APPENDIX A

***Technical Memorandum* TM-31-2**

FARMINGTON RIVER WATERSHED 2001 BIOLOGICAL ASSESSMENT

John F. Fiorentino
Massachusetts Department of Environmental Protection
Division of Watershed Management
Worcester, MA

1 October 2003

CONTENTS

Tables and Figures

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. 1999, 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 (MA DEP/DWM) 2001 Farmington River watershed assessments, aquatic benthic macroinvertebrate biomonitoring was conducted to evaluate the biological health of various streams within the watershed. A total of 8 biomonitoring stations were sampled to investigate the effects of various nonpoint source (NPS) stressors on resident benthic communities. All stations sampled during the 2001 survey were historical MA DEP biomonitoring stations—most recently assessed in 1996 (Fiorentino 1997; MA DEP 1998). The 2001 benthos data, then, will allow MA DEP to determine if water quality and habitat conditions have improved or worsened over time. To minimize the effects of temporal (seasonal and year to year) variability, sampling was conducted at approximately the same time of the month as the 1996 biosurveys. Sampling locations, along with station identification numbers and sampling dates for benthos monitoring, are noted in Table 1. Sampling locations are also shown in Figure 1.

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 Farmington River watershed macroinvertebrate biomonitoring stations were compared to a regional reference station most representative of the "best attainable" (i.e., least-impacted) conditions in the watershed. Use of a regional reference station is particularly useful in assessing nonpoint source pollution (Hughes 1989), as well as nutrient/BOD loadings originating from multiple and/or unknown sources in a watershed. As with the 1996 biomonitoring survey, regional reference stations were established in Hubbard Brook (fourth-order) and Valley Brook (second/third-order). Both stations were unaffected by point sources of water pollution (there are no known point source discharges in their watersheds), and they were also assumed (based on topographic map examinations and field reconnaissance) to be relatively unimpacted by nonpoint sources. The decision of which reference station to use for comparisons to a study site was based on comparability of stream morphology, flow regimes, and drainage area. In some cases, study sites were compared to both reference stations.

During "year 1" of its "5-year basin cycle", problem areas within the Farmington River watershed were better defined through such processes as coordination with appropriate groups (EOEA Farmington River Watershed Team, local watershed associations, MA DEP/DWM, MA DEP/WERO), assessing existing data, and conducting site visits. Following these activities, the 2001 biomonitoring plan was more closely focused and the study objectives better defined. Table 2 includes a summary of the perceived problems and primary issues—both historical and current—addressed during the 2001 Farmington River watershed biomonitoring survey.

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

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

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

3. Using the benthic macroinvertebrate data, and supporting water chemistry (when available) and field/habitat data:

- assess the types of water quality and/or water quantity problems that are present.
- make recommendations for remedial actions or additional monitoring and assessment.
- provide macroinvertebrate and habitat data to MA DEP/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 agencies.

Table 1. List of biomonitoring stations sampled during the 2001 Farmington River watershed survey, including station identification number, mile point (distance from mouth), upstream drainage area, station description, and date.

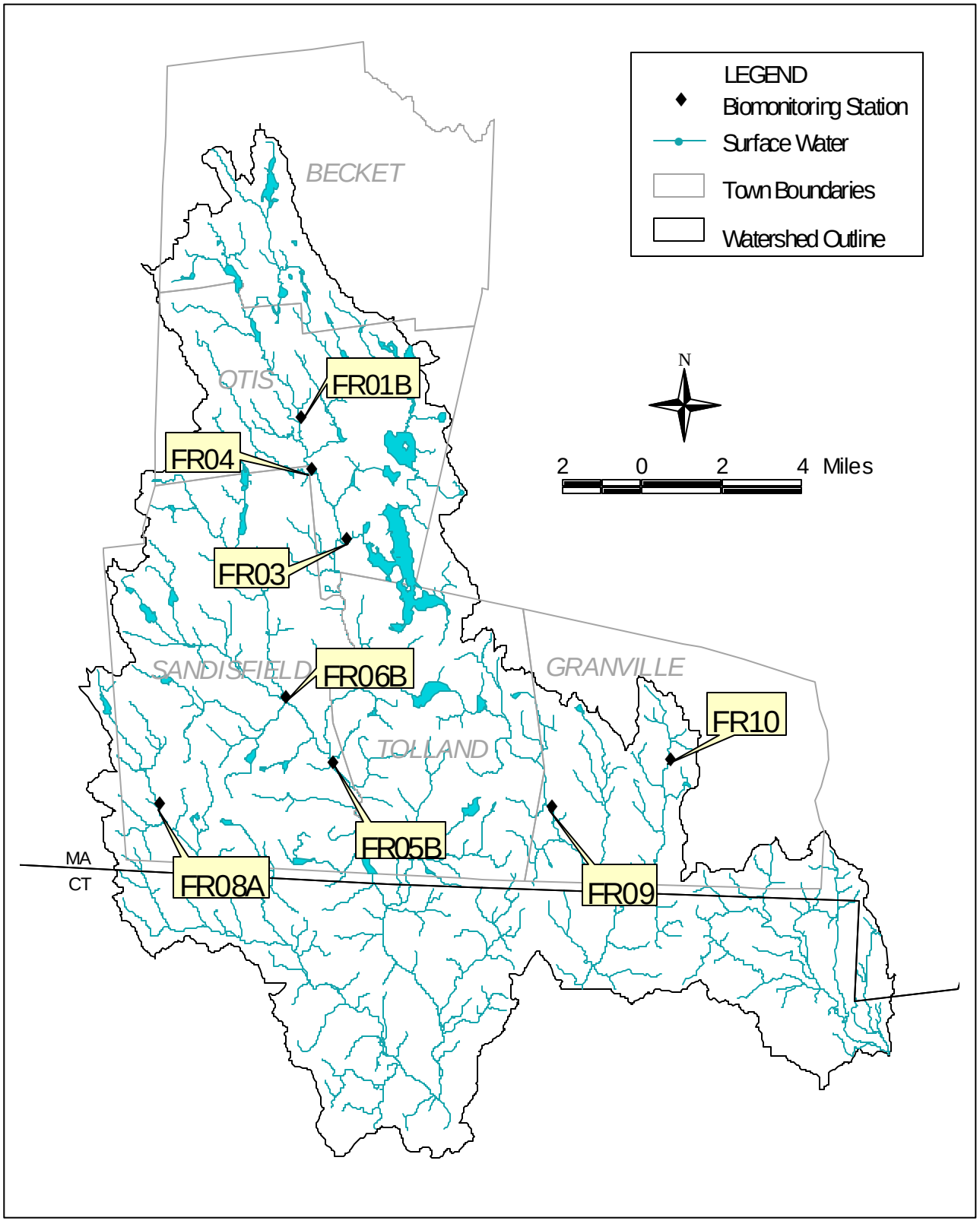
Station ID	Mile Point	Upstream Drainage Area (mi^2)	**Farmington River Watershed** Station Description	Sampling Date
FR09	3.2	11.72	Hubbard Brook, 300 m upstream from West Hartland Rd., Granville, MA	13 August 2001
FR10	4.1	2.14	Valley Brook, 500 m upstream from Rt. 57, Granville, MA	13 August 2001
FR01B	14.0	15.52	West Branch Farmington River, upstream from Otis, near Rt. 8, Otis, MA	14 August 2001
FR05B	3.5	91.76	West Branch Farmington River, 5 m upstream from Clark Rd., Sandisfield, MA	13 August 2001
FR04	0.3	4.12	Benton Brook, 150 m downstream from Beech Plain Rd., Sandisfield, MA	14 August 2001
FR03	0.2	16.54	Fall River, 20 m upstream from Reservoir Rd., Otis, MA	14 August 2001
FR06B	1.9	22.07	Clam River, 10 m upstream from Beech Plain Rd., Sandisfield, MA	13 August 2001
FR08A	11.1	4.68	Sandy Brook, 500 m downstream from Norfolk Rd., Sandisfield, MA	14 August 2001

Table 2. List of perceived problems addressed at each station during the 2001 Farmington River watershed biomonitoring survey.

Station	Issues/Perceived Problems
Hubbard Brook (FR09) Valley Brook (FR10)	-Reference Condition[1] -Reference Condition[1]
West Branch Farmington River (FR01B)	-Runoff from adjacent residences (lawns, horses)[1] -Eutrophic impoundment (Shaw Pond) effects [2] -NPS inputs (sand, salt piles) from DPW property[1,3,4]
West Branch Farmington River (FR05B)	-NPS inputs (sand, septic leachate, carwash) from New Boston and West New Boston (via Clam River) [1,3,4]
Benton Brook (FR04)	-NPS inputs from new home construction[1,4] -Road runoff[1,4]
Fall River (FR03)	-Impoundment (Otis Reservoir; Big Pond) effects [2,3] -NPS inputs (runoff, trash) from adjacent road[1,4]
Clam River (FR06B)	-NPS inputs (road/lawn runoff)[1,3,4] -Eutrophic impoundment (Upper Spectacle Pond) effects[2] -Septic leachate[3]
Sandy Brook (FR08A)	-Eutrophic impoundment (York Lake) effects[2] -Septic leachate[3] -NPS inputs (runoff from adjacent road, upstream sawmill) [1,3,4]

[1](Fiorentino 1997); [2](MA DEP 1999); [3](MA DEP 1998); [4](MA DEP 2001)

FARMINGTON RIVER WATERSHED
BIOMONITORING STATIONS
Figure 1



METHODS

Macroinvertebrate Sampling

The macroinvertebrate sampling procedures employed during the 2001 Farmington River watershed biomonitoring survey are described in the standard operating procedures (Nuzzo 1999), and are based on US EPA Rapid Bioassessment Protocols (RBPs) for wadeable streams and rivers (Barbour et al. 1999). 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 (Figure 2). Sampling activities were conducted in accordance with the Quality Assurance Project Plan (QAPP) for benthic macroinvertebrate biomonitoring (Fiorentino 2001). Sampling was conducted at each station by MA DEP/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 MA DEP/DWM lab for further processing.

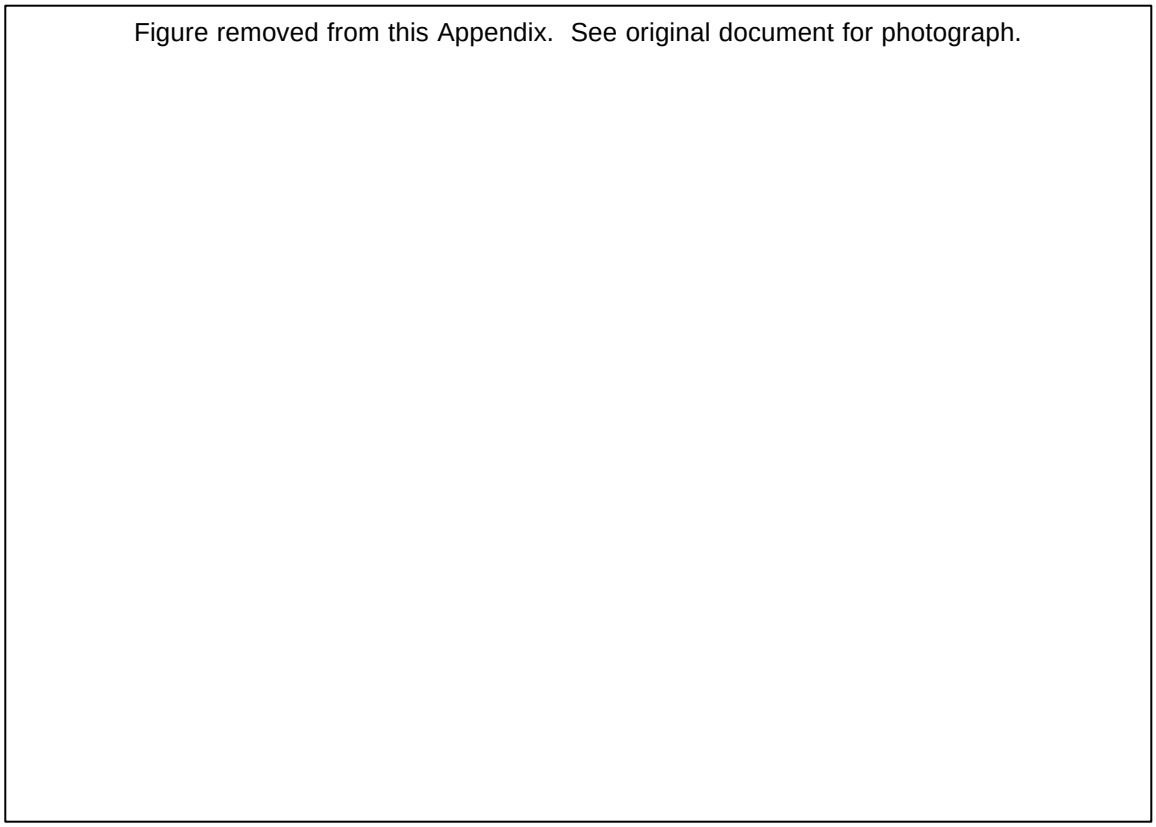


Figure 2. MA DEP/DWM biologist collecting macroinvertebrates using “kick-sampling”

Macroinvertebrate Sample Processing and Analysis

The macroinvertebrate sample processing and analysis procedures employed for the 2001 Farmington River watershed biomonitoring samples are described in the standard operating procedures (Nuzzo 1999) and were conducted in accordance with the Quality Assurance Project Plan (QAPP) for benthic macroinvertebrate biomonitoring (Fiorentino 2001). 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 (Barbour et al. 1999). RBPIII offers a more rigorous bioassessment than RBPII, which was employed in the analyses of the 1996 family-level macroinvertebrate data for the Farmington River watershed. By increasing the level of taxonomic resolution; that is, by performing taxonomic identification to the lowest practical level, the ability to discriminate the level of impairment is enhanced. While this additional taxonomy requires considerably more time, discrimination of additional degrees of aquatic impairment is achieved. 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 (Barbour et al. 1999). 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. The analysis separates sites into four categories: non-impacted, slightly impacted, moderately impacted, and severely impacted. Each impact category corresponds to a specific aquatic life use-support determination used in the CWA Section 305(b) water quality reporting process—non-impacted and slightly impacted communities are assessed as "support" in the 305(b) report; moderately impacted and severely impacted communities are assessed as "impaired." A definition of the *Aquatic Life* use designation is provided in the *Massachusetts Surface Water Quality Standards* (SWQS) (MA DEP 1996). 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 (Barbour et al. 1999). Those biological metrics calculated and used in the analysis of 2001 Farmington River watershed macroinvertebrate data are listed and defined below [For a more detailed description of metrics used to evaluate benthos data see Barbour et al. (1999)]:

1. Taxa Richness—a measure based on the number of taxa present. Generally greater with better 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 MA DEP/DWM biologists were originally developed by Hilsenhoff and have since been supplemented by Bode et al. (1991) and Lenat (1993). 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 number 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 (Barbour et al. 1999). 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 Farmington 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; Barbour et al. 1999). 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 2001 Farmington River watershed biosurveys, habitat qualities were scored using a modification of the evaluation procedure in Barbour et al. (1999). The matrix used to assess habitat quality is based on key physical characteristics of the water body and related streamside features. Most parameters evaluated are instream physical attributes often related to overall land-use and are potential sources of limitation to the aquatic biota (Barbour et al. 1999). 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 2001 biosurveys are attached as an Appendix (Tables A1 – A4). 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.

Summary tables of the macroinvertebrate data analyses, including biological metric calculations, metric scores, and impairment designations, are included in the Appendix as well. Table A2 is the summary table for those biomonitoring stations that used the Hubbard Brook site (FR09) as the regional reference station. Table A3 is the summary table for station comparisons to the Valley Brook reference site (FR10). Habitat assessment scores for each station are also included in the summary tables, while a more detailed summary of habitat parameters is shown in Table A4.

As was determined following the 1996 Farmington River watershed survey, the 2001 macroinvertebrate biomonitoring data generally indicated excellent overall water quality and biological health at the sampling stations investigated. In fact, the Farmington River watershed remains one of the least disturbed basins in the Commonwealth in terms of the resident aquatic biota encountered there, with only slight and generally localized areas of nonpoint source pollution at a few of the MA DEP study sites. Reference-quality biomonitoring stations in Hubbard Brook (FR09) and Valley Brook (FR10) continue to support diverse and well-balanced aquatic communities as expected in a "least-impacted" stream system.

Farmington River Watershed

The Farmington River watershed drains a total area of 602 square miles in Massachusetts and Connecticut. Only 156 square miles, or about 25% of the total watershed is located in Massachusetts, lying between the Housatonic and Westfield River watersheds. A major portion of the Massachusetts section of the watershed is drained by the West Branch of the Farmington River and its tributaries. Originating in Becket in the southern Berkshire Mountains of southwestern Massachusetts, the West Branch of the Farmington River runs for 18 miles before entering northwestern Connecticut. Here it is impounded to form Colestream Reservoir, a back-up drinking water supply for the City of Hartford. The remaining eastern-most watershed area in Massachusetts drains into Hubbard Brook and Valley Brook, which form the East Branch of the Farmington River, just below the state line in Connecticut. The East Branch is impounded in Connecticut to form the Barkhampsted and Nepaug Reservoirs, primary drinking water supplies for the metropolitan Hartford area. In Connecticut, the Farmington flows for over 60 miles before joining the Connecticut River in Windsor.

In Massachusetts, the West Branch is characterized by numerous rapids created by an average fall rate of nearly 100 feet per mile. The major tributaries are the Clam and Fall Rivers. The Fall River is formed primarily by drainage from Big Pond and Otis Reservoir. Flow in the Fall River is regulated by Otis Reservoir which is used for storage and recreational activities. The headwaters of the Clam River are formed by many small streams in large tracts of undeveloped forested land. The Clam River is joined by the Buck River about two miles above its confluence with the West Branch of the Farmington River. There are a total of 41 named streams in the watershed stretching over 116 miles and 51 named lakes and ponds covering 3595 acres.

The United States Geological Survey (USGS) operates a gage on the West Branch of the Farmington River in Sandisfield in the village of Roosterville, 0.3 miles below the confluence with the Clam River. This gage represents drainage from an area of 91.7 square miles and has an average discharge of 182 cfs over 82 years of record (USGS 2003). Mean monthly streamflow over the 80 year period for the month of August is 85.5 cfs, which is dramatically different than during August 2001 when streamflow measured a mere 13.6 cfs. As a result, low flow effects (e.g., less than optimal channel flow status, exposed instream substrates, shallow or lack of pool areas) were observed at several of the biomonitoring stations sampled during the 2001 survey.

In Massachusetts, the Farmington River watershed encompasses major portions of the towns of Becket, Otis, Sandisfield, Tolland, and Granville. Small areas of the watershed also extend into the towns of Southwick, Blandford, Tyringham, Monterey, and New Marlborough. Over 85% of the watershed in Massachusetts is forested, providing timber resources for related industries for over two centuries. Numerous lakes and several state forests, including those in Sandisfield, Otis, Granville and Tolland cover large areas of the watershed and provide popular areas for outdoor recreation, including fishing, hunting, camping, canoeing, and hiking. The Farmington River is unique in Massachusetts as the only major river that does not receive a single permitted municipal or industrial surface wastewater discharge. In addition, there are no major water withdrawals for consumptive use in the Massachusetts portion of the watershed.

Hubbard Brook

Hubbard Brook is formed at the confluence of Babcock Brook and Hall Pond Brook in Tolland, just north of where Route 57 crosses into Granville. After entering Granville the river flows southeast along the west flank of Ore Hill over moderately steep undeveloped terrain. It then flows into Granville State Forest, crossing under West Hartland Road. From this point the valley terrain becomes steeper, the stream gradient higher, and the river flows more eastward. The segment ends at the Hartland, Connecticut/Granville, Massachusetts border. Just after crossing the state line into Connecticut, the river enters a delta before flowing into the north end of Barkhamsted Reservoir, which is also the beginning of the East Branch Farmington River.

FR09—Hubbard Brook, mile point 3.20, 300 m upstream from West Hartland Road, Granville, MA.

Habitat

FR09 meandered through extensive forest area with an even mix of evergreens and deciduous trees. The 100 m reach sampled was approximately 300 m upstream from West Hartland Road in Granville State Forest. Almost completely open-canopied (<5% shaded), the reach was approximately 7 m wide, with a relatively uniform depth of 0.40 m throughout much of its riffle-dominated length. Channel flow status was optimal, with water reaching the base of both banks and leaving virtually no exposed substrates. The reach was dominated by shallow and deep riffles, with occasional deep (0.50 m) pools and runs. A variety of velocity/depth patterns and stable rock substrates offered superb habitat for fish and macroinvertebrates. Boulders—many with dense moss cover—were the predominant substrate sampled, although kicks were made in cobbled riffle areas as well. Algal cover was minimal (<5%) and consisted of filamentous green algae attached to some rocks. There was no evidence of instream sediment deposition or embeddedness, and the dense woodland setting provided an undisturbed riparian zone along both sides of the reach. Although the gradient of the riparian zone increased rapidly from both sides of the channel, bank stability was reinforced with large boulders. Both stream banks were well vegetated with various forms of herbaceous (ferns; Joe-Pye weed, *Eupatorium*; grasses) and shrubby (witch-hazel, *Hamamelis virginiana*; riverbank grape, *Vitis riparia*) growth before giving way to tree (hemlock, *Tsuga canadensis*; birch, *Betula* sp; ash, *Fraxinus amaricana*; red maple, *Acer rubrum*) cover.

FR09 received a composite habitat score of 185/200—one of the higher habitat evaluations received by a biomonitoring station in the Farmington River watershed (Table A4). Those primary instream habitat parameters directly pertinent to the support of aquatic communities and weighted the highest in the assessment matrix—substrate type and stability, availability of refugia, and velocity/depth regimes—scored exceptionally well. This was used as the primary reference station for comparisons to biomonitoring stations in the West Branch Farmington River (FR01B, FR05B) and Clam River (FR06B)—all of which are predominately open-canopied reaches with comparable flow regimes, instream habitat, and upstream drainage areas. Designation of FR09 as a reference condition was based on its high habitat evaluation, presumed good water quality, absence of nonpoint source pollution inputs, and minimal upstream/adjacent land-use impacts (e.g., absence of point source inputs, lack of channelization, minimal development and agricultural activity nearby, undisturbed and well vegetated riparian zone).

Benthos

The Hubbard Brook biomonitoring station was characterized by a macroinvertebrate assemblage indicating a healthy aquatic community, with metric values indicative of good water quality and "least-impacted" conditions (Table A2). In particular, those attributes that measure components of community structure (i.e., Taxa Richness, Biotic Index, EPT Index)—which have been shown to display the lowest inherent variability among commonly used metrics (Resh 1988)—scored well, further corroborating the designation as a reference station. A low Biotic Index, a high (second highest value in the survey) EPT Index, and low dominance of a single taxon indicated a dominance of pollution-sensitive taxa and good overall community balance among the FR09 benthos assemblage. And while chironomids were fairly well represented here, the dominant midge taxon, *Polypedilum aviceps*, is considered a "clean water" indicator—assigned a low tolerance value and rarely associated with impacted waters (Bode and Novak 1998). The FR09 benthic community received a total metric score of 42 out of a possible score of 42 (Table A2).

Valley Brook

Valley Brook drains a small wetland northwest of Holden Hill in Granville and flows south over moderately sloped undeveloped terrain into Twining Hollow before passing under Route 57. From this point on the valley floor widens, the stream gradient lessens, and there is some floodplain development allowing the stream to meander. The stream then begins to flow toward the southwest, crossing into Connecticut at the Hartland, Connecticut/Granville, Massachusetts border. From here it continues to its confluence with Hubbard Brook forming the East Branch Farmington River at the north end of Barkhamsted Reservoir.

FR10—Valley Brook, mile point 4.10, 500 m upstream from Route 57, Granville, MA.

Habitat

The FR10 sampling reach began approximately 500 m upstream from Route 57 (Main Road) and meandered through a heavily wooded hemlock forest that provided a completely (100% shaded) closed canopy. Well developed, albeit shallow (0.2 m), riffle areas with a variety of stable hard substrates (mostly boulder) offered exceptional benthos habitat in this small (5 m wide) tributary. And though marginal channel flow status resulted in much exposed substrates along the margins of the stream, dense (90% coverage within reach) bryophyte cover on instream boulders provided additional productive microhabitat for macroinvertebrates. Fish cover was somewhat compromised due to the shallow nature of the stream which resulted in shallow pools (0.2 m) and unusable (exposed) woody habitat (e.g., snags, logs, etc.). Embeddedness and deposition were virtually nonexistent, as were other signs of nonpoint source pollution. Bank stability was excellent due to dense moss cover and large boulders, and the well established hemlock (*Tsuga canadensis*) forest and accompanying understory vegetation (mountain laurel, *Kalmia latifolia*) on both sides of the stream provided an unlimited and undisturbed riparian vegetative zone throughout the reach.

FR10 received a composite habitat score of 167/200 (Table A4). This was used as the primary reference station for comparisons to biomonitoring stations in Benton (FR04) and Sandy (FR08A) brooks—both of which are mostly closed-canopied reaches with comparable flow regimes, instream habitat, and drainage area. In addition, FR10 served as a reference station for FR03—a station with considerably more drainage area (due to contributions from Otis Reservoir), yet comparable to Valley Brook in terms of stream order, canopy cover, and gradient. Designation of FR10 as a reference condition was based on its high habitat evaluation, presumed good water quality, absence of nonpoint source pollution inputs, and minimal upstream/adjacent land-use impacts (i.e., absence of point source inputs, lack of channelization, minimal development and agricultural activity nearby, undisturbed and well vegetated riparian zone).

Benthos

FR10 was characterized by a diverse, taxa-rich assemblage that included a number of highly intolerant EPT taxa (Table A1). In fact, the Plecoptera, generally considered the most pollution-sensitive insect order, was represented by three taxa with a Tolerance Value of 0. In general, the benthic community here was well-

balanced—Percent Dominant Taxon was low—with all major trophic groups represented. This was the only biomonitoring station in the survey in which the numerically dominant taxon was a plecopteran—in this case the highly sensitive (TV=0) shredder, *Leuctra* sp. (Table A1).

FR10 received a total metric score of 42 (Table A3). The optimum community structure and balanced trophic structure exhibited in the macroinvertebrate assemblage at this station suggest that this portion of Valley Brook is indeed indicative of the "best-attainable" conditions in the Farmington River watershed.

West Branch Farmington River

The outflow from Hayden Pond spills over the dam forming the West Branch Farmington River and continues flowing southeast over fairly flat terrain paralleling Route 8. The river enters a wetland area and then a series of small impoundments passing through the town center of Otis. From here it enters a relatively long, straight reach of low gradient and receives the flow from the Fall River. The West Branch Farmington River continues to the southeast, paralleling Route 8, flowing by the Cold Spring Campground before entering a narrow, steep river valley that is the corporate boundary between the towns of Sandisfield and Tolland. The river makes some large meanders in this narrow section and begins to flow to the southwest to the village of New Boston in Sandisfield. About a mile downstream from New Boston, just above the Village of Roosterville, is the confluence with the Clam River. Continuing to parallel Route 8, the West Branch Farmington River veers back towards the southeast and then enters the impounded area of Colestream River Reservoir where the interstate boundary between Massachusetts and Connecticut bisects the reservoir.

FR01B—West Branch Farmington River, mile point 14.0, upstream from Otis, near Rt. 8, Otis MA .

Habitat

The FR01B sampling reach began immediately upstream from a large pool area and ended approximately 20 m downstream from the property of the Otis Department of Public Works located on Route 8. The fully open-canopied reach was 10 m wide and virtually one long riffle, with cobble/boulder-dominated substrates of varying depths (0.10 - 0.40 m) providing excellent epifaunal habitat for macroinvertebrates. Fish habitat was also optimal, with large boulders and overhanging shrubs providing the majority of stable cover. Channel flow status was good, with water reaching the base of both banks and only a minimum (<5%) amount of exposed substrates. Instream algal cover was minimal, covering about 5% of rocky substrates in the reach and comprised of filamentous green forms. Banks were stable and well vegetated along the left (east) bank, with a dense asasemblage of grasses, shrubs (*Viburnum* sp.; dogwood, *Cornus stolinifera*; elderberry, *Sambucus canadensis*) and herbaceous (jewelweed, *Impatiens capensis*; Joe-pye weed, *Eupatorium* sp; cardinal flower, *Lobelia cardinalis*) vegetation giving way to a wide and heavily forested (red maple, *Acer rubrum*; elm, *Ulmus* sp.; white pine, *Pinus strobus*) riparian zone. Right (west) bank stability was also good due to large boulders along the stream margin and the well established grass/shrub/herbaceous layer. The riparian zone, however, was extremely reduced due to adjacent residential properties. A horse paddock occupied the majority of the zone, while expansive lawns encroached upon the bottom of the reach and the DPW's paved lot was situated in close proximity to the top of the reach. While the lawn offered potential nonpoint source inputs (geese were observed on the lawn and in a large pool) just downstream from the sampling reach, clear signs of runoff from both the paddock and the DPW property were observed during the biosurvey here. Substantial deposits of sand and other fine materials were accumulated immediately upstream from the reach, with additional signs of instream deposition throughout the sampling reach—particularly along the right margin of the channel. As a result, sediment deposition at FR01B was worse than any other biomonitoring station in the Farmington River watershed—most likely the result of a combination of sand pile inputs from the DPW property and runoff associated with the horse paddock. It is unclear whether slight turbidity observed at FR01B was the result of water quality impairment related to inputs from these adjacent properties or other more upstream sources [(e.g., Shaw Pond which is 303(d)-listed for organic enrichment and about 3 mi upstream from FR01B) (MA DEP 1999)].

FR01B received a total habitat assessment score of 170/200 (Table A4). Riparian zone degradation in the form of a reduced vegetated buffer along the right bank affected the overall score most negatively. Instream

sediments directly impacted available epifaunal habitat for macroinvertebrates throughout the sampling reach in addition to settling out in the large pool immediately downstream from the reach and threatening fish habitat. Sedimentation effects at FR01B may in fact be more pronounced in 2001 than during the 1996 biosurvey here, when sediment inputs appeared to be confined to only a small area just upstream from the sampling reach and only minimally (score: 18/20) affected the sediment deposition habitat parameter at FR01B (Fiorentino 1997).

Benthos

The FR01B benthos assemblage received a total metric score of 40, which was highly (95%) comparable to the reference station (FR09) at Hubbard Brook (Table A2). Six of the seven metrics received the highest possible (score =6) score. Only the EPT Index metric suffered point reductions—the result of a slight decline in numbers of pollution sensitive taxa compared to the reference community. Nevertheless, the macroinvertebrate community here was found to be "non-impacted" (Table A2).

Despite the "non-impacted" bioassessment at FR01B, instream habitat constraints—especially sediment deposition—may threaten biological potential here. Sand and other fine sediments can drastically reduce macroinvertebrate microhabitat. These fine materials can be deleterious because they can reduce light penetration (and consequently plant/algal growth), smother hard surfaces, and fill the interstitial spaces within epifaunal substrates (Wiederholm 1984). Resident biota at FR01B, then, may be subsequently affected by obstructions to food collection or respiration caused by fine deposits of organic/inorganic matter. In addition, the filling of pools with sediment reduces fish cover and may be detrimental to fish spawning habitat and egg incubation. The reduction in EPT taxa at FR01B may be at least partially attributed to sediment deposition—the lowest scoring habitat parameter of all the Farmington River watershed biomonitoring stations (Table A4). A recent study by Zweig and Rabeni (2001) found EPT density and EPT richness to be significantly negatively correlated with deposited sediment at their macroinvertebrate biomonitoring sites.

FR05B—West Branch Farmington River, mile point 3.5, upstream from Clark Road, Sandisfield, MA .

Habitat

The FR05B sampling reach began almost (5 m) immediately upstream from Clark Road and a USGS gage in the Roosterville section of Sandisfield. The wide (18 m) nature of this portion of the West Branch Farmington River afforded minimal (5% shaded) canopy cover to the FR05B reach. An abundance of cobble/boulder substrates in wide riffles of varying (0.25 – 0.40 m) depth resulted in excellent benthos habitat. Massive boulders and deep pool areas, especially in the upper half of the reach, provided fish with optimal cover. Instream algal growth, comprised of thin layers of periphyton and filamentous green algae attached to rocky substrates, covered approximately 10% of the reach and were observed only in areas with swift current velocity. Channel flow status was optimal, with water reaching the base of both banks and leaving only a minimal (<5%) amount of channel substrate exposed.

Both stream banks were well vegetated and stabilized with a profusion of grasses, herbaceous (cardinal flower, *Lobelia cardinalis*; Joe-Pye weed, *Eupatorium* sp.; purple loosestrife, *Lythrum salicaria*; goldenrod, *Salidago* sp.) growth, and shrubs (willow, *Salix* sp.; alder, *Alnus* sp.; riverbank grape, *Vitis riparia*; witch-hazel, *Hamamelis virginiana*). Red oak (*Quercus rubra*), elm (*Ulmus* sp.), and black birch (*Betula lenta*) dominated the riparian zone farther from the stream banks. A residential property adjacent to the right (west) bank and a pasture near the left (east) bank resulted in a somewhat reduced (12 – 18 m wide) riparian vegetative buffer. Nevertheless, there was no visible evidence of nonpoint source pollution inputs to the FR05B sampling reach.

FR05B received a total habitat assessment score of 186/200 (Table A4). This was the highest habitat evaluation given to a biomonitoring station in the 2001 survey, including the reference station (FR09) for FR05B. Habitat parameters performed slightly better than during the 1996 biosurvey here, most likely the result of improved channel flow status.

Benthos

As a quality control measure, two side-by-side duplicate benthos samples were collected in the FR05B sampling reach for estimation of sampling precision (or measurement error). Each sample was treated as a discreet sample and processed separately, with the full suite of metrics calculated for each duplicate. Precision was calculated to measure mutual agreement of metric values among duplicate samples. As outlined in the Quality Assurance Project Plan (QAPP) for benthic macroinvertebrate biomonitoring (Fiorentino 2001), precision was calculated from the two samples using Relative Percent Difference (RPD). All metrics calculated for each duplicate received the highest scores possible when compared to their reference station metrics (i.e., score=6; Table A2). In fact, most FR05B metrics performed better than the reference station, demonstrating optimum community structure and good trophic balance. Total Taxa Richness and EPT Index metric values for both duplicates were higher than any other biomonitoring station in the survey, and Dominant Taxa were the least numerous—comprising only 9% and 7% of the FR05B duplicate samples respectively (Tables A2 and A3). Both samples received total metric scores of 42 out of a possible 42, representing 100% comparability to the FR09 reference condition and resulting in an assessment of "non-impacted" for biological condition (Table A2).

Benton Brook

Benton Brook begins as drainage from Hayden Swamp in Otis on the east side of Long Mountain. The stream flows southeast through wetlands and then into an impoundment. From there it crosses under West Center Road and then flows into a series of small impoundments crossing under Route 23. The stream then meanders across a wide floodplain and flows into a small impoundment. It then flows down moderately steep terrain to an impoundment in a residential development. From here it flows more easterly down steep terrain, crossing under Beech Plain Road and then Route 8, to its confluence with the West Branch Farmington River, just south of the town center of Otis.

FR04—Benton Brook, mile point 0.30, 150 m downstream from Beech Plain Road, Sandisfield MA.

Habitat

The FR04 sampling reach began approximately 150 m downstream from Beech Plain Road and ended at the confluence of a small, unnamed tributary near the remnants of an old mill structure. Evergreens (hemlock, *Tsuga canadensis*; white pine, *Pinus strobus*) and various hardwoods (ash, *Fraxinus americana*; red maple, *Acer rubrum*; yellow birch, *Betula lutea*; beech, *Fagus* sp.) provided a mostly (90% shaded) closed canopy over this small stream, whose width was approximately 4 m and depth was no more than 0.10 m in both riffle and pool areas. The shallow nature of the stream resulted in a channel that was only 75% full of water and with an abundance of exposed rocky substrates. Nevertheless, those substrates that remained submerged were subjected to swift current velocity and provided excellent epifaunal habitat for macroinvertebrates. Fish habitat was slightly less than optimal, with boulders offering the most stable cover. Instream aquatic vegetation was absent from the FR04 sampling reach. Stream banks were well vegetated with herbaceous (ferns, mosses, and grasses) growth and occasional shrubs (witch-hazel, *Hamamelis virginiana*). Bank stability was excellent along the right (south) bank, while small areas of erosion were observed along the left (north) bank. Compounding the effects of erosion along the left bank were a narrow riparian vegetative zone and the close proximity of the adjacent road (Beech Plain Road), which offered potential nonpoint source pollution inputs (though sediment inputs and other signs of runoff were not observed). The riparian buffer along the right bank was well developed and extensively forested.

FR04 received a total habitat assessment score of 153/200 (Table A4). The effects of low baseflow (e.g., exposed substrates, shallow pools, unusable fish cover) compromised habitat quality more here during the 2001 biosurvey than in 1996, when water filled the majority of the channel (Fiorentino 1997).

Benthos

The FR04 benthos assemblage received a total metric score of 40, representing 95% comparability to its reference station in Valley Brook (FR10) and resulting in a bioassessment of "non-impacted" (Table A3). All

but one metric outperformed those for the reference community. Only the Reference Affinity metric suffered point deductions (score=4)—probably the result of different trophic structure compared to the reference station assemblage. As evidenced by the numerous algal scraping taxa (and a high Scrapers/Filterers metric value) such as the elmid (*Oulimnius latiusculus*; *Stenelmis* sp.; *Promoresia* sp.) beetles observed here, the FR04 assemblage is likely more periphyton-based than the benthic community found at FR10, which appears to be CPOM-based and more reliant on allochthonous food resources—not surprising given the dense hemlock cover afforded that small second-order stream. Indeed, shredders such as leuctrid stoneflies were abundant at the reference station but much less common at FR04 (Table A1). The FR04 benthos sample contained the highest EPT/Chironomidae density and highest richness (n=14) of pollution sensitive EPT taxa than any of the low-order test streams sampled during the 2001 Farmington River watershed survey (Table A3).

Fall River

Much of the headwaters of the Fall River are formed by Big Pond and Otis Reservoir. Flow in the river is regulated by outlet structures at Otis Reservoir, which is used for water storage and recreation. From the Otis Reservoir outlet, the river flows north, receiving the drainage of Larkum Pond before heading southwest down steep terrain to its confluence with the West Branch Farmington River in Otis. The USGS operates a gage on the Fall River in Otis. The drainage area at the gage is 16.5 square miles, with an average discharge of 49 cfs (USGS 2003).

FR03—Fall River, mile point 0.20, 20 m upstream from Reservoir Road, Otis MA.

Habitat

FR03 was located approximately 20 m upstream from Reservoir Road and about 500 m upstream from the confluence with the West Branch Farmington River. The stream reach was approximately 3 m wide and afforded a fully (100%) shaded canopy by the surrounding hemlock forest. The high gradient reach consisted of a series of fast/cascading riffles (0.20 – 0.30 m deep) with occasional pools that were small but of adequate (0.40 m) depth for fish. In addition to the wide variety of velocity/depth combinations, abundant rock substrates (mostly boulder) provided excellent habitat for macroinvertebrates and stable fish cover. Dense moss cover provided additional epifaunal habitat. Other than these instream bryophytes, macrophyte and algal growth were absent. Despite the lack of true deep (>0.50 m) areas in most of the sampling reach, channel flow status was adequate with water nearly reaching the base of both banks and leaving less than 25% of the streambed substrates exposed.

Both stream banks were well vegetated with mosses, ferns, and witch-hazel (*Hamamelis virginiana*) and were highly stabilized by the massive boulders along the stream margins. The hemlock (*Tsuga canadensis*) dominated riparian zone extended undisturbed along the left (south) bank and provided a 15 m buffer between the right (north) bank and the adjacent road (Reservoir Road). The extreme steepness of the right bank along the upper portion of the reach resulted in some small areas of erosion; the bank was also susceptible to NPS inputs from the nearby road, and was in fact, littered with trash (scrap metal, cans, car parts). Instream evidence of NPS pollution was absent—sediment deposition and substrate embeddedness were virtually nonexistent.

FR03 received a total habitat assessment score of 174/200, which was higher than the habitat score received by its reference station FR10 (Table A4). FR03 habitat parameters performed similarly during the 1996 biomonitoring survey here (Fiorentino 1997).

Benthos

The FR03 benthos assemblage received a total metric score of 36, representing 86% comparability to reference conditions at FR10 (Table A3). Despite the lowest EPT Index (8) received by a biomonitoring station in the 2001 survey, overall biological condition here was found to be “non-impacted”. Metrics for

Taxa Richness, EPT/Chironomidae, and Percent Dominant Taxon performed better than for the reference station and corroborate the "least-impacted" conditions documented here.

As was the case during the 1996 biosurvey at FR03, filter-feeders such as hydropsychid caddisflies were well represented—no doubt the result of an ample supply of suspended FPOM originating from upstream impoundments. As is typical in lentic systems such as lakes and impoundments, autochthonous forms of organic matter become an important food resource for downstream lotic communities such as that encountered at FR03 (Wetzel 1975). When these lentic systems are subjected to increasingly productive conditions, the result can be an almost complete displacement of other trophic guilds by filter feeding taxa downstream from the impoundment. Filter feeders did not hyperdominate the FR03 community, however. In fact, no single taxon dominated the 2001 asemblage, as evidenced in the extremely low Percent Dominant Taxon metric value (Table A3). The presence of numerous algal grazers (e.g., elmid beetles) and other feeding guilds (e.g., shredders, predators) in the FR04 benthos sample demonstrates that other food resources (e.g., periphyton, CPOM) were important here as well (Table A1), and coupled with a high affinity (Reference Affinity=76%) to the reference community further supports that this is a fairly well balanced macroinvertebrate community in terms of trophic structure and community composition.

The resulting 2001 biological assessment of FR03, "non-impacted", was better than the assessment received following the 1996 biosurvey here. In 1996, comparisons of the FR03 benthos to the reference station (FR10) resulted in a bioassessment of "moderately impaired", with an assemblage structured in response to moderate levels of organic enrichment (Fiorentino 1997). It is important to note, however, that the level of analysis (RBPII) performed on the 1996 benthos data was less rigorous than the bioassessment (RBPIII) performed in 2001. In addition, comparisons of the 2001 benthos data at FR03 to previous sampling years should be made with caution due to the potential for metric variability attributable to natural (e.g., temporal) factors. However, this most recent biological assessment of resident benthos at FR03—based on comparisons to current reference conditions—is encouraging, and may suggest some improvement in water quality in this portion of the Fall River subwatershed.

Clam River

The headwaters of the Clam River drain from a small wetland just west of the village of West Otis in the town of Otis. The river flows southeast through a series of small impoundments, crosses into the town of Sandisfield, and then enters a narrow, steep river valley for a short distance. From here it enters a wider flood plain, flows into two small impoundments and then enters a reservoir. The river continues to flow southeast through moderately steep terrain to its confluence with the Buck River in the Village of West New Boston in Sandisfield.

After receiving the considerable discharge contribution from the Buck River subwatershed, the Clam River meanders slightly towards its confluence with the West Branch Farmington River just north of the village of Roosterville in Sandisfield.

FR06B—Clam River, mile point 1.9, 10 m upstream from Beech Plain Road, Sandisfield, MA.

Habitat

The FR06B sampling reach began just upstream from the Beech Plain Road crossing and ended at the mouth of the Buck River. The reach was approximately 5 m wide and minimally (10%) shaded, with a depth ranging from 0.25 m in the riffle areas to almost 0.50 m in the pools. Boulder and cobble/gravel were the predominant substrate types and were subjected to a variety of flow regimes. Riffle/run areas were common and offered exceptional habitat for macroinvertebrates. Stable refugia (boulders, snags, submerged woody material) and adequate depth in pools provided fish with optimal cover. Both fish and invertebrates benefited from minimal embeddedness or sediment deposition. A thin layer of periphyton coated most of the rocky substrates in the fast water areas of the sampling reach, while filamentous green algae were observed in some pools. Other forms of aquatic plant growth (mosses, macrophytes) were absent. Channel flow status was slightly less than optimal, with water nearly reaching the base of both banks and leaving minimal (<25%) amounts of streambed substrate exposed.

Banks were well vegetated with herbaceous growth (ferns, mosses, grasses) and shrubs (rose, *Rosa* sp.; riverbank grape, *Vitis riparia*) throughout the reach. Channelization has historically altered stream morphology here due to the presence of an old stone wall along the left bank; however, the structure's present impact on habitat quality seems insignificant. Bank stability appeared good on both sides of the channel; however, disturbances along the left (west) bank (mowed lawn close to stream, grass clipping and leaf waste piled near bank) resulted in a reduced vegetated riparian zone and potential NPS inputs near the bottom of the reach. A forested riparian buffer, comprised of various hardwoods (red oak, *Quercus rubra*; red maple, *Acer rubrum*; elm, *Ulmus* sp.; ash, *Fraxinus americana*), lined the stream on both sides of the channel before giving way to uncultivated pastureland.

FR06B received a habitat assessment score of 177/200, which was comparable to habitat conditions at the reference station in Hubbard Brook (Table A4). Habitat parameters at FR06B performed slightly better than during the 1996 biosurvey here (Fiorentino 1997).

Benthos

The FR06B benthos assemblage received a total metric score of 38, representing 90% comparability to the reference station and placing the community in the "non-impacted" category for biological condition (Table A2). Slight reductions in both total taxa and EPT taxa richness compared to reference conditions in Hubbard Brook resulted in scoring deductions for these metrics, while other metrics (e.g., EPT/Chironomidae; Biotic Index; Percent Dominant Taxon) performed as well as or better than FR09 (Table A2).

Sandy Brook

Sandy Brook begins as the outlet from York Lake and then flows southeast over relatively flat terrain through a series of small ponds into a wetland, then into a small impoundment where it is joined by Cherry Brook. From there Sandy Brook flows by the village of South Sandisfield and through a narrow river valley closely paralleling South Sandisfield/New Marlborough Road. The stream then enters a wetland where it has a confluence with an unnamed stream originating from Wolf Swamp. The stream continues to flow southeast into a narrow steep valley where it crosses the Massachusetts border into Connecticut.

FR08A—Sandy Brook, mile point 11.10, 500 m downstream from Norfolk Road, Sandisfield, MA.

Habitat

To better assess potential upstream impacts originating in the vicinity of South Sandisfield and farther upstream in its headwaters (York Lake), the FR08A sampling reach was located a short distance (3 km) upstream from the reach sampled during the 1996 biosurvey of Sandy Brook. The reach meandered through a maple (*Acer rubrum*) and hemlock (*Tsuga canadensis*)-dominated forest that provided almost a completely closed (100% shaded) canopy over the sampling area. The stream was approximately 4 m wide and with a fairly uniform depth of 0.10 – 0.20 m throughout its course—the exception being a deep (1 m) pool at the top of the reach. An abundance of cobble substrates and extensive, albeit shallow, riffle areas provided macroinvertebrates with excellent epifaunal habitat. Larger substrates (boulders) and submerged woody materials provided fish with optimal cover as well, especially in the pools. Water filled approximately 75% of the channel, resulting in some exposed substrates, especially along the margins of the stream. Instream algae and vegetation were absent. Interestingly, periphyton cover was extensive in the reach (FR08) sampled during the 1996 biosurvey in Sandy Brook; however, the partially open canopy in the portion of the stream sampled during the 1996 survey was probably more conducive to instream algal colonization than at the fully shaded FR08A.

Both stream banks were well vegetated with a dense layer of herbaceous plants (ferns and mosses) and shrubs (witch-hazel, *Hamamelis virginiana*; buckthorn, *Rhamnus* sp.; elderberry, *Sambucus canadensis*). Along with this streamside vegetation, large boulders provided additional bank stabilization, although the steepness of both banks resulted in some areas of presumably naturally-occurring erosion. Riparian vegetation was dominated by extensive forest and a mountain laurel (*Kalmia latifolia*) understory along

the right (south) bank, while the adjacent road (New Marlborough Road) resulted in a reduced riparian buffer along the left (north) bank. The road was especially close to the top of the reach; however, impacts from nonpoint source pollution (e.g., sediment inputs, instream deposition, substrate embeddedness) associated with road runoff were not observed.

FR08A received a total habitat assessment score of 174/200, which was higher than the habitat evaluation given to its reference station in Valley Brook (FR10) (Table A4). Instream effects resulting from the shallow nature of this portion of the stream—most notably, the lack of deep riffles and marginal channel flow status—contributed most to habitat scoring reductions.

Benthos

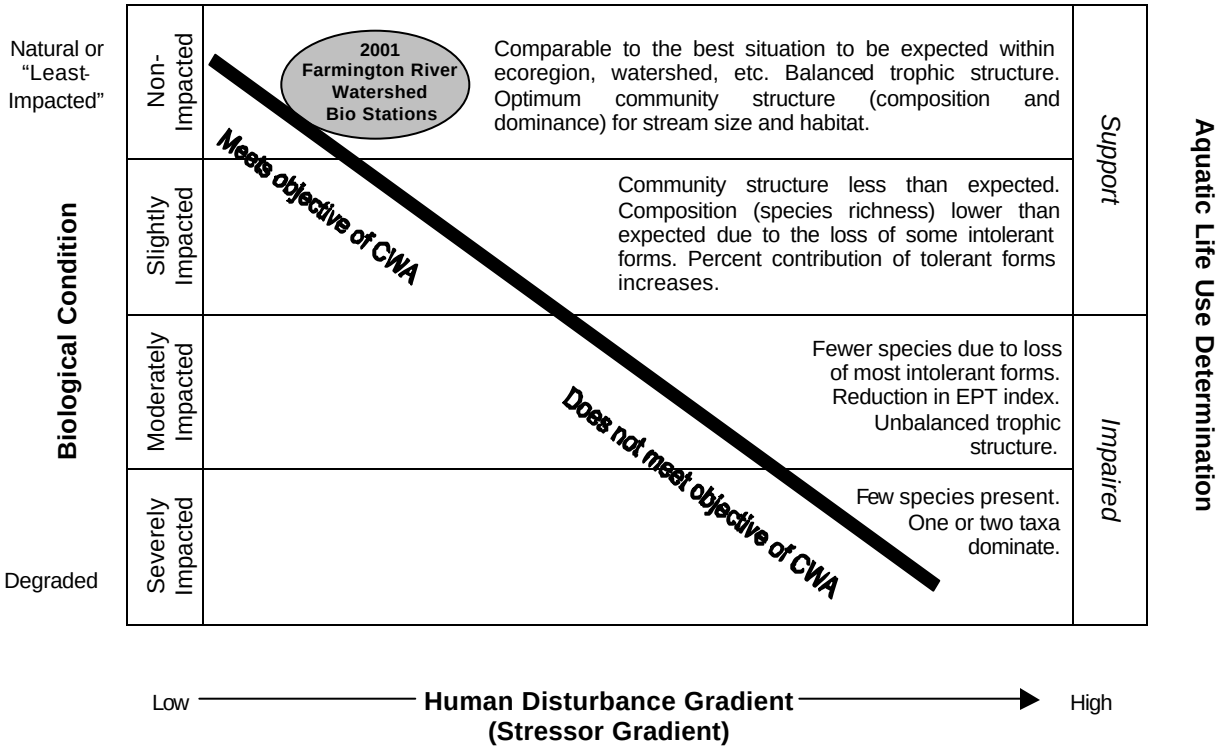
The FR08A benthos assemblage received a total metric score of 40, representing 95% comparability to the reference station and resulting in an assessment of "non-impacted" for biological condition (Table A3).

The FR08A sampling reach supported one of the most diverse macroinverebrate assemblages sampled in the Farmington River watershed, with a taxa richness of 35. High scores (6) for both the EPT Index metric and Biotic Index indicate the presence of numerous pollution-sensitive taxa as well. The presence of several (n=18) chironomids, most notably *Micropsectra* sp., contributed to slight point (score=4) reductions for the EPT/Chironomidae metric and a slightly elevated (18%) Percent Dominant Taxon metric value. The abundance of *Micropsectra* sp. among the FR08A benthos assemblage may be a reflection of the low baseflow conditions observed in this portion of Sandy Brook during the 2001 survey, as this taxon has been known to predominate in streams subjected to periods of reduced flow (Fiorentino 2000; Fiorentino 1999; Bode, NY DEC, personal communication, 1998). Indeed, channel flow status here was only marginal, scoring 10 out of a possible 20 points for this habitat parameter and resulting in temporarily exposed substrates and flow regimes that may favor taxa more tolerant of these low-flow conditions. *Micropsectra* sp. was well represented among the chironomid component of the reference benthos assemblage at FR10 as well. As with FR08A, instream habitat at the reference station (FR10) in Valley Brook exhibited the effects of reduced baseflow, particularly in the low-scoring parameters for channel flow status (10/20) and velocity-depth combinations (8/20).

SUMMARY AND RECOMMENDATIONS

Reference-quality biomonitoring stations in Hubbard Brook (FR09) and Valley Brook (FR10) continue to support the diverse and well-balanced aquatic communities expected in a "least-impacted" stream system. In addition, all six Farmington River watershed biomonitoring study stations were found to be "non-impacted" relative to reference conditions in the watershed. These stations, in addition to their respective reference sites, should receive *Support* status during upcoming 305(b) reporting of aquatic life use determinations for this watershed.

The schematic below 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 outlined in the RBPIII biological assessment methodology currently used by MA DEP and the Tiered Aquatic Life Use (TALU) conceptual model developed by 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. Minimally or non-impacted aquatic communities, such as those encountered in the Farmington River watershed, 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).



Hubbard Brook

FR09

Benthos: Watershed reference for study stations in high order streams.
Habitat: Watershed reference for study stations in high order streams.

The FR09 benthic community was thought to represent the "best attainable" conditions in the watershed with respect to biological integrity, habitat quality, and water quality. As a reference condition, biomonitoring is recommended here during the next MA DEP Farmington River watershed survey in 2006, especially if evaluations of third to fifth-order stream biota are again planned. Fish population sampling should accompany the macroinvertebrate sampling effort. In addition, water quality monitoring here would help to establish baseline conditions while supplementing the biological data. To maintain the biological integrity of Hubbard Brook, every effort should be made to properly manage land development in this relatively pristine subwatershed.

Valley Brook

FR10

Benthos: Watershed reference for study stations in low order streams.
Habitat: Watershed reference for study stations in low order streams.

Despite a slight reduction in baseflow conditions and the resulting limitations to instream habitat, FR10 was thought to represent the "best attainable" conditions in the watershed with respect to biological integrity, habitat quality, and water quality. As a reference condition, biomonitoring is recommended here during the next MA DEP Farmington River watershed survey in 2006, especially if evaluations of first to second-order stream biota are again planned. Fish population sampling should accompany the macroinvertebrate sampling effort. In addition, water quality monitoring here would help to establish baseline conditions while supplementing the biological data. New home construction is an ongoing practice in the upper portions of the Valley Brook subwatershed. To maintain the biological integrity of Valley Brook, every effort should be made to properly manage land development in this relatively pristine subwatershed.

West Branch Farmington River

FR01B

Benthos: "Non-impacted" compared to reference station (FR09).
Habitat: 92% comparable to reference station (FR09).

While habitat and benthos scores indicated non-impairment, considerable habitat degradation in the form of sediment deposition persists in this portion of the river. As was observed during the 1996 biosurvey conducted here, sediments originating from sand piles on the DPW property continue to enter the river near the top of the FR01B sampling reach, compromising instream epifaunal habitat and threatening biological integrity. In fact, instream deposition at FR01B, while confined to only the upper portion of the reach in 1996 appears now to be more extensive. In addition, a horse paddock adjacent to the FR01B reach is an obvious source of runoff-related nonpoint pollution. Installation or improved maintenance of existing BMPs is recommended for both these properties. Riparian disruption also exists near the bottom of the FR01B sampling reach where an extensive manicured lawn runs to the river's edge. Outreach efforts are recommended to educate the abutting landowner on the importance of maintaining an adequate riparian buffer zone. Biomonitoring is recommended here during the next MA DEP Farmington River watershed survey in 2006. Fish population sampling should accompany the macroinvertebrate sampling effort.

FR05B

Benthos: "Non-impacted" compared to reference station (FR09).
Habitat: 100% comparable to reference station (FR09).

Several of the metrics calculated for the duplicate benthos samples collected at FR05B outperformed those for the reference community at FR09. Based on the biological assessment of the macroinvertebrate community encountered at FR05B, it appears that potential water quality effects that may originate from upstream sources in New Boston and West New Boston are absent or imperceptible here. The resident biota, instead, appear to reflect the diverse and high quality habitat afforded them in this portion of the West Branch. As the most downstream station on the mainstem West Branch where macroinvertebrate biomonitoring can be successfully conducted before the river enters Connecticut, biomonitoring is recommended here during the next MA DEP Farmington River watershed survey in 2006. Fish population sampling should accompany the macroinvertebrate sampling effort.

Benton Brook

FR04

Benthos: "Non-impacted" compared to reference station (FR10).
Habitat: 92% compared to reference station (FR10).

Naturally-occurring low-flow conditions encountered here during the biosurvey led to the lowest habitat evaluation received by a biomonitoring station in the 2001 survey. While the shallow nature of this portion of the river may compromise fish habitat during the summer months, the abundance of rocky substrates and swift current velocity offered excellent epifaunal habitat during the 2001 biosurvey. As a result, the macroinvertebrate community displayed biological attributes that were highly comparable to the reference community. Though not a high priority, biomonitoring is recommended here during the next MA DEP Farmington River watershed survey in 2006. Fish population sampling should accompany the macroinvertebrate sampling effort.

Fall River

FR03

Benthos: "Non-impacted" compared to reference station (FR10).
Habitat: 100% compared to reference station (FR10).

Though not at a gross level, the FR03 benthic community continues to reflect the organically enriched conditions expected downstream from a productive impoundment. Filter-feeding macroinvertebrates, though well represented in the FR03 benthos assemblage, were not hyperdominant. A higher Taxa Richness than at the reference station, and one of the lowest values for Percent Dominant Taxon, corroborate the relatively well balanced trophic and community structure displayed by the macroinvertebrate community in this portion of the Fall River.

It is unclear whether the "non-impacted" bioassessment here—an improvement from the "moderately impaired" bioassessment received during the 1996 survey—is a result of improvements in water quality at FR03 or in the upstream impoundments, or a result of variability attributed to naturally occurring factors from one sampling year to the next. To continue to monitor potential impoundment effects in this portion of the Fall River, biomonitoring is recommended here during the next MA DEP Farmington River watershed survey in 2006. Fish population sampling should accompany the macroinvertebrate sampling effort.

Clam River

FR06B

Benthos: "Non-impacted" compared to reference station (FR09).
Habitat: 96% compared to reference station (FR09).

As was the case during the 1996 biosurvey conducted in the Clam River, the FR06B benthic community was highly comparable to the "least-impacted" conditions in the Farmington River watershed. Potential water quality impacts related to upstream nonpoint source pollution and productive impoundment (Upper Spectacle Pond) effects appear to be absent or imperceptible in this portion of the Clam River.

As the major tributary to the West Branch Farmington River, biomonitoring may be warranted here during the next MA DEP Farmington River watershed survey in 2006. Fish population sampling should accompany the macroinvertebrate sampling effort.

Sandy Brook

FR08A

Benthos: "Non-impacted" compared to reference station (FR10).
Habitat: 100% compared to reference station (FR10).

Despite slight effects resulting from reduced baseflow here, as reflected in the somewhat reduced epifaunal substrate availability and confirmed by the presence of some potential low-flow indicator species, the benthic community at FR08A displayed the highest Taxa Richness and lowest Biotic Index of all the low-order study sites in the 2001 survey. It appears, then, that effects from suspected nonpoint source inputs originating in South Sandisfield, as well as productive source waters (i.e., York Lake), are absent or imperceptible in this portion of Sandy Brook. Though not a high priority, biomonitoring is recommended here during the next MA DEP Farmington River watershed survey in 2006. Fish population sampling should accompany the macroinvertebrate sampling effort.

LITERATURE CITED

Barbour, M. T., J. B. Stribling, and J. R. Carr. 1995. The multimetric approach for establishing biocriteria and measuring biological condition. pp. 63-80. in W. S. Davis and T. P. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL. 415 p.

Barbour, M. T., J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Rivers: Periphyton, Benthic Macroinvertebrates, and Fish. Second Edition. EPA 841-B-99-002. Office of Water, US Environmental Protection Agency, Washington, DC. 151 p. + appendices

Bode, R. W., M. A. Novak, and L. E. Abele. 1991. Quality Assurance Work Plan for Biological Stream Monitoring in New York State. Stream Biomonitoring Unit, Division of Water, NYS Department of Environmental Conservation. Albany, NY. 78 p.

Bode, R. W. and M. A. Novak. 1998. Differences in environmental preferences of sister species of Chironomidae. 22nd Annual Meeting. New England Association of Environmental Biologists, Kennebunkport, ME. Stream Biomonitoring Unit, Division of Water, NYS Department of Environmental Conservation. Albany, NY.

Environmental Law Reporter. 1988. Clean Water Deskbook. Environmental Law Institute. Washington, D.C.

Fiorentino, J. F. 1997. Farmington River Watershed Benthic Macroinvertebrate Biomonitoring. Technical Memorandum TM-31-1. Massachusetts Department of Environmental Protection, Division of Watershed Management, Worcester MA. 24 p.

Fiorentino, J. F. 1999. Charles River Watershed 1997/1998 Water Quality Assessment Report: Appendix C—1997 Charles River Watershed Biological Monitoring. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA. 64 p.

Fiorentino, J. F. 2000. Blackstone River Watershed Benthic 1998 Biological Assessment. Technical Memorandum. Massachusetts Department of Environmental Protection, Division of Watershed Management, Worcester MA. 42 p.

Fiorentino 2001. 2001 Benthic Macroinvertebrate Biomonitoring Quality Assurance Project Plan. CN 63.0. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA. 58 p.

Hilsenhoff, W. L. 1982. Using a Biotic Index to Evaluate Water Quality in Streams. Technical Bulletin No. 132. Department of Natural Resources, Madison, WI.

Hughes, R. M. 1989. Ecoregional biological criteria. Proceedings from EPA Conference, Water Quality Standards for the 21st Century. Dallas, Texas. 1989: 147-151.

Karr, J. R., K. D. Fausch, P. L. Angermeier, P. R. Yant, and I. J. Schlosser. 1986. Assessing Biological Integrity in Running Waters: A Method and Its Rationale. Special Publication 5. Illinois Natural History Survey. Champaign, IL. 28 p.

Lenat, D. R. 1993. A biotic index for the southeastern United States: derivation and list of tolerance values, with criteria for assigning water-quality ratings. J. N. Am. Benthol. Soc., 12(3): 279-290.

MA DEP. 1996. Massachusetts Surface Water Quality Standards. Department of Environmental Protection, Division of Water Pollution Control, Technical Services Branch. Westborough, MA. 114p.

MA DEP. 1998. Draft Farmington River Watershed 1996 Resource Assessment Report. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA. 27 p.

MA DEP. 1999. Massachusetts Section 303(d) List of Waters – 1998. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA. 129 p.

MA DEP. 2000. Commonwealth of Massachusetts Summary of Water Quality 2000. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA.

MA DEP 2001. Final Draft Quality Assurance Project Plan for Year 2001 Watershed Assessments of the Farmington, Westfield, Concord, Taunton, and South Coastal Basins. CN 062.0. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA. 256 p.

Merritt, R. W., K. W. Cummins, and T. M. Burton. 1984. The role of aquatic insects in the processing and cycling of nutrients. pp. 134-163. in V. H. Resh and D. M. Rosenberg (eds.). The Ecology of Aquatic Insects. Praeger Publishers, New York, NY. 625 p.

Minshall, G. W. 1984. Aquatic insect-substratum relationships. pp. 358-400 in V. H. Resh and D. M. Rosenberg (eds.). The Ecology of Aquatic Insects. Praeger Publishers, New York, NY. 625 p.

Novak, M. A. and R. W. Bode. 1992. Percent model affinity: a new measure of macroinvertebrate community composition. J. N. Am. Benthol. Soc., 11(4): 80-110.

Nuzzo, R. M. 1999. Standard Operating Procedures (Working Draft): Water Quality Monitoring in Streams Using Aquatic Macroinvertebrates. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA. 8 p.

Plafkin, J. L., M. T. Barbour, K. D. Porter, S. K. Gross, and R. M. Hughes. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish. EPA/440/4-89-001. Office of Water, US Environmental Protection Agency, Washington, DC.

Resh, V. H. 1988. Variability, accuracy, and taxonomic costs of rapid bioassessment approaches in benthic biomonitoring. Presented at the 36th annual North American Benthological Society meeting at Tuscaloosa, Alabama, 17-20 May 1988.

US EPA. 1995. Generic Quality Assurance Project Plan Guidance for Programs Using Community Level Biological Assessment in Wadeable Streams and Rivers. U.S. Environmental Protection Agency, Office of Water. 71 p.

US EPA. 2003. Using Biological Assessments to Refine Designated Aquatic Life Uses. Presented at the National Biological Assessment and Criteria Workshop: Advancing State and Tribal Programs. Coeur d' Alene, ID. 31 March-4 April 2003.

USGS. 2003. United States Geological Survey, National Water Information System (NWISWeb) streamflow measurement data available on the World Wide Web, accessed 2003, at URL. http://waterdata.usgs.gov/ma/nwis/help.

Wetzel, R. G. 1975. Limnology. W. B. Saunders Co., Philadelphia, PA. 743 p.

Wiederholm, T. 1984. Responses of aquatic insects to environmental pollution. pp. 508-557. in V. H. Resh and D. M. Rosenberg (eds.). The Ecology of Aquatic Insects. Praeger Publishers, New York, NY. 625 p.

Zweig, L. D. and C. F. Rabeni. 2001. Biomonitoring for deposited sediment using benthic invertebrates: a test on 4 Missouri streams. J. N. Am. Benthol. Soc., 20(4): 643-657.

APPENDIX

Macroinvertebrate taxa list, Benthos data analyses, and Habitat evaluations

Table A1. Taxa (species-level) list and counts, functional feeding groups (FG), and tolerance values (TV) for macroinvertebrates collected from stream sites during the 2001 Farmington River watershed survey on 13 and 14 August 2001. Refer to Table 1 for a complete listing and description of sampling stations.

Taxon	FG[1]	TV[2]	FR09[3]	FR10[3]	FR01B	FR04	FR03	FR06B	FR05B	FR05B (dup)[4]	FR08A
Ferrissia sp.	SC	6					1		2	3	
Planorbidae	SC	6					1				
Pisidiidae	FC	6				3	2			1	3
Enchytraeidae	GC	10				1					
Nais alpina	GC	8					1				
Nais communis	GC	8		1		3	1				
Tubificidae (immature, hair chaetae)	GC	10				1					
Lumbriculus sp.	GC	8		6			8				
Hydrachnidia	PR	6	3	4		4	1				1
Baetidae	GC	4			7			9	4	5	
Baetis (cerci only) sp.	GC	6							4		
Baetis (short terminal filament) sp.	GC	6							2		
Baetis (subequal terminal filaments) sp.	GC	6				2			1	2	
Heterocloeon sp.	GC	2			1					1	
Baetidae (cerci only)	GC	6	1					12			
Baetidae (short terminal filament)	GC	6	1		3						
Baetidae (subequal terminal filaments)	GC	6	7	2	2			7			
Ephemerellidae	GC	1				1		4	2	1	1
Ephemerella sp.	GC	1								2	
Eurylophella sp.	GC	2	1								
Serratella sp.	GC	2								1	
Heptageniidae	SC	4			2			5			2
Epeorus sp.	SC	0				2		2		4	
Stenonema sp.	SC	3	9	2				1	4		
Isonychia sp.	GC	2			9	4	1	11	3	3	
Leptophlebiidae	GC	2			8				6	1	
Paraleptophlebia sp.	GC	1	10	1		10		4			7
Potamanthus sp.	GC	2								1	
Siphlonurus sp.	GC	7						1			
Cordulegaster sp.	PR	3					1				
Lanthus sp.	PR	5				2			1		
Capniidae	SH	1	1								
Sweltsa sp.	PR	0		1					3		
Leuctra sp.	SH	0	3	11		3	2	7	2	2	4
Tallaperla sp.	SH	0	1			1					
Acroneuria sp.	PR	0			2				2		
Neoperla sp.	PR	3			1						
Paragnetina sp.	PR	1	2		2	3		4		5	3
Perlesta sp.	PR	5							1		
Pteronarcys sp.	SH	0		2			1				1
Nigronia sp.	PR	0			1	2	3				6
Brachycentridae	FC	1								1	
Micrasema sp.	SH	2			2						
Glossosomatidae	SC	0		1							

Table A1 (cont.)

Taxon	FG[1]	TV[2]	FR09[3]	FR10[3]	FR01B	FR04	FR03	FR06B	FR05B	FR05B (dup)[4]	FR08A
Glossosoma sp.	SC	0									1
Protoptila sp.	SC	1							3	4	
Helicopsyche borealis	SC	3								1	
Cheumatopsyche sp.	FC	5	2			4	8	4	7	2	
Hydropsyche sp.	FC	4		4			9			1	
Hydropsyche betteni gr.	FC	6				4	7			1	1
Hydropsyche morosa gr.	FC	6	2	2	9	1	4	2	6	2	2
Mayatrichia sp.	SC	6								1	
Lepidostoma sp.	SH	1	2	2						2	1
Leptoceridae	PR	4			1	1					
Apatania sp.	SC	3	1							4	
Chimarra sp.	FC	4	4		12				2	1	
Dolophilodes sp.	FC	0	6	4	1	2	8	4		2	14
Rhyacophila sp.	PR	1		8		1	3	1	3	1	2
Macronychus glabratus	SH	5									1
Optioservus sp.	SC	4			4			2			
Optioservus trivittatus	SC	4							8		
Oulimnius latiusculus	SC	4	3	6	3	15	1	1	2	1	1
Promoresia sp.	SC	2		2	3						1
Promoresia tardella	SC	2	2			6	8				
Stenelmis sp.	SC	5			4	4			10		1
Stenelmis crenata	SC	5								7	
Ectopria sp.	SC	5	1						1		
Psephenus herricki	SC	4	2		3	1			2	2	1
Atherix sp.	PR	4	1								1
Ceratopogonidae	PR	6		1							
Bezzia sp.	PR	6							1		
Demicryptochironomus sp.	GC	2									1
Lauterborniella agrayloides	GC	8			2						
Microtendipes pedellus gr.	FC	6				2	1		1	1	
Microtendipes rydalensis gr.	FC	6	1		1			2	4	5	1
Nilothauma sp.	GC	6									2
Polypedilum sp.	SH	6									2
Polypedilum aviceps	SH	4	7	2	3			9	4	6	
Polypedilum flavum	SH	6						1			
Polypedilum halterale gr.	SH	6					2				
Polypedilum tritum	SH	6	1	1							
Stenochironomus sp.	GC	5								1	1
Micropsectra sp.	GC	7	7	6	1		1	3		1	18
Rheotanytarsus distinctissimus gr.	FC	6					2		1		1
Rheotanytarsus exiguus gr.	FC	6	1	1	2		1		1	2	
Sublettea coffmani	FC	4			1		1				
Tanytarsus sp.	FC	6		5	1	2					
Zavrelia/Stempellinella sp.	GC	4				1	3	1			1
Pagastia sp.	GC	1					5		1		
Potthastia gaedii gr.	GC	2								1	
Corynoneura sp.	GC	4		1				1	1		
Cricotopus/Orthocladius sp.	GC	7							1	2	
Eukiefferiella pseudomontana gr.	GC	8							1		
Lopescladius sp.	GC	4			2	1		1	1	2	
Nanocladius (*Plecopteracoluthus*) sp.	GC	3						1	1	1	2
Orthocladius sp.	GC	6	1		1						

Table A1 (cont.)

Taxon	FG[1]	TV[2]	FR09[3]	FR10[3]	FR01B	FR04	FR03	FR06B	FR05B	FR05B (dup)[4]	FR08A
Parachaetocladius sp.	GC	2			1	2			4	6	
Parametriocnemus sp.	GC	5	3	3	4		1				3
Rheocricotopus sp.	GC	6		1			1				
Synorthocladius sp.	GC	6		1	1		1				
Tvetenia bavarica gr.	GC	5		3						1	2
Tvetenia vitracies gr.	GC	5								1	
Conchapelopia sp.	PR	6	2		3	1		1	1		3
Larsia sp.	PR	7	1								
Thienemannimyia sp.	PR	6	1								
Hemerodromia sp.	PR	6			3				2		
Simulium sp.	FC	5		3			5		1		
Antocha sp.	GC	3					2				
Dicranota sp.	PR	3	1	3				4			6
Hexatoma sp.	PR	2								1	3
Pseudolimnophila sp.	SH	3					1				
Total			91	90	106	90	98	105	107	96	101

[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 organisms very tolerant.

[3]Reference station

[4]Duplicate sample

Table A2. Summary of RBP III data analysis for macroinvertebrate communities sampled during the Farmington River watershed survey on 13 and 14 August 2001. Shown are the calculated metric values, metric scores (in italics) based on comparability to the Hubbard Brook reference station (FR09), and the corresponding assessment designation for each biomonitoring station. Refer to Table 1 for a complete listing and description of sampling stations.

STATION	**FR09**		**FR01B**		**FR05B**		**FR05B** (duplicate)		**FR06B**	
STREAM	Hubbard River		West Branch		West Branch		West Branch (duplicate)		Clam River	
HABITAT SCORE	185		170		186		--		177	
TAXA RICHNESS	33	*6*	34	*6*	39	*6*	41	*6*	26	*4*
BIOTIC INDEX	3.67	*6*	4.00	*6*	3.94	*6*	3.39	*6*	3.50	*6*
EPT INDEX	16	*6*	14	*4*	16	*6*	22	*6*	14	*4*
EPT/CHIRONOMIDAE	2.12	*6*	2.70	*6*	2.50	*6*	1.70	*6*	3.90	*6*
SCRAPERS/FILTERERS	1.13	*6*	0.70	*6*	1.39	*6*	1.42	*6*	0.92	*6*
% DOMINANT TAXON	11%	*6*	11%	*6*	9%	*6*	7%	*6*	11%	*6*
REFERENCE AFFINITY	100%	*6*	88%	*6*	85%	*6*	89%	*6*	76%	*6*
TOTAL METRIC SCORE	*42*		*40*		*42*		*42*		*38*	
% COMPARABILITY TO REFERENCE STATION			95%		100%		100%		90%	
BIOLOGICAL CONDITION -DEGREE IMPACTED	**REFERENCE**		**NON-IMPACTED**		**NON-IMPACTED**		**NON-IMPACTED**		**NON-IMPACTED**	

Table A3. Summary of RBP III data analysis for macroinvertebrate communities sampled during the Farmington River watershed survey on 13 and 14 August 2001. Shown are the calculated metric values, metric scores (in italics) based on comparability to the Valley Brook reference station (FR10), and the corresponding assessment designation for each biomonitoring station. Refer to Table 1 for a complete listing and description of sampling stations.

STATION	**FR10**		**FR04**		**FR03**		**FR08A**	
STREAM	Valley Brook		Benton Brook		Fall River		Sandy Brook	
HABITAT SCORE	167		153		174		174	
TAXA RICHNESS	29	*6*	31	*6*	33	*6*	35	*6*
BIOTIC INDEX	3.70	*6*	3.59	*6*	4.03	*6*	3.31	*6*
EPT INDEX	11	*6*	14	*6*	8	*2*	12	*6*
EPT/CHIRONOMIDAE	1.67	*6*	4.33	*6*	2.26	*6*	1.05	*4*
SCRAPERS/FILTERERS	0.58	*6*	1.56	*6*	0.23	*4*	0.32	*6*
% DOMINANT TAXON	12%	*6*	17%	*6*	9%	*6*	18%	*6*
REFERENCE AFFINITY	100%	*6*	64%	*4*	76%	*6*	78%	*6*
TOTAL METRIC SCORE	*42*		*40*		*36*		*40*	
% COMPARABILITY TO REFERENCE STATION			95%		86%		95%	
BIOLOGICAL CONDITION -DEGREE IMPACTED	**REFERENCE**		**NON-IMPACTED**		**NON-IMPACTED**		**NON-IMPACTED**	

Table A4. Habitat assessment summary for biomonitoring stations sampled during the 2001 Farmington River watershed survey on 13 and 14 August 2001. 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 complete listing and description of sampling stations.

STATION		FR09*	FR10*	FR01B	FR04	FR03	FR06B	FR05B	FR08A
PRIMARY PARAMETERS (range is 0-20)		**SCORE**							
INSTREAM COVER		19	13	16	15	17	20	17	18
EPIFAUNAL SUBSTRATE		19	18	19	18	17	20	20	19
EMBEDDEDNESS		20	20	18	16	20	20	20	20
CHANNEL ALTERATION		20	20	20	17	20	15	20	20
SEDIMENT DEPOSITION		18	18	13	16	19	18	19	18
VELOCITY-DEPTH COMBINATIONS		12	8	14	10	11	17	18	15
CHANNEL FLOW STATUS		17	10	18	10	15	15	18	10
SECONDARY PARAMETERS (range is 0-10 for each bank)		**SCORE**							
BANK VEGETATIVE PROTECTION	left	10	10	10	10	10	9	10	10
	right	10	10	10	9	10	10	10	10
BANK STABILITY	left	10	10	10	8	10	7	10	8
	right	10	10	10	9	8	10	10	8
RIPARIAN VEGETATIVE ZONE	left	10	10	2	6	10	8	8	8
	right	10	10	10	9	7	8	6	10
TOTAL SCORE		**185**	**167**	**170**	**153**	**174**	**177**	**186**	**174**

*Reference station

APPENDIX B

Technical Memorandum
FARMINGTON RIVER BASIN 2001 PERIPHYTON DATA

Prepared by Joan Beskenis
MA DEP/Division of Watershed Management, Worcester, MA
June 2003

During the summer of 2001, DEP personnel collected periphyton (attached algal community) samples from stations in the Farmington River basin. Sampling was limited to sites chosen for macroinvertebrate investigations and was conducted as part of the macroinvertebrate/habitat assessment. It consisted of random scrapes of the substrate within the riffle zone for algal identifications and estimations of the percent cover of the algae within the reach. Occasionally other habitats, such as pools, were included for investigation. The aquatic communities (macroinvertebrates, periphyton and fish) are assessed, in part, to determine if the designated uses (Massachusetts Surface Water Quality Standards, 1996) are being supported, threatened or lost in particular reaches. The Farmington River is a Class B, Cold Water Fishery. Periphyton data can be used to evaluate two uses of the Farmington River: Aquatic Life and Aesthetics.

Aquatic life evaluations are used to determine if suitable habitat is available for "sustaining a native, naturally diverse, community of aquatic flora and fauna." Natural diversity and the presence of native species may not be sustained when there are dense growths of a monoculture of a particular alga. This alteration of the community structure can mean that the aquatic life use support is lost or threatened. Important components of the food chain, which are vital for use support, may be lost from this alteration. In addition, the large amounts of biomass from macroalgae when they deteriorate and die can fill in the interstitial sites in the substrate and degrade this habitat for the benthic invertebrates, thus further compromising the aquatic life use support. Nuisance growths of algae can compromise the substrates and alter water chemistry (e.g., dissolved oxygen values).

Nuisance amounts of algae can be determined by gathering estimates of the percent cover as well as determining the relative amounts of both macroalgae (visible with naked eye) or microalgae (examined microscopically) in a particular habitat (e.g. riffles or pool) (Biggs, 1996, Barbour et al., 1999). The percent cover by filamentous green algae (macroalgae) greater than 40% is an indication that nuisance amounts of algae are present and that use of the benthic habitat by aquatic life may be threatened (Biggs 1996, Barbour et al., 1999).

The algal data are also used to determine if aesthetics have been impacted. Floating scums of previously attached benthic mats can make an area visually unappealing, as can large areas of the bottom substrates covered with long streamers of algae. Sites with excessive algal growth are likely to have water quality problems as well.

The objectives of the periphyton sampling were to document if nuisance amounts of algal growth were present. This is based upon percent cover of the algal population as well as determination of the type and form of the algae that were present. Other objectives of the periphyton sampling were to learn more about the biota in the streams and rivers, to offer a means of comparing biological communities in conjunction with the macroinvertebrate and habitat information, and to examine community changes over time.

MATERIALS and METHODS

Periphyton Identifications and Relative Abundance

Periphyton data were gathered along with the macroinvertebrate and habitat data using methods described in Barbour et al. (1999). Sampling was done by John Fiorentino and consisted of randomly scraping rocks and cobble substrates, typically within the riffle area, with a knife and collecting the material in a labeled glass vial. The samples were transported to the DEP-DWM-Worcester laboratory without refrigeration; but once at the lab they were refrigerated until identifications were completed.

The vial was shaken to get a uniform sample before subsampling. If filamentous algae comprised most of the sample they were removed first, identified separately and then the remainder of the sample was examined. An Olympus BH2 compound microscope with Nomarski optics was used for the identifications. Slides were typically examined under 200 power. Either a Palmer drop cell or a Sedgwick-Rafter cell were used in the examinations. If higher magnifications were needed then a water mount was prepared on a pre-cleaned glass slide. A modified method for periphyton analysis developed by Bahls (1993) was used. The scheme for determining abundance is as follows:

R (rare)	fewer than one cell per field of view at 200x, on the average;
C (common)	at least one, but fewer than five cells per field of view;
VC (very common)	between 5 and 25 cells per field;
A (abundant)	more than 25 cells per field, but countable;
VA (very abundant)	number of cells per field too numerous to count.

This determination of abundance provides a relative approximation of the taxa that contribute the most to the biomass in the riffle or pool habitats. Information obtained from the algal identifications and relative abundance is combined with information obtained in the habitat assessment. Typically, a minimum of 10 fields are examined, but if only “rare” species are found then the entire slide will be scanned and after reshaking the sample, a second slide is prepared to make certain that clumping or some other non-uniform sampling error had not occurred.

RESULTS

Table 1 lists the stations that were included in this study and presents descriptions of their locations as well as the percent canopy cover and the percent algal cover. The data are included in the Appendix.

Table 1: **Periphyton Sampling Results Farmington River System - 2001**

Station #	Location	Date	% Canopy Cover	% Algal Cover	Dominant algal type/habitat/growth form
FR01B	West Branch Farmington River downstream from Otis DPW, Otis	14 Aug 2001	5	5	Green-cobble-riffle-filamentous-*Oedogonium* sp.
FR04	Benton Brook, downstream from Beech Plain Rd., Sandisfield	14 Aug 2001	90	0	not collected
FR06B	Clam River, upstream from Beech Plain Rd., Sandisfield	13 Aug 2001	10	95	Green-riffle-thin film-(id not complete) Green-pool-filamentous-*Spirogyra* sp./*Mougeotia* sp.
FR05B	West Branch Farmington, upstream from Clark Rd., Sandisfield	13 Aug 2001	5	10	Green-cobble/riffle-filamentous-*Oedogonium* sp.
FR08A	Sandy Brook, downstream from Norfolk Rd., Sandisfield	14 Aug 2001	98	<1	Blue-green-filamentous-*Lyngbya versicolor*
FR09	Hubbard River, upstream from West Hartland Rd., Granville	13 Aug 2001	5	<5	Blue-green-riffle/mat-*Phormidium* sp.
FR10	Valley Brook, upstream from Rte 57, Granville	13 Aug 2001	100	% algae not recorded, but 90% mosses	not collected

The algal cover at the Farmington River watershed sites did not exceed 10% except for the station FR06B in the Clam River upstream from Beech Plain Rd., Sandisfield. At this station the percent algal cover within the reach was 95%. It is noted in the field sheets that the substrates in the riffle were covered by a thin film of green algae while green, filamentous macroalgae (*Spirogyra* sp. and *Mougeotia* sp.) were present in the pool, suggesting a possible condition of over-enrichment from plant nutrients (Appendix A). Determination of the percent algal cover is made in the riffle and this habitat did not exhibit excessive growth of green macroalgae. The canopy at this station is open with only 10% cover. The possible source of the excess nutrients was not identified, with 50% of the riparian zone forested, 25% field/pasture and 25% residential.

Other stations with open canopies had low percent algal cover such as FR01B - West Branch downstream of the Otis DPW (5%) (Table 1). There were several types of nonpoint sources in the vicinity of this station, but there was little vegetation present (5% algae, 0% aquatic vegetation). The potential

nonpoint sources present included the Otis DPW, a horse paddock, a lawn abutting the river banks, and a pool with geese.

The West Branch of the Farmington River upstream of Clark Rd., Sandisfield (FR05B) had 5% canopy cover, but only 10% algal cover. This station also had potential nonpoint sources of pollution with 25% of the surrounding land use in field/pasture and 75% residential. Both of these stations were dominated by *Oedogonium* sp. which was very abundant in the sample, but the amount of algal growth estimated over the sampling reach was low.

DISCUSSION

The algal cover was very sparse at the sites assessed in this watershed. Macroalgal percent cover (the green filamentous algae) was not estimated at greater than 40%, and in almost all stations it was 10% or less. Forty percent is the level that is considered to represent nuisance growth (Biggs, 1996, Barbour et al., 1999). A percent cover of greater than 40% would indicate that both aquatic life and aesthetic uses could be threatened. This is not the case at the Farmington River although future surveys should include FR01B on the West Branch of the Farmington River since this station had nonpoint sources, open canopy and some patches of the green, filamentous alga *Oedogonium* sp. This alga is commonly found when nitrogen and phosphorus levels are relatively high and there is sufficient sunlight (Borchardt, 1996) and this can result in large amounts of biomass especially in a stream with low velocity runs and pools (Biggs, 1996).

Station FR06B on the Clam River should also be investigated more intensively in the next sampling round. Although local sources of nonpoint pollution were not evident, the 95% algal cover - largely a thin film (personal communication with John Fiorentino, DEP) but with some unknown percentage of filamentous, green algae - may indicate an algal community in transition. A switch to dominance by green macroalgae throughout this reach would affect both the food supply for macroinvertebrates as well as substrate conditions.

REFERENCES CITED

Bahls, L. L. 1993. Periphyton Bioassessment Methods for Montana Streams. Water Quality Bureau, Dept. of Health and Environmental Sciences. Helena, Montana.

Barbour, M., Gerritsen, J, Snyder, B. D. and J. B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, 2nd edition. EPA 841-B-99-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

Biggs, B. J. F. 1996. *Patterns of benthic algae in streams.* IN Algal Ecology: Freshwater Benthic Ecosystems. R. J. Stevenson, M. Bothwell, and R. L. Lowe. Pp 31-55. Academic Press, San Diego, California.

Borchardt, M. A., 1996. *Nutrients*. IN: Algal Ecology: Freshwater Benthic Ecosystems. Edit. R.J. Stevenson, M. L. Bothwell. R. L. Lowe. Academic Press. New York.

MA DEP.1996. Massachusetts Surface Water Quality Standards. Massachusetts Department of Environmental Protection. Division of Water Pollution Control, Technical Services Branch. Westborough, MA 114p.(Revision of 314 CMR 4.00, effective June 23, 1996).

Reinke, D. 1984. Algal Identification Workshop. Kansas Biological Survey. Lawrence.

APPENDIX

Date	Habitat	Class	Genera	Abundance
Location: West Branch Farmington River downstream from Otis DPW, Otis. Station FR01B				
14 August 2001	cobble/riffle (Lab# 12a)	Bacillariophyceae	*Cymbella* sp.	R
		Bacillariophyceae	*Fragilaria* sp.	R
		Bacillariophyceae	*Gomphonema* sp.	R
		Chlorophyceae	*Oedogonium* sp.	VA
		Cyanophyceae	*Oscillatoria* sp.	R
Location: Clam River, upstream from Beech Plain Road, Sandisfield. Station FR06B				
13 August 2001	riffle (Lab# 11a)	Chlorophyceae	*Cladophora* sp.	Not recorded
	pool (Lab# 16a)	Chlorophyceae	*Mougeotia* sp.	VA
		Chlorophyceae	*Spirogyra* sp.	VA
Location: West Br Farmington upstream Clark Road, Sandisfield. Station FR05B				
13 August 2001	cobble-riffle (Lab# 17a)	Chlorophyceae	*Oedogonium* sp.	VA
Location: Sandy Brook, downstream from Norfolk Road, Sandisfield. Station FR08A				
14 August 2001	riffle (Lab #15a)	Cyanophyceae	*Lyngbya versicolor*	VA
Location: Hubbard River, upstream from West Hartland Road, Granville. Station FR09				
13 August 2001	riffle (Lab #13a)	Chlorophyceae	*Spirogyra* sp.	VA
		Chlorophyceae	*Ulothrix* sp.	A
	riffle-algal mat (Lab #14a)	Cyanophyceae	*Phormidium* sp.	VA

APPENDIX C

DEP/DWM TECHNICAL MEMORANDUM
FARMINGTON RIVER WATERSHED BENTHIC MACROINVERTEBRATE BIOMONITORING (1996)

TECHNICAL MEMORANDUM TM-31-1
Farmington River Watershed Benthic Macroinvertebrate Biomonitoring

To: Farmington River Basin Team

Cc: Arthur Johnson, DEP DWM
Richard McVoy, DEP DWM
Bob Nuzzo, DEP DWM
Christine Duerring, DEP DWM
Lawrence Golonka, DEP WERO

From: John Fiorentino, DEP DWM

Date: 8 March 1997

INTRODUCTION

Biological monitoring is a useful means of detecting anthropogenic impacts on 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 as well as cumulative pollution and habitat alteration (Plafkin et al. 1989, Barbour et al. 1995). Biological surveys and assessments are the primary approaches to biomonitoring.

Robert Nuzzo and I conducted biomonitoring based on USEPA Rapid Bioassessment Protocols (RBP) at 13 sites requested by the DEP Farmington River Basin Team as part of the 1996 watershed survey. A biosurvey, which focused on the standardized sampling of benthic macroinvertebrates, was supplemented with a habitat assessment to evaluate water quality and habitat quality at each study site. The sampling sites were in: West Branch Farmington River (FR01A, FR01B, FR05A, FR05B); Cone Brook (FR02); Fall River (FR03); Benton Brook (FR04); Clam River (FR06A, FR06B); Buck River (FR07); Sandy Brook (FR08); Hubbard Brook (FR09); Valley Brook (FR10)--all in Massachusetts.

METHODS

The macroinvertebrate collection procedure utilized kick sampling, a method of sampling benthic organisms by kicking or disturbing bottom sediments and catching the dislodged organisms downstream with an aquatic net. Sampling was conducted throughout a 100 m reach, in riffle/run areas with fast currents and cobble and gravel substrates--generally the most productive habitats, supporting the most diverse communities in the stream system. A kick net with an opening approximately 0.45 m wide and a mesh size of 590 microns was used to collect samples from a total area of approximately 2.5 m^2--ten 0.25 m^2 kicks were taken at each station, then composited in the field and preserved with 95% ethanol before processing.

In the laboratory, a subsample of 100 macroinvertebrates was separated from the original sample collected at each site, and specimens were identified to family (Rapid Bioassessment Protocol II, or RBP II) to the extent their condition allowed. Based on this family-level taxonomy, various community, population, and functional parameters, or "metrics," are calculated which allow an investigator to measure 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). The percent comparability of study site metric scores to those for a selected unimpaired reference station (i.e. "best attainable" situation) yields an impairment score for each site. RBP II analysis separates sites into three categories: non-impaired, moderately impaired, and severely impaired. Impairment of 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).

RBP II also utilizes a habitat assessment matrix for rating habitat quality, an integral component in the final evaluation of impairment. The habitat assessment is intended to support the biosurvey and enhance the interpretation of the biological data. The matrix used to assess habitat quality is based on key physical characteristics of the water body and surrounding land use. All parameters evaluated are 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, 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. The habitat parameters included in the matrix were evaluated at all sites sampled in the Farmington River Basin. Ratings were then totaled and compared to a regional reference station and/or a site-specific control (upstream reference) station to provide a final habitat ranking.

RESULTS

Biomonitoring data collected during the 1996 Farmington River Basin survey are attached as an appendix. Table 1 is the family-level taxonomic list of macroinvertebrates collected from each site. The taxa list includes total organism counts, and the functional feeding group (FFG) and tolerance value (TV) of each taxon.

Also included in the appendix are summary tables for the RBP II data analyses, including biological metric calculations, metric scores, and final impairment scores. Habitat assessment scores for each station are also included in the summary table. Table 2 is the data analysis summary when stations are compared to the regional reference station FR10. Table 3 is the analysis using FR09 as the reference station. Table 4 is the data analysis summary for those stations being compared to an upstream reference station (FR01A, FR05A, or FR06A).

FR10--Valley Brook, Granville MA (26 August 1996)

HABITAT

The FR10 sampling reach began approximately 500 m upstream from Route 57 (Main Road) and meandered through a heavily wooded cedar forest. Well developed (albeit shallow) riffle areas with a variety of stable hard substrates offered exceptional habitat for fish, and especially, invertebrates. Dense bryophyte cover on much of the rock substrates provided additional productive microhabitat for macroinvertebrates. Embeddedness and deposition were virtually nonexistent. Bank stability was excellent, and the dense forest on both sides of the stream provided an unlimited and undisturbed riparian vegetative zone throughout the reach. FR10 received a total habitat assessment score of 178 out of a possible 200. A total of ten “kicks” were made in primarily shallow riffles. Sampling was confined to the rocky substrates--cobble/gravel and boulder--which were predominant throughout the reach. Those larger boulders which would not move required gentle hand-rubbing to remove attached organisms.

FR10 was designated a regional reference station for the Farmington River Basin by virtue of its high habitat evaluation, and minimal upstream and surrounding gross land use abuse (e.g. absence of point source inputs, lack of nearstream agriculture and channelization activity, minimal development, undisturbed riparian zones with woody vegetation, lack of other anthropogenic impacts) relative to the overall watershed. As a relatively small second order stream, FR10 served as a primary reference station for those study sites in streams with a similar drainage area (FR02, FR03, FR04, FR07, FR08); however, study sites in considerably larger sub-basins required a reference site with a greater discharge. Large streams such as the West Branch Farmington River, then, will be compared to the regional reference station FR09--a third order stream which will be discussed later. The two Clam River sites (FR06A, FR06B), which may be intermediate to the drainage areas of Valley Brook and Hubbard Brook, will receive both a primary comparison to FR09 and a secondary comparison to FR10. Fall River (FR03), a first order stream with a considerable drainage area (Otis Reservoir), will use the FR09 station as a secondary reference site.

BENTHOS

The taxonomic list of macroinvertebrates collected at FR10 can be found in Table 1. Because FR10 is a reference station, it does not receive an impairment score for the aquatic community found there. However, the metric values (Table 2) calculated as part of the RBP II analysis reflect the healthy benthic community one would expect to find in a "least impacted" stream. In particular, those parameters that measure components of community structure (taxa richness, biotic index, and EPT index)--which display the lowest inherent variability among the RBP metrics used (Resh 1988)--scored well and corroborate the designation as a reference station. FR10 received a total metric score of 42 out of a possible 42.

FR09--Hubbard Brook, Granville MA (26 August 1996)

HABITAT

A beautiful portion of Hubbard Brook, FR09 meandered naturally through a dense forest with an even mix of evergreens and deciduous trees. The 100 m reach sampled was approximately 300 m upstream from West Hartland Road in Granville State Forest. The reach was dominated by shallow and deep riffles, with occasional deep pools and runs. A variety of velocity/depth patterns and stable rock substrates offered superb habitat for fish and macroinvertebrates. Boulders, many with dense moss cover, were the predominant substrate sampled, although kicks were made in cobble-dominated riffles as well. There was no evidence of sediment deposition or embeddedness, and the dense woodland setting provided an undisturbed riparian zone along both sides of the reach. Although the gradient of this riparian zone increased rapidly from both sides of the channel, bank stability was reinforced with large boulders. A total of eight samples were taken from fast riffle areas of varying depths, while the remaining two were collected in fast runs.

FR09 received a habitat score of 195, which was the highest of the Farmington River Basin biomonitoring stations. Those primary instream habitat parameters directly pertinent to the support of aquatic communities and weighted the highest in the assessment matrix--substrate type and stability, availability of refugia, and velocity/depth regimes--scored exceptionally well. The excellent habitat evaluation, coupled with minimal anthropogenic influence on the stream community, led to the designation as a regional reference site. In particular, FR09 served as a primary reference station for those third and fourth order streams sampled (FR01A, FR01B, FR05A, FR05B, FR06A, FR06B). As previously mentioned, the Clam River stations (FR06A, FR06B) will also use FR10 as a secondary reference site; The Fall River station (FR03) will use FR09 as a secondary reference site.

BENTHOS

When serving as a reference station, FR09 received a total metric score of 42 out of a possible 42 (Table 3). A diverse macroinvertebrate assemblage dominated by intolerant forms such as EPT taxa, indicates both a balanced trophic structure and optimum community structure, representative of the "best attainable" situation expected in the watershed.

FR01A--West Branch Farmington River, Otis MA (27 August 1996)

HABITAT

An upstream/downstream (site-specific) sampling approach was implemented in an attempt to bracket possible nonpoint source (NPS) effects from the Massachusetts Department of Public Works facility on the downstream aquatic community in this portion of the river. Specifically, stakeholders in the watershed have expressed concerns that road salt and sand stored in the DPW yard adjacent to the river may be a potential risk to the biological integrity of the downstream community. As part of the site-specific approach, the aquatic community and habitat below the DPW yard (downstream study site) were compared to an upstream control site (FR01A) representative of the "best attainable" conditions in the waterbody.

While the alternative to this approach is to compare the study site to a regional reference station, the site-specific approach is more appropriate for an assessment of an impact site (Plafkin et al. 1989). In addition, both upstream and downstream stations were compared to the regional reference stations (primary=FR09).

The FR01A reach began approximately 500 m upstream from the DPW property, where it meandered through a forest of predominantly white pine with occasional floodplain vegetation (e.g. grasses and ferns) along the margins of the channel. An abundance of hard substrates (boulder and cobble) subjected to a variety of velocity/depth patterns provided excellent habitat for macroinvertebrates. Deep pools, submerged logs, and boulders offered exceptional fish cover as well. Aquatic mosses covered much of the boulder substrates, while occasional patches of periphyton were observed on cobble surfaces. All ten kicks were made in riffle areas with rock substrates. Boulders and large cobble that were difficult to dislodge by foot were rubbed by hand.

FR01A received a total habitat assessment score of 193. A 98% comparability to the regional reference station FR09 indicates that this station is indeed comparable to the best situation to be expected within the watershed in terms of habitat quality and quantity.

BENTHOS

When using the Hubbard Brook (FR09) station as the primary regional reference site, FR01A received a total metric score of 39, representing a 93% comparability to reference conditions and placing the aquatic community in the non-impaired category (Table 3). In fact, most metrics for FR01A scored better than the reference station, reflecting a healthy macroinvertebrate community that serves as a good upstream control for comparisons with the aquatic assemblage downstream of the DPW.

FR01B--West Branch Farmington River, Otis MA (27 August 1996)

HABITAT

The top of the FR01B reach was approximately 100 m downstream of the DPW yard. As with the upstream control, the left riparian zone was heavily wooded (even mix of evergreen and hardwood), with wetland vegetation (grasses) along the channel margin; however, the right bank of the reach was abutted by the lawns of several residential properties, with only occasional buffered areas of wetland grasses and a few white pines. Both ends of the sampling reach were dominated by varying depths of fast riffle areas with an abundance of cobble and boulder substrates, offering excellent habitat for macroinvertebrates. Some substrates were covered with a fair amount of periphyton. A very large pool with good depth and a variety of hard substrates provided fish with additional cover and habitat midreach. All sample kicks were made in cobble or boulder substrates in both shallow and deep riffles.

FR01B received a habitat assessment score of 182. While this represents a highly comparable habitat comparison to the "best attainable" conditions upstream and regionally (94% and 93% comparable to upstream control and primary regional reference site respectively), instream habitat degradation immediately upstream of the sampling reach was observed. Large quantities of sand, apparently originating from the edge of the DPW yard, appear to be eroding into the stream. As a result, considerable deposition has occurred in the river adjacent to the DPW property. While instream sedimentation was apparently confined to only a small stream area during the time of the survey, continued displacement of otherwise superb invertebrate microhabitat seems inevitable without adequate runoff control. An investigation into this nonpoint source problem by the Farmington River Basin Team is advised.

BENTHOS

When compared to the upstream reference station FR01A, FR01B received a total metric score of 39, representing a 93% comparability and placing the study site in the non-impaired category (Table 4). In terms of taxonomic composition, the macroinvertebrate assemblage of FR01B is strikingly similar (71%) to the

upstream control. Activities associated with the DPW property, then, do not appear to have detrimental effects on downstream aquatic community integrity in terms of water quality and habitat quality, save for the localized effects of deposition immediately adjacent to the yard, where sampling was not conducted.

A high comparability to the primary regional reference station FR09 further corroborates the non-impaired status of the FR01B biota. The total metric score of 36 (Table 3) represents an 86% comparability to the "least impacted" conditions found at Hubbard Brook.

FR02--Cone Brook, Otis MA (27 August 1996)

HABITAT

From its headwaters in Beartown State Forest, this small first order stream meanders through an extensive and relatively undeveloped tract of woodland before flowing into Hayden Pond in Otis. The sampling reach began approximately 150 m upstream from Hayden Pond, near the mouth of Cone Brook. Here the forest was dominated by white/red pine and hemlock, with a profusion of ferns and mosses in the understory. The stream reach was relatively flat and well defined immediately upstream of the pond; however, above the top of the reach the gradient became very steep, and the stream geomorphology changed dramatically. Upon hiking further upstream from the sampling reach, it was difficult to follow the main channel, as the stream was poorly defined--much of it braided out in several directions, disappearing from sight under the very thin soils and numerous massive boulders. This very unique habitat, not observed elsewhere in the basin during the summer survey, proved to be inadequate for our sampling methodology. As a result, then, the designated sampling area was restricted to the reach immediately upstream from the pond and limited to less than 100 m. Flow here was less than desirable, leaving much "snag" and cobble/boulder habitat exposed and unavailable for aquatic invertebrates. Those substrates submerged were dominated by moss-covered cobble, gravel, and sand. The low water level provided very shallow riffle areas for macroinvertebrates and only a few shallow pools for fish.

FR02 received a habitat assessment score of 157, representing an 88% comparability (habitat assessment category="supporting") to the primary regional reference station FR10. Primary habitat parameters most pertinent to the support of benthic communities (i.e. substrate type and stability, availability of refugia, passage potential) were no doubt limited by low flow, while secondary and tertiary parameters scored relatively well.

BENTHOS

When compared to the reference station at Valley Brook (FR10), FR02 received a total metric score of 21, representing only a 50% comparability to reference conditions (Table 2). This was the lowest benthos evaluation in the Farmington River Basin survey, indicating moderate impairment to the macroinvertebrate community. The reliable richness metrics (taxa richness, EPT index)--which generally increase with increasing water quality, habitat diversity, and habitat suitability--scored particularly poorly (Table 2).

The attainable biological potential of a site is primarily determined by the quality of the habitat at that site (Plafkin et al. 1989). The premise behind RBP data interpretation is that in areas of good (assessment category="supporting") or excellent (assessment category="comparable to reference") habitat, biological communities will reflect degraded conditions when water quality effects are present. Thus, when habitat quality is similar between study site and reference site, detected impacts can be attributed to water quality factors. While the habitat evaluation at FR02 ("supporting") suggests that it is water quality rather than habitat quality that is limiting to instream biological potential, the lack of anthropogenic influence on the Cone Brook benthic community infers that water quality problems are absent. It should be mentioned that new house construction adjacent to the stream was observed off Dimmock Road near the headwaters; however, impacts to the downstream community--if any--would probably be in the form of habitat degradation rather than water quality problems.

Although the habitat assessment at FR02 was considered "supporting," those habitat parameters most dependent on flow were somewhat limiting. Flow regime and current velocity are important hydrologic determinants of benthic community ecology. Flow volume and velocity/depth combinations can have effects on substrate composition and stability, the amount of channel under water, and food availability (Minshall 1984). Current plays a crucial role in the distribution of benthic macroinvertebrates--current velocity affects an insect's ability to gather food, meet respiratory requirements, avoid competition and predation, and colonize or vacate certain habitats (Minshall 1984). Short-term flow fluctuations (e.g. the effects of strong rain events in this typically "flashy" basin) may modify aquatic insect communities in several ways, most notably by stranding aquatic insect in pockets of standing water or on exposed substrates. The potential for stranding at FR02 may explain the lack of Ephemeroptera, as mayflies are particularly susceptible to stranding (Ward 1984). Decreasing discharge may induce drift of aquatic insects; that is, the downstream transport by current of benthic animals as a means of escape or dispersal (Wiley and Kohler 1984; Ward 1984). This taxa depletion, either by drift or the periodic loss of riffle habitat, may contribute to the low taxa richness (score=3) and EPT index (score=0), and subsequent moderate impairment at FR02.

In addition to low flow effects on the benthic community at FR02, the unique habitat--especially immediately upstream of the sampling reach--may shape the community structure and composition found there, resulting in the moderately impaired biological status. As mentioned earlier, much of the stream appeared "subterranean" in nature--flowing under thin soils, large root masses, and boulders before cascading into the sampling reach and then into the pond. While this "subsurface" flow of surface water may not technically comprise a true hyporheic zone (the water filled interstitial habitat in the rithron region of a lotic system), physicochemical similarities with the hyporheic zone may nevertheless exist which may influence the benthic community downstream. Like the hyporheic environment, much of the available habitat upstream of the FR02 sampling reach probably receives minimal light (especially when compounded by the effects of a dense forest canopy), thus precluding photosynthesis and resulting in an assemblage dominated by detritivores and predators while lacking algae-grazing scrapers (Williams 1984). Particulate organic matter, a principal food material for the hyporheos (Williams 1984), is probably the dominant nutrition source at FR02 as well, where highly heterogenous substrates (especially throughout the subterranean segments) lead to the trapping of detritus as it moves along the streambed. The macroinvertebrate assemblage at FR02, then, may be a result of habitat conditions and food resources immediately upstream of the sampling reach--more predators were found here than elsewhere in the survey (Table 1), while gatherers of organic matter (e.g. Hydropsychidae, Chironomidae) were the numerically dominant feeding group (Table 1). Particularly affected by this trophic milieu was the scraper/filterer metric (Table 2), which received a score of 0 due to high densities of Hydropsychidae and a lack of scrapers. The metric for percent contribution of dominant family also scored poorly (Table 2), due to the dominance of Hydropsychidae and Chironomidae.

Thus, the moderately impaired biological condition at FR02 is probably a result of two factors working together to shape the downstream benthic community: 1) naturally-induced flow reductions, and 2) a unique upstream environment that may have pronounced effects on a downstream macroinvertebrate assemblage that is not as comparable to reference conditions as initially thought following habitat evaluations.

FR03--Fall River, Otis MA (27 August 1996)

HABITAT

Biomonitoring was conducted in Fall River to investigate possible water quality degradation effects on the instream community due to anthropogenic perturbations upstream. Several impoundments with considerable shoreline development--most notably Otis Reservoir, where many lakefront cottages have known septic system problems--drain into the West Branch Farmington River via this small (in terms of length, not drainage) stream. In addition, Reservoir Road--which closely follows much of the length of Fall River--was a suspected source of NPS inputs (e.g. road runoff) to the stream, possibly affecting water/habitat quality and the benthic assemblage found there.

FR03 was located approximately midway between the Otis Reservoir (and Larkin Pond) outlet and the Fall River confluence with the West Branch Farmington River. The sampling reach flowed through a fairly dense evergreen forest with an abundance of ferns throughout the understory, and heavy bryophyte cover both instream and along the stream bank. As this was a high gradient stream, the reach consisted of a series of fast/cascading riffles with occasional pools that were small but of adequate depth for fish. In addition to the wide variety of velocity/depth combinations, abundant rock substrates (mostly boulder) provided excellent habitat for macroinvertebrates. All ten kicks were made in the rock substrates of well developed riffle areas, with the often immoveable boulders requiring surface rubbing by hand.

Erosional areas were observed along much of the extremely steep right stream bank, further compounding concerns with road runoff and apparently resulting in some areas of instream deposition. In addition, a considerable amount of trash (oven, car parts, empty paint and oil cans) had been dumped along this bank, much of it reaching the edge of the sampling reach. Nevertheless, FR03 received a habitat assessment score of 177, representing a 99% comparability to the FR10 reference station and a 91% comparability to the secondary reference station FR09.

BENTHOS

When using FR10 as the primary reference site, FR03 received a total metric score of 30. This represents a 71% comparability to the reference, placing FR03 in the moderately impaired category for biological integrity (Table 2). Total metric scores improve slightly when using FR09 as the reference station--33 represents a 79% comparability to the control, placing FR03 in the non-impaired category (Table 3). A highly comparable habitat to either reference station, particularly FR10, indicates that impairment to the FR03 aquatic community is the result of water quality factors. The low score for the EPT index (score=0) is especially indicative of water quality degradation, as this index usually increases with increasing water quality (Plafkin et al. 1989).

It is difficult to determine the source of biological impairment to the FR03 community--the impoundment upstream or NPS inputs from the adjacent road. However, the low scraper/filterer ratio (Table 2) and the abundance of filter-feeders (Table 1), suggest a possibly enriched aquatic environment. Typically, in lentic systems such as the impoundment upstream of FR03, the primary source of organic matter is autochthonous (produced within the system), with secondary inputs of allochthonous (transported into the system from someplace else) materials from shoreline vegetation and fluvial inputs (Wetzel 1975, Merritt et al. 1984). Phytoplankton production--and to a lesser extent, littoral vascular plant production--and associated dissolved organic matter (DOM), are the primary source of autochthonous matter (Wetzel 1975). It is the physical-chemical flocculation of this DOM which leads to the formation of FPOM, the primary nutrition resource utilized by filter-feeders such as Hydropsychidae and Philopotamidae (Wetzel 1975). While FPOM production in lotic systems is primarily a result of the processing of microbial-colonized Course Particulate Organic Material (CPOM) by aquatic shredders, the high concentration of FPOM in stream systems immediately below pond and reservoir outlets has mainly lentic origins. If these lentic systems are subjected to increasingly eutrophic conditions from inorganic/organic inputs (such as from failed septic systems), the resulting effects of enrichment (i.e. increased algal, plant, and DOM production) can be seen not only in the lentic fauna, but also the aquatic communities immediately downstream. The filter-feeding invertebrate assemblage at FR03 appears to reflect the effects of only mild upstream enrichment, as several of the metrics for this site (e.g. taxa richness, biotic index, percent contribution of dominant family, EPT/Chironomidae) scored quite well (Table 2) and are indicative of a fairly well balanced community. Data from the most recent baseline survey (DEQE: Division of Water Pollution Control, August 1992) conducted in Otis Reservoir's "deep hole station" (the closest station to the Fall River outlet) suggest the release of orthophosphates from littoral sediments. However, removal of near-anoxic water with frequent hypolimnetic withdrawals likely prevents significant "internal loading" of orthophosphate to the water column. While visible growth of phytoplankton was evident throughout the reservoir's water column in 1992, density was not sufficient to discolor the water.

The low ratio of scrapers (organisms that thrive in healthy diatom-dominated periphyton communities) to filterers at FR03 may simply be the result of dense instream bryophyte cover so typical of the closed-canopy

stream systems in western Massachusetts. While these mosses--which cannot be effectively harvested by scrapers-- displace the scraper community, they provide good attachment site and additional microhabitat for filtering collectors (Plafkin et al. 1989).

FR04--Benton Brook, Sandisfield MA (27 August 1996)

HABITAT

The FR04 sampling reach began approximately 100 m downstream from Beech Plain Road and immediately below a minor tributary. Here this first order (small second order?) stream meandered through a fairly dense forest of evergreen and deciduous vegetation (50/50 mix), although tree clearing was observed near the right stream bank and a few homes were located not far from the left bank. These homes, the close proximity of roads (Beech Plain Road and a logging road) to the stream, and newly constructed homes further upstream, were all potential sources of NPS inputs to the stream.

The majority of instream substrates consisted of large rubble and boulder, with the remainder comprised of cobble and gravel. These rocky substrates, along with numerous well developed riffle/run areas, offered excellent habitat for macroinvertebrates. Cover for fish was less than optimal, however, as pools lacked deep areas and offered a limited mixture of stable habitats. The ten kicks were made in rocky riffle areas of varying depths and velocities. Hand- rubbing of rock surfaces was not necessary, as most of the substrates were dislodged easily by foot.

Riparian and bank structure were good, with the exception of a reduced riparian buffer along the left bank due to the nearby road (Beech Plain Road) which parallels much of the reach. A few piles of sand had been deposited along the right stream bank, possibly a result of erosion where tree clearing had occurred; however, instream deposition was not observed in the sampling reach and substrate embeddedness was very minimal. FR04 received a habitat assessment score of 170, which was 96% comparable to the primary reference station FR10.

BENTHOS

RBP II analysis indicates that this is a healthy benthic community. A total metric score of 36 represents an 86% comparability to the "best attainable" conditions found at FR10, placing FR04 in the non-impaired category for biological integrity (Table 2). In fact, FR04 contains the most pollution-intolerant (biotic index=3.64) assemblage of macroinvertebrates of any station sampled in the Farmington River Basin survey. It is recommended that biomonitoring be conducted here during future basin surveys, as house construction nearby (as indicated by nearstream tree clearing and road improvements) and continued development upstream seems imminent.

FR05A--West Branch Farmington River, Sandisfield MA (19 August 1996)

HABITAT

There were two main objectives to conducting biomonitoring at FR05A: 1) To investigate a variety of potential NPS inputs originating upstream in the vicinity of New Boston--most notably, septic system related problems that may be affecting water quality downstream, road runoff effects from Route 8 (which runs very close to the river's left bank in this area, and a carwash adjacent to the river in New Boston center. 2) FR05A would serve as an upstream control for the downstream study site FR05B, in an attempt to bracket the confluence with the Clam River and associated upstream water/habitat quality impacts which may be originating further upstream (particularly in the vicinity of West New Boston and New Boston, both of which lie on the Clam River a short distance upstream of the confluence with the West Branch Farmington River).

FR05A was located approximately 500 m upstream from the confluence with the Clam River, and immediately upstream from a small tributary entering the river from the right bank. The sampling reach was

accessed via the back property of an American Legion recreation center which bordered much of the reach. The very narrow riparian zone between this property (mowed lawn) and the channel offered only a minimal buffer from a variety of human perturbations--grass clippings, trash, and other debris were deposited on or near the riverbank. The riparian vegetative zone of the right bank was considerably more extensive, with a dense deciduous forest extending undisturbed to the banks of the nearby Clam River.

The sampling reach was comprised of a series of riffles and fast runs of varying depths, with occasional pools interspersed among these faster areas. The well-developed flow regimes, coupled with a variety of hard substrates (mostly boulder and cobble with some gravel), provided abundant productive habitat for macroinvertebrates. Instream fish cover was less than optimal, however, as a limited variety of stable refugia (e.g. snags, submerged logs) left fish somewhat exposed. Most kicks were made in riffle areas of varying velocities (larger substrates required surface rubbing by hand), although a few samples were taken from runs. Substrate surfaces appeared completely devoid of organic material and aquatic vegetation, including bryophytes and periphyton. FR05A received a total habitat assessment score of 180, which was 92% comparable to habitat quality at the primary regional reference station FR09.

BENTHOS

RBP II analysis indicates that upstream anthropogenic activities have not impacted water quality or biological integrity in the FR05A reach. A total metric score of 36, representing an 86% comparability to the regional reference site, placed the FR05A macroinvertebrate community in the non-impaired category (Table 3). Several of the biological metrics (EPT/Chironomidae, scraper/filterer, percent contribution of dominant family) actually scored better than those for reference conditions. That the biological integrity at FR05A is representative of "best attainable" conditions further validates its use as an upstream control station for the FR05B study site, whose status is discussed next.

FR05B--West Branch Farmington River, Sandisfield MA (19 August 1996)

HABITAT

Biomonitoring was conducted at FR05B in an attempt to investigate possible water/habitat quality stressors that may be entering the West Branch Farmington River from the Clam River, particularly in the vicinity of West New Boston and New Boston. The sampling reach was located immediately upstream of the Clark Road footbridge and approximately 500 m downstream of the confluence with the Clam River. Instream habitat here was much like the upstream control--flow regimes were dominated by a series of riffles and runs, and boulder and cobble substrates were predominant throughout the reach. While these conditions provided excellent habitat for macroinvertebrates, limited deep pool areas provided fish with less than optimal cover. Instream vegetation was virtually absent, although the riparian vegetative zone (mostly deciduous trees on right bank; trees and shrubs along left bank) was stable and fairly extensive on both sides of the river save for a driveway adjacent to the right bank. There was no visible evidence of nonpoint source inputs directly into the sampling reach, and those habitat parameters most affected by habitat degradation (embeddedness, channel alteration, deposition) scored well. Ten kicks were made in areas of cobble substrates--seven samples were taken from riffle areas and three from fast run areas.

FR05B received a habitat score of 173, which was 96% comparable to upstream reference conditions at FR05A. When compared to the primary regional reference station (FR09), habitat was 89% comparable (="supporting").

BENTHOS

Due to the high degree of habitat comparability between FR05B and FR05A (which is not surprising given that they are located in the same waterbody), the upstream control site (FR05A) received priority over the regional reference site (FR09) as a reference station for FR05B. With that said, FR05B received a total metric score of 36, representing an 86% comparability to the "best attainable" conditions upstream and placing the

biological status in the non-impaired category (Table 4). EPT index (9) and biotic index (3.82) values were actually slightly higher here than at the reference site. It appears, then, that inputs from the Clam River have not significantly altered the status of water quality, habitat quality, or biological integrity at FR05B relative to upstream conditions.

When using the regional reference station at Hubbard Brook as the control site, FR05B received a total metric score of 33 (Table 3). While this comparability (79%) was slightly less than when using the upstream/downstream comparison, the benthic community at FR05B again fell into the non-impaired category, further corroborating that this is indeed a healthy aquatic community indicative of good water quality and habitat quality.

FR06A--Clam River, Sandisfield MA (22 August 1996)

HABITAT

FR06A was used primarily as an upstream control site for FR06B, in an attempt to bracket the Buck River (which flows into the Clam River immediately below the FR06A sampling reach) and suspected NPS inputs which may be entering the Buck River and ultimately the Clam River as well. Specific NPS concerns were: 1) The close proximity of Route 57 to the river (particularly in areas with a reduced vegetative buffer), and especially the potential for sand to enter the river. 2) The close proximity of several homes to the river, especially in the vicinity of Montville. In addition, many of these residential properties have gardens located very close to the river bank. Thus, septic related problems, pesticides/herbicides, fertilizers, grass clippings, and sediments are all potential water/habitat quality stressors that may affect biological integrity in the Buck River and further downstream.

The lack of development and other potentially detrimental land use activities (much of the land in the vicinity of the headwaters is state forest) upstream of FR06A infers that this station is indeed representative of the "best attainable" conditions in the waterbody. Nevertheless, habitat and benthos comparisons were made to the regional reference stations as well.

The bottom of the FR06A sampling reach was approximately 10 m upstream from the confluence with the Buck River. Here the stream meandered naturally through an area of dense forest (a 50/50 mix of evergreen and deciduous trees) that was particularly steep to the right of the channel. This dramatic gradient may be responsible for the sediment deposition observed throughout the slower areas of the reach. Fine silt in pools and on cobble substrate surfaces in slow run areas was evident, although deposition and embeddedness was not a factor where appreciable current existed. Much of the hard instream substrate was boulder with the remaining substrates comprised of cobble and gravel. As flow regimes were diverse and well developed, macroinvertebrate habitat was abundant and considered excellent. A variety of stable habitats and numerous deep pool areas provided fish with excellent cover and habitat as well. Stream banks were well stabilized with boulders and grassy vegetation on both sides before giving way to tree cover further away from the channel. As mentioned above, a virtually unlimited forested riparian zone extended from both sides of the stream, and NPS inputs or other anthropogenic perturbations were absent. Of the ten kick samples taken, seven were from fast riffles of varying depths, while three were from fast run areas. Much of the substrates required surface rubbing by hand, as large cobble and boulder were often difficult to dislodge by foot.

FR06A received a habitat assessment score of 181. As this represents a 93% comparability to its primary regional reference station (FR09) and is a higher score than that received by the secondary regional reference station (FR10), the use of FR06A as an upstream control seems justified.

BENTHOS

FR06A received a total metric score of 36, representing an 86% comparability to the regional reference station FR09 and placing the aquatic community in the non-impaired category (Table 3). A comparison to the secondary reference station again found biological integrity to be non-impaired, with a total metric score of 33

representing a 79% comparability (Table 2). RBP II analysis, then, coupled with the excellent habitat evaluation, indicates that this station is indeed representative of "best attainable" conditions in the waterbody and the subecoregion as a whole.

FR06B--Clam River, Sandisfield MA (20 August 1996)

HABITAT

Sampling was conducted throughout the entire stream segment between Beech Plain Road and the confluence with the Buck River. Instream habitat was very similar to the upstream control--boulder and cobble/gravel were the predominant substrate types and were subjected to a variety of flow regimes. Riffle/run areas were common and offered exceptional habitat for macroinvertebrates. Stable refugia and adequate depth in pools provided fish with optimal cover. Both fish and invertebrates benefitted from minimal embeddedness or sediment deposition. While an old stone wall may have altered stream morphology years ago, its present impact on habitat quality seemed insignificant. Bank stability appeared good on both sides of the channel; however, disturbances along the left bank (mowed lawn close to stream, grass clipping and leaf waste piled near bank) resulted in a reduced vegetative riparian zone and potential NPS inputs. Possible pollution inputs originating upstream (Buck River) have been mentioned. Six kicks were made in cobble substrates in fast riffles, while the remaining four were made in fast runs.

FR06B received a habitat assessment score of 169, representing a 93% comparability to the upstream control site (the most appropriate reference site for FR06B). Habitat was classified as "supporting" (87% comparability) when compared to the regional reference station FR09, while a 95% comparability was calculated when using the Valley Brook (FR10) station as a reference site.

BENTHOS

When using the site-specific (upstream) control as a reference station, FR06B received a total metric score of 36, representing an 86% comparability to reference conditions and placing the biological integrity at FR06B in the non-impaired category (Table 4). Surprisingly, five out of the seven metrics--including taxa richness, biotic index, and EPT index--scored better than the control site. In fact, the FR06B macroinvertebrate assemblage was more diverse and pollution-intolerant than all but a few of the biomonitoring stations.

FR06B was equally comparable (79%) to both regional reference stations, receiving a total metric score of 33. As with the upstream comparison, biological integrity was considered non-impaired (Tables 2 and 3).

It appears, then, that NPS inputs upstream (in the vicinity of the Buck River) or adjacent to the sampling reach are not impacting biological conditions at FR06B, as reflected in the healthy benthos found there. An investigation of habitat and benthos in the Buck River itself will be discussed next.

FR07--Buck River, Sandisfield MA (22 August 1996)

HABITAT

This dramatic high gradient segment of the Buck River is essentially a series of riffles cascading over large boulder and cobble substrates. The sampling reach began immediately above the Clam River confluence and extended upstream for approximately 60 m. A 100 m delineation was not possible due to the expansive pool area over bedrock just above the top of the reach. Habitat in this area was not suitable for kick sampling due to the absence of riffles and inadequate substrates for macroinvertebrate colonization. The riparian zone adjacent to the left bank was undisturbed and well vegetated with deciduous trees (this is the same riparian zone as that adjacent to the right bank of FR06A), while the right bank was poorly buffered and altered along the upper half due to residential activities. The mowed lawns of two homes extend to the right bank along much of the reach. In addition, an old stone wall bordering the property of the more upstream home has

essentially become the right stream bank, resulting in the straightening of this portion of the reach. Where the stone wall ends and the second property begins, some erosional areas were observed along the relatively steep bank. The lower portion of the reach was fairly well stabilized and buffered with a stand of evergreen trees. Thus, the FR07 reach is subjected to possible NPS inputs from upstream (as discussed in the habitat description for FR06A) as well as from the adjacent residential properties (lawn inputs, habitat alteration effects) along the reach.

The abundance of cobble and boulder, subjected to varying riffle depths, provided macroinvertebrates with excellent epifaunal habitat. While large boulders provided fish with some cover, habitat was somewhat limited due to an absence of pool areas. As in the Clam River stations, the sampling reach was devoid of any visible aquatic vegetation. All ten kick samples were apportioned to riffle/run areas with cobble or boulder (requiring surface rubbing by hand) substrates--seven kicks were made in true riffles while three were made in fast runs. FR07 received a total habitat assessment score of 168, representing a 94% comparability to its primary regional reference station FR10 (probably more appropriate as a reference than the FR09 reference station in terms of drainage area).

BENTHOS

The macroinvertebrate community found at FR07 shows no sign of water quality degradation. A total metric score of 36 represents an 86% comparability to the FR10 reference station, placing the community in the non-impaired category for biological status (Table 2).

NPS inputs adjacent to, or upstream of, the FR07 sampling reach do not appear to impair aquatic community health in this area. This supports/supplements findings from the upstream/downstream comparison of the Clam River sites used to bracket potential impacts in the Buck River.

FR08--Sandy Brook, Sandisfield MA (26 August 1996)

HABITAT

FR08 was located approximately 100 m upstream from New Marlboro Road and about 500 m upstream from the Massachusetts-Connecticut border. Sampling was conducted to investigate the effects of suspected septic system failures upstream in the vicinity of South Sandisfield. In addition, a saw mill operation in South Sandisfield and the close proximity of New Marlboro Road were potential sources of habitat degradation to the stream.

The sampling reach meandered through undisturbed forest, save for the road which was a good distance (>18 m) from the reach along this portion of the stream. A high gradient stand of hemlocks dominated the forest on the right side of the stream, although floodplain vegetation was abundant along the margin. A combination of deciduous and evergreen trees was present between the left bank and New Marlboro Road, with mountain laurel common in the understory. Instream habitat was dominated by riffle areas at both ends of the reach, while a large deep pool made up the middle of the reach. Boulder and submerged logs were common throughout the reach and were supplemented by cobble/gravel substrates in the riffles. Much of the hard substrates were covered with bryophytes and periphyton (probably the highest densities seen in the basin survey). This diversity of stable substrates and flow regimes provided excellent habitat for both macroinvertebrates and fish. The only habitat parameter found to be less than optimal was bank stability along the right stream bank; The steep gradient of the forest along this portion of the stream resulted in occasional areas of erosion, although impacts to instream habitat seemed minimal. Kick sampling was confined to the riffle (eight kicks) and fast run (two kicks) areas at the top and bottom of the reach where substrates were primarily cobble and boulder.

FR08 received a total habitat score of 191, representing greater than 100% comparability to the primary regional reference station (FR10). This was the third highest habitat evaluation in the Farmington River Basin

survey. Clearly, upstream habitat alteration activities are not having an impact on habitat quality this far downstream.

BENTHOS

RBP II analysis of the invertebrate community at FR08 found biological integrity to be non-impaired. A total metric score of 36 represents an 86% comparability when compared to FR10 (Table 2). In terms of taxa richness, the FR08 macroinvertebrate assemblage was the most diverse (taxa richness=24) of the biomonitoring stations in the Farmington River Basin survey. In addition, only two other survey sites had more EPT taxa present.

The combination of excellent habitat evaluation and high total metric score indicate that the FR08 station is not impacted by human perturbations upstream. It is recommended that future sampling activities in this stream be conducted further upstream in the vicinity of South Sandisfield, where sawmill operations and other anthropogenic activities (e.g. road salting/sanding) may be more readily detected.

SUMMARY/RECOMMENDATIONS

The following is a brief recapitulation of present or potential "problem areas" observed during the 1996 Farmington River Basin biomonitoring survey:

FR01B--While habitat and benthos scores indicated non-impairment, considerable habitat degradation in the form of sand deposition was observed immediately upstream of the sampling reach. The erosion of sand piles, originating near the edge of the DPW yard, has led to sediment inputs to the river during rain events. An investigation into this nonpoint source problem is recommended. Implementation of adequate buffers, or relocation of sand piles (assuming sand is not being dumped illegally) would easily remedy the situation.

FR03--Dumping activities along the steep right bank of this portion of Fall River appear to be originating from the nearby road. While it is obviously difficult to control such practices, occasional trash cleanups by volunteering stakeholders or watershed association members would do much to keep illegal dumping in check.

FR04--This portion of Benton Brook (excellent habitat and water quality at present time) may soon see an increase in anthropogenic impacts. Road improvements and tree clearing indicate that house construction, which has already occurred upstream, may soon take place near this sampling reach. Macroinvertebrate sampling should be repeated at this site during future Farmington River Basin surveys to provide trend-monitoring data.

FR08--This sampling reach was probably too far downstream of South Sandisfield to detect suspected water/habitat quality impacts (saw mill operations, septic system failures). It is recommended that future biomonitoring be conducted somewhere between Norfolk Road and Rood Hill Road. As this portion of Sandy Brook runs very close to New Marlborough Road, impacts from road sanding/salting may be detected as well.

FR02--Although the Cone Brook station received a moderate impairment score for biological integrity, detected impairment may simply be the result of its unique habitat and low-flow conditions. While it may be interesting to monitor the benthos here in the future, the use of an adequate reference station and/or modified sampling methodology will be necessary.

CONCLUSION

It is important to recognize that Rapid Bioassessment Protocol II (RBP II) is merely a semi-quantitative screening tool which allows investigators to evaluate a large number of sites with relatively limited time and effort. The protocol is best used to prioritize sites for more intensive evaluation, such as RBP III, toxicity

testing, or quantitative replicate sampling. The information derived from RBP II provides a basis for ranking sites as non, severely, or moderately impaired. This classification can then be used to focus on additional study or regulatory action.

Two of the sites investigated in the Farmington River Basin survey, FR02 and FR03, received RBP II scores indicating moderate impairment when compared to the primary regional reference station. Because the moderate impairment category offers a wide ranging and somewhat ambiguous assessment, this suggests that the basin team may want to gather more information on the aquatic invertebrate assemblage collected at these stations. To achieve this, I recommend applying Rapid Bioassessment Protocol III (RBP III), a more rigorous bioassessment technique than RBP II, which allows detection of more subtle degrees of impairment.

By increasing the level of taxonomic resolution; that is, by performing taxonomic identification to the lowest practical level, the ability to discriminate the level of impairment is enhanced. While this additional taxonomy (genus/species level identification) requires considerably more time, discrimination of four levels of impairment--non, slight, moderate, and severe--becomes possible following recalculation of metrics. If the Farmington River Basin Team wishes to have this taxonomy and subsequent metric analysis completed, a written request should be made to Bob Nuzzo and/or myself.

LITERATURE CITED

Barbour, M. T., J. B. Stribling, and J. R. Carr. 1995. The multimetric approach for establishing biocriteria and measuring biological condition. pp. 63-80. *in* W. S. Davis and T. P. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Lamberti, G. A. and J. W. Moore. 1984. Aquatic insects as primary consumers. pp. 164-195. *in* V. H. Resh and D. M. Rosenberg (eds.). The Ecology of Aquatic Insects. Praeger Publishers, New York, NY.

Merritt, R. W. and K. W. Cummins (eds.). 1984. An Introduction to the Aquatic Insects of North America. Second edition. Kendall/Hunt Publishing Co., Dubuque, Iowa.

Merritt, R. W., K. W. Cummins, and T. M. Burton. The role of aquatic insects in the processing and cycling of nutrients. pp. 134-163. *in* V. H. Resh and D. M. Rosenberg (eds.). The Ecology of Aquatic Insects. Praeger Publishers, New York, NY.

Minshall,G. W. 1984. Aquatic insect-substratum relationships. pp. 358-400. *in* V. H. Resh and D. M. Rosenberg (eds.). The Ecology of Aquatic Insects. Praeger Publishers, New York, NY.

Plafkin, J. L., M. T. Barbour, K. D. Porter, S. K. Gross, and R. M. Hughes.1989.Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish. EPA/440/4-89- 001. Office of Water, US Environmental Protection Agency, Washington, DC.

Resh, V. H. 1988. Variability, accuracy, and taxonomic costs of rapid bioassessment approaches in benthic biomonitoring. Presented at the 36th annual North American Benthological Society meeting at Tuscaloosa, Alabama, 17-20 May 1988.

Ward, J. V. 1984. Ecological perspectives in the management of aquatic insect habitat. pp. 558-577. *in* V. H. Resh and D. M. Rosenberg (eds.). The Ecology of Aquatic Insects. Praeger Publishers, New York, NY.

Wetzel,R. G. 1975.Limnology. W.B. Saunders Co., Philadelphia, PA. 743 pp.

Wiederholm, T. 1984. Responses of aquatic insects to environmental pollution. pp. 508-557. *in* V. H. Resh and D. M. Rosenberg (eds.).The Ecology of Aquatic Insects. Praeger Publishers, New York, NY.

Wiley,M. and S.Kohler. 1984. Behavioral adaptations of aquatic insects. pp. 101-133. *in* V. H. Resh and D. M. Rosenberg (eds.). The Ecology of Aquatic Insects. Praeger Publishers, New York, NY.

Williams, D. D. 1984. The hyporheic zone as a habitat for aquatic insects and associated arthropods. pp. 430-455. *in* V. H. Resh and D. M. Rosenberg (eds.). The Ecology of Aquatic Insects. Praeger Publishers, New York, NY.

Table 1. Taxa list and counts, functional feeding groups, and tolerance values for macroinvertebrates collected from 13 stream sites in the Farmington River watershed between 19 and 27 August 1996.

TAXON	FFG	TV	FR01A	FR01B	FR02	FR03	FR04	FR05A	FR05B	FR06A	FR06B	FR07	FR08	FR09	FR10
Ancylidae	SC	7						1					2		3
Pisidiidae	FC	6				1							2		
Lumbricina	GC	8	1												
Enchytraeidae	GC	10				1								1	
Naididae	GC	9				1		1							
Lumbriculidae	GC	8		1											
Hyalellidae	GC	8				1									
Hydracarina	PR	6		1	1				1	1		2	6		1
Baetidae	GC	4	9	28	4			24	16	14	36	15	7	6	2
Oligoneuriidae	GC	4	7	8		1	7	6	3	5	6	11	3		
Heptageniidae	SC	4	5	6		2	16	9	11	3	3	9	16	6	8
Ephemerellidae	GC	1	5	7		1	2	1	1	1	6		6	1	1
Leptophlebiidae	GC	2	3	2			17			3		4	4	2	1
Gomphidae	PR	5	2			2		2		1			1	1	
Coenagrionidae	PR	9	1	1											
Peltoperlidae	SH	0				3	1				1			3	8
Nemouridae	SH	2									1				
Leuctridae	SH	0	1	1	4		3			2	1		1	3	2
Perlidae	PR	1					1		5	3	4	2		1	1
Perlodidae	PR	2			13										2
Chloroperlidae	PR	1			1	4		1	5	1	3	18	3	1	6
Sialidae	PR	8	1	2			2						1		
Corydalidae	PR	5								2	2	2	1	2	
Philopotamidae	FC	3	7	10	2	11	1	3	9	12	4	3	1	3	1
Psychomyiidae	GC	2	1				1								
Polycentropodidae	FC	6								1		2			2
Hydropsychidae	FC	4	9	6	32	20	20	8	10	12	13	3	6	18	11
Rhyacophilidae	PR	0			2	8	2		1				1		2
Glossosomatidae	SC	0									1		2		
Hydroptilidae	GC	4											1		
Brachycentridae	FC	1	1					1							2
Lepidostomatidae	SH	1	1		2						1	2		7	
Psephenidae	SC	4	4	7		5	5	1	1	3	2	4	11	6	
Elmidae	SC	4	16	9	8	14	5	19	25	6	6	1	1	12	19
Tipulidae	SH	5			2		3	3		3	4	3	5	2	1
Psychodidae	GC	10											1		
Ceratopogonidae	PR	6			1		1	1							
Simuliidae	FC	6				6	1				4	1	1		1
Chironomidae	GC	6	21	12	32	27	10	27	13	32	11	14	16	27	21
Athericidae	PR	2								3					
Empididae	PR	6	1	2				1			1	2			
Muscidae	PR	6													1
TOTAL			96	103	104	108	98	109	101	108	110	98	99	102	96

Table 2. Summary of RBP II data analysis for macroinvertebrate communities sampled at 8 stream sites in the Farmington River watershed. Seven biological metrics were calculated and scored (in parentheses) for taxa collected at each station. Scores were then totaled and compared to the regional reference station FR10. The percent comparability to the reference station yields a final impairment score for each station.

STATION #	FR02	FR03	FR04	FR06A	FR06B	FR07	FR08	FR10
STREAM	Cone Brook	Fall River	Benton Brook	Clam River	Clam River	Buck River	Sandy Brook	Valley Brook*
HABITAT SCORE	157	177	170	181	169	168	191	178
TAXA RICHNESS	13 (3)	17 (6)	18 (6)	19 (6)	20 (6)	18 (6)	24 (6)	21 (6)
BIOTIC INDEX	4.08 (6)	4.14 (6)	3.64 (6)	4.25 (6)	3.80 (6)	3.69 (6)	4.21 (6)	3.76 (6)
EPT INDEX	8 (0)	8 (0)	11 (3)	11 (3)	13 (6)	10 (3)	12 (3)	14 (6)
EPT/CHIRONOMIDAE	1.88 (6)	1.85 (6)	7.10 (6)	1.78 (6)	2.22 (6)	4.93 (6)	3.19 (6)	2.33 (6)
SCRAPER/FILTERER	0.24 (0)	0.55 (3)	1.18 (6)	0.48 (3)	0.57 (3)	1.56 (6)	3.20 (6)	1.76 (6)
% CONTRIBUTION DOMINANT FAMILY	31% (3)	25% (6)	20% (6)	30% (6)	33% (3)	18% (6)	16% (6)	22% (6)
COMMUNITY SIMILARITY	52% (3)	61% (3)	46% (3)	53% (3)	41% (3)	43% (3)	47% (3)	100% (6)
TOTAL METRIC SCORE	21	30	36	33	33	36	36	42
% COMPARABILITY TO REFERENCE	50%	71%	86%	79%	79%	86%	86%	
BIOLOGICAL STATUS - DEGREE IMPAIRMENT	MODERATELY IMPAIRED	MODERATELY IMPAIRED	NON-IMPAIRED	NON-IMPAIRED	NON-IMPAIRED	NON-IMPAIRED	NON-IMPAIRED	*REFERENCE*

* Primary reference station for FR02, FR03, FR04, FR07, FR08; Secondary reference station for FR06A, FR06B

Table 3. Summary of RBP II data analysis for macroinvertebrate communities sampled at 8 stream sites in the Farmington River watershed. Seven biological metrics were calculated and scored (in parentheses) for taxa collected at each station. Scores were then totaled and compared to the regional reference station FR09. The percent comparability to the reference station yields a final impairment score for each station.

STATION #	FR01A	FR01B	FR03	FR05A	FR05B	FR06A	FR06B	FR09
STREAM	W. Branch Farmington R.	W. Branch Farmington R.	Fall River	W. Branch Farmington R.	W. Branch Farmington R.	Clam River	Clam River	Hubbard Brook*
HABITAT SCORE	193	182	177	180	173	181	169	195
TAXA RICHNESS	19 (6)	16 (6)	17 (6)	17 (6)	13 (3)	19 (6)	20 (6)	18 (6)
BIOTIC INDEX	4.20 (6)	4.08 (6)	4.14 (6)	4.54 (6)	3.82 (6)	4.25 (6)	3.80 (6)	4.04 (6)
EPT INDEX	11 (6)	8 (3)	8 (3)	8 (3)	9 (3)	11 (6)	13 (6)	11 (6)
EPT/CHIRONOMIDAE	2.33 (6)	6.17 (6)	1.85 (6)	1.96 (6)	4.69 (6)	1.78 (6)	2.22 (6)	1.89 (6)
RIFFLE COMMUNITY: SCRAPERS/FILTERERS	1.47 (6)	1.38 (6)	0.55 (3)	2.5 (6)	1.95 (6)	0.48 (3)	0.57 (3)	1.14 (6)
% CONTRIBUTION DOMINANT FAMILY	22% (6)	27% (6)	25% (6)	25% (6)	25% (6)	30% (6)	33% (3)	26% (6)
COMMUNITY SIMILARITY	67% (3)	51% (3)	70% (3)	64% (3)	53% (3)	69% (3)	50% (3)	100% (6)
TOTAL METRIC SCORE	39	36	33	36	33	36	33	42
% COMPARABILITY TO REFERENCE STATION	93%	86%	79%	86%	79%	86%	79%	
BIOLOGICAL STATUS - DEGREE IMPAIRMENT	NON-IMPAIRED	NON-IMPAIRED	NON-IMPAIRED	NON-IMPAIRED	NON-IMPAIRED	NON-IMPAIRED	NON-IMPAIRED	*REFERENCE*

* Primary reference station for FR01A, FR01B, FR05A, FR05B, FR06A, FR06B, Secondary reference station for FR03

Table 4. Summary of RBP II data analysis for macroinvertebrate communities sampled at 6 stream sites in the Farmington River watershed. Seven biological metrics were calculated and scored (in parentheses) for taxa collected at each station. Scores were then totaled and compared to the upstream reference station. The percent comparability to the reference station yields a final impairment score for each station.

STATION #	FR01A*	FR01B	FR05A**	FR05B	FR06A***	FR06B
STREAM	W. Branch Farmington R.	W. Branch Farmington R.	W. Branch Farmington R.	W. Branch Farmington R.	Clam River	Clam River
HABITAT SCORE	193	182	180	173	181	169
TAXA RICHNESS	19 (6)	16 (6)	17 (6)	13 (3)	19 (6)	20 (6)
BIOTIC INDEX	4.20 (6)	4.08 (6)	4.54 (6)	3.82 (6)	4.25 (6)	3.80 (6)
EPT INDEX	11 (6)	8 (3)	8 (6)	9 (6)	11 (6)	13 (6)
EPT/CHIRONOMIDAE	2.33 (6)	6.17 (6)	1.96 (6)	4.69 (6)	1.78 (6)	2.22 (6)
RIFFLE COMMUNITY: SCRAPERS/FILTERERS	1.47 (6)	1.38 (6)	2.5 (6)	1.95 (6)	0.48 (6)	0.57 (6)
% CONTRIBUTION DOMINANT FAMILY	22% (6)	27% (6)	25% (6)	25% (6)	30% (6)	33% (3)
COMMUNITY SIMILARITY	100% (6)	71% (6)	100% (6)	70% (3)	100% (6)	63% (3)
TOTAL METRIC SCORE	42	39	42	36	42	36
% COMPARABILITY TO REFERENCE STATION		93%		86%		86%
BIOLOGICAL STATUS - DEGREE IMPAIRMENT	*REFERENCE*	NON-IMPAIRED	*REFERENCE*	NON-IMPAIRED	*REFERENCE*	NON-IMPAIRED

* Upstream reference station for FR01B

** Upstream reference station for FR05B

*** Upstream reference station for FR06B

APPENDIX D

MA DEP/DWM 1996 – 1997 Farmington River Watershed Water Quality, Sediment Monitoring Data, and Lakes Synoptic Survey Information

MA DEP DWM 1996/1997 WATER AND SEDIMENT QUALITY MONITORING DATA
FARMINGTON RIVER WATERSHED

Water quality sampling in the Farmington River Watershed was conducted by MA DEP DWM between April 1996 and June 1997. The sampling plan was designed by the Farmington Watershed team to meet two general objectives: 1) to characterize the current condition of water, sediment, and habitat quality at selected sites in the watershed and; 2) to identify potential sources of non-point source pollution.

MATERIALS AND METHODS

Quality Assurance And Quality Control

In general, monitoring surveys in the Farmington River Watershed in 1996/1997 were performed with attention to maintaining quality assurance and control of field samples and field-generated data. Field monitoring activities followed accepted DWM standard operating procedures. Where strict procedures were not in place or necessary it is assumed that DWM field staff exercised best professional judgment. Procedures used for sampling technique and sample handling are outlined in the *Basins Program Standard Operating Procedures River and Stream Monitoring* (MA DEP 1990a). The Wall Experiment Station (WES), the Department's analytical laboratory, supplied bottles and field preservatives for all sampling, which were prepared according to the WES *Laboratory Quality Assurance Plan and Standard Operating Procedures* (MA DEP 1995). Samples were preserved in the field as necessary, transported on ice to WES, and analyzed according to the WES standard operating procedures (SOP). Quality control samples included field blanks and field replicates. Phytoplankton enumeration was performed in accordance with Biomonitoring Program 1990 Standard Operating Procedures (MA DEP 1990b).

Rivers

Water quality sampling was conducted on a monthly basis at three sampling locations (downstream from Hayden Pond at Jones Road in Otis, near Reservoir Road downstream from the confluence with the Fall River in Otis, and near the USGS flow gaging station in Roosterville (Sandisfield). *In-situ* measurements were made of pH, conductivity, dissolved oxygen, and temperature. Samples were collected and analyzed for nutrients, fecal coliform bacteria, total and suspended solids, chlorides, alkalinity, and turbidity. Streamflow measurements were also made by DWM personnel according to standard operating procedures (MA DEP 1990a) using a Swoffer meter (Model 2100) or a Price Type AA meter with polymer buckets using a bridge board. Field data were recorded on standard flow gaging field sheets. Data reduction and stream discharge calculations were performed at the DWM office in Worcester. Data gathered at three stations on the West Branch Farmington River were used to estimate annual loading of nitrogen and phosphorus to the Colebrook Reservoir. Selected tributaries, storm drains, pipes, culverts and catch basins throughout the basin were also sampled for fecal coliform bacteria, total and suspended solids, chlorides, conductivity, temperature, and turbidity to investigate potential problems from highway runoff (predominately sediment and salt) and failing septic systems.

Conditions prior to the surveys were characterized by analyzing precipitation and streamflow data. Three weather stations, Department of Environmental Management's (DEM) Blandford Station 214 and Otis Station 115, and the National Weather Service Granville Station 19-9191-2 were used to determine precipitation and weather conditions prior to the sampling dates: data for these stations were provided by DEM, Office of Water Resources. Discharge, (hereinafter referred to as streamflow) and duration data were obtained from a continuous United States Geological Survey (USGS) stream gage (Roosterville - 01185500) on the West Branch Farmington at Station FR03, located 0.3 miles downstream from the confluence with the Clam River. The data from this gage were used to calculate streamflow characteristics for the period of record. These statistical analyses can be found in *Water Resources Data Massachusetts and Rhode Island, Water Year 1996* (Socolow et al. 1997).

Sediments

In the lab, prior to sampling, petite Ponar dredges were cleaned to remove any residual sediment. The inside of the dredges were then rinsed with reagent grade acetone, followed by a rinse with reagent grade hexane, followed by a final rinse with distilled water. Sediments were collected by boat using the pre-cleaned petite Ponar dredges at the deep hole station of Shaw Pond and Benton Pond in August 1996. Two samples (replicates) were collected in Benton Pond (Station BP01) and one sample (no replicate) was collected from Shaw Pond (Station SH01). Sediment sampling was conducted in October 1997 in the West Branch Farmington River in Sandisfield (near the MA/CT state line at the upstream end of Colebrook Reservoir) in an area of low velocity flow and apparent deposition (Stations FR06A, B and C). Stations were accessed by wading from shore. Three replicate grabs each for metals and organics were collected using a petite Ponar dredge. For metals samples the dredge contents were

emptied into a plastic tray and subsamples of the sediment were scooped with plastic scoops into specially cleaned 16 oz. glass jars prepared for metals. For organics the dredge contents were emptied into a stainless steel tray and subsamples scooped with stainless steel scoops into specially cleaned 16 oz. glass jars prepared for organics. All samples were identified with tags and stored on ice in coolers for delivery to WES. The sediments were analyzed at WES laboratory for the following parameters: PCB, total PAH, total DDT, Al, Fe, As, Cd, Cr, Cu, Hg, Pb, Ni, Zn, Se, total Kjeldahl nitrogen, total phosphorus.

Sediment metals were compared to the L-EL and S-EL (lowest and severe effect levels, respectively) published by Persaud et al. (1993). Additionally the sediment data were normalized to the iron content and average earth crustal values (Schropp and Windom 1988) to calculate enrichment ratios (ERs) defined as follows:

$$ER_x = (X/Fe)_{sediment}/(X/Fe)_{crust}$$

where ER_x = enrichment ratio for metal x
$(X/Fe)_{sediment}$ = weight ratio in sediment
$(X/Fe)_{crust}$ = weight ratio in average crustal material

Generally, enrichment ratios above one are interpreted to mean that chemicals are present above natural levels. The determination of natural ratios would require collecting data from selected uncontaminated sites. Sufficient data of this nature were unavailable for this study. Instead, the approach of assuming a metal to iron ratio based on values in the literature for average crustal abundance was used to estimate the natural component of As, Cd, Cr, Cu, Hg, Pb, Ni, and Zn.

Lake Baseline Surveys

A bathymetric map revealed deep holes in both the northern and southern lobes of Shaw Pond, so in-lake stations were established at both locations. Two tributaries flowing into the northern lobe of Shaw Pond were also sampled. Benton Pond, a kettle hole pond, had one in-lake deep hole station and no tributary stations. Baseline survey sampling took place before stratification of Shaw and Benton Ponds in order to get an idea of nutrient availability and overall water quality conditions during turnover and were repeated during the height of the growing season in order to assess water quality and trophic status during "worst case" conditions. Water sampling was conducted once in May during spring turnover and once during August 1996 at the in-lake deep hole(s) and all flowing tributaries. Grab samples, taken with a Van Dorn sampler, were collected one meter below the surface in May and August and from approximately 0.5 meters above the bottom in August during stratification. Surface grab samples were collected from the tributaries, if flowing. Samples were analyzed for nutrients, bacteria, alkalinity, hardness, chlorides, total and suspended solids, turbidity and fecal coliform (tributaries only), and phytoplankton. Samples for phytoplankton enumeration were collected at the inlake stations in August. An integrated 100 ml sample of the water column to the thermocline was collected using a length of Tygon tubing. Profiles of dissolved oxygen, pH, and temperature were recorded *in-situ* and a Secchi disk depth was also measured at each deep hole station. Finally, an aquatic macrophyte growth survey was performed on each lake in August to identify species present and assess their percent cover. These 1996 data were compared to historical data collected by DWPC staff in the 1970s (Whittaker 1982) and early 1990s (Haynes 1991) to evaluate changes in trophic status as well as aquatic macrophyte density and species composition.

Synoptic Lake Surveys

Synoptic surveys were conducted by DWM at 14 lakes, ponds, or reservoirs including both Shaw Pond and Benton Pond during the summer of 1996 to assess general lake conditions, aquatic vegetation cover, access, trophic status and presence of non-native vegetation. Observations, from at least one access point on each lake (multiple access points on larger lakes) were recorded on standardized field sheets. An attempt was made to observe the entire surface area of each lake to determine the extent of aerial macrophyte cover. At each sampling location general water quality conditions, identification and abundance of aquatic and wetland macrophyte plant species, and estimates of total percent aerial coverage were recorded (Table D11). Macrophyte visual observations were augmented at each station by identifying plant specimens collected from the lake bottom. Specimens were retrieved using a “rake” (a short handled, double-sided garden rake on a 50 foot line) thrown to its maximum extension in multiple directions at each station. Macrophytes collected in the “rake” were identified (*in-situ* or back at the DWM laboratory) and recorded on the field sheets. Transparency was measured where possible using a standard 20-centimeter diameter Secchi disk. Where Secchi disk measurements were not feasible, transparency was estimated as being above or below 1.2 meter (bathing beach guideline). Trophic status was estimated primarily using visual observations of macrophyte cover and

phytoplankton populations. A more definitive assessment of trophic status would require more extensive collection of water quality and biological data.

The water quality-sampling matrix for the 1996/1997 Farmington River Watershed surveys is summarized in Table D1. Sampling locations are identified in Figure D1.

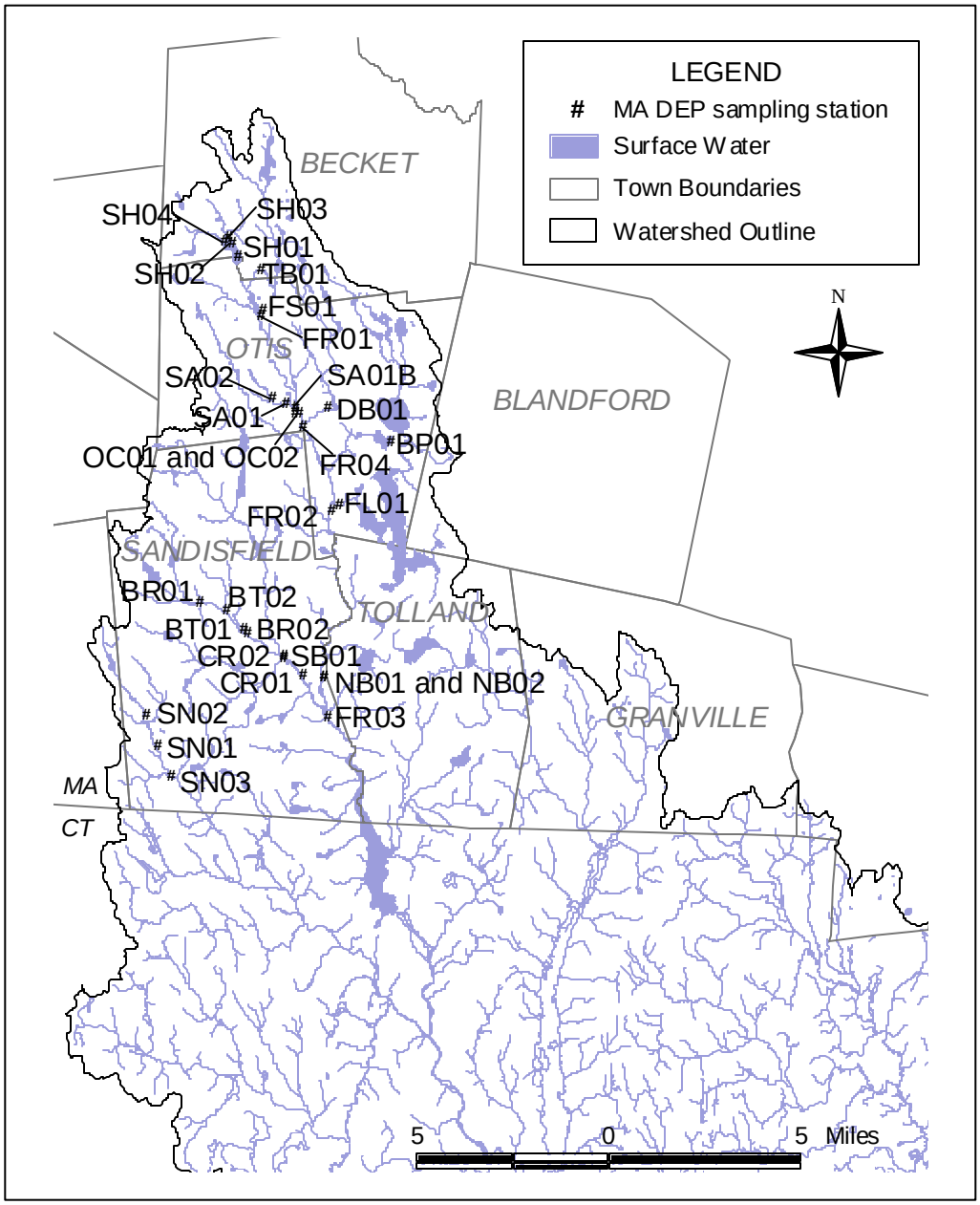


Figure D1. 1996/1997 MA DEP water quality monitoring stations in the Farmington River Watershed.

Table D1. Sampling matrix for 1996/1997 Farmington River Watershed Water Quality Surveys.

STATION	1996 APRIL	1996 MAY	1996 JUNE	1996 JULY	1996 AUG	1996 SEPT	1996 OCT	1996 DEC	1997 FEB	1997 APRIL	1997 JUNE	1997 OCT
FR01	B,H,N,C,F	B,H,N,C,F	B,H,N,C,F	H,N,C,F	B,H,N,C,F	B,H,N,C,F	H,N,C,F	B,H,N,C,F	H,N,C,F	B,H,N,C,F	B,H,N,C,F	
FR02	B,H,N,C,F	B,H,N,C,F	B,H,N,C,F	H,N,C,F	B,H,N,C,F	B,H,N,C,F	H,N,C,F	B,H,NC,F	H,N,C,F	B,H,N,C,F	B,H,N,C,F	
FR03	B,H,N,C,F	B,H,N,C,F	B,H,N,C,F	H,N,C,F	B,H,N,C,F	B,H,N,C,F	H,N,C,F	B,H,NC,F	H,N,C,F	B,H,N,C,F	B,H,N,C,F	
FR04								B,C				
FR06 (A,B,C)												S
NB01				B,C,Y							B,C	
NB02											B,C	
TB01		B,C,Y										
FS01		B,C,Y	B,C,Y	B,C,Y	B		C	B,C		B,C	B,C	
SA01		B,C,Y	B,C,Y									
SA01B		Y	Y	Y			C	B,C		B,C		
SA02		B,C,Y	B,C,Y									
OC01		B,C,Y	Y	Y	B		C	B,C		B,C	B,C	
OC02		Y	Y	Y								
DB01		B,C,Y										
FL01		B,C,Y										
CR01		B,C,Y										
CR02		B,C,Y	B,C,Y	B,C,Y						B,C		
SB01		B,C,Y	Y				C			B,C		
BR01			B,C,Y									
BR02							C					
BT01			B,C,Y				C					
BT02			B,C,Y									
SN01			B,C,Y	B,C,Y								
SN02				B,C,Y								
SN03				B,C,Y								
SH01		H,C,N			H,C,N,S,P							
SH02		H,C,N			H,C,N,P							
SH03		H,C,N,B			H,C,N							
SH04		H,C,N,B			H,C,N							
BP01		C,N			H,C,N,S,P							

B = Fecal coliform bacteria;
C = Chemistry (alkalinity, hardness, chloride, total suspended solids, total solids, turbidity);
F = Flow measurement;
H = Hydrolab meter (pH, temperature,dissolved oxygen, specific conductance);
N = Nutrients (total phosphorus, ammonia nitrogen, nitrate nitrogen, total Kjeldahl nitrogen);
P = Phytoplankton enumeration;
S = Sediment sampling (organics, metals);
Y = YSI meter (salinity, conductivity)

RESULTS

Quality Assurance And Quality Control

The water quality sample data were validated by reviewing QC sample results, analytical holding time compliance, QC sample frequency and related ancillary data/documentation (at a minimum). Data not meeting general data quality objectives of DWM were censored (no data were qualified). Data validation for the 1995/1996 DWM water quality surveys is available in a Memorandum - *1994, 95 & 96 QA/QC Assessment Report* (MA DEP 2000). Specific decisions pertaining to the Farmington River Watershed data were excerpted from this memorandum and appear in Table D2. All Hydrolab® and YSI® multi-probe data were validated using multi-staff review. Data symbols (e.g., ** for censored/missing data) were applied to these data as necessary (see Tables D3 and D5). Sediment data have not undergone formal DWM data validation and are provided for discussion purposes only.

In-situ Hydrolab® and YSI® data from the 1996/1997 Farmington River Watershed monitoring surveys are presented in Table D3. Fecal Coliform bacteria data are presented in Table D4. Physico/chemical water quality data are presented in Table D5. Streamflow data are presented in Table D6. Sediment quality data for the West Branch Farmington River and Shaw and Benton Ponds can be found in Table D7. Semivolatile organic compound sediment data for the West Branch Farmington River can be found in Table D8. Phytoplankton enumeration and a macrophyte species composition list for Shaw and Benton Ponds can be found in Tables D9 and D10, respectively. The status of lakes in the Farmington River watershed are summarized in Table D11.

Table D2. 1996/1997 DWM Data Decisions for Farmington River Watershed Discrete Sample Data (excerpted from MA DEP 2000).

OWMID	Qualifier
31-0116-124	Suspended Solids had been analyzed outside the established holding time of 7 days (see condition "a"). Samples were collected on 06/02/97 and analyzed on 06/10/97.
31-0100, 31-0095-097	Hardness had been analyzed outside of the established holding time of 14 days. Samples were collected on 12/17/96 and analyzed on 01/10/97.
31-0086-091, 31-0081-084	Turbidity had been analyzed outside of the established holding time of 48 hrs. Samples were collected on 10/24/96 and analyzed on 10/29/96.
31-0081-085	Hardness had been analyzed outside of the established holding time of 14 days. Samples were collected on 10/24/96 and analyzed on 12/4/96.
31-0074-078	Hardness had been analyzed outside of the established holding time of 14 days. Samples were collected on 9/24/96 and analyzed on 10/9/96
31-0128, 31-0068-070 31-0072-073	Fecal Coliform had been analyzed outside of the established holding time of 6 hrs. Samples were collected on 8/22/96 and analyzed on 8/23/96.
31-0050-053	Hardness had been analyzed outside of the established holding time of 14 days. Samples were collected on 7/23/96 and analyzed on 8/14/96.
31-0011-013	Fecal Coliform had been analyzed outside of the established holding time of 6 hrs. Samples were collected on 5/14/96 and analyzed on 5/15/96.
31-0044-49	No field blank or field replicate samples had been collected during the 7/11/96 sampling survey (see condition "a").
31-0050-053	No field blank had been collected during the 7/23/96 sampling survey (see condition "a").
31-0077	Failed to meet Hardness field blank and holding time data quality objectives for the 9/24/96 sampling survey (31-0074-078). Therefore, censor Hardness result.
31-0057	The 8/07/96 blank result for Hardness failed to achieve the stated data quality objective but no other evidence was available to justify censoring the entire days results (see condition "a"). Therefore, censor Hardness result.
31-0071	The MDL for the 8/22/96 Hardness sampling survey was reported as 3.0mg/L. The reported result of 1.5mg/L is below the stated MDL level and cannot be reported with confidence. The reported value must be changed to <3.0mg/L
31-0032/33	Replicate results are at or below the ideal counting range of 20 CFU for Fecal Coliform analysis.
31-0060/067	No problems or aberrant trends were noted on the chain of custody or the OWM field sheet. There was not enough evidence to censor these replicate hardness results.
31-0041/042	These replicate samples fell outside of the stated quality objective of 20% RPD. No problems or aberrant trends were noted on the chain of custody or the OWM field sheet. There was not enough evidence to censor these replicate chloride results.
31-0074/075	These replicate samples fell outside of the stated quality objective of 20% RPD. No problems or aberrant trends were noted on the chain of custody or the OWM field sheet. There was not enough evidence to censor these replicate suspended solids results.
31-0068/028, 31-0001/002	These replicate samples fell outside of the stated quality objective of 20% RPD. No problems or aberrant trends were noted on the chain of custody or the OWM field sheet. There was not enough evidence to censor these replicate total solids results.
31-0068/128, 31-0060/067	Most of these replicate concentrations were reported close to the established laboratory MDL (see condition "d"). No problems or aberrant trends were noted on the chain of custody or the OWM field sheet. There was not enough evidence to censor these replicate ammonia results.
31-0068/128	These replicate samples fell outside of the stated quality objective of 30% RPD. No problems or aberrant trends were noted on the chain of custody or the OWM field sheet. There was not enough evidence to censor these replicate nitrate results.
31-0074/075, 31-0006/007	Most of these replicate concentrations were reported close to the established laboratory MDL (see condition "d"). No problems or aberrant trends were noted on the chain of custody or the OWM field sheet. There was not enough evidence to censor these replicate total phosphorus results.

Notes:

1) The DWM QA Program was not fully established during the 1994, 95 and 96 sampling surveys. In addition, DWM relied on WES to supply the reagent water for field blanks. DWM staff members were not always supplied with contaminant-free reagent water. If the field blank objective was violated the associated survey data were not necessarily suspect unless a trend was found or there was documented evidence that aberrant collection, handling or analysis procedures were used. If, however, two or more data quality objectives were violated then all associated data by that sampling crew on that day were be censored.

2) Statistically, slight differences between replicate values at or near a low MDL will result in an increase in relative percent difference (%RPD) values. This increase can create a false impression that replicate data are not meeting their set quality control limits. For replicate values at or near method detection limits ($\leq$1 mg/L) a 30% RPD data quality objective was applied to help counter this statistical effect. Replicate values > 1mg/L were reviewed independently against other quality control factors (i.e. field blank data, documentation) and a decision made on their validity.

Table D3. 1996/1997 Farmington River Watershed *in-situ* Hydrolab® data.

Date	OWMID[1]	Time (24hr)	Depth (m)	Temp (°C)	pH (SU)	Cond@ 25°C (µS/cm)	TDS (mg/l)	DO (mg/l)	SAT (%)	Turbidity (NTU)
Benton Pond	Unique_ID[2]: W0347	Station: BP01	Description: Deep hole, Otis.							
5/14/1996	31-0006	12:11	0.1i	12.6	7.2	126	80.8	10.1	94	--
5/14/1996	31-0006	12:14	1.0	12.6	7.2	126	80.9	10.1	94	--
5/14/1996	31-0006	12:18	2.0	12.5	7.2	126	80.9	10.1	94	--
5/14/1996	31-0006	12:21	3.0	12.5	7.3	127	80.9	10.1	94	--
5/14/1996	31-0006	12:23	4.0	12.4	7.3	126	80.9	10.1	94	--
5/14/1996	31-0006	12:25	5.0	12.3	7.3	126	80.9	10.1	93	--
5/14/1996	31-0006	12:27	6.0	12.1	7.3	126	80.9	10.1	93	--
5/14/1996	31-0006	12:29	7.0	12.0	7.2	127	81.1	10.0	92	--
8/7/1996	31-0054	11:33	** i	25.4	7.3	130	83.4	8.1	97	--
8/7/1996	31-0054	11:34	1.0	24.7	7.3	130	83.3	8.1	97	--
8/7/1996	31-0054	11:35	2.0	23.6	7.3	129	82.4	8.2	95	--
8/7/1996	31-0054	11:37	3.0	22.7	7.4	129	82.7	8.3	95	--
8/7/1996	31-0054	11:38	4.0	22.0	7.4	128	82.0	8.0	91	--
8/7/1996	31-0054	11:40	5.0	21.5	7.2	128	82.0	6.7	75	--
8/7/1996	31-0054	11:42	6.0	19.7	6.6	132	84.2	0.7	7	--
8/7/1996	31-0054	11:44	6.8	16.7	6.5	145	92.7	<0.2	<2	--
Shaw Pond	Unique_ID: W0348	Station: SH01	Description: Deep hole, center of southern lobe, Otis.							
5/14/1996	31-0009	11:29	0.2	12.2	6.9	218	139	9.6	89	--
5/14/1996	31-0009	11:35	1.0	11.9	7.0	219	140	9.7	88	--
5/14/1996	31-0009	11:38	2.0	11.7	7.0	221	142	9.7	88	--
5/14/1996	31-0009	11:40	3.0	11.4	7.0	223	143	9.7	88	--
5/14/1996	31-0009	11:43	3.8	11.4	7.0	222	142	9.5	85	--
8/7/1996	31-0058	11:02	0.4	24.4	7.6	163	104	8.5	100	--
8/7/1996	31-0058	11:08	1.0	23.5	7.5	163	104	8.5	98	--
8/7/1996	31-0058	11:10	2.0	21.3	7.1	161	103	6.7	74	--
8/7/1996	31-0058	11:11	3.0	20.0	6.8	172	110	3.7	40	--
8/7/1996	31-0058	11:15	3.5	19.2	6.7	180	115	0.9	9	--
Shaw Pond	Unique_ID: W0349	Station: SH02	Description: Center of northern lobe, Otis.							
5/14/1996	31-0010	12:10	0.2	11.7	7.1	217	139	9.8	89	--
5/14/1996	31-0010	12:12	1.0	11.6	7.1	218	140	9.8	89	--
5/14/1996	31-0010	12:14	2.0	11.6	7.1	217	139	9.8	89	--
5/14/1996	31-0010	12:16	3.0	11.2	7.1	218	140	9.4	85	--
5/14/1996	31-0010	12:18	4.0	10.7	7.0	209	134	9.2	82	--
8/7/1996	31-0060	11:54	0.5	24.3	7.6	164	105	8.6	101	--
8/7/1996	31-0060	12:02	1.0	23.8	7.5	164	105	8.7	101	--
8/7/1996	31-0060	12:05	2.0	21.5	7.2	162	104	7.4	82	--
8/7/1996	31-0060	12:07	2.8	20.2	6.8	167	107	4.4	48	--
8/7/1996	31-0060	12:12	4.0	18.6	6.7	185	119	<0.2	<2	--
Unnamed Tributary	Unique_ID: W0193	Station: SH03	Description: Eastern most unnamed tributary into northern lobe of Shaw Pond upstream from confluence with Shaw Pond, Becket.							
5/14/1996	31-0011	12:47	** m	**m	**m	**m	**m	**m	**m	--
8/7/1996	31-0062	12:51	** i	20.7	6.7	445	285	2.7	29	--

[1] OWMID = sample tracking number, [2] Unique ID = unique station identification number, ** = censored data, m = method not followed, u = unstable readings, i = inaccurate readings from multi-probe likely

Table D3 (continued). 1996/1997 Farmington River Watershed *in-situ* Hydrolab® data.

Date	OWMID[1]	Time (24hr)	Depth (m)	Temp (C°)	pH (SU)	Cond@ 25°C (µS/cm)	TDS (mg/l)	DO (mg/l)	SAT (%)	Turbidity (NTU)
WEST BRANCH FARMINGTON RIVER Unique_ID: W0196 Station: FR01 Description: Ed Jones Road bridge, approximately 150 feet below Hayden Pond outlet/dam, Otis.										
4/25/1996	31-0005	14:30	0.1i	10.2	6.7	110	70.5	10.6	94	--
5/29/1996	31-0017	12:36	** i	17.4	6.8	137	87.4	9.0	94	--
6/18/1996	31-0032	12:11	** i	24.7	6.9	140	89.5	7.5	90	--
7/23/1996	31-0053	11:55	** i	20.0	7.0	100	64.0	7.8	86	--
8/22/1996	31-0070	12:35	** i	24.2	7.0	132	84.4	7.4	88	--
9/24/1996	31-0078	12:08	** i	14.3	6.9	92.4	59.1	9.2	89	--
10/24/1996	31-0083	13:06	** i	11.5	6.8	76.1	48.7	10.2	94	--
12/17/1996	31-0099	11:56	** i	1.6	6.7	81.5	52.2	12.3	87	--
2/25/1997	31-0101	10:09	** i	1.0	6.9	103	65.8	12.7	87	--
4/16/1997	31-0112	12:13	** i	6.7	6.9	108	69.1	11.0	90	--
6/2/1997	31-0116	11:54	** i	16.6	7.1	131	84.0	8.8	87	2.5i
WEST BRANCH FARMINGTON RIVER Unique_ID: W0198 Station: FR02 Description: Reservoir Road bridge, Otis.										
4/25/1996	31-0004	12:26	0.2	10.5	6.9	94.2	60.3	10.9	97	--
5/29/1996	31-0016	11:52	** i	16.1	7.2	117	75.0	10.1	102	--
6/18/1996	31-0031	11:17	** i	21.8	7.4	139	88.6	8.7	99	--
7/23/1996	31-0051	11:23	** i	18.4	7.3	106	67.9	8.6	91	--
8/22/1996	31-0069	11:41	** i	20.5	7.2	126	80.7	9.3	102	--
9/24/1996	31-0076	11:23	** i	13.2	7.0	81.4	52.1	9.7	92	--
10/24/1996	31-0082	11:50	** i	10.9	6.9	69.4	44.4	10.5	95	--
12/17/1996	31-0097	11:03	** i	2.0	6.7	80.4	51.5	12.8	91	--
2/25/1997	31-0102	10:47	** i	0.0	7.1	102u	65.3u	13.4	89	--
4/16/1997	31-0110	11:22	** i	6.3	7.0	98.6	63.1	11.5	93	--
6/2/1997	31-0117	11:26	** i	14.7	7.4	109	69.5	9.7	92	5.0i
WEST BRANCH FARMINGTON RIVER Unique_ID: W0201 Station: FR03 Description: Clark Road bridge, Sandisfield.										
4/25/1996	31-0001	11:27	0.2	9.7	6.8	66.9	42.8	11.2	98	--
5/29/1996	31-0014	11:14	0.2	14.1	7.4	97.2	62.2	10.6	102	--
6/18/1996	31-0030	10:42	** i	20.8	7.5	121	77.3	9.0	100	--
7/23/1996	31-0050	10:51	0.1i	17.9	7.4	90.7	58.1	8.9	93	--
8/22/1996	31-0128	09:44	** i	18.7	7.3	113	72.5	9.3	99	--
9/24/1996	31-0074	10:44	** i	13.3	6.6	46.8	30.0	9.8	94	--
10/24/1996	31-0081	11:17	** i	11.2	6.5	44.2	28.3	10.4	95	--
12/17/1996	31-0095	10:21	** i	2.7	6.5	**	**	12.3	90	--
2/25/1997	31-0103	11:36	** i	0.5	6.6	47.6u	30.4u	13.1	89	--
4/16/1997	31-0106	10:29	** i	5.3	6.9	75.0u	48.0u	11.7	92	--
6/2/1997	31-0118	10:50	** i	14.0	7.4	87.1	55.7	9.9	93	<1.0i
SHALES BROOK Unique_ID: W0213 Station: SH04 Description: Upstream from confluence with Shaw Pond, Becket.										
5/14/1996	31-0012	13:40	** m	**m	**m	**m	**m	**m	**m	--
8/7/1996	31-0063	13:20	** i	19.3	7.2	46.6	29.8	8.6	92	--

[1] OWMID = sample tracking number, [2] Unique ID = unique station identification number, ** = censored data, m = method not followed, u = unstable readings, i = inaccurate readings from multi-probe likely

Table D4. 1996/1997 Farmington River Watershed water quality and bacteria data. (Units are mg/L unless otherwise expressed.)

Date	OWMID[1]	QAQC	Time (24hr)	Depth (m)	Alkalinity (mg/l)	Hardness (mg/l)	Spec. Cond (µmhos)	Chloride (mg/l)	TSolids (mg/l)	SSolids (mg/l)	Turb (NTU)	TKN (mg/l)	NH3-N (mg/l)	NO3-NO2-N (mg/l)	TPhos (mg/l)	T-Coli (cfu/100ml)	Fecal (cfu/100ml)
Field Blank Sample Unique_ID[2]: W00-8 Station: BLANK Description: QAQC: Field Blank Sample																	
4/25/1996	31-0003	BLANK	**	--	<1	--	--	--	--	--	--	<0.10	<0.02	<0.02	<0.01	--	--
5/14/1996	31-0008	BLANK	**	--	--	<0.70	--	--	--	--	--	--	<0.02	<0.02	<0.01	--	--
5/29/1996	31-0015	BLANK	**	--	--	<0.70	--	--	--	<2.5	--	--	0.04	<0.02	<0.01	--	--
6/18/1996	31-0034	BLANK	**	--	--	--	--	--	--	--	--	--	<0.02	<0.02	<0.01	--	--
8/7/1996	31-0057	BLANK	11:50	--	--	**	--	--	--	--	--	--	0.02	<0.02	<0.01	--	--
8/22/1996	31-0071	BLANK	12:35	--	--	<3.00	--	--	--	--	--	--	0.02	<0.02	<0.01	--	**
9/24/1996	31-0077	BLANK	**	--	--	**	--	--	--	--	--	<0.10	<0.02	<0.02	<0.01	--	--
10/24/1996	31-0085	BLANK	**	--	--	**	--	--	--	--	--	--	<0.02	<0.02	<0.01	--	**
12/17/1996	31-0100	BLANK	12:00	--	--	**	--	--	--	--	--	--	<0.02	<0.02	<0.01	--	--
2/25/1997	31-0105	BLANK	**	--	--	<0.13	--	--	--	--	--	--	<0.02	<0.02	<0.01	--	--
4/16/1997	31-0113	BLANK	12:26	--	--	<0.70	--	--	--	--	--	--	<0.02	<0.02	<0.01	--	--
6/2/1997	31-0120	BLANK	10:10	--	3	--	--	1.0	--	**	<0.1	--	<0.02	<0.02	0.02	--	--
Benton Pond Unique_ID: W0347 Station: BP01 Description: Deep hole, Otis.																	
5/14/1996	31-0006	31-0007	12:16	1.0	19	12	--	22	54	<2.5	--	--	<0.02	<0.02	0.03	--	--
5/14/1996	31-0007	31-0006	12:16	1.0	18	11	--	23	64	<2.5	--	--	<0.02	<0.02	0.01	--	--
8/7/1996	31-0054	31-0055	11:35	1.0	20	19	--	--	84	<2.5	0.72	--	0.02	<0.02	<0.01	--	--
8/7/1996	31-0055	31-0054	11:35	1.0	20	22	--	--	76	<2.5	0.70	--	0.02	<0.02	<0.01	--	--
8/7/1996	31-0056		11:45	6.0	20	--	--	--	82	<2.5	0.70	--	0.02	<0.02	<0.01	--	--
Shaw Pond Unique_ID: W0348 Station: SH01 Description: Deep hole, center of southern lobe, Otis.																	
5/14/1996	31-0009		11:35	1.0	25	16	--	46	112	<2.5	--	--	<0.02	<0.02	<0.01	--	--
8/7/1996	31-0058		11:02	0.4	26	27	--	--	102	<2.5	1.3	--	0.11	<0.02	0.01	--	--
8/7/1996	31-0059		11:15	3.5	26	17	--	--	106	<2.5	2.0	--	0.08	<0.02	0.01	--	--
Shaw Pond Unique_ID: W0349 Station: SH02 Description: Center of northern lobe, Otis.																	
5/14/1996	31-0010		12:12	1.0	20	16	--	46	118	<2.5	--	--	<0.02	<0.02	0.02	--	--
8/7/1996	31-0060	31-0067	11:54	0.5	27	25	--	--	114	<2.5	1.3	--	0.05	<0.02	0.01	--	--
8/7/1996	31-0067	31-0060	11:54	0.5	26	15	158	--	116	<2.5	1.5	--	0.03	<0.02	0.01	--	--
8/7/1996	31-0061		12:10	4.0	28	27	--	--	114	<2.5	1.9	--	0.08	<0.02	0.02	--	--
Unnamed Tributary to the West Branch Farmington River Unique_ID: W0350 Station: SA02 Description: Pearl Road bridge, Otis (upstream Otis Ridge Ski Area).																	
5/29/1996	31-0022		10:45	--	--	--	--	2.0	**	<2.5	0.35	--	--	--	--	--	<20
6/18/1996	31-0037		10:10	--	33	--	85	3.0	52	<2.5	0.62	--	--	--	--	--	10
Unnamed Tributary to the West Branch Farmington River Unique_ID: W0351 Station: SA01 Description: West Center Road bridge, Otis (downstream Otis Ridge Ski area).																	
5/29/1996	31-0021		10:30	--	--	--	--	26	**	<2.5	0.25	--	--	--	--	--	<20
6/18/1996	31-0036		10:00	--	46	--	241	46	136	<2.5	0.60	--	--	--	--	--	10

[1] OWMID = sample tracking number, [2] Unique ID = unique station identification number, ** = missing/censored data, -- = no data

Table D4 (Continued). 1996/1997 Farmington River Watershed water quality and bacteria data. (Units are mg/L unless otherwise expressed.)

Date	OWMID[1]	QAQC	Time (24hr)	Depth (m)	Alkalinity (mg/l)	Hardness (mg/l)	Spec. Cond (µmhos)	Chloride (mg/l)	TSolids (mg/l)	SSolids (mg/l)	Turb (NTU)	TKN (mg/l)	NH3-N (mg/l)	NO3-NO2-N (mg/l)	TPhos (mg/l)	T-Coli (cfu/100ml)	Fecal (cfu/100ml)
Unnamed Tributary/ditch to West Branch Farmington River Unique_ID[2]: W0194 Station: OC01 Description: Upstream from Route 23 culvert between First National Bank and fire station parking lots, Otis.																	
5/29/1996	31-0024		11:10	--	--	--	--	19	**	3.5	1.0	--	--	--	--	--	<20
8/22/1996	31-0072		12:12	--	--	--	--	--	--	--	--	--	--	--	--	--	**
10/24/1996	31-0088		09:35	--	29	--	117	14	82	<2.5	**	--	--	--	--	--	**
12/17/1996	31-0094		08:55	--	26	--	201	40	118	11	13	--	--	--	--	--	140
4/16/1997	31-0115		12:55	--	18	--	115	19	58	<2.5	0.50	--	--	--	--	2000	600
6/2/1997	31-0122		12:15	--	18	--	--	13	--	**	2.4	--	--	--	--	--	--
Unnamed Tributary to Hayden Pond Unique_ID: W0352 Station: FS01 Description: Route 8, Otis (across from Otis Chicken Farm).																	
5/29/1996	31-0020		10:00	--	--	--	--	1.0	**	<2.5	0.45	--	--	--	--	--	60
6/18/1996	31-0035		09:35	--	23	--	68	1.0	111	5.0	1.4	--	--	--	--	--	80
7/11/1996	31-0044		10:00	--	33	--	96	4.0	122	<2.5	0.71	--	--	--	--	--	140
8/22/1996	31-0073		12:25	--	--	--	--	--	--	--	--	--	--	--	--	--	**
10/24/1996	31-0086		09:10	--	14	--	50	1.0	62	<2.5	**	--	--	--	--	--	**
12/17/1996	31-0092		08:30	--	16	--	76	4.0	62	8.0	6.2	--	--	--	--	--	4,000
4/16/1997	31-0111		11:58	--	8	--	46	2.0	34	<2.5	0.60	--	--	--	--	4000	420
6/2/1997	31-0121		12:30	--	10	--	--	1.0	--	**	1.2	--	--	--	--	--	--
Pipe/Discharge to Unnamed Tributary to West Branch Farmington River Unique_ID: W0367 Station: SA01B Description: Stormdrain downstream side Route 8 at church parking lot, Otis. (downstream Otis Ridge Ski Area).																	
10/24/1996	31-0087		09:25	--	25	--	132	20	86	<2.5	**	--	--	--	--	--	**
12/17/1996	31-0093		08:45	--	20	--	122	17	58	<2.5	0.70	--	--	--	--	--	<20
4/16/1997	31-0114		12:45	--	20	--	135	26	80	<2.5	0.20	--	--	--	--	40	<10
Unnamed Tributary to Buck River Unique_ID: W0191 Station: BT01 Description: Mile marker 12.7 on Route 57, Sandisfield.																	
6/18/1996	31-0039		11:25	--	20	--	66	1.0	74	<2.5	0.63	--	--	--	--	--	50
10/24/1996	31-0090		10:30	--	17	--	60	3.0	48	<2.5	**	--	--	--	--	--	**
Unnamed Tributary to Buck River Unique_ID: W0192 Station: BT02 Description: Route 57 bridge between Town Hill and Hammertown roads, Sandisfield.																	
6/18/1996	31-0040		11:45	--	20	--	77	5.0	44	<2.5	0.36	--	--	--	--	--	10
Unnamed Tributary Unique_ID: W0193 Station: SH03 Description: Eastern most unnamed tributary into northern lobe of Shaw Pond upstream from confluence with Shaw Pond, Becket.																	
5/14/1996	31-0011		12:48	--	27	18	--	54	130	<2.5	--	--	<0.02	<0.02	<0.01	--	**
8/7/1996	31-0062		12:51	--	65	50	--	--	270	<2.5	3.7	--	0.03	<0.02	0.02	--	--

[1] OWMID = sample tracking number, [2] Unique ID = unique station identification number, ** = missing/censored data, -- = no data

Table D4 (Continued). 1996/1997 Farmington River Watershed water quality and bacteria data. (Units are mg/L unless otherwise expressed.)

Date	OWMID[1]	QAQC	Time (24hr)	Depth (m)	Alkalinity (mg/l)	Hardness (mg/l)	Spec. Cond (µmhos)	Chloride (mg/l)	TSolids (mg/l)	SSolids (mg/l)	Turb (NTU)	TKN (mg/l)	NH3-N (mg/l)	NO3-NO2-N (mg/l)	TPhos (mg/l)	T-Coli (cfu/100ml)	Fecal (cfu/100ml)
WEST BRANCH FARMINGTON RIVER Unique_ID[2]: W0196 Station: FR01 Description: Ed Jones Road, approximately 150 feet below Hayden Pond outlet/dam, Otis.																	
4/25/1996	31-0005		14:30	--	10	11	--	24	94	<2.5	0.87	0.12	<0.02	0.04	0.02	--	<10
5/29/1996	31-0017	31-0018	12:35	--	16	16	--	25	**	<2.5	0.80	--	0.04	<0.02	0.02	--	<20
5/29/1996	31-0018	31-0017	12:35	--	16	18	--	25	**	<2.5	0.75	--	0.04	<0.02	0.02	--	<20
6/18/1996	31-0032	31-0033	12:10	--	19	--	133	24	76	<2.5	1.0	--	<0.02	<0.02	0.02	--	8
6/18/1996	31-0033	31-0032	12:10	--	19	--	132	25	76	<2.5	1.0	--	<0.02	<0.02	0.02	--	<2
7/23/1996	31-0052	31-0053	11:56	--	16	**	98	15	76	<2.5	0.75	--	0.02	0.03	0.01	--	--
7/23/1996	31-0053	31-0052	11:56	--	16	**	98	16	74	<2.5	0.75	--	0.02	0.03	0.02	--	--
8/22/1996	31-0070		12:35	--	23	26	--	22	51	<2.5	0.70	--	0.02	<0.02	0.02	--	**
9/24/1996	31-0078		12:07	--	15	**	--	14	76	2.5	0.89	0.35	<0.02	<0.02	0.02	--	50
10/24/1996	31-0083	31-0084	13:06	--	12	**	78	12	62	<2.5	**	--	<0.02	<0.02	0.01	--	**
10/24/1996	31-0084	31-0083	13:06	--	13	**	78	12	60	<2.5	**	--	<0.02	<0.02	0.01	--	**
12/17/1996	31-0099		11:57	--	11	**	88	14	49	3.0	0.60	--	<0.02	0.07	0.01	--	<20
2/25/1997	31-0101		10:09	--	12	23	96	19	68	--	0.70	--	0.02	0.13	<0.01	--	--
4/16/1997	31-0112		12:13	--	10	18	108	22	56	<2.5	0.60	--	<0.02	0.05	0.01	80	<10
6/2/1997	31-0116		11:54	--	16	--	--	26	--	**	0.80	--	<0.02	0.04	0.03	--	--
WEST BRANCH FARMINGTON Unique_ID: W0197 Station: FR04 Description: Route 8 across from intersection of Beech Plain Road, Otis (south of Otis center).																	
12/17/1996	31-0098		11:03	--	13	--	102	16	64	2.5	0.95	--	--	--	--	--	20
WEST BRANCH FARMINGTON RIVER Unique_ID: W0198 Station: FR02 Description: Reservoir Road bridge, Otis.																	
4/25/1996	31-0004		12:25	--	10	10	--	18	74	<2.5	0.82	0.11	<0.02	0.02	0.01	--	20
5/29/1996	31-0016		11:49	--	16	14	--	19	**	<2.5	0.60	--	0.02	<0.02	0.02	--	<20
6/18/1996	31-0031		11:14	--	21	--	133	23	74	<2.5	1.2	--	<0.02	0.09	0.02	--	10
7/23/1996	31-0051		11:23	--	18	**	104	17	86	<2.5	1.1	--	0.02	0.05	0.01	--	--
8/22/1996	31-0069		11:41	--	24	25	--	20	64	<2.5	0.81	--	<0.02	<0.02	0.01	--	**
9/24/1996	31-0076		11:22	--	14	**	--	12	72	3.0	0.76	0.34	<0.02	0.02	0.02	--	90
10/24/1996	31-0082		11:50	--	11	**	71	10	48	<2.5	**	--	<0.02	<0.02	0.02	--	**
12/17/1996	31-0097		11:03	--	11	**	87	13	52	3.0	0.90	--	<0.02	0.08	0.01	--	<20
2/25/1997	31-0102		10:50	--	12	26	103	20	72	--	0.70	--	<0.02	0.14	<0.01	--	--
4/16/1997	31-0110		11:22	--	10	18	99	20	58	<2.5	0.40	--	<0.02	0.07	0.01	40	<10
6/2/1997	31-0117		11:26	--	15	--	--	19	--	**	0.70	--	<0.02	0.07	0.02	--	--
WEST BRANCH FARMINGTON RIVER Unique_ID: W0199 Station: NB01 Description: Route 8/57 bridge, Sandisfield.																	
7/11/1996	31-0045		11:10	--	20	--	118	21	92	<2.5	1.2	--	--	--	--	--	<20
6/2/1997	31-0123		11:45	--	12	--	--	15	--	**	0.40	--	--	--	--	--	--
Pipe/Discharge to WEST BRANCH FARMINGTON RIVER Unique_ID: W0200 Station: NB02 Description: Storm drain in stone retaining wall below Route 8/57 bridge, Sandisfield.																	
6/2/1997	31-0124		11:50	--	40	--	--	12	--	**	34	--	--	--	--	--	--

[1] OWMID = sample tracking number, [2] Unique ID = unique station identification number, ** = missing/censored data, -- = no data

Table D4 (Continued). 1996/1997 Farmington River Watershed water quality and bacteria data. (Units are mg/L unless otherwise expressed.)

Date	OWMID[1]	QAQC	Time (24hr)	Depth (m)	Alkalinity (mg/l)	Hardness (mg/l)	Spec. Cond (µmhos)	Chloride (mg/l)	TSolids (mg/l)	SSolids (mg/l)	Turb (NTU)	TKN (mg/l)	NH3-N (mg/l)	NO3-NO2-N (mg/l)	TPhos (mg/l)	T-Coli (cfu/100ml)	Fecal (cfu/100ml)
WEST BRANCH FARMINGTON RIVER Unique_ID[2]: W0201 Station: FR03 Description: Clark Road bridge, Sandisfield.																	
4/25/1996	31-0001	31-0002	11:25	--	7	7.1	--	11	96	<2.5	0.70	**	<0.02	0.02	0.01	--	20
4/25/1996	31-0002	31-0001	11:25	--	7	7.1	--	11	64	<2.5	0.77	0.10	<0.02	0.02	0.01	--	--
5/29/1996	31-0014		11:12	--	14	13	--	15	**	<2.5	0.40	--	0.06	<0.02	0.02	--	<20
6/18/1996	31-0030		10:39	--	21	18	118	17	56	<2.5	0.84	--	<0.02	0.13	0.02	--	20
7/23/1996	31-0050		10:52	--	14	**	82	11	60	<2.5	0.85	--	0.07	0.06	0.01	--	--
8/22/1996	31-0068	31-0128	09:44	--	24	25	--	17	40	<2.5	0.52	--	0.02	<0.02	0.01	--	**
8/22/1996	31-0128	31-0068	09:44	--	24	24	--	16	50	<2.5	0.55	--	0.03	0.04	<0.01	--	**
9/24/1996	31-0074	31-0075	10:43	--	8	**	--	6.0	48	<2.5	0.86	0.24	<0.02	0.02	0.02	--	30
9/24/1996	31-0075	31-0074	10:43	--	8	**	--	6.0	47	4.0	0.76	0.19	<0.02	0.02	0.02	--	--
10/24/1996	31-0081		11:17	--	7	**	50	6.0	44	<2.5	**	--	<0.02	<0.02	0.02	--	**
12/17/1996	31-0095	31-0096	10:22	--	6	**	52	5.0	40	<2.5	0.70	--	<0.02	0.06	0.01	--	<20
12/17/1996	31-0096	31-0095	10:22	--	6	**	54	5.0	34	<2.5	0.65	--	<0.02	0.05	0.01	--	<20
2/25/1997	31-0103	31-0104	11:41	--	4	<0.13	42	5.0	40	--	0.50	--	<0.02	0.09	<0.01	--	--
2/25/1997	31-0104	31-0103	11:41	--	4	<0.13	41	5.0	42	--	0.40	--	<0.02	0.09	0.01	--	--
4/16/1997	31-0107	31-0106	10:28	--	6	13	69	12	40	<2.5	0.40	--	<0.02	0.05	0.01	120	<10
4/16/1997	31-0106	31-0107	10:31	--	6	13	68	11	36	3.0	0.40	--	<0.02	0.05	0.01	120	10
6/2/1997	31-0118	31-0119	10:50	--	14	--	--	14	--	**	0.40	--	<0.02	0.07	0.02	--	--
6/2/1997	31-0119	31-0118	10:50	--	13	--	--	14	--	**	0.40	--	<0.02	0.07	0.02	--	--
SANDY BROOK Unique_ID: W0202 Station: SN02 Description: South Sandisfield Road (Sandy Road Turnpike) bridge, Sandisfield.																	
7/11/1996	31-0047		11:50	--	23	--	66	4.0	60	<2.5	2.4	--	--	--	--	--	<20
SANDY BROOK Unique_ID: W0203 Station: SN01 Description: Norfolk Road bridge, Sandisfield.																	
6/18/1996	31-0043		12:20	--	23	--	62	1.0	42	<2.5	1.1	--	--	--	--	--	10
7/11/1996	31-0048		12:05	--	24	--	59	<1.0	52	<2.5	0.99	--	--	--	--	--	20
SANDY BROOK Unique_ID: W0204 Station: SN03 Description: Rood Hill Road bridge, Sandisfield.																	
7/11/1996	31-0049		12:10	--	16	--	171	2.7	112	<2.5	0.36	--	--	--	--	--	20
CLAM RIVER Unique_ID: W0205 Station: CR02 Description: Beech Plain Road bridge, Sandisfield (upstream confluence with Silver Brook).																	
5/29/1996	31-0027		13:00	--	--	--	--	4.0	**	<2.5	0.40	--	--	--	--	--	<20
6/18/1996	31-0038		11:05	--	19	--	75	5.0	90	<2.5	0.76	--	--	--	--	--	20
7/11/1996	31-0046		11:25	--	21	--	86	9.0	76	<2.5	0.84	--	--	--	--	--	<20
4/16/1997	31-0108		10:57	--	10	--	58	7.0	36	<2.5	0.40	--	--	--	--	140	<10
CLAM RIVER Unique_ID: W0206 Station: CR01 Description: Route 57 bridge, Sandisfield.																	
5/29/1996	31-0026		12:40	--	--	--	--	4.0	**	<2.5	0.45	--	--	--	--	--	<20

[1] OWMID = sample tracking number, [2] Unique ID = unique station identification number, ** = missing/censored data, -- = no data

Table D4 (Continued). 1996/1997 Farmington River Watershed water quality and bacteria data. (Units are mg/L unless otherwise expressed.)

Date	OWMID[1]	QAQC	Time (24hr)	Depth (m)	Alkalinity (mg/l)	Hardness (mg/l)	Spec. Cond (µmhos)	Chloride (mg/l)	TSolids (mg/l)	SSolids (mg/l)	Turb (NTU)	TKN (mg/l)	NH3-N (mg/l)	NO3-NO2-N (mg/l)	TPhos (mg/l)	T-Coli (cfu/100ml)	Fecal (cfu/100ml)
SILVER BROOK Unique_ID[2]: W0207 Station: SB01 Description: Route 57 bridge, Sandisfield.																	
5/29/1996	31-0028	31-0029	12:55	--	--	--	--	5.0	**	<2.5	0.40	--	--	--	--	--	<20
5/29/1996	31-0029	31-0028	12:55	--	--	--	--	5.0	**	<2.5	0.40	--	--	--	--	--	<20
10/24/1996	31-0089		10:05	--	16	--	55	2.0	48	<2.5	**	--	--	--	--	--	**
4/16/1997	31-0109		10:58	--	10	--	50	4.0	32	<2.5	0.60	--	--	--	--	160	10
BUCK RIVER Unique_ID: W0208 Station: BR01 Description: West Street bridge, Sandisfield.																	
6/18/1996	31-0041	31-0042	11:50	--	15	--	55	2.0	30	<2.5	0.98	--	--	--	--	--	90
6/18/1996	31-0042	31-0041	11:50	--	15	--	55	1.0	34	<2.5	0.96	--	--	--	--	--	100
BUCK RIVER Unique_ID: W0209 Station: BR02 Description: Route 57, Sandisfield (downstream from confluence of unnamed tributary to Buck River near Route 57 mile marker 12.7).																	
10/24/1996	31-0091		10:40	--	19	--	60	2.0	46	<2.5	**	--	--	--	--	--	**
FALL RIVER Unique_ID: W0210 Station: FL01 Description: Reservoir Road bridge, Otis.																	
5/29/1996	31-0025		12:25	--	--	--	--	10	**	<2.5	0.40	--	--	--	--	--	<20
DIMMOCK BROOK (Unique_ID: W0211 Station: DB01 Description: Route 23 bridge, Otis.																	
5/29/1996	31-0023		11:00	--	--	--	--	7.0	**	<2.5	0.90	--	--	--	--	--	<20
THOMAS BROOK Unique_ID: W0212 Station: TB01 Description: Werden Cross Road bridge, Becket.																	
5/29/1996	31-0019		09:30	--	--	--	--	16	**	<2.5	0.95	--	--	--	--	--	<20
SHALES BROOK Unique_ID: W0213 Station: SH04 Description: Upstream from confluence with Shaw Pond, Becket.																	
5/14/1996	31-0012	31-0013	13:41	--	6	4.9	--	1.0	10	<2.5	--	--	<0.02	<0.02	0.03	--	**
5/14/1996	31-0013	31-0012	13:41	--	--	--	--	--	--	--	--	--	--	--	--	--	**
8/7/1996	31-0063		13:20	--	14	14	--	--	52	<2.5	0.58	--	0.02	0.05	<0.01	--	--

[1] OWMID = sample tracking number, [2] Unique ID = unique station identification number, ** = missing/censored data, -- = no data

Table D5. 1996/1997 Farmington River Watershed *in-situ* YSI meter data.

Date	OWMID[1]	Time (24hr)	Meter	Temp (°C)	Conductivity (un-compensated) (µmhos/cm)
Unnamed Tributary Unique_ID[2]: W0350 Station: SA02 Description: Pearl Road bridge, Otis (upstream Otis Ridge Ski Area).					
5/29/1996	31-0022	10:45	YSI-33/51B/54A	12.0is	50is
6/18/1996	31-0037	10:10	YSI-33/51B/54A	18.5is	70is
Unnamed Tributary Unique_ID: W0351 Station: SA01 Description: West Center Road bridge, Otis (dow nstream Otis Ridge Ski area).					
5/29/1996	31-0021	10:30	YSI-33/51B/54A	11.5is	120is
6/18/1996	31-0036	10:00	YSI-33/51B/54A	19.0is	200is
Unnamed Tributary Unique_ID: W0194 Station: OC01 Description: Upstream from Route 23 culvert between First National Bank and fire station parking lots, Otis.					
5/29/1996	31-0024	11:10	YSI-33/51B/54A	14.0is	85is
6/18/1996	31-0133	10:20	YSI-33/51B/54A	18.0is	400is
7/11/1996	31-0136	10:45	YSI-33/51B/54A	17.0is	250is
Unnamed Tributary Unique_ID: W0352 Station: FS01 Description: Route 8, Otis (across from Otis Chicken Farm).					
5/29/1996	31-0020	10:00	YSI-33/51B/54A	12.0is	25is
6/18/1996	31-0035	09:35	YSI-33/51B/54A	17.0is	50is
7/11/1996	31-0044	10:00	YSI-33/51B/54A	17.0is	78is
Pipe/Discharge to Unnamed Tributary Unique_ID: W0367 Station: SA01B Description: Storm drain to Unnamed tributary to West Branch Farmington River downstream from Otis Ridge Ski area. Accessed from downstream side of Route 8 at church parking lot, Otis.					
5/29/1996	31-0130	10:20	YSI-33/51B/54A	13.5is	170is
6/18/1996	31-0131	09:50	YSI-33/51B/54A	19.0is	310is
7/11/1996	31-0135	10:22	YSI-33/51B/54A	17.5is	310is
Unnamed Tributary to Buck River Unique_ID: W0191 Station: BT01 Description: Mile marker 12.7 on Route 57, Sandisfield.					
6/18/1996	31-0039	11:25	YSI-33/51B/54A	16.0is	42is
Unnamed Tributary to Buck River Unique_ID: W0192 Station: BT02 Description: Route 57 bridge between Town Hill and Hammertown roads, Sandisfield.					
6/18/1996	31-0040	11:45	YSI-33/51B/54A	14.7is	55is
Unnamed Tributary/ditch to West Branch Farmington River Unique_ID: W0195 Station: OC02 Description: Storm drain at junction of Route 23 and Route 8 at elementary school entrance road, Otis. (Drain in a swale area with grate cover.)					
5/29/1996	31-0129	11:30	YSI-33/51B/54A	12.0is	440is
6/18/1996	31-0132	10:35	YSI-33/51B/54A	15.0is	500is
7/11/1996	31-0137	10:30	YSI-33/51B/54A	16.0is	620is
WEST BRANCH FARMINGTON RIVER (Saris: 3106850) Unique_ID: W0199 Station: NB01 Description: Route 8/57 bridge, Sandisfield.					
7/11/1996	31-0045	11:10	YSI-33/51B/54A	19.5is	100is
SANDY BROOK Unique_ID: W0202 Station: SN02 Description: South Sandisfield Road (Sandy Road Turnpike) bridge, Sandisfield.					
7/11/1996	31-0047	11:50	YSI-33/51B/54A	22.0is	65is
SANDY BROOK Unique_ID: W0203 Station: SN01 Description: Norfolk Road bridge, Sandisfield.					
6/18/1996	31-0043	12:20	YSI-33/51B/54A	22.0is	50is
7/11/1996	31-0048	12:05	YSI-33/51B/54A	20.0is	50is
SANDY BROOK Unique_ID: W0204 Station: SN03 Description: Rood Hill Road bridge, Sandisfield.					
7/11/1996	31-0049	12:10	YSI-33/51B/54A	22.0is	52is

[1] OWMID = sample tracking number, [2] Unique ID = unique station identification number, i = inaccurate readings from field probe likely, s = field sheet recorded data were used to accept data.

Table D5 (Continued). 1996/1997 Farmington River Watershed *in-situ* YSI meter data.

Date	OWMID[1]	Time (24hr)	Meter	Temp (°C)	Cond (un-compensated) (µmhos/cm)
CLAM RIVER Unique_ID: W0205 Station: CR02 Description: Beech Plain Road bridge, Sandisfield (upstream confluence with Silver Brook).					
5/29/1996	31-0027	13:00	YSI-33/51B/54A	14.0is	40is
6/18/1996	31-0038	11:05	YSI-33/51B/54A	20.0is	60is
7/11/1996	31-0046	11:25	YSI-33/51B/54A	19.5is	70is
CLAM RIVER Unique_ID[2]: W0206 Station: CR01 Description: Route 57 bridge, Sandisfield.					
5/29/1996	31-0026	12:40	YSI-33/51B/54A	13.8is	42is
SILVER BROOK Unique_ID: W0207 Station: SB01 Description: Route 57 bridge, Sandisfield.					
5/29/1996	31-0028	12:55	YSI-33/51B/54A	13.5is	50is
6/18/1996	31-0134	11:10	YSI-33/51B/54A	18.0is	70is
BUCK RIVER Unique_ID: W0208 Station: BR01 Description: West Street bridge, Sandisfield.					
6/18/1996	31-0041	11:50	YSI-33/51B/54A	21.5is	50is
FALL RIVER Unique_ID: W0210 Station: FL01 Description: Reservoir Road bridge, Otis.					
5/29/1996	31-0025	12:25	YSI-33/51B/54A	15.8is	50is
DIMMOCK BROOK Unique_ID: W0211 Station: DB01 Description: Route 23 bridge, Otis.					
5/29/1996	31-0023	11:00	YSI-33/51B/54A	16.0is	48is
THOMAS BROOK Unique_ID: W0212 Station: TB01 Description: Werden Cross Road bridge, Becket.					
5/29/1996	31-0019	09:30	YSI-33/51B/54A	15.0is	70is

[1] OWMID = sample tracking number, [2] Unique ID = unique station identification number, i = inaccurate readings from field probe likely, s = field sheet recorded data were used to accept data.

Table D6. 1996/1997 DWM Farmington River Watershed stream discharge measurements (cfs) and mean daily discharge reported by USGS for the Farmington River USGS (Gage 01185500) near Roosterville.

DATE	STATION FR01*	STATION FR02*	STATION FRO3 USGS GAGE 01185500**
25 April 1996	no measurement	133***	395
29 May 1996	14.7	35.5	98
18 June 1996	8.94	20.1	44
23 July 1996	25.2	45.9	96
22 August 1996	3.59	7.45	23
24 September 1996	100	191***	420
24 October 1996	78.2	340***	585
17 December 1996	63.0	197***	513
25 February 1997	42.3	137***	170
16 April 1997	53.2	112***	262
2 June 1997	13.8	43.6	78

* Field measurements made using a Swoffer meter (Model 2100) unless otherwise noted.

** Reported mean daily discharge of the West Branch Farmington River near New Boston, MA by USGS (Socolow *et al.* 1997)

*** Denotes stream discharge measurements using a Price Type AA meter with polymer buckets suspended by a bridge board.

Table D7. Sediment quality data (expressed as mg/kg dry weight unless otherwise noted) for sediment collected in Benton and Shaw ponds in August 1996 and from the West Branch Farmington River near Colebrook Reservoir in October 1997. Threshold levels (*) extracted from Persaud *et al.* 1993 are also reported where the L-EL represents the concentration of a contaminant where no adverse impacts would be expected as well as the S-EL where the concentrations would cause severe detrimental impacts to the biota. Sediment enrichment ratios (based on normalization to iron and crustal values) were also calculated.

		TS(%)	TP	TKN	Al	As	Cd	Cr	Cu	Fe	Pb	Hg	Ni	Se	Zn	PCB	DDE	DDD
L-EL*		NA	600	550	NA	6	0.6	26	16	2%	31	0.2	16	NA	120	0.07	0.005	0.008
S-EL*			2000	4800		33	10	110	110	4%	250	2	75		820			
Benton Pond	31-0064	7	1400	16000		6.3	<1.43	<1.43	30	1.9E+4	160	<0.03	<1.43	1.2	200	ND	0.029	0.041
Benton Pond	31-0065	7	1600	14000		6.9	<1.43	<1.43	33	1.7E+4	160	<0.03	6.6	1.0	200	ND	0.014	0.031
Shaw Pond	31-0066	12	1700	8300		110	<0.83	<0.83	34	3.3E+4	130	<0.02	<0.83	0.63	283	ND	0.005	0.0087
FR06A	31-0125	30	1500	6000	20000	<1.33	6.7	22	28	2.5E+4	43	0.15	17	<1.33	187	ND	ND	ND
FR06B	31-0126	41	1000	3100	7500	<0.97	2.4	9.2	11	1.1E+4	15	0.07	6.8	<0.97	68	ND	ND	ND
FR06C	31-0127	35	1000	4300	9700	<1.14	3.1	11	13	1.4E+4	20	0.06	8.6	<1.14	89	ND	ND	ND
ENRICHMENT RATIO (based on normalization to iron)																		
Crustal (mg/kg)					82300	1.8	0.2	100	55	56300	12.5	0.08	75		70			
Benton Pond	31-0064					11			2		39				9			
Benton Pond	31-0065					13			2		42		0.3		9			
Shaw Pond	31-0066					103			1		18				7			
FR06A	31-0125				0.5		74	0.5	1		8	4	0.5		6			
FR06B	31-0126				0.5		63	0.5	1		6	5	0.5		5			
FR06C	31-0127				0.5		65	0.5	1		6	3	0.5		5			

NA - Not Applicable

Table D8. Gas Chromatography-Mass Spectrometry Analysis of Semivolatile Organic Compounds in sediment from the West Branch Farmington River near Colebrook Reservoir in October 1997 (results reported in ug/Kg dry weight).

COMPOUND	FR06A	FR06B	FR06C	COMPOUND	FR06A	FR06B	FR06C
9-Hexadecanoic acid			*	.gamma.-sitosterol	*		*
Hexadecanoic acid	*	*	*	% Dry solids @ 105°C, 41			*
2-methyl-tridecane			*	2,6,10,14-tetramethylnonadecane		*	
13-Octadecenal			*	Cyclotetracosane		*	
Nonahexacontanoic acid		*	*	% Dry solids @ 105°C, 39			
Tetracosane			*	Eicosane	*		
Hexadecanal			*	Docosane	*		
Heneicosane	*	*	*	% Dry solids @ 105°C, 34			

*No target compounds. No standard available for quantification or verification. The mass spectrum was compared to a mass spectral index and a mass spectral data base for tentative identification.

Note: Sediment data have not undergone formal DWM data validation and are provided for discussion purposes only.

Table D9. Results of phytoplankton enumeration (Natural Units per ml.) in Shaw and Benton Ponds, 7 August 1996.

SHAW POND			BENTON POND	
	Station SH01	Station SH02		Station BP01
Cyanophyceae (blue-greens)			Cyanophyceae (blue-greens)	
Anacystis sp.	22.2	44.4	0	0
Chroococcus sp.	199.8	111		
Coelosphaerium sp.	11.1	22.2	Chlorophyceae (Greens)	
Nostoc sp.	---	11.1	*Oocystis* sp.	11.1
			Quadrigula sp.	11.1
Chlorophyceae (greens)				
Gloeocystis sp.	33.3	---	Dinophyceae	
Haematococcus sp.	11.1	11.1	0	0
Scenedesmus sp	11.1	11.1		
Sphaerocystis sp.	44.4	77.7	Chrysophyceae	
Quadrigula sp.	11.1	---	Unidentified colonial	11.1
Unidentified coccoid	---	133.2		
Unidentified filament	11.1	---	Euglenophyceae	
Unidentified flagellate	---	11.1	0	0
Dinophyceae				
Peridinium sp.	---	11.1		
Bacillariophyceae				
Melosira sp.	3.33	---		
Chrysophyceae				
Chrysococcus sp.	---	11.1		
Dinobryon sp.	11.1	---		
Uroglenopsis sp.	11.1	22.2		
Unidentified flagellate	---	22.2		
Euglenophyceae				
Euglena sp.	---	11.1		
TOTAL	**410.7**	**410.7**		**33.3**

Table D10. Macrophyte species observed in Shaw Pond and Benton Pond on 7 August 1996.

SHAW POND	BENTON POND
1. *Utricularia* sp.	1. *Potamogeton Robbinsii*
2. *Nymphaea* sp.	2. *Vallisneria americana*
3. *Nuphar* sp.	3. *Elodea* sp.
4. *Lythrum Salicaria*	4. *Nitella* sp.
5. *Decodon verticillatus*	5. *Nymphaea* sp.
6. *Peltandra virginica*	6. *Decadon verticillatus*
7. *Pontederia cordata*	7. *Najas* sp.
8. *Eleocharis* sp.	8. *Potamogeton* (thin-leaf) sp.
9. *Potamogeton* sp.	9. *Myriophyllum spicatum*
10. *Potamogeton* sp.	10. *Pontederia cordata*
11. *Typha latifolia*	11. *Eriocaulon* sp.
12. *Typha angustifolia*	12. *Sparganium* sp.
13. *Scripus* sp.	13. *Potamogeton amplifolius*
	14. *Utricularia* sp.
	15. *Sagittaria* sp.
	16. *Eleocharis* sp.
	17. *Elatine* sp.
	18. *Lobelia Dortmanna*
	19. *Typha* sp.
	20. *Nuphar* sp.
	21. *Nymphoides cordata*
	22. *Phragmites* sp.
	23. *Scripus sp.*
	24. *Utricularia purpurea*
	25. *Isoetes* sp.

Table D11. 1996 Farmington River Watershed – summer lake observations and trophic status estimates.

Lake (local name), Location	Waterbody Identification Code (WBID)	Size (Acres)	Trophic Status Estimate	Survey Observations
Benton Pond, Otis	MA31003	61	M	Sparse to moderate development around entire shoreline, steep gradients and exposed bedrock along northern shoreline; few patches of dense to very dense plants in south and northwest coves; non-native aquatic (**Ms**) and wetland plants (**Pa**).
Cranberry Pond, Tolland	MA31008	75	U	Water slightly turbid, slight brown silt on rocks, and gravel bottom; sparse aquatic plants.
Dimmock Brook Pond, Otis	MA31010	15	E	Pond is much smaller (dam apparently breached); existing water has very dense emergent and floating plant cover.
Hayden Pond, Otis	MA31016	28	M	Moderate stain, slight turbidity, dark silt on rocks and gravel, powdery and oily scum against dam; water level low (~ 5' shore visible); ***Myriophyllum sp***. (**M. sp**.) possibly non-native species; patches of moderate to dense plants throughout lower pond; upper end very dense in cove areas, particularly on western side (~ 10% of the total area); poor dam condition, water leaking under and through it.
Long Bow Lake, Becket	MA31019	26	M	Slight stain, slight turbidity, slight brown silt over sandy bottom; some green algal masses; non-native wetland plants (**Pa** and **Ls**); very dense stands of emergents around entire perimeter, few patches of floating leaf plants, dense submergents at north end of the main basin; moderate density of the submerged and floating leaf-plants over most of the north basin.
Lower Spectacle Pond, Sandisfield	MA31020	70	U	Moderate tea stain, slight turbidity, silty brown bottom over gravel; sparse patches of very dense floating vegetation at the north end.
Noyes Pond, Tolland	MA31026	166	U	No stain, slight turbidity, slight white foam on windward shore, slight organic matter on rocks and gravel bottom; non-native aquatic plant (**Mh**); sparse plant cover.
Royal Pond, Monterey/Otis	MA31034	7	E	Entire pond covered with very dense floating and emergent plants, 90-100% covered, non-native wetland plant (**Ls**).
Shaw Pond, Becket	MA31036	80	M	Scattered patches of dense to very dense plants along north, southwest, and southern shores, non-native wetland plant (**Ls**).
Silver Shield Pond, Becket	MA31054	10	U	Slight stain, slight turbidity, slight brown silt over vegetation, mucky bottom with undecomposed debris; very dense stands of non-native wetland plant, (**Pa**) around entire pond.
Upper Spectacle Pond, Sandisfield/ Otis	MA31044	53	U	Heavy tea stain; slight silt on rocky bottom; dense to very dense patches of emergent and floating leaf vegetation along shore in southern quarter of pond, the majority of the pond is sparsely affected.

Table D11 continued. 1996 Farmington River Watershed – summer lake observations and trophic status estimates.

Ward Pond, Becket	MA31047	27	M	Slight stain, slight turbidity, weedy bottom, very dense floating, emergent and submergent plants around entire perimeter (1/4-1/3 of the pond affected); non-native wetland plant (**Ls**).
Watson Pond, Otis	MA31009	52	M	Slight stain, moderate turbidity, moderate brown silt on rocks, vegetation on bottom; moderate to dense growth of floating leaf plants in north end and along south and western shore; east shore and center is open water; dense floating leaf plants north and west of island; quarter of total acreage affected; non- native wetland plant (**Pa**).
West Lake, Sandisfield	MA31050	60	U	No stain, very slight turbidity, brown silt coating over rocks, gravel and sand; water level low (~5' shore showing), sparse plant cover.
White Lily Pond, Otis	MA31051	62	U	Slight stain, slight turbidity, slight brown silt coating over rocks; occasional patches of floating leaf plants.
York Lake, New Marlborough	MA31052	29	U	Slight tea stain, slight turbidity (Secchi disk 2.7+ m. - on bottom), brown silt over rocks, algae on many rocks; dense patch of floating plants in southwest corner of pond.

Trophic State: O= Oligotrophic, M= Mesotrophic, E= Eutrophic, H=Hypereutrophic, U= Undetermined
Non-native Wetland Plants: **Ls** = *Lythrum salicaria*, **Pa** = *Phragmites australis*
Non-native Aquatic Plants: **Mh** = *Myriophyllum heterophyllum*, **Ms** = *Myriophyllum spicatum,*
M. sp. = Possible *Myriophyllum heterophyllum*, requires further confirmation when flowering heads are evident.

DISCUSSION

River Water Quality

Water quality sampling of the rivers in the Farmington River Watershed in 1996/97 revealed generally high quality conditions. Although not representative of worse-case (i.e., pre-dawn) conditions, in-stream dissolved oxygen (DO) was not less than 7.4 mg/L or 86% saturation (Table D3). Water temperatures in the West Branch Farmington exceeded 20ºC in June and August 1996. Nutrient concentrations were low (maximum concentration of ammonia-nitrogen and total phosphorus 0.07 mg/L and 0.03 mg/L, respectively). Two unnamed tributaries had elevated fecal coliform bacteria counts, however, none of the samples collected from the West Branch Farmington River or its named tributaries exceeded 100 cfu/100 mL (Table D4).

River Sediments

No PCB or organochlorine pesticides were detected in any of the three replicate sediment samples collected from the West Branch Farmington River (Stations FR06 A, B, and C) (Table D8). The presence of several semivolatile organic compounds was detected in each replicate sample but no standard was available for quantification or verification at WES. The mass spectrum was compared to a mass spectral index and a mass spectral database for tentative identification. These data are reported in Table D8. Compounds that may have been present were reported to be high molecular weight petroleum hydrocarbons and high molecular weight organic acids (Flaherty 1998). One replicate sample (FR06A) exceeded the S-EL for TKN by a factor of 1.3, the other two replicates were between the L-EL and S-EL (Table D7). Cadmium and TP were between the L-EL and S-EL range in all three replicates. Several metals (Cu, Fe, Pb, Ni, and Zn) at FR06A were also between the L-EL and S-EL. However, in the other two replicates all were below the L-EL. Three metals (As, Cr, and Hg) were below the L-EL in all samples analyzed. Enrichment ratios were also calculated (based on normalization to iron concentration) for the replicate samples collected at FR06. Four metals (Cd, Pb, Zn, Hg, and Cu) had enrichment ratios above one (Cd 63-74; Pb 6-8; Zn 5-6; Hg 3-5).

Lake Baseline Surveys

In May 1996 at Shaw Pond epilymnetic nitrogen and total phosphorus levels were low at both inlake stations suggesting that nutrient availability for the season's growth of algae and aquatic macrophytes was not excessive. The lake was not thermally stratified and dissolved oxygen was high (9.2mg/l - 9.8mg/l) throughout the water column. Figure D2 depicts conditions in the deep hole of the southern lobe of Shaw Pond (SH01). Secchi disk readings suggested a slight to moderate impairment of transparency, ranging from 2.8 -2.9 meters at the inlake stations.

Dissolved oxygen and temperature profiles from the August survey are illustrated in Figure 3. Hypolimnetic oxygen was depleted (< 1.0mg/l) and, although hypolimnetic phosphorus concentrations were slightly higher than epilimnetic concentrations at both inlake stations, the difference is insignificant (0.014mg/l and 0.015mg/l vs. 0.011mg/l and 0.013mg/l). Phosphorus levels appear to be low throughout the water column of the lake (Tables D3 and D5). Phytoplankton counts (Table D9) were relatively low (410.7 cells/ml) and Secchi disk readings ranged from 2.3 - 2.4 meters, indicating a slight reduction in transparency from the spring conditions.

Two tributary stations enter the north lobe of Shaw Pond; Shales Brook (Station SH04) into the northwest corner and an unnamed tributary (Station SH03) into the northeast corner. The water quality of the two tributaries is very different, reflecting influence from their respective subwatershed drainage characteristics. The Shales Brook tributary demonstrated lower alkalinity concentrations, especially during the spring sampling date, suggesting reduced buffering capacity and vulnerability to acid deposition, although this was not reflected in the pH readings (6.73 - 7.18) (Tables D3 and D4). Ionic concentrations, including chloride, conductivity, and hardness, were also low in this tributary as were solids and nutrients. In comparison, the unnamed tributary had elevated conductivity, chloride and total solids concentrations suggesting that runoff from Interstate 90 or other landuses may be impacting this subwatershed. In addition, dissolved oxygen was very low at this station in August, which may reflect the influence of the large wetland system (or other unknown sources of organic enrichment) that this tributary drains. Fecal coliform bacteria counts (only sampled in May) were low at both tributary stations (Table D4). Assessment of possible impacts to the lake from septic systems in these tributary watersheds cannot be made with only one bacteria sample, although low nutrient concentrations in both streams support the assumption that this is not a serious problem.

Comparison of 1996 data to historical water quality data collected at Shaw Pond in 1974 (Whittaker 1982) suggests some degree of eutrophication has occurred over the last 22 years. This enrichment is demonstrated most obviously by the anoxic conditions in the hypolimnion. In June of 1974 hypolimnetic dissolved oxygen was 7.3mg/l and in August of 1996 it was 0.1mg/l. Some of this difference is likely due to seasonal effects, and also there are year-to-year and sample-to-sample variations that can occur in measured parameters. The magnitude of change in hypolimnetic dissolved oxygen concentration over time can only be measured by more frequent, periodical monitoring.

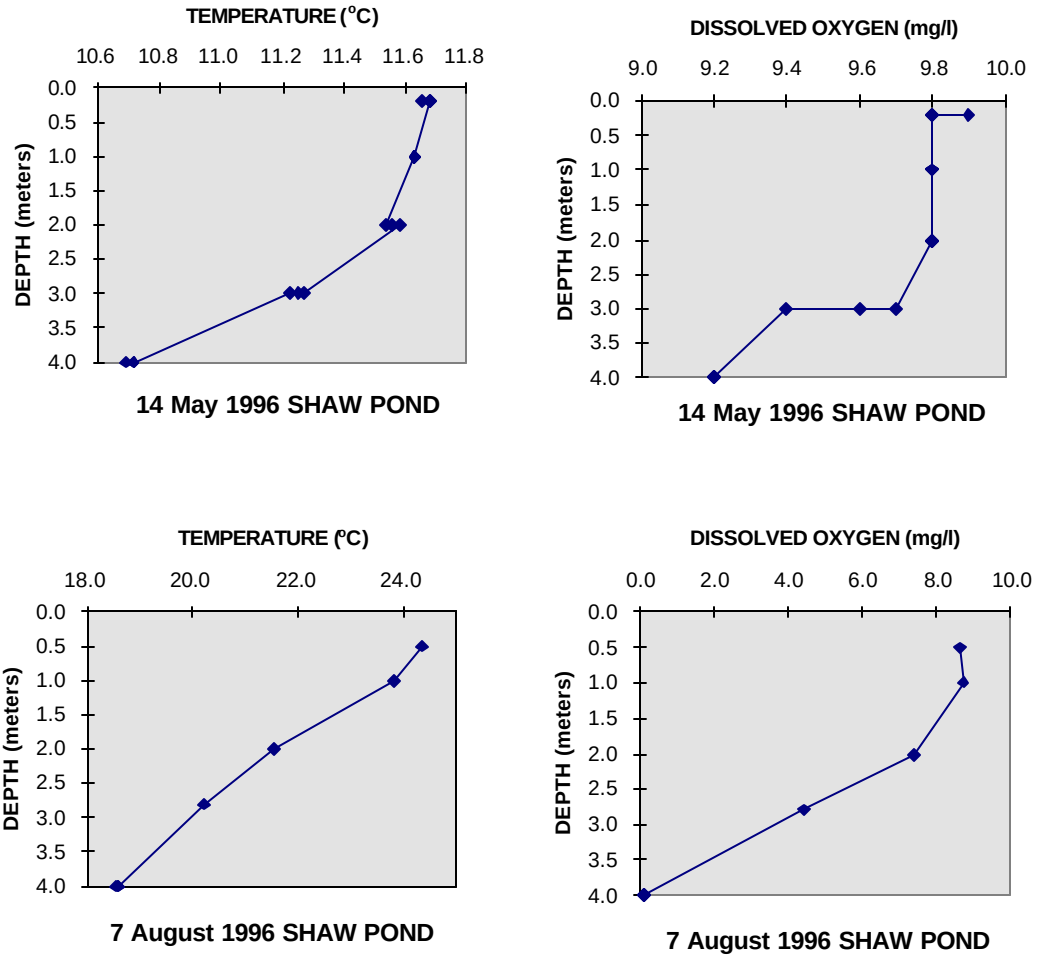


FIGURE D2. Temperature and dissolved oxygen profiles in the southern lobe deep-hole of Shaw Pond (Station SH01).

Aquatic macrophyte density in Shaw Pond appears to have only slightly increased, predominately by expanding out from areas noted on the 1974 weed map (Whittaker 1982). Current aquatic macrophyte species composition (Table D10) is also fairly similar to that observed in 1974, with the exception that *Utricularia sp.* (bladderwort) appears to have spread to the northern end and is much more dominant now. Other species that were not observed in 1974, but were observed in 1996 include: *Peltandra virginica* (arrow arum), *Eleocaris sp.* (spike rush), *Pontederia cordata* (pickerelweed), *Lythrum salicaria* (spiked loosestrife), and *Scirpus sp.* (bulrush). *Decodon verticullatus* (swamp loosestrife) appeared to be encroaching into the lake from the large wetland area at the north end of the pond. See Table D10 for a complete macrophyte species list.

Benton Pond data collected in May 1996 showed that this lake also had not yet stratified (Figure 3). Nutrient and ionic concentrations were all low and the Secchi disk depth was 4.8 meters. Although the alkalinity of Benton Pond was relatively low (ranging from 11 mg/l in the spring - 22 mg/l in August) pH values remained neutral throughout the water column (Tables D3 and D4).

In August 1996, Benton Pond was stratified and hypolimnetic dissolved oxygen was depleted (1.0 mg/l at 6 meters) (Figure D3). However, nutrient and ionic concentrations remained low even in the anoxic hypolimnion. The Secchi disk depth was even greater than the spring reading at 5.4 meters. Phytoplankton counts (Table D9) in 1996 were very low (33.3 cells/ml).

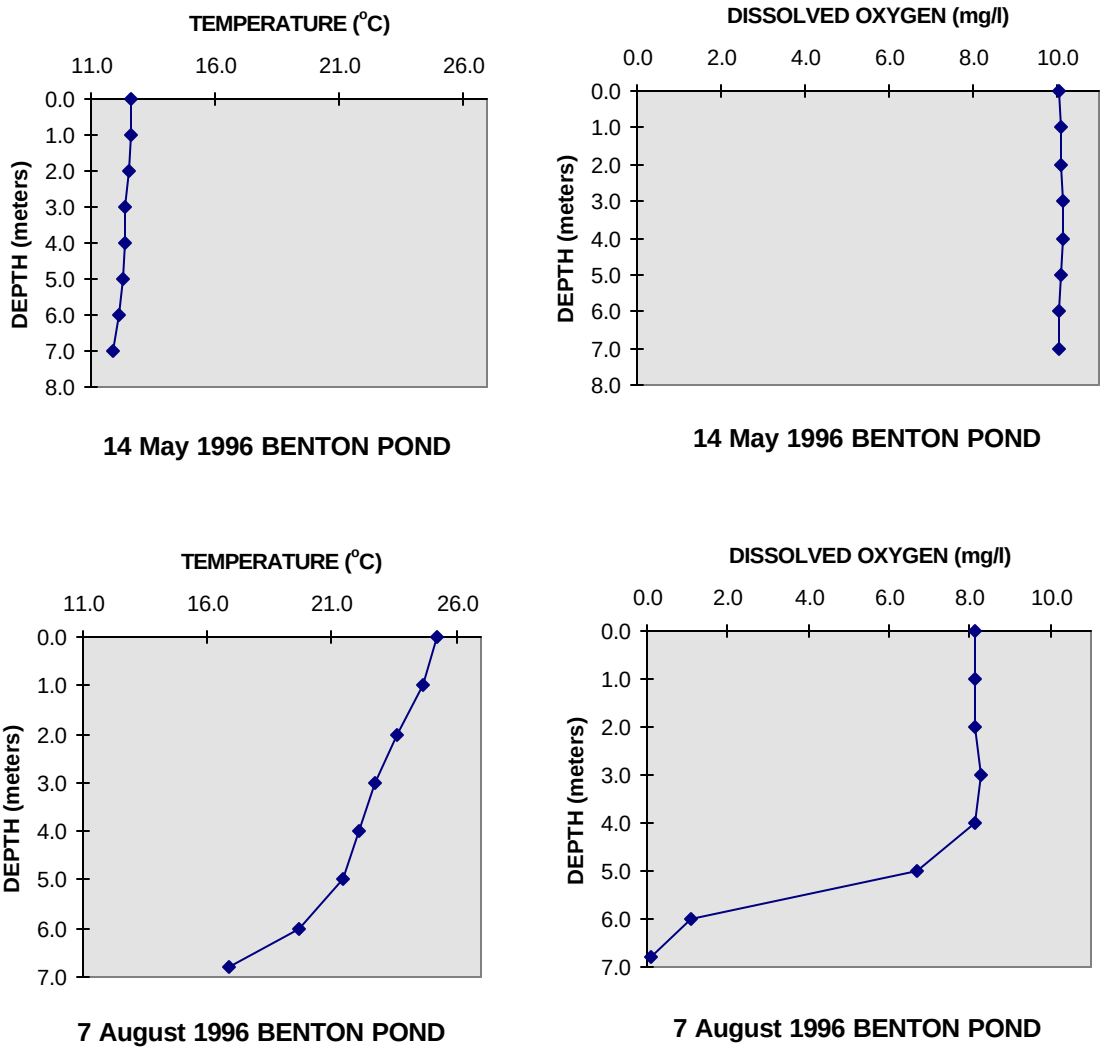


FIGURE D3. Temperature and dissolved oxygen profiles at the deep-hole in Benton Pond (Station BP01).

Comparison of the August 1996 data to historical data collected on 31 July 1979 (Whittaker 1982) and 4 September 1991(Haynes 1991) from Benton Pond suggests that the lake has experienced a very slight increase in trophic state, expressed mainly by the decline in hypolimnetic oxygen concentration measured at approximately 6 meters (6.5 mg/l in 1979, 3.0 mg/l in 1991 and 1.0 mg/l in 1996). If these data are an accurate representation of a loss of hypolimnetic oxygen over time it would indicate a significant change in water quality and a loss of habitat for cold water fishes that may populate the pond. However, hypolimnetic oxygen often declines over the summer in stratified lakes and ponds such as Benton Pond. For this reason it

is important to note the dates of sampling were different and that there may be year-to-year and sample-to-sample variations.

The 1996 Secchi disk reading was 5.4 meters as compared to the 1979 measurement of 6.4 meters (Whittaker 1982). The 1991 Secchi disk depth was 4.1 meters (Haynes 1991). Although Secchi disk measurements are prone to variation due to the influence of cloud cover, surface water effects (e.g., waves), and the possibility that bottom sediments were temporarily resuspended under the influence of strong winds, depth of visibility appears to have decreased since 1979.

There has been no detectable increase in the concentration of nutrients in Benton Pond within the last 17 years. Aquatic macrophyte density appears to have only slightly increased. Several species not recorded in 1979 were observed in 1996, most notably: *Myriophyllum spicatum* (eurasian milfoil), and several pondweeds - *Potamogeton Robbinsii* (flatleaf pondweed), *Potamogeton sp.* (thin-leaved pondweed) and *Phragmites sp.* (reed grass). See Table D10 for a complete macrophyte species list. *M. spicatum* was observed during the 1991 (Haynes 1991) survey and it appears to have expanded its coverage somewhat along the northern and eastern shore.

Lake Sediments

Sediments were collected at the deep hole of both Shaw and Benton Ponds on 7 August 1996. PCB were not detected in either lake's sediments date (Table D7), but organochlorine pesticides (DDE and DDD) were detected in both at low levels. Benton Pond sediments contained approximately 3 - 4 times more of both compounds than Shaw Pond sediments. Comparison of the DDE and DDD levels detected in these lakes to threshold levels established by Persaud et al. (1993) show that concentrations in Shaw Pond are within the No Effect Level (N-EL) and concentrations in Benton are within the Lowest Effect Level (L-EL). The L-EL indicates a level of sediment contamination that can be tolerated by the majority of benthic organisms.

The results of the sediment chemical analyses (as well as reference L-EL and S-EL concentrations) are presented in Table D7. The concentration of heavy metals and nutrients in Shaw Pond sediment was comprised of 12% solids and exceeded the S-EL for TKN and As. Four metals (Cu, Fe, Pb, and Zn) and TP were within the range between the L-EL and the S-EL. Although Cd is also slightly higher than the L-EL it was reported less than the minimum detection limit so this interpretation should be used with caution. The remaining metals (Cr, Hg, and Ni) were below the L-EL. It should be noted that the As concentration exceeded the S-EL by a factor of three and TKN exceeded the S-EL by almost a factor of two. The S-EL is the sediment concentration of a compound that would be detrimental to the majority of benthic species. The reasons for these elevated concentrations are unknown. Enrichment ratios for As, Pb, and Zn exceeded one and were calculated to be 103, 18, and 7, respectively, also reported in Table D7.

Sediments collected from Benton Pond were comprised of 7% solids. Both replicate samples exceeded the S-EL level for TKN only. Four metals (As, Cu, Pb, and Zn) and TP fell between the lowest and severe effect levels. Cd was also higher than the L-EL, but since it was reported less than the minimum detection limit, this interpretation should be used with caution. All remaining metals (Cr, Fe, Hg, and Ni) were below the L-EL. TKN exceeded the S-EL by a factor of three. Enrichment ratios for Pb, As, Zn, and Cu exceeded one (Table D7).

The concentration of heavy metals in lake sediments collected in the Farmington River Watershed (Figure D4 fall below the estimated means noted by Rojko (1990) in sediments of Massachusetts lakes and ponds.

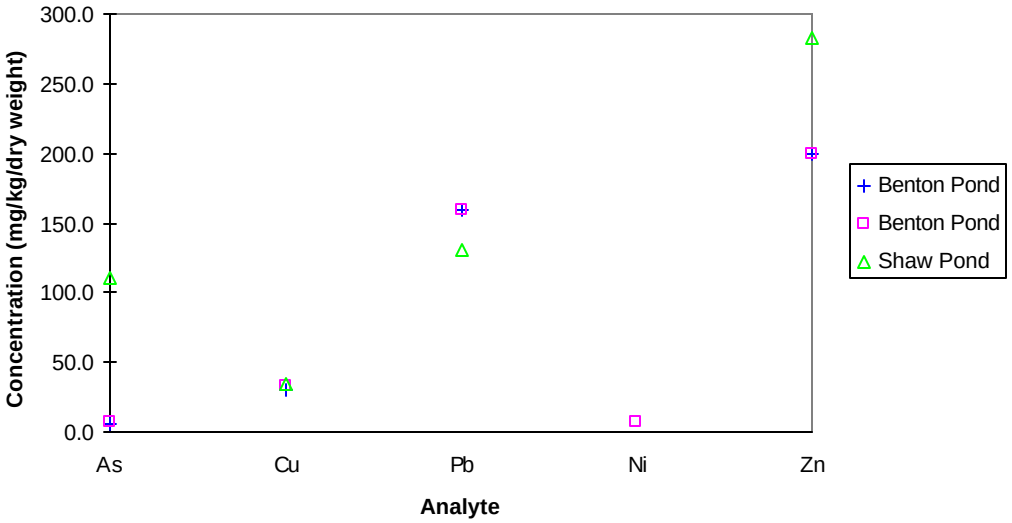


Figure D4. Select metal concentrations in sediment samples from the deep-hole stations of Shaw Pond and Benton Pond (one replicate). The ranges (min., mean, and max.) of heavy metals in the sediments of Massachusetts lakes and ponds (Rojko 1990) noted below for comparison.

Concentration (mg/kg)	As	Cu	Pb	Ni	Zn
Min	0.0	2.9	3.0	0.0	5.0
Mean	22.4	268	244	152	332
Max	336	3663	2478	2158	1922

REFERENCES

Flaherty, A. 1998. Personal communication. *Petroleum hydrocarbons and organic acids detected in sediment samples*. Massachusetts Department of Environmental Protection, Division of Environmental Analysis, Wall Experiment Station. Lawrence, MA.

Haynes, R.C. 1991. Personal communication via letter to JoAnne Urstadt dated 10 December. *DWPC 1991 water quality survey of Benton Pond*. Massachusetts Department of Environmental Protection, Division of Water Pollution Control. Boston, MA.

MA DEP 1990a. *Basins Program Standard Operating Procedures River and Stream Monitoring.* Massachusetts Department of Environmental Protection, Division of Water Pollution Control, Technical Services Branch. Westborough, MA.

MA DEP 1990b. *Biomonitoring Program Standard Operating Procedures 1990.* Massachusetts Department of Environmental Protection, Division of Water Pollution Control, Technical Services Branch. Westborough, MA.

MA DEP. 1995, January Draft. *Laboratory Quality Assurance Plan and Standard Operating Procedures.* Massachusetts Department of Environmental Protection, Division of Environmental Analysis. Wall Experiment Station, Lawrence, MA.

MA DEP. 2000. Memorandum to Rick McVoy, Laurie Kennedy, Tom Dallaire, Arthur Johson and Mollie Weinstein from Mark Guilmain dated February 2000. *1994, 95 & 96 QA/QC Assessment Report.* CN 36.0. Division of Watershed Management Department of Environmental Protection. Worcester, MA

Persaud, D., R. Jaagumagi, and A. Hayton. 1993. *Guidelines for the protection and management of aquatic sediment quality in Ontario*. Water Resources Branch, Ontario ministry of the Environment. Ontario, Canada.

Rojko, A.M. 1990. *Heavy metals in the sediments of Massachusetts lakes and ponds.* (Masters report) Northeas tern University. Boston, MA.

Schropp, S.J. and H.L. Windon, (editors). 1988. *A guide to the interpretation of metal concentrations in estuarine sediments*. Coastal Zone Management Section. Florida Department of Environmental Regulation. Tallahassee, FL.

Socolow, R.S., Domenic Murino, Jr., R.G. Casey, and L.R. Ramsbey. 1997. *Water Resources Data Massachusetts and Rhode Island Water Year 1996.* U.S. Geological Survey Report MA-RI-96-1. U.S. Geological Survey, Water Resources Division. Marlborough, MA.

Whittaker, G.E. 1982. *Baseline water quality studies of selected lakes and ponds in the Farmington River Basin.* Massachusetts Department of Environmental Quality Engineering, Division of Water Pollution Control, Technical Services Branch, Westborough, MA.

APPENDIX E
STATE AND FEDERAL WATER QUALITY RELATED GRANT AND LOAN PROJECTS IN THE FARMINGTON WATERSHED

MASSACHSUETTS WATERSHED INITIATIVE

The Massachusetts Watershed Initiative (MWI) was active during the years of 1998-2003. During those years, EOEA Watershed Team Leaders, in conjunction with State and Federal agencies, municipal governments and regional planning agencies, universities, local watershed associations, businesses and other groups, developed work plans that identified the most important goals for each watershed and the specific projects and programs that were needed to meet those goals. Projects funded under the MWI include: hydrologic and water quality monitoring and assessment, habitat assessment, non-point source assessment, hydrologic modeling, open space and growth planning, and technical assistance and outreach. MWI funded projects in the Farmington Watershed include the following.

- MWI Farmington Workplan Project FY01-FY02: ***DEP/WERO Wetlands Circuit Rider Position (Greater Connecticut Watershed Regional Project)*** to support the funding of a full time wetlands circuit rider at MA DEP Western Regional Office for two years. The Circuit Rider provided technical assistance and outreach to municipalities in the Western Region, including all towns in the Farmington Watershed, on local implementation and enforcement of the Wetlands Protection Act. Cost (two years): $85,500 (MA DEP)
- MWI Project 01-10MWI: ***Dirt Road Maintenance and Repair Pilot and Feasibility Study*** conducted by the Berkshire Regional Planning Commission in the Farmington, Hudson, Housatonic, Deerfield, and Westfield Basins to demonstrate the application of a Generic Notice of Intent (GNOI) for use on road repair and maintenance work. Cost - $35,000 funded 100% by EOEA in 2001 and 2002.
- MWI Project: ***Otis Reservoir Diagnostic/Feasibility Study –2000*** administered by MA DEM (now DCR) and conducted by ENSR to perform a management-oriented comprehensive study of Otis Reservoir and its watershed including an assessment of available information, water and sediment quality sampling, hydrologic analysis, nutrient loading, biological evaluation, and an evaluation of management needs, objectives, and options. Cost – $85,000 funded by MA DEM (now DCR).

SECTION 319 NONPOINT SOURCE GRANT PROGRAM

This grant program is authorized under Section 319 of the CWA for implementation projects that address the prevention, control, and abatement of nonpoint source (NPS) pollution. Section 319 is administered by the U.S. Environmental Protection Agency (EPA), which oversees the awards to individual states. The MA DEP Bureau of Resource Protection administers this award as part of the Massachusetts Nonpoint Source Program. In order to be considered eligible for funding projects must: implement measures that address the prevention, control, and abatement of NPS pollution; target the major source(s) of nonpoint source pollution within a watershed/subwatershed; have a 40 percent non-federal match of the total project cost (match funds must meet the same eligibility criteria as the federal funds); contain an appropriate method for evaluating the project results; address activities that are identified in the Massachusetts NPS Management Program Plan. Section 319 projects in the Farmington Watershed include the following.

- Section 319 NPS Project 97-04/319: ***Alternative Septic Systems Technologies Workshop Program*** conducted by the Berkshire Regional Planning Commission in the Housatonic and Farmington River Basins to present 15 to 20 workshops on MA DEP approved alternative on-site septic system technologies, the septic system repair program and recent changes to Title 5 in order to remediate water quality problems due to failing septic systems and to educate homeowners on proper septic system maintenance. Cost – $34,000 funded in 1997 by the U.S. Environmental Protection Agency, Berkshire Regional Planning Agency, Tri-Town Health Department, PioneerValley Planning Commission, and the Berkshire Housing Development Corporation.

- Section 319 NPS Project 98-06/319 ***- NPS Pollution Correction in the Farmington River Watershed - Dirt Roads BMP Handbook*** developed by the Berkshire Regional Planning Commission in the Farmington Watershed to provide detailed, practical instructions for dirt roads Best Management Practices implementation for use by Highway Departments. The project also involved demonstration of selected BMP test cases for road improvements and workshops to distribute the manual and discuss the results of the test cases. Cost - $73,750 funded in 1998 by the U.S. Environmental Protection Agency, Town of Sandisfield, and the Berkshire Regional Planning Commission.
- Section 319 NPS Project 01-04/319: ***Massachusetts Buffer Manual and Demonstration Projects*** conducted by the Berkshire Regional Planning Commission in the Housatonic and Farmington Watersheds to promote vegetated buffers as an effective and attractive way to minimize NPS pollution. The project involved writing and distributing a Buffer Manual, installing five demonstration buffers, and conducting public outreach and education on the need and effectiveness of vegetated buffers. Cost - $147,000 funded in 2001 by the U.S. Environmental Protection Agency, property owners, MA DEM (now DCR), and EOEA, Watershed Initiative.

SECTION 604(B) WATER QUALITY PLANNING GRANT PROGRAM

This grant program is authorized under Section 604(b) of the Federal Clean Water Act and funds are awarded to individual states through the U.S. EPA. In Massachusetts the 604(b) Program is administered by the MA DEP, Bureau of Resource Protection. The program is designed to assist eligible recipients in providing water quality assessment and planning assistance to local communities. Priority is given to projects that provide diagnostic information to support the MA DEP's watershed management activities and to projects located in one of the priority watersheds targeted for assessment work by the MA DEP. Section 604(b) projects in the Farmington Watershed are as follows.

- Section 604(b) Project 95-02/604: ***Farmington River Watershed Action Plan – A Comprehensive Management Plan to Address Nontpoint Source Pollution*** conducted by the Berkshire Regional Planning Commission to do a watershed-wide inventory of physical characteristics and natural features; identify existing and potential nonpoint source pollution problems; and develop a watershed action plan and management strategy to address remediation of existing nonpoint source pollution problems and prevention of potential future nonpoint source pollution. Cost - $51,508 funded in 1995 by the U.S. Environmental Protection Agency and the Berkshire Regional Planning Commission.
- Section 604(b) Project 2001-01: ***Assess Unpaved Roadways in the Farmington River Watershed*** conducted by the Berkshire Regional Planning Commission and the Pioneer Valley Planning Commission in the Farmington River Watershed to assess unpaved roads using the Roadway Surface Management System to identify potential environmentally degrading unpaved roadway maintenance and management practices that contribute to NPS pollution. The project addressed remediation of existing roadway problems, set goals for prevention of potential NPS problems, and developed proactive strategies for management and maintenance of unpaved roads. Cost - $54,000 funded in 2001 by the U.S. Environmental Protection Agency and the Berkshire Regional Planning Commission.

WELLHEAD PROTECTION GRANT PROGRAM

The Wellhead Protection Grant Program was developed in support of the 1996 Safe Drinking Water Act Amendments and the MA DEP's Source Water Assessment Program. Funding is provided from the Drinking Water State Revolving Fund and is available to public water systems for developing and implementing wellhead protection projects and plans. Currently there are no Wellhead Protection Projects in the Farmington Watershed.

104(b)(3) WETLANDS AND WATER QUALITY GRANT PROGRAM

This grant program is authorized under Wetlands and Clean Water Act Section 104(b)(3) of the federal Clean Water Act. Grant funds under the 104(b)(3) program are made available to Massachusetts agencies under the National Environmental Performance Partnership Agreement (NEPPA) with the U.S. Environmental Protection Agency. These grants, administered by the MA DEP, Bureau of Resource Protection, provide a results-oriented approach that focuses attention on environmental protection goals and the efforts to achieve them. The goals of the NEPPA are: 1) ensure safe drinking water; 2) reduce,

eliminate and/or control point and non-point source pollution; 3) protect wetland quality and function and ensure no-net-loss of wetlands; 4) reduce and reverse acidification of water bodies. There were no 104(b)(3) projects in the Farmington Watershed during the period evaluated for this assessment report (1998-2008).

RESEARCH AND DEMONSTRATION GRANT PROGRAM

The Research and Demonstration Program (R&D) is authorized by section 38 of Chapter 21 of the Massachusetts General Laws and is funded by proceeds from the sale of Massachusetts bonds. It is administered by the MA DEP, Bureau of Resource Protection. Specifically, the R&D Program was established to enable the Department to conduct a program of study and research and demonstration relating to water pollution control and other scientific and engineering studies "...so as to insure cleaner waters in the coastal waters, rivers, streams, lakes and ponds of the Commonwealth." There were no Research and Demonstration grant projects in the Farmington Watershed during the period evaluated for this assessment report (1998-2008).

SOURCE WATER PROTECTION TECHNICAL ASSISTANCE/LAND MANAGEMENT GRANT PROGRAM

The Source Water Protection Technical Assistance/Land Management Grant Program was developed in support of the 1996 Safe Drinking Water Act Amendments and the MA DEP's Source Water Assessment Program. Funding is provided from the Safe Drinking Water Revolving Fund and is available to public water suppliers and third party technical assistance organizations to assist public water suppliers in protecting local and regional ground and surface drinking water supplies. There were no Source Water Protection projects in the Farmington Watershed during the period evaluated for this assessment report (1998-2008).

CLEAN WATER STATE REVOLVING LOAN FUND (SRF) PROGRAM

The Massachusetts State Revolving Loan Fund for water pollution abatement projects was established to provide a low-cost funding mechanism to assist municipalities seeking to comply with federal and state water quality requirements. This program assists cities, towns, and wastewater districts in the financing of water pollution abatement projects, including nonpoint source projects. The financial assistance takes the form of subsidized loans at a 2% interest rate to borrowers. The SRF Program is jointly administered by the Division of Municipal Services of the MA DEP and the Massachusetts Water Pollution Abatement Trust. The SRF Program now provides increased emphasis on watershed management priorities. A major goal of the SRF Program is to provide incentives to communities to undertake projects with meaningful water quality and public health benefits and which address the needs of the communities and the watershed. There were no SRF Program projects in the Farmington Watershed during the period evaluated for this assessment report (1998-2008).

MASSACHUSETTS DRINKING WATER STATE REVOLVING FUND PROGRAM

The Massachusetts Drinking Water State Revolving Fund (DWSRF) uses EPA grant funds from the Safe Drinking Water Act to provide low-cost financing to help community public water suppliers comply with federal and state drinking water requirements. The DWSRF Program's goals are to protect public health and strengthen compliance with drinking water requirements, while addressing the Commonwealth's drinking water needs. The Program incorporates affordability and watershed management priorities. The DWSRF Program is jointly administered by the Division of Municipal Services of the Department of Environmental Protection and the Massachusetts Water Pollution Abatement Trust. The current subsidy level is equivalent to a 50% grant, which approximates a two percent interest loan. There were no Drinking Water SRF Program projects in the Farmington Watershed during the period evaluated for this assessment report (1998-2008).

COMMUNITY SEPTIC MANAGEMENT PROGRAM

The enactment of the Open Space Bond Bill in March of 1996 provided new opportunities and stimulated new initiatives to assist homeowners with failing septic systems. The law appropriated $30 million to the MA DEP to assist homeowners. The Department uses the appropriation to fund loans through the Massachusetts Water Pollution Abatement Trust. The fund provides a permanent state/local administered revolving fund to assist income-eligible homeowners in financing necessary Title 5 repairs. Working together, the MA DEP and the Trust have created the Community Septic Management Program

to help Massachusetts' communities protect threatened ground and surface waters while making it easier to comply with Title 5. This loan program offers three options from which a local governmental unit can choose. Currently there are no Community Septic Management projects active in towns in the Farmington Watershed.

DEPARTMENT OF CONSERVATION AND RECREATION (DCR) LAKES AND PONDS GRANT PROGRAM

The Department of Conservation and Recreation, (formerly MA DEM) Lakes and Ponds Grant Program assists municipalities and local organizations that are striving to meet the challenges of long term lake and pond management by awarding grants for the protection, preservation and enhancement of public lakes and ponds in the Commonwealth. A maximum grant of $25,000 per project is available to eligible applicants on a 50/50 cost-sharing basis. Grant applicants must be municipalities, local commissions, local authorities or lake districts. DCR's Lake and Pond grant program awards grants for the protection, preservation and enhancement of public lakes and ponds in the Commonwealth. A key goal of the program is to promote a holistic approach to lake management that is based on sound scientific principles and emphasizes the integrated use of watershed management, in-lake management, pollution prevention and education to provide long-term solutions to lake problems.

- DCR Demonstration Restoration and Protection Projects ***- Otis Reservoir Lake and Watershed Protection Initiative*** conducted by the Town of Otis in partnership with the Berkshire Regional Planning Commission, Farmington River Watershed Association, Otis Reservoir Property Owners Association, and Big Pond Association to implement a series of protective structural and non-structural best management practices within Otis Reservoir and its subwatershed. Based on technical analysis and recommendations contained in a Diagnostic/Feasibility Study (ENSR, 2001), the project seeks to implement a series of protective structural and non-structural best management practices within Otis Reservoir and its subwatershed and to continue efforts to protect water quality in this pristine watershed by empowering residents to take local action on lake and watershed issues. Cost - $128,800 funded in 2001 by MA DEM, the Town of Otis, the Berkshire Regional Planning Commission, the Otis Reservoir Property Owners Association, and the Farmington River Watershed Association.

- DCR Lakes and Ponds Grant – Control of Eurasian Watermilfoil in Shaw Pond using herbicide treatment (1998). Cost - $10,000 funded by DCR (formerly MA DEM) and $10,000 funded by local match.

DEPARTMENT OF FISH AND GAME, RIVERWAYS SMALL GRANTS PROGRAM

Initiated in 1987, the Riverways Small Grants Program provides modest amounts of money to promote the restoration and protection of the ecological integrity of Commonwealth's rivers, streams, and adjacent lands. The grants foster action and result in benefits to the community that continue well after the grant period ends, as well as leverage local and foundation funding. In addition to providing seed money, Riverways also offers technical assistance, as appropriate, to both groups receiving grant awards and those that do not. The Riverways Program, Department of Fish and Game, solicits project proposals for Small Grants from municipal governments and non-profit organizations for projects to be implemented by June 30, each year. There were no Riverways Small Grants projects in the Farmington Watershed during the period evaluated for this assessment report (1998-2008).

MASSACHUSETTS ENVIRONMENTAL TRUST

The Massachusetts Environmental Trust (MET) is an office within the Executive Office of Environmental Affairs that protects and preserves the Commonwealth's water resources and their ecosystems through its grant making programs. The Trust's ability to support critical environmental initiatives throughout Massachusetts comes from the sale of special environmental license plates and the proceeds from environmental litigation settlements. The Trust is dedicated to promoting proactive environmental stewardship, environmental awareness, and the protection of our state's water-related resources through annual competitive grants to local, regional and statewide non-profit organizations, educational institutions, and government agencies. There were no MET projects in the Farmington Watershed during the period evaluated for this assessment report (1998-2008).

APPENDIX F

Farmington River Watershed
Fish Toxics Monitoring - 1997 and 2001

TECHNICAL MEMORANDUM TM-31-3

1997 Farmington River Watershed
Fish Contaminant Monitoring Surveys

By Robert J. Maietta
Massachusetts Department of Environmental Protection
Division of Watershed Management
Worcester, MA

October 2003

Introduction

Fish contaminant monitoring is a cooperative effort between three MA DEP Offices/Divisions, (Watershed Management, Research and Standards, and Environmental Analysis), the Department of Fisheries and Wildlife Environmental Law Enforcement, and the Department of Public Health (MDPH). Fish contaminant monitoring is typically conducted to assess the concentrations of toxic contaminants in freshwater fish, identify waterbodies where those concentrations may pose a risk to human health, and identify waters where toxic contaminants may impact fish and other wildlife. Fish contaminant monitoring was designed to screen the edible fillets of several species of fish desired by the angling public for consumption, as well as species representing different feeding guilds (i.e., bottom dwelling omnivores, top-level predators, etc.) for the presence of heavy metals (Pb, Cd, Se, Hg, As), PCBs, and organochlorine pesticides (MA DEP 1999). These data are used by the Massachusetts Department of Public Health in assessing human health risks associated with the consumption of freshwater fishes.

During the winter of 1997, as part of a larger watershed-wide sampling effort conducted during 1996 and 1997, fish from Benton Pond, Otis Reservoir, and Shaw Pond were collected and analyzed for selected metals, PCBs and organochlorine pesticides. The objective of this particular study was to screen the edible fillets of fishes for potential contaminants. All results were submitted to the Massachusetts Department of Public Health (MDPH) for review.

Field Methods

All locations were sampled using ice fishing techniques including tip-ups (tilts) baited with live golden shiners *Notemigonus crysoleucas*, and jigs baited with either golden shiner pieces or the eyes of yellow perch *Perca flavescens*. Fish that were included in the sample were stored on ice.

Field Results

The following samples were retained and subsequently submitted for analysis.

Waterbody	Date Sampled	Fish Species (number of fish)
Benton Pond	2/11/97	largemouth bass *Micropterus salmoides* (3) chain pickerel *Esox niger* (3) yellow perch (5)
Otis Reservoir	2/5/97	yellow perch (4)
Shaw Pond	2/25/97	yellow perch (3) largemouth bass (1)

Laboratory Methods

Fish were placed on ice and brought to the DEP Division of Watershed Management (DWM) in Worcester where they were measured, weighed, and a body part(s) (i.e. scales, spine or fin ray) was removed for aging the specimens. Notes were taken as to an individual fish's general condition. Species, length, and weight data can be found in Table 1.

Fish were filleted on glass cutting boards, the skin was removed, and samples were prepared for freezing. All equipment used in the filleting process was rinsed in tap water to remove slime, scales, and blood, and then re-rinsed twice in de-ionized water before and/or after each individual fish or composite. Fillets targeted for metals analysis were placed in VWR 32 ounce high-density polyethylene cups with covers. The opposite fillets were wrapped in aluminum foil for % lipids, PCB and organochlorine pesticide analysis. In the case of composite samples, three to five fillets from like-sized individuals of the same species were wrapped together in aluminum foil or stored in a single sample container. All samples were composited by species except for the individual largemouth bass captured at Shaw Pond. Samples were tagged and frozen for subsequent delivery to MADEP's Wall Experiment Station (WES).

Methods used at WES for metals analysis include a cold vapor method using a VGA hydride generator for mercury and Varian 1475 flame atomic absorption for the remaining metals. PCB/organochlorine pesticide analysis was performed on a gas chromatograph equipped with an electron capture detector. Additional information on analytical techniques used at WES is available from the laboratory.

Results

Quality Assurance Quality Control and Data Validation for Fish Contaminant Monitoring Data

Due to the need to disseminate information quickly, DWM/WES generated/lab-validated fish contaminant data are typically used directly (upon receipt from the lab) by several groups (including DWM) without extensive external data validation. DWM does not (*ex post facto*) censor or qualify fish contaminant data once it has been used. Rather, specific comments are provided where poor field and/ or analytical accuracy/precision may have occurred. Additional discussion and QC sample data for fish contaminants from 1995-2000 can be found in the Data Validation Report for Year 2000 Project Data (MA DEP 2003). Methods used at the Department's analytical laboratory, Wall Experimental Station (WES) for metal and organic analysis are provided in Appendix C of this technical memorandum (Table C1 and Table C2) and additional information is available from the WES laboratory (MA DEP 1995).

Cadmium (MDL = 0.020 mg/Kg), lead (MDL = 0.140 mg/Kg), and arsenic (MDL = 0.040 mg/Kg) were below detection in all samples analyzed. Selenium was detected in all samples analyzed and ranged from 0.123 mg/kg in a composite of yellow perch (SPF97-1-3) from Shaw Pond to 0.292 mg/kg in a composite of yellow perch (BPF97-07-11) from Benton Pond. Mercury concentration varied among waterbodies and species but was highest in top-level predators. The mean and ranges of mercury in fish tissue by waterbody is as follows:

Waterbody	$\overline{X}$ total Hg concentration (mg/Kg wet weight)	Range of total Hg concentrations (min-max)
Benton Pond	0.22 (n*=3)	0.16 - 0.27
Otis Reservoir	0.20 (n=1)	Not applicable
Shaw Pond	0.25 (n=2)	0.19 - 0.315

*n= number of samples analyzed

It should be noted that Benton Pond and Otis Reservoir mercury data are qualified because the samples were analyzed beyond the USEPA recommended holding time of 28 days. The samples were analyzed at approximately 39 and 46 days following collection respectively. Quality assurance and quality control data for metals are available from the laboratory or the DWM upon request.

PCBs and organochlorine pesticides were below method detection limits in all samples analyzed. Analytical results can be found in Table 1.

Discussion

Benton Pond: Benton Pond is a 63-acre pond located in the town of Otis. The very small watershed surrounding the pond is sparsely developed with residences and otherwise forested. Route 23 transects the southwest portion of the watershed and runs along the southwest shore of the pond.

Mercury was well below the MDPH "trigger level" of 0.5 mg/kg in all three composite samples that were analyzed, including the two predatory species (pickerel and bass). It is unclear what, if any effect, the exceedance of holding times for mercury had on mercury concentrations. Arsenic, lead, cadmium and selenium were either below MDLs or at concentrations that do not appear to be of concern. PCBs and organochlorine pesticides were not detected in fish samples from Benton Pond.

Otis Reservoir: Otis Reservoir is a 969-acre lake located in the towns of Otis/Tolland/Blandford. The watershed surrounding the lake is sparsely developed and predominantly forested. However, the shoreline is approximately 50 to 60% developed with seasonal and year round residences. There is a large state forest with a camping area (Tolland State Forest) located on the western shoreline of the reservoir.

Mercury in yellow perch was below the MDPH "trigger level" of 0.5 mg/kg, however, it should be noted that top-level predators (which typically contain the highest mercury concentrations) were not collected in 1997. In addition, it is unclear what, if any effect, the exceedance of holding times for mercury had on mercury concentrations. Arsenic, lead, cadmium and selenium were either below MDLs or at concentrations that do not appear to be of concern. PCBs and organochlorine pesticides were not detected in yellow perch.

Shaw Pond: Shaw Pond is a 100-acre pond located in the town of Otis and Becket. Land use within the 4.389 square mile watershed is predominantly forested with a small area of low and medium density residential development. The Massachusetts Turnpike (Interstate 90) bisects the eastern half of the watershed and runs just east of the pond. Slightly less than one-half the shoreline is developed with residences. There is a large wetland area located just upstream (north) of the pond.

Mercury was well below the MDPH "trigger level" of 0.5 mg/kg in the both samples analyzed, including an individual largemouth bass. Arsenic, lead, cadmium and selenium were either below MDLs or at concentrations that do not appear to be of concern. PCBs and organochlorine pesticides were not detected in either sample from Shaw Pond.

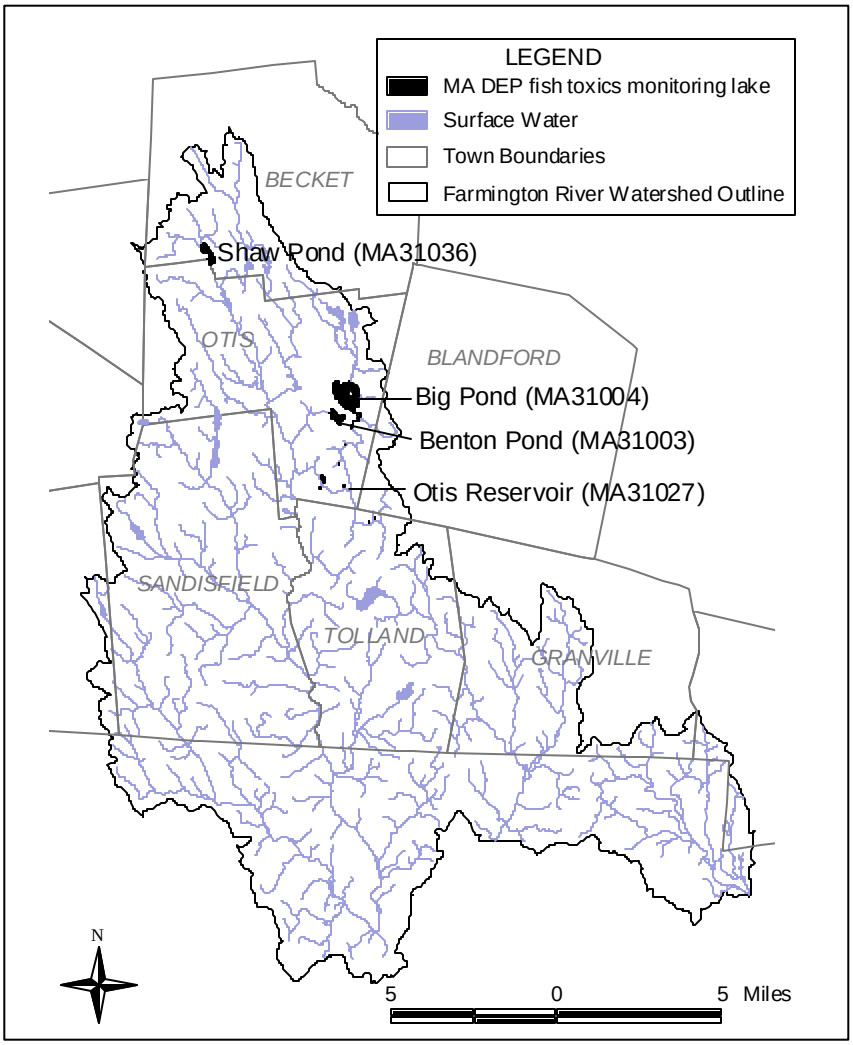


Figure 1. 1997 and 2001 MA DEP Fish Toxics Monitoring Lakes

Table 1. MA DEP Farmington River Watershed fish contaminant monitoring data for Benton Pond, Otis, Otis Reservoir, Otis/Tolland and Shaw Pond, Becket. Results, reported in mg/kg wet weight unless otherwise noted, are from individual or composite samples of fish fillets with skin off.

Analysis #	Sample ID	Collection Date	Species Code[1]	Sample Type[2]	Length (cm)	Weight (g)	Cd	Pb	Hg	As	Se	% Lipids	PCB (µg/g)	Pesticides (µg/g)
Benton Pond														
96053	BPF97-01	02/11/97	LMB	C	36.0	680.0	<0.02	<0.140	0.270*	<0.040	0.178	0.03	ND[3]	ND
	BPF97-02	02/11/97	LMB	C	38.2	800.0								
	BPF97-03	02/11/97	LMB	C	34.7	680.0								
96054	BPF97-04	02/11/97	CP	C	37.6	305.0	<0.02	<0.140	0.240*	<0.040	0.163	0.15	ND	ND
	BPF97-05	02/11/97	CP	C	37.9	330.0								
	BPF97-06	02/11/97	CP	C	36.7	260.0								
96055	BPF97-07	02/11/97	YP	C	22.6	120.0	<0.02	<0.140	0.160*	<0.040	0.292	0.14	ND	ND
	BPF97-08	02/11/97	YP	C	22.7	120.0								
	BPF97-09	02/11/97	YP	C	22.1	145.0								
	BPF97-10	02/11/97	YP	C	22.4	130.0								
	BPF97-11	02/11/97	YP	C	22.3	150.0								
Otis Reservoir														
96052	ORF97-1	02/05/97	YP	C	22.0	113.0	<0.02	<0.140	0.200*	<0.040	0.284	0.16	ND	ND
	ORF97-2	02/05/97	YP	C	21.0	100.0								
	ORF97-3	02/05/97	YP	C	22.1	115.0								
	ORF97-4	02/05/97	YP	C	26.0	225.0								
Shaw Pond														
96060	SPF97-1	02/25/97	YP	C	22.0	150.0	<0.02	<0.140	0.190	<0.040	0.123	0.35	ND	ND
	SPF97-2	02/25/97	YP	C	20.3	107.0								
	SPF97-3	02/25/97	YP	C	21.1	120.0								
96061	SPF97-4	02/25/97	LMB	I	34.9	562.0	<0.02	<0.140	0.315	<0.040	0.143	0.12	ND	ND

Notes:

[1]Species:
chain pickerel (CP) *Esox niger*
largemouth bass (LMB) *Micropterus salmoides*
yellow perch (YP) *Perca flavescens*

[2]Sample Type (All samples were fillets with skin off.): C = Composite, I = Individual

[3]ND = Not Detected

*Analyzed beyond EPA recommended holding time of 28 days.

REFERENCES

MA DEP. 1995, January Draft. *Laboratory Quality Assurance Plan and Standard Operating Procedures.* Massachusetts Department of Environmental Protection, Division of Environmental Analysis. Wall Experiment Station, Lawrence, MA.

MA DEP. 1999. *Fish Contaminant Monitoring Program, Quality Assurance Project Plan, 1999.* CN 13.0. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA.

MA DEP. 2003. *DATA VALIDATION REPORT for Year 2000 Project Data.* CN 83.0, March 5, 2003. Division of Watershed Management Department of Environmental Protection. Worcester, MA.

Farmington River Watershed Fish Toxics Monitoring Data 2001 excerpted from the report entitled *2001 Fish Toxics Monitoring Public Request and Year 2 Watershed Surveys* (Maietta *et al*. 2002).

Fish were collected from two waterbodies in the Farmington River Watershed in 2001– Big Pond in Otis and Otis Reservoir in Otis/Tolland/ Blandford. Details related to the collection, handling, and processing of samples collected from Big Pond and Otis Reservoir are presented in the report entitled *2001 Fish Toxics Monitoring Public Request and Year 2 Watershed Surveys* (Maietta et al. 2002). According to standard practice, all laboratory analytical results were forwarded to the Massachusetts Department of Public Health.

Big Pond: Big Pond is a 331-acre pond located in the town of Otis. The watershed surrounding the pond is sparsely developed and predominantly forested. However, approximately 75% of the shoreline area is developed with seasonal and year round residences. There is a large tributary wetland located to the north of Big Pond.

Mercury exceeded the MDPH "trigger level" of 0.5 mg/kg in both largemouth and smallmouth bass (1.2, and 0.89 mg/kg respectively). It should be noted that the largemouth bass collected and analyzed were slightly larger than the smallmouth bass collected and analyzed. The MDPH issued the following fish consumption advisory in June of 2002.

> "Children younger than 12 years, pregnant women, and nursing mothers should not eat any fish from this water body. The general public should not consume largemouth bass from this waterbody. The general public should limit consumption of all fish from this waterbody to two meals per month. "

Although mercury in yellow perch was below the MDPH "trigger level" it should be noted that these fish were relatively small and that larger yellow perch will contain slightly higher concentrations of mercury. Arsenic, lead, cadmium and selenium were either below MDLs or at concentrations which do not appear to be of concern.

PCBs and organochlorine pesticides were below detection in all samples analyzed from Big Pond. Method Detection Limits (MDLs) can be found in Table 3.

Otis Reservoir: Otis Reservoir is a 1200-acre lake located in the town of Otis/Tolland/Blandford. The watershed surrounding the lake is sparsely developed and predominantly forested. However, the shoreline is approximately 50 to 60% developed with seasonal and year round residences. There is a large state forest with a camping area (Tolland State Forest) located on the western shoreline of the reservoir.

Mercury exceeded the MDPH "trigger level" of 0.5 mg/kg in largemouth bass, smallmouth bass, and white perch (0.68, 0.67, and 0.69 mg/kg respectively). As a result, the MDPH issued the following fish consumption advisory in June of 2002.

> "Children younger than 12 years, pregnant women, and nursing mothers should not eat any fish from this water body."
>
> "The general public should limit consumption of all fish from this waterbody to two meals per month."

Although mercury in yellow perch was below the MDPH "trigger level" it should be noted that these fish were relatively small. Brown bullhead fillets were found to be very low in mercury, which is consistent with most waterbodies. Arsenic, lead, cadmium and selenium were either below MDLs or at concentrations which do not appear to be of concern.

PCBs and organochlorine pesticides were below method detection limits (MDLs) in all samples analyzed from Otis Reservoir. MDLs can be found in Table 3.

Table 2. 2001 MA DEP Farmington River Watershed fish contaminant monitoring data excerpted from *2001 Fish Toxics Monitoring Public Request and Year 2 Watershed Surveys* (Maietta *et al*. 2002). Results, reported in wet weight, are from composite samples of fish fillets with skin off.

Sample ID	Collection Date	Species Code[1]	Length (cm)	Weight (g)	Sample ID (laboratory sample #)	Cd (mg/kg)	Pb (mg/kg)	Hg (mg/kg)	As (mg/kg)	Se (mg/kg)	% Lipids (%)	PCB Arochlors and Congeners (µg/g)	Pesticides (µg/g)
Big Pond, Otis, Farmington River Watershed													
BPF01-01	6/27/01	LMB	41.9	980	2001012 (L2001236-1) (L2001274-1)	<0.080	<0.80	1.2	<0.040	0.27	0.06	ND	ND
BPF01-02	6/27/01	LMB	38.1	770									
BPF01-03	6/27/01	LMB	37.2	720									
BPF01-04	6/27/01	SMB	33.7	430	2001013 (L2001236-2) (L2001274-2)	<0.080	<0.80	0.89	<0.040	0.21	0.07	ND	ND
BPF01-05	6/27/01	SMB	30.1	320									
BPF01-06	6/27/01	SMB	30.3	320									
BPF01-07	6/27/01	YP	22.0	130	2001014 (L2001236-3) (L2001274-3)	<0.080	<0.80	0.33	<0.040	0.20	0.15	ND	ND
BPF01-08	6/27/01	YP	19.6	90									
BPF01-09	6/27/01	YP	19.0	90									
BPF01-10	6/27/01	BB	30.4	420	2001015 (L2001236-4) (L2001274-4)	<0.080	<0.80	0.19	<0.040	0.11	0.15	ND	ND
BPF01-11	6/27/01	BB	29.3	320									
BPF01-12	6/27/01	BB	28.1	280									
Otis Reservoir, Otis, Farmington River Watershed													
ORF01-01	6/26/01	LMB	33.3	460	2001007 (L2001235-1) (L2001273-1)	<0.080	<0.80	0.68	<0.060	0.27	0.02	ND	ND
ORF01-02	6/26/01	LMB	31.6	400									
ORF01-03	6/26/01	LMB	29.9	380									
ORF01-04	6/26/01	SMB	26.3	240	2001008 (L2001235-2) (L2001273-2)	<0.080	<0.80	0.67	<0.060	0.18	0.15	ND	ND
ORF01-05	6/26/01	SMB	26.9	220									
ORF01-06	6/26/01	SMB	26.0	210									
ORF01-07	6/26/01	WP	26.1	230	2001009 (L2001235-3) (L2001273-3)	<0.080	<0.80	0.69	<0.060	0.48	0.26	ND	ND
ORF01-08	6/26/01	WP	25.5	240									
ORF01-09	6/26/01	WP	25.1	240									
ORF01-10	6/26/01	BB	31.1	400	2001010 (L2001235-4) (L2001273-4)	<0.080	<0.80	0.16	<0.060	0.15	0.25	ND	ND
ORF01-11	6/26/01	BB	29.8	320									
ORF01-12	6/26/01	BB	29.0	250									
ORF01-13	6/26/01	P	20.1	200	2001011 (L2001235-5) (L2001273-5)	<0.080	<0.80	0.26	<0.060	0.31	0.37	ND	ND
ORF01-14	6/26/01	P	19.4	150									
ORF01-15	6/26/01	B	19.2	160									

[1] Species (LMB) largemouth bass *Micropterus salmoides*
(SMB) smallmouth bass *Micropterus dolomieu*
(YP) yellow perch *Perca flavescens*
(BB) brown bullhead *Ameiurus nebulosus*
(WP) white perch *Morone americana*
(P) pumpkinseed *Lepomis gibbosus*
(B) bluegill *Lepomis macrochirus*

ND - not detected or the analytical result is at or below the established method detection limit (MDL). See Table 3 for MDL listings.

Table 3. 2001 Fish Toxics Analytical Methods and MDLs/RDLs excerpted from *2001 Fish Toxics Monitoring Public Request and Year 2 Watershed Surveys* (Maietta *et al*. 2002).

Fish Tissue Analytes	EPA Method	Other Methods	Method Detection Limit	Reporting Detection Limit
PCB Arochlor 1232		AOAC 983.21**	0.019 ug/g wet wt	0.057 ug/g wet wt
PCB Arochlor 1242		AOAC 983.21**	0.019 ug/g wet wt	0.057 ug/g wet wt
PCB Arochlor 1248		AOAC 983.21**	0.038 µg/g wet wt	0.11 ug/g wet wt
PCB Arochlor 1254		AOAC 983.21**	0.013 µg/g wet wt	0.039 ug/g wet wt
PCB Arochlor 1260		AOAC 983.21**	0.022 µg/g wet wt	0.066 ug/g wet wt
Chlordane		AOAC 983.21**	0.046 µg/g wet wt	0.14 ug/g wet wt
Toxaphene		AOAC 983.21**	0.045 µg/g wet wt	0.14 ug/g wet wt
a-BHC		AOAC 983.21**	0.0054µg/g wet wt	0.016 ug/g wet wt
b-BHC		AOAC 983.21**	0.0055µg/g wet wt	0.017 ug/g wet wt
Lindane		AOAC 983.21**	0.0056µg/g wet wt	0.017 ug/g wet wt
d-BHC		AOAC 983.21**	0.012 µg/g wet wt	0.036 ug/g wet wt
Hexachlorocyclopentadiene		AOAC 983.21**	0.038 µg/g wet wt	0.11 ug/g wet wt
Trifluralin		AOAC 983.21**	0.032 µg/g wet wt	0.096 ug/g wet wt
Hexachlorobenzene		AOAC 983.21**	0.018 µg/g wet wt	0.054 ug/g wet wt
Heptachlor		AOAC 983.21**	0.0078 µg/g wet wt	0.023 ug/g wet wt
Heptachlor Epoxide		AOAC 983.21**	0.0057 µg/g wet wt	0.017 ug/g wet wt
Methoxychlor		AOAC 983.21**	0.027 µg/g wet wt	0.087 ug/g wet wt
DDD		AOAC 983.21**	0.0051 µg/g wet wt	0.015 ug/g wet wt
DDE		AOAC 983.21**	0.0055 µg/g wet wt	0.017 ug/g wet wt
DDT		AOAC 983.21**	0.0064 µg/g wet wt	0.019 ug/g wet wt
Aldrin		AOAC 983.21**	0.0057 µg/g wet wt	0.017 ug/g wet wt
PCB Toxic Congener BZ#81		AOAC 983.21**	0.001µg/g wet wt	0.003 ug/g wet wt
PCB Toxic Congener BZ#77		AOAC 983.21**	0.00078 µg/g wet wt	0.0023 ug/g wet wt
PCB Toxic Congener BZ#123		AOAC 983.21**	0.0013 µg/g wet wt	0.0039 ug/g wet wt
PCB Toxic Congener BZ#118		AOAC 983.21**	0.0012 µg/g wet wt	0.0036 ug/g wet wt
PCB Toxic Congener BZ#114		AOAC 983.21**	0.0013 µg/g wet wt	0.0039 ug/g wet wt
PCB Toxic Congener BZ#105		AOAC 983.21**	0.0013 µg/g wet wt	0.0039 ug/g wet wt
PCB Toxic Congener BZ#126		AOAC 983.21**	0.001 µg/g wet wt	0.003 ug/g wet wt
PCB Toxic Congener BZ#167		AOAC 983.21**	0.0012 µg/g wet wt	0.0036 ug/g wet wt
PCB Toxic Congener BZ#156		AOAC 983.21**	0.0011 µg/g wet wt	0.0033 ug/g wet wt
PCB Toxic Congener BZ#157		AOAC 983.21**	0.0012 µg/g wet wt	0.0036 ug/g wet wt
PCB Toxic Congener BZ#180		AOAC 983.21**	0.0014 µg/g wet wt	0.0042 ug/g wet wt
PCB Toxic Congener BZ#169		AOAC 983.21**	0.00059 µg/g wet wt	0.0018 ug/g wet wt
PCB Toxic Congener BZ#170		AOAC 983.21**	0.0013 µg/g wet wt	0.0039 ug/g wet wt
PCB Toxic Congener BZ#189		AOAC 983.21**	0.0013 µg/g wet wt	0.0039 ug/g wet wt
Arsenic	EPA 200.9*****		0.040 mg/kg wet wt 0.060 mg/kg wet wt	0.040 mg/kg wet wt 0.080 mg/kg wet wt
Mercury	EPA 245.6*****		0.010 mg/L wet wt	0.030 mg/kg wet wt

Table 3. Continued 2001 Fish Toxics Analytical Methods and MDLs/RDLs excerpted from *2001 Fish Toxics Monitoring Public Request and Year 2 Watershed Surveys* (Maietta *et al*. 2002).

Lead	EPA 200.7*****		0.8 mg/kg wet wt 0.080 mg/kg wet wt 0.20 mg/kg wet wt	2.4 mg/kg wet wt 2.4 mg/kg wet wt 0.20 mg/kg wet wt
Selenium	EPA 200.9*****		0.060 mg/kg wet wt	0.080 mg/kg wet wt
Cadmium	EPA 200.7*****		0.08 mg/kg wet wt 0.080 mg/kg wet wt 0.040 mg/kg wet wt	0.24 mg/kg wet wt 0.24 mg/kg wet wt 0.040 mg/kg wet wt

***** "Methods for Chemical Analysis of Water and Wastes", Environmental Protection Agency, Environmental Monitoring Systems Laboratory – Cincinnati (EMSL-CI), EPA-600/4-79-020, Revised March 1983 and 1979 where applicable.

****** WES SOP *Determination of Chlorinated Pesticides, PCB Arochlor(s) and PCB congeners in Fish and Biological Tissue* (modified AOAC 983.21)

*** Multiple MDLs and/or RDLs reflect different detection levels established by WES for unique batches of fish tissue samples analyzed at different times.

REFERENCES

Maietta, R. J, J. Colonna-Romano, and R.F. Chase. 2002. *2001 Fish Toxics Monitoring Public Request and Year 2 Watershed Surveys*. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA.

APPENDIX G

2001 DEP DWM FISHERIES MONITORING TECHNICAL MEMORANDUM

Subject: FARMINGTON RIVER WATERSHED 2001 FISH POPULATION ASSESSMENT

Prepared by: Peter Mitchell, DEP/ Division of Watershed Management, Worcester, MA

Date: 10/28/2003

2001 Farmington River Watershed Fish Population Surveys

The DWM conducted biological surveys on the Farmington River and selected tributaries to the Farmington River during the summer of 2001. Sampling was conducted as part of a more comprehensive water quality monitoring project by the Division of Watershed Management. A total of eight stations were sampled (Table 1). Surveys were conducted using techniques similar to Rapid Bioassement Protocols III (benthic macroinvertebrates) and V (fish) as described by Plafkin (1989). Surveys also included a habitat assessment component modified from that described in the aforementioned document (Table 2). The results from the macroinvertebrate survey are reported in a separate document.

Fish populations were sampled by electrofishing using a Coffelt Mark 18 gas powered backpack electrofisher. A reach of between 80m and 100m was sampled by passing a pole mounted anode ring, side to side through the stream channel and in and around likely fish holding cover. All fish shocked were netted and held in buckets. Sampling proceeded from an obstruction or constriction, upstream to an endpoint at another obstruction or constriction such as a waterfall or shallow riffle. Following completion of a sampling run, all fish were identified to species, measured, weighed, and released. Results of the fish population surveys can be found in Table 3.

The Farmington watershed was affected by drought during the time of sampling. This condition resulted in extremely low water levels (figure 1), and increased water temperatures. These conditions resulted in a reduction of available, adequate habitat (Table 2).

Station Specific Conditions and Findings:

Waterbody Name:	Valley Brook
Waterbody Location:	Route 57, Granville
	Latitude: 42.04.54
	Longitude: 72.54.34
Sampling Date:	August 14, 2001

The stream reach was heavily forested with both coniferous and deciduous trees. The canopy cover was 100% through the reach. The understory was limited due to lack of sunlight. However, the shading helped to reduce evaporation and radiational heating of the water and substrate. There is almost no permanent human activity proximal to this reach. Moss-covered boulders dominated the substrate. This station received the third highest habitat score (164) of all stations assessed. One of its key shortcomings is the lack of a variety of velocity and depth combinations.

One hundred twenty one fish were collected at this station: [brook trout (*Salvelinus fontinalis*, n=58), dace (*Rhinicthys sp.,* n=44), slimy sculpin (*Cottus cognatus,* n=19)]. This community was representative of a high-quality, cold-water stream. All fishes collected were fluvial. The brook trout appear to be reproducing, based on the range of lengths of those collected (42mm – 212mm).

Waterbody Name: Hubbard Brook
Waterbody Location: West Hartland Road, Granville
Latitude: 42.03.51
Longitude: 72.58.00
Sampling Date: August 14, 2001

The habitat parameters assessed were all within the optimal ranges. However, this station (as with all stations in the Farmington watershed) was affected by drought. Low flow conditions limited the amount of available instream habitat. The canopy cover was extensive (>90%), and aided in the reduction of solar radiation. Boulders that provided the majority of instream fish cover dominated the substrate. This station received the highest habitat score (184 – tied with Sandy Brook) of all stations assessed.

Ninety-three fish were collected from this station (brook trout (n=38), dace (n=46), brown trout (*Salmo trutta,* n=2), creek chub (*Semotilus atromaculatus,* n=3), white sucker (*Catostomus commersoni,* n=3), fallfish (*Semotilus corporalis,* n=1)). Brook trout and dace dominated the fish community sampled. The trout represented a number of different age classes. Brown trout, creek chub, fallfish, and white sucker were also collected, although their overall numbers were low. The presence of, and dominance by, brook trout is indicative of excellent water and habitat quality.

Waterbody Name: West Branch Farmington River at Roosterville
Waterbody Location: Clark Road, Sandisfield
Latitude: 42.04.44
Longitude: 73.04.23
Sampling Date: August 14, 2001

The sampling reach was located near the USGS gage. The daily mean stream flow on the date of sampling was 19 cfs. The mean flow at this gage (over 90 years) is usually 87 cfs (USGS 2002). The gradient at this station is limited, as is the canopy cover. This is due to the width of the sampled reach (~50'), and a lack of riparian vegetative cover. Instream habitat was pool dominated, and this station displayed the lowest variety of velocity and depth combinations. Although there were several boulders in the stream, the substrate was dominated by sand and gravel. The width of the stream, and lack of instream habitat structure, made sampling difficult. Some fish were seen, but escaped capture. This site had the lowest habitat score of all stations assessed (124). The lack of fish cover, shading, and variety of flow and depth conditions detracted from the habitat score.

The stream width and lack of habitat structure made electrofishing at this station very problematic. Fish species collected at this station, in order of abundance, included: dace (n=5), smallmouth bass (*Micropterus dolomieu,* n=5), cutlips minnow (*Exoglossum maxillingua,* n=3), pumpkinseed (*Lepomis gibbosus,* n=1), and tessellated darter (*Etheostoma olmstedi,* n=1). The total number of fishes collected was very low (n=15). Many of the fish (n=9) were young of the year.

Waterbody Name: Clam River
Waterbody Location: Beech Plain Road, Sandisfield
Latitude: 42.07.58
Longitude: 73.06.19
Sampling Date: August 15, 2001

This segment is located 0.35 river miles downstream of an un-named reservoir in Sandisfield. The sampling reach displayed a diverse mix of pool, riffle, and run/glide habitat containing excellent fish cover in the form of snags, undercut banks, and boulders. Water was clear but highly colored. The reach was well shaded by trees and some woody shrubs. This station received the second highest habitat score (179).

The fishes collected were; dace (n=66), cutlips minnow (n=39), slimy sculpin (n=29), brown trout (n=18), white sucker (*Catostomus commersoni*, n=11), brook trout (n=6), and pumpkinseed (n=1). The trouts were represented by a number of different age classes, and the white suckers were mostly "young of the year". The trouts collected were all intolerant, fluvial dependents and fluvial specialists. The variation in

trout age-classes (and the presence of slimy sculpin) implies that this stream is capable of supporting reproducing cold-water populations.

Waterbody Name: Sandy Brook
Waterbody Location: Route 183, Sandisfield
Latitude: 42.03.59
Longitude: 73.09.28
Sampling Date: August 15, 2001

This stream reach is high-gradient, with a boulder dominated substrate. The proximal riparian zone is heavily forested, providing complete canopy cover. The instream habitat is best described as a "pool / drop" habitat; with almost no "run" habitat. Abrupt drops over large boulders separate small pools. These conditions stand in contrast to the conditions existing 0.6 river miles upstream. At this upstream location, the stream is impounded in an area of wetlands. This reach received the highest habitat score (184 – tied with Hubbard Brook) of all stations assessed. This reach had excellent riparian buffer, bank protection, and instream cover.

The fish community sample contained dace (n=88), common shiner (*Luxilus cornutus*, n=69), creek chub (n=31), white sucker (n=9), pumpkinseed (n=8), brown bullhead (*Ameirus nebulosus*, n=3), brook trout (n=3), American eel (*Anguilla rostrata*, n=2), and chain pickerel (*Esox niger*, n=1). Although the brook trout are intolerant, fluvial dependents there was a lack of multiple age-classes collected. Other species collected - pumpkinseed, chain pickerel, and brown bullhead - represent macrohabitat generalists that are indicative of lentic, slow moving, or impounded lotic environments. It is possible that these warm-water fishes have emigrated from upstream, lacustrine, waters.

Waterbody Name: Fall River
Waterbody Location: Reservoir Road, Otis
Latitude: 42.09.31
Longitude: 73.04.07
Sampling Date: August 15, 2001

This stream reach is located ~0.7 river miles below the outfall of Otis Reservoir. The reach displayed signs of drought affectation, in that the majority of the boulder dominated substrate was exposed. The proximal riparian zone was dominated by forest, providing a complete canopy. The stream, at this location, is considered to be high-gradient, and the instream habitat quality is optimal. However, the quantity of available instream habitat was lacking due to low flow conditions. This station received the third lowest habitat score (160). This station's shortcomings were channel flow status (due to the lack of water), and riparian vegetation (due to the proximity of Reservoir Road). The channel flow status at this station score was eight; the lowest score of all stations assessed.

The sample of the fish community contained dace (n=31), brook trout (n=5), and largemouth bass (n=2). The total number of fish collected was quite low in this segment of the Fall River. This outfall reach received very little water from Otis Reservoir due to drought conditions. The reduced flow, in turn, reduced the amount of available habitat. Although the presence of brook trout is heartening, the presence of young of the year largemouth bass is indicative of potential immigration of lentic species from the proximal, upstream, impoundment.

Waterbody Name: Benton Brook
Waterbody Location: Beech Plain Road, Otis
Latitude: 42.11.01
Longitude: 73.05.14
Sampling Date: August 15, 2001

This is a first-order stream segment. It is located ~0.4 river miles downstream of an impoundment (Owl Pond), with abutting, yet sparse, residential development. The proximal riparian zone is dominated by coniferous forest, providing almost a complete canopy. The segment is considered high gradient, with a boulder-dominated substrate. The instream habitat contains a "pool / drop" flow regime, with optimal

cover in the form of snags, undercut banks, and boulders. This station received the second lowest habitat score (154) of all stations assessed. This low score is due, primarily, to the proximal residential development. However, Owl Pond seems to be providing adequate flows, even during these drought conditions.

The fish community sample contained common shiner (n=37), dace (n=23), golden shiner (*Notemigonus crysoleucas*, n=21), cutlips minnow (n=5), creek chub (n=3), brook trout (n=3), and white sucker (n=2). The brook trout were "young of the year", and the other species were all fluvial dependants or fluvial specialists.

Waterbody Name:	West Branch Farmington (Otis)
Waterbody Location:	Route 8, Otis
	Latitude: 42.11.42
	Longitude: 73.05.27
Sampling Date:	August 15, 2001

This reach is located along Route 8, ~0.2 river miles upstream of the Route 23 bridge in the town of Otis. The proximal riparian area is lawn with a brief zone of deciduous trees and woody shrubs. This provides a limited canopy cover. The substrate is primarily boulder dominated with some cobble. Instream habitat is comprised of some pools and snags. This segment is not high gradient, yet receives relatively high velocity flows in the spring.

Low water levels, combined with many boulders, made electrofishing in this reach difficult, by reducing our ability to easily move among the boulders. Collected fishes included common shiner (n=58), dace (n=41), smallmouth bass (n=39), white sucker (n=17), cutlips minnow (n=6), and golden shiner (n=1). The appearance of lentic species may be due to the presence of a large pool immediately downstream of the sampled stream reach. The lack of an extensive canopy over this reach, and the downstream lentic section, allow for heating of the substrates and water.

Summary of Conditions

The drought of 2001 greatly affected the Farmington watershed. The lack of rain reduced the quantity, but not the quality, of the available habitat. Valley Brook, Hubbard Brook, and the Clam River all supported cold-water species (brown trout and brook trout). Valley Brook and the Clam River also contained populations of slimy sculpin that supports the designation of these waters as cold-water fisheries.

Fall River appears to be most affected by drought of all the stations examined. This is most likely due to the fact that its source is the outfall from Otis Reservoir. The reservoir elevation was reduced during the summer of 2001, and did not supply as much water to this segment as may normally be expected. Although brook trout were collected at this station, the similarity of their lengths (from 129mm to 195mm), and their small numbers (5 fish collected), points towards a non-reproducing population.
The Farmington watershed displays the least amount of anthropogenic impact of all the watersheds in Massachusetts. The mainstem stations (West Branch Farmington at Roosterville, and West Branch Farmington at Otis) appeared to be capable of supporting a warm-water fishery.

Literature Cited

U.S. Geological Survey 2002. Water resources Data for Massachusetts and Rhode Island, Water Year 2001. Authors: Socolow, R.S., C.R. Leighton, J.S. Whitley, D.J. Ventetuolo. *USGS-WDR-MA-RI-01-1*. Department of the Interior, Virginia.

Figure 1: Massachusetts Surface-Water Runoff Conditions, August 2001.
(Courtesy of http://ma.water.usgs.gov/current_cond/images/01_08_sw_map.gif)

Figure deleted for this electronic copy. See original document or web link for figure.

Table 1: 2001 Farmington Watershed Fish Population Station Locations

Waterbody	Location	Lat. / Lon.	Date	Segment
Valley Brook	~400m upstream of Rte. 57, Granville	42.04.54/ 72.54.34	14 August 2001	31-15
Hubbard Brook	~300m upstream of West Hartland Rd. Bridge, Granville	42.03.51/ 72.58.00	14 August 2001	31-16
West Branch Farmington River (Roosterville)	~ 30m downstream of Clark Road, Sandisfield	42.04.44/ 73.04.23	14 August 2001	31-01
Clam River	Beech Plain Road, Sandisfield	42.07.58/ 73.06.19	15 August 2001	31-03
Sandy Brook	Route 183, Sandisfield	42.03.59/ 73.09.28	15 August 2001	31-14
Fall River	Reservoir Road, Otis	42.09.31/ 73.04.07	15 August 2001	31-02
Benton Brook	Beech Plain Road, Otis	42.11.01/ 73.05.14	15 August 2001	31-11
West Branch Farmington (Otis)	Route 8, Otis	42.11.42/ 73.05.27	15 August 2001	31-01

Table 2: Habitat assessment summary for fish population stations sampled during the 2001 Farmington river watershed survey on 14 and 15 August 2001.

Habitat Parameter	Valley Brook		Hubbard Brook		W.Br. Farmington (Roosterville)		Clam River		Sandy Brook		Fall River		Benton Brook		W.Br. Farmington (Otis)	
Instream Cover	18		17		8		19		19		17		17		16	
Epifaunal Substrate	8		16		7		17		19		18		16		17	
Embeddedness	17		18		19		18		17		19		17		17	
Channel Alteration	20		20		20		19		19		19		18		19	
Sediment Deposition	18		19		12		17		18		15		14		13	
Velocity-Depth Combination	5		17		3		17		16		15		10		14	
Channel Flow Status	18		17		18		16		16		8		13		18	
Bank Vegetative Protection	10	10	10	10	7	3	10	10	10	10	10	7	8	10	9	7
Bank Stability	10	10	10	10	9	9	10	10	10	10	9	9	8	9	9	9
Riparian Vegetative Cover	10	10	10	10	8	1	8	8	10	10	10	4	4	10	9	6
TOTAL SCORE	164		184		124		179		184		160		154		163	

Table 3. Fish population data collected by DWM at eight biomonitoring stations in the Farmington River watershed between 14 and 16 August 2001. Sampling stations were at: Valley Brook, Hubbard Brook, West Branch Farmington River (Roosterville)(R), Clam River, Sandy Brook, Fall River, Benton Brook, and West Branch Farmington (Otis)(O). Refer to Table 1 for a complete listing and description of sampling stations.

TAXON		Habitat Class[1]	Trophic Class[2]	Tolerance Class[3]	Valley Brook	Hubbard Brook	W Br. Farm. (R)	Clam River	Sandy Brook	Fall River	Benton Brook	WBr. Farm. (O)
common shiner	*Luxilus cornutus*	FDR	GF	M	-	-	-	-	69	-	37	58
dace	*Rhinichthys sp.*	FS	**GF/BI**	T/M	44	46	5	66	88	31	23	41
creek chub	*Semotilus atromaculatus*	MG	GF	M	-	3	-	-	31	-	3	-
fallfish	*Semoilius corporalis*	RFS	GF	M	-	1	-	-	-	-	-	-
cutlips minnow	*Exoglossum maxillingua*	-	BI	T	-	-	3	39	-	-	5	6
golden shiner	*Notemigonus crysoleucas*	FDR	GF	T	-	-	-	-	-	-	21	1
white sucker	*Catostomus commersoni*	FDR	GF	T	-	3	-	11	9	-	2	17
brown bullhead	*Ameiurus nebulosus*	MG	GF	T	-	-	-	-	3	-	-	-
yellow perch	*Perca flavescens*	MG	TC	M	-	-	-	-	-	-	-	-
tessellated darter	*Etheostoma olmstedi*				-	-	1	-	-	-	-	-
brown trout	*Salmo trutta*	FS	TC	I	-	2	-	18	-	-	-	-
brook trout	*Salvelinus fontinalis*	FDR	TC	I	58	38	-	6	3	5	3	-
largemouth bass	*Micropterus salmoides*	MG	TC	M	-	-	-	-	-	2	-	-
smallmouth bass	*Micropterus dolomieu*	MG	TC	M	-	-	5	-	-	-	-	39
pumpkinseed	*Lepomis gibbosus*	MG	GF	M	-	-	1	1	8	-	-	-
American eel	*Anguilla rostrata*	MG	TC	T	-	-	-	-	2	-	-	-
slimy sculpin	*Cottus cognatus*	FS	BI	I	19	-	-	29	-	-	-	-
chain pickerel	*Esox niger*	-	TC	M	-	-	-	-	1	-	-	-

[1] Habitat Class - FS (fluvial specialist), FDR (fluvial dependent reproduction), MG (macrohabitat generalist). From Bain and Meixler (2000), modified for Massachusetts

[2] Trophic Class - GF (generalist feeder), BI (benthic invertivore), TC (top carnivore), WC (water column invertivore). From Halliwell et al. (1999)

[3] Tolerance Classification - I (intolerant), M (moderately tolerant), T (tolerant). From Halliwell et al. (1999)

(R) = Roosterville, (O) = Otis