7.0 BIOLOGICAL DATA COLLECTION SUMMARY

Two biological field surveys were performed in July 1999 and August/September 2000 concurrent with intensive summer surveys. Biological surveys included characterization of the nature and extent of the aquatic biologic communities in river impoundments. The biological surveys are described in this section. A glossary of aquatic biology terms is provided in Section 7.4 to assist the reader and includes definitions of key technical terms. Also, illustrations of a set of aquatic macrophytes commonly observed in the Assabet River are provided in Figures 7-1 through 7-7.

River impoundments were the focus of the biological surveys because the effects of eutrophication have been observed to be most acute in impoundments. The biological surveys included the following components:

- Water column sampling for chlorophyll-a, an indicator of algal population, at 23 river locations, 5 impoundment locations, and 10 tributary locations.
- Aquatic biology surveys in five impoundments, including:
  - Phytoplankton sampling,
  - Zooplankton sampling (2000 only),
  - Assessment of macrophyte community features, and
- Assays intended to evaluate potential response of dominant plants to changes in nutrient levels (2000 only).

The following five river impoundments were surveyed:

- #1 - Allen Street Dam Impoundment (RM 25.6);
- #2 - Hudson/Rte 85 Dam Impoundment (RM 18.3);
- #3 - Gleasondale Impoundment (RM 14.2);
- #4 - Ben Smith Impoundment (RM 8.8); and
- #5 - Power Mill Impoundment (RM 6.3).

The locations of the 5 river impoundments are illustrated in the Assabet River map (Figure 3-1). Section 6 provides a description of the river impoundments, including impoundment bathymetry and sediment thicknesses. Summaries of the Summer 1999 and Summer 2000 biological data collection programs are provided below followed by a comparison of the two surveys (Section 7.3).

7.1 Summer 1999 Biological Data Collection

The Summer 1999 biological data collection program may be summarized as assessments of the nature and extent of phytoplankton and macrophyte communities in the Assabet River system.

7.1.1 Summer 1999: Phytoplankton Assessment

Water samples were collected throughout the Assabet River on July 21-23, 1999 and analyzed for chlorophyll-a and phaeophytin concentrations (Table 7-1). Total chlorophyll-a concentration measurements ranged from 0.2 to 45.9 ug/l and included only plankton (not algal mats or other macrophytes). Total chlorophyll-a concentration measurements at river locations were typically 1.0 - 4.0 ug/l. Total chlorophyll-a concentrations in river impoundments were typically significantly higher than those of river stations. In the Ben Smith and Powdermill Impoundments, total chlorophyll-a was measured to be 34.8 and 45.8 ug/L, respectively. In general, however, water column phytopigment levels were not unusually high; most pigment was associated with algal mats and vascular plants not sampled for phytopigment concentration.

Taxonomic content of the algal assemblage (Tables 7-2 and 7-3) included many species associated with nutrient-enriched systems, but biomass was generally low (range = 470 -1290 ug/L, with values <1000 ug/L typically considered low). The number of genera present in samples was low to moderate, suggesting that the community is not particularly rich. Seven major algal divisions were represented, but the number of genera from each division was limited, sometimes to a single genus. No taxa were especially dominant, but the distribution of cells among the taxa present was uneven and resulted in low diversity and evenness measures of community structure. Blue-green algae (more properly Cyanobacteria) were numerically most abundant, but small cell size limits their contribution to biomass.

Algal mats were not included in the plankton analysis, as these mats are defined as macrophytes ("large plants"). These mats represented a substantial portion of the algal biomass in the impoundments at the time of sampling and are described below.

7.1.2 Summer 1999: Macrophyte Assessment

A field survey of macrophytes in five impoundments of the Assabet River was performed on July 23, July 26, and July 27, 1999. At each impoundment surveyed, a series of transects perpendicular to the perceived stream channel were established. At multiple points along each of these transects, the dominant vegetation was identified, plant distribution was mapped, and cover and biomass ratings were assigned. Ratings involved a scale of 0-5, with 0 indicating no plants and 5 signifying complete cover or filling of the water column (biovolume was used as a surrogate for biomass). Values of 1 through 4 represent quartiles for cover or biomass. The information gathered from these transects was combined to give a general picture of the impoundment macrophyte community.

The composition, relative abundance, and biomass estimates from the impoundment surveys are provided in Table 7-4. Maps of macrophyte coverage and biomass in each of the 5 major river impoundments are provided in Figures 7-8 through 7-17. A description of macrophytes present in each river impoundment during the Summer 1999 survey is provided below.

The overall composition of the macrophyte assemblages in the five impoundments includes three major groups of plants. The three major groups of plants are listed below along with references to figures illustrating each species:

- Floating forms not rooted in the sediment, including duckweed (Figure 7-1), watermeal (Figure 7-2), and green algal mats.
- Floating forms rooted in the sediment, including water lilies (Figure 7-3) and water chestnut (Figure 7-4).
- Submergent rooted forms, including waterweed (Figure 7-5), pondweeds (Figure 7-6), and coontail (Figure 7-7).

Each group is dominant in different locations and at various times. Introduced invasive species include water chestnut (*Trapa natans*), curlyleaf pondweed (*Potamogeton crispus*) and fanwort (*Cabomba caroliniana*), none of which was a widespread dominant in the Assabet River impoundments during the Summer 1999 survey. Duckweed (*Lemna minor*), watermeal (*Wolfia columbiana*) and filamentous green algal mats were observed to completely cover the surface of the some impoundments, and waterweed (*Elodea canadensis*) and coontail (*Ceratophyllum demersum*) was observed to fill much of the water column underneath, at some locations.

Collection and identification of mat-forming algal genera (Table 7-5) indicates that the mesh-like chlorococcalean green alga Hydrodictyon is dominant in virtually all impoundments, sometimes with large quantities of several filamentous green algal genera (Rhizoclonium/Cladophora and Spirogyra). Other, smaller chlorococcalean greens were also common, but do not provide nearly the biomass of the mesh or filamentous forms. Several diatom genera were also associated with the mats, but represented only limited biomass. Virtually all species present are typically associated with high levels of N and P, and show a general preference for higher N:P ratios. Rooted plant biomass is also large in these impoundments.

Conversion of plant density classes (rating of 0 to 5) to actual biomass values is required in order to estimate biomass. Initially for the Summer 1999 survey data, literature-based estimates of density class to biomass conversion factors were applied to convert density classes (ratings of 0 to 5) to biomass in kg/m^2. During the Summer 2000 survey, more robust field macrophyte biomass measurements were collected by ranking and weighing many biological samples. The Summer 2000 survey included development of a set of site-specific density class (0 to 5 ranking) to biomass conversion factors. The site-specific conversion factors were then applied to recalculate the conversion of density class rankings (0 to 5) to biomass in kg/m^2 for Summer 1999 data. As a result of this more robust method of estimating biomass in the Assabet River, Summer 1999 biomass estimates have been modified and are more accurate.

A brief description of macrophytes in each impoundment is provided below.

Allen Street Dam Impoundment

Figures 7-8 and 7-9 contain maps of estimated macrophyte coverage and biomass in the Allen Street Dam Impoundment during the Summer 1999 survey. The most abundant plant taxa noted was filamentous green algae (FGA) which comprised about 40% of the vegetation by cover. The other dominant macrophytes identified included waterweed (*Elodea canadensis*), duckweed (*Lemna minor*), watermeal (*Wolffia columbiana),* and curly-leaved pondweed (*Potamogeton crispus*), with some narrowleaf pondweed (*Potamogeton pusillus* var. *tenuissimus)* also detected. Total biomass was estimated at about 5960 kg with an average density of 0.72 kg/m^2.

Hudson/Rt 85 Dam Impoundment

Figures 7-10 and 7-11 contain maps of estimated macrophyte coverage and biomass in the Hudson/Rt 85 Dam Impoundment during the Summer 1999 survey. Macrophyte abundance was much greater at this impoundment than upstream, to the point of impeding boat movement. At this impoundment coontail (*Ceratophyllum dermersum*) was the dominant taxon at 41% of the cover. Other dominant macrophytes identified included waterweed, duckweed, watermeal and FGA. The total biomass was significantly higher than at Allen Street Dam Impoundment and was estimated at 118,000 kg with an average density of 2.31 kg/m^2.

Gleasondale Impoundment

Figures 7-12 and 7-13 contain maps of estimated macrophyte coverage and biomass in the Gleasondale Impoundment during the Summer 1999 survey. The pattern of macrophyte dominance in Gleasondale Impoundment was the same as that of the Hudson Impoundment. Other taxa of lesser prominence included narrowleaf pondweed, broadleaf pondweed (*Potamogeton amplifolius*), white water lily (*Nymphaea odorata*), yellow water lily (*Nuphar variegata*) and bur-reed (*Sparganium* spp.). The estimated amount of biomass was 83,000 kg with an average density of 1.91 kg/m^2.

Ben Smith Impoundment

Figures 7-14 and 7-15 contain maps of estimated macrophyte coverage and biomass in the Ben Smith Impoundment during the Summer 1999 survey. The vegetation composition at the Ben Smith Impoundment included 11 taxa. The dominant taxon was FGA, with duckweed, watermeal, coontail and flatstem pondweed (*Potamogeton zosteriformis*) present in substantial quantities. Also found at low levels (<1%) were water chestnut (*Trapa natans*), curlyleaf pondweed, narrowleaf pondweed, waterweed, and fanwort (*Cabomba caroliniana*). The estimated biomass was 93,600 kg with an average density of 1.01 kg/m^2.

Powder Mill Impoundment

Figures 7-16 and 7-17 contain maps of estimated macrophyte coverage and biomass in the Powder Mill Impoundment during the Summer 1999 survey. The Powder Mill Impoundment was another highly productive. The field survey noted that the pond surface was 100% covered with macrophytes. The most abundant species were coontail, waterweed, duckweed, watermeal, FGA and fanwort, with 5 other species present in lesser abundance. The estimated biomass was 183,000 kg with an average density of 1.90 kg/m^2.

7.2 Summer 2000 Biological Data Collection

The Summer 2000 biological data collection program may be summarized as assessments of the nature and extent of phytoplankton, zooplankton, and macrophyte communities in the Assabet River systems. In addition, an algal assay experiment was performed to evaluate the growth patterns of dominant macrophytes under different nutrient availability conditions was performed and is summarized (Section 7.2.4).

7.2.1 Summer 2000 Phytoplankton Assessment

Water samples were collected throughout the Assabet River on August 29, 2000 and analyzed for chlorophyll-a and phaeophytin concentrations (Table 7-6). Total chlorophyll-a concentration measurements ranged from 0.58 to 41.7 ug/l and included only plankton (not algal mats or other macrophytes). Chlorophyll-a values were elevated in and around the Ben Smith Impoundment where values ranged from 13.4 to 41.7 ug/L (RM 11.4 to 8.6). Except for the Ben Smith Impoundment, chlorophyll values were lower than impoundment chlorophyll-a values measured during the Summer 1999 survey. This may be partially due to differences in hydrologic conditions between the Summer 2000 and Summer 1999 surveys. Specifically, during the Summer 2000 survey, water levels were higher and flushing rates in impoundments faster than those of the Summer 1999 survey. As a result, phytoplankton would have less residence time in impoundments time to grow and increase in density under Summer 2000 survey hydrologic conditions.

Phytoplankton in the Assabet River were assessed from whole water samples collected near the surface of each of five impoundments, but away from substantial macrophyte growths (including algal mats). A summary of phytoplankton variety and density is provided in Table 7-7 and a summary of estimated phytoplankton biomass is provided in Table 7-8. Phytoplankton analysis results indicate low to moderate phytoplankton abundance, with cell densities and biomass estimates similar to those observed during the Summer 1999 survey. Four out of five impoundments exhibited phytoplankton biomasses near 1000 ug/L, the general limit for low vs. moderate biomass. High flushing and light restrictions imposed by macrophyte cover appear to be important controls on phytoplankton biomass.

Species richness was also low to moderate, while diversity and evenness (measures of the distribution of individuals among taxa present) were moderate to high. In general, no single or small set of taxa dominated the phytoplankton; a fairly even mix of algal groups was present in most samples. Diatoms were most abundant overall, followed by flagellates (cryptomonads and dinoflagellates). Blue-green algae, or more properly Cyanobacteria, were uncommon except in the most downstream impoundment. The pattern of blue-green biomass is often linked to organic nitrogen levels, and is consistent with the pattern of high initial levels declining in the downstream direction.

7.2.2 Summer 2000: Zooplankton Assessment

Zooplankton were collected from each of five Assabet River impoundments on August 31, 2000 by towing a plankton net with a mesh size of 53 microns through the water column. Slightly less than 1000 L of water were filtered in this manner, yielding a representative sample of zooplankton present in each impoundment. As shown in Tables 7-9 and 7-10, zooplankton were scarce in the open water of the Assabet River impoundments during the Summer 2000 survey. Zooplankton biomass ranged from 1.2 to 17.2 ug/L, with values less than about 100 ug/L considered low. Rotifers, copepods and cladocera were detected, but none in even moderate abundance. No large bodied forms were encountered. The number of species in each sample increased in the downstream direction, but was not large in any sample. The low species richness yielded widely varying and generally non-conclusive diversity and evenness values.

7.2.3 Summer 2000: Macrophyte Assessment

A field survey of macrophytes in five impoundments of the Assabet River was performed during the Summer 2000 survey. The Summer 2000 macrophyte assessment included development of a set of site-specific density scale to biomass conversion factors. To establish a set of site-specific density scale to biomass conversion factors, numerous aerial plots characterized as belonging to either density class 1, 2 3 or 4 for macrophyte biomass ratings were harvested and weighed. Resulting density classes and equivalent biomass estimates are provided in Table 7-11. Plot areas rated as a “1” for biomass averaged 438 g/m^2, while areas rated as “2” averaged 1,100 g/m^2, areas rated as “3” averaged 1,950 g/m^2, and areas rated as “4’ averaged 3,500 g/m^2. There is some overlap among rating classes; the high end of each class overlapped the low end of the class above. There is a distinct separation of means and medians, however, indicating that the estimation of biomass associated with the conversion is appropriate and useful.

The vascular plants and visible algal mats in the five Assabet River impoundments were quantitatively assessed and mapped based on the August 2000 survey data (Table 7-12, Figures 7-18 through 7-27), applying the same methodology as for the Summer 1999 survey data. Total biomass in each impoundment ranged from 3,720 to 116,000 kg, with average densities ranging from 0.46 to 1.67 kg/m^2. Corresponding total biomass values and density levels observed during the Summer 2000 survey were smaller than those of the Summer 1999 survey, with only the Summer 2000 values in the Ben Smith Impoundment approaching Summer 1999 levels. During both surveys, however, aquatic biomass values were very high and were indicative of extremely productive environments.

Several additional macrophyte taxa were detected during the Summer 2000 survey. This may be a consequence of lesser cover by floating species, allowing greater light penetration and survival by submergent species less tolerant of low light conditions. Water starwort (*Callitriche stagnalis*), another species of bur-reed (*Sparganium emersum*), a benthic macroalga (*Nitella flexilis*) and three additional pondweed species (*Potamogeton confervoides, P. spirillus, and P. robbinsii*) were found, but none were dominant.

The pattern of plant biomass and community composition observed in the Summer 2000 survey was similar to that observed in Summer 1999 survey, but with reduced abundance of floating species (duckweed, watermeal and FGA) and increased abundance by submergent species (especially coontail and waterweed). A shift was also observed in the composition of the filamentous green algal mats, with *Cladophora* becoming dominant over *Hydrodictyon*. Figures 7-1 through 7-7 contain illustrations of aquatic macrophytes commonly observed in the Assabet River Impoundments.

A brief description of macrophytes in each impoundment is provided below.

Allen Street Dam Impoundment

Figures 7-18 and 7-19 contain maps of estimated macrophyte coverage and biomass in the Allen Street Dam Impoundment during the Summer 2000 survey. There was no strong dominance of the Summer 2000 survey plant assemblage. Filamentous green algae (FGA) comprised the greatest portion of the vegetation by cover at 34%, followed closely by waterweed at 28%. Eight other taxa were present, including 5 not observed in 1999. Total biomass was estimated at about 3,720 kg with an average density of 0.46 kg/m^2.

Hudson/Rt 85 Dam Impoundment

Figures 7-20 and 7-21 contain maps of estimated macrophyte coverage and biomass in the Hudson/Rt 85 Dam Impoundment during the Summer 2000 survey. Macrophyte abundance was much greater at this impoundment than upstream, but was visibly reduced from Summer 1999 levels. Coontail (*Ceratophyllum dermersum*) was the dominant taxon at 37% of the cover, followed by waterweed at 24%. Other dominant macrophytes identified included duckweed, watermeal and FGA, all at 8-9% cover. The total biomass was estimated at 85,400 kg with an average density of 1.67 kg/m^2.

Gleasondale Impoundment

Figures 7-22 and 7-23 contain maps of estimated macrophyte coverage and biomass in the Gleasondaly Impoundment during the Summer 2000 survey. The pattern of macrophyte dominance in Gleasondale Impoundment was similar to that of Hudson Impoundment. Three species not encountered in Summer 1999 survey were noted in the Summer 2000 Gleasondale Impoundment Survey, the most abundant of which was Nitella fexilis at 14% cover. The estimated amount of biomass was 50,400 kg with an average density of 1.17 kg/m^2.

Ben Smith Impoundment

Figures 7-24 and 7-25 contain maps of estimated macrophyte coverage and biomass in the Ben Smith Impoundment during the Summer 2000 survey. The dominant taxon was FGA 48% cover (as it was in the Summer 1999 survey), with coontail the next most abundant taxon at 18% cover. Previously observed species were again observed, with one additional taxon detected, but all at relatively lower densities (compared to the Summer 1999 survey). The estimated biomass was 92,300 kg with an average density of 1.00 kg/m^2; these values were very similar to the Summer 1999 levels in the Ben Smith Impoundment.

Powder Mill Impoundment

Figures 7-26 and 7-27 contain maps of estimated macrophyte coverage and biomass in the Ben Smith Impoundment during the Summer 2000 survey. The most abundant species were waterweed (37% cover) and coontail (34% cover), with duckweed, watermeal, and FGA present in lesser abundance (6-8%). Other taxa, including two species not previously observed in this impoundment, were present at low levels. The estimated biomass was 116,000 kg with an average density of 1.21 kg/m^2.

7.2.4 Bioassay Assessment

Bioassays were performed for two common floating species from the Assabet River impoundments, duckweed and *Cladophora* (FGA). A pre-weighed sample of a healthy population collected from the impoundments was placed in a beaker containing one of several Assabet River solutions and kept under simulated ambient light conditions for one week (7 days). Treatments included untreated Assabet River water, dilutions of Assabet River water at 10:1, 50:1 and 100:1, alum-treated Assabet River water (reduces P to a low level, but does not affect N), and distilled water. Treatments were generally run in sets of 5 replicates. Biomass and phytopigment concentrations were assessed after the 7-day period.

Assays have rarely been performed for floating vascular plants or mat-forming algal species, due to logistical difficulties. It was believed, however, that some effort should be devoted to assessing potential response to changing nutrient levels, and some success has been achieved recently on a similar project within the SuAsCo basin (in Hop Brook, Marlborough and Sudbury). These assays are experimental, however, and results should be interpreted with caution at this stage.

The results of the assays (Figure 7-28) indicate relatively little change in the mass or pigment content of either duckweed or *Cladophora* in response to altered nutrient levels or ratios. Tukey tests for significant ANOVAs are reported as brackets in Figure 7-28. Previous results with *Hydrodictyon* (from the Hop Brook study) had suggested that a 4-7 day assay period was sufficient, but for the chosen taxa this length of incubation was apparently inadequate to manifest any impact of reduced nutrient availability.

There were some slight shifts in biomass and pigment content from either the initial cultures from which biomass was withdrawn for the assay or the ambient culture (i.e., grown in undiluted Assabet River water), but no change was striking and most were statistically insignificant. The most significant change was an increase in the relative percent of active chlorophyll-a vs. phaeophytin degradation products, suggesting that under stress the plants conserve chlorophyll-a. Luxury uptake by duckweed and Cladophora appears sufficient to maintain populations through at least a week of reduced nutrient availability. The bioassay assessment was not successful in quantifying the relationship between growth vs. available nutrients for dominant macrophytes. This assessment demonstrated that these species are very persistent once established. Additional assays would have to be performed, for a period of at least one month, to quantify the growth vs. nutrient availability relationship for these robust and persistent macrophytes.

7.3 Biological Assessment Summary

The overall findings of the Assabet River biological data collection program are summarized below, including comparisons of Summer 1999 and Summer 2000 observations.

7.3.1 Phytoplankton

Phytoplankton density, as cell counts or biomass, was observed to be low to moderate in all 5 river impoundments during the Summer 1999 and Summer 2000 surveys. It should be noted, however, that this assessment did not include algal mats, which were incorporated into the macrophyte assessment. Although phytoplankton productivity (generation of new algae) could be high in this system, the accumulated phytoplankton biomass is not unusually large.

Data for water chemistry and zooplankton suggest that biomass accumulation would not be limited by nutrient availability or grazing. It appears more likely that the low phytoplankton accumulation is a function of light limitation on productivity or flushing of biomass from the impoundments under sporadic high flows. Even during dry periods, detention times in the impoundments are relatively short compared to pond and lake system (e.g. several days rather that months). Consequently, true phytoplankton populations were not dominant factors in the functioning of the Assabet River impoundments during the biological surveys.

7.3.2 Zooplankton

The absence of large bodied zooplankters and the overall low zooplankton biomass (Summer 2000) indicates a major ecological imbalance in the river impoundments. As a result, grazing pressure on phytoplankton is minimal and food for planktivorous fish is scarce. It is possible that this situation is the result of intense predation, toxicity, low oxygen, or potentially high flushing rate. Zooplankton were not assessed as part of the Summer 1999 survey, when flushing rates were lower, and the Summer 2000 survey was performed during a relatively wet summer season with high flushing rates. While flushing is undoubtedly a factor in determining the composition and structure of the zooplankton community, it may not be the dominant factor leading to the observed assemblage.

Intense predation pressure could be responsible for observed conditions, but only if high densities of filter feeding fish (e.g., alewife, golden shiner) are present. Recent fishery data are lacking. Alternatively, introduction of toxic substances or periodic lack of oxygen could create the observed community structure. Recent major inputs of toxic substances have not been documented (ammonia levels, for example, are low) and, while oxygen levels are surely low at the sediment-water interface, complete anoxia in the water column of the impoundments was not observed. It is therefore uncertain why the impoundments host such unfavorable zooplankton populations, but some combination of predation, flushing and localized low oxygen appears plausible as an explanation.

7.3.3 Macrophytes

Excess growth of macrophytes was observed in river impoundments during the Summer 1999 and Summer 2000 surveys. The presence of dense macrophyte growths is known to inhibit phytoplankton production and biomass accumulation, and appears to have done so in the Assabet River impoundments. Filamentous algal mats of the division Chlorophyta are grouped with macrophytes in river impoundments, as those growths behave functionally more like vascular plants than phytoplankton. Green algal mats typically begin their life cycle from resting spores in the bottom sediments, growing to visible size before trapping enough photosynthetic gas to float to the surface of each impoundment. If light and nutrient availability is sufficient, algal mats may continue to grow for up to about two months and cover large expanses of impoundment surface. The chlorophytes *Cladophora* and *Hydrodicton* are the most troublesome mat-forming algae in the Assabet River impoundments, with *Hydrodictyon* more common during the Summer 1999 survey and *Cladophora* more abundant during the Summer 2000 survey. Mats of these algae are functionally equivalent to dense growths of duckweed or watermeal, which are also abundant in the Assabet River impoundments during summer.

The abundance of green algal mats, duckweed and watermeal is indicative of very high inorganic nitrogen concentrations. Available phosphorus must also be abundant to support such extensive growths, but a high N:P ratio is suggested by the species present. At such high densities, oxygen fluctuations could be expected, with high daytime values and low overnight values typical. Just how high or low is partly a function of flushing rate, which was always at least moderate in this system and was quite high in summer 2000. Even during the dry summer of 1999, background flows and discharges keep detention times below those typical for non-impounded lakes in Massachusetts. Flushing also affects biomass build-up, with lower values observed in 2000 when flushing was higher than in 1999. However, the combination of rooted species and entangled algal mats resulted in large macrophyte biomasses in both years.

The primary rooted species are waterweed and coontail, but there are many other submergent rooted species present in the Assabet River impoundments. The primary introduced species known to be invasive and deleterious to habitat and human uses are water chestnut, fanwort and curlyleaf pondweed. None of these invasive species was dominant in the system during summer 1999 or summer 2000 surveys, but the potential for expansion by one or more of these species exists. It is suspected that high cover by floating species has kept the submergent invasive species in check to date. This poses a dilemma for water quality management; improved water quality should lead to a decrease in floating species (duckweed, watermeal, and filamentous green algae), but could enhance conditions for submergent growth.

7.3.4 Summary

Macrophytes are dominant in Assabet River Impoundments. Phytoplankton and zooplankton appear to be relatively minor components of the Assabet River impoundment ecosystem. Far more biomass is presented by vegetation, especially floating species not rooted in sediment and rooted submergent species. Filamentous green algae mats are included as floating species and can be a dominant component of the macrophyte community in these impoundments. Vegetation density was observed to be at levels likely to significantly impair water quality and designated uses during both summer surveys.

Most of the dominant species observed in the Assabet River take their nutrition from the water column, an unusual situation typically associated with high dissolved nutrient levels. In particular, many of the vascular plants in the impoundments are known to take nutrition from the water column. This is not typical of vascular plants, but the nutrient rich waters of the Assabet appear to favor plants that are not rooted firmly in the sediment and can extract nutrients directly from the water column.

All of the species identified above are known to respond positively to eutrophication (i.e., grow aggressively to high density in the presence of elevated nutrient concentrations in the water), and assays with duckweed and the filamentous green alga *Cladophora* indicated that they are highly resistant to short-term reductions in nutrient availability. All of the currently abundant macrophyte species in the Assabet River impoundments are native to New England. Several potentially invasive non-native aquatic macrophytes were identified in the Assabet River, but none of these non-native species has achieved high densities in the Assabet River impoundments.

The biological data collection program was successful in capturing aquatic biological conditions in the Assabet River during the summers of 1999 and 2000. Biological measurements will be applied to support assessment of biological activity on the nutrient budget and to support mathematical models of the Assabet River system.

7.4 Glossary of Aquatic Biology Terms

ALGA (pl. **ALGAE**). Photosynthetic organisms, typically visible only with the aid of a microscope, that utilize solar energy and dissolved nutrients (Mn, N, P, Si) to live and reproduce. Algae can live either be suspended in the water column ("phytoplankton") or attached to some substrate ("periphyton"). Some are capable of swimming, others float in the water column. Aglae may be unicellular, colonial, or filamentous. Algae are grouped by main phytopigments, that typically give them characteristic colorations. Diatoms, green, and golden-brown algae are the most common freshwater forms, and red algae are usually found only in streams. Typical unicellular algae are diatoms and many green algae (e.g., *Chlorella*); colonial forms include *Volvox*, and filaments include *Spirogyra* and *Cladophora*. Blue-green algae are ecologically similar to "regular" algae, but are more appropriately categorized as specialized bacteria (Cyanobacteria). The most common cyanobacteria include *Microcystis*, *Oscillatoria*, *Anabaena*, which may grow to nuisance levels, and may release toxins in the water column.

BIOMASS. The total mass of living matter within a given unit of environmental area or volume.

CHLOROPHYLL *a*. Major light gathering pigment of all photosynthetic organisms (cyanobacteria, algae and vascular plants), essential for the process of photosynthesis, and giving the green coloration to most algae and plants. There are seven known types of chlorophyll; chlorophyll *a* is common to all photosynthetic organisms, and the amount present in surface waters may be correlated with the amount of suspended algae ("phytoplankton").

LIMITING FACTOR. A condition whose absence or excessive concentration is incompatible with the needs or tolerance of a species or population, and which may have a negative influence on their ability to thrive and/or survive. Most common factors limiting plants and algae are temperature, light, or a chemical constituents (including nutrients) that limits the organism's existence, growth, abundance, or distribution. Freshwater algae are typically limited by phosphorus availability; vascular plants may be limited by nutrients, light, and nature of the substrate (e.g., sand *vs.* boulders). Heterotrophic organisms (animals) are limited more typically by temperature or chemical constituents.

MACROPHYTE. A plant that is visible at the naked eye (without a microscope). Macrophytes include algae whose biomass becomes large to form a "plant-like" structure (e.g., benthic or floating algal mats), and all vascular plants. Macrophytes may be fully submerged (e.g., waterweed, fanwort), submerged with floating leaves (e.g., waterlilies, water chestnut), or free-floating (e.g., duckweed, water hyacinth). Fully submerged vascular plants grow flowers accompanied by a few floating leaves to the water surface during the flowering season.

PERIPHYTON. Algae living attached to a submerged substrate (rocks, macrophytes, sand, etc.), as opposed to free-floating forms ("phytoplankton").

PHOTOSYNTHESIS. The process in vascular plants, algae, and cyanobacteria by which carbohydrates are synthesized from carbon dioxide (CO_2) and water using light as an energy source. Most forms of photosynthesis release oxygen (O_2) as a byproduct. Chlorophylls typically act as the catalyst in this process.

PHYTOPIGMENT. Compound that gives a photosynthetic organism (algae and plants) a characteristic coloration, and captures the light energy required for photosynthesis. Chlorophylls are the most common phytopigments in all photosynthetic organisms, and give a green coloration. Other phytopigments give orange, red, or blue coloration.

PHYTOPLANKTON. Microscopic floating algae and cyanobacteria that live suspended in bodies of water and that drift about because they cannot move by themselves or because they are too small or too weak to swim effectively against a current.

PRODUCTIVITY. Energy in an ecosystem represented by the biomass produced minus the energy that went into its production, or the rate at which new biomass is produced in an ecosystem. High levels of energy in an ecosystem lead to high productivity and therefore to high biomass (e.g., high phytoplankton biomass in the presence of high nutrient concentrations).

SPECIES (or **TAXONOMIC**) **DIVERSITY**. A biological metric of ecosystems that reflects the degree of dominance (or lack thereof) of species or taxa within an ecological community, and the number of different species or taxa as well. A diverse community is characterized as having many species or taxa, none of which clearly dominates.

SPECIES (or **TAXONOMIC**) **EVENNESS**. A biological metric of ecosystems that reflects the degree of dominance (or lack thereof) of species or taxa within an ecological community, regardless of the number of different species or taxa (i.e., a normalized species diversity index).

SPECIES (or **TAXONOMIC**) **RICHNESS**. A biological metric of ecosystems that reflects how many species or taxa are present in an ecological community, i.e., the number of different species or taxa in a community.

TAXON (pl. **TAXA**). Groups of organisms that share similar charateristics. Typically, taxa represent species (e.g., *Hydrodictyon reticulatum*) or genera (e.g., *Hydrodictyon* sp.), but higher levels are also possible (e.g., Chlorophyta).

VASCULAR PLANTS. Macrophytes that are physiologically organized into multicellular bodies with specialized internal organs, such as sap vessels, and produce seeds. Aquatic macrophytes also typically produce flowers.

ZOOPLANKTON. Small, usually microscopic animals found in lakes, reservoirs, and rivers, that possess little or no means of propulsion. Consequently, animals belonging to this class drift along with the currents. Some may be barely visible at the unaided eye. Typically feed on phytoplankton.

Table 7-1 Summer 1999: Summary of Assabet River Chlorophyll-a Measurements

Sample Location			July 21, 1999			July 22, 1999			July 23, 1999		
Station	Rivermile	Description	phaeo (ug/l)	chl a (ug/l)	tot chl (ug/l)	phaeo (ug/l)	chl a (ug/l)	tot chl (ug/l)	phaeo (ug/l)	chl a (ug/l)	Tot chl (ug/l)
R28	30.7	Maynard St. Westborough	1.18	0.00	1.18				0.41	1.38	1.79
	30.5	Above Westborough WWTP	NA	NA	NA				0.20	0.00	0.20
R27	29.8	Rt. 9 Westborough	0.26	0.76	1.02				NA	NA	NA
R26	28.9	Rt. 135 Westborough	0.56	0.91	1.46				0.29	0.84	1.13
R25	28.0	School St. Northborough	0.49	1.07	1.56				0.72	1.16	1.88
R24	25.9	River St. Northborough	1.57	6.02	7.59				1.75	8.74	10.49
R23	25.1	Allen St. Impoundment, N'boro				1.48	4.13	5.62			
R22	25.0	Below Allen St. Impoundment	1.68	10.65	12.33				3.16	8.59	11.75
R21	23.9	Boundary St. Marlborough	0.34	1.23	1.57				0.46	1.85	2.31
R20	23.5	Robin Hill Rd. Marlborough	0.39	0.92	1.31				0.88	1.99	2.87
R19	21.7	Bigelow Rd. Berlin	0.65	1.86	2.51				1.09	3.32	4.41
R18	19.2	Chapin Rd. Hudson	0.35	0.94	1.29				0.58	1.64	2.22
R17	17.9	Hudson Center Impoundment				1.31	6.68	7.99			
R16	17.6	Rt. 85 Hudson	0.35	1.11	1.46				0.94	3.33	4.27
R15	15.9	Cox St. Hudson	0.24	0.90	1.14				0.34	0.67	1.02
R13	14.1	Gleasondale Impoundment				0.36	0.75	1.11			
R12	13.9	Below Gleasondale Dam, Stow	0.29	0.93	1.23				0.55	1.98	2.53
R11	11.4	Boon Road, Stow	0.90	2.58	3.48				0.79	3.94	4.73
R10	9.2	White Pond Road, Maynard	3.52	9.87	13.39				0.67	2.84	3.51
R9	8.7	Ben Smith Impoundment				5.05	29.72	34.77			
R8	8.6	Rt. 117/62 Maynard	3.76	8.47	12.23				0.59	2.25	2.84
R7	7.4	USGS Gauge, Maynard	1.65	6.23	7.88				1.03	1.89	2.92
R6	6.2	Powder Mill Impoundment				11.24	34.56	45.80			
R5	6.1	Below Powder Mill Dam	1.97	3.99	5.95				1.68	1.79	3.47
R4	4.4	Damonmill, Concord	0.74	3.52	4.26				0.57	2.26	2.83
R3	3.1	Rt. 62, Concord	0.67	2.09	2.77				0.58	1.80	2.38
R2	2.4	Rt. 2 Bridge, Concord	1.01	3.10	4.11				0.90	2.60	3.50
Tributary Sampling Locations											
T11	29.4	Hop Brook	0.75	2.60	3.35				0.61	1.00	1.61
T7	18.1	Hog Brook	0.37	2.01	2.38				1.14	1.98	3.12
T6	17.8	Mill Brook	0.95	4.30	5.25				0.96	2.58	3.55
T3	4.3	Second Division Brook	1.39	4.08	5.47				2.50	3.84	6.34
T2	3.0	Nashoba Brook	1.69	5.51	7.20				2.14	5.23	7.37

Notes:
Bold horizontal line indicates approximate impoundment dam locations

Table 7-2 Summer 1999: Phytoplantion Density in the Assabet River Impoundments

PHYTOPLANKTON DENSITY (CELLS/ML)						
TAXON	**Allen St. Impoundment (RM 25.6)**	**Hudson Impoundment (RM 18.3)**	**Gleasondale Impoundment (RM 14.2)**	**Ben Smith Impoundment (RM 8.8) 1st Half**	**Ben Smith Impoundment (RM 8.8) 2nd Half**	**Powdermill Impoundment (RM 6.3)**
BACILLARIOPHYTA						
Cocconeis	36	60	36	0	0	36
Eunotia	0	0	36	0	36	36
Fragilaria	216	90	0	0	36	432
Melosira	36	0	0	30	180	720
Navicula	72	30	36	30	0	0
Nitzschia	36	0	36	0	0	36
Stephanodiscus	36	90	36	0	0	36
Synedra	108	30	36	0	0	36
CHLOROPHYTA						
Ankistrodesmus	36	0	0	0	0	0
Botryococcus	432	0	0	0	0	0
Chlamydomonas	0	0	36	0	36	0
Cosmarium	0	0	0	0	0	36
Eudorina	0	0	0	0	0	432
Oocystis	0	120	0	0	0	0
Pandorina	0	240	0	120	0	144
Scenedesmus	0	0	0	120	0	1150
Schroederia	0	0	0	30	0	0
Tetraedron	0	0	36	0	0	36
CHRYSOPHYTA						
Mallomonas	0	30	0	0	0	0
CRYPTOPHYTA						
Cryptomonas	360	180	72	1860	1692	144
CYANOPHYTA						
Merismopedia	5760	0	0	0	0	0
Microcystis	0	0	0	0	0	3600
Oscillatoria	0	1800	5040	600	0	0
EUGLENOPHYTA						
Phacus	0	30	0	0	0	36
Trachelomonas	36	60	0	0	36	36
PYRRHOPHYTA						
Ceratium	0	0	0	30	36	0
Peridinium	0	0	0	30	0	0
SUMMARY STATISTICS						
BACILLARIOPHYTA	540	300	216	60	252	1330
CHLOROPHYTA	468	360	72	270	36	1800
CHRYSOPHYTA	0	30	0	0	0	0
CRYPTOPHYTA	360	180	72	1860	1690	144
CYANOPHYTA	5760	1800	5040	600	0	3600
EUGLENOPHYTA	36	90	0	0	36	72
PYRRHOPHYTA	0	0	0	60	36	0
TOTAL PHYTOPLANKTON	7160	2760	5400	2850	2050	6950
TAXONOMIC RICHNESS						
BACILLARIOPHYTA	7	5	6	2	3	7
CHLOROPHYTA	2	2	2	3	1	5
CHRYSOPHYTA	0	1	0	0	0	0
CRYPTOPHYTA	1	1	1	1	1	1
CYANOPHYTA	1	1	1	1	0	1
EUGLENOPHYTA	1	2	0	0	1	2
PYRRHOPHYTA	0	0	0	2	1	0
RHODOPHYTA	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL PHYTOPLANKTON	12	12	10	9	7	16
S-W DIVERSITY INDEX	0.38	0.60	0.17	0.48	0.32	0.71
EVENNESS INDEX	0.35	0.56	0.17	0.51	0.37	0.59

Table 7-3 Summary 1999: Phytoplankton Biomass in the Assabet River Impoundments

	PHYTOPLANKTON BIOMASS (UG/L)					
TAXON	Allen St. Impoundment (RM 25.6)	Hudson Impoundment (RM 18.3)	Gleasondale Impoundment (RM 14.2)	Ben Smith Impoundment (RM 8.8) 1st Half	Ben Smith Impoundment (RM 8.8) 2nd Half	Powdermill Impoundment (RM 6.3)
BACILLARIOPHYTA						
Cocconeis	14.4	24.0	14.4	0.0	0.0	14.4
Eunotia	0.0	0.0	36.0	0.0	36.0	36.0
Fragilaria	64.8	27.0	0.0	0.0	10.8	130
Melosira	10.8	0.0	0.0	9.0	54.0	216.
Navicula	36.0	15.0	18.0	15.0	0.0	0.0
Nitzschia	28.8	0.0	28.8	0.0	0.0	28.8
Stephanodiscus	252.	630.0	252.	0.0	0.0	252.
Synedra	86.4	24.0	28.8	0.0	0.0	28.8
CHLOROPHYTA						
Ankistrodesmus	3.6	0.0	0.0	0.0	0.0	0.0
Botryococcus	86.4	0.0	0.0	0.0	0.0	0.0
Chlamydomonas	0.0	0.0	3.6	0.0	3.6	0.0
Cosmarium	0.0	0.0	0.0	0.0	0.0	28.8
Eudorina	0.0	0.0	0.0	0.0	0.0	173
Oocystis	0.0	48.0	0.0	0.0	0.0	0.0
Pandorina	0.0	96.0	0.0	48.0	0.0	57.6
Scenedesmus	0.0	0.0	0.0	12.0	0.0	115.
Schroederia	0.0	0.0	0.0	75.0	0.0	0.0
Tetraedron	0.0	0.0	21.6	0.0	0.0	21.6
CHRYSOPHYTA						
Mallomonas	0.0	15.0	0.0	0.0	0.0	0.0
CRYPTOPHYTA						
Cryptomonas	72.0	36.0	14.4	372.	338.	28.8
CYANOPHYTA						
Merismopedia	57.6	0.0	0.0	0.0	0.0	0.0
Microcystis	0.0	0.0	0.0	0.0	0.0	108.
Oscillatoria	0.0	18.0	50.4	6.0	0.0	0.0
EUGLENOPHYTA						
Phacus	0.0	9.0	0.0	0.0	0.0	10.8
Trachelomonas	36.0	60.0	0.0	0.0	36.0	36.0
PYRRHOPHYTA						
Ceratium	0.0	0.0	0.0	522.0	626.	0.0
Peridinium	0.0	0.0	0.0	63.0	0.0	0.0
SUMMARY STATISTICS						
BACILLARIOPHYTA	493.	720.	378.	24.0	101.	705.
CHLOROPHYTA	90.0	144.	25.2	135.	3.6	396.
CHRYSOPHYTA	0.0	15.0	0.0	0.0	0.0	0.0
CRYPTOPHYTA	72.0	36.0	14.4	372.	338.	28.8
CYANOPHYTA	57.6	18.0	50.4	6.0	0.0	108.
EUGLENOPHYTA	36.0	69.0	0.0	0.0	36.0	46.8
PYRRHOPHYTA	0.0	0.0	0.0	585.	626.	0.0
RHODOPHYTA	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL PHYTOPLANKTON	749.	1000.	468.	1120.	1110.	1290.

Table 7-4 Summer 1999: Plant Community Assessment for the Assabet River Impoundments

Type	Species	Allen St. Impoundment (RM 25.6)	Hudson Impoundment (RM 18.3)	Gleasondale Impoundment (RM 14.2)	Ben Smith Impoundment (RM 8.8)	Powdermill Impoundment (RM 6.3)
1999 - Estimated Composition %						
FF	Wolfia columbiana	13.8	14.9	11.5	9.6	11.8
FF	Lemna minor	15.6	15.9	11.7	12.4	21.3
FF	Filamentous green algae	39.7	7.1	5.3	67.0	7.4
RF	Trapa natans	0.0	0.0	0.0	0.9	2.7
RF	Nymphaea odorata	0.0	0.0	0.4	0.0	0.0
RF	Nuphar variegata	0.0	0.0	0.4	0.0	0.0
RS	Potamogeton zosteriformis	0.0	0.0	0.0	3.5	3.0
RS	Potamogeton crispus	18.1	0.0	0.0	0.6	1.2
RS	P. pusillus var. tenuissimus	5.6	0.0	4.3	0.3	3.3
RS	P. amplifolius	0.0	0.0	0.5	0.0	0.0
RS	Elodea canadensis	18.1	20.8	14.6	0.6	19.1
RS	Ceratophyllum demersum	0.0	41.3	48.0	4.6	24.5
RS	Cabomba caroliana	0.0	0.0	0.0	0.4	5.5
RE	Sparganium sp	0.0	0.0	3.4	0.0	0.3
RS	Potamogeton epihydrus	0.0	0.0	0.0	0.0	0.0
FF	Callitriche stagnalis	0.0	0.0	0.0	0.0	0.0
RS	Sparganium emersum	0.0	0.0	0.0	0.0	0.0
RS	Potamogeton conferoides	0.0	0.0	0.0	0.0	0.0
RS	Nitella flexilis	0.0	0.0	0.0	0.0	0.0
RS	Potamogeton spirillus	0.0	0.0	0.0	0.0	0.0
RS	Potamogeton robbinsii	0.0	0.0	0.0	0.0	0.0
TOTAL		100	100	100	100	100
1999 - Estimated Biomass (kg)						
FF	Wolfia columbiana	768	15900	8950	7180	21000
FF	Lemna minor	833	17600	8940	9150	30100
FF	Filamentous green algae	2280	9350	4560	69760	15200
RF	Trapa natans	0	0	0	815	6190
RF	Nymphaea odorata	0	0	399	0	0
RF	Nuphar variegata	0	0	399	0	0
RS	Potamogeton zosteriformis	0	0	0	2440	5530
RS	Potamogeton crispus	474	0	0	347	3160
RS	P. pusillus var. tenuissimus	410	0	2440	198	3030
RS	P. amplifolius	0	0	598	0	0
RS	Elodea canadensis	1200	28900	13700	334	37900
RS	Ceratophyllum demersum	0	46500	40400	3190	49900
RS	Cabomba caroliana	0	0	0	136	10100
RE	Sparganium sp	0	0	2640	0	306
RS	Potamogeton epihydrus	0	0	0	0	0
FF	Callitriche stagnalis	0	0	0	0	0
RS	Sparganium emersum	0	0	0	0	0
RS	Potamogeton conferoides	0	0	0	0	0
RS	Nitella flexilis	0	0	0	0	0
RS	Potamogeton spirillus	0	0	0	0	0
RS	Potamogeton robbinsii	0	0	0	0	0
TOTAL		5960	118000	83000	93600	183000

Macrophyte Types:
FF: free floating
RF: rooted floating
RS: rooted submerged
RE: rooted emergent

Table 7-5 Summer 1999: Summary of Assabet River Impoundment Algal Surface Mat Composition

TAXON	Allen St. Impoundment (RM 25.6)	Hudson Impoundment (RM 18.3)	Gleasondale Impoundment (RM 14.2)	Ben Smith Impoundment (RM 8.8) 1st Half	Ben Smith Impoundment (RM 8.8) 2nd Half	Powdermill Impoundment (RM 6.3)
BACILLARIOPHYTA						
Eunotia sp.	X					X
Fragilaria sp.	X					XX
Melosira varians	XX					X
CHLOROPHYTA						
Chlorococcales		X	X	XX	XX	X
Cladophora sp.	X					
Hydrodictyon reticulatum	XXX	XXX	XXX	XXX	XXX	XXX
Oedogonium sp.		X				
Rhizoclonium sp.	XX	XXX	X		X	XX
Spirogyra spp.	X	X	XXX	XXX	X	X
Notes: X=Present XX=Common XXX=Abundant						

Table 7-6 Summer 2000: Summary of Assabet River Chlorophyll-a Measurements

Sample Location					
Station	Rivermile	Description	phaeo (ug/l)	chl a (ug/l)	tot chl (ug/l)
R28	30.7	Maynard St. Westborough	1.15	6.59	7.75
R27	29.8	Rt. 9 Westborough	0.20	0.38	0.58
R26	28.9	Rt. 135 Westborough	0.38	0.50	0.88
R25	28.0	School St. Northborough	0.26	0.66	0.92
R24	25.8	River St. Northborough	0.29	0.85	1.13
R23	25.6	Allen St. Impoundment, N'boro	0.60	2.20	2.81
R22	25.1	Below Allen St. Impoundment	0.78	3.07	3.85
R21	23.9	Boundary St. Marlborough	0.36	1.49	1.85
R20	23.4	Robin Hill Rd. Marlborough	0.70	2.44	3.15
R19	21.5	Bigelow Rd. Berlin	0.24	0.90	1.14
R18	19.4	Chapin Rd. Hudson	0.45	0.50	0.95
R17	18.3	Hudson Center Impoundment	0.63	1.72	2.35
R16	17.9	Rt. 85 Hudson	0.54	2.48	3.02
R15	15.9	Cox St. Hudson	0.31	0.59	0.90
R14	15.8	Below Cox St. Hudson	0.78	3.56	4.34
R13	14.2	Gleasondale Impoundment	0.41	1.97	2.37
R12	13.9	Below Gleasondale Dam, Stow	0.03	1.03	1.06
R11	11.4	Boon Road, Stow	5.51	36.24	41.74
R10	9.2	White Pond Road, Maynard	1.88	11.53	13.41
R9	8.8	Ben Smith Impoundment	3.62	27.59	31.21
R8	8.6	Rt. 117/62 Maynard	2.43	14.44	16.87
R7	7.4	USGS Gauge, Maynard	1.72	4.77	6.49
R6	6.3	Powder Mill Impoundment	1.71	7.84	9.54
R5	6.1	Below Powder Mill Dam	1.08	4.06	5.14
R4	4.4	Damonmill, Concord	0.78	2.93	3.72
R3	3.1	Rt. 62, Concord	0.18	1.11	1.29
R2	2.4	Rt. 2 Bridge, Concord	0.92	3.74	4.66
R1	1.6	Park Street, Concord	0.35	4.39	4.75
Tributary Sampling Locations					
T11	29.5	Hop Brook	0.46	2.45	2.91
T10	26.0	Cold Harbor Brook, N'boro	0.56	1.27	1.83
T9	24.3	Stirrup Brook, Marlborough	0.43	1.05	1.47
T8	22.4	North Brook, Berlin	0.24	0.50	0.73
T7	18.1	Hog Brook, Hudson	1.67	7.42	9.09
T6	17.8	Mill Brook, Hudson	0.29	0.91	1.20
T5	12.9	Ft. Meadow Brook, Hudson	0.01	0.72	0.72
T4	9.5	Elizabeth Brook	0.72	1.83	2.55
T3	4.3	Second Division Brook	1.62	3.89	5.51
T2	3.0	Nashoba Brook	0.11	0.61	0.73
T1	1.3	Spencer Brook, Concord	0.17	1.96	2.13

Table 7-7 Summer 2000: Phytoplankton Density in the Assabet River Impoundments

PHYTOPLANKTON DENSITY (CELLS/ML)					
TAXON	Allen St. Impoundment (RM 25.6)	Hudson Impoundment (RM 18.3)	Gleasondale Impoundment (RM 14.2)	Ben Smith Impoundment (RM 8.8)	Powdermill Impoundment (RM 6.3)
BACILLARIOPHYTA					
Achnanthes	120	40	0	30	20
Cocconeis	0	120	144	15	40
Cyclotella	0	20	12	2160	240
Cymbella	24	0	12	0	10
Diatoma	0	0	0	0	10
Eunotia	0	0	0	0	10
Fragilaria	0	80	0	30	60
Gomphonema	24	0	0	15	30
Melosira	0	200	216	45	80
Meridion	0	0	0	0	20
Navicula	96	40	24	30	220
Nitzschia	96	40	60	210	180
Stephanodiscus	0	0	0	0	10
Synedra	0	0	12	15	10
CHLOROPHYTA					
Actinastrum	0	20	12	90	140
Closterium	0	0	12	0	0
Cosmarium	0	0	0	0	10
Euastrum	0	0	12	0	0
Golenkinia	48	0	0	0	0
Scenedesmus	0	0	96	60	200
Sphaerocystis	0	0	0	360	320
CHRYSOPHYTA					
CRYPTOPHYTA					
Cryptomonas	168	100	72	330	170
Rhodomonas	120	40	12	90	40
CYANOPHYTA					
Anabaena	0	0	0	0	200
Aphanizomenon	0	0	0	0	1800
Oscillatoria	0	1600	480	600	1200
EUGLENOPHYTA					
Euglena	48	0	0	0	10
Trachelomonas	0	0	0	15	10
PYRRHOPHYTA					
Peridinium	168	0	0	45	10
SUMMARY STATISTICS					
BACILLARIOPHYTA	360	540	480	2550	940
CHLOROPHYTA	48	20	132	510	670
CHRYSOPHYTA	0	0	0	0	0
CRYPTOPHYTA	288	140	84	420	210
CYANOPHYTA	0	1600	480	600	3200
EUGLENOPHYTA	48	0	0	15	20
PYRRHOPHYTA	168	0	0	45	10
RHODOPHYTA	0	0	0	0	0
TOTAL PHYTOPLANKTON	912	2300	1176	4140	5050
TAXONOMIC RICHNESS					
BACILLARIOPHYTA	5	7	7	9	14
CHLOROPHYTA	1	1	4	3	4
CHRYSOPHYTA	0	0	0	0	0
CRYPTOPHYTA	2	2	2	2	2
CYANOPHYTA	0	1	1	1	3
EUGLENOPHYTA	1	0	0	1	2
PYRRHOPHYTA	1	0	0	1	1
RHODOPHYTA	0	0	0	0	0
TOTAL PHYTOPLANKTON	10	11	14	17	26
S-W DIVERSITY INDEX	0.93	0.54	0.81	0.74	0.93
EVENNESS INDEX	0.93	0.52	0.71	0.60	0.65

Table 7-8 Summer 2000: Phytoplankton Biomass in the Assabet River Impoundments

PHYTOPLANKTON BIOMASS (UG/L)					
TAXON	Allen St. Impoundment (RM 25.6)	Hudson Impoundment (RM 18.3)	Gleasondale Impoundment (RM 14.2)	Ben Smith Impoundment (RM 8.8)	Powdermill Impoundment (RM 6.3)
BACILLARIOPHYTA					
Achnanthes	12.0	4.0	0.0	3.0	2.0
Cocconeis	0.0	72.0	86.4	6.0	16.0
Cyclotella	0.0	50.0	30.0	216.0	278.0
Cymbella	24.0	0.0	12.0	0.0	10.0
Diatoma	0.0	0.0	0.0	0.0	3.0
Eunotia	0.0	0.0	0.0	0.0	40.0
Fragilaria	0.0	24.0	0.0	9.0	18.0
Gomphonema	24.0	0.0	0.0	15.0	30.0
Melosira	0.0	480.0	518.4	13.5	108.0
Meridion	0.0	0.0	0.0	0.0	6.0
Navicula	156.0	110.0	66.0	15.0	290.0
Nitzschia	76.8	86.0	80.4	168.0	198.0
Stephanodiscus	0.0	0.0	0.0	0.0	70.0
Synedra	0.0	0.0	96.0	12.0	8.0
CHLOROPHYTA					
Actinastrum	0.0	4.0	2.4	9.0	14.0
Closterium	0.0	0.0	48.0	0.0	0.0
Cosmarium	0.0	0.0	0.0	0.0	80.0
Euastrum	0.0	0.0	48.0	0.0	0.0
Golenkinia	21.6	0.0	0.0	0.0	0.0
Scenedesmus	0.0	0.0	9.6	6.0	76.0
Sphaerocystis	0.0	0.0	0.0	72.0	104.0
CHRYSOPHYTA					
CRYPTOPHYTA					
Cryptomonas	268.8	76.0	48.0	276.0	666.0
Rhodomonas	24.0	8.0	2.4	18.0	8.0
CYANOPHYTA					
Anabaena	0.0	0.0	0.0	0.0	260.0
Aphanizomenon	0.0	0.0	0.0	0.0	234.0
Oscillatoria	0.0	16.0	4.8	6.0	12.0
EUGLENOPHYTA					
Euglena	24.0	0.0	0.0	0.0	5.0
Trachelomonas	0.0	0.0	0.0	15.0	10.0
PYRRHOPHYTA					
Peridinium	352.8	0.0	0.0	94.5	21.0
SUMMARY STATISTICS					
BACILLARIOPHYTA	292.8	826.0	889.2	457.5	1077.0
CHLOROPHYTA	21.6	4.0	108.0	87.0	274.0
CHRYSOPHYTA	0.0	0.0	0.0	0.0	0.0
CRYPTOPHYTA	292.8	84.0	50.4	294.0	674.0
CYANOPHYTA	0.0	16.0	4.8	6.0	506.0
EUGLENOPHYTA	24.0	0.0	0.0	15.0	15.0
PYRRHOPHYTA	352.8	0.0	0.0	94.5	21.0
RHODOPHYTA	0.0	0.0	0.0	0.0	0.0
TOTAL PHYTOPLANKTON	984.0	930.0	1052.4	954.0	2567.0

Table 7-9 Summer 2000: Zooplankton Density in the Assabet River Impoundments

ZOOPLANKTON DENSITY (#/L)					
TAXON	**Allen St. Impoundment (RM 25.6)**	**Hudson Impoundment (RM 18.3)**	**Gleasondale Impoundment (RM 14.2)**	**Ben Smith Impoundment (RM 8.8)**	**Powdermill Impoundment (RM 6.3)**
PROTOZOA					
Ciliophora	0.0	0.0	0.0	0.0	0.0
Mastigophora	0.0	0.0	0.0	0.0	0.0
Sarcodina	0.0	1.3	0.0	0.0	1.1
ROTIFERA					
Asplanchna	1.2	1.3	1.2	2.6	1.1
Brachionus	0.0	0.0	0.0	0.0	1.1
Euchlanis	0.0	0.0	1.2	1.3	0.0
Keratella	0.0	0.0	0.0	0.0	1.1
COPEPODA					
Copepoda-Cyclopoida					
Copepoda-Calanoida					
Copepoda-Harpacticoida	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Adults	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Copepodites	0.0	0.0	0.0	1.3	1.1
Other Copepoda-Nauplii	0.0	1.3	0.0	2.6	1.1
CLADOCERA					
Bosmina	0.0	0.0	1.2	1.3	1.1
Ceriodaphnia	0.0	0.0	0.0	1.3	1.1
Chydorus	0.0	2.6	1.2	2.6	1.1
OTHER ZOOPLANKTON					
Bryozoa	0.0	0.0	0.0	0.0	0.0
Chaoboridae	0.0	0.0	0.0	0.0	0.0
Chironomidae	0.0	0.0	0.0	0.0	0.0
Coelentarata	0.0	0.0	0.0	0.0	0.0
Culicidae	0.0	0.0	0.0	0.0	0.0
Eubranchiopoda	0.0	0.0	0.0	0.0	0.0
Gastrotrichia	0.0	0.0	0.0	0.0	0.0
Hydracarina	0.0	0.0	0.0	0.0	0.0
Mysidacea	0.0	0.0	0.0	0.0	0.0
Nematoda	0.0	0.0	0.0	0.0	0.0
Ostracoda	0.0	0.0	0.0	0.0	0.0
SUMMARY STATISTICS					
PROTOZOA	0.0	1.3	0.0	0.0	1.1
ROTIFERA	1.2	1.3	2.4	3.9	3.3
COPEPODA	0.0	1.3	0.0	3.9	2.2
CLADOCERA	0.0	2.6	2.4	5.2	3.3
OTHER ZOOPLANKTON	0.0	0.0	0.0	0.0	0.0
TOTAL ZOOPLANKTON	1.2	6.5	4.8	13.0	9.9
TAXONOMIC RICHNESS					
PROTOZOA	0	1	0	0	1
ROTIFERA	1	1	2	2	3
COPEPODA	0	1	0	2	2
CLADOCERA	0	1	2	3	3
OTHER ZOOPLANKTON	0	0	0	0	0
TOTAL ZOOPLANKTON	1	4	4	7	9
S-W DIVERSITY INDEX	0.00	0.58	0.60	0.82	0.95
EVENNESS INDEX	0.00	0.96	1.00	0.97	1.00

Table 7-10 Summer 2000: Zooplankton Biomass in the Assabet River Impoundments

ZOOPLANKTON BIOMASS (UG/L)					
TAXON	**Allen St. Impoundment (RM 25.6)**	**Hudson Impoundment (RM 18.3)**	**Gleasondale Impoundment (RM 14.2)**	**Ben Smith Impoundment (RM 8.8)**	**Powdermill Impoundment (RM 6.3)**
ROTIFERA					
Ciliophora	0.0	0.0	0.0	0.0	0.0
Mastigophora	0.0	0.0	0.0	0.0	0.0
Sarcodina	0.0	0.0	0.0	0.0	0.0
ROTIFERA					
Asplanchna	1.2	1.3	1.2	2.6	1.1
Brachionus	0.0	0.0	0.0	0.0	0.1
Euchlanis	0.0	0.0	0.1	0.1	0.0
Keratella	0.0	0.0	0.0	0.0	0.1
COPEPODA					
Copepoda-Cyclopoida					
Copepoda-Calanoida					
Copepoda-Harpacticoida	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Adults	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Copepodites	0.0	0.0	0.0	0.4	0.3
Other Copepoda-Nauplii	0.0	3.4	0.0	6.9	2.9
CLADOCERA					
Bosmina	0.0	0.0	1.2	1.3	1.1
Ceriodaphnia	0.0	0.0	0.0	3.4	2.9
Chydorus	0.0	2.5	1.2	2.5	1.1
OTHER ZOOPLANKTON					
Bryozoa	0.0	0.0	0.0	0.0	0.0
Chaoboridae	0.0	0.0	0.0	0.0	0.0
Chironomidae	0.0	0.0	0.0	0.0	0.0
Coelentarata	0.0	0.0	0.0	0.0	0.0
Culicidae	0.0	0.0	0.0	0.0	0.0
Eubranchiopoda	0.0	0.0	0.0	0.0	0.0
Gastrotrichia	0.0	0.0	0.0	0.0	0.0
Hydracarina	0.0	0.0	0.0	0.0	0.0
Mysidacea	0.0	0.0	0.0	0.0	0.0
Nematoda	0.0	0.0	0.0	0.0	0.0
Ostracoda	0.0	0.0	0.0	0.0	0.0
SUMMARY STATISTICS					
PROTOZOA	0.0	0.0	0.0	0.0	0.0
ROTIFERA	1.2	1.3	1.3	2.7	1.3
COPEPODA	0.0	3.4	0.0	7.3	3.2
CLADOCERA	0.0	2.5	2.4	7.2	5.0
OTHER ZOOPLANKTON	0.0	0.0	0.0	0.0	0.0
TOTAL ZOOPLANKTON	1.2	7.3	3.7	17.2	9.6
MEAN LENGTH: ALL FORMS	0.30	0.25	0.25	0.32	0.27
MEAN LENGTH: CRUSTACEANS	0.30	0.30	0.30	0.36	0.38

Table 7-11 Summer 2000: Biomass Measurements Associated with each Biomass Rating in the Assabet River Impoundments

Variable	**Grams/square meter for each Bio-Class**			
Bio-Class	**1**	**2**	**3**	**4**
Mean	438	1100	1950	3510
Median	411	817	1760	3130
Minimum	84	252	904	1680
Maximum	1100	3030	4240	6950

Table 7-12 Summer 2000: Plant Community Assessment for the Assabet River Impoundments

2000 - Estimated Composition %						
Type	Species	Allen St. Impoundment (RM 25.6)	Hudson Impoundment (RM 18.3)	Gleasondale Impoundment (RM 14.2)	Ben Smith Impoundment (RM 8.8)	Powdermill Impoundment (RM 6.3)
FF	Wolfia columbiana	8.8	7.7	17.2	8.9	5.6
FF	Lemna minor	8.8	7.8	17.2	8.9	5.6
FF	Filamentous green algae	34.2	9.1	6.9	47.9	8.0
RF	Trapa natans	0.0	0.0	0.0	0.2	2.3
RF	Nymphaea odorata	0.0	0.0	0.0	0.0	0.0
RF	Nuphar variegata	0.0	0.0	0.0	0.0	0.0
RS	Potamogeton zosteriformis	0.0	0.0	2.1	5.1	1.3
RS	Potamogeton crispus	2.3	0.0	0.0	1.8	3.5
RS	P. pusillus var. tenuissimus	0.0	0.0	0.0	0.0	0.0
RS	P. amplifolius	0.0	0.0	0.0	0.0	0.0
RS	Elodea canadensis	28.1	24.1	20.6	4.8	37.2
RS	Ceratophyllum demersum	0.0	36.6	28.8	17.9	34.3
RS	Cabomba caroliana	0.0	0.0	2.1	3.2	0.0
RE	Sparganium sp	5.0	0.3	0.0	0.0	0.0
RS	Potamogeton epihydrus	8.1	0.2	0.0	0.0	1.0
FF	Callitriche stagnalis	1.5	0.0	0.0	0.0	0.0
RS	Sparganium emersum	2.3	0.0	5.2	0.0	0.0
RS	Potamogeton conferoides	0.8	0.0	0.0	0.0	0.0
RS	Nitella flexilis	0.0	14.4	0.0	0.0	0.0
RS	Potamogeton spirillus	0.0	0.0	0.0	0.0	1.2
RS	Potamogeton robbinsii	0.0	0.0	0.0	1.2	0.0
TOTAL		100	100	100	100	100
2000 - Estimated Biomass (kg)						
FF	Wolfia columbiana	256	6080	5820	6380	5800
FF	Lemna minor	256	6190	5820	6380	5800
FF	Filamentous green algae	1030	6850	3190	42900	7660
RF	Trapa natans	0	0	0	298	844
RF	Nymphaea odorata	0	0	0	0	0
RF	Nuphar variegata	0	0	0	0	0
RS	Potamogeton zosteriformis	0	0	852	4650	2870
RS	Potamogeton crispus	314	0	0	2080	5920
RS	P. pusillus var. tenuissimus	0	0	0	0	0
RS	P. amplifolius	0	0	0	0	0
RS	Elodea canadensis	895	23600	13000	4610	40500
RS	Ceratophyllum demersum	0	38100	19300	20300	41600
RS	Cabomba caroliana	0	0	1160	3120	0
RE	Sparganium sp	186	56	0	0	0
RS	Potamogeton epihydrus	316	219	0	0	1610
FF	Callitriche stagnalis	45	0	0	0	0
RS	Sparganium emersum	314	0	1330	0	0
RS	Potamogeton confervoides	105	0	0	0	0
RS	Nitella flexilis	0	4330	0	0	0
RS	Potamogeton spirillus	0	0	0	200	3400
RS	Potamogeton robbinsii	0	0	0	1360	0
TOTAL		3720	85400	50400	92300	116000

Macrophyte Types:
FF: free floating
RF: rooted floating
RS: rooted submerged
RE: rooted emergent