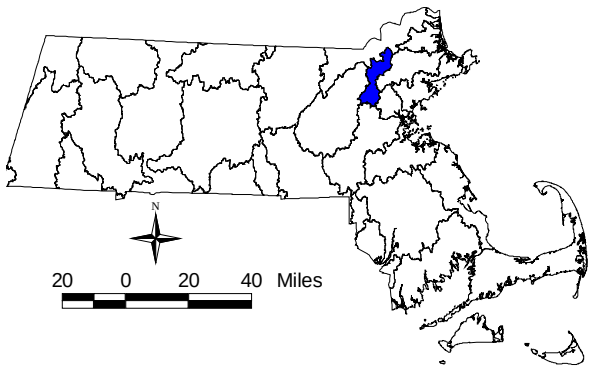

Figure 1. Location of Shawsheen River Watershed

The mainstem Shawsheen River flows for 25 miles, dropping 70 feet in elevation, from its headwaters at Hanscom Field in Bedford to its confluence with the Merrimack River in Lawrence. The main-stream channel depth generally ranges between one-half and five feet. It is impounded by dams at Ballardvale Village and at Stevens Street, both in Andover. Elsewhere, the relatively narrow channel, comprised primarily of coarse sand and gravel substrates, meanders generally on a northeasterly course through broad floodplains and extensive freshwater wetlands that provide excellent habitat for beaver, mink, muskrat and several species of waterfowl. The USGS maintains two streamflow gaging stations on the Shawsheen River. One gage (01100600), located in Wilmington, measures flow from an area of 36.5 square miles. A second gage (01100568), located at Hanscom Air Force Base (HAFB), Bedford, records drainage from an area of 2.09 square miles (Socolow et al. 2002).

Portions of 12 cities or towns, representing both Middlesex and Essex counties, lie within the Shawsheen watershed. These are Andover, Bedford, Billerica, Burlington, Concord, Lawrence, Lexington, Lincoln, North Andover, Tewksbury, Wilmington, and Woburn. While portions of Andover, Lawrence and Lexington are the most urban in character, almost all of these municipalities are densely populated. This places demand on the water resources in the drainage basin for water supply even though several municipalities actually derive their water supply from surface or groundwater sources outside of the Shawsheen River watershed. The Town of Burlington maintains the only direct withdrawal of surface water from the Shawsheen River. Bedford, Burlington, and Tewksbury pump water from wells situated near the Shawsheen River or its tributaries for at least a portion of their public water supply. High population density has also led to the need for sound wastewater management practices. Over one third (38%) of the land area in the watershed is residential, mostly zoned for house lots between 1/4 and 1/2 acre. Some of these residential areas are served by municipal wastewater collection systems, which deliver sewage to publicly owned treatment works (POTWs) located in neighboring watersheds. However, many residences continue to rely on individual, on-site septic systems for sewage disposal. Other than these, few, if any, wastewater discharges occur to ground or surface waters in the Shawsheen River watershed.

METHODS

Macroinvertebrate Sampling - RBPIII

Macroinvertebrate sampling activities employed for the 2005 Shawsheen River watershed survey were conducted in accordance with the Quality Assurance Project Plan (QAPP) for benthic macroinvertebrate biomonitoring (MassDEP 2004). The sampling procedures are described in the standard operating procedures *Water Quality Monitoring In Streams Using Aquatic Macroinvertebrates* (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.

Macroinvertebrate Sample Processing and Analysis

The macroinvertebrate sample processing and analysis procedures employed for the 2005 Shawsheen River watershed biomonitoring samples are described in the standard operating procedures (Nuzzo 2003) and were conducted in accordance with the Quality Assurance Project Plan (QAPP) for benthic macroinvertebrate biomonitoring (MassDEP 2004a). Macroinvertebrate sample processing entailed distributing whole samples in pans, selecting grids within the pans at random, 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. Taxonomic data were analyzed using a modification of Rapid Bioassessment Protocol III (RBP III) metrics and scores (Plafkin et al. 1989). 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 community. This integrated approach provides more assurance of a valid assessment because a variety of biological parameters are evaluated. Deficiency of any one metric should not invalidate the entire approach (Plafkin et al. 1989). 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 a selected "least-impacted" reference station yields 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 communities are assessed as "support" in the 305(b) report; moderately and severely impaired communities are assessed as "non-support" A detailed description of the *Aquatic Life* use designation is outlined in the *Massachusetts Surface Water Quality Standards* (SWQS) (MassDEP 2006). Impacts to the benthic community may be indicated by the absence of generally pollution-sensitive macroinvertebrate taxa such as Ephemeroptera, Plecoptera, and Trichoptera (EPT); dominance of a particular taxon, especially the pollution-tolerant Chironomidae and Oligochaeta taxa; low taxa richness; or shifts in community composition relative to the reference station (Plafkin et al. 1989). Those biological metrics calculated and used in the analysis of Shawsheen River watershed macroinvertebrate data are listed and defined below [For a more detailed description of metrics used to evaluate benthos data see Plafkin et al. 1989:

1. Taxa Richness—a measure based on the number of taxa present. Generally increases with increasing water quality, habitat diversity, and habitat suitability. The lowest possible taxonomic level is assumed to be genus or species.

2. EPT Index—a count of the number of genera/species from the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). As a group these are considered three of the more sensitive aquatic insect orders. Therefore, the greater the contribution to total richness from these three orders, the healthier the community.

3. Biotic Index—Based on the Hilsenhoff Biotic Index (HBI), this is an index designed to produce a numerical value to indicate the level of organic pollution (Hilsenhoff 1982). Organisms have been assigned a value ranging from zero to ten based on their tolerance to organic pollution. Tolerance values currently used by DEP/DWM biologists were originally derived from Hilsenhoff and have since been revised by Bode et al. (1991). A value of zero indicates the taxon is highly intolerant of pollution and is likely to be found only in pollution-free waters. A value of ten indicates the taxon is tolerant of pollution and may be found in highly polluted waters. The number of organisms and the individually assigned values are used in a mathematical formula that describes the degree of organic pollution at the study site. The formula for calculating HBI is:

$$HBI = \sum \frac{x_i t_i}{n}$$

where

x_i = number of individuals within a taxon
t_i = tolerance value of a taxon
n = total number of organisms in the sample

4. Ratio of EPT and Chironomidae Abundance—The EPT and Chironomidae abundance ratio uses relative abundance of these indicator groups as a measure of community balance. Skewed populations having a disproportionate number of the generally tolerant Chironomidae ("midges") relative to the more sensitive insect groups may indicate environmental stress.

5. Percent Contribution Dominant Taxon—is the percent contribution of the numerically dominant taxon (genus or species) to the total numbers of organisms. A community dominated by few species indicates environmental stress. Conversely, more balance among species indicates a healthier community.

6. Ratio of Scraper and Filtering Collector Functional Feeding Groups—This ratio reflects the community food base. The proportion of the two feeding groups is important because predominance of a particular feeding type may indicate an unbalanced community responding to an overabundance of a particular food source (Plafkin et al. 1989). Scrapers predominate when diatoms are the dominant food resource, and decrease in abundance when filamentous algae and mosses prevail. Filtering collectors thrive where filamentous algae and mosses are prevalent and where fine particulate organic matter (FPOM) levels are high.

7. Community Similarity—is a comparison of a study site community to a reference site community. Similarity is often based on indices that compare community composition. Most Community Similarity indices stress richness and/or richness and abundance. Generally speaking, communities with comparable habitat will become more dissimilar as stress increases. In the case of the Shawsheen River watershed bioassessment, an index of macroinvertebrate community composition was calculated based on similarity (i.e., affinity) to the reference community, expressed as percent composition of the following organism groups: Oligochaeta, Ephemeroptera, Plecoptera, Coleoptera, Trichoptera, Chironomidae, and Other. This approach is based on a modification of the Percent Model Affinity (Novak and Bode 1992). The reference site affinity (RSA) metric is 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 RBPIII scores as follows: <35% receives 0 points; 2 points in the range from 35 to 49%; 4 points for 50 to 64%; and 6 points for ≥65%.

Habitat Assessment

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). Before leaving the sample reach during the 2005 Shawsheen River watershed biosurveys, habitat qualities were scored using a modification of the evaluation procedure in Plafkin et al. (1989). 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 often related to overall land-use and 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 (when facing downstream) bank vegetative protection, right and left bank stability, right

and left bank riparian vegetative zone width. Habitat parameters are scored, totaled, and compared to a reference station to provide a final habitat ranking.

RESULTS AND DISCUSSION

The biological and habitat data collected at each sampling station during the 2005 biosurveys are attached as an Appendix (Tables A1 – A3). Included in the macroinvertebrate taxa list (Table A1) are total organism counts, the functional feeding group designation (FG) for each macroinvertebrate taxon, and the tolerance value (TV) of each taxon.

Also included in the Appendix is a summary table (Table A2) of the RBP III macroinvertebrate data analyses, including biological metric calculations, metric scores, and impairment designations. Habitat assessment scores for each station are also presented in the summary tables, while a more detailed summary of habitat parameters is shown in Table A3.

According to USGS stream discharge data, surface water runoff for the majority of eastern Massachusetts, and including the Shawsheen River watershed, was within normal monthly ranges for May through August 2005 (USGS 2008).

Shawsheen River

Prior to the construction of Hanscom Field in 1947, the Shawsheen River originated in a small wetland located just north of Great Road (between Virginia Road and Massachusetts Avenue) in Lincoln and flowed in a north then northeasterly direction to be joined by two small unnamed tributaries prior to its confluence with Kiln Brook in Bedford. The United States Geological Survey (USGS) 7.5 Minute Series Topographic Concord Quadrangles published after the development of Hanscom Field depict the segment as an intermittent stream that disappears just north of Hanscom School and reappears as a perennial unnamed tributary between the airfield runway and the Boston & Maine Railroad line near Wood Road in Bedford. The Shawsheen River will be recognized as a named stream according to its original stream channel. The drainage area for the Shawsheen River headwaters area encompasses the southwest portion of the watershed, which is comprised primarily by Hanscom Field. The Hanscom properties total approximately 1,300 acres. The property encompasses parts of Bedford, Concord, Lexington, and Lincoln. The majority of the base is owned and operated by the Massachusetts Port Authority (Massport) as a civilian airfield and tenant areas, while the remainder of the base is operated by the USAF.

Downstream from Hanscom Field and the commercial corridor of Route 4-225 in Bedford, the Shawsheen River continues its course, flowing in a generally northeasterly direction through mainly residential portions of Bedford, Billerica, and Tewksbury. Upon crossing Interstate 93, the river enters Andover and the Ballardvale Impoundment (Lowell Junction Pond). Downstream from the Ballardvale Dam, the river continues to meander north, crossing Interstate 495 and draining increasingly urban portions of Andover, North Andover, and Lawrence before making its confluence with the Merrimack River.

The total watershed drainage area upstream from biomonitoring stations SH00, SR01, and SH09 are 7.2 mi^2, 46.2 mi^2, and 69 mi^2, respectively.

SR01—Shawsheen River, downstream from Mill Street, Tewksbury, MA

Habitat

SR01 received a composite habitat score of 165/200—the highest received by a biomonitoring station during the 2005 Shawsheen River watershed survey (Table A3). Despite marginal channel flow status (75% full), all four velocity-depth combinations were observed, and rocky epifaunal substrates and stable cover provided both macroinvertebrates and fish with excellent instream habitat. This was the designated

regional reference station based on its habitat evaluation and generally good water quality as documented by MassDEP (2003). While not without potential threats to water quality and biological integrity (Table 2), SR01 is thought to represent "least disturbed" stream conditions relative to other portions of the Shawsheen Watershed and given today's state of the landscape. It is believed to be unimpacted by point sources of pollution, and only minimally affected by other upstream/nearstream land-use impacts (i.e., lack of channelization, minimal development or agricultural activity nearby, undisturbed and well-vegetated riparian zone, minimal NPS inputs).

Benthos

The benthic macroinvertebrate community at SR01 received the maximum attainable total metric score of 42, adding credence to its suitability as a reference site for the 2005 Shawsheen River watershed survey. Total taxa richness (25) and EPT richness (11) were the highest of any site assessed, and most of the metrics outperformed those calculated for the test sites. The macroinvertebrate community was well represented by filtering collectors, suggesting a plentiful supply of fine particulate organic matter (FPOM) emanating from the extensive wetlands adjacent to the river. Nonetheless, the EPT richness and relatively low HBI (4.52) and percent dominant taxon (20%) metrics were indicative of a balanced macroinvertebrate community comprising several taxa that are intolerant of organic enrichment.

SH00—Shawsheen River, downstream from Routes 4/225, Bedford, MA

Habitat

SH00 received a composite habitat score of 80/200—the lowest (along with EB02) received by a biomonitoring station during the 2005 Shawsheen River watershed survey (Table A3). Severe sediment deposition and associated substrate embeddedness, eroding and poorly vegetated stream banks, and riparian disruption (reduced vegetative zone, and NPS inputs from adjacent parking lots and roads) along both banks affected the overall assessment most negatively. Channel flow status was marginal, with only about half the channel full of water and resulting in exposed epifaunal substrates and fish cover.

Benthos

The benthos at SH00 received a total metric score of 24, representing 57% comparability to the reference community at SR01 and resulting in a bioassessment of "slightly impaired". Only the HBI and scraper/filterer metrics scored similarly to the reference site. The EPT richness, EPT/Chironomidae ratio and percent dominant taxon metrics affected the overall score most negatively. The poor condition of the habitat likely affected community structure at SH00 making it difficult to distinguish potential water quality impacts. Nonetheless, three filtering collector taxa (i.e., *Hydropsyche betteni, Chimarra obscura* and *Simulium tuberosum* complex) accounted for 66% of the total number of organisms in the sample, indicating an imbalanced invertebrate community likely structured in response to an abundance of FPOM in the water column.

SH09—Shawsheen River, downstream from Central Street, Andover, MA.

Habitat

SH09 received a total habitat assessment score of 153/200, which was highly comparable (93%) to habitat conditions at the SR01 reference station (Table A3). Channel flow status was optimal, reaching the base of both banks and providing all four velocity-depth patterns. Epifaunal substrates were excellent for macroinvertebrates, and appeared to be unaffected by the small amounts of sediment deposition (some new increases in bar formation affecting 5% of the stream bottom) observed. Algae coverage was fairly extensive (40%) throughout the sampling reach, consisting of matted and filamentous forms of green algae in both pool and riffle areas. An adjacent railroad and associated "rip-rap" reduced the riparian vegetative zone along the left (north) bank). Otherwise, bank and riparian parameters scored fairly well.

Benthos

The macroinvertebrate community metrics for SH09 generally compared favorably to those of SR01, but decreases in the number of total as well as EPT taxa contributed to a bioassessment of "slightly impaired". Pollution-intolerant taxa were well represented in the community as evidenced by a HBI value (4.74) only slightly higher than that exhibited by the reference site (4.52). However, consistent with the findings at the other two mainstem Shawsheen River sampling sites, three filtering collector taxa (i.e., *Hydropsyche betteni, Chimarra obscura* and *Cheumatopsyche s*p.) made up 62% of the sample obtained from SH09.

Elm Brook

Elm Brook is a second-order stream that originates in a wetland just north of Route 2 in Lincoln. The stream meanders in a northerly direction through wetland and forested portions of Lincoln and Bedford before veering east towards Hanscom Field. Stormwater runoff from the Massport property at Hanscom field discharges to Elm Brook through two direct and two indirect outfalls (MassDEP 2003). The drainage from a 242-acre vegetated area discharges via overland flow into Elm Brook. Drainage from approximately 50 acres of runway and infield area discharges indirectly into Elm Brook through a 36-inch reinforced concrete pipe located approximately 900 feet away from the main channel of the brook. Another drainage area contributes runoff from a 211-acre area comprised mainly of the runways and infield grass areas as well as the Massachusetts Institute of Technology's Lincoln Laboratory through a 54-inch reinforced concrete pipe at a location 500 feet from Elm Brook. All stormwater discharges from the Massport property are regulated under an NPDES permit (MassDEP 2008).

Downstream from Hanscom Field, Elm Brook continues eastward, crossing the heavily developed commercial corridor of Routes 4/225 before making its confluence with the mainstem Shawsheen River near downtown Bedford. The total watershed drainage area upstream from EB01 is 5.88 mi^2.

EB02—Elm Brook, downstream from Routes 4/225, Bedford, MA

Habitat

EB02 received a composite habitat score of 80/200—the lowest (along with SH00) received by a biomonitoring station during the 2005 Shawsheen River watershed survey (Table A3). Habitat conditions at EB02 were very similar to those in the nearby SH00 reach, which was separated from EB02 by a narrow "wedge" of trees and a parking lot. As was the case at SH00, severe sediment deposition and substrate embeddedness, eroding and poorly vegetated stream banks, and riparian disruption (reduced vegetative zone, and NPS inputs from adjacent parking lots and roads) along both banks affected the overall habitat assessment at EB02 most negatively. Channel flow status was marginal, with only about half the channel full of water and resulting in much exposed epifaunal substrate and a lack of stable fish cover. A considerable amount of trash was observed both instream and along both stream banks of the sampling reach.

Benthos

The macroinvertebrate community at EB02 was found to be "slightly impaired". Richness metrics (total and EPT) and the percent dominant taxon accounted for most of the reduction in the overall metric score, although the HBI Index (5.48) was also substantially higher than that of the reference community. *Hydropsyche betteni* represented 53% of the sample and was the only EPT taxon present. The habitat score (80) at EB02 was poor and this, along with water quality, likely affected the overall macroinvertebrate community structure. The prevalence of filtering collector taxa and elevated HBI Index are indicative of moderate levels of nutrient enrichment.

Content Brook

A first-order stream, Content Brook originates from a series of impoundments, including the eutrophic Long Pond—a Massachusetts Category 5 waterbody impaired due to organic enrichment/low DO, nutrients, noxious aquatic plants, and turbidity (MassDEP 2007). After leaving the Richardson Pond outlet, the stream flows in an easterly direction through East Billerica, meeting the confluence with the Middlesex Canal—receiving water for the Eastern Terminals Inc. Iron Horse Park Property (a federal Superfund site) industrial discharge—then crossing into Tewksbury to join the mainstem Shawsheen River. The total watershed drainage area upstream from CB01A is 5.2 mi^2.

CB01A—Content Brook, upstream from Whipple Road, Billerica, MA

Habitat

CB01A received a total habitat assessment score of 137/200 (Table A3). Instream sediment deposition, which affected half the stream bottom here and led to considerable substrate embeddedness, impacted habitat quality at CB01A most. Both stream banks were fairly stable and well vegetated. Yard waste (grass clippings, leaves) associated with an adjacent residence near the top of the sampling reach offered a potential source of NPS pollution for this portion of the stream.

Benthos

The total metric score (20) for the benthic invertebrate community in Content Brook was 48% comparable to that of the reference community resulting in a bioassessment of “moderately impaired”. While all but one metric compared poorly with the reference community measures, the reductions in EPT taxa and EPT/Chironomidae ratio, as well as the elevated % dominant taxon value, influenced the overall metric score the most. Typical of most of the streams examined during the 2005 Shawsheen Watershed survey, the benthic community in Content Brook was dominated by filter-feeding caddisflies, indicating the presence of an abundant supply of FPOM.

Rogers Brook

Rogers Brook is a small first-order stream that originates in a small, unnamed pond just north of Highland Road in Andover. The stream flows westerly towards Andover center before being culverted underground for 0.60 mile under the downtown section of Andover. The stream resurfaces just west of the Boston Commuter Rail tracks, and for its remaining 0.70 mile course it drops steeply before joining the mainsten Shawsheen River. The total watershed drainage area upstream from RB01A is approximately 1.4 mi^2.

RB01A—Rogers Brook, upstream from confluence with Shawsheen River, Andover.

Habitat

RB01A received a total habitat assessment score of 155/200, which was highly comparable (94%) to the reference station and the second highest score received by a biomonitoring station during the 2005 survey (Table A3). The steep gradient of this portion of Rogers Brook, coupled with an abundance of cobble substrates, provided macroinvertebrates with excellent epifaunal habitat. Fish habitat was less than optimal, however, due to the shallow nature of the stream—water filled less than half the available channel and resulted in much exposed fish cover. Bank and riparian parameters scored generally well—the exception being a moderately unstable, undercut left (north) bank. Trash was observed along the right bank near the top of the sampling reach.

Benthos

The benthic macroinvertebrate community at RB01A received a total metric score of 30, representing 71% comparability to the reference community at SR01 and resulting in a bioassessment of “slightly impaired”. While total taxa richness was comparable to that of the reference community, EPT taxa were reduced from 11 to 6. Once again filter-feeding caddisflies represented the predominant taxa.

SUMMARY AND RECOMMENDATIONS

Station SR01 exhibited "least-disturbed" conditions for the Shawsheen River Watershed and, as such, provided a suitable reference site for the 2005 survey. All of the other biomonitoring stations revealed some degree of impairment. Habitat degradation, urban runoff and other forms of nonpoint source (NPS) pollution compromised biological integrity throughout the watershed—most notably in Content Brook. In fact, the benthic macroinvertebrate community at all of the sampling sites could be characterized as structured in response to varying levels of organic enrichment. While habitat degradation clearly affected the benthic invertebrate community in Elm Brook and the upper portion of the Shawsheen River in Bedford (Station SH00), the benthos at all of the study sites was shifted in favor of filtering collectors, such as net-spinning caddisflies and black flies, that were able to utilize fine particulate organic matter (FPOM) from the water column as a food source. Furthermore, the relative lack of EPT taxa other than net-spinning caddisflies, and slightly elevated HBI values encountered at all of the sampling stations suggest a community of invertebrate species populations capable of withstanding the depleted dissolved oxygen concentrations often associated with an overabundance of organic matter.

The schematic below (Figure 2) is based on a proposed conceptual model that predicts the response of aquatic communities to increasing human disturbance. It incorporates both the biological condition impact categories (non-, slightly, moderately, severely impacted) outlined in the RBPIII biological assessment methodology currently used by MassDEP and the Tiered Aquatic Life Use (TALU) conceptual model developed by the US EPA and refined by various state environmental agencies (US EPA 2003). The model summarizes the main attributes of an aquatic community that can be expected at each level of the biological condition category, and how these metric-based bioassessments can then be used to make aquatic life use determinations as part of the 305(b) reporting process. Non-impacted or Slightly Impacted aquatic communities—such as those encountered at SR01, SH00, SH09, EB02 and RB01A —support the Massachusetts SWQS designated *Aquatic Life* use in addition to meeting the objective of the Clean Water Act (CWA), which is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters (Environmental Law Reporter 1988). The moderately impacted community observed at CB01A does not support the *Aquatic Life* use and fails to meet the goals of the CWA. MassDEP will continue to refine the TALU classifications for Massachusetts surface waters as new biological data become available. This in turn may affect future Aquatic Life use determinations (e.g., support, impaired) as they relate to the biological condition categories (non-, slightly, moderately, severely impacted).

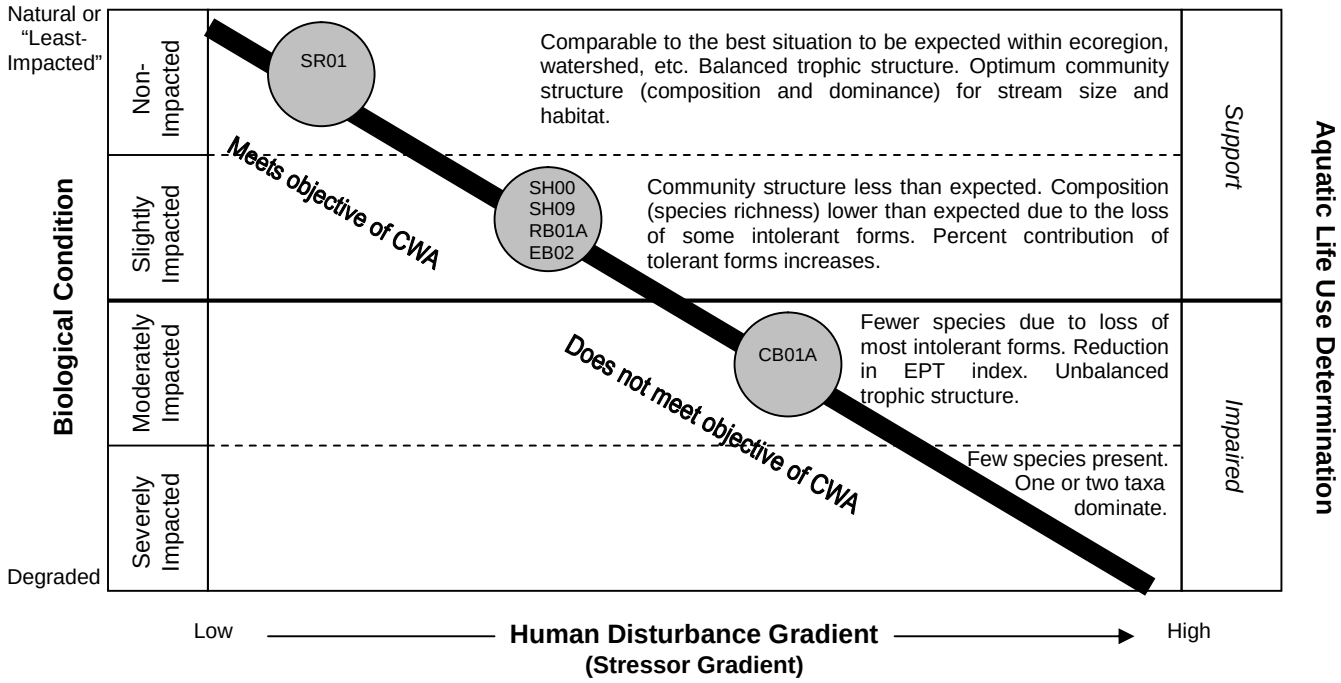

Figure 2. A schematic of results of the RBPIII analysis of the 2005 Shawsheen River watershed biomonitoring stations as they relate to Tiered Aquatic Life Use.

While the RBP analysis of benthic macroinvertebrate communities is an effective means of determining severity of water quality impacts, it is less effective in determining what kinds of pollution are causing the impact (i.e., ascertaining cause and effect relationships between potential stressors and affected biota). Nevertheless, in some situations a close examination of individual metric performance, taxon absence or presence, habitat evaluations, or other supporting field data can lead to inferences of potential anthropogenic causes of perturbation. Table 3 lists the potential causes of benthic community impairment, where applicable, observed at each biomonitoring station. The table also includes recommendations addressing the various types of impairment and general conditions observed. The list is by no means exhaustive, but rather a summary of suggestions for additional monitoring efforts, BMP implementation, and other recommendations for follow-up activities while still working within the framework of the "5-Year Basin Cycle" and using the resources routinely available to DWM personnel.

Table 3. A summary of potential causes of benthos and habitat impairment observed at each biomonitoring station during the 2005 Shawsheen River watershed survey. Where applicable, recommendations have been made.

SITE	POSSIBLE CAUSES OF IMPAIRMENT	RECOMMENDATIONS
SR01	-Slight instream sediment deposition; -Channel only 75% full of water	-Biomonitoring during next MassDEP Shawsheen River watershed survey -Water quality monitoring during next MassDEP Shawsheen River watershed survey -Continued use as watershed reference station
SH00	-Severe habitat degradation—sediment deposition/embeddedness; lack of bank/riparian vegetation; bank erosion; channelized -Low baseflow (channel half full of water) -Adjacent impervious surfaces/Stormwater -Water quality degradation (organic enrichment/low DO)	-Biomonitoring during next MassDEP Shawsheen River watershed survey -Water quality monitoring during next MassDEP Shawsheen River watershed survey -Improve vegetative buffer along banks -Stream-cleanup to address trash inputs -Field reconnaissance in subbasin to investigate land-uses that may contribute NPS inputs -Investigate possible sources of sediment inputs—implement BMPs as needed
EB02	-Severe habitat degradation—sediment deposition/embeddedness; lack of bank/riparian vegetation; bank erosion; channelized -Low baseflow (channel half full of water) -Adjacent impervious surfaces/Stormwater -Water quality degradation (organic enrichment/low DO)	-Biomonitoring during next MassDEP Shawsheen River watershed survey -Water quality monitoring during next MassDEP Shawsheen River watershed survey -Improve vegetative buffer along banks -Stream-cleanup to address trash inputs -Field reconnaissance in subbasin to investigate land-uses that may contribute NPS inputs -Investigate possible sources of sediment inputs—implement BMPs as needed
CB01A	-Sediment deposition -NPS inputs (yard waste) from adjacent lawn -Water quality degradation (organic enrichment/low DO)	-Biomonitoring during next MassDEP Shawsheen River watershed survey -Water quality monitoring during next MassDEP Shawsheen River watershed survey -Field reconnaissance in subbasin to investigate land-uses that may contribute NPS inputs, especially sediments—implement BMPs as needed -Outreach to address NPS inputs (yard waste) from abutting residence
SH09	-Water quality degradation (organic enrichment/low DO, nutrients) -Bank erosion -Trash	-Biomonitoring during next MassDEP Shawsheen River watershed survey -Water quality monitoring during next MassDEP Shawsheen River watershed survey -BMPs to address bank erosion along left (west) bank near railroad tracks -Outreach/Stream-cleanup to address trash inputs
RB01A	-Low baseflow (channel <50% full of water) -Erosion along right (north) bank -Trash along right (north) bank -Water quality degradation (organic enrichment/low DO)	-Biomonitoring during next MassDEP Shawsheen River watershed survey -Water quality monitoring during MassDEP Shawsheen River watershed survey -BMPs to address bank erosion along left (north) bank near railroad tracks -Outreach/Stream-cleanup to address trash inputs

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APPENDIX

Macroinvertebrate taxa list, RBPIII macroinvertebrate analysis, and habitat evaluations

Contents

Table A1. Species-level taxa list and counts, functional feeding groups (FG), and tolerance values (TV) for macroinvertebrates collected from stream sites during the 2005 Shawsheen River watershed survey between 26 and 27 July 2005. Refer to Table 1 for a listing and description of sampling stations.

Taxon	FG[1]	TV[2]	Sampling Stations					
			SR01[3]	SH00	EB02	CB01A	SH09	RB01A
Pisidiidae	FC	6		1				
Enchytraeidae	GC	10				1		
Nais communis	GC	8				1		1
Pristina aequiseta	GC	8						6
Tubificidae IWP	GC	10				1		1
Lumbriculidae	GC	7		1				8
Caecidotea sp.	GC	8		1	1			
Crangonyx sp.	GC	6	1			1		
Gammarus sp.	GC	6			6	4	1	
Baetidae	GC	4	1				1	
Heterocloeon curiosum	GC	2					6	
Maccaffertium sp.	SC	3	1				5	
Cordulegaster maculata	PR	3			1			
Zygoptera	PR	7						1
Nigronia serricornis	PR	0					1	
Brachycentrus sp.	FC	1	9					
Micrasema sp.	SH	2	1					
Glossosoma sp.	SC	0	1					4
Cheumatopsyche sp.	FC	5	16	5			23	32
Diplectrona sp.	FC	0						1
Hydropsyche betteni	FC	6	20	16	51	32	25	8
Hydropsyche morosa gr.	FC	6						14
Macrostemum sp.	FC	3	2				1	
Lepidostoma sp.	SH	1	1					
Oecetis sp.	PR	5	1					
Chimarra aterrima	FC	4						11
Chimarra obscura	FC	4	15	12			18	
Dubiraphia sp.	GC	6	1					
Macronychus glabratus	SH	5	2					
Oulimnius latiusculus	SC	4	1				4	
Stenelmis sp.	SC	5	3	4	24	3	3	
Dineutus sp.	PR	4					1	
Psephenus herricki	SC	4	1				1	
Probezzia sp.	PR	6		1				
Chironomini	GC	6						1
Microtendipes pedellus gr.	FC	6				5		
Microtendipes rydalensis gr.	FC	6	4					
Polypedilum sp.	SH	6		1				
Polypedilum flavum	SH	6	4	3		2	8	
Polypedilum scalaenum gr.	SH	6				1		
Tribelos/Phaenopsectra sp.	GC	7						1
Tanytarsini	FC	6			1			
Micropsectra sp.	GC	7		2				1
Rheotanytarsus exiguus gr.	FC	6	1		1	7		
Rheotanytarsus pellucidus	FC	5				6		1
Tanytarsus sp.	FC	6		1				
Zavrelia/Stempellinella sp.	GC	4				1		
Diamesa sp.	GC	5						7

Chaetocladius sp.	GC	6		1				2
Corynoneura sp.	GC	4		1				
Cricotopus bicinctus	GC	7		2				
Rheocricotopus robacki	GC	5		1	1			
Thienemanniella sp.	GC	6						1
Tvetenia paucunca	GC	5		7	1	11		6
Tvetenia vitracies	GC	5	5				7	1
Conchapelopia sp.	PR	6	1			2		1
Hemerodromia sp.	PR	6	1			1		
Simulium sp.	FC	5			2			3
Simulium tuberosum complex	FC	4	8	34		13	2	
Antocha sp.	GC	3	1		6	2		
Dicranota sp.	PR	3			1	4		
Total			102	94	96	98	107	112
HBI			4.52	4.89	5.48	5.43	4.74	5.35

[1]Functional Feeding Group (FG) 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

Table A2. Summary of RBP III data analysis for macroinvertebrate communities sampled during the Shawsheen River watershed survey between 26 and 27 July 2005. Shown are the calculated metric values, metric scores (in italics) based on comparability to the regional reference station (SR01), and the corresponding assessment designation for each biomonitoring station. Refer to Table 1 for a listing and description of sampling stations.

SAMPLING STATION	**SR01**		**SH00**		**EB02**		**CB01A**		**SH09**		**RB01A**	
STREAM	Shawsheen River		Shawsheen River		Elm Brook		Content Brook		Shawsheen River		Rogers Brook	
HABITAT SCORE	165		80		80		137		153		155	
TAXA RICHNESS	25	*6*	17	*4*	11	*2*	19	*4*	16	*4*	22	*6*
BIOTIC INDEX	4.52	*6*	4.89	*6*	5.48	*4*	5.43	*4*	4.74	*6*	5.35	*4*
EPT INDEX	11	*6*	3	*0*	1	*0*	1	*0*	7	*0*	6	*0*
EPT/CHIRONOMIDAE	4.53	*6*	1.74	*2*	12.75	*6*	0.91	*0*	5.27	*6*	3.33	*4*
SCRAPER/FILTERER	0.09	*6*	0.06	*6*	0.44	*6*	0.05	*6*	0.19	*6*	0.06	*6*
% DOMINANT TAXON	20%	*6*	36%	*2*	53%	*0*	33%	*2*	23%	*4*	29%	*4*
REFERENCE AFFINITY	100%	*6*	65%	*4*	76%	*6*	61%	*4*	90%	*6*	81%	*6*
TOTAL METRIC SCORE	*42*		*24*		*24*		*20*		*32*		*30*	
% COMPARABILITY TO REFERENCE	--		57%		57%		48%		76%		71%	
BIOLOGICAL CONDITION -DEGREE IMPACTED	**REFERENCE**		**SLIGHTLY IMPAIRED**		**SLIGHTLY IMPAIRED**		**MODERATELY IMPAIRED**		**SLIGHTLY IMPAIRED**		**SLIGHTLY IMPAIRED**	

Table A3. Habitat assessment summary for biomonitoring stations sampled during the 2005 Shawsheen River watershed survey. For primary parameters, scores ranging from 16-20 = optimal; 11-15 = suboptimal; 6-10 = marginal; 0-5 = poor. For secondary parameters, scores ranging from 9-10 = optimal; 6-8 = suboptimal; 3-5 = marginal; 0-2 = poor. Refer to Table 1 for a listing and description of sampling stations.

STATION	SR01*	SH00	EB02	CB01A	SH09	RB01A
PRIMARY PARAMETERS (range is 0-20)	**SCORE**					
INSTREAM COVER	18	4	6	9	15	11
EPIFAUNAL SUBSTRATE	18	17	11	15	18	19
EMBEDDEDNESS	15	8	11	12	17	18
CHANNEL ALTERATION	15	11	11	13	11	20
SEDIMENT DEPOSITION	15	4	5	10	14	19
VELOCITY-DEPTH COMBINATIONS	19	7	8	12	17	12
CHANNEL FLOW STATUS	10	8	9	16	18	7
SECONDARY PARAMETERS (range is 0-10 for each bank)	**SCORE**					
BANK VEGETATIVE PROTECTION left	10	7	3	8	6	9
BANK VEGETATIVE PROTECTION right	10	3	2	9	8	9
BANK STABILITY left	8	5	3	7	8	5
BANK STABILITY right	8	3	3	8	9	8
RIPARIAN VEGETATIVE ZONE WIDTH left	10	2	5	8	3	10
RIPARIAN VEGETATIVE ZONE WIDTH right	9	1	3	10	9	8
TOTAL SCORE	**165**	**80**	**80**	**137**	**153**	**155**

*Reference Station