EXECUTIVE SUMMARY

This report serves to document the water quality status of the Assabet River as part of a nutrient Total Maximum Daily Load (TMDL) evaluation and allocation process. A field investigation of the Assabet River system was conducted from July 1999 through October 2000 and a review of historic water quality studies were performed. The field investigation featured collection of measurements of the hydrology, water quality, and aquatic biology of the Assabet River during 13 surveys. The goal of the field investigation was to quantify and document the presence of eutrophic conditions and associated factors in the Assabet River. Nutrient loadings and dynamics in the Assabet River were a primary focus of the investigation. The study also focused on characterizing the aquatic biology of the Assabet River and the interrelationship between nutrients and biology in the system.

The field investigation concluded that the Assabet River receives an excess of the nutrients, phosphorus and nitrogen, resulting in nutrient saturation and excessive growth of aquatic vegetation. Summer-time dissolved oxygen concentration measurements in the Assabet River were frequently below the water quality standard of 5.0 mg/l. Summer-time vegetation densities in the Assabet River were observed to be at levels associated with impairment of water quality and designated uses. The ENSR 1999-2000 Assabet River water quality field investigation along with a review of historic water quality surveys is documented in this report

This executive summary contains the following components:

- An overview of the Assabet River's water quality impairment,
- A description of the TMDL allocation process,
- A brief summary of the review of historic water quality studies,
- A brief summary of the ENSR 1999-2000 Assabet River field investigation, and
- Conclusions.

Overview

The Assabet River experiences a severe ecological condition known as eutrophication. Eutrophication is a process of nutrient accumulation and ecosystem change that can occur in aquatic ecosystems. This process can occur naturally as part of a long-term transition (e.g., from lake to marsh). Eutrophication can also occur culturally whereby the process is dramatically accelerated by the activities of man (McNaughton and Wolf, 1973). In the Assabet River, cultural eutrophication has occurred in the presence of excessive nutrient loadings and dammed impoundments.

The presence of eutrophication in the Assabet River is problematic because high growth rates of biota have been observed to result in production of nuisance aquatic vegetation such as algal mats, floating

macrophytes, rooted vegetation, and phytoplankton. These growths are aesthetically undesirable and, due to impacts on dissolved oxygen, they threaten the existence of fish and other aquatic organisms.

Phosphorus and nitrogen are the two primary essential nutrients for plant growth. Phosphorus is found in dissolved and particulate forms in the aquatic environment. Dissolved phosphorus contains ortho-phosphorus that is representative of biologically available phosphorus. Ortho-phosphorus may be readily taken up by aquatic organisms. Total phosphorus represents both the dissolved form (including ortho-phosphorus) and the particulate form that must be converted by natural biological processes prior to aquatic plant uptake. Thus, ortho-phosphorus is readily available phosphorus and total phosphorus represents the total amount of phosphorus that may potentially be taken up by aquatic organisms.

Nitrogen is found in several forms in the aquatic environment. Some nitrogen forms are more readily available for uptake by aquatic organisms than others. Ammonium and nitrate are the two forms of nitrogen that are most readily accessible for biological uptake. Organic nitrogen, in contrast, is bound up in organic material and is unavailable for immediate bioligical uptake. Organic nitrogen is also important, however, because it may converted through natural biological processes into ammonium and nitrate forms and taken up by aquatic organisms.

As a result of water quality problems associated with eutrophication, the Assabet River was placed on a list of impaired waterbodies requiring water quality improvement, known as a Section 303(d) list (SuAsCo, 1996). Specifically, the Assabet River, designated as a Class B waterbody, has been observed to frequently fail to meet applicable numerical water quality standards for dissolved oxygen concentration, fecal coliform bacteria counts, and pH and for applicable narrative criteria for nuisance aquatic vegetation during the summer-time. According to the Clean Water Act, states are required to develop a Total Maximum Daily Load (TMDL) allocation plan for all priority waterbodies on the Section 303(d) list. Thus, the Massachusetts Department of Environmental Protection (DEP), in conjunction with the US Army Corps of Engineers (Corps), is currently developing a TMDL allocation for nutrients in the Assabet River.

Corps involvement with the TMDL process has been limited to the collection of data and study preparation. Authority for Corps participation is provided in its Section 22 “Planning Assistance to States” program (Water Resources Development Act of 1974, Public Law 93-251, as amended) which enables Corps cooperation with the states in preparation of plans for the development, utilization, and conservation of water and related land resources. A Cost Sharing Agreement was signed by the Corps and the DEP (the non-Federal sponsor) on March 25, 1999 (amended on May 3, 2000 and again on January 11, 2001), enabling the Corps and DEP to split the cost of this work on a 50/50 basis.

The TMDL Allocation Development Process

A TMDL allocation is an analysis that establishes the maximum loadings that a waterbody may receive and maintain its water quality standards and designated uses, including compliance with numeric and narrative standards. The TMDL development process has been specified by USEPA (1991) and may be described in five steps, as follows:

1. Determination and documentation of whether or not a waterbody is presently meeting its water quality standards and designated uses,

2. Assessment of present water quality conditions in the waterbody, including estimation of present loadings of constituents of concerns from both point and non-point sources,

3. Determination of the loading capacity of the waterbody. EPA regulations define the loading capacity as the greatest amount of loading that a waterbody may receive without violating water quality standards. If the waterbody is not presently meeting its designated uses, then the loading capacity will represent a reduction relative to present loadings.

4. Specification of load allocations, based on the loading capacity determination, for non-point sources (LAs) and point sources (WLAs), that will ensure that the waterbody will not violate water quality standards.

5. Development of a plan to (1) implement load allocations and wasteload allocations developed based on the waterbody loading capacity determination and (2) monitor the waterbody to ensure compliance with water quality standards.

The TMDL development process begins with assessment of the present condition of a waterbody and concludes with specification and implementation of a set of modified loadings deemed necessary to bring the waterbody into compliance with water quality standards. The steps of the TMDL can be divided into Assessment (Steps 1 and 2); Analysis (Steps 3 and 4), often through numerical modeling; and Planning (Step 5). This report supports the waterbody assessment steps listed above through the 1999-2000 field investigation and the review of previous water quality studies.

Water quality modeling is necessary to determine the loading capacity of the Assabet River and to allocate acceptable point and non-point source loadings (i.e., Steps 3 and 4 above). Determination of the loading capacity of the Assabet River is a complex task requiring sufficient supporting data and an appropriate assessment tool. The most reliable and defensible assessment tool for establishing loading capacities is a mathematical water quality model. A water quality model provides a numerical representation of the physical, hydrological, chemical, and biological characteristics of a river.

The field investigation described in this report was designed to collect the measurements required to support development of a water quality modeling application for the Assabet River. A water quality model requires a sufficient set of data to achieve project objectives. Once established, water quality models are capable of simulating present conditions in the river in terms of hydrology, water quality, and biology. More importantly, water quality models are capable of predicting water quality and biological conditions associated with hypothetical scenarios (e.g., nutrient reduction scenarios). The five steps outlined and discussed above must be performed in order to successfully complete the TMDL allocation process.

Review of Previous Studies

A review of previous studies on the Assabet River system was performed to enhance understanding of the hydrology, water quality, and ecology of the Assabet River. The review of previous studies provided strong evidence that eutrophic conditions have been present in the Assabet River for at least the past 30 years. Results from previous water quality surveys consistently indicate that nutrient concentrations in the Assabet River have long been sufficient to support eutrophic conditions. Other indicators of eutrophic conditions, such as large diurnal DO concentration variations and extensive biomass production were also consistently observed in previous surveys.

Previously collected biological measurements of the Assabet River are scarce. Results of previous biological surveys do, however, provide good circumstantial evidence to indicate that abundant macrophyte communities in the Assabet River have been well established for at least the last 30 years. Limited historic observations suggest that duckweed and pondweed have been important components of the macrophyte community for many years. The presence of duckweed supports the assumption that eutrophic conditions have existed historically as such forms are favored in slow-moving waters with high nutrient enrichment.

The primary factors contributing to the eutrophic status of Assabet River impoundments, namely availability of excess nutrients in slow-moving, impounded waterbodies, and the presence of optimum growth conditions (summer-time) appear to have long been in place and supporting eutrophic conditions in the Assabet River.

Water Quality Field Investigation: 1999-2000

Thirteen (13) field surveys were conducted from July 1999 through September 2000 and featured collection a wide range of measurements including the following:

- River streamflow and time of travel measurements,
- Continuous measurements of dissolved oxygen concentration dynamics,

- Water column sampling and analysis of several nutrient constituent concentrations throughout the Assabet River,
- Point source nutrient load measurements from POTWs,
- Non-point source nutrient loading measurements from tributaries,
- Sediment nutrient flux measurements, and
- Biological surveys quantifying the nature and extent of aquatic vegetation during summer-time conditions.

Field measurements were collected under a variety of conditions including summer-time and winter-time, low-streamflow and high-streamflow, dry-weather and wet-weather to provide measurements required to support the assessment. The following observations were made of water quality conditions in the Assabet River during the field investigation:

- Surveys were performed under a wide range of hydrologic conditions. For example, a worst-case summer-time survey was conducted at near 7Q10 low-flow conditions (15 cfs, July 1999) and a winter-time wet-weather survey was conducted at relatively high-flow conditions (375 cfs, March 2000).
- Time of travel surveys found that travel times through the Assabet River mainstem were greater than 18 days and that travel time through each river impoundment was 1 to 3 days under average summer-time conditions.
- During summer-time surveys, Publicly-Owned Treatment Works (POTW) effluent flows accounted for large proportions of total river streamflow. Under low-flow conditions (July 1999), POTW effluent flows contributed approximately 80% of the total river streamflows. Under near-average flow conditions (August 2000), POTW effluent flows contributed approximately 34% of the total river streamflow.
- During summer-time surveys, dissolved oxygen (DO) concentrations experienced large diurnal variations (e.g., 4 mg/l to 13 mg/l) throughout the river as is indicative of intensive biological activity. DO concentrations were frequently observed below the ambient water quality standard of 5.0 mg/l.
- Nutrient concentrations, both phosphorus and nitrogen species, were observed to be at levels indicative of nutrient saturation (i.e., neither nutrient was limiting) and were more than sufficient to support eutrophication. Typical ranges of nutrient concentrations during the summer-time surveys were:
  - Total phosphorus: 0.2 to 0.8 mg/l
  - Ortho-phosphorus: 0.1 to 0.6 mg/l
  - Nitrate: 0.5 to 8.0 mg/l

- For each nutrient constituent, concentrations were observed to be at least one order of magnitude (i.e., 10 times) higher than nutrient limiting concentrations indicating that concentrations of these nutrients would have to be reduced dramatically before biologic productivity in the system diminished.
- Sediment nutrient flux surveys confirmed the hypothesis that nutrients enter river impoundment sediments during the winter-time and are released from sediments to the water column during the summer-time. The magnitude of sediment nutrient flux was observed to be modest, however, contributing approximately 3% to 5% of ambient water column nutrient concentrations. Laboratory analyses indicated that under anoxic conditions, believed to be unusual in the Assabet River system, impoundment sediments flux would increase dramatically making sediments a major component of the overall nutrient budget. The sediment nutrient flux evaluation concluded that impoundment sediments represent a relatively minor component of the overall Assabet River nutrient budget.
- Eutrophic conditions were measured directly through summer-time phytoplankton and macrophyte surveys, each resulting in findings of extensive volumes of productive biomass. Summer-time vegetation densities in the Assabet River were observed to be at levels associated with impairment of water quality and designated uses.
- Total nutrient loadings to the Assabet River from point and non-point sources were collected during six (6) surveys and ranged as follows:
  - Ortho-phosphorus loadings: 61 to 319 lbs/day
  - Total Phosphorus loadings: 66 to 1,390 lbs/day
  - Nitrate loadings: 980 to 2,250 lbs/day
  - Total Nitrogen loadings: 1,190 to 3,850 lbs/day
- Point sources were observed to contribute the majority of nutrient loadings to the Assabet River during most surveys. The following observations were made based on nutrient loadings estimates from the 6 water quality surveys.
  - During all 6 surveys, the vast majority of available phosphorus (i.e., ortho-phosphorus) loadings came from the point sources (88% to 98%).
  - During summer-time conditions when eutrophication occurs (July 1999, August 2000, and September 2000), the vast majority of all 4 nutrient constituent loadings came from the point sources (83% to 98%).
  - During relatively high-flow and wet-weather events (two March 2000 surveys), the majority of total phosphorus and total nitrogen loadings were observed to come from non-point sources (52% to 77%).

Conclusions

Water quality impairments in the form of excessive growth of aquatic vegetation and failure to meet the water quality standard for ambient dissolved oxygen concentration were documented during several summer-time surveys. In-stream nutrient concentration measurements were typically an order of magnitude higher than potentially limiting concentrations during numerous surveys indicating that nutrient concentrations would have to be reduced dramatically before biological production in the system diminished. Point sources were identified as contributing the majority of nutrient loadings during most surveys and were identified as contributing the vast majority of the critical nutrient constituent, ortho-phosphorus, during all 6 water quality surveys evaluated. Non-point sources were observed to contribute the majority of most nutrient constituents during 2 of 3 surveys conducted under wet-weather and relatively high-streamflow conditions.

The ENSR 1999-2000 field investigations were successful in documenting the presence of eutrophic conditions and factors effecting eutrophic conditions in the Assabet River. Measurements required to support development of a water quality modeling application for the Assabet River were successfully collected. This report represents the successful completion of a major portion of the Assabet River nutrient TMDL allocation development project.