ESS Group, Inc.

DIAGNOSTIC AND FEASIBILITY STUDY
ASHMERE LAKE
Hinsdale, Massachusetts

Prepared For:	**Town of Hinsdale** John A. Eagar Lake Management Committee P.O. Box 657 Hinsdale, Massachusetts 01235
Prepared By:	**ESS Group, Inc.** 888 Worcester Street, Suite 240 Wellesley, Massachusetts 02482
Project No.:	**H119-000**
Date:	**May 31, 2003**

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EXECUTIVE SUMMARY

ESS Group, Inc. (ESS) conducted an investigation of Ashmere Lake in the Town of Hinsdale, located in western Massachusetts, beginning during the winter of 2002 and concluding during the early fall of 2002. The investigation was initiated to serve as the basis for the development of a comprehensive lake and watershed management plan. The management plan is based on data collected during this investigation and is specifically designed to maintain healthy water quality conditions and control the encroachment of nuisance aquatic vegetation, while ensuring that the habitat quality of the downstream Hinsdale Flats Area of Critical Environmental Concern (ACEC), is not compromised.

The current study included an assessment of a wide range of physical, chemical and biological characteristics of the lake and its watershed. Based on these assessments it is apparent that although Ashmere Lake enjoys relatively good water quality at present, nutrient levels in the lake (particularly phosphorus) are approaching levels characteristic of a mesotrophic (moderate amounts of nutrients) system. The lake is and has been receiving nutrients (primarily phosphorus and nitrogen) from its watershed predominately during wet weather events, although one tributary was found to have excessive levels of nitrogen and bacteria during dry weather conditions. These nutrients have the potential to promote the growth of algae (phytoplankton) within the water column and the bacteria has the potential to threaten human health. In addition, the particulate forms of these nutrients, which are primarily carried to the lake via stormwater runoff, settle on the lake bottom and contribute to the already rich, organic muck that is ideally suited to the growth of rooted vegetation (macrophytes).

Dense beds of aquatic macrophytes ($\geq$50% cover) had colonized a significant portion of Ashmere Lake's shallow water areas by the end of the growing season in 2002. This growth, although actively managed through herbicide treatment, is still at a level that could inhibit recreational activities in several areas of the lake. The greatest threat to the lake comes from the exotic, invasive species, such as Eurasian watermilfoil (*Myriophyllum spicatum*), brittle waternymph (*Najas minor*), and curly-leaf pondweed (*Potamogeton crispus*) that have expanded their coverage into the lake's open water habitat resulting in the exclusion of the more desirable native plant species.

In order to maintain the integrity of this open water system, it is recommended that management actions including continued herbicide application or possibly hand-harvesting and benthic barriers be implemented in order to control nuisance plant species while maintaining a healthy balance of native plants. In addition, it is recommended that efforts be made to ensure that development and activities within the watershed be carried out in a manner that is protective of the lake's generally good water quality conditions. Several potential sources of non-point source pollution (nutrients and sediment) were identified, but these will require additional investigation to isolate and develop remedial solutions. Accumulated fine sediment within the lake was found to have elevated levels of some metals;

these metals have the potential to accumulate in game fish that may be consumed by humans. It is recommended that a fish tissue analysis be performed in order to assess whether fish consumption restrictions need to be implemented. Finally, it is recommended that efforts be made to monitor the plant community thoroughly each year, especially during seasons in which an herbicide treatment is to be implemented. Monitoring should also include an assessment of water quality conditions in the lake in order to identify any future problems, should they arise, and to track the success or failure of any implemented management actions.

Estimated costs for improving the lake will be dependent upon the level of implementation. Estimated costs for controlling the existing vegetation problem in accordance with the recommended management program should be anticipated on the order of between $5,000 and $14,000 initially and then $4,000 to $6,000 annually depending upon the method selected and the level of implementation. Costs to prepare an educational brochure ($2,500) are also recommended in order to encourage watershed residents to make efforts to protect the water quality of the lake. Given the extent of the investment needed to restore and protect Ashmere Lake, it would be wise to establish a long-term monitoring program that could be conducted annually or semi-annually to assess basic water quality and the condition of the aquatic plant community. An estimated cost for such a program would be $6,000/year, but would provide early warning of potential problems and could save money over the long term if problems are addressed before conditions worsen.

1.0 INTRODUCTION

The desire to assess the extent and cause of the nuisance weed problem prompted the initiation of a limnological investigation at Ashmere Lake, located in the Town of Hinsdale, Massachusetts. ESS began the study during the winter of 2002 and concluded the field work portion of the study during the early fall of 2002. The investigations included an evaluation of pertinent watershed features as well as a variety of physical, chemical, and biological features of the lake.

The goals of the investigation were defined during the initial "kick-off" meeting with representatives from the Hinsdale Lake Management Committee on February 4th, 2002. During the kick-off meeting it was made clear to ESS that the Town wished to actively manage nuisance aquatic plant growths in order to maintain the biological, recreational and aesthetic value of the lake. The Town and representatives from the Massachusetts Department of Environmental Management (MADEM) also stated that management actions going forward would need to be considerate of the aquatic and semi-aquatic resources associated with the Hinsdale Flats ACEC located downstream of the lake.

Lake and watershed residents have become increasingly concerned at the prevalence of invasive and exotic plant species within the lake, particularly Eurasian watermilfoil (*Myriophyllum spicatum*), brittle waternymph (*Najas minor*), and curly-leaf pondweed (*Potamogeton crispus*). Once established, these species are able to spread throughout a waterbody and if left unchecked, are likely to inhibit the recreational utility of the lake by impeding swimming, boating and aesthetic values. Much of the shallow water area of Ashmere Lake's north basin was once dominated by Eurasian watermilfoil; however, as a result of an ongoing effort to control this species through herbicide applications, a more balanced plant community has been restored. Unfortunately, the pre-treatment condition was poorly documented. However, it appears that past treatment efforts have controlled the spread of exotic plants within the lake and enabled the abundance and diversity of the native plant community to return, at least to some degree. This also suggests that previous management efforts have not been excessively disruptive to the native plant community.

With respect to the perceived water quality of the lake, many lake and watershed residents reported being very pleased with the present quality and clarity of the water. The stated goal for water quality was to maintain this quality by ensuring that development or activities within the watershed are compatible with maintaining current water quality conditions. One key aspect of ensuring that water quality within the lake would remain of high quality was to assess the effectiveness of the stormwater settling basin north of Peru Road that was designed to minimize the transport of particulates to the south basin of the lake.

The investigation of Ashmere Lake consisted of seven key components: 1) assessing the in-lake water quality; 2) evaluating the quantity and quality of water entering and leaving the lake during dry weather and wet weather conditions; 3) assessing the lake's aquatic plant community pre- and post-herbicide application; 4) reporting fish and wildlife occurring in the lake and within the Hinsdale Flats ACEC via direct observation and through an historic data review; 5) characterizing and determining the quality of in-lake sediments; 6) assessing aquatic invertebrate communities in and around the lake; and 7) using data collected and long-term climatological data to calculate the annual hydrologic and nutrient budget for the lake.

The investigation was conducted in order to provide viable management alternatives and approximate cost estimates for maintaining or improving the overall quality of Ashmere Lake. A lake and watershed management plan has been prepared for the Town of Hinsdale to achieve this goal without risk to the Hinsdale Flats ACEC, including areas adjacent to and within the watershed of the lake and to areas downstream within the ACEC.

2.0 STUDY APPROACH

The assessment of Ashmere Lake and its watershed consisted of a review of background information, field data collection, nutrient and hydrologic modeling, and the preparation of a management strategy. The water quality data collected provides insight into potential sources and the degree of pollutant (nutrient and sediment) loading to the system. While longer-term (multiple years) measurement would be desirable, this brief investigation provides sufficient data to make reasonable assumptions regarding pollutant loading and in-lake water quality.

Background data and general lake and watershed information were compiled from existing sources, including the United States Geological Survey (USGS, 2000) topographic map (Figure 1), 1999 Massachusetts Geographical Information System (GIS) land-use data (Table 1, Figure 2), sewerage and zoning information provided by the Town of Hinsdale, and historic studies of Ashmere Lake provided by the Hinsdale Lake Management Committee.

Field data was collected in accordance with standard sampling protocols and included the following key tasks:

- Water samples were collected in order to characterize water quality conditions from in-lake stations, the major tributaries, a significant stormwater outfall and immediately downgradient of the lake's outlet. Sampling water quality from these locations allows for lake managers to quantify and prioritize sources of pollution entering the lake and provides insight into in-lake chemical and physical processes that ultimately affect a lake's overall hydrologic and nutrient budget. The following water quality parameters were assessed during each field visit, as applicable: Secchi disk transparency, temperature, dissolved oxygen, conductivity, fecal coliform, total alkalinity, total phosphorus, dissolved phosphorus, nitrate nitrogen, total Kjeldahl nitrogen, ammonia nitrogen, pH, flow rate and turbidity.
- Water depth was measured along 15 appropriately spaced transects crossing the lake. Data collected was used to develop water depth contours (Table 2, Figures 3 and 4).

- Water quality was monitored at the deepest spot in each basin of Ashmere Lake, designated as Sites AS-1S & AS-1B, and AN-1S & AN-1B for surface and bottom sampling locations of the south and north basin, respectively (Figure 5). Water quality monitoring stations were also established at the unnamed tributary near Camp Danbee, which feeds into the eastern cove of the south basin of Ashmere Lake (AS-2); an unnamed tributary, which crosses George Schnopps Road, which feeds into the northeastern cove of the north basin of Lake Ashemere (AN-2); a storm drain located along Peru Road (Route 143), which drains into the northern cove of the south basin of Ashmere Lake (AS-3); and at a location immediately downstream of the outlet (AS-4). Hereafter, sampling locations will be referenced by shorthand notation (e.g., AS-1S). All sampling locations are depicted on Figure 5.
- Water quality monitoring of the in-lake station was conducted on dry weather days during the spring, summer and fall of 2002. The outlet was sampled once during dry weather on the summer sampling date. The tributaries were sampled once during dry weather and once during wet weather. Only one storm drain (AS-3) was observed to be flowing at the time of sample collection throughout the study period and this drain was sampled once during wet weather conditions. Dry weather samples were obtained on May 21st, August 27th, and October 31st, while wet weather samples were obtained on September 15th, 2002. Refer to Tables 3, 4 and 5 for field and laboratory water quality data and Figures 6 and 7 for the temperature and dissolved oxygen profiles from the in-lake stations.
- Sediment samples were collected in order to ascertain the potential for sediment to influence water quality and plant growth as well as to determine potential threats to ecological or human health. Sediment samples were analyzed for the following parameters: total phosphorus, total solids, percent water and percent organic content (Table 6). In addition, sediment samples were analyzed for arsenic, cadmium, chromium, copper, lead, mercury, nickel, vanadium, zinc, polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPH), and sediment grain size as per the 401 Water Quality Certification for Discharge of Dredge and Fill Materials (314 CMR 9.00) (Table 7).
- Aquatic plants (including emergent, floating leaved, and submergent species) in and around Ashmere Lake were mapped on May 20th and August 26th, 2002 (pre- and post-herbicide application) in order to document the seasonal patterns of aquatic plant growth within the basins, as well as track the efficacy of the ongoing herbicide application program (Table 8 and Figures 8 through 13).
- A comprehensive assessment of the biologic community, including fish, wildlife, plants, and aquatic invertebrates, was conducted in and around Ashmere Lake. ESS personnel obtained data by researching historical records, contacting state agencies, habitat-based computer simulations, and in-field observations. These data will be incorporated into proposed lake management strategies, to ensure that the biologic integrity of the region is preserved.
- Fish and wildlife communities occurring in the lake and within its watershed were documented via direct observation throughout the course of the study, through the NEWild (Thomasma et. al, 1999) program and by searching the Natural Heritage and Endangered Species Program (NHESP) for rare and endangered species (Appendix A). Wildlife species that were observed or are expected to occur within the Ashmere Lake watershed are presented in Table 9. Also, areas downstream of Ashmere Lake were investigated for the presence of any state-listed species reported to occur within the

Hinsdale Flats ACEC. Species historically documented to occur within the Hinsdale Flats ACEC, which may potentially be affected by lake management activities, are listed in Table 10.

- Aquatic invertebrates were collected from the major tributaries, the outlet and along the lake margins on October 31st, 2002. Sampling locations are depicted in Figure 5 and data is presented in Table 11.

The hydrologic (water flow) and nutrient (phosphorus and nitrogen) budgets for Ashmere Lake were modeled from long-term climatological data and from field data collected during this study (Appendix C). Nutrient budgets were determined using a variety of limnological modeling techniques based on watershed features and field data specific to the lake. The modeling effort relied heavily upon system hydrology and in-lake nutrient concentrations. Nutrient loading to the lake was further categorized by itemizing various inputs to the lake from the land use data and tributary data collected as part of this study.

One important value of the current investigation, in addition to evaluating water quality, assessing aquatic plants and recommending appropriate management techniques, is the broad range of environmental variables that have been examined. The data collected as part of this relatively comprehensive study will provide an excellent framework by which the success or potential impacts of any implemented management actions can be measured.

3.0 STUDY RESULTS

3.1 Watershed Features

A USGS topographic map was used to identify the watershed of Ashmere Lake (Figure 1). Although this is likely to be a very close approximation of the true watershed boundary, it is possible that the storm drainage systems in the watershed might not mirror surface topography. Barring a more detailed analysis of the storm drainage system, the watershed, including Ashmere Lake, was calculated to be approximately 2,824 acres or approximately 11 times the area of the lake itself.

The majority of land within the Ashmere Lake watershed is forested (73%) and a lesser component is devoted to residential (10%). Other land uses include cropland, pasture, wetlands, open land, participant recreation, commercial urban open and water (Figure 2, Table 1). Although the majority of the Ashmere Lake watershed is forested, Peru Road (Route 143), a heavily traveled roadway, bisects the south and north basins, and stormwater generated from this impervious surface is discharged into the lake. It is not known what materials are applied to the roadways in the immediate vicinity of Ashmere Lake, although it is expected to be either sand or a mix of sand and salt. Confirmation of this would need to be obtained from either the Hinsdale DPW or MassHighway.

Further delineation of the watershed allowed ESS to designate eight (8) discrete watershed sub-basins (Figure 2, Table 1). Land use data of these sub-basin delineations indicate that sub-basin 1, located east of the south basin, is predominately comprised of forest (85%) and residential (10%); sub-basin 2, located northeast of the south basin, is predominately comprised of forest (85%), and residential (9%); sub-basin 3, located northeast of the south basin, is predominately comprised of participant recreation (68%), forest (17%), residential (8%), and water (7%); sub-basin 4, located east of the north basin, is predominately comprised of forest (61%) and residential (35%); sub-basin 5, located north of the north basin, is predominantly comprised of forest (90%), wetland (3%), and open land (3%); sub-basin 6, located west of the north basin, is predominantly comprised of forest (68%), participant recreation (13%), and residential (12%); sub-basin 7, located northwest of the south basin, is predominantly comprised of forest (46%), residential (36%), and open land (16%); and sub-basin 8, located southwest of the south basin, is predominantly comprised of forest (99%).

Current watershed land uses, zoning, slopes, soils, rail lines, road rights-of-way (ROWs), and political boundaries were incorporated into a GIS data layer and a corresponding figure (Table 1b, Figure 14) in order to project a 100% build-out scenario for the Ashmere Lake watershed (MassGIS, 1999). Build-out analyses calculate the theoretical maximum amount of development that would occur if all developable land within a specific watershed were to be developed. A build-out analysis is a valuable tool for watershed management as it enables stakeholders to understand the potential land use outcomes of zoning ordinances, and provides a framework for assessing the impacts of future development under alternative zoning scenarios (Somerset County, 1997).

Build out analysis for the Ashmere Lake watershed indicates that the majority of the watershed (62%) is developable land with partial (293.2 acres, 10%) or no constraints (1,457 acres, 52%) (Table 1a, Figure 14). Partial constraints are features that make land more difficult to develop and reduce the amount of what is likely to be built there (MassGIS, 1999). A lesser percentage of land within the Ashmere Lake watershed is categorized as absolute developmental constraints (1,073.8 acres, 38%) (Table 1a, Figure 14). Absolute developmental constraints depict land that is already developed, approved for development, permanently protected, or have environmental features that make development very unlikely (MassGIS, 1999). These data indicate that the majority of the Ashmere Lake watershed is potentially developable. Some development was observed to be ongoing along the immediate shoreline of the lake's north basin at the time of this study. Although not foreseen as an imminent problem, rapid, widespread development of the watershed could significantly impact water quality within the lake by reducing the amount of pervious area in the watershed, resulting in an increased volume of untreated stormwater being discharged directly to the basin.

Soils in the Ashmere Lake watershed were characterized based on the most recent Soil Survey of Berkshire County Massachusetts (USDA 1988). Soils in the watershed are predominately comprised of the Tunbridge-Lyman-Peru Series, which are shallow to very deep soils that are moderately well drained to excessively drained. These soils are generally loamy soils formed on glacial till derived from schist, gneiss, and granite, on uplands.

3.2 Lake Features

3.2.1 Physical Characteristics

Ashmere Lake is approximately 257 acres in size and consists of a south and north basin (Table 2). Peru Road (Route 143) bisects the lake between the north and south basin. An inter-basin connector, located under Peru Road, allows for flow to move from the north basin to the south basin. Three major tributaries feed into Ashmere Lake. These consist of: 1) an unnamed tributary near Camp Danbee, which feeds into the eastern cove of the south basin; 2) an unnamed tributary, which crosses George Schnopps Road, which feeds into the northeastern cove of the north basin; and 3) an unnamed tributary, which runs adjacent to Raymond Road and flows into a detention pond before being culverted under Peru Road (Route 143) and discharging into the south basin. The headwaters of these three tributaries consist of mainly forested or wetland areas (Figure 1).

The outlet from Ashmere Lake is located in the southwestern cove of the south basin (Figure 5) and consists of a concrete outlet structure and spillway. Water discharged from Ashmere Lake forms Bennett Brook, which runs southwest approximately one mile before discharging into the state Division of Fisheries and Wildlife's (MassWildlife) Hinsdale Flats Wildlife Management Area, within the ACEC.

Water depths in the lake were measured along 10 appropriately spaced transects within each basin on May 20th, 2002. The maximum depth observed was 24 feet in the south basin and 14 feet in the north basin, with an average water depth of 13 and 6.5 feet for the south and north basins, respectively (average water depth for the entire lake is 10.7 feet; Table 2). Calculations based on our bathymetric survey indicate that the lake has an approximate volume of slightly greater than 119 million cubic feet of water (Table 2).

The south basin of Ashmere Lake is relatively deep and is characterized by three major coves. A forested island is located within the south basin near the eastern shore and Camp Danbee (Figure 3). Other small islands, consisting of aggregates of large boulders, exist in the south basin and become exposed during lower water levels.

The north basin of Ashmere Lake is considerably more shallow than the south basin and has a highly irregular shoreline perimeter (Figure 4). The north basin of Ashmere Lake is characterized by six major coves. A large forested island delineates the northern and southern coves of the north basin.

ESS conducted a review of existing data for Ashmere Lake and its watershed. Municipal representatives at the Town of Hinsdale were contacted in order to obtain town sewer and zoning maps. Staff from the Town of Hinsdale public works department notified ESS that all neighborhoods surrounding Ashmere Lake had been put on a sewer system approximately three years ago and that only a few residences remain on septic. Water resources within the Ashmere Lake watershed are illustrated on Figure 15. As indicated by MassGIS, water resources present in the Ashmere Lake watershed, include fourteen community and non-community (private) water supply wells, all of which are encompassed by an interim wellhead protection area. In addition, six of the public water supply wells (wells 1132008-01G, 1132001-01G, 1132001-02G, 1132002-1G, 1132002-2G, and 1132012-1G) are encompassed by a community interim wellhead protection area (Figure 15). No MADEP Approved Zone II areas are currently mapped by MassGIS within the Ashmere Lake watershed. This was confirmed through a review of MADEP records by ESS. Interim wellhead protection areas are approved by the Massachusetts Department of Environmental Protection (MADEP) so that the primary recharge areas surrounding each well is protected, however, approved Zone II delineation is still expected to be required for the six community wells.

Historic studies of Ashmere Lake were provided by the Hinsdale Lake Management Committee and consist of the MADEM Inspection/Evaluation Report of the Ashmere Lake Dam (Baystate Environmental Consultants, Inc. 1999) and a letter report from Lycott Environmental Inc. (October 17th, 2001) describing aquatic plant herbicide treatments. More detailed information concerning past herbicide applications to Ashmere Lake was obtained via a telephone conversation with representatives from Lycott Environmental Inc. on December 16th, 2002 (Lyman pers. comm. 2002). Information or data obtained from these reports has been referenced throughout this document as applicable.

3.2.2 Chemical Characteristics

3.2.2.1 Surface Water Analysis

Water quality was assessed at the deepest spot in both basins of Ashmere Lake, designated as Sites AS-1S and AS-1B, and AN-1S and AN-1B (Figure 5). Water quality monitoring stations were also established at the two major tributaries (AS-2 and AN-2), a storm drain (AS-3), and at the outlet (AS-4). Every attempt was made in the field to sample the unnamed tributary that flows adjacent to Raymond Road and ultimately into a detention pond before being culverted under Peru Road where it discharges into the south basin. Unfortunately, the outfall of this culvert remained below in-lake water levels throughout the course of the study and therefore, flowing water samples could not be collected from this location.

Water quality monitoring was conducted on three dry weather dates (defined as a minimum of 72 hours antecedent with less than 0.1 inch of rainfall). Monitoring occured on May 21st, August 27th, and October 31st, 2002. Water quality was monitored at the tributaries on one dry weather date (August 27th, 2002) and one wet weather date (September 15th, 2002). Wet weather conditions were defined as a precipitation event of $\geq$0.25 inches, which was preceded by a minimum of 72 hours with less than 0.1 inch of rainfall. Water quality was monitored at the stormdrain, which discharges to the south basin of Ashmere Lake, on one wet weather date (September 15th, 2002). Water quality was monitored at the outlet on one dry weather date (August 27th, 2002). Results from the water quality monitoring program are summarized below for each parameter and presented in Tables 3, 4 and 5 and Figures 6 and 7.

Dissolved Oxygen and Temperature

Dissolved oxygen is the amount of molecular oxygen (O_2) dissolved in water. Dissolved oxygen below 6.0 mg/L and 75% saturation is generally considered unsuitable for many forms of aquatic life. Additionally, release of phosphorus (which promotes algal and plant growth) from bottom sediments can often be enhanced under anoxic (no oxygen) or very low oxygen (<1.0 mg/L) conditions. Temperature and dissolved oxygen are typically measured within the water column to determine the extent of lake stratification. Dissolved oxygen and temperature profiles for the dry weather sampling dates are presented in Table 4 and profiles are depicted graphically in Figures 6 and 7.

Dissolved oxygen profile data for Ashmere Lake indicate that the lake was not strongly stratified with respect to temperature during the May, August and October 2002 sampling dates (Figures 6 and 7). In contrast, dissolved oxygen levels decreased significantly with depth, with the most dramatic decreases in dissolved oxygen levels occurring at an approximate depth of 5.0 and 3.0 meters in the south and north basins of Ashmere Lake, respectively. In all instances, the dissolved oxygen levels in the epilimnion (i.e., waters above the thermocline) are greater than 6.0 mg/L and therefore, reflect a moderately well oxygenated environment; however, in several instances, the lake bottom was found to be poorly oxygenated (≤1.0mg/L) (Table 4).

Average dissolved oxygen levels measured at AN-2 and AS-3 were well above the 6.0 threshold indicating adequate oxygen levels for maintaining fish and other aquatic organisms. However, average oxygen levels measured at AS-2 and the lake outlet (AS-4), were slightly low (5.2 and 5.9 mg/L, respectively).

Conductivity

Conductivity measures the resistance of a solution to electrical flow and can be used as an indirect measure of dissolved solids in water, which in turn can be an indication of water fertility.

Average conductivity values measured at the in-lake stations ranged from 103 to 121 μmhos/cm (Table 4). Average conductivity values from the tributaries (AS-2 & AN-2), the storm drain, (AS-3), and the outlet (AS-4) are 128, 68, 61, and 126 μmhos/cm, respectively (Table 4). These values suggest only moderate fertility and are comparable to other generally healthy Massachusetts waterbodies.

Turbidity

Turbidity is an indirect measure of the quantity and size of particles (sediment, algae cells, debris, etc.) in a water sample. Turbidity values less than 10 NTU (nephelometric turbidity units) are generally assumed to have minimal impact on habitat and biota.

Average turbidity values exhibited at in-lake stations ranged from 0.6 to 5.3 NTU, indicating the presence of a relatively insignificant amount of particulate matter in the water column (Table 4). Average turbidity levels from the tributaries (AS-2 & AN-2), the storm drain, (AS-3), and the outlet (AS-4) are 1.2, 1.0, 80.0, and 1.0 NTU, respectively (Table 4). High turbidity values exhibited at the storm drain (AS-3) suggest that particulate matter accumulating on Peru Road (Route 143) may become mobilized and be discharged into the south basin of Ashmere Lake, particularly during precipitation events. Although the settling basin to the north of Peru Road was not sampled due to a lack of flow through the system during the sampling event, it is likely that stormwater entering this basin is also carrying a large sediment load. At this time, it appears that the basin is capturing a significant portion of this sediment load, however, regular maintenance is required in order to ensure that the effectiveness of such a structure is maintained.

pH

The pH value is a measure of acids and bases dissolved in water. In general, pH values for most lakes and streams in Massachusetts range from 6.0 to 7.5 SU (standard units). However, most lakes in the Berkshires are influenced by underlying limestone deposits and therefore often have values that exceed 7.0 SU or even 8.0 SU (exhibiting more basic conditions) due to the breakdown of calcium carbonate (limestone) which produces a strong base, calcium hydroxide, and a weak acid, carbonic acid.

Average pH values exhibited at the in-lake stations ranged from 7.2 to 7.4 SU (Table 4). Average pH values measured at the tributary stations (AS-2 & AN-2), the storm drain, (AS-3), and the outlet (AS-4) are 7.0, 7.4, 7.9, and 6.7 SU, respectively (Table 4). The range of pH values exhibited during this study do not appear to indicate any adverse pollutant loading; however, the sample collected from the storm drain site does seem to exceed the background levels observed within the lake itself.

Alkalinity

Alkalinity is a measure of the buffering capacity, or ability of the waterbody to neutralize strong acids. Lakes with high alkalinity can neutralize the deleterious effects of acid rain. The main source of alkalinity is usually carbonate rock, such as limestone. The average alkalinity level measured at the in-lake stations was 26 mg/L, while alkalinity levels measured at the tributaries (AS-2 & AN-2), the storm drain (AS-3), and the lake outlet (AS-4) were 47, 26, 13, and 37 mg/L, respectively (Table 5). These data suggest that all sampling locations were characterized as exhibiting soft waters (WDNR, 1999). In general, alkalinity values in excess of 25 mg/L generally suggest that there will be adequate buffering capacity to neutralize acidic inputs. Given that the in-lake station averaged 26 mg/L, it appears that Ashmere Lake is not very susceptible to acidic inputs.

Water Transparency

Water transparency (or clarity) in Ashmere Lake was measured in the field with a Secchi disk from each in-lake surface station (Table 4). Factors such as plankton concentration, water color, and suspended particles within the water column, directly impact Secchi depth measurements.

Secchi depth values were moderately high throughout the study and ranged between 2.3 and 3.2 meters (Table 4). Typically, Secchi depths from 2 to 3 meters are indicative of late-mesotrophic (moderate fertility) waterbodies (Canavan and Siver, 1995) and would be considered good for a Massachusetts lake.

Fecal Coliform

Fecal coliform bacteria are used as an indication of potential sewage contamination since these bacteria are commonly found in both human and animal feces. Fecal coliform bacteria are not harmful themselves, but are believed to be indicative of the presence of other more harmful pathogens. For Massachusetts Class B waters, fecal coliform values averaging less than 400 colonies/100mL during dry weather conditions and equal or less than 2,000 colonies/100mL during wet weather conditions are considered acceptable for primary contact recreation by the State of Massachusetts (MADEP, 1996).

Average fecal coliform values measured at the in-lake surface stations are low and exhibited 18 and seven colonies/100mL, for AS-1 and AN-1, respectively (Table 5). These values are well below state standards and therefore, may be considered acceptable for primary contact recreation by the State of Massachusetts (MADEP, 1996).

Similarly, average fecal coliform values are low from the unnamed tributary, (AN-2), the storm drain (AS-3), and the outlet (AS-4), totaling only 13, 80 and 5 colonies/100mL, respectively. These low values are well below state standards and therefore, may be considered acceptable for primary contact recreation by the State of Massachusetts (MADEP, 1996).

Average fecal coliform levels from the unnamed tributary (AS-2) are slightly elevated and totaled 400 colonies/100mL. However, because dry weather bacteria levels are below 400 colonies/100mL (30 colonies/100mL) and wet weather bacteria levels are below 1,000 colonies/100mL (770 colonies/100mL), these waters may be considered acceptable for primary contact recreation by the State of Massachusetts (MADEP, 1996).

Although these data provide adequate background information from which to develop a management program for the lake, additional bacteria sampling (including both fecal coliform and *E. coli*) during early and late stages of a particular wet weather event would aid in accurately characterizing the degree of bacterial contamination within the lake.

Phosphorus and Nitrogen

Phosphorus and nitrogen are essential plant nutrients. Excessive concentrations of one or both of these nutrients can result in undesirable growth of algae in the water column (phytoplankton) and accumulations of attached algae (periphyton) on the shallower bottom sediments (within the euphotic zone). In addition, excessive quantities of these nutrients can also promote rooted plant growth.

Phosphorus

Typically, phosphorus values of less than 0.02 mg/L are desirable for maintaining low algal biomass and high water clarity, while concentrations above 0.05 mg/L are considered excessive and indicative of a hyper-eutrophic system (Canavan and Siver, 1995).

Total phosphorus values measured at the in-lake stations are relatively low, averaging 0.035 mg/L in the south basin and 0.020 mg/L in the north basin. These data suggest that only moderate amounts of phosphorus are available within the water column to fuel algal and plant growths (Table 5). In addition, the presence of a well-developed thermocline, particularly in the deeper south basin during the peak growing period, will also mitigate the effect of the extremely elevated phosphorus values (0.80 mg/L) observed at the bottom of the south basin during the August sampling event.

Slightly elevated average total phosphorus values of 0.03, 0.03 and 0.04 mg/L were also observed at monitoring stations AS-2, AN-2 and AS-4, respectively (Table 5). AS-2 and AN-2 are stations located on the major tributaries feeding the lake and indicate that the lake is receiving a substantial portion of its nutrients from these tributaries, particularly during dry weather periods.

Total phosphorus levels exhibited at the storm drain sampling location (AS-3) were also excessive at 0.11 mg/L (Table 5). This indicates that stormwater runoff associated with Peru Road (Route 143), and most likely many of the other roads within the watershed, may still be contributing excessive levels of phosphorus to Ashmere Lake despite the recent improvements and added Best Management Practices (BMPs) to the stormwater system. Regular maintenance of the settling basin located on the north side of Peru Road will be necessary in order to ensure that its pollutant trapping effectiveness is maintained.

Average dissolved phosphorus values measured at the in-lake stations are relatively low and totaled 0.015 mg/L (Table 5). Similarly, average dissolved phosphorus values at the tributaries (AS-2 and AN-2), and the outlet (AS-4), are relatively low and totaled 0.02 mg/L at each sampling location.

Average dissolved phosphorus levels exhibited at the storm drain (AS-3), are slightly elevated and totaled 0.04 mg/L (Table 5). These data further provide evidence that stormwater runoff associated with Peru Road (Route 143) may be contributing excessive levels of phosphorus to the south basin of Ashmere Lake.

In-lake total phosphorus levels are often correlated with water clarity. Typically, elevated concentrations of phosphorus result in increases in phytoplankton, and consequently lower in-lake water clarity. Water clarity was generally good for Ashmere Lake and the relationship between total phosphorus and water clarity within Ashmere Lake is graphically depicted in Figure 17.

Nitrogen

Nitrate-nitrogen, one of the several major forms of nitrogen, within Ashmere Lake was low compared to the normal background level of 0.05 mg/L, which is typical for Massachusetts lakes and ponds (MAPC, 1983). Nitrate-nitrogen averaged 0.01 mg/L for all in-lake sampling stations in Ashmere Lake (Table 5). Similarly, nitrate-nitrogen levels from the outlet (AS-4) are low and totaled 0.01 mg/L (Table 5). Nitrate-nitrogen levels are greater at the tributaries (AS-2 and AN-2), and the storm drain (AS-3), and totaled 0.2, 0.15, and 0.29, respectively (Table 5). These elevated levels of nitrate-nitrogen suggest that excessive levels of this nutrient are discharging into the basins from tributaries and stormwater drainage. It is interesting to note that at the two tributary sampling locations, the greatest nitrate-nitrogen values occurred during dry weather conditions, suggesting a potential septic leachate problem or possibly an illegal sewage hookup issue within the upgradient reaches of these tributaries.

Ammonia-nitrogen concentrations were also found to be low at the in-lake sampling stations, averaging 0.015 mg/L (Table 5). Ammonia-nitrogen levels measured at the tributary (AN-2) and the outlet (AS-4) were also low, both averaging 0.01 mg/L (Table 5). Ammonia-nitrogen levels were greater at the tributary (AS-2), and the storm drain (AS-3), averaging 0.13 and 0.07 mg/L, respectively. Ammonia-nitrogen levels at the tributary (AS-2) were greatest during the dry weather sampling effort, thereby suggesting yet again that a potential septic leachate problem or an illegal sewage hookup may exist within the upgradient reaches of this tributary.

The third form of nitrogen assessed as part of this study was total Kjeldahl nitrogen or TKN. TKN is a measure of the amount of ammonia and organic nitrogen in a sample. The average TKN value for the in-lake stations was 0.425 mg/L (Table 5). Average TKN values exhibited at the tributaries (AS-2 and AN-2), the storm drain (AS-3), and the outlet (AS-4) were 0.7, 0.5, 0.3, and 0.7 mg/L, respectively (Table 5).

Together, TKN and nitrate-nitrogen form the significant portion of total nitrogen that is typically observed in aquatic systems (nitrite, not analyzed in the present study, is typically present as an insignificant fraction comprising total nitrogen). Typically, total nitrogen values no greater than 0.2 mg/L are desirable for maintaining high water quality, while concentrations above 1.0 mg/L are considered excessive and indicative of a hyper-eutrophic system (Canavan and Siver, 1995). Average total nitrogen levels for all in-lake stations are 0.44 mg/L, respectively (Table 5). These data suggest that despite the slightly elevated levels of nitrogen exhibited in inflowing water from tributaries and storm drains, Ashmere Lake is presently characterized by low levels of in-lake available total nitrogen. Average total nitrogen levels are similarly low for other sampling stations and averaged 0.27, 0.65, 0.59 and 0.71 mg/L for the tributaries (AS-2 & AN-2), the storm drain (AS-3), and the outlet (AS-4), respectively (Table 5).

3.2.2.2 Sediment Characterization and Analysis

A quantitative assessment of sediment quality was performed for Ashmere Lake on February 7th, 2002. The purpose of the soft sediment analysis was to screen sediment for pollutants and to assess the potential for any reported pollutants to affect ecological and/or human health. Sediment quality is an indicator of long-term contaminant contributions from the watershed to a waterbody. Moreover, sediment quality can affect the health of aquatic organisms exposed to the sediment and can ultimately result in the bio-accumulation of contaminants within higher trophic levels of the food chain, including fish and humans. This characterization of sediments is part of a "screening process" designed to reveal, if present, the severity of sediment contamination and to aid in the development of future management strategies.

Results of the sediment sampling and subsequent laboratory analysis are presented in Table 6. Grab samples were collected from the lake bottom using an Ekman dredge, which collects the soft surficial sediment and the associated organic material. Samples were collected from three different locations within the lake basin and composited to prepare a single sample from the lake for laboratory analysis (Figure 5). The relatively shallow grab samples collected are representative of the depth of muck that is biologically available to organisms within the lake and that may possibly be affecting conditions within the lake's water column or contributing to rooted aquatic plant growth. Sediment samples were analyzed for the following parameters: total phosphorus, total solids, percent water, percent organic content, arsenic, cadmium, chromium, copper, lead, mercury, nickel, vanadium, zinc, PAHs, PCBs, TPHs, and sediment grain size.

Sediment quality guidelines by which environmental impairment is defined is based on the Long and Morgan freshwater criteria (1995) which presents threshold levels of chemical contaminants that affect human and environmental health. Under this classification system, contaminant levels below the Effects Range Low (ER-L) value represent a condition in which adverse biologic effects would rarely be observed (Table 7). Concentrations equal to and above the ER-L, but below the Effects Range Medium (ER-M), represent a condition in which adverse biological effects would be expected to occasionally occur. Finally, concentrations equivalent to and above the ER-M value represent a condition in which adverse biologic effects would be expected to frequently occur.

A second sediment quality classification system is based on the Great Lakes sediment quality criteria established by the United States Environmental Protection Agency (USEPA 1977) (Table 7). These standards describe a range of threshold values, which are considered to reflect "unpolluted" to "severely polluted" conditions.

Further evaluation of sediment quality was based on the Massachusetts Interim Policy for Sampling, Analysis, Handling and Tracking Requirements for Dredged Sediment Reused or Disposed at Massachusetts Permitted Landfills (Interim Policy # COMM-94-007) (Table 7). The Interim Policy integrates the applicable elements of the MADEP's Interim Policy BWP-94-037 (MADEP 2000) and 401 Water Quality Certification regulations at 314 CMR 9.00 (CMR 1995). The MADEP plans to promulgate Comprehensive Dredging and Disposal Regulations in the near future. Once the potential for sediment removal has been established, the allowable method for sediment removal was determined according to 314 CMR 9.03. Sediment acquired from the lake was defined as impaired when any of the measured sediment quality parameters exceeded the threshold guidelines.

Of the potential contaminants investigated, cadmium, lead, and zinc were the only parameters found to exceed the ER-L guideline due to a reported concentration of 1.3 mg/Kg, 55.0 mg/Kg and 160.0 mg/Kg, respectively (Table 6), indicating that prolonged exposure to the sediments may detrimentally affect the biological community and possibly even human health. According to the Great Lakes sediment quality criteria, levels of arsenic, cadmium, lead, and zinc (5.4, 1.3, 55.0 and 160.0 mg/Kg, respectively) are greater than what is characteristic of unpolluted sediments and levels of copper and total phosphorus (25 and 1,100 mg/kg) are above the level characteristic of severely polluted sediments (Table 6).

PCBs are very similar, chemically, to many pesticides; however, most PCB compounds were intended for use in closed systems such as electrical transformers and capacitors. Some were also used as lubricants or as heat transfer and hydraulic fluids. Fortunately, PCBs were not detected in sediment samples collected from Ashmere Lake (Table 6).

PAHs are generated through the incomplete combustion of carbon compounds, often associated with industrial activities. PAHs may attach to small particles in the atmosphere and be transported for considerable distances before returning to earth directly or in rainfall and therefore, are often distributed in the environment in low concentrations (The Green Lane, 2001). Many PAHs are quite persistent and some are potent carcinogens in mammals (Rand & Petrocelli 1985). Total PAHs measured in the sediments of Ashmere Lake were well below those required for disposal at Massachusetts lined landfills (100 mg/Kg). However, one compound, Perylene, was detected and exhibited a value of 0.72 mg/Kg in the sediments (Table 6). Pyrelene is known to form from the early diagenisis of plant pigments such as chlorophyll *a*, so its presence in the sediment may not necessarily indicate anthropogenic contamination (Irwin, 1997). Given that other PAH compounds were not found in the Ashmere Lake sediments, it is likely that the Pyrelene found was of natural origin.

Sediment particle size is a measurement that refers to the relative quantity of sediment sizes that are present in a sediment sample. Samples collected from Ashmere Lake consisted primarily of silts and clays, fine sands and medium sands, coarse sands, and gravel with these size fractions accounting for approximately 45, 52.7, 2.1, and 0.2% of the material present in the lake basin, respectively (Table 6). Large pulses of fine sediments are typically transported and deposited to waterbodies during moderate and extreme storm flow conditions.

The sediment sampled from Ashmere Lake is well below state criteria for disposal at Massachusetts lined landfills and is classified as Category 1 Type C material, one of the more chemically benign sediment categories according to 314 CMR 9.03. This designation allows for sediments to be hydraulically or mechanically dredged; however, sediments cannot be sidecast (deposit of excavated materials on adjacent slopes or upland areas). Land disposal would be approvable; however, control of effluents would be required throughout the removal and disposal process. It is important to note that sediments were designated as Type C materials solely due to the elevated percent water content of the sample. It is probable that if sediment was adequately dewatered upon dredging, it could be reclassified as Type A material and therefore, could qualify for standard trucking or sidecast disposal methods.

3.2.3 Hydrologic and Nutrient Loading

It is possible to estimate the amount (load) of phosphorus and nitrogen being contributed to Ashmere Lake by its watershed when an estimate of water flowing into the lake and the concentration of each nutrient in this water is known. Water flowing into Ashmere Lake (and any other waterbody) comes from three primary sources: surface water, groundwater, and direct precipitation.

Surface water flows can be estimated from actual flow data or from known relationships for water yield from similar watersheds. Three primary tributaries to Ashmere Lake exist; however, surface water also enters the lake directly during rain events as overland runoff. The average annual flow rate to the lake was calculated to include both sources of flow and was based on the area of the watershed and local precipitation data. An estimate of the rate of groundwater movement into the lake was based on averages obtained for New England lakes and lakes of similar geo-morphometry. Inputs from direct precipitation were determined from long-term climatological data for the region (Pittsfield, Massachusetts) and the known surface area of the lake.

Estimated average water input to Ashmere Lake from surface water, groundwater, and direct precipitation was calculated to be approximately 6.54, 0.80 and 0.89 cfs, respectively, for a total average annual flow of approximately 8.22 cfs (Table 12, Appendix C). This flow will vary appreciably among seasons and weather conditions. Surface water runoff was found to contribute significantly (79.5%) to the total lake inflow, while groundwater inflow (9.7%) and precipitation (10.8%) make up the remainder. Typically, surface water flow can be further divided into dry weather (background) flows and wet weather (storm) flows. For Ashmere Lake, dry weather flows were calculated to be approximately 0.04 cfs (0.5% of total water input), while wet weather flows were calculated to be 6.50 cfs (79.0% of total water input).

Based on total lake volume and the calculated flow through the lake, average detention time was calculated to be 167.9 days (0.46 years) (Table 12). Detention time represents the duration of time necessary to exchange the volume of water in the lake one time. Flushing rate is the inverse of detention time, and represents the number of times per year the lake volume is replaced; for Ashmere Lake the flushing rate is about 2.2 times per year. This is a moderate flushing rate, but would be anticipated for a lake of these dimensions with its relatively small watershed.

When detention time is known, a calculation can be made to determine response time (time needed for a lake to fully realize nutrient inputs), which for Ashmere Lake ranges between 144 days and 240 days (Dillon and Rigler, 1975). Since Ashmere Lake's detention time (167.9 days) is within the range of its response time, the effect of nutrients entering the lake are likely to be expressed fully before passing through the system (i.e., the conditions within the lake are expected to be reflective of the water quality it receives).

The nutrient water quality data can be placed into perspective once the values are interpreted as a measurement of the nutrient load to Ashmere Lake (Table 13, Appendix C). In order to accurately characterize in-field conditions as precisely as possible with the relatively limited data that was obtained during the field collection effort, the following items were incorporated into the model:

1) Average in-lake nutrient levels used during the modeling effort were calculated from surface depths (AS-1S & AN-1S) only.
2) An estimate of the rate of groundwater movement into the lake was based on averages obtained for Berkshire lakes and lakes of similar geo-morphometry. Specifically, groundwater inflow was assumed to be 10 $l/m^2/day$ and this average flow rate was expected to occur up to 50 feet from the shoreline perimeter out into the basin.
3) Average phosphorus concentration in groundwater flows was approximated at 0.02 mg/L.
4) Iron was not assessed during this project. Elevated levels of iron in the water column promote the formation of iron phosphates, which are highly insoluble in oxygenated water and thereby, effectively reduce the bioavailability of phosphorus within the water column. Consequently, the annual phosphorus loading estimates presented in the study may be representative of an upper limit of in-lake conditions.
5) Precipitation data utilized for modeling was reported as the average annual precipitation for Pittsfield, MA (44.8 inches).

A calculation of minimum nutrient load was made by multiplying the volume of the lake by its flushing rate and the average concentration of the nutrient observed during this study. The minimum phosphorus and nitrogen loads delivered to Ashmere Lake were determined to be 0.12 $g/m^2/yr$ (18.33 kg/yr) and 3.1 $g/m^2/yr$ (472.5 kg/yr), respectively, based on the in-lake concentration data collected during this study (Table 13, Appendix C). The actual load of phosphorus or nitrogen will exceed the estimated minimum load as a consequence of loss processes that reduce the in-lake concentration over time. Since phosphorus is viewed as the nutrient that controls productivity in this freshwater lake, emphasis is placed on a more detailed modeling analysis of its loading to Ashmere Lake.

A more detailed and realistic estimate of nutrient loading can be obtained by using a combination of actual field data and in-lake modeling theory. Nutrient loads are calculated based on nutrient values measured within the lake and hydraulic features of the lake. The predicted phosphorus load necessary to achieve the values found in Ashmere Lake ranges between 0.20 $g/m^2/yr$ (208 kg/yr) and 0.37 $g/m^2/yr$ (383 kg/yr) (Jones-Bachmann 1976, Reckhow 1977) based on this approach (Table 13, Appendix C). The average predicted phosphorus load for all models was 0.26 g/m2/yr (267 kg/yr). The nitrogen load necessary to achieve the observed in-lake concentrations was estimated to be 4.98 g/m2/yr (5,171 kg/yr) (Bachmann 1980) in this manner (Table 13).

Typically, nitrogen to phosphorus ratios less than 10 are indicative of nitrogen limited waterbodies, while ratios in excess of 15 are considered phosphorus limited waterbodies. Based on data obtained by ESS during the 2002 sampling effort, the in-lake nitrogen to phosphorus ratio is 38.8, indicating that at present Ashmere Lake is phosphorus limited.

Vollenweider (1968) established criteria for calculating the phosphorus load below which no productivity problems were expected (permissible load) and above which productivity problems were almost certain to persist (critical load). These loading limits are also based on the hydraulic properties of the lake and depend upon average depth and detention time. For Ashmere Lake, Vollenweider's permissible load is 276 kg/yr, while the critical load is 552 kg/yr (Table 13).

The average predicted phosphorus loads calculated for the lake through in-lake modeling (267 kg/yr) is just slightly less than the permissible load of 276 kg/yr and is considerably lower than the critical level of 552 kg/yr (Table 13). This indicates that phosphorus in Ashmere Lake is approaching levels that may eventually result in degraded water quality conditions in the future if left unchecked. This knowledge is useful for determining the value of the various management alternatives, and can be particularly helpful when prioritizing their order of implementation under fiscal constraints.

Similar loading limits for nitrogen have not been established, owing to the less predictable relationship between nitrogen, lake hydrology, and primary productivity. Although nitrogen data are very useful in understanding lake conditions and processes, phosphorus is the limiting nutrient and is therefore the logical target of management actions aimed at controlling algal biomass and plant growth.

An itemized phosphorus load can be developed when nutrient data from each of the various sources has been determined. Annual phosphorus loading itemized by sources to Ashmere Lake based on 2002 data suggests that the actual load of phosphorus could be lower than the load indicated by the in-lake models or concentration. The wet weather surface flow inputs stand out as the dominant influence at just over 116.1 kg/yr, and representing approximately 69% of the total estimated phosphorus load (Table 14, Figure 19). In contrast, the phosphorus load being contributed via direct precipitation, groundwater, surface water dry weather and internal nutrient recycling were estimated to be approximately 14.3%, 8.5%, 0.8%, and 7.4%, respectively (Table 14). It should be noted that these estimates are based on the relatively limited number of samples collected over a very short period of time (2002) and could be greatly influenced by the weather conditions prior to the commencement of the sampling or by the size of the particular storm events sampled.

A third approach for estimating the nutrient load to Ashmere Lake, that may be the most insightful method when long term data are not available, would be to calculate the nutrient load generated by each acre of land in the watershed based on its predominant use (Tables 15 and 16). Nutrient export coefficients are used to calculate the total load that is generated from each land use category along with selected attenuation coefficients to determine the load that would actually be expected to reach the lake based on the structure of the sub-watershed features and the relative distance from the lake. The watershed to Ashmere Lake is relatively small and is primarily forested (Table 1). An average of 48% of the phosphorus and nitrogen load generated within the watershed would be expected to reach Ashmere Lake; however, this varies for each watershed sub-basin.

Tables 15 and 16 summarize the above calculation for the Ashmere Lake watershed. The expected average nitrogen load to Ashmere Lake based on these calculations would be approximately 1,708 kg/yr and the expected average phosphorus load to the lake would be approximately 150 kg/yr. The predicted average nitrogen load is far below the load that was modeled from actual in-lake data (Table 13). This indicates that the watershed of Ashmere Lake is actually contributing far more nitrogen to the system than would be expected. In fact, Table 15 indicates that this maximum nitrogen load to the lake would not exceed 4,920 kg/yr when in fact modeling data based on the in-lake concentration of nitrogen indicates that the lake actually may be receiving as much as 5,171 kg/yr. Given that nitrogen is readily abundant, it is clear that phosphorus would be the nutrient that controls the algal growth. Phosphorus loading based on land use characteristics (150 kg/yr) was determined to be substantially lower than the effective load (i.e., 267 kg/yr) suggested by the actual data collected and modeled. It is likely that much of the incoming phosphorus to the lake is rapidly taken up by aquatic plants and algae growing in the lake.

3.2.4 Biological Community

3.2.4.1 Macrophytes

Macrophytes refer to the more complex aquatic plants found in association with aquatic environments. These plants may or may not have roots and can be broadly grouped into three categories based on their growth habits: the emergent plants, the floating-leafed plants, and the submerged plants. Macrophytes are critical elements of the littoral zone (shallow water areas), providing structure and habitat for fish and invertebrate communities, and helping to mediate some of the nutrient interactions between land and water. However, in areas subject to elevated nutrient and sediment loads, aquatic plant growth of "nuisance species" may become excessive and result in significant habitat degradation. High densities of "nuisance" plant species may choke out native wetland vegetation, displace animals dependent upon open water areas, hinder recreational activities and impede the downstream connectivity of waterways.

Historic reports indicate that nuisance plant growth has been a concern at Ashmere Lake for some time and various herbicides including Reward (active ingredient diquat), Sonar (active ingredient fluridone), and Aquathol K (active ingredient dipotassium salt of endothall), have been applied in the south and north basins of Ashmere Lake approximately every other year since 1998 (Lyman pers. comm., 2002). Widespread herbicide treatments were not deemed necessary in 1999 and 2001 due to the low abundance of nuisance species observed within the lake, which may be attributed to the efficacy of the prior year's herbicide application. Historically, herbicide applications are reported to have focused on the north basin and targeted species have included Eurasian watermilfoil (*Myriophyllum spicatum*), large-leaf pondweed (*Potamogeton amplifolius*), and fern pondweed (*Potamogeton robbinsii*). Although watermilfoil is an exotic species, the two potamogeton species are native and would generally be considered desirable unless they were found to be growing to excessive densities or in high use areas.

Unfortunately, no effort has been made to either report or control the curly-leaf pondweed (*Potamogeton crispus*) or brittle waternymph (*Najas minor*), both exotic plant species. The 2002 herbicide application was reported to be applied on June 4th to various locations throughout the south and north basins of Ashmere Lake (Lyman pers. comm., 2002). Specifically, a solution of diquat (Reward) was applied to a few relatively small areas in the south basin and liberally to the eastern and northeastern coves of the north basin of Ashmere Lake. The application of this solution was designed to target Eurasian watermilfoil, though it also appears to be effective on waterweed (*Elodea spp*), which was abundant during the 2002 plant assessment.

Aquatic plants in and around Ashmere Lake were mapped twice during the study (pre- and post-herbicide application) in order to document the seasonal patterns of aquatic plant growth within the basins, as well as track the effectiveness of the scheduled summer herbicide application. ESS assessed aquatic plant growth on May 20th and August 26th, 2002 in Ashmere Lake thereby bracketing the June 4th, 2002 herbicide application.

During each aquatic plant mapping effort the location of major plant beds was mapped and an estimate of plant percent coverage throughout the entire lake's surface area was recorded. In addition, a list of all plant species identified in Ashmere Lake during both plant assessments is provided as Table 8. Figures depicting dominant plant species and plant percent cover from the May 20th, 2002 plant assessment are included as Figures 8 and 9, for the south and north basins of Ashmere Lake, respectively. Due to the increase in abundance of aquatic plant growths encountered during the August 26th, 2002 plant assessment, it was determined that separate figures depicting dominant plant species and plant percent cover would facilitate analysis of the data. As such, figures depicting dominant plant species from the August 26th, 2002 assessment are included as Figures 10 and 12, for the south and north basins of Ashmere Lake, respectively, and figures depicting plant percent cover from the August 26th, 2002 assessment are included as Figures 11 and 13, for the south and north basins of Ashmere Lake, respectively.

During the May 20th, 2002 assessment, the aquatic plant community of the south basin of Ashmere Lake was relatively sparse. Dominant plant species included stands of cattail (*Typha latifolia*) and the exotic species common reed (*Phragmites australis*) along the lake edges with isolated patches of stonewart (*Nitella spp.*)

within the littoral zone of the lake (Figure 8). Although the vast majority of the basin was devoid of aquatic vegetation at the time of this survey, isolated patches of dense plant growths (>75% cover) were observed in several coves within the basin (Figure 8).

In contrast, the north basin of Ashmere Lake exhibited a substantially greater abundance of plant growth than the south basin during the May 20th, 2002 assessment. Dominant plant species within the north basin included stands of cattail along the lake edges with isolated patches of stonewart, waterweed (*Elodea canadensis*), and yellow pond lily (*Nuphar variegatum*) inhabiting the major coves (Figure 9). At the time of the May 20th, 2002 survey, several coves in the north basin of Ashmere Lake exhibited dense plant growth (>75% cover) including the northeast cove along George Schnopps Road, the eastern cove between Ashmere Drive and Cove Land, and the southwestern cove between Skyline Drive and Peru Road (Figure 9).

Aquatic plants mapped by ESS on August 26th, 2002, just after the peak of the growing season and following herbicide treatment, revealed that, in general, a greater abundance and diversity of plants occurred in both basins of Ashmere Lake compared to the May 20th, 2002 assessment (Figures 10 - 13). At the time of the August 26th, 2002 plant survey, elevated plant growths (>50% cover) covered approximately 20 acres (873,360 feet^2) of Ashmere Lake's two basins.

The aquatic plant community of the south basin of Ashmere Lake was dominated by the native plant species: pipewort (*Eriocaulon aquaticum*), hedge hyssop (*Gratiola L.*), fern pondweed (*Potamogeton robbinsii*), moss (*Musci spp.*) and common reed during the August 26th sampling date (Figure 10). Plant abundances increased only slightly in the south basin of Ashmere Lake between the May 20th and the August 26th, 2002 plant assessment dates, with the most notable increases in plant abundances occurring in the eastern cove downgradient of the unnamed tributary adjacent to Camp Danbee and in the southern cove upgradient of the outlet (Figure 11). Other areas, particularly the central portions of the basin, are of sufficient depth to preclude plant growth as a result of light limitation. At the time of the August 26th, 2002 plant survey, elevated levels of plant growth (>50% cover) covered approximately 3.7 acres (161,640 feet^2) of the south basin of Ashmere Lake (Figure 11), although most of this plant cover was comprised of native species.

The greatest abundances of aquatic plants observed throughout the study were reported from the north basin of Ashmere Lake on August 26th, 2002. Dominant plant species observed within the north basin include ribbonleaf pondweed (*Potamogeton epihydrus*), cattail, pipewort, stonewart, fern pondweed and common reed (Figure 12), all of which are native to Massachusetts. At the time of the August 26th, 2002 plant survey, roughly half of the entire shoreline perimeter of the north basin of Ashmere Lake was occupied by elevated plant growths (>50% cover). The cumulative area covered by aquatic plants in excess of 50% coverage was approximately 16.3 acres (711,720 feet^2) (Figure 13). Coves possessing the greatest plant growth at the time of the August 26th, 2002 survey included: the northwestern cove, south of George Schnopps Road, the eastern cove between Ashmere Drive and Cove Lane, and the southwestern cove between Skyline Drive and Peru Road (Figure 13). Although the north basin was substantially shallower than the south basin, the central portion of the basin was sufficiently deep to preclude plant growth due to light limitation.

The aquatic plant abundance documented on August 26th, 2002 indicates that although an herbicide treatment was conducted on June 4th, 2002, it appears that the plant communities in both the north and south basins of Ashmere Lake continued to develop throughout the growing season. If fact, the greatest plant abundance was observed during our post-treatment survey in the more extensively treated north basin of Ashmere Lake. The fact that most plant growth observed within the lake were native species appears to indicate that herbicide treatments are not having an impact on the native plant community.

ESS did observe the presence of Eurasian watermilfoil in several coves of Ashmere Lake during the May 20th, 2002 assessment, though it was not observed to be growing at "nuisance" levels. However, Eurasian watermilfoil was not observed during the post-herbicide aquatic plant assessment. Despite low abundances following the 2002 herbicide treatment, the historic presence of this species, as well as the presence of other exotic species within Ashmere Lake, such as brittle waternymph (*Najas minor)* and curly-leaf pondweed (*Potamogeton crispus*), should remain a concern for watershed stakeholders. Large beds of these aggressive species may rapidly out-compete native species for resources, resulting in the displacement of native flora from the lake. Even small populations of exotic species should be continuously monitored in order to detect any significant changes in distribution within the basin or other signs of population expansion. The high-water clarity and gently sloping shorelines in Ashmere Lake may provide ideal habitat for the continued colonization and even re-colonization of exotic plant species.

It should be noted that the herbicide treatment that was performed during 2002 appeared to have had the desired effect of controlling the target species, Eurasian watermilfoil, while having minimal effect on the native and more desirable species. However, the lack of adequate plant mapping and proper plant identification appears to have allowed two other exotic plant species to grow undetected and unmanaged. Future management actions should include efforts to adequately monitor and control the spread of the exotic submergent (watermilfoil, curly-leaf pondweed, and brittle waternymph) and emergent (common reed) plant species.

3.2.4.2 Invertebrates

An assessment of the benthic invertebrate community associated with Ashmere Lake and its major tributaries was conducted October 31st, 2002. Invertebrates were collected over an approximate 10 ft^2 bottom area using a "kick sampling" technique and a standard D-frame net. Sampled areas include the tributaries (AS-2 & AN-2), the lake outlet (AS-4), and locations along the lake margins of the north and south basin (Figure 5). At each sampling location the sampling personnel disturbed the sediments or agitated plants in order to dislodge and collect a representative sample of the benthic invertebrate community.

Bottom substrate at the tributaries (AS-2 & AN-2), and at the outlet (AS-4) was representative of fast flowing or lotic-type habitats. Detritus overlying a gravel and cobble substrate characterized both sampling locations. In addition, significant amounts of aquatic plants (primarily attached algae) and large woody debris were observed downgradient of the outlet.

The sampling locations along the margins of the north and south basin were characteristic of a ponded or lentic-type habitat. A variety of substrate types were observed at these locations including silt, sand, gravel, and cobbles.

In total, 27 invertebrate taxa were identified in and around Ashmere Lake, representing a relatively diverse and healthy aquatic invertebrate community (Table 11). The most abundant taxa observed from the tributaries (AS-2 & AN-2), are considered generalists or opportunistic species, and are regarded as being only moderately tolerant of pollution, suggesting relatively good habitat conditions. In addition, four mayfly (Ephemeroptera) taxa observed from these two sampling locations are considered "sensitive benthos" (EPA 2002). It should be noted, however, that the presence of pouch snails (Physidae) and midge larvae (Chironomidae), observed from the tributary sites, can be associated with nutrient enriched conditions and poorer water quality conditions (EPA 2002).

At the outlet (AS-4), the netspinner caddisfly, (Hydropsychidae) dominated the aquatic invertebrate community (Table 11). The majority of the invertebrate taxa observed at the outlet are typical of the lotic-type waters and are primarily "filter feeders" (i.e., these organisms use appendages to gather particles of algae and other fine organic particles from the water column for food). This type of invertebrate community is typical of a community located downstream of an impoundment. It is likely that water flowing out of Ashmere Lake provides a significant source of organic particles in the form of zooplankton and phytoplankton. The majority of species observed at the outlet are considered only moderately tolerant of pollution, are therefore suggest relatively healthy water conditions (EPA 2002).

The in-lake invertebrate community was similar in composition between the south and north basins (Table 11). Most organisms collected from the in-lake samples are considered generalists or opportunistic species and are only moderately tolerant to pollution. In addition, five mayfly taxa and an alewife floater mussel (*Anodonta implicata*) were collected from the in-lake sampling locations. These taxa are considered "sensitive benthos" (EPA 2002), and support the conclusion that aquatic habitats of Ashmere Lake are relatively healthy.

3.2.4.3 Fish, Wildlife, and Areas of Critical Environmental Concern

Fish and Wildlife

Information obtained from the Massachusetts Division of Fish and Wildlife indicates that Ashmere Lake is a highly regarded freshwater fishery in the state of Massachusetts. Ashmere Lake was stocked in 1999 with Tiger muskellunge (*Esox lucius x Esox masquinongy*) and is considered by Mass Wildlife to be one of the state's "best bets" for largemouth (*Micropterus salmoides*), smallmouth (*Micropterus dolomieui*) and calico bass (*Pomoxys sparoides*) fishing. Other fish species present in the basin include pickerel (*Stizostedion vitreum vitreum*) and black crappie (*Pomoxis nigromaculatus*) (MassWildlife, 2002).

ESS contacted the Massachusetts Division of Fisheries & Wildlife to obtain information on threatened or endangered species that are listed in the Ashmere Lake watershed (Figure 1) and an area approximately one mile downstream of the outlet. A letter from the Massachusetts Division of Fisheries & Wildlife dated February 28th, 2002 (Appendix A) indicates that the Wood Turtle (*Clemmys insculpta*), a species of special concern, is known to occur in the vicinity of the site. No field observations of this organism were observed during the 2002 field season. The Natural Heritage Endangered Species Program (NHESP) Classifications and ACEC for the Ashmere Lake watershed is provided as Figure 20.

The vast majority of land surrounding Ashmere Lake is forested, and therefore provides suitable habitat for wildlife, particularly birds and small mammals. ESS personnel noted wildlife and wildlife indicators during each field visit to Ashmere Lake and these data, along with data generated from the NEWild program (Thomasma et. al, 1999) have been summarized in Table 9.

ESS personnel noted the presence of flocks of Canada geese (*Branta canadensis*) utilizing the lake on several dates. Large populations of waterfowl can contribute a significant source of nutrients (up to 1 kg/bird/year of phosphorus) into the waterbody through their defecation. This additional input of nutrients can serve to fuel nuisance algal blooms and aquatic plant growth and, in extreme circumstances, may hinder activities for recreational enthusiasts as a result of introduced bacteria and associated pathogens.

Ashmere Lake is also reported to be inhabited by an exotic freshwater jellyfish (*Craspedacusta sowerbyi*) (FCSC, 2002). This species is indigenous to China, but has become widely spread throughout the United States. Freshwater jellyfish do not pose a threat to human recreational activities as their nematocysts cannot penetrate skin (Peard, 2002), but may affect the lake's community structure, through its predation of fish eggs, larvae and zooplankton (FCSC, 2002).

Area of Critical Environmental Concern

The watershed of Ashmere Lake is part of the 14,500-acre Hinsdale Flats ACEC (MADEM Office of Natural Resources, 1991). The Hinsdale Flats ACEC consists of extensive wetlands and floodplains associated with the headwaters of the East Branch of the Housatonic River. The majority of this wetland complex is bounded by forested hillsides, which feed tributary streams to the north-flowing East Branch.

The Hinsdale Flats ACEC is also important for its historical, archaeological, agricultural, and scenic values, and contains numerous waterbodies and public lands that are utilized for a wide range of recreational activities. This area harbors an outstanding variety of natural communities and wildlife, including six state-listed rare species. Historic reports indicate that the Hinsdale Flats ACEC contain populations of small yellow lady's-slipper (*Cypripedium calceolus* var. *parviflorum*), a state-listed Endangered Species, as well as woodland millet (*Millium effusum*), a state-listed Threatened Species. The Hinsdale Flats ACEC also harbors four state-listed Species of Special Concern: the wood turtle (*Clemmys insculpta*), hemlock parsley (*Conioselum chinense*), bristly black current (*Ribes triste*), and showy lady's-slipper (*Cypripedium reginae*). It should be noted that within the area immediately surrounding Ashmere Lake only the wood turtle is known to occur; however, it was deemed essential by DEM that a search be conducted to assess the area more thoroughly as part of this study.

The state-endangered small yellow lady's-slipper is a diminutive orchid with attractive blooms. Commonly, this species is found growing in swamps and semi-open, calcareous fens (minerotrophic wetlands with peat substrate that are characterized by sedges, grasses, mosses, shrubs, and stunted trees (NHESP, 1992). Populations of this species have significantly declined in recent years and are now restricted to only a few locales in western Massachusetts. Loss of wetland habitat and alteration of water levels appear to be significant factors contributing to its decline.

The state-threatened woodland millet is a perennial grass of calcareous forests with rich soils, where it tends to prefer drier, rocky upper slopes (NHESP, 1985). Steeply sloping mesic forests are relatively few in number in Massachusetts, and as a result, it is likely that woodland millet has never been particularly common in the state. Most of its present populations are small and are vulnerable to various forms of disturbance. The upland, forested habitat preference of this species does not make it particularly susceptible to upstream lake and pond management activities.

The wood turtle is a reptile of riparian areas and upland forests and fields (NHESP, 1994). The wood turtle breeds in slow-moving streams with densely vegetated sandy banks and hibernates along muddy banks and stream bottoms. Pollution of streams is one of the factors that have led to a decline in wood turtle populations, although development along wooded streambanks, highway casualties, and collection of the species as pets may also be responsible.

Hemlock parsley is a tall, perennial herbaceous plant of coniferous and hardwood forested fens, often occurring on sphagnum hummocks (NHESP, 1985). Populations of this species in Massachusetts are generally small and occur in remote places, where disturbances are relatively infrequent (NHESP, 1985).

Showy lady's-slipper is a large, attractive perennial orchid that inhabits coniferous-forested fens and open peatlands with calcareous groundwater seepage (NHESP, 1985). Destruction of its habitat appears to have contributed to its rarity in the state.

Bristly black current is a low, creeping, spiny shrub of cool, higher-elevation forests where it typically grows on rock ledges along streams (NHESP, 1994). Massachusetts represents the southernmost range for this species.

The wetland habitat preference of the above-described state-listed species makes them particularly susceptible to certain upstream lake and pond management activities. It is imperative that proposed management strategies are designed to the maximum extent practical to not inadvertently disturb populations or habitat of any of these wetland plants or organisms.

During each site visit made during the 2002 field season, ESS personnel conducted field surveillance for these rare, threatened and endangered species, which could potentially inhabit the shoreline and wetland areas associated with Ashmere Lake or its downgradient waters. Searches were conducted to a distance of approximately 1,000 feet downstream of the Ashmere Lake outlet. This surveillance effort focused on those species as identified in the February 28th, 2002 NHESP letter (Appendix A) and those "sensitive" species historically documented in the Hinsdale Flats ACEC.

Only one state-listed species historically documented in the Hinsdale Flats ACEC, the wood turtle, was identified by the NHESP to also occur within the watershed. No field observations of this organism were made during the 2002 field season. In addition, throughout the entirety of the project, no rare, threatened or endangered species were located along the shorelines areas and wetland areas downgradient of the Ashmere Lake outlet. The vegetation identified within the area downstream of the lake outlet was characterized by a dense canopy of eastern hemlock (*Tsuga canadensis*), and an herbaceous understory of skunk cabbage (*Symplocarpus foetidus*), asters (*Asteraceae spp.*), and sedges (*Cyperaceae. spp*).

In addition to the state-listed rare species described above, ESS has identified several other species that have been historically reported to occur within the Hinsdale Flats ACEC. These species are listed in Table 10 as they too have the potential to be affected by upstream management activities (EOEA, 1992).

4.0 MANAGEMENT FEASIBILITY ASSESSMENT FOR ASHMERE LAKE

4.1 Management Objectives

Just how a lake is managed will depend upon its intended uses, which are decided partly based on environmental law (e.g., protection of certain habitats or species) and partly on human needs and desires. Ashmere Lake is ideally suited to serving a variety of human purposes, including boating, fishing, skating, and passive aesthetic enjoyment. Ashmere Lake also serves as the recreational focal point for several summer camps located on the lake. These recreational uses have historically been threatened or impaired during the growing season due to the growth of nuisance aquatic weeds. Although ongoing and active management of the weed problem has been successful, the present study was conducted to determine whether the current approach is the most effective and environmentally desirable method for achieving a balanced and diverse aquatic plant community. Ashmere Lake also serves as habitat for a variety of aquatic and semi-aquatic life forms, both plant and animal, and is located within the Hinsdale Flats ACEC. As such, management actions taken within the lake have the potential to affect the biota within the lake and potentially within downgradient areas that receive water from the lake outlet. Ashmere Lake is not a potable water supply, although it does interact with groundwater and supports numerous public and private water supply wells. The priority of uses has not been completely defined, but enjoyment of the lake is perceived to be one of the highest priorities and this use has been threatened in recent years as a result of increasing plant densities, particularly the density of the invasive and exotic species, Eurasian watermilfoil. The goals of the management section of this report are to assess the short- and long-term management options for Ashmere Lake.

The selection of management actions should be driven by the long-term management objectives of the Ashmere Lake community. Management for recreation is not the same as management for fish yield, which is dissimilar to management for wildlife viewing. The recreational goal is believed to be appropriate for Ashmere Lake at this time, as this water body is intended to provide opportunity to a wide variety of users as evidenced by the three summer camps, MADEM's property stake, the state boat ramp, and other privately owned shoreline amenities. Management goals for Ashmere Lake should include: providing adequate habitat for waterfowl, fish, reptiles and amphibians; unhindered opportunity for motorized and non-motorized watercraft; and aesthetic appeal for passive users. Maintaining generally good water quality is also a priority.

More specifically, physical features of the lake are to be managed to provide appropriate fish habitat, maximize safety and enjoyment for human users, minimize shoreline erosion, and prevent excessive plant growths or other abnormal biological nuisances. Short-term management effort is clearly needed with regard to rooted aquatic plant nuisances, while long-term management should be directed toward protecting water quality and providing a sustainable solution to the rooted aquatic plant problem.

With the preferred uses in mind, the following specific management objectives are suggested:

1. Control and limit nuisance aquatic plant growth to levels appropriate for habitat enhancement, recreational use, and safety considerations.
2. Curtail excessive nutrient (phosphorus) and related pollutant inputs associated with groundwater inputs and tributary inputs, thereby improving water quality.
3. Further investigate the possible causes for the unnamed tributary adjacent to Camp Danbee (AS-2) failing to meet the state's dissolved oxygen criteria and exhibiting elevated levels of ammonia, nitrogen and phosphorus during normal baseflow conditions as well as elevated levels of fecal coliform during wet weather.
4. Conduct an analysis of fish tissue from representative fish species to determine whether the elevated levels of cadmium, lead, and zinc documented within the lake sediments have the potential to adversely affect humans.
5. Establish a cost-effective monitoring program that provides early warning of potential problems within the lake or within the downgradient waters to track the progress of any implemented management measures in achieving stated goals and to ensure that downstream resources are adequately protected.

4.2 Management Options

The range of options for managing Ashmere Lake is not especially large, particularly given that the waterbody is located within a sensitive resource area (Hinsdale Flats ACEC). Management methodologies can be subdivided in a number of ways, but those subdivisions tend to deal with the details of application, not the fundamental approach. With a specific management objective in mind, management methodologies can be examined to determine the applicability and feasibility of options for meeting that objective. A review of these management options for each of the five suggested management objectives is presented below.

4.2.1 Control and Limit Nuisance Aquatic Plant Growth

Readily available phosphorus in the water column, good water clarity, and an expansive, organically-rich soft substrate in the shallower portions of the lake combine to make an ideal environment for aquatic plant growth in Ashmere Lake. Although the exotic and aggressive Eurasian watermilfoil plant has previously overrun the lake, active management through targeted herbicide application has substantially controlled this species. Currently, plant growth occurs throughout much of the lake's littoral zone; however, as a result of management efforts, the plant growth is at a level that is not impairing the recreational utility of the lake. Plant densities are being maintained at levels at which they are providing adequate cover and food value to fish or waterfowl.

Although plant growth appears to be relatively well managed and a balance has been maintained between what is desirable for recreational and aesthetic enjoyment of the waterbody and what is required to maintain a diverse and productive ecosystem, future efforts will be required to effectively control invasive and exotic species. Recommendations for future management of nuisance and exotic species focus on continued and regular monitoring as well as implementation of a more effective management program. In addition to Eurasian watermilfoil, two other exotic species identified in this study that are of particular concern, these are curly-leaf pondweed and brittle waternymph.

Eurasian watermilfoil is a perennial plant with stems arising from short rhizomes with fibrous roots. This species of watermilfoil is locally abundant and aggressive in numerous lakes and ponds throughout the Berkshires and New England. Watermilfoil plants can flower and may produce viable seeds; however, dispersal typically relies on vegetative reproduction (plant fragmentation). Despite this, it is still recommended that efforts to control this plant be conducted in mid-June prior to potential seed formation.

Control of Eurasian watermilfoil has been extremely successful when attempted. Biological controls (watermilfoil beetles), hydro-raking, or chemical treatment provide some level of control. Traditional harvesting, which has rarely been capable of eradicating any species, would prove problematic in Ashmere Lake. Traditional harvesting is not a recommended approach since watermilfoil fragments would be likely to spread to currently uncolonized areas. Although complete eradication of watermilfoil is unlikely, the plant has been adequately controlled in Ashmere Lake through the ongoing management efforts and is no longer the primary component of the plant community.

Curly-leaf pondweed was identified in the lake in 2002, although it has not previously been reported as a target for management action. Curly-leaf pondweed is an exotic species that can grow to dominate a lake if left unmanaged. Control of curly-leafed pondweed can be achieved by either chemical or mechanical (harvesting) methods; however, given the presence of watermilfoil within the lake, it would be unwise to use the harvesting approach unless it can be guaranteed that watermilfoil is not in the area to be harvested. Chemical treatment would be likely to consist of treatment with the herbicide diquat (trade name Reward). Treatment should be repeated for two to three successive years to ensure that control is achieved since this plant reproduces primarily through seed formation.

Brittle waternymph is an exotic species that can be mistaken for several similar but native species. Brittle waternymph grows over the bottom of a waterbody, although at the time of our survey it was observed to be forming floating mats that were washing ashore. As with both watermilfoil and curly-leaf pondweed, brittle waternymph can be effectively controlled with the herbicide diquat. A non-chemical alternative would be to harvest before seeds are dropped. Timing for the control of waternymph will not be similar to that of curly-leaf pondweed since curly-leaf pondweed must be treated much earlier in the growing season, often before brittle waternymph has even begun to develop. A phased treatment approach would be necessary.

A full discussion of each of the plant management alternatives that might be employed in Ashmere Lake is provided below.

Dredging (Not Recommended)

Removing nutrient rich sediments and deepening waterbodies is sometimes used to control nuisance aquatic vegetation. This would be a major undertaking at Ashmere Lake, considering both the associated permitting issues and project expense. Most successful dredging operations designed to control rooted plant growth target reaching a minimum depth of eight to ten feet in order to preclude light for plants to grow. In Ashmere Lake, the target depth would need to be substantially greater (between 15 and 20 feet) as a result of the lake's relatively clear water. Since a substantial portion of the lake already exceeds this depth, dredging would actually need to be conducted around the perimeter of the lake resulting in extremely steep, and potentially undesirable, bottom slopes.

Dredging may be applicable on a very limited basis, possibly focusing on specific areas in which increasing the depth and removing sediments and associated plant biomass would be desirable. Hydraulic or suction dredging can be performed while the lake is full. This involves the use of a barge with an auger head that grinds the lake sediments into a slurry and pumps them to a nearby containment basin or other dewatering system. Locating and obtaining a suitable upland location near the lake to create an adequate containment basin may prove to be the greatest obstacle to overcome, although recent technology allows this to be conducted within an area of less than one acre. Another concern would be whether the desired 15-20 foot depths could be attained, since most suction-type dredges can only slurry the unconsolidated sediments, penetration into an existing "hard" refusal layer is not possible. If depths of only 15 feet or less could be achieved, rooted plant growth would not be discouraged.

The costs associated with a limited dredging project of just eight to ten acres would be substantial. Feasibility, design and permitting fees alone would be expected to exceed $50,000. The actual operation costs would ultimately depend upon the approach and amount of material being dredged. Assuming a conservative dredging estimate of eight feet of sediment over eight acres yields a sediment volume of nearly 105,000 cubic yards. Given a dredging unit cost of $10-$15/cubic yard yields a dredging cost of roughly $1,050,000-$1,575,000. Costs may also run higher depending upon certain permit conditions or other complicating factors. It should also be noted that dredging does not always eliminate nuisance aquatic vegetation problems, and other in-lake management activities may still be required in order maintain desired conditions. It is unlikely that such a disruptive management action would be allowed to proceed in this waterbody given that it is within the Hinsdale Flats ACEC, a sensitive resource area.

The next steps in the pursuit of a dredging project, should such a project be desired, would be assessment of funding options and initiation of the permitting process (ENF filing for MEPA review). These activities might be expected to cost between $20,000 and $30,000, but would be essential to determining the feasibility of such a project.

Drawdown (Not Recommended)

Lake level drawdown involves lowering the water level of a lake to expose bottom sediments and associated plants to drying and/or freezing. Drawdown sometimes offers a low or no-cost management alternative. It is suitable for use in deeper waterbodies, where an ample water volume will remain to support fish and other aquatic organisms. Drawdown can be effective against species which reproduce mainly by vegetative means (such as watermilfoil), but is generally ineffective against annual plants which depend on seeds for regrowth each year (such as curly-leaf pondweed or brittle waternymph), as the seeds are often stimulated by the drawdown rather than destroyed.

Ashmere Lake is sufficiently deep and drawdown would be a viable long-term management option (once control of the curly-leaf pondweed was achieved); however, given the poor condition of its dam and outlet control structure, it is unlikely that this management option could be employed until repairs to the dam are made (Baystate 1999). According to the Baystate report (1999) the dam's appurtenance structures are not able to maintain the desired lake level and significant alterations and/or repairs are required.

Lake level drawdown as a long-term aquatic plant management option at Ashmere Lake would be likely to require more effort than would typically be required for most lakes with regard to the design and permitting of a drawdown program since it is located within the Hinsdale Flats ACEC. The additional effort (and cost) would be required to provide advanced agency coordination and possibly a more careful examination of potential downstream impacts than would typically be required. In addition, it is likely that close agency scrutiny would result in a drawdown program laden with conditions and costly monitoring requirements. It would be imperative that the drawdown program be designed and managed to ensure that flow is maintained to the downstream resource areas, particularly during periods when wildlife are breeding, spawning, or hibernating. Research would also need to be conducted to determine the magnitude and timing of the flows required to be protective of wetland habitat, and in particular, habitats for the state-listed rare, threatened and endangered species.

Drawdown can be conducted at any time, but the interaction of drying and freezing is preferred suggesting that late autumn and winter drawdown will be most effective. Performing an effective drawdown depends on the ability to control the water level and the configuration and type of bottom sediments, which must at least partially de-water. As mentioned previously, Ashmere Lake is not equipped with an appropriate means for implementing a drawdown of sufficient depth (>6 feet). However, if the dam were to be repaired, this may ultimately be a management option worth consideration.

Costs to initially design and permit such a drawdown would be approximately $25,000, but would be essentially zero to maintain once the program became established. Permitting would need to demonstrate that the project meets the MADEP's interim guidelines for drawdown, and permission would need to be granted through the local Conservation Commission as a Notice of Intent (NOI).

Bottom Water Aeration (Not Recommended)

Aeration of a lake's bottom waters is sometimes effective at reducing the frequency of algae blooms by reducing or eliminating the release of phosphorus from lake sediments. Aeration does not offer any control over vascular (rooted) plants. Since algal blooms are not a problem in Ashmere Lake at this time, aeration is not a recommended management technique.

Benthic Barriers (Recommended on a Limited Basis)

Benthic barriers are negatively buoyant materials, usually in sheet form, which can be applied on top of plants to limit light, physically disrupt growth, and allow unfavorable chemical reactions to interfere with further development of plants. A variety of solid and porous materials have been used. Commercial production of effective materials has occurred since the late 1970's, although creative lake managers found ways to cover plants long before then. In theory, benthic barriers should be a highly effective plant control technique, at least on a localized scale. In practice, however, there have been many difficulties in the deployment and maintenance of benthic barriers, limiting their utility in the broad range of field conditions.

The ability of vegetative fragments to recolonize porous (mesh) benthic barriers has made porous barriers less useful for combating infestations by watermilfoil on any but the smallest scale, as sheets must be removed and cleaned at least yearly. Solid barriers have been more useful, although gas entrapment has been troublesome; billowing occurs without venting and anchoring, yet appropriate venting and anchoring creates problems for eventual maintenance or redeployment. Expense dictates that only limited areas can be treated without re-use of a deployed barrier. Nevertheless, benthic barriers are capable of providing control of watermilfoil, and other undesirable growth, on at least a localized basis and have such positive side effects as creating more edge habitat within dense plant assemblages and minimizing turbidity generation from fine bottom sediments.

Plants under the barrier will usually die completely after about a month, with solid barriers more effective than porous ones in killing the whole plant. Barriers of sufficient tensile strength can then be moved to a new location, although continued presence of at least solid barriers restricts recolonization.

Cost and labor are the main factors limiting the use of benthic barriers in most lakes, and would be prime deterrents for Ashmere Lake. Cost per installed square foot is on the order of $1.20, leading to an expense of over $50,000 per acre. Bulk purchase and use of volunteer labor can greatly decrease costs, but use over the entire area infested with nuisance vegetation is highly unlikely.

The application of solid barriers such as Palco Pond Liner is useful in controlling small (<1 acre) beds of rooted aquatic plants where the material is left in place and where effort is expended on removing any peripheral growths. Redeployment of barriers will reduce the overall cost of this approach and is consistent with the goal of restoring a desirable plant assemblage to areas infested with watermilfoil, but is likely to require additional effort at the original application site to prevent recolonization. Such effort might include hand harvesting of watermilfoil plants for at least two growing seasons after removal of the barrier, or might involve augmentation of the native population in the formerly covered area.

Benthic barriers offer some potential for localized control of nuisance vegetation in Ashmere Lake. The use of benthic barriers by individuals or small groups would seem to be a logical approach to weed control in critical use areas or by individual property owners.

Biological Controls (Recommended for Further Consideration)

The purpose of a biological control is not to eradicate a species, but to prevent it from becoming problematic. Biological controls do not work as rapidly as other management techniques. Depending on the size of the infestation, it may take five to seven years before any level of control is observed.

Eurasian watermilfoil has been shown, at least experimentally, to be able to be controlled using "watermilfoil beetles" (*E. lecontei*). The larvae of this beetle burrow into the stems of the watermilfoil plant, consuming the plant tissue within the stem, which ultimately results in the collapse of the plant to the pond bottom. As a control technique, the beetle larvae are introduced to a lake by placing infested watermilfoil strands within the targeted watermilfoil beds of the lake. Costs for this treatment are variable; however, a strand of infested watermilfoil will typically cost $1 "installed." Costs for watermilfoil beetle control in Ashmere Lake would be expected to cost between $3,000 and $6,000 with an additional $3,000 recommended for monitoring of potential effects.

This approach was first implemented in Massachusetts at Goose Pond in Lee, Massachusetts, with varying degrees of success. The best results are usually achieved in controlling watermilfoil in lakes with dense, monotypic stands of watermilfoil with several years being required to measure a positive effect. Since Ashmere Lake is essentially devoid of watermilfoil as a result of repeated chemical applications, the watermilfoil beetle approach would not be expected to succeed unless watermilfoil was allowed to return. Although it would be unwise to allow an invasive species to return to a waterbody, if herbicide treatments were for some reason prohibited in the future and the watermilfoil population returned to its former vigor, then this relatively economical and ecologically benign approach may be an option worth considering.

Biological controls for the other problem species, including curly-leaf pondweed and brittle waternymph, are almost unknown. An herbivorous fish (*Ctenopharyngodon idella*, the grass carp) has been used for general macrophyte control in smaller lakes in Connecticut and New York, but has not shown a preference for any one species. Given little choice, it might reduce plant densities in Ashmere Lake, but the stocking of this non-native fish is currently illegal in Massachusetts.

Harvesting Approaches (Hand-harvesting Recommended as Option)

Harvesting includes a wide range of plant removal techniques; the simplest form is hand pulling of selected plants. Successively more complicated approaches include manual cutting, mechanical cutting and collection, aquatilling (underwater rototilling), suction dredging, and hydro-raking (mechanical whole plant harvesting with some minor collection of sediment). Harvesting can be an effective longer-term control technique when the target plants reproduce by seed and harvesting is timed properly to eliminate annual seed production. Usually several successive years of effort are necessary, as seeds deposited prior to management can be expected to germinate over more than one year. There is some evidence that intense harvesting of plants reproducing by vegetative propagation limits survival over the winter, but the effect varies by species and location. Harvesting can be an effective short-term control strategy for any aquatic plant nuisance, analogous to mowing the lawn.

Harvesting techniques which allow plant fragments to escape are generally not appropriate for longer-term control of species that reproduce vegetatively, and may actually be counterproductive to control. While short-term control may be achieved in the target area, long-term control is rare since viable plant fragments typically colonize new sites. Any of the cutting techniques without collection, and often even with collection effort, can be expected to result in the spread of vegetatively reproducing species. For that reason, only harvesting approaches with a very low probability of fragments being left in the water (e.g., hand harvesting or hydro-raking) might be appropriate for longer-term control of the watermilfoil problem in Ashmere Lake. Given that watermilfoil in Asmere Lake is very sparse, it would not be appropriate to employ a harvester of any type for watermilfoil control at the current time.

Harvesting would be an acceptable management alternative for the curly-leaf pondweed and brittle waternymph problem; however, such efforts could only be conducted *after* Eurasian watermilfoil has been controlled chemically (with diquat – see below) or biologically (with weevils). Harvesting of curly-leaf pondweed it is not recommended solely due to the risk of fragmenting and spreading the watermilfoil, which may occur within the same plant beds.

Hand-harvesting of watermilfoil has some potential and is proven to be a successful management technique when densities of watermilfoil within a waterbody are very low and a strong well-trained volunteer base exists. Ashmere Lake currently has watermilfoil under control and if a group of volunteers were willing, they could become trained and equipped to effectively maintain control of this nuisance species. Our experience working with other lake groups has found that preparing a workshop for the volunteers along with an educational brochure on hand-harvesting techniques is the best approach. Costs for such a program would be on the order of $3,000 and the purchase of any necessary equipment (mask, snorkel, hand rake, collection bag, etc.) would be expected to be less than $100 per volunteer. Hand-harvesting in Ashmere Lake could possibly maintain control of the watermilfoil population, but at a minimum would be expected to extend the time between any necessary chemical treatments.

Hydro-raking would be the only other viable mechanical harvesting technique. Hydro-raking generally costs $160/hour and in a lake of this size would require a second boat at a cost of $120/hour to efficiently transport the removed plant biomass to shore. It generally takes between 12 and 24 hours of time to hydro-rake one acre depending upon the type of plant and the overall plant density. If hydro-raking were employed to remove targeted plants from all of Ashmere Lake, the total cost for the project would range between approximately $17,000 and $34,000 for approximately five selected acres of plants from depths of less than eight feet (the depth to which a hydro-rake can effectively harvest). In addition, trucking costs for removal of the plant material will range from $10,000 to $20,000 assuming a contracted company is hired. It might be possible that the Town of Hinsdale DPW would remove the material for free or at a minimal charge, however, hydro-raking would still be an expensive undertaking. Given other possible alternatives, and the risk of exacerbating the watermilfoil problem, hydro-raking is not a recommended approach for Ashmere Lake.

Chemical Control (Recommended)

There are few aspects of plant control that generate more controversy than chemical control through the use of herbicides, which are a subset of all chemicals known as pesticides. Part of the problem stems from pesticides which have come on the market, enjoyed widespread use, been linked to environmental or human health problems, and been banned from further use. Many pesticides in use even 25 years ago are not commonly used or even approved for use today.

Yet as chemicals are an integral part of life and the environment, it is logical to seek chemical solutions to problems such as plant species that grow to nuisance proportions, just as we seek physical and biological solutions. Current pesticide registration procedures are far more rigorous than in the past. While no pesticide is considered unequivocally "safe," a premise of federal pesticide regulation is that the potential benefits derived from use outweigh the risks when the chemical is used according to label restrictions.

The most cost-effective and appropriate means by which to achieve the goal of reducing aquatic weed biomass in Ashmere Lake over the short term would be chemical treatment. Among the variety of herbicides available today, only two have potential applicability for the nuisance plant species found in Ashmere Lake. The first of these is fluridone (tradename Sonar), a systemic chemical that affects target plants by inhibiting critical metabolic pathways after uptake through roots, leaves or shoots. Fluridone (1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-4[1H]-pyridinone) is typically applied at a dose of 15 to 20 ppb (parts per billion) to selectively remove watermilfoil and curly-leaf pondweed. Fluridone was reported to have been applied to the lake, at least initially, to restore the open water conditions within the lake by controlling extensive growth of Eurasian watermilfoil. Given that there is no longer a lake-wide plant problem, it would not be economical to use floridone to manage the plant problem in Asmere Lake.

Treatment of the exotic plant problem in the lake as it currently exists will most effectively be achieved with "spot" treatments using the herbicide diquat dibromide (trade name Reward). Diquat [6,7-dihydrodipyrido (1,2-a:2',1'-c) pyrrazinediium dibromide] is a non-selective broadleaf contact herbicide that would be recommended for control of all three exotic species common to Ashmere Lake. Unlike floridone, control would be immediate, resulting in the decomposition of any killed plants. Consequently, treatment area should be limited to no more than 1/3 of the area of the lake basin being treated to minimize the potential for causing excessive nutrient releases and any associated algal bloom or fish kill. Given that only spot treatments would be required and that this herbicide has been used effectively in the past at Ashmere Lake without causing detrimental effect for the past several years, it is reasonable to expect that the continued use of this product would not pose any additional risk to the Ashmere Lake system.

Costs for the diquat "spot" treatment program are estimated to range between $200 and $400 per treated acre, and will require reapplication on an annual basis initially to gain control of the seed producing species (brittle waternymph and curly-leaf pondweed) and then on a semi-annual basis to maintain control. It is estimated that up to ten acres of lake bottom are presently supporting one or more of the three exotic species found in the lake. At a maximum cost of $400/acre, the treatment cost could approach $4,000/year for the first two years, but would be considerably less thereafter as control is achieved. It is not known whether additional permits would be required, although it is expected that the existing application permit would cover this ongoing management effort. It has been reported that the current cost for the herbicide treatment program at Ashmere Lake is $8,000. This cost may have been justified in the past if the area treated has exceeded 20 acres.

Although the decision whether to continue to employ the use of chemicals is entirely up to the community and watershed stakeholders, treating the nuisance vegetation with a U.S. EPA/MADEP registered aquatic herbicide is likely to be the most cost-effective management alternative at Ashmere Lake. Spot treatment with diquat will provide for area-specific plant control. Typically, late spring treatments will be required for control of curly-leaf pondweed, while early summer treatments would be more effective for control of Eurasian watermilfoil and brittle waternymph. Plant regrowth in subsequent seasons is often reduced, allowing reductions in the frequency and amount of chemical application required. Other management options each have their own set of economical and/or ecological drawbacks, which need to be evaluated with regard to their predicted level of success.

4.2.2 Curtail Excessive Contaminant Loading

Existing water quality within Ashmere Lake is generally acceptable or superior for most intended uses of the lake (boating, wildlife viewing, fishing, etc.). However, concentrations of phosphorus, considered to be the most important plant nutrient, were relatively high during storm events in both of the major tributaries to the lake. Although not currently a problem, the condition may worsen as additional development of the watershed occurs.

Due to the watershed's highly residential usage, sources of contaminants are numerous in this watershed. Lawn fertilizers and other maintenance chemicals, pet and wildlife wastes, car washing, road sanding and salting, erosion from new construction, and a variety of routine activities within the watershed generate pollutants that are washed with runoff into the storm water drainage system and eventually enter Ashmere Lake. Additionally, "dryfall" (particulates which fall from the sky) can contain substantial pollutants that originated outside the watershed and are deposited continuously. These substances would become part of the soil base in a forested system, but are easily washed from pavement, rooftops, and packed dirt roadways in a residential watershed with each storm event.

The storm drain sites that were monitored exhibited high levels of turbidity and particulate phosphorus during the wet weather event that was sampled. The tributary sites that were monitored were found to presently be delivering moderate contaminant loads; however, one tributary located adjacent to Camp Danbee was found to be delivering excessive loads given the limited extent of development in this watershed sub-basin.

Loading analysis suggests that the phosphorus load to Ashmere Lake is within the permissible level, suggesting that eutrophic conditions would only be expected if loading from the watershed increases. Preventative management actions within the drainage basin are justified, and primary consideration should be given to managing nutrient (especially phosphorus), sediment and even fecal coliform inputs. Stormwater runoff is believed to be responsible for a major fraction of the phosphorus load. Possible actions include additional assessment (see Section 4.2.3 below), behavioral modifications, increased detention, increased street sweeping and catch basin cleaning, and additional land use planning.

Behavioral Modifications: Behavioral modifications include alteration of individual or group practices that lead to increased runoff or pollutant loading. Actions relating to lawn care, yard waste disposal, automotive cleaning and maintenance, and deicing would be likely targets for this approach. Modifications are usually attained by a combination of education and regulation, but there are practical limits once the land has become developed. Most behavioral controls are best implemented on a voluntary basis, but are unlikely to provide more than a five to ten percent reduction in loads. Mandatory controls are better suited to situations of clear non-compliance, as with illegal hook-ups to the storm drainage system or Title V violations. Since many of the homes surrounding the lake and within the watershed area are sewered, it is likely that Title V violations are occurring in a relatively limited number of homes. Further study should be conducted to identify specific violations or to identify areas in which stormwater runoff quality is exceedingly poor. Such a study might require a search of the Board of Health records for systems that are not conforming to Title V specifications or may involve expanded monitoring of discharges within the watershed or groundwater seepage into the lake at key locations to define any "hot spots." Funding on the order of $8,000 is estimated be necessary, although some cost savings may be achieved by having volunteers conduct their own research at the Board of Health in the Town of Hinsdale.

Another significant source of contaminant loading is often more controversial. The presence of waterfowl is generally considered an aesthetic amenity and indicator of a healthy aquatic system. However, an overabundance of waterfowl, and in particular, geese, has definite implications on system conditions and recreational utility. The presence of geese (and other waterfowl that conduct land-based foraging) at Ashmere Lake must be balanced against the need to minimize nutrient inputs and maintain useable space around the lake. Most community residents would probably consider elimination of geese desirable, particularly if the geese were supplanted by a higher diversity of ducks, wading birds and other migratory species. Canada geese pose the greatest problem, as they are large, abundant, and do more damage to the lake than most other species.

Perhaps the single greatest influence on the abundance of Canada geese is the ease with which water to land transitions can be made. These birds prefer to land and take off in water, but spend considerable time on adjacent lawn areas. When fences or vegetative barriers have been erected at the edge of the water, geese become less common. These actions can be implemented by individual property owners with cost varying by method selected and the level of effort employed. There is a wealth of public and commercial information that is readily available pertaining to methods for discouraging geese.

There are typically no permits or tangible costs associated with any of the above-described behavioral modifications, but compliance is difficult to measure and major changes in water quality are rarely observed as a result. It would be beneficial, however, to encourage appropriate residential property management through the development of an educational brochure aimed at informing watershed residents of their link to water quality and role in protecting it. Such a brochure could be professionally produced for an estimated cost of $2,500 and for significantly less if produced by a small group of motivated volunteers.

Increased Detention: Detention approaches suffer from limits on land availability and treatment efficiency. The runoff produced from a 1-inch storm would occupy over 9 million cubic feet, probably the minimum detention volume for a system with detectable benefit to Ashmere Lake. As an acre-foot equates to 43,560 cubic feet of water, somewhere between 200 and 220 acre-feet of detention area would be needed to effectively treat the runoff now entering Ashmere Lake during storms of sub-two year frequency. Presently, the detention system located to the north of Peru Road between the north and south basins is estimated to provide less than 1 acre-feet of storage. With complete dredging of the basin it may be able to provide up to 3 acre-feet of storage. This basin only addresses runoff from watershed sub-basin 3, which is not heavily populated at the present time. If increased detention is a goal for management action, the development of significant amounts of new storage will be required, particularly within watershed sub-basins 5, 6, and 7.

Treatment efficiency for detention systems varies by parameter and system design, but typical systems can be expected to remove 30%-40% for phosphorus without auxiliary treatment of some kind (Schueler 1987). Removal rates may be higher for particulate phosphorus, but the average is lowered by the inability of the system to remove most of the dissolved phosphorus. Both dissolved and particulate forms are important in this watershed. Storm water represents a significant input source, constituting nearly 70% of the total phosphorus load but the effectiveness of removal would be dependent upon the design, location, and capacity of the detention system(s).

Assuming land could be made available (approximately 40 to 50 acres), design and permitting of an appropriately designed series of systems could cost up to $230,000. In addition, at a rough cost of $5/cubic yard of detention capacity gained (based on a minimum excavation rate), the construction of suitable detention facilities (totaling 200-220 acre-feet) would cost between $1,600,000 and $1,800,000. While any detention would represent an improvement, substantial detention would be needed to adequately address stormwater runoff within the watershed. Given that water quality conditions within the lake are not problematic at this time and that detention of runoff can realistically only control a very limited fraction of the runoff, it would seem that the best approach for maintaining water quality within the lake would be to focus on controlling future development within the watershed and possibly restoring existing detention facilities such as that adjacent to Peru Road. The estimated cost for design, permitting, and dredging of the Peru Road system is expected to be on the order of between $60,000 and $80,000. If watershed development is to continue, detention facilities should be considered a requirement of new construction.

Increased Street Sweeping and Catch Basin Maintenance: By increasing the frequency of street sweeping and catch basin cleaning, the Town of Hinsdale could remove some potential runoff pollutants. Catch basins should be cleaned at least once or twice per year, although this does not happen in many municipalities. Street sweeping could be performed far more frequently, as sediment (and the associated phosphorus) should be removed from the street between storms. A frequency of at least monthly would be necessary, perhaps even more often. Additionally, vacuum equipment is far more effective than conventional brush technology, which picks up less than half the load in most cases.

A program which provides monthly vacuuming of all streets and semi-annual cleaning of all catch basins in the Ashmere Lake watershed would carry a capital cost of over $50,000 and an operational cost of at least $15,000/year. This approach would address only those pollutants on roadways or trapped by catch basins. While roadway pollutants could be an important source of contamination, contaminants on lawns are likely to be at least equally important, and would not be appropriately addressed by a street-sweeping program. Beyond normal street and catch basin maintenance, this approach has only limited merit for the Ashmere Lake watershed.

Land Use Planning: The lake is a reflection of its watershed, which is currently well developed around much of the lake's perimeter, but less so throughout the majority of its watershed. It is recommended that efforts be made to preserve natural areas not subject to protection (as with wetlands) and encourage BMPs for landscaping, agriculture (including gardens) and construction. Costs for such actions are highly variable and unpredictable, but could be minimal with thoughtful use of existing regulations and programs. The limited build-out analysis of the Ashmere Lake watershed conducted as part of this study suggests that given the significant amount of land available for development within the watershed, there is a strong likelihood that water quality would deteriorate if development were allowed to proceed unchecked.

4.2.3 Identify Potential Sources of Contamination to Tributaries

Potential sources of contamination to the unnamed tributary which flows adjacent to Camp Danbee should be more closely investigated (Figure 1). This unnamed tributary drains watershed sub-basin 1 (Figure 1) and receives flow from a relatively large and undeveloped watershed. The samples collected from this tributary were collected during both dry and wet weather conditions and it was determined that these samples failed to meet the state's dissolved oxygen criteria during dry weather conditions and also exhibited elevated levels of ammonia, nitrogen and phosphorus during these normal baseflow conditions. In addition, elevated levels of fecal coliform were observed during the wet weather sampling date.

It is possible that the source of contamination is related to natural conditions resulting from the wetland located at the headwaters of the tributary; however, it is also possible that the contamination could be the result of human activity within the watershed, particularly from either Peru Road or from Camp Danbee. It should be noted that Camp Danbee is reportedly served by the town sewer system.

Additional investigation would require that this sub-basin be sampled more intensively. Samples will need to be collected upgradient of Camp Danbee, immediately downgradient of the headwater wetland, and from any drainage structures associated with Peru Road. Samples will need to be collected during a minimum of one dry and one wet weather date and should include the same suite of parameters assessed as part of this study. Additional research at the Town of Hinsdale Board of Health may also prove beneficial. Records on well water quality and Title V compliance for individual lots may be available. Costs for a thorough investigation, including selected water quality sampling, would be on the order of $12,000. Such a program is warranted at the current time to ensure that conditions within the lake do not continue to worsen and that public health is not threatened. Once such a study has been conducted, possible alternatives for remediation can be evaluated and implemented as necessary.

4.2.4 Fish Tissue Analysis

Elevated levels of cadmium, lead, and zinc were found within the sediment sample collected from Ashmere Lake (Long and Morgan 1995). In addition, copper and arsenic were also found at levels that would be considered polluted (USEPA 1977). Given that these potentially toxic metals are present in the environment, it would be advisable to conduct an analysis of fish tissue from representative game fish species to determine whether the lake sediments have the potential to adversely affect human health. Such a study typically entails the collection of specific size categories of a variety of game fish species. Fish fillets are then sent to a laboratory for analysis to determine whether the fish are accumulating metals at a level that could ultimately affect humans that consume the fish.

The MADEP often conducts these surveys through their Interagency Committee on Fish Toxics Monitoring. According to Robert Mayetta of MADEP, a fish tissue survey has not been performed for Ashmere Lake. A request can be submitted for such an assessment through the MADEP and may be performed at their discretion at no charge to the Town of Hinsdale. If a similar testing program were to be performed by a private consultant, the cost would be expected to range between $8,000 and $10,000 depending upon the number of fish analyzed. Once the fish tissue data has been obtained from either the MADEP or from the private consultant, the results should be submitted to the Massachusetts Department of Public Health to determine the level of risk to human consumers.

4.2.5 Long-term Annual Monitoring of Ashmere Lake

In addition to the four objectives discussed above, it would be of great benefit to the future protection and management of Ashmere Lake to implement a cost-efficient, long-term annual monitoring program. This would provide continuous background data for the purpose of tracking the effectiveness of future management practices that may be implemented. Since water quality is currently acceptable, the monitoring program for water quality should focus on tracking in-lake conditions during the peak growing season each year. This will allow quantification of the normal range of parameter values and recognition of any potentially detrimental shifts or trends.

Phosphorus and nitrogen levels would be the key variables in this regard. Also, assessment of easily measured field parameters (pH, oxygen, temperature, conductivity, turbidity and Secchi depth) would be beneficial. Evaluation of plant species density and distribution should be the focus of biological monitoring with particular focus on the distribution of exotic plant species.

Evaluating water quality and plant coverage trends requires several years of continuous data, with multiple sample dates in each year. Evaluation of management techniques would be more immediate, allowing comparisons between pre- and post-management periods. It would seem most appropriate to collect a single sample from a central area of the lake's main basin in June and August to represent the period of greatest usage and potential impact. If funding were available, it would be useful to include investigative sampling to further characterize stormwater and tributary inputs over time. Annual plant mapping should also be conducted, with particular attention to the growth and spread of nuisance and potential invasive species.

A proposed monitoring plan is outlined in Table 17. This program, if implemented for Ashmere Lake alone, would cost approximately $6,000 per year. Substantial cost savings could be achieved if implemented in conjunction with monitoring programs for other area lakes. Most of the tasks could be carried out through a volunteer monitoring program at a reduced cost after some initial training and equipment purchases. The value of a long-term database collected through such a simple program would be extremely valuable.

5.0 RECOMMENDED LAKE AND WATERSHED MANAGEMENT PROGRAM

Based on the previous discussion and consideration of options, the recommended program for achieving the stated objectives would include five distinct phases: aquatic weed control, nutrient source control through public education, investigation of potential sources of groundwater contamination, and annual monitoring. Estimated costs for controlling the existing vegetation problem in accordance with the recommended management program should be anticipated on the order of between $5,000 and $14,000 initially and then $4,000 to $6,000 annually depending upon the method selected and the level of implementation.

1. Control and limit nuisance and exotic aquatic plants, with emphasis on Eurasian watermilfoil curly-leaf pondweed and brittle waternymph by one or more of the following means:

   a) Given that there still remain significant populations of exotic species within the lake, even after the herbicide treatment of 2002, it is recommended that additional herbicide treatment be performed following a more thorough pre-application plant survey. A thorough pre-application plant survey conducted by an independent contractor is warranted given that previous plant monitoring conducted by the herbicide applicator has proven insufficient for effectively monitoring and managing this lake. The herbicide diquat (Reward) would be the most appropriate choice for control of all three exotic plant species common to the lake. Cost for this effort is estimated at between $200 and $400 per acre for the 10-acre area requiring treatment, or between $2,000 and $4,000 per year along with an additional cost of $2,000 per year for independent pre-treatment monitoring. Actual treatment costs for the recommended herbicide program should be anticipated on an annual basis, at least initially, and then on a semi-annual basis thereafter. Herbicide treatment is essential to restoring the lake and protecting the native plant species. Longer-term solutions, described below, should be pursued concurrently so that the frequency and amount of herbicide being applied can be reduced or eliminated.

b) If herbicide treatment is delayed or denied, other plant management actions that could be considered, at least on a property by property basis, could include the use of benthic barriers combined with volunteer hand pulling and even manual re-vegetation of areas treated with the barriers. Costs and the level of treatment may be highly variable with this approach; however, an estimate of $1,000 per individual property waterfront should be anticipated assuming volunteer labor is utilized. Benthic barriers would only be feasible if employed on a smaller scale in specific high-use or access areas and not as a lake-wide solution.

c) One longer-term solution that may prove effective against Eurasian watermilfoil is the use of the aquatic beetle larvae (*E. lecontii*). This biological alternative to chemical treatment may be desired in the event that chemical application becomes unacceptable. For Ashmere Lake the biological control effort is likely to cost up to $9,000 and the effectiveness of the approach will be uncertain. Monitoring is essential to such a project to determine whether the beetle larvae have over wintered and to ensure that the watermilfoil does not continue to spread throughout the lake. This approach will not provide the level of success that has been achieved by past herbicide applications and will not provide any control of species other than watermilfoil.

d) Hand-harvesting of watermilfoil is a viable option, particularly given that very few watermilfoil plant remain in the lake. Hand-harvesting is typically carried out by volunteers which will need to be organized, equipped, and trained if they are available. Costs for professional organization and training should be on the order of $3,000 and would be a one-time cost. Such a program would reduce reliance on herbicide application and would save cost over the long-term.

2. Curtail excessive nutrient and related pollutant inputs associated with groundwater loading and storm events, thereby improving aquatic conditions and improving water quality through emphasis on behavioral modifications by watershed residents.

   a) Additional study is required, particularly relating to possible septic influences on the lake. A groundwater seepage survey should be conducted along with a thorough review of Board of Health records. Such an investigation can be conducted for less than $8,000.

   b) Develop and distribute an educational brochure for watershed residents. This could be prepared by an outside consultant at a cost of approximately $2,500, or with some research, by a motivated group of volunteers for substantially less. If there is enough interest, a workshop explaining the problem and the necessary management actions could also be conducted as part of the educational program for very little additional expense.

c) Although increased detention is not deemed a viable solution for the entire Ashmere Lake watershed, maintaining (dredging) existing detention facilities such as the basin located along Peru Road may be advisable as a means for controlling sediment transport to the lake from watershed sub-basin 3. Estimated cost for design, permitting, and dredging is expected to range between $60,000 and $80,000.

3. Potential sources of contamination to tributaries, particularly the unnamed tributary that discharges into the south basin of Ashmere Lake by Camp Danbee should be more closely investigated. This tributary is a major source of pollutants and may even pose a health risk due to elevated levels of fecal coliform. The costs to conduct an investigation and evaluate the feasibility of possible solutions to the problem are estimated at $12,000.

4. Fish tissue analysis may need to be performed given that elevated levels of toxic metals were found in the sediment of Ashmere Lake. Tissue analysis will determine whether fish are accumulating these metals at a level that would warrant a restriction or ban on fish consumption. The MADEP accepts requests for such assessments annually and performs these services at no cost to the town. If such an assessment cannot be performed in the very near future, the Town or MADEM should consider funding the assessment independently at a cost of less than $10,000.

5. Establish a monitoring program to provide early warning of future problems and to track the progress of management efforts. An annual cost of $6,000 is expected, exclusive of any special monitoring costs that may be required by local permitting authorities in association with plant control techniques. Substantial savings in cost may be achieved if several area lakes are monitored concurrently.

Finally, the potential sources of funding for management currently available at the state and federal level for water quality and aquatic habitat restoration are limited. Many of these available sources are in jeopardy due to budgetary issues at the state and some sources, such as the MADEM Lakes and Ponds Grant Program, have been eliminated until at least 2005. Given this, many of the recommended actions may need to be funded through local sources, the lake association, or through private donations.

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7.0 GLOSSARY

Abiotic: A term that refers to the nonliving components of an ecosystem (e.g., sunlight, physical and chemical characteristics).

Algae: Typically microscopic plants that may occur as single-celled organisms, colonies or filaments.

Alkalinity: A measure of the buffering capacity of a system, typically measured as milligrams of calcium carbonate per liter. Lakes and ponds with an alkalinity below 10mg $CaC0_3$/L may be susceptible to acidification.

Anoxic: Greatly deficient in oxygen.

Aquifer: A water-bearing layer of rock (including gravel and sand) that will yield water in usable quantity to a well or spring.

Aquatic plants: A term used to describe a broad group of plants typically found growing in water bodies. The term may generally refer to both algae and macrophytes, but is commonly used synonymously with the term macrophyte.

Bacteria: Typically single celled microorganisms that have no chlorophyll, multiply by simple division, and occur in various forms. Some bacteria may cause disease, but many do not and are necessary for fermentation, nitrogen fixation, and decomposition of organic matter.

Bathymetric Map: A map illustrating the bottom contours (topography) and depth of a lake or pond.

Best Management Practices (BMPs): Any of a number of practices or treatment devices that reduce pollution in runoff via runoff treatment or source control.

Biomass: A term that refers to the weight of biological matter. Standing crop is the amount of biomass (e.g., fish or algae) in a body of water at a given time. Biomass is often measured in grams per square meter of surface.

Biota: All living organisms in a given area.

Cultural Eutrophication: The acceleration of the natural eutrophication process caused by human activities, occurring over decades as opposed to thousands of years.

Ecosystem: An interactive community of living organisms, together with the physical and chemical environment they inhabit.

Endangered/Threatened Species: An animal or plant species that is in danger of extinction that is recognized and protected by state or federal agencies.

Erosion: A process of breakdown and movement of land surface that is often intensified by human disturbances.

Eutrophication: The process, or set of processes, driven by nutrient, organic matter, and sediment addition to a pond that leads to increased biological production and decreased volume. The process occurs naturally in all lakes and ponds over thousands of years.

Exotic Species: Species of plants or animals that occur outside of their normal, indigenous ranges and environments. Populations of exotic species may expand rapidly and displace native populations if natural predators are absent or if conditions are more favorable for the exotics growth than for native species.

Fecal Coliform Bacteria: Found in the intestinal tracts of mammals, this bacteria in water or sludge is an indicator of pollution and possible contamination by pathogens.

Filamentous: A term used to refer to a type of algae that forms long filaments composed of individual cells.

Groundwater: Water found beneath the soil surface and saturating the layer at which it is located.

Habitat: The natural dwelling place of an animal or plant; the type of environment where a particular species is likely to be found.

Herbicide: Any of a class of compounds that produce mortality in plants when applied in sufficient concentrations.

Infiltration Structures: Any of a number of structures used to treat runoff quality or control runoff quantity by infiltrating runoff into the ground. Includes infiltration trenches, dry wells, infiltration basins, and leaching catch basins.

Invasive: Spreading aggressively from the original site of planting.

Littoral Zone: The shallow, highly productive area along the shoreline of a lake or pond where rooted aquatic plants grow.

Macroinvertebrates: Aquatic insects, worms, clams, snails and other animals visible without aid of a microscope that may be associated with or live on substrates such as sediments and macrophytes. They supply a major portion of fish diets and consume detritus and algae.

Macrophytes: Macroscopic vascular plants present in the littoral zone of lakes and ponds.

Mesotrophic: A trophic state (degree of eutrophication) in which a lake or pond is slightly nutrient rich and sustains moderate levels of biological productivity. Moderately dense macrophyte growth, moderate sediment accumulation, occasional algae blooms, moderate water transparency and infrequent oxygen depletion in the hypolimnion are common characteristics.

Morphometry: A term that refers to the depth contours and dimensions (topographic features) of a lake or pond.

Nonpoint Source: A source of pollutants to the environment that does not come from a confined, definable source such as a pipe. Common examples of non-point source pollution include urban runoff, septic system leachate, and runoff from agricultural fields.

Nutrient Limitation: The limitation of growth imposed by the depletion of an essential nutrient.

Nutrients: Elements or chemicals required to sustain life, including carbon, oxygen, nitrogen and phosphorus.

Oligotrophic: A trophic state (degree of eutrophication) in which a lake or pond is nutrient poor and sustains limited levels of biological productivity. Sparse macrophyte growth, low rates of sediment accumulation, rare algae blooms, high water transparency, and rare occurrences of oxygen depletion in the hypolimnion are common characteristics.

pH: An index derived from the inverse log of the hydrogen ion concentration that ranges from zero to 14 indicating the relative acidity or alkalinity of a liquid.

Photosynthesis: The process by which plants use chlorophyll to convert carbon dioxide, water and sunlight to oxygen and cellular products (carbohydrates).

Phytoplankton: Algae that float or are freely suspended in the water.

Pollutants: Elements and compounds occurring naturally or man-made introduced into the environment at levels in excess of the concentration of chemicals naturally occurring.

Secchi disk: A black and white or all white 20 cm disk attached to a cord used to measure water transparency. The disk is lowered into the water until it is no longer visible (secchi depth). Secchi depth is generally proportional to the depth of light penetration sufficient to sustain algae growth.

Seepage meter: A device used to measure the groundwater volume entering a lake, pond or stream over time.

Sediment: Topsoil, sand, and minerals washed from the land into water, usually after rain or snowmelt.

Septic system: An individual wastewater treatment system that includes a septic tank for removing solids, and a leachfield for discharging the clarified wastewater to the ground.

Septic System Leachate: The clarified wastewater discharged into the ground from a septic system.

Siltation: The process in which inorganic silt settles and accumulates at the bottom of a lake or pond.

Stormwater Runoff: Runoff generated as a result of precipitation or snowmelt.

Temperature Profile: A series of temperature measurements collected at incremental water depths from surface to bottom at a given location.

Thermal Stratification: The process by which a lake or pond forms several distinct thermal layers. The layers include a warmer well-mixed upper layer (epilimnion), a cooler, poorly mixed layer at the bottom (hypolimnion), and a middle layer (metalimnion) that separates the two.

Thermocline: A term that refers to the plane of greatest temperature change within the metalimnion.

TKN: Total Kjeldahl nitrogen, essentially the sum of ammonia nitrogen and organic forms of nitrogen.

Turbidity: A measure of the light scattering properties of water; often used more generally to describe water clarity or the relative presence or absence of suspended materials in the water.

Vegetated Buffer: An undisturbed vegetated land area that separates an area of human activity from the adjacent water body; can be effective in reducing runoff velocities and volumes and the removal of sediment and pollutant from runoff.

Water Column: Water in a lake or pond between the interface with the atmosphere at the surface and the interface with the sediment at the bottom.

Water Quality: A term used to reference the general chemical and physical properties of water relative to the requirements of living organisms that depend upon that water.

Watershed: The surrounding land area that drains into a water body via surface runoff or groundwater recharge and discharge.

Zooplankton: Microscopic animals that float or are freely suspended in the water.

TABLES

Monnelly, Anne (DCR)

From: Hutchins, Linda (DCR) [Linda.Hutchins@state.ma.us]
Sent: Monday, December 18, 2006 10:26 AM
To: Cohen, Sara (DCR)
Cc: Monnelly, Anne (DCR)
Subject: FW: Outflow from Ashmere Dam, Hinsdale MA to Bennett Brook
Follow Up Flag: Follow up
Flag Status: Flagged

I haven't had time to take any action or respond to this. Hopefully Sara can.

Linda Marler Hutchins, Hydrologist
Department of Conservation and Recreation
251 Causeway Street, Suite 800
Boston, Massachusetts 02114
Phone:617-626-1384 Fax: 617-626-1455
email: linda.hutchins@state.ma.us
Visit our rainfall web site: http://www.mass.gov/dcr/waterSupply/rainfall/index.htm

-----Original Message-----
From: Beede, Susan (DCR) [mailto:Susan.Beede@state.ma.us]
Sent: Tuesday, August 29, 2006 3:18 PM
To: Hutchins, Linda (DCR)
Subject: Outflow from Ashmere Dam, Hinsdale MA to Bennett Brook

Hi Linda,
Liz Sorenson and I met with Bill Salomaa and Mike Misslin on August 11th to discuss reconstruction of the Ashmere Dam in Hinsdale. (The Ashmere Dam is located within the Hinsdale Flats Watershed ACEC.) Among other things, we requested that the new dam provide seasonally appropriate flows to Bennett Brook. Bill told us that he would consult with you concerning target outflows for the dam. I have been away on vacation since that meeting and wondered if you and Bill had spoken yet. I am curious what outflows to Bennett Brook you think are desirable.

Thanks.

Sue

Susan F. Beede
ACEC Inland Coordinator
Department of Conservation and Recreation
251 Causeway St., Ste. 700, Boston, MA 02114
Phone: 617-626-1341 FAX: 617-626-1349
http://www.mass.gov/dcr/stewardship/acec

Table 1a. Land use for the Ashmere Lake watershed.
The Ashmere Lake watershed and sub-basin delineations are depicted on Figures 1 and 2.

Land Use Class	Basin 1 (acres)	Basin 2 (acres)	Basin 3 (acres)	Basin 4 (acres)	Basin 5 (acres)	Basin 6 (acres)	Basin 7 (acres)	Basin 8 (acres)	Ashmere Lake (acres)	Total Watershed (acres)	Percentage of Watershed
Cropland	0.0	0.0	0.0	0.0	2.6	0.0	0.0	0.4	0.0	2.9	0%
Pasture	2.9	25.3	0.0	0.0	1.5	0.0	0.0	0.0	0.0	29.6	1%
Forest	582.9	653.1	5.5	127.0	362.9	165.6	48.7	73.8	28.8	2048.2	73%
Wetland	4.4	2.2	0.0	2.8	13.0	5.5	0.0	0.0	0.2	28.2	1%
Open Land	14.2	12.2	0.0	3.9	12.5	2.5	16.8	0.0	0.4	62.6	2%
Participation Recreation	16.9	2.1	21.8	0.0	0.0	32.2	0.0	0.0	2.4	75.4	3%
Water Based Recreation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Residential (R1)	0.0	0.0	0.0	23.1	0.0	5.6	0.0	0.0	2.0	30.7	1%
Residential (R2)	0.0	0.0	0.0	8.9	0.0	25.4	31.9	0.0	3.8	70.0	2%
Residential (R3)	66.1	68.1	2.6	40.6	5.2	0.0	6.9	0.1	4.5	194.1	7%
Commercial	1.1	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	4.4	0%
Urban Open	0.1	2.2	0.0	0.0	4.3	0.6	1.3	0.0	0.0	8.4	0%
Waste Disposal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Water	1.1	4.9	2.1	1.4	0.0	2.5	0.7	0.1	256.8	269.5	10%
Total	689.7	770.1	32.0	207.7	401.9	243.2	106.3	74.3	298.8	2824.0	100%

Based on MassGIS, Land Use 1999

Table 1b. Build out land use for the Ashmere Lake watershed.

Build out land use classificaitons are depicted on Figure 14.

Build Out Land Use Class	Total Watershed (feet)	Total Watershed (acres)	Percentage of Watershed
Absolute Developmental Constraints	24,505,080	562.55	32%
Future Developmental Constraints	41,751,180	958.45	55%
Partial Developmental Constraints	9,549,450	219.22	13%
Total	**75,805,710**	**1740.23**	**100%**

Based on MassGIS, Land Use 1999

Table 2. Area and volume calculations from bathymetric contours of Ashmere Lake, Hinsdale, MA.

Bathymetry data was collected on April 26, 2002. Data based upon Lake Ashmere, at a water level of 0.0 feet at staff gauge at interbasin channel.

Depth Contour (feet below water level)	Area (sq. ft.)	Avg. Area (sq. ft.)	Incremental Volume (cu. ft.)	Cumulative Volume (cu. ft.)
25.0	0			
20.0	559,800	279,900	1,399,500	1,399,500
15.0	3,060,000	1,809,900	9,049,500	10,449,000
10.0	5,948,856	4,504,428	22,522,140	32,971,140
8.0	6,937,254	6,443,055	12,886,110	45,857,250
6.0	8,240,184	7,588,719	15,177,438	61,034,688
4.0	9,185,004	8,712,594	17,425,188	78,459,876
2.0	10,247,328	9,716,166	19,432,332	97,892,208
0.0	11,185,270	10,716,299	21,432,598	119,324,806

Total water volume in Lake Ashmere = 119,324,806 cu. ft.

Mean Depth = 10.67 ft

Table 3. Dissolved Oxygen Profile for the In-Lake Sampling Stations (AS-1 & AN-1) at Ashmere Lake.

Sampling locations are illustrated in Figure 5.
Temperature and dissolved oxygen profiles for AN-1 and AS-1 are depicted in Figures 6 and 7, respectively.

Site	Date	Depth (Meters)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)	Conductivity (umhos/cm)
AS-1	5/21/02	0.0	11.1	9.01	81.7	98.2
		0.5	11.1	8.99	81.7	98.1
		1:0	11.1	8.77	79.6	98.1
		1.5	11.1	8.93	81.1	98.2
		2.0	11.0	8.92	81.1	98.2
		2.5	11.0	8.99	81.2	98.2
		3.0	11.0	9.02	81.9	98.2
		3.5	11.0	8.97	81.4	98.2
		4.0	11.0	8.73	79.3	98.1
		4.5	11.0	8.94	80.7	98.1
		5.0	10.7	8.21	74.2	97.3
		5.5	10.5	7.77	69.7	96.6
		6.0	10.3	7.41	66.2	96.4
		6.5	10.4	5.39	47.1	100.6
		7.0	10.4	3.39	30.3	100.6
		7.5	10.4	3.14	28.5	100.4
		8.0	10.4	2.83	25.2	100.6
		8.5	10.4	1.90	15.0	102.9
AS-1	8/27/02	0.0	23.1	7.30	84.8	103.4
		0.5	23.2	7.24	84.0	104.0
		1.0	23.1	7.20	84.0	104.0
		1.5	23.1	7.40	86.0	104.2
		2.0	23.1	7.20	82.8	104.1
		2.5	23.0	6.89	80.5	104.0
		3.0	22.9	6.35	73.7	104.0
		3.5	22.8	6.20	71.3	104.1
		4.0	22.8	6.52	75.0	104.3
		4.5	22.7	6.41	74.4	104.3
		5.0	22.6	5.86	68.1	104.3
		5.5	22.4	5.32	62.0	104.6
		6.0	21.8	2.51	29.2	107.6
		6.5	20.3	0.41	5.2	137.1
AS-1	10/31/02	0.0	7.2	11.28	94.0	107.1
		0.5	7.3	10.90	90.0	107.6
		1.0	7.1	10.19	91.2	107.8
		1.5	7.0	11.20	92.0	108.0
		2.0	7.0	11.25	92.7	108.0
		2.5	6.9	11.35	93.0	108.0
		3.0	6.9	11.35	93.5	108.0
		3.5	6.9	11.35	92.0	108.0
		4.0	6.9	11.30	93.3	108.0
		4.5	6.8	11.35	92.5	108.0
		5.0	6.7	11.34	92.7	108.0
		5.5	6.6	11.40	93.0	108.0
		6.0	6.7	7.24	56.0	108.0
		6.5	6.9	0.85	8.1	114.0
AN-1	5/21/02	0.0	11.3	8.74	79.6	85.5
		0.5	11.3	8.82	80.9	85.5
		1.0	11.3	8.52	78.5	85.4
		1.5	11.3	8.81	80.5	85.4
		2.0	11.3	8.78	79.9	85.5
		2.5	11.2	8.84	80.9	85.4
		3.0	11.2	8.86	80.6	85.4
		3.5	11.1	8.79	79.9	84.8
		4.0	11.1	4.09	36.6	85.7
		4.5	11.1	0.86	8.3	85.2
AN-1	8/27/02	0.0	23.1	7.06	82.7	125.0
		0.5	23.1	6.90	80.2	125.4
		1.0	23.0	6.66	77.2	125.4
		1.5	22.8	6.67	76.0	125.7
		2.0	22.3	6.29	72.6	125.2
		2.5	22.2	5.66	65.0	124.9
		3.0	22.0	5.30	60.2	124.8
		3.25	21.9	4.96	56.0	124.6
		3.5	21.9	3.00	0.2	148.0
AN-1	10/31/02	0.0	6.0	11.98	96.3	128.7
		0.5	6.0	12.07	96.9	129.0
		1.0	6.0	12.05	97.0	129.0
		1.5	5.9	12.14	97.0	129.0
		2.0	5.9	12.10	97.3	129.1
		2.5	5.7	12.20	97.4	129.0
		3.0	5.6	11.43	91.3	128.7

Table 4. Field Water Quality Data for Ashmere Lake, 2002.

Arithmetic Means are presented for field parameters.
Average of Turbidity corresponds to the absolute value of the difference between Average Dry data and Average Wet data, if applicable.
In some cases, flow rates were below detection levels of field instrumentation and therefore, are reported as <0.01 mgd.
Less than (<) are divided by two before incorporating into the calculation of Means.
N/A: Not applicable, sampling of parameter not required as per Scope of Work.
Refer to Section 3.2 for a more detailed explanation of water quality standards employed for this analysis.
Sampling locations are illustrated in Figure 5.

Site	Date	Sample Type (Dry or Wet)	Temperature (Celsius)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)	Turbidity (NTU)	pH (SU)	Conductivity (umhos/cm)	Secchi (meters)	Flow (mgd)
AS-1 Surface	5/21/02	Dry	11.1	9.01	81.7	0.7	7.0	98	4.0	N/A
AS-1 Surface	8/27/02	Dry	23.1	7.30	84.8	3.9	7.1	103	2.1	N/A
AS-1 Surface	10/31/02	Dry	7.2	11.28	94.0	11.4	7.6	107	3.4	N/A
AVERAGE			13.8	[illegible]	86.8	[illegible]	[illegible]	103	[illegible]	N/A
AS-1 Bottom	5/21/02	Dry	10.4	1.90	15.0	6.5	6.9	103	N/A	N/A
AS-1 Bottom	8/27/02	Dry	20.3	0.41	5.2	1.6	6.8	137	N/A	N/A
AS-1 Bottom	10/31/02	Dry	6.9	0.33	2.6	3.0	7.8	113	N/A	N/A
AVERAGE			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	N/A	N/A
AS-2 Tributary	8/27/02	Dry	17.5	[illegible]	41.5	1.7	6.6	140	N/A	<0.01
AS-2 Tributary	9/15/02	Wet	16.3	6.55	67.0	0.8	7.4	115	N/A	0.009
AVERAGE			16.9	[illegible]	[illegible]	[illegible]	[illegible]	128	N/A	[illegible]
AS-3 Storm drain	9/15/02	Wet	20.4	8.20	85.0	[illegible]	7.9	61	N/A	0.0001
AVERAGE			20.4	[illegible]	85.0	[illegible]	7.9	61	N/A	0.0001
AS-4 Outlet	8/27/02	Dry	20.4	5.85	65.0	1.0	6.7	126	N/A	0.97
AVERAGE			20.4	[illegible]	65.0	1.0	[illegible]	126	N/A	[illegible]
AN-1 Surface	5/21/02	Dry	11.3	8.74	79.6	1.5	7.0	86	2.4	N/A
AN-1 Surface	8/27/02	Dry	23.1	7.06	82.7	0.0	7.1	125	2.0	N/A
AN-1 Surface	10/31/02	Dry	6.0	11.98	96.3	0.2	7.8	129	2.6	N/A
AVERAGE			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	N/A
AN-1 Bottom	5/21/02	Dry	11.1	0.86	8.3	1.9	7.0	85	N/A	N/A
AN-1 Bottom	8/27/02	Dry	21.9	3.00	0.2	2.4	7.0	148	N/A	N/A
AN-1 Bottom	10/31/02	Dry	5.6	11.43	91.3	1.9	8.1	129	N/A	N/A
AVERAGE			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	N/A	N/A
AN-2 Tributary	8/27/02	Dry	17.0	8.27	85.4	0.0	7.0	70	N/A	0.02
AN-2 Tributary	9/15/02	Wet	17.0	7.96	82.4	2.1	7.8	65	N/A	0.22
AVERAGE			17.0	[illegible]	83.9	1.0	[illegible]	68	N/A	[illegible]

Table 5. Laboratory Water Quality Data for Ashmere Lake, 2002.

Arithmetic Means are presented for laboratory parameters.
DUP: Duplicate sample collected in field
Less than (<) are divided by two before incorporating into the calculation of Means.
N/A: Not applicable, sampling of parameter not required as per Scope of Work.
Refer to Section 3.2 for a more detailed explanation of water quality standards employed for this analysis.
Sampling locations are illustrated in Figure 5.

Sample ID	Date	Sample Type (Dry vs. Wet)	Fecal coliform (Col/100 ml)	Total Alkalinity (mg/L) (mg/L)	Ammonia Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Phosphorus (mg/L)	Dissolved Phosphorus (mg/L)
AS-1 Surface	5/21/02	Dry	<10	19	<0.01	<0.01	<0.1	0.03	<0.01
AS-1 Surface-DUP	5/21/02	Dry	<10	NO DUP	NO DUP	NO DUP	NO DUP	NO DUP	NO DUP
AS-1 Surface	8/27/02	Dry	10	25	<0.01	<0.01	0.6	0.02	0.01
AS-1 Surface	10/31/02	Dry	<10	24	0.01	<0.01	0.3	0.01	0.01
AVERAGE			18	23	0.01	0.01	0.3	0.02	0.01
AS-1 Bottom	5/21/02	Dry	N/A	19	<0.01	<0.01	<0.1	0.03	<0.01
AS-1 Bottom	8/27/02	Dry	N/A	26	0.01	<0.01	0.8	0.03	<0.01
AS-1 Bottom	10/31/02	Dry	N/A	24	<0.01	<0.01	0.4	0.08	<0.01
AVERAGE			N/A	23	0.01	0.01	0.4	0.05	0.01
AS-2 Tributary	8/27/02	Dry	30	42	0.24	0.36	1.3	0.04	0.01
AS-2 Tributary	9/15/02	Wet	770	52	0.02	0.04	<0.1	0.02	0.02
AVERAGE			400	47	0.13	0.20	0.7	0.03	0.02
AS-3 Storm drain	9/15/02	Wet	80	13	0.07	0.29	0.3	0.11	0.04
AVERAGE			80	13	0.07	0.29	0.3	0.11	0.04
AS-4 Outlet	8/27/02	Dry	<10	37	<0.01	<0.01	0.7	0.04	0.02
AVERAGE			5	37	0.01	0.01	0.7	0.04	0.02
AN-1 Surface	5/21/02	Dry	10	24	<0.01	0.01	<0.1	0.01	<0.01
AN-1 Surface-DUP	5/21/02	Dry	NO DUP	24	<0.01	<0.01	<0.1	0.01	<0.01
AN-1 Surface	8/27/02	Dry	<10	35	0.03	<0.01	1.4	0.02	0.01
AN-1 Surface	10/31/02	Dry	<10	32	0.02	<0.01	0.4	0.02	0.01
AVERAGE			[illegible]	29	0.02	0.01	0.5	0.02	0.01
AN-1 Bottom	5/21/02	Dry	N/A	24	<0.01	<0.01	<0.1	0.01	<0.01
AN-1 Bottom	8/27/02	Dry	N/A	35	0.03	<0.01	1.0	0.03	0.01
AN-1 Bottom	10/31/02	Dry	N/A	32	0.01	<0.01	0.4	0.02	0.01
AVERAGE			N/A	30	0.02	0.01	0.6	0.02	0.02
AN-2 Tributary	8/27/02	Dry	<10	28	<0.01	0.18	0.5	0.04	0.02
AN-2 Tributary	9/15/02	Wet	20	24	0.01	0.12	0.5	0.02	0.02
AVERAGE			13	26	0.01	0.15	0.5	0.03	0.02

Table 6. Laboratory sediment quality data for Ashmere Lake.
Sediment samples collected on February 7, 2002.
Sampling locations are illustrated in Figure 5.

Parameter	Units	Results	Detection Limits
Total Solids	%	23.0	0.1
Total Phosphorus	mg/Kg	1100.0	34
Total Petroleum Hydrocarbons	mg/Kg	600.0	430
Percent Water	%	77.0	0.1
Percent Organic Content	%	3.7	0.1
Particle Size			
Gravel (>2.0 mm)	%	0.2	0.1
Coarse Sand (2.0 mm-0.425 mm)	%	2.1	0.1
Medium and Fine Sands (0.425 mm-0.063 mm)	%	52.7	0.1
Silts and Clays (<0.063 mm)	%	45.0	0.1
Total Metals			
Arsenic	mg/Kg	5.4	1.7
Cadmium	mg/Kg	1.3	0.9
Chromium	mg/Kg	21.0	1.7
Copper	mg/Kg	25.0	1.7
Lead	mg/Kg	55.0	8.6
Mercury	mg/Kg	0.14	0.1
Nickel	mg/Kg	19.0	4.3
Vanadium	mg/Kg	38.0	1.7
Zinc	mg/Kg	160.0	8.6
PAHs			
2-Chloronaphthalene	µg/Kg	ND	170
1-Methylnaphthalene	µg/Kg	ND	170
2-Methylnaphthalene	µg/Kg	ND	170
Acenaphthene	µg/Kg	ND	170
Acenaphthylene	µg/Kg	ND	170
Anthracene	µg/Kg	ND	170
Benzo(a)anthracene	µg/Kg	ND	170
Benzo(a)pyrene	µg/Kg	ND	170
Benzo(b)fluoranthene	µg/Kg	ND	170
Benzo(e)pyrene	µg/Kg	ND	170
Benzo(k)fluoranthene	µg/Kg	ND	170
Benzo (ghi) perylene	µg/Kg	ND	170
Biphenyl	µg/Kg	ND	170
Chrysene	µg/Kg	ND	170
Dibenzo(a,h)Anthracene	µg/Kg	ND	170
Fluoranthene	µg/Kg	ND	170
Fluorene	µg/Kg	ND	170
Indeno(1,2,3-cd)Pyrene	µg/Kg	ND	170
Naphthalene	µg/Kg	ND	170
Perylene	µg/Kg	720.0	170
Phenanthrene	µg/Kg	ND	170
Pyrene	µg/Kg	ND	170
PCBs			
Arochlor 1016	µg/Kg	ND	1090
Arochlor 1221	µg/Kg	ND	1090
Arochlor 1232	µg/Kg	ND	1090
Arochlor 1242	µg/Kg	ND	1090
Arochlor 1248	µg/Kg	ND	1090
Arochlor 1254	µg/Kg	ND	1090
Arochlor 1260	µg/Kg	ND	1090

ND = Non detect

Table 7. Sediment quality guidelines.

Contaminant	ER-L (mg/Kg)[1]	ER-M (mg/Kg)[2]	USEPA (mg/Kg)[3]	MADEP - Landfill (mg/Kg)[4]
Arsenic	8.2	70	3-8	40
Cadmium	1.2	9.6	-	80
Chromium	81	370	22-75	1,000
Copper	34	270	25-50	-
Lead	46.7	218	40-60	2,000
Mercury	0.15	0.71	-	10
Nickel	20.9	51.6	20-50	-
Zinc	150	410	90-200	-
PCBs	22.7 ug/kg	180 ug/kg	-	<2
PAHs	-	-	-	100
TPHs	-	-	-	5,000
Total Phosphorus	-	-	420-650	-

1 = Effects Range Low, Long and Morgan, 1995
2 = Effects Range Medium, Long and Morgan, 1995
3 = Great Lakes Criteria for unpolluted (lower limit) and severely polluted (upper limit) USEPA, 1977
4 = Interim Policy (COMM-94-007) for Sampling, Handling and Tracking Requirements for Dredged Sediment Reused or Disposed at Massachusetts Permitted Landfills, MADEP, 2000

Table 8. Plant species historically and recently documented in Ashmere Lake.
Plant species distributions are depicted on Figures 7 through 10.
ESS 2002 plant assessment conducted on May 20th, and August 26th, 2002.

Common Name	Scientific Name	Presence or absence of historically documented species observed by ESS, 2002
Watershield[2]	*Brasenia schreberi* [2]	*no*
Stonewart	*Chara spp.*	*yes*
Sedge	*Cyperaceae spp.*	*yes*
Waterweed	*Elodea canadensis*	*yes*
Waterweed[2]	*Elodea spp.* [2]	*yes*
Pipewort	*Eriocaulon aquaticum*	*yes*
Hedge hyssop	*Gratiola L.*	*yes*
Unknown rush	*Juncus spp.*	*yes*
Moss	*Musci spp.*	*yes*
Eurasian milfoil[1,2]	*Myriophyllum spicatum* [1,2]	*yes*
Brittle waternymph[1]	*Najas minor* [1]	*yes*
Stonewart	*Nitella spp.*	*yes*
Yellow pond lily	*Nuphar variagatum*	*yes*
Water lily[2]	*Nymphaea spp.* [2]	*no*
Ditch stonecrop	*Penthorum sedoides*	*yes*
Common reed[2]	*Phragmites communis* [2]	*yes*
Water smartweed[2]	*Polgonum punctatum* [2]	*no*
Pickerelweed	*Pontederia cordata*	*yes*
Large-leaved pondweed[2]	*Potamogeton amplifolius* [2]	*no*
Curly pondweed[1]	*Potamogeton crispus* [1]	*yes*
Small pondweed	*Potamogeton pusillus*	*yes*
Richardson's pondweed[2]	*Potamogeton richardsonii* [2]	*no*
Fern pondweed[2]	*Potamogeton robbinsii* [2]	*no*
Wool grass	*Scirpus cyperinus*	*yes*
Sago pondweed	*Stuckenia pectinatus*	*yes*
Cattail[2]	*Typha latifolia* [2]	*yes*
Bladderwort[2]	*Utricularia spp.* [2]	*yes*
Wild celery	*Vallisneria americana*	*yes*

1 = Non-native "exotic" species
2 = Observed by Lycott Environmental, Inc. 2001. Letter to Lake Management Committee, DEP File No. 181-77, October 17, 2001.

Table 9. Observed and expected wildlife species at Ashmere Lake.

Common Name	Common Name
American black duck[1]	Hooded merganser[1]
American coot[1]	Indiana myotis[1]
American widgeon[1]	Keen's myotis[1]
Bald eagle[1] (Endangered - MA Status)	Least bittern[1]
Beaver[1,2]	Little brown myotis[1]
Belted kingfisher[1]	Mallards[1,2]
Big brown bat[1]	Map turtle[1]
Black bear[1]	Midland painted turtle[1]
Black tern[1]	Mink[1]
Blanding's turtle[1] (Threatened - MA Status)	Mink frog[1]
Bufflehead[1]	Moose[1]
Bullfrog[1]	Mudpuppy[1]
Canada goose[1,2]	Muskrat[1]
Canvasback[1]	Mute swan[1]
Common crow[1,2]	Northern leopard frog[1]
Common goldeneye[1]	Northern ribbon snake[1]
Common grackle[1]	Northern water snake[1]
Common loon[1] (Special Concern - MA Status)	Northing spring peeper[1]
Common merganser[1]	Osprey[1]
Common moorhen[1] (Special Concern - MA Status)	Painted turtle[1,2]
Common raven[1]	Pickerel frog[1]
Common snapping turtle[1]	Plymouth redbelly turtle[1]
Eastern American toad[1]	Purple martin[1]
Eastern painted turtle[1]	Red bat[1]
Eastern pipistrelle[1]	Red-breasted merganser[1]
Eastern ribbon snake[1]	Red-eared slider[1]
Eastern spiny softshell[1]	Red-spotted newt[1]
Fish crow[1]	Redwing blackbird[1,2]
Fowler's toad[1]	Ring-billed gull[1]
Gadwall[1]	Ring-necked duck[1]
Glossy ibis[1]	River otter[1]
Gray treefrog[1]	Silver-haired bat[1]
Great blue heron[1,2]	Spotted sandpiper[1]
Green frog[1]	Star-nosed mole[1]
Green-backed heron[1]	Stinkpot[1]
Gull[1,2]	Tree swallow[1,2]
Herring gull[1]	Water shrew[1] (Special Concern - MA Status)
Hoary bat[1]	Wood duck[1]
	Wood turtle[3] (Special Concern - MA Status)

1= Expected wildlife species are based upon the NEWild program (Thomasma et. al, 1999).

2 = Observed wildlife species reported by ESS personnel during 2002 field season.

3 = Wildlife species reported to occur within the watershed, NHESP 2002 (Appendix B).

Table 10. Species documented in Hinsdale Flats watershed supporting ACEC designation.

Species list obtained from Executive Office of Environmental Affairs. 1992. Inland Area of Critical Environmental Concern Data Sheet.

Common Name	Scientific Name
REPTILES	
Northern Ringneck snake	*Diadophis punctatus*
Wood turtle*	*Clemmys insculpta*
MAMMALS	
Black bear	*Ursus americanus*
Bobcat	*Lynx rufus*
BIRDS	
Great blue heron	*Ardea herodias*
FISH	
Rainbow Trout	*Oncorhychus mykiss*
Brook Trout	*Salvelinus fontinalis*
Brown Trout	*Salmo trutta*
Slimy Sculpin	*Cottus cognatus*
Perch	*Perca spp.*
Bass	*Micropterus spp.*
Pickerel	*Esox spp.*
AMPHIBIANS	
Red-backed salamander	*Plethodon cinereus*
INVERTEBRATES	
Dreamy duskwing	*Erynnis icelus*
PLANTS	
Hemlock parsley*	*Conioselum chinense*
Bristly black currant*	*Ribes triste*
Woodland millet**	*Millium effusum*
Showy lady-slipper*	*Cypripedium reginae*
Small yellow lady-slipper***	*Cypripedium calceolus var. parviflorum*
Indian cucumber-root	*Medeola virginiana*

*** State-listed Endangered Species.

** State-listed Threatened Species.

* State-listed Species of Special Concern.

Table 11. Invertebrate taxa observed at Ashmere Lake and its tributaries, October 31st, 2002.
Sampling locations are illustrated in Figure 5.

Taxa	Common Name	In-lake South basin	In-lake North basin	AS-2 Tributary	AN-2 Tributary	AS-1 Outlet
Amphipoda (Scuds)						
Hyalella sp.	Scud	A	A	A		R
Bivalvia (Mussels & Clams)						
Anodonta implicata	Alewife floater mussel	C				
Sphaerium sp.	Fingernail clams		R	C	C	
Coleoptera (Beetles)						
Haliplidae (adult)	Crawling water beetles		C			
Decapoda						
Cambaridae	Crayfish					R
Diptera (True Flies)						
Chironomidae (larvae)	Midges	C	C		A	C
Simulidae	Blackflies					C
Tapanidae (larvae)	Horseflies				C	
Ephemeroptera (Mayflies)						
Baetidae	Small minnow mayflies		C	C		
Ephemerellidae	Spiny Crawler mayflies				R	
Ephemera sp.	Common burrowers	C				
Heptageniidae	Flatheaded mayflies		R			
Leptophlebiidae	Small squaregills	A	C	C	R	
Stenonema sp.	Flatheaded mayflies	C		C		
Gastropoda (Snails)						
Hydrobiidae	Mud snails	C	A	A		
Physidae	Pouch snails			C		
Planorbidae	Rammshorn snails		R			
Megaloptera						
Sialis sp.	Alderfly	R	R			
Odonata (Dragonflies)						
Aeshnidae	Hawkers			C		
Corduliidae	Spiketails	R	A			
Lestidae	Clubtails	C	A	A		
Oligochaeta (Segmented worms)						
Oligochaeta sp.		R	C			
Trichoptera (Caddisflies)						
Glossosomatidae	Saddlecase makers				R	
Hydropsychidae	Common netspinners	C				A
Leptoceridae	Longhorned casemakers			R		
Limnephilidae	Northern casemakers		R		R	
Philopotamidae	Finger-net caddisfly					R
Rhyacophilidae	Free living caddisfly					C
Total number of taxa		12	14	10	7	7

A = Abundant
C = Common
R = Rare

Table 12. Annual hydrologic loading for Lake Ashmere.

Source	Load (cfs)	(m3/yr)	(%)
Direct Precipitation w/ Evapotranspiration	0.89	792,225	10.8
Ground Water Inseepage	0.80	711,806	9.7
Surface Water	6.54	5,840,221	79.5
Dry Weather*	0.04	34,827	0.5
Wet Weather*	6.50	5,805,394	79.0
Total Annual	8.22	7,344,033	100.0

*Subset of surface water total

Lake Ashmere Statistics:

Volume	119,324,806	cu. ft
Mean Depth	10.67	ft
Detention Time	167.9	days (0.46 yrs)
Flushing Rate	2.2	times/year
Response Time	144-240	days

Table 13. Nutrient loads for Ashmere Lake.

Variable	Total Phosphorus	Total Nitrogen
In-lake concentration (mg/l)	0.0183	0.473
Min. load g/m2/yr	0.13	3.34
In-lake Predictive Models		
Bachmann (N) g/m2/yr		4.98
Bachmann (N) kg/yr		5,171
Kirchner-Dillon (P) g/m2/yr	0.29	
Vollenweider (P) g/m2/yr	0.21	
Reckhow (general P) g/m2/yr	0.37	
Larsen and Mercier (P) g/m2/yr	0.22	
Jones and Bachman (P) g/m2/yr	0.20	
Average all phosphorus models g/m2/yr	0.26	
Average all phosphorus models kg/yr	267	
Vollenweider's permissible		
load g/m2/yr	0.27	
load kg/yr	276	
load mg/L	0.0376	
Vollenweider's critical		
load g/m2/yr	0.53	
load kg/yr	552	
load mg/L	0.075	

Table 14. Annual phosphorus loads (kg/yr) for Ashmere Lake listed by source as derived from in-field measurements, regional data, and hydrologic modeling.

Source	Phosphorus Loads	
	(kg/yr)	(%)
Direct Precipitation	24.09	14.3%
Ground Water Inseepage	14.2	8.5%
Surface Water		
Dry Weather	1.4	0.8%
Wet Weather*	116.1	69.0%
Internal Release (from lake sediments)	12.5	7.4%
Total Annual	**168.3**	**100.0%**

* Only includes data from tributaries, not storm drains

Table 15. Maximum, mean and minimum expected nitrogen loading (kg/yr) to Ashmere Lake listed by sub-basin as determined from land use modeling within each of the watershed's sub-basins.

Maximum	Sub-Basin 1	Sub-Basin 2	Sub-Basin 3	Sub-Basin 4	Sub-Basin 5	Sub-Basin 6	Sub-Basin 7	Sub-Basin 8	Total for Watershed
Industrial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Commercial	16.8	0.0	0.0	0.0	0.0	51.3	0.0	0.0	16.8
Agriculture	35.6	315.6	0.0	0.0	50.6	0.0	0.0	4.5	351.2
Forest	1,476.7	1,654.6	13.9	321.7	919.3	419.6	123.5	186.9	3,466.8
Transportation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open	178.5	180.0	0.0	49.0	209.0	38.3	226.0	0.0	407.5
Residential	1,029.8	1,061.0	41.0	1,130.0	80.7	483.1	604.0	1.1	3,261.7
Recreation	211.6	26.1	272.1	0.0	0.0	401.8	0.0	0.0	509.8
Wetland	11.1	5.5	0.0	7.2	33.1	13.9	0.0	0.0	23.9
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Disposal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Load	2,960.1	3,242.7	327.0	1,507.8	1,292.6	1,408.1	953.4	192.5	8,037.6
Attenuation Coefficient	0.6	0.6	0.9	0.6	0.5	0.7	0.8	0.7	
Adjusted Total Load	1,776.1	1,945.6	294.3	904.7	646.3	985.7	762.8	134.8	4,920.7

Mean	Sub-Basin 1	Sub-Basin 2	Sub-Basin 3	Sub-Basin 4	Sub-Basin 5	Sub-Basin 6	Sub-Basin 7	Sub-Basin 8	Total for Watershed
Industrial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Commercial	4.3	0.0	0.0	0.0	0.0	13.3	0.0	0.0	4.3
Agriculture	10.0	88.5	0.0	0.0	14.2	0.0	0.0	1.3	98.5
Forest	674.6	755.9	6.4	147.0	420.0	191.7	56.4	85.4	1,583.9
Transportation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open	50.1	50.5	0.0	13.7	58.6	10.7	63.4	0.0	114.3
Residential	266.9	275.0	10.6	292.8	20.9	125.2	156.5	0.3	845.3
Recreation	59.3	7.3	76.3	0.0	0.0	112.7	0.0	0.0	142.9
Wetland	5.1	2.5	0.0	3.3	15.1	6.4	0.0	0.0	10.9
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Disposal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Load	1,070.3	1,179.7	93.3	456.8	528.8	460.0	276.3	87.0	2,800.1
Attenuation Coefficient	0.6	0.6	0.9	0.6	0.5	0.7	0.8	0.7	
Adjusted Total Load	642.2	707.8	84.0	274.1	264.4	322.0	221.0	60.9	1,708.1

Minimum	Sub-Basin 1	Sub-Basin 2	Sub-Basin 3	Sub-Basin 4	Sub-Basin 5	Sub-Basin 6	Sub-Basin 7	Sub-Basin 8	Total for Watershed
Industrial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Commercial	0.6	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.6
Agriculture	1.7	15.1	0.0	0.0	2.4	0.0	0.0	0.2	16.8
Forest	325.5	364.7	3.1	70.9	202.7	92.5	27.2	41.2	764.3
Transportation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open	8.6	8.6	0.0	2.3	10.0	1.8	10.8	0.0	19.5
Residential	39.6	40.8	1.6	43.5	3.1	18.6	23.2	0.0	125.5
Recreation	10.2	1.3	13.1	0.0	0.0	19.3	0.0	0.0	24.5
Wetland	2.5	1.2	0.0	1.6	7.3	3.1	0.0	0.0	5.3
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Disposal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Load	388.7	431.8	17.7	118.3	225.5	137.2	61.3	41.5	956.5
Attenuation Coefficient	0.6	0.6	0.9	0.6	0.5	0.7	0.8	0.7	
Adjusted Total Load	233.2	259.1	15.9	71.0	112.8	96.1	49.0	29.0	579.2

Table 16. Maximum, mean and minimum expected phosphorus loading (kg/yr) to Ashmere Lake listed by sub-basin as determined from land use modeling within each of the watershed's sub-basins.

Maximum	Sub-Basin 1	Sub-Basin 2	Sub-Basin 3	Sub-Basin 4	Sub-Basin 5	Sub-Basin 6	Sub-Basin 7	Sub-Basin 8	Total for Watershed
Industrial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Commercial	2.7	0.0	0.0	0.0	0.0	8.3	0.0	0.0	2.7
Agriculture	5.7	50.1	0.0	0.0	8.0	0.0	0.0	0.7	55.8
Forest	195.8	219.4	1.8	42.7	121.9	55.6	16.4	24.8	459.7
Transportation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open	28.4	28.6	0.0	7.8	33.2	6.1	35.9	0.0	64.7
Residential	166.8	171.8	6.6	183.0	13.1	78.2	97.8	0.2	528.2
Recreation	33.6	4.1	43.2	0.0	0.0	63.8	0.0	0.0	81.0
Wetland	1.5	0.7	0.0	1.0	4.4	1.8	0.0	0.0	3.2
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Disposal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Load	434.4	474.8	51.7	234.4	180.6	213.9	150.1	25.7	1,195.2
Attenuation Coefficient	0.4	0.4	0.7	0.4	0.3	0.5	0.6	0.5	
Adjusted Total Load	173.7	189.9	36.2	93.7	54.2	107.0	90.0	12.8	493.6

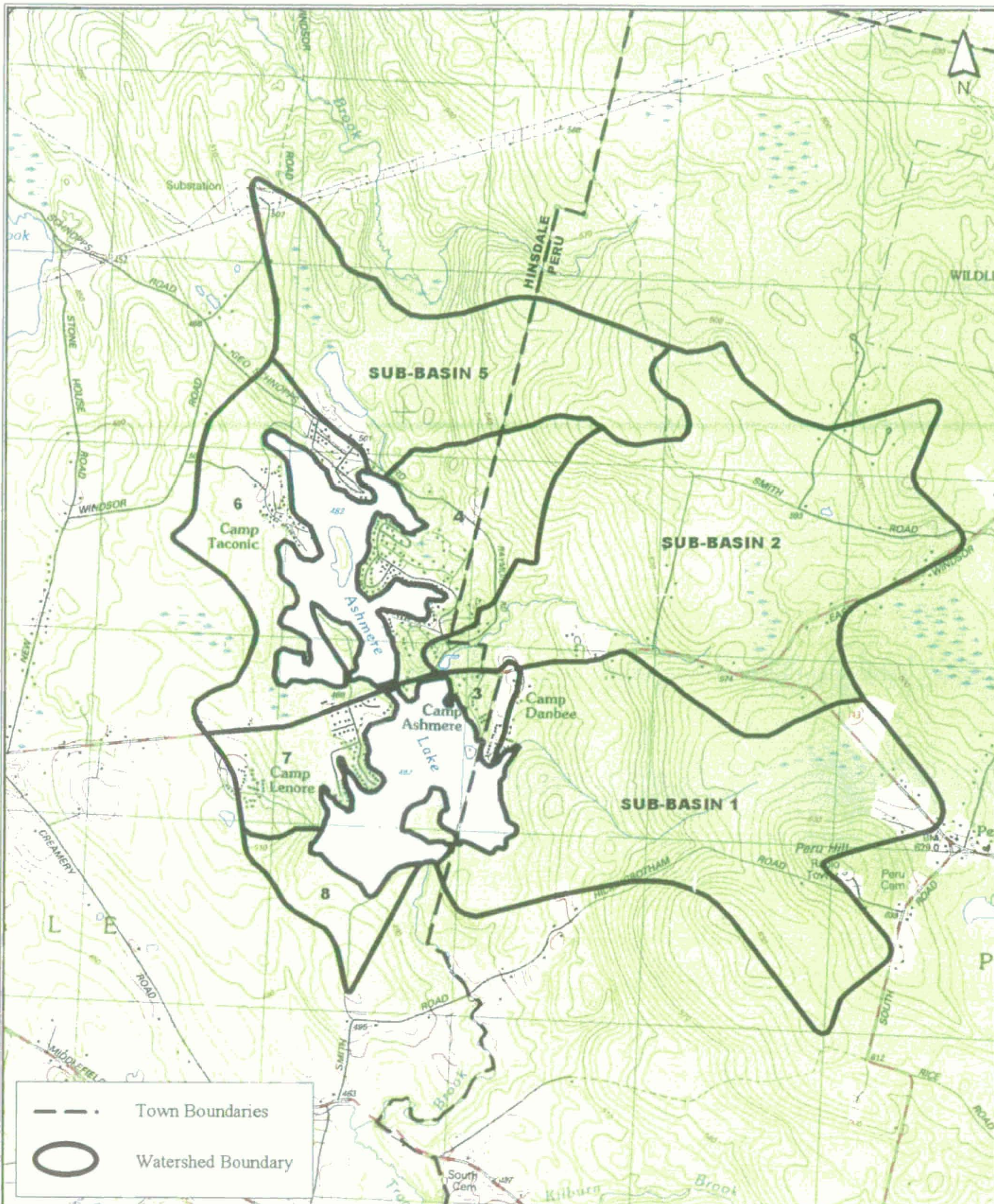
Mean	Sub-Basin 1	Sub-Basin 2	Sub-Basin 3	Sub-Basin 4	Sub-Basin 5	Sub-Basin 6	Sub-Basin 7	Sub-Basin 8	Total for Watershed
Industrial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Commercial	0.8	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.8
Agriculture	2.2	19.5	0.0	0.0	3.1	0.0	0.0	0.3	21.7
Forest	56.6	63.4	0.5	12.3	35.2	16.1	4.7	7.2	132.9
Transportation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open	8.7	8.8	0.0	2.4	10.2	1.9	11.0	0.0	19.8
Residential	51.1	52.7	2.0	56.1	4.0	24.0	30.0	0.1	161.9
Recreation	10.3	1.3	13.2	0.0	0.0	19.5	0.0	0.0	24.8
Wetland	0.4	0.2	0.0	0.3	1.3	0.5	0.0	0.0	0.9
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Disposal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Load	130.2	145.9	15.8	71.1	53.8	64.6	45.7	7.5	362.9
Attenuation Coefficient	0.4	0.4	0.7	0.4	0.3	0.5	0.6	0.5	
Adjusted Total Load	52.1	58.4	11.1	28.4	16.1	32.3	27.4	3.8	149.9

Minimum	Sub-Basin 1	Sub-Basin 2	Sub-Basin 3	Sub-Basin 4	Sub-Basin 5	Sub-Basin 6	Sub-Basin 7	Sub-Basin 8	Total for Watershed
Industrial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Commercial	0.1	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.1
Agriculture	0.2	1.4	0.0	0.0	0.2	0.0	0.0	0.0	1.6
Forest	4.7	5.3	0.0	1.0	2.9	1.3	0.4	0.6	11.1
Transportation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open	0.8	0.8	0.0	0.2	0.9	0.2	1.0	0.0	1.8
Residential	5.1	5.2	0.2	5.6	0.4	2.4	3.0	0.0	16.1
Recreation	1.0	0.1	1.2	0.0	0.0	1.8	0.0	0.0	2.3
Wetland	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Disposal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Load	11.9	12.9	1.5	6.9	4.6	6.0	4.4	0.6	33.1
Attenuation Coefficient	0.4	0.4	0.7	0.4	0.3	0.5	0.6	0.5	
Adjusted Total Load	4.7	5.2	1.0	2.7	1.4	3.0	2.6	0.3	13.7

FIGURES

Table 17. Proposed Long-Term Monitoring Program for Ashmere Lake.

Parameter	Utility	Proposed Locations	Proposed Frequency
Secchi transparency	Water clarity	In-lake	2/yr, June, August
Total phosphorus	Fertility	In-lake (Surface/Bottom)	2/yr, June, August
Total nitrogen	Fertility	In-lake (Surface/Bottom)	2/yr, June, August
Temperature	Fish health	In-lake (Surface/Bottom)	2/yr, June, August
Dissolved Oxygen	Fish health	In-lake (Surface/Bottom)	2/yr, June, August
pH	Fish health	In-lake (Surface/Bottom)	2/yr, June, August
Conductivity	Dissolved solids	In-lake (Surface/Bottom)	2/yr, June, August
Turbidity	Suspended solids	In-lake (Surface/Bottom)	2/yr, June, August
Plant density/distrib.	Plant nuisances	In-lake	Annually, late June



Ashmere Lake Watershed Delineation
Hinsdale - Peru, Massachusetts

Source: 1) MassGIS, USGS DRG, 1988
2) ESS, Ashmere Watershed Delineation, 2002

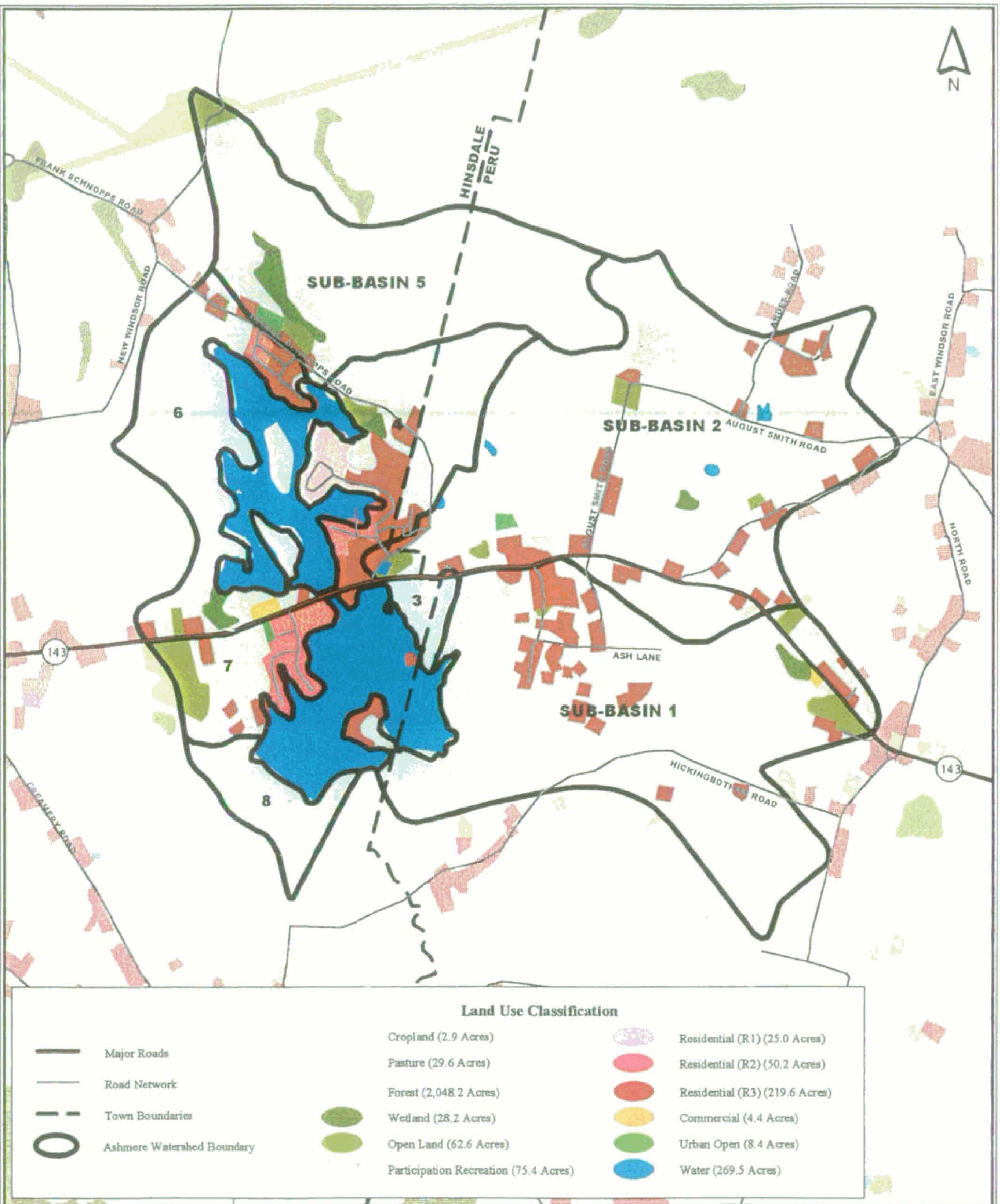
Scale: 1" = 2,500'

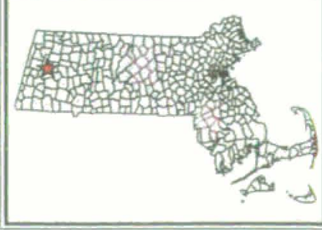
Ashmere Lake Diagnostic and Feasibility Study Plan

FIGURE NO.
1
Sheet 1 of 1
Project No.
H119-000

Date: 12/24/02
Location: G:\H119\ESS-Ashmere.apr Layout: Ash Site Locus

ESS





Land Use Classification and Sub-Basin Delineation of the Ashmere Lake Watershed

Source: 1) MassGIS, Land Use, 1999 2) MassGIS, MHD Roads, 2000 3) MassGIS, Towns, 1992 4) ESS, Ashmere Watershed Delineation, 2002

Scale: 1" = 2,500'

Ashmere Lake Diagnostic and Feasibility Study Plan

FIGURE NO. 2

Sheet 1 of 1

Project No. H119-000

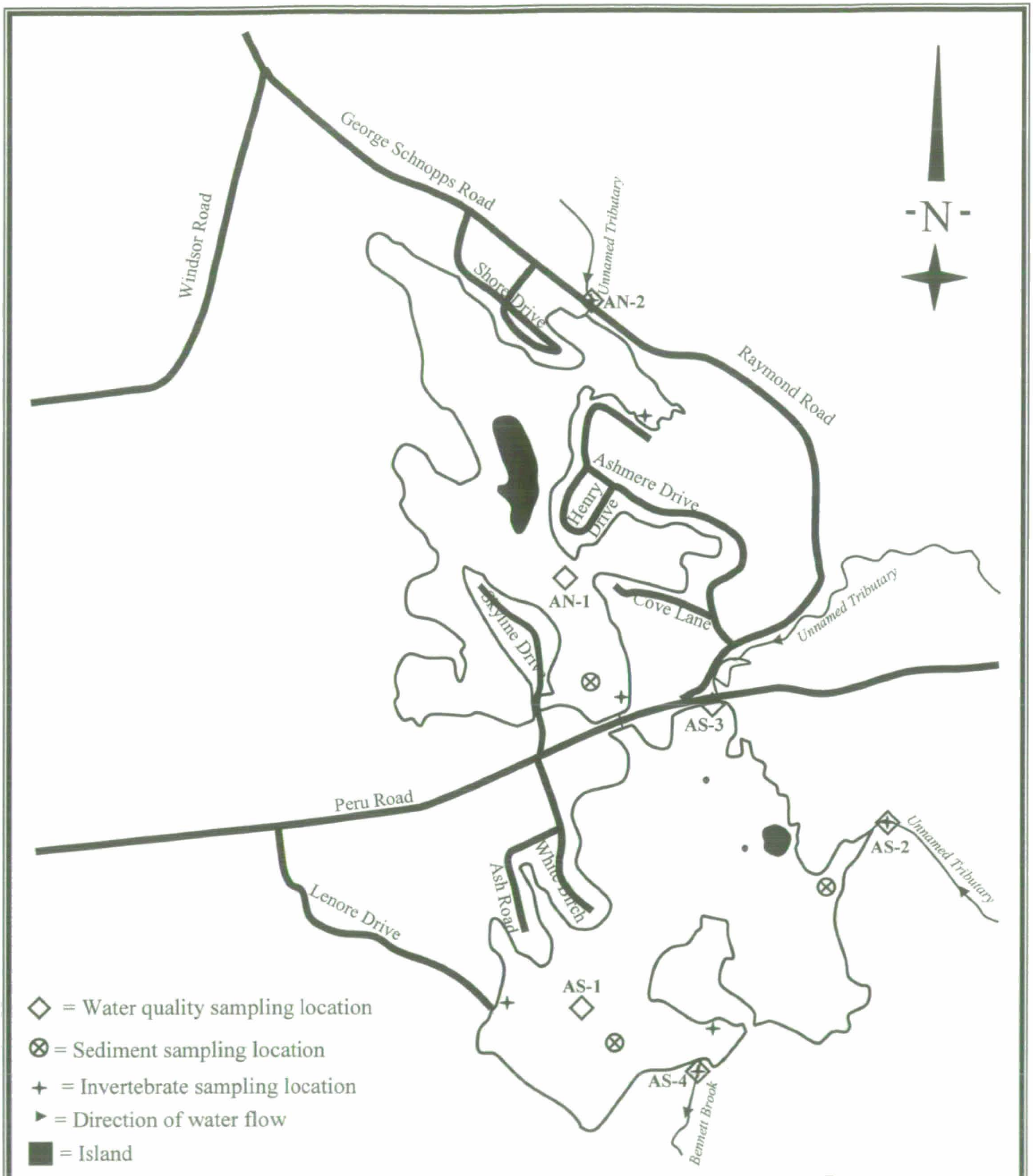
Date: 1/2/03
Location: G:\H119\ESS-Ashmere.apr Layout: Ash Land Use

0 ft 600 ft Approximate Scale	**Bathymetric Contour Map** **Ashmere Lake, South Basin** **Hinsdale, Massachusetts** **5/20/02**	FIGURE NO. 3 PROJECT NO H119-000

ESS Group Inc.

0 ft 600 ft Approximate Scale	**Bathymetric Contour Map** **Ashmere Lake, North Basin** **Hinsdale, Massachusetts** **5/20/02**	FIGURE NO. 4 PROJECT NO. H119-000

ESS Group Inc.



0 1000 ft

Approximate Scale

Water Quality, Sediment and Invertebrate Sampling Locations
Ashmere Lake
Hinsdale, Massachusetts

FIGURE NO.
5

PROJECT NO.
H119-000

ESS Group Inc.

Figure 6. Temperature and Dissolved Oxygen Profile at Ashmere Lake, South Basin.

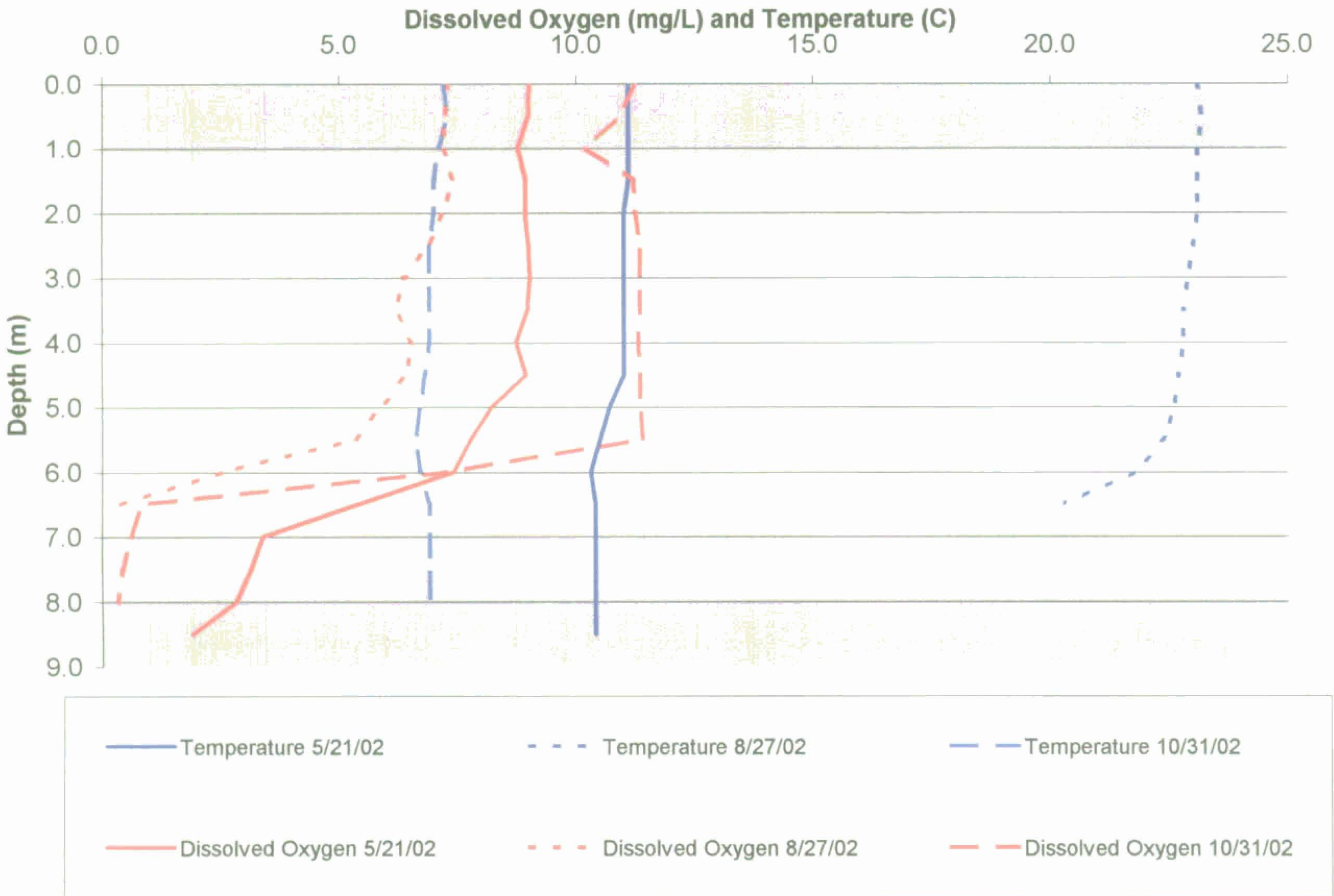
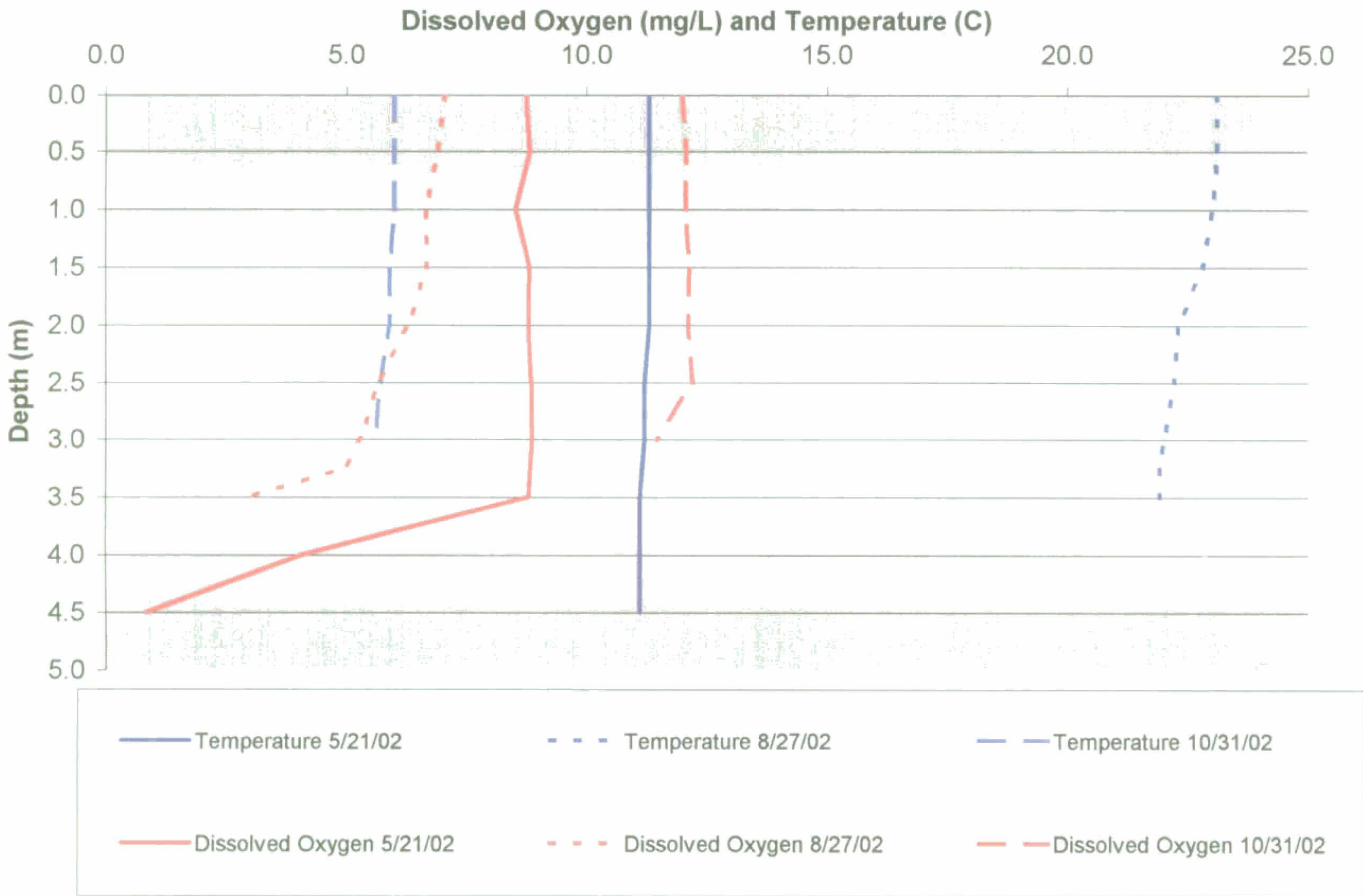
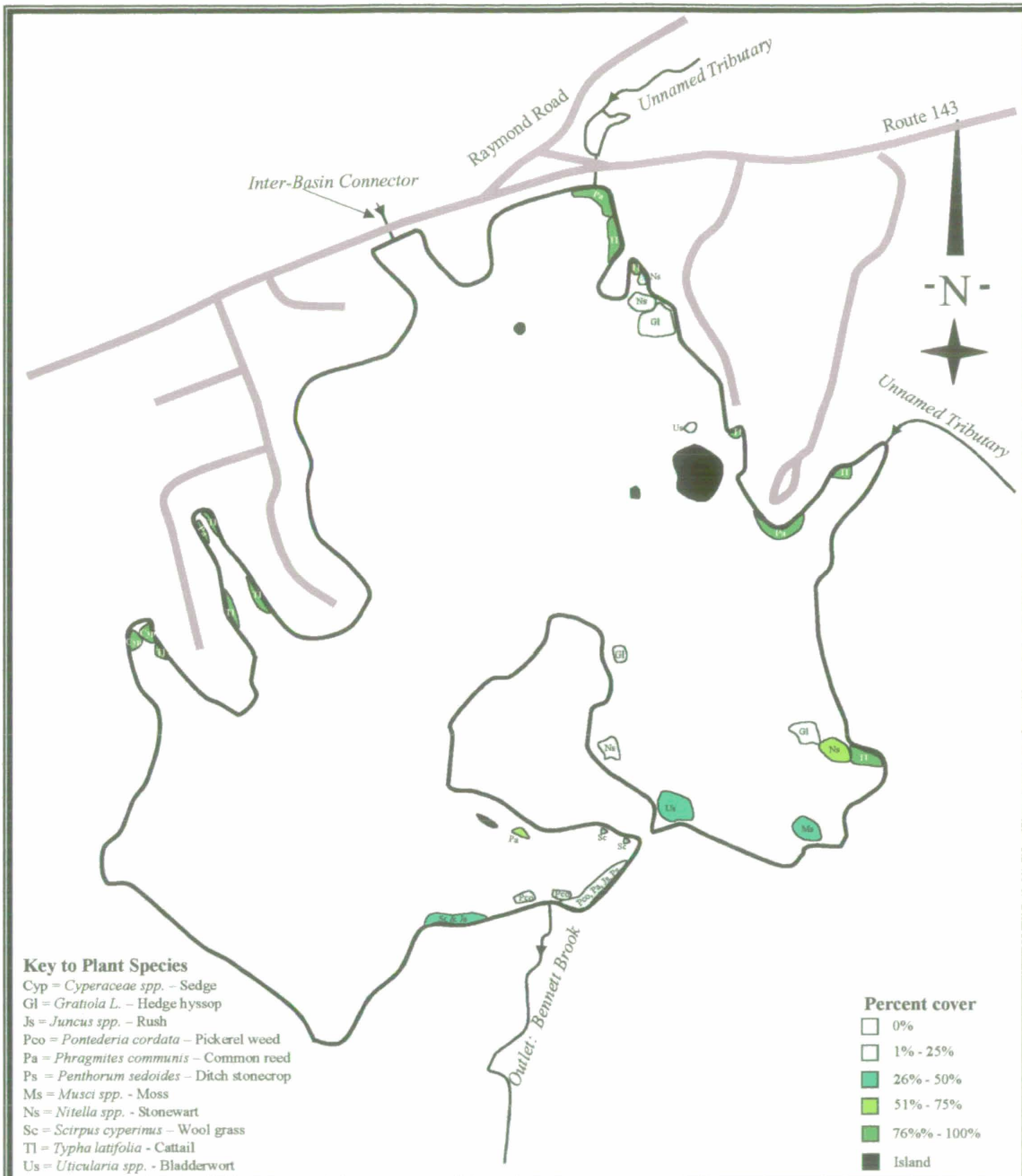


Figure 7. Temperature and Dissolved Oxygen Profile at Ashmere Lake, North Basin.





0 ft 600 ft

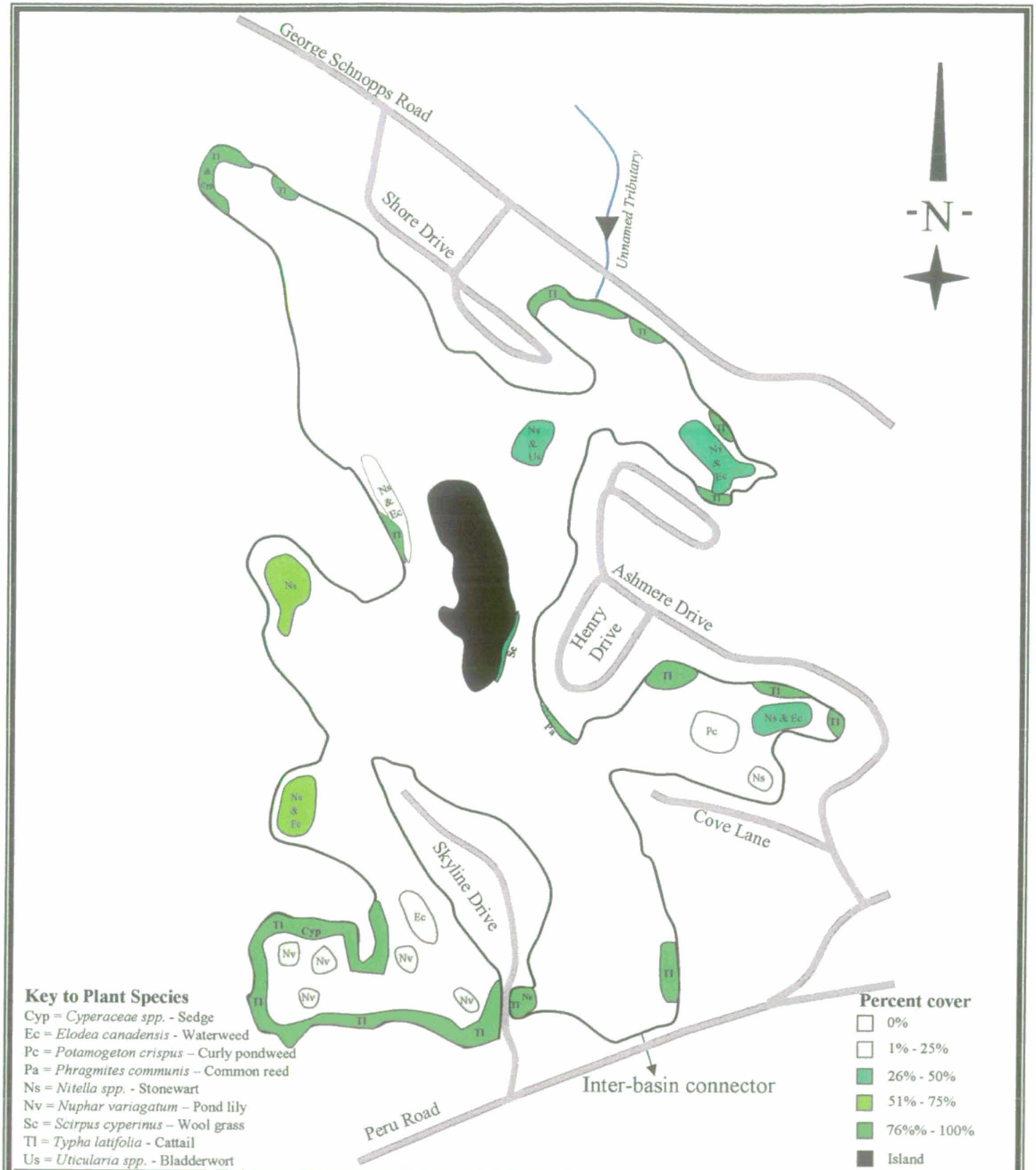
Approximate Scale

Dominant Plant Species Distribution and Percent Cover
Ashmere Lake, South Basin
Hinsdale, Massachusetts
5/20/02

FIGURE NO.
8

PROJECT NO.
H119-000

ESS Group Inc.



0 ft 600 ft

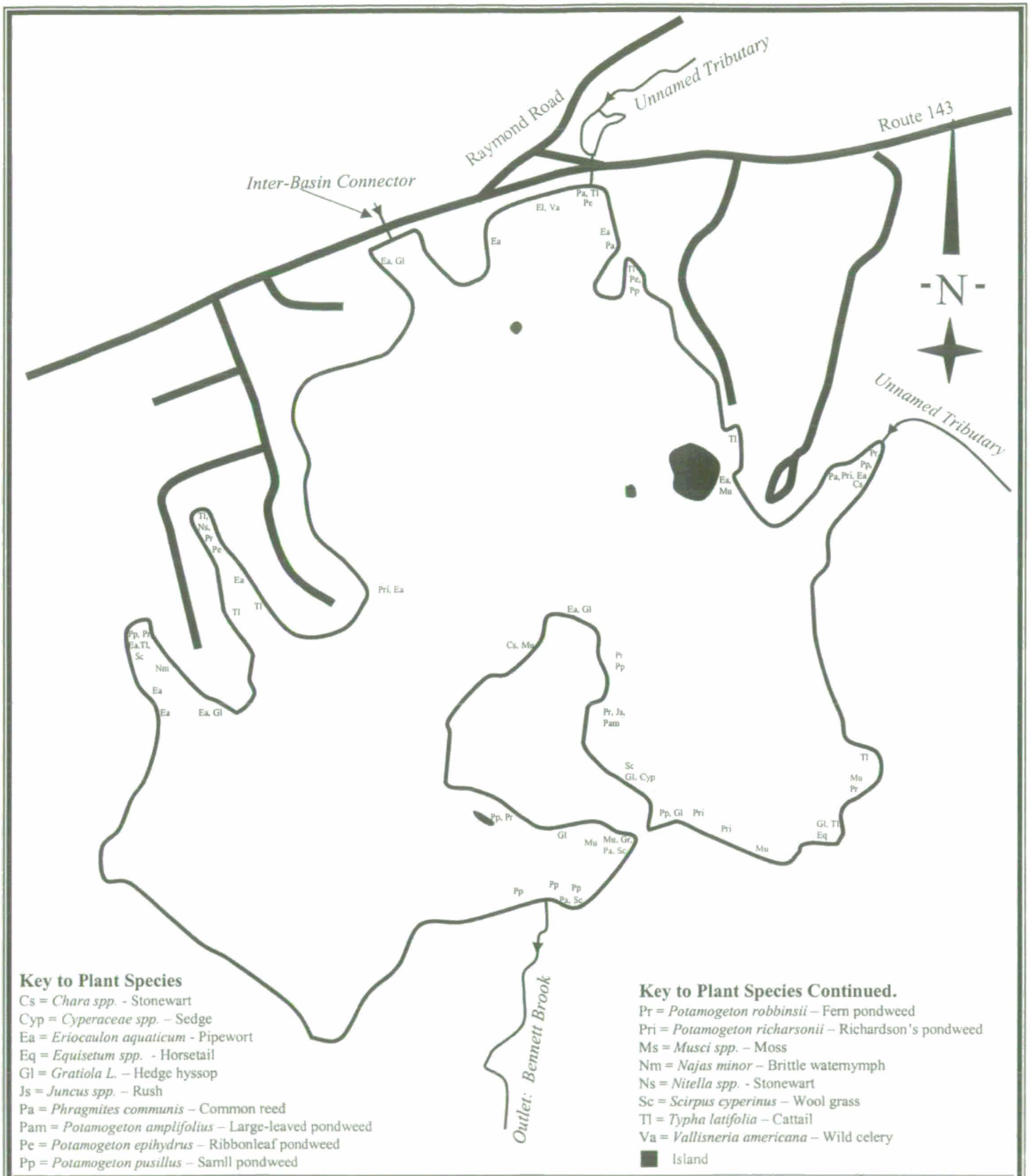
Approximate Scale

Dominant Plant Species Distribution and Percent Cover
Ashmere Lake, North Basin
Hinsdale, Massachusetts
5/20/02

FIGURE NO.
9

PROJECT NO.
H119-000

ESS Group Inc.



0 ft 600 ft

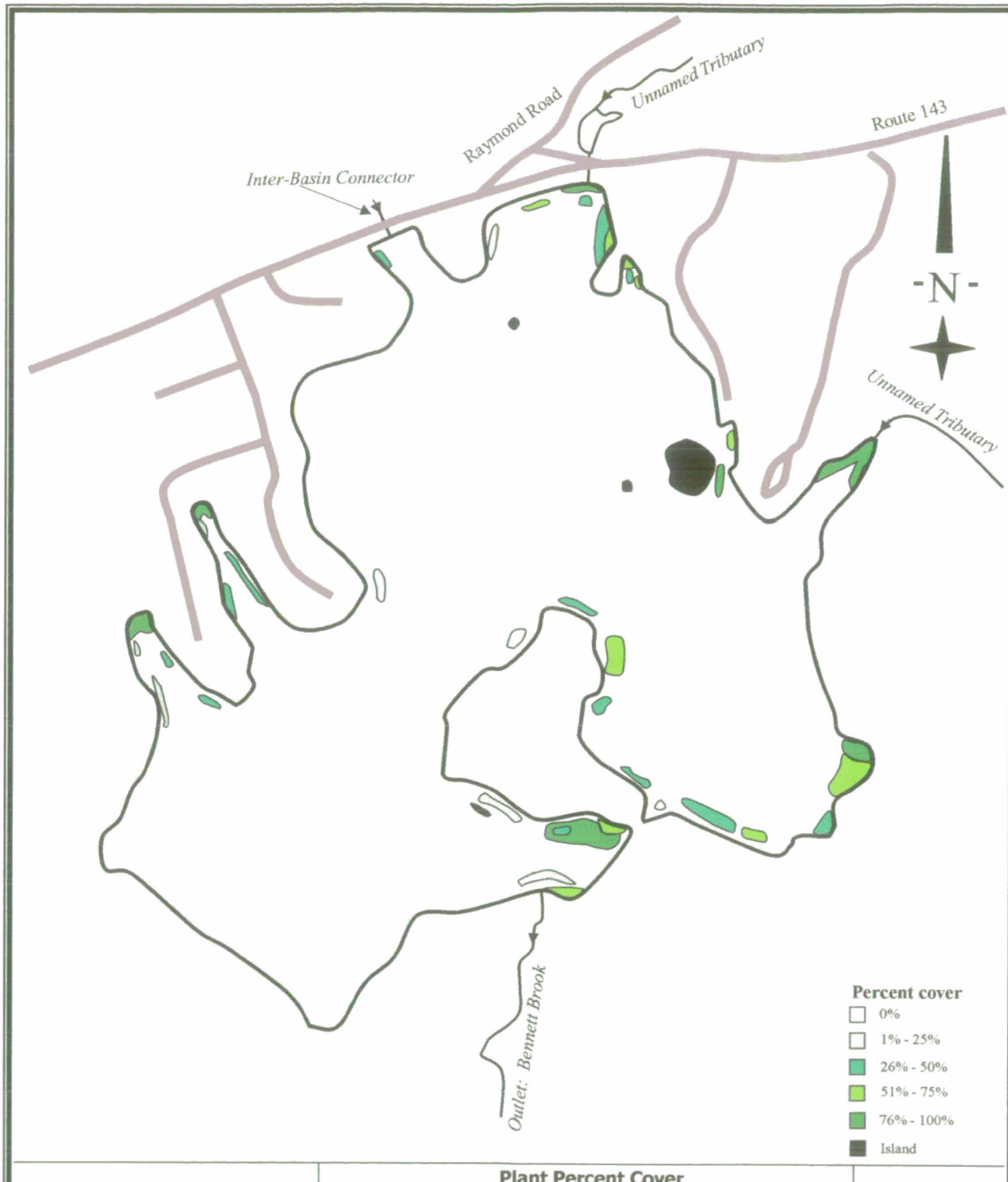
Approximate Scale

Dominant Plant Species
Ashmere Lake, South Basin
Hinsdale, Massachusetts
8/26/02

FIGURE NO.
10

PROJECT NO
H119-000

ESS Group Inc.

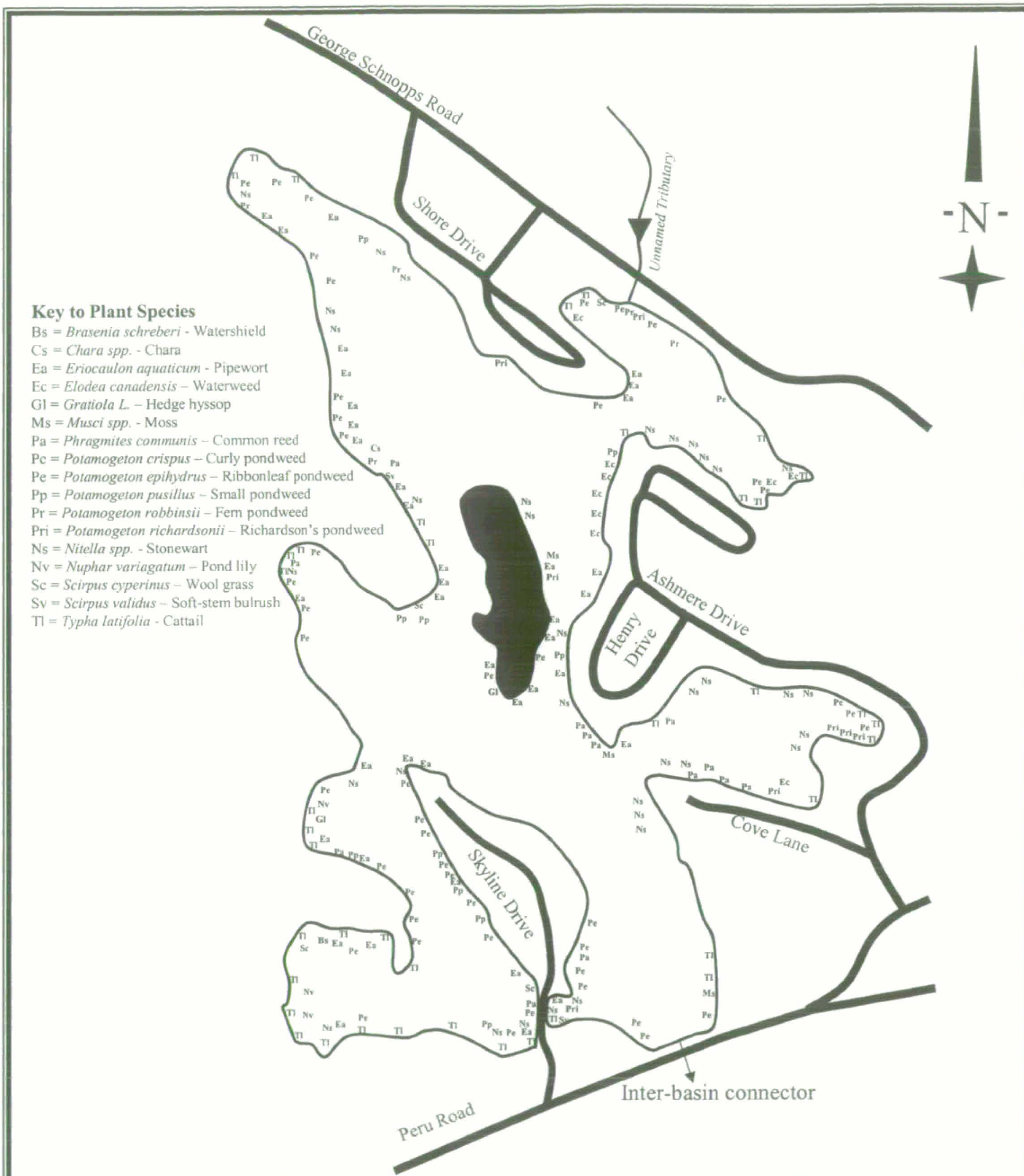


Plant Percent Cover
Ashmere Lake, South Basin
Hinsdale, Massachusetts
8/26/02

FIGURE NO.
11

PROJECT NO.
H119-000

ESS Group Inc.



0 ft — 600 ft Approximate Scale	**Dominant Plant Species** **Ashmere Lake, North Basin** **Hinsdale, Massachusetts** **8/26/02**	FIGURE NO. 12 PROJECT NO. H119-000

ESS Group Inc.

0 ft 600 ft

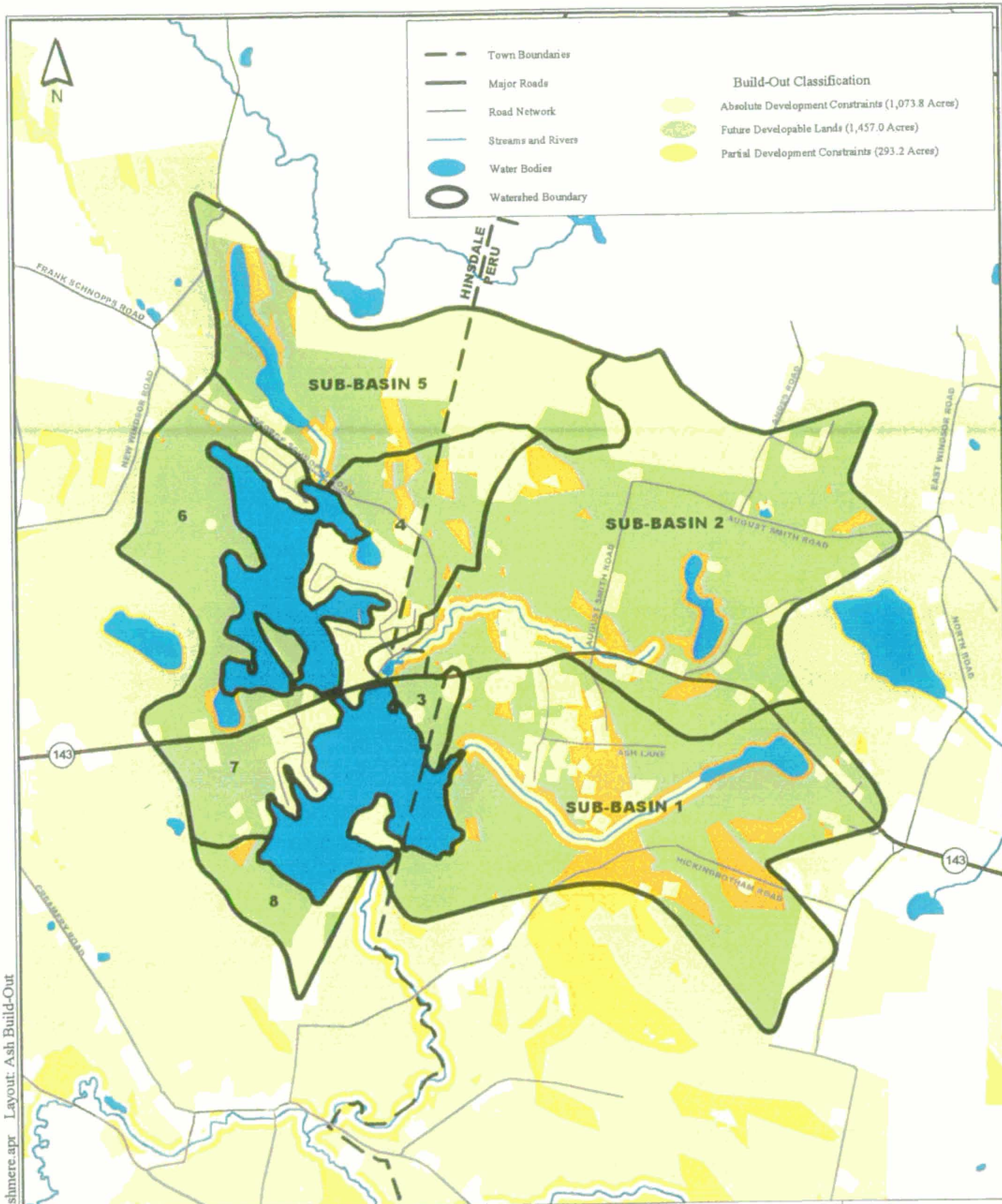
Approximate Scale

Plant Percent Cover
Ashmere Lake, North Basin
Hinsdale, Massachusetts
8/26/02

FIGURE NO.
13

PROJECT NO.
H119-000

ESS Group Inc.



Date: 1/2/03
Location: G:\H119\ESS-Ashmere.apr Layout: Ash Build-Out

Build-Out Land Use Classification
of the Ashmere Lake Watershed

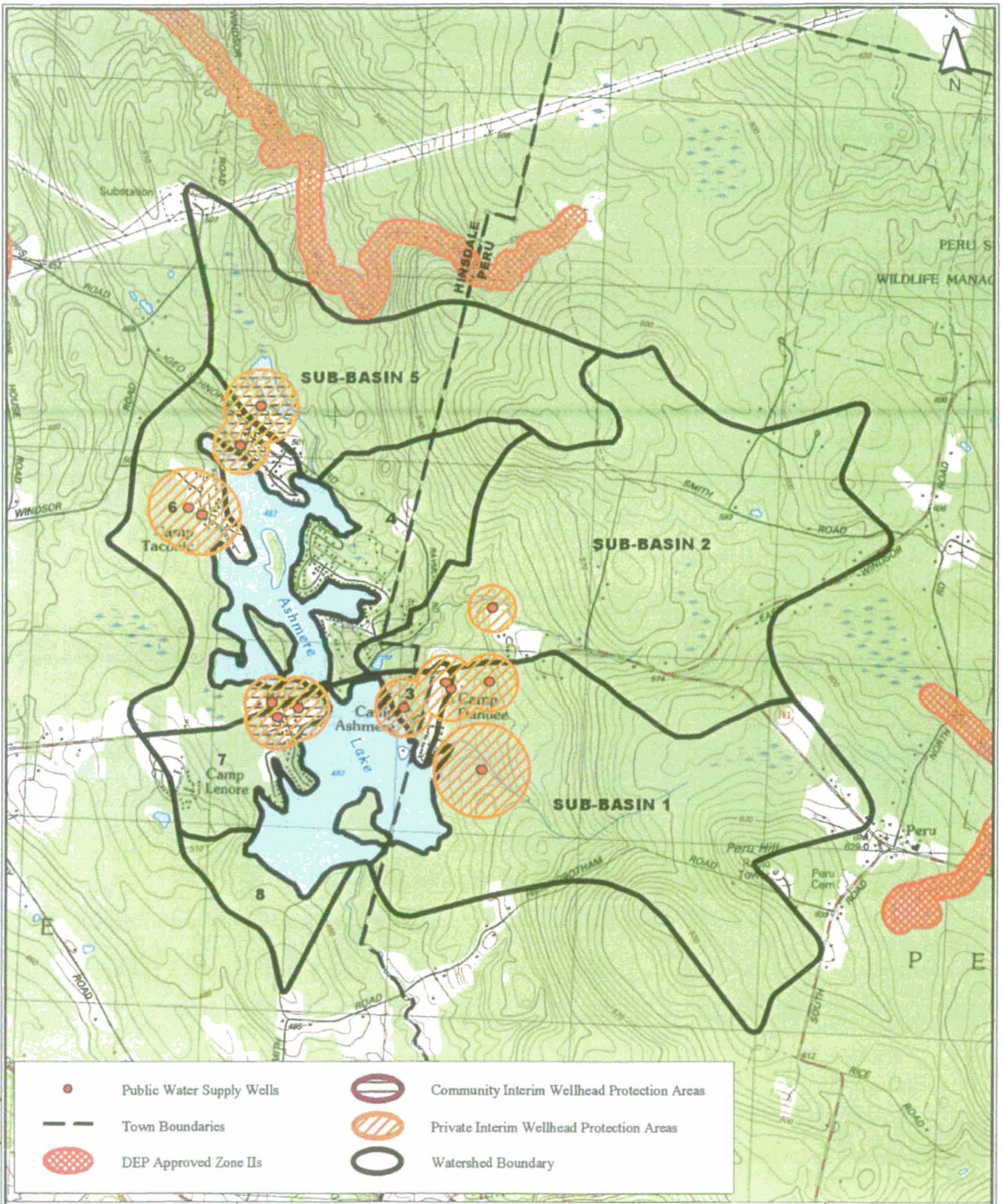
Source: 1) MassGIS, Land Use, 1999 2) EOEA, Buildout Land Use, 2002
3) ESS, Ashmere Watershed Delineation, 2002

Scale: 1" = 2,500'

Ashmere Lake Diagnostic and Feasibility Study Plan

FIGURE NO.
14
Sheet 1 of 1
Project No.
H119-000

ESS



Water Resources of the Ashmere Lake Watershed

Source: 1) MassGIS, DEP Approved Zone IIs, 2002
2) ESS, Ashmere Watershed Delineation, 2002 3) MassGIS, USGS DRG, 1988
4) MassGIS, Public Water Supply Wells

Scale: 1" = 2,500'

Ashmere Lake Diagnostic and Feasibility Study Plan

FIGURE NO.
15
Sheet 1 of 1
Project No.
H119-000

Date: 1/2/03
Location: G:\H119\ESS-Ashmere.apr Layout: Ash Water Resources

ESS

Figure 16. Average Total Phosphorus (mg/L) Levels at Ashmere Lake, 2002.

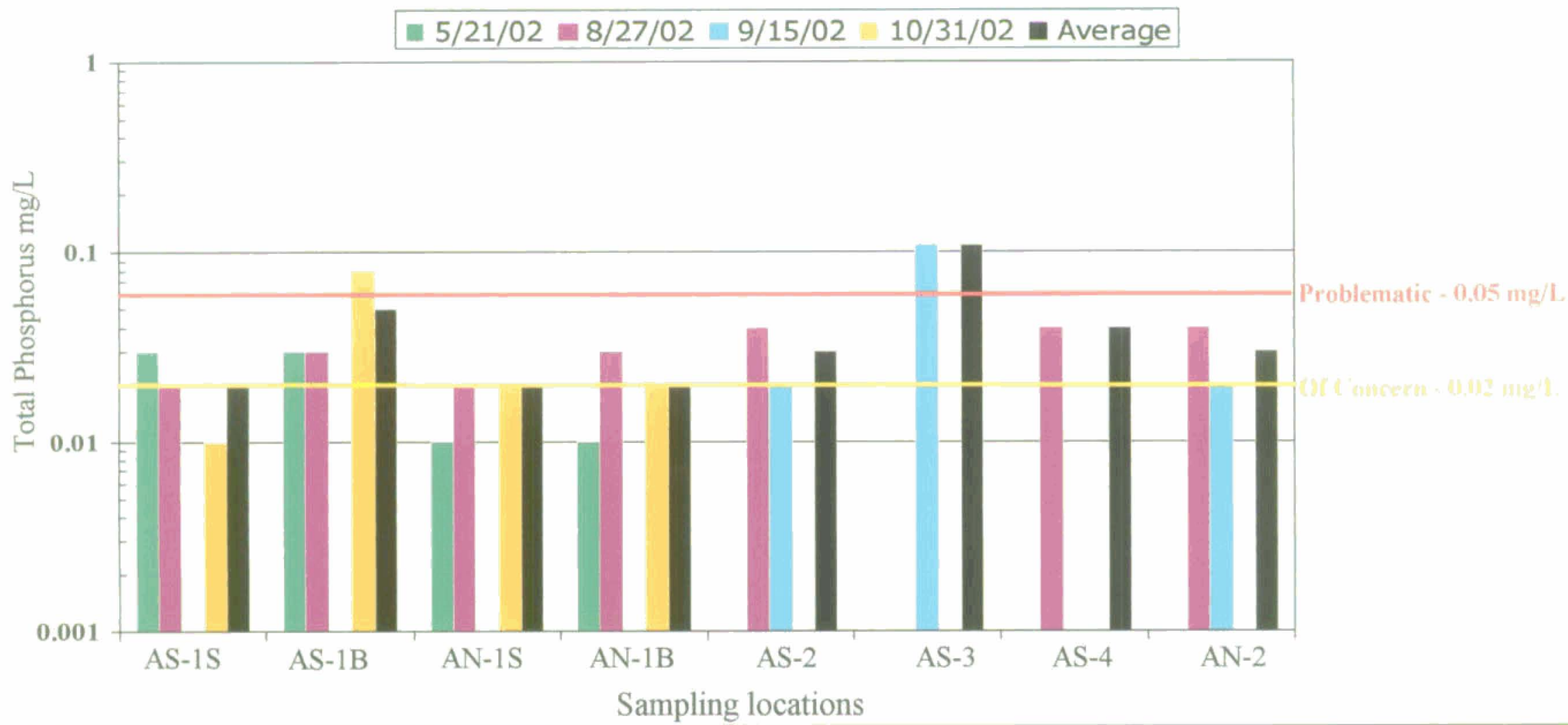


Figure 17. Relationship between Total Phosphorus and Water Clarity, Ashmere Lake.
Average of in-lake surface sampling locations (AS-1S & AN-1S).

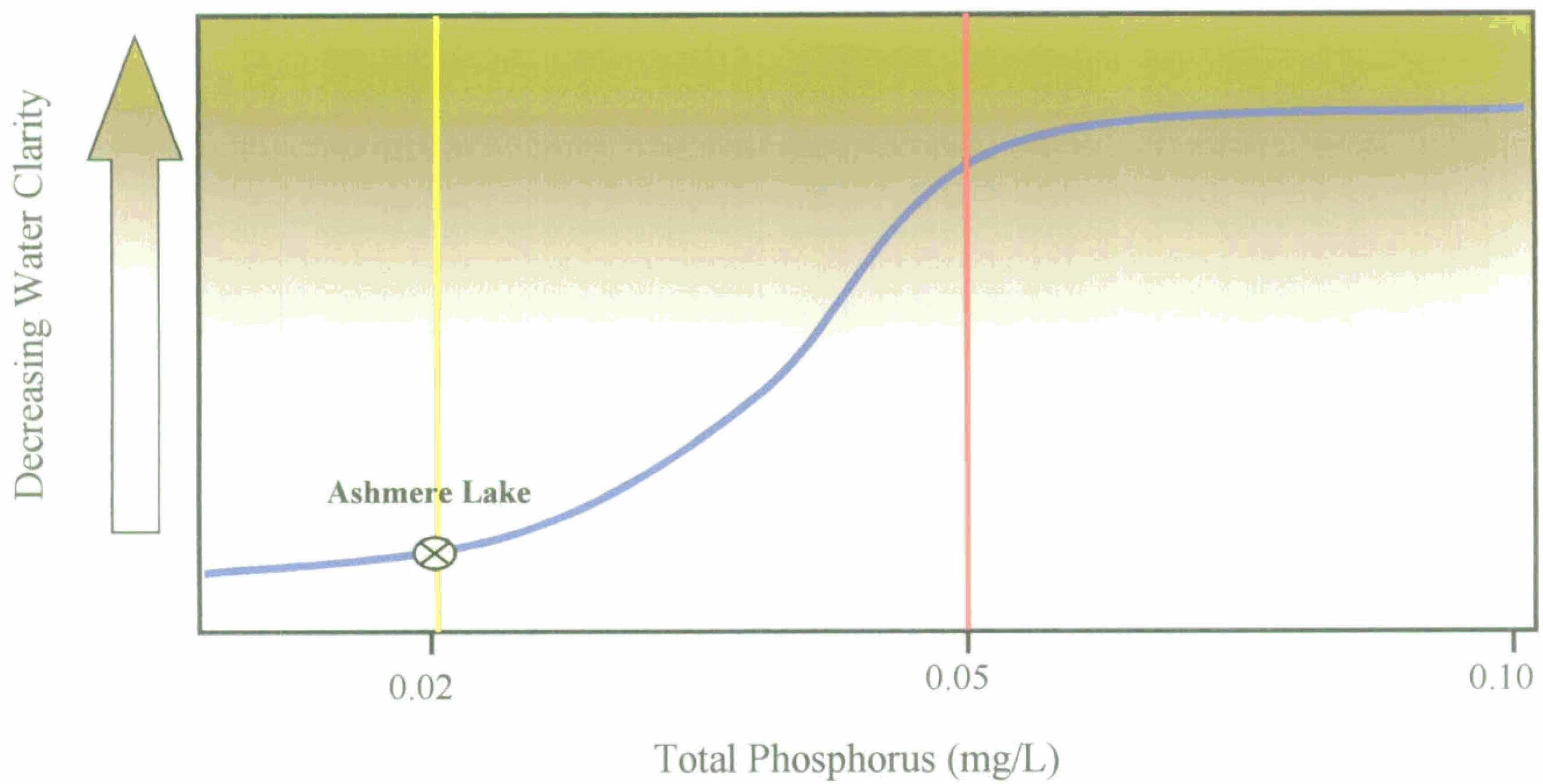


Figure 18. Average Total Nitrogen (mg/L) Levels at Ashmere Lake, 2002.

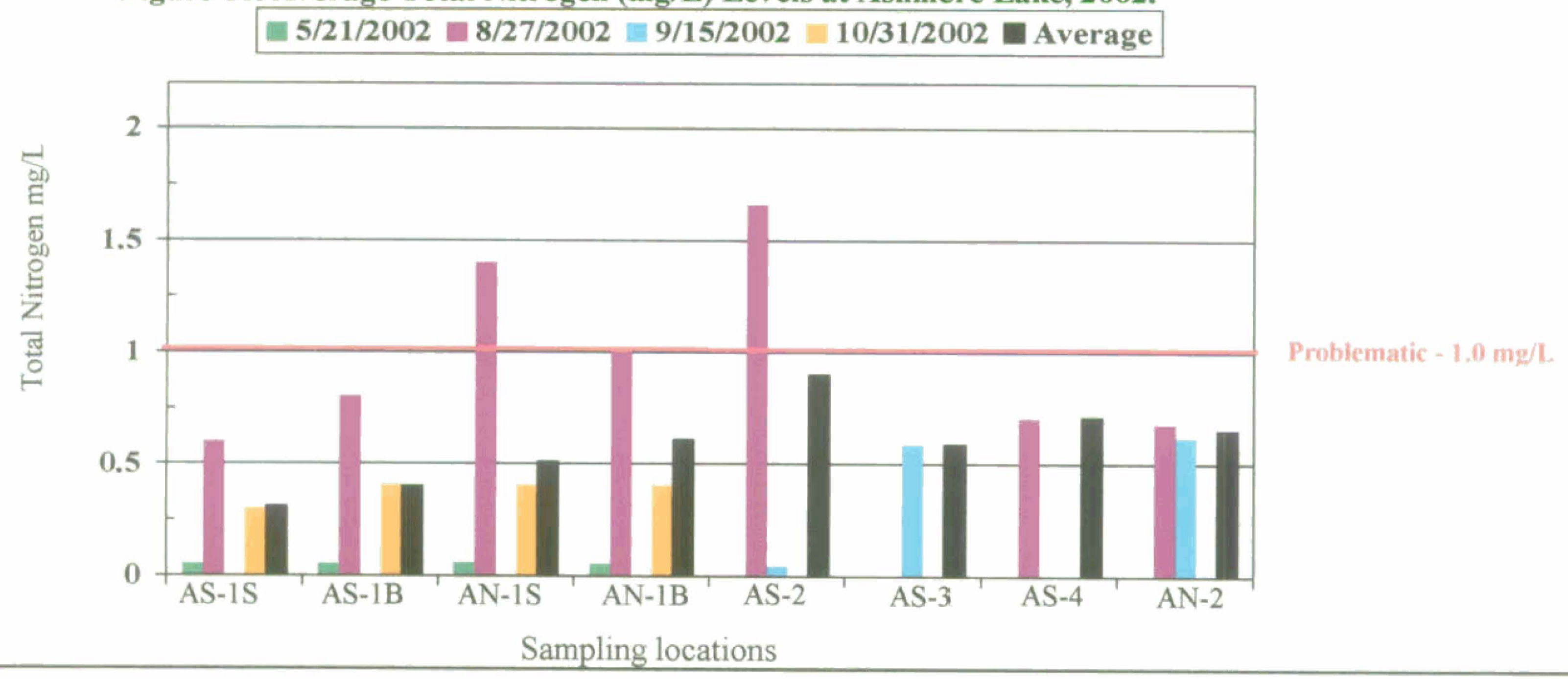
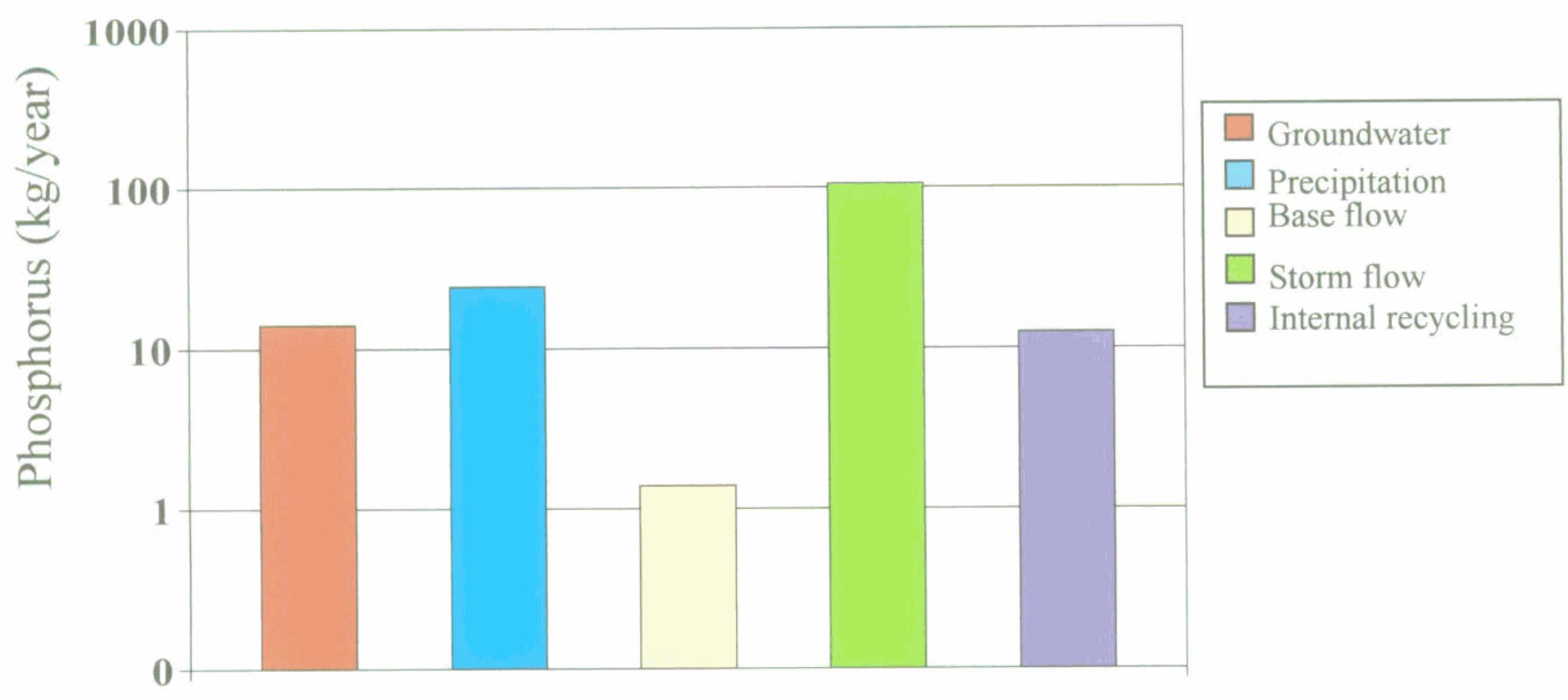
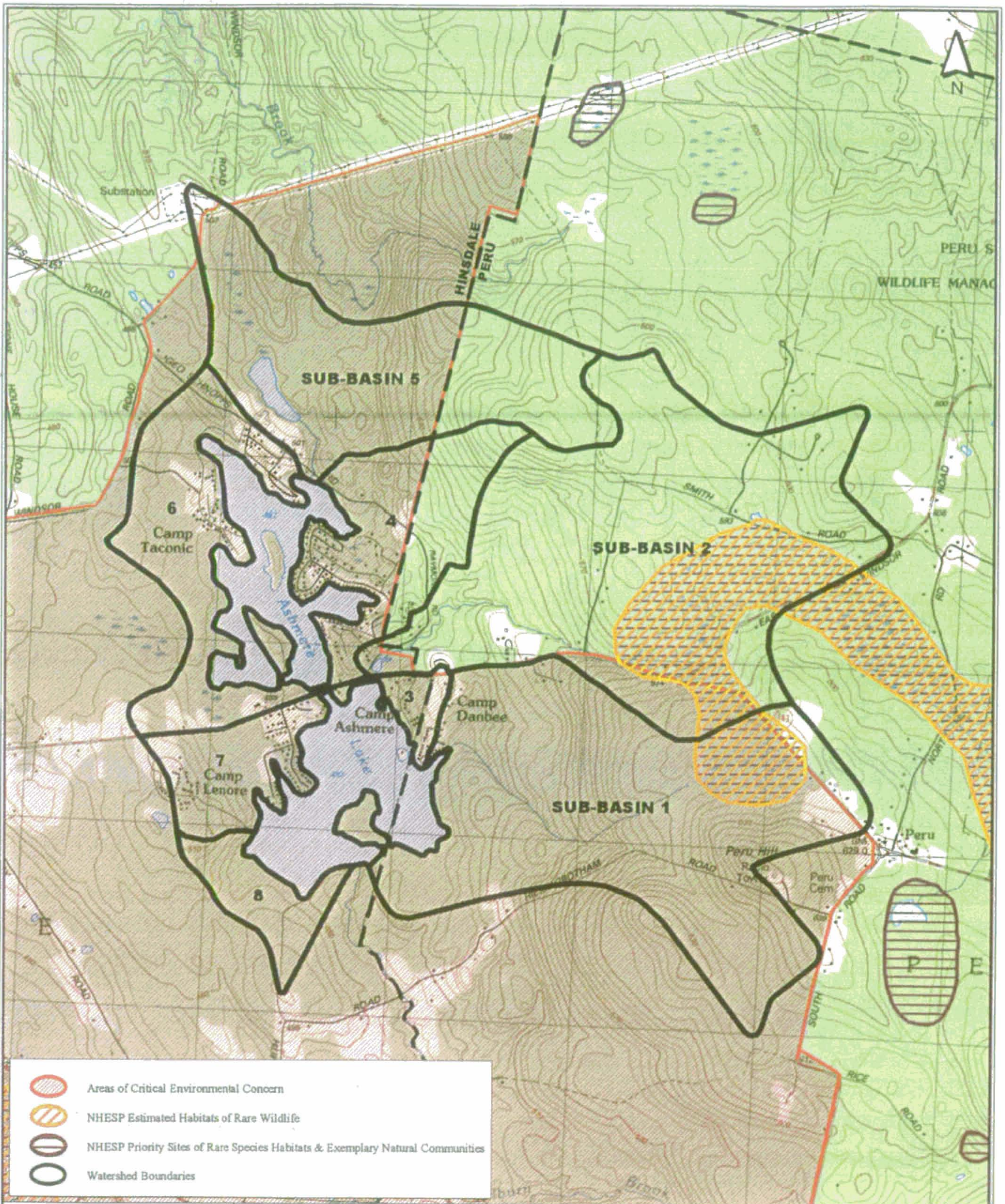


Figure 19. Annual Phosphorus load (kg/yr) for Ashmere Lake listed by source.





Date: 1/2/03
Location: G:\H119\ESS-Ashmere.apr Layout: Ash NHESP

Natural Heritage Endangered Species Classification and Area of Critical Environmental Concern, Ashmere Lake Watershed

Source: 1) MassGIS, NHESP Datalayers, 1999-2001 2) ESS, Ashmere Watershed Delineation, 2002 3) MassGIS, USGS DRG, 1988 4) MassGIS, Areas of Env. Concern, 2000

Scale: 1" = 2,500'

Ashmere Lake Diagnostic and Feasibility Study Plan

FIGURE NO.
20
Sheet 1 of 1
Project No.
H119-000

ESS

APPENDIX A

Division of Fisheries and Wildlife Correspondence – NHESP File: 02-10122

Commonwealth of Massachusetts

Division of Fisheries & Wildlife

Wayne F. MacCallum, *Director*

February 28, 2002

George Landman
Environmental Science Services, Inc.
888 Worcester Street, Suite 240
Wellesley, MA 02482

Re: Ashmere Lake
Hinsdale, MA
NHESP File: 02-10122

Dear Mr. Landman,

Thank you for contacting the Natural Heritage and Endangered Species Program for information regarding state-protected rare species in the vicinity of the above referenced site. I have reviewed the site and would like to offer the following comments.

Our database indicates that the Wood Turtle (*Clemmys insculpta*), a species of special concern, is known to occur in the vicinity of the site. This species is protected under the Massachusetts Endangered Species Act (M.G.L. c. 131A) and its implementing regulations (321 CMR 10.00) as well as the state's Wetlands Protection Act (M.G.L. c. 131, s. 40) and its implementing regulations (310 CMR 10.00). Fact sheets for this species can be found on our website at www.state.ma.us/dfwele/dfw.

This evaluation is based on the most recent information available in the Natural Heritage database, which is constantly being expanded and updated through ongoing research and inventory. Should your site plans change, or new rare species information become available, this evaluation may be reconsidered.

Please do not hesitate to call me at (508)792-7270 x154 if you have any questions.

Sincerely,

Christine Vaccaro

Christine Vaccaro
Environmental Review Assistant

Natural Heritage & Endangered Species Program
Route 135, Westborough, MA 01581 **Tel:** (508) 792-7270 x 200 • **Fax:** (508) 792-7821
An Agency of the Department of Fisheries, Wildlife & Environmental Law Enforcement
http:/www.state.ma.us/dfwele/dfw/nhesp

Natural Heritage &
Endangered Species
Program

Commonwealth of Massachusetts
Division of Fisheries & Wildlife
Route 135
Westborough, MA 01581
(508) 792-7270

MASSACHUSETTS SPECIES OF SPECIAL CONCERN

Wood Turtle
(Clemmys insculpta)

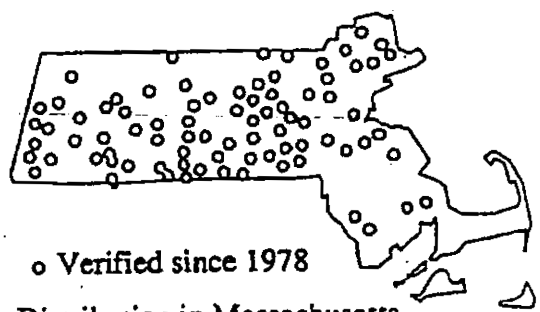
DeGraaf, Richard M. and Rudis, Deborah D. Amphibians and Reptiles of New England. Amherst, Massachusetts: The University of Massachusetts, 1983.

DESCRIPTION: The Wood Turtle is one of the most terrestrial of North American turtles. It is a medium sized turtle and the largest member of its genus, ranging from 12-23 cm (5-9 in) in length. The Wood Turtle is so named because the roundish segments of its upper shell (carapace) resemble a wood-grained cross-section of a branch complete with growth rings. The carapace is characteristically rough and is sculptured with grooves and ridges that rise upward to form individual pyramids. The raised pyramid-like shields, prominent central keel, and slight upward flare of the pointed posterior marginals give this turtle its unique shape. It is this sculptured appearance that has earned the Wood Turtle its species name insulpta.

The carapace is brown, often with yellow streaks radiating from protruding black flecked centers. The undershell (plastron) is bone yellow with an irregular black blotch on the outside posterior corner of each scute (plate-like scale). The head, top of the neck and tail, and the outer scales of the legs and the claws are black. The undersides of the neck and legs are orange or red thus giving rise to the vernacular name "redlegs"; used during the early part of the 20th century when these turtles were sold as food. The legs are clad with thick protective scutes, particularly on the male. The sides of the head are arched downward, and this trapezoid shape, along with moist dark eyes, gives the Wood Turtle a sad look.

Males can be distinguished from females by their longer, thicker tail, a concave plastron with a deeply notched rear margin, and prominent scales on the front of the forelegs. Males are generally larger than females. Young are a gray brown with no red or orange color, the shell is keelless, and the tail as long as the carapace.

Range of the Wood Turtle



Distribution in Massachusetts

SIMILAR SPECIES IN MASSACHUSETTS: The habitat of the Eastern Box Turtle (Terrapene carolina) and the Blanding's Turtle (Emydoidea blandingi) may overlap that of the Wood Turtle, but neither has the Wood Turtle's pyramidal shell segments. Unlike the Wood Turtle, the Box and Blanding's Turtle have hinged plastrons into which they can withdraw or partially withdraw if threatened. The Northern Diamondback Terrapin (Malaclemmys terrapin) has a shell similar to that of the Wood Turtle, but its skin is grey and it lives only near saltwater (which the Wood Turtle avoids).

RANGE: The Wood Turtle can be found throughout New England, north to Nova Scotia, west to eastern Minnesota, and south to northern Virginia.

HABITAT IN MASSACHUSETTS: The preferred habitat of the Wood Turtle is riparian areas. Slower moving streams are favored, with sandy bottoms and heavily vegetated stream banks. The bottoms and muddy banks provide hibernating sites for overwintering, and sandy or gravelly banks are used for nesting. The Wood Turtle spends most of the spring and summer in meadows and upland forests and returns to the streams in late summer or early fall to mate and overwinter. During the day, it is often seen in woodlands, hayfields, and along roadsides adjacent to streams.

LIFECYCLE/BEHAVIOR: The Wood Turtle has a way of life that makes it at home either in or out of the water. Next to the box turtle, it our most terrestrial species; possessing exceptional intelligence and a unique climbing ability. In southern or coastal areas of its range, the Wood Turtle becomes active in late March, but elsewhere it is usually mid-to late April or even May before it is sighted. Upon coming out of hibernation, the Wood Turtle begins its terrestrial activity by moving up on the river bank to bask in the sun. This species is diurnal (active by day), foraging in midday and sunning on logs in streams or along muddy river banks in the early morning and late afternoon. It is this habit of basking on the muddy river banks which has given the Wood Turtle the popular name "mud turtle." The Wood Turtle leads a rather solitary life and rarely will one find more than a single wood turtle at a time.

Wood Turtles remain relatively close to their streams and rivers, rarely getting more than a few hundred meters away from the banks. They have relatively linear home ranges that tend to run up to 1.6 km (a mile) in length. Males have been observed exhibiting aggressive behavior such as chasing, biting, and butting both during the mating season and at other times. This behavior appears to be more about social status than territorial ownership. Typically, one or both males make an "open mouth" gesture, snapping open and closing the mouth near the other's head, rarely resulting in actual biting. Prolonged interactions are often accompanied by audible hissing from one or both animals. Females tend to be more peaceable; interactions seldom involve more than a simple nose touching and departure.

The Wood Turtle becomes sexually active in the spring when the water temperature reaches 15 C (59 F). This species has a courtship ritual involving a "dance" that takes place for several hours prior to mating. The dance involves the male and female approaching each other slowly with necks extended and their heads up. Before they actually touch noses, they lower their heads and swing them from side to side. Courting adults may produce a very subdued whistle that is rarely heard by observers. These courtship behaviors occur on land, yet actual mating appears to take place only in the water.

The female Wood Turtle wanders in search of a nest site in late May or mid-June. She often digs her nest during or just after a slight rainstorm. Nest-digging can begin relatively early in the morning or late in the afternoon. The female Wood Turtle generally digs several six-inch holes before deciding on a definite nest site. The function of this may be to confuse nest predators that are searching for buried eggs. The female digs her nest using her hind feet only. The nest is a six-inch hole dug in sandy or soft loam sand areas, including gravel banks, roadsides, fields and meadows. It is generally high enough out of the river's floodplain to avoid inundation by fluctuating water levels. A clutch of 4 to 12 (generally 7 to 9) eggs are deposited inside the nest, covered with sand, and left to incubate for ten to sixteen weeks in the warmth of the sun. The eggs are white, smooth, and elliptical measuring 3.4 cm (1.4 in) in length and 2.4 cm (0.95 in) in width. From beginning to end, the nesting process may take three or four hours. Wood turtles lay only one clutch per year.

Hatchlings may leave the nest immediately or may remain in the nest over the winter and emerge in early spring. The young turtles are miniatures of the adults but have long tails. Once out of the nest, the young seek out the deep portions of streams where they virtually disappear until they become sexually mature at the age of twelve to fifteen years. The life span of the adult Wood Turtle is easily 50 years and may frequently reach 80 years of age.

The Wood Turtle is omnivorous and an unusual member of its family in that it exploits both aquatic and terrestrial food sources. Its diet consists of plant material from algae and grasses to berries and animal matter including insects, fish, earthworms, tadpoles, and carrion from many kinds of animals. The Wood Turtle often exhibits an unusual feeding behavior referred to as "stomping." In its search for food, this species will stomp on the ground alternating its front feet, creating vibrations in the ground resembling rainfall. Earthworms, responding as though to rainfall, rise to the ground's surface to keep from drowning. Instead of rain, the earthworm is met by the Wood Turtle, and is promptly devoured.

In October, the Wood Turtle returns to the deep channels of streams for the winter. With head and limbs tucked in under the carapace and tail extended, it lies next to submerged anchored stumps and logs on the sides of the stream away from the main current. It also may hibernate in large groups in community burrows which may include muddy banks, stream bottoms, deep pools, decaying forest vegetation, and abandoned muskrat burrows.

POPULATION STATUS IN MASSACHUSETTS: The Wood Turtle is listed as a "Species of Special Concern" in Massachusetts. Since 1978, there have only been 153 sightings reported to the Massachusetts Natural Heritage and Endangered Species Program in 97 different locations across the state. It should be noted that these sightings are not indicative of populations but may be road crossing sightings or single individuals. Population decline of this species has been caused by pollution of streams, development of wooded streambanks, the unnatural increase in predation due to human presence, highway casualties, and extensive commercial and incidental collection of specimens for pets. Wood turtles are also killed during hay-mowing operations.

MANAGEMENT RECOMMENDATIONS: In order to ensure the longevity of the Wood Turtle as a species, the following recommendations regarding specific habitat preservation are suggested. In reference to timber harvesting, the primary concerns are the preservation of the local environments near streams and the prevention of siltation. Establishment of a minimum 50-foot no-cut buffer zone along the streams and rivers; the implementation of erosion controls that may be appropriate for the specific site (particularly recommended in steep slope situations); and utilization of portable or temporary bridges rather than fording to cross streams are strongly suggested. Selective rather than regeneration cutting within 50-300 feet of streams known to be inhabited by Wood Turtles may also help to maintain suitable habitat for this species. Wood Turtles often use clearings and meadows and would probably benefit from slash piles. Avoid use of heavy equipment within 50 feet of streams and minimize use 50-100 feet from streams.

Enforcement of the Massachusetts Endangered Species Act is also needed to protect this species from the pet trades and biological supply. In a five-year study in Pennsylvania by John H. Kaufmann, research showed that though this species is long lived, population data may be misleading as the individuals sighted were older turtles, and not reproducing at a sustainable population rate. It is estimated that there may be as much as a 99% mortality rate from hatching to adulthood (Robakiewicz). In small populations such as those in Massachusetts, such a high mortality rate could prove disastrous.

In summary, the Wood Turtle populations and their habitats need protection This species is attracted to tangles of vegetation, though the specific type of plant matter appears to be unimportant. Not mowing within 100 meters (100 yds) of stream banks encourages woody vegetation such as gray dogwood to flourish. In upland sites, fallen trees should be left. Meadows dense with many layers of vegetation are preferred by Wood Turtles over well-mown lawns. Encourage brushy tangles and get local gardeners to allow a few tomatoes and strawberries to run rampant so that turtles can harvest some of the fruit. Protecting riverine corridors is important to prevent fragmentation of habitats and populations. In addition, protecting wetlands and water quality is critical as these turtles show a tendency to return to the same stream each year, and they are sensitive to pollution (Robakiewicz).

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Partially funded by a grant from DEM Forest Stewardship Program

APPENDIX B

Hydrologic and Nutrient Budget Calculations

Annual Hydrologic Loading for Lake Ashmere, 2002

Lake Ashmere - HYDROLOGIC ASSESSMENT

Watershed for Lake Ashmere =		**2824.0** acres		123015182.4 SF		4.4125625 sq mi
Lake Area		**256.8** acres		11184901.2 SF		1039111.3 meters2
Area of Watershed - Lake Area		2567.3 acres		111830281.2 SF		
Lake Circumference		**42000** feet				
Lake Volume		**119,324,806** cubic feet				3378902.6 meters3
Area influenced by seepage		2100000 ft2	=	195096.3 m2		
Groundwater (data)		**10** l/m2/day=		0.353 cf/m2/day		
			=	68868.994 cf/day		
			=	0.797 cfs		
Annual PPT/yr		**44.8** inches				
Annual PPT - ET	30.02	2.50 ft/yr		0.887 cfs		
Runoff (watershed)	**22**	1.83 ft/yr		6.501 cfs		
Base Flow (Streams) as measured during dry weather				**0.039** cfs		

	Ground	PPT	Surfacewater	Total
Dry	0.797	0.000	0.039	0.836
Wet	0.000	0.887	6.501	7.388
Total	**0.797**	**0.887**	**6.540**	**8.224** cfs
				7344155 m3/yr
				259356366 CubicFt/Yr
				7344155323 L/yr

Estimated range of total input into lake:
(1.5 to 2 cfs/sq mi of watershed) =
6.62 to 8.83 cfs

4536132.4

ASHMERE LAKE - Existing Conditions

In-lake N and P derived from surface depth only

IN-LAKE MODELS FOR PREDICTING PHOSPHORUS LOADS AND CONCENTRATIONS

THE TERMS

SYMBOL	PARAMETER	UNITS	DERIVATION	VALUE
TP	Lake Total Phosphorus Conc.	ppb	From data or model	18.333
L	Phosphorus Load to Lake	g P/m2/yr	From data or model	0.13
TPin	Influent (Inflow) Total Phosphorus	ppb	From data	30
TPout	Effluent (Outlet) Total Phosphorus	ppb	From data	40
I	Inflow	m3/yr	From data	7344155
A	Lake Area	m2	From data	1039111
V	Lake Volume	m3	From data	3378903
Z	Mean Depth	m	Volume/area	3.25
F	Flushing Rate	flushings/yr	Inflow/volume	2.17
S	Suspended Fraction	no units	Effluent TP/Influent TP	1.33
Qs	Areal Water Load	m/yr	Z(F)	7.07
Vs	Settling Velocity	m	Z(S)	4.34
R	Retention Coefficient (from TP)	no units	(TPin-TPout)/TPin	-0.333
Rp	Retention Coefficient (settling rate)	no units	((Vs+13.2)/2)/(((Vs+13.2)/2)+Qs)	0.554
Rlm	Retention Coefficient (flushing rate)	no units	1/(1+F^0.5)	0.404

THE MODELS

NAME	FORMULA	PREDICTION CONC. (ppb)	PREDICTION LOAD (g/m2/yr)
Mass Balance	TP=L/(Z(F))*1000	18	
(minimum load)	L=TP(Z)(F)/1000		0.13
Kirchner-Dillon 1975	TP=L(1-Rp)/(Z(F))*1000	8	
(K-D)	L=TP(Z)(F)/(1-Rp)/1000		0.29
Vollenweider 1975	TP=L/(Z(S+F))*1000	11	
(V)	L=TP(Z)(S+F)/1000		0.21
Reckhow 1977 (General)	TP=L/(11.6+1.2(Z(F)))*1000	25	
(Rg)	L=TP(11.6+1.2(Z(F)))/1000		0.37
Larsen-Mercier 1976	TP=L(1-Rlm)/(Z(F))*1000	11	
(L-M)	L=TP(Z)(F)/(1-Rlm)/1000		0.22
Jones-Bachmann 1976	TP=0.84(L)/(Z(0.65+F))*1000	12	
(J-B)	L=TP(Z)(0.65+F)/0.84/1000		0.20
Average of Model Values		13	
(without mass balance)			0.26
Reckhow 1977 (Anoxic)	TP=L/(0.17(Z)+1.13(Z(F)))*1000	15	
(Ra)	L=TP(0.17(Z)+1.13(Z(F)))/1000		0.16
From Vollenweider 1968			
Permissible Load	Lp=10^(0.501503(log(Z(F)))-1.0018)		0.27
Critical Load	Lc=2(Lp)		0.53

LOAD ANALYSIS

MODEL	ESTIMATED LOAD (kg/yr)	ESTIMATED LOAD (mg/L)
Phosphorus		
Mass Balance (no loss)	135	
Kirchner-Dillon 1975	302	
Vollenweider 1975	217	
Reckhow 1977 (General)	383	
Larsen-Mercier 1976	228	
Jones-Bachmann 1976	208	
Model Average (without mass balance)	267	0.036
Reckhow 1977 (Anoxic)	183	
Permissible Load	276	0.0376
Critical Load	552	0.0751
Nitrogen		
Mass Balance (no loss)	3470	
Bachmann 1980	5171	0.70

PREDICTED WATER CLARITY

PREDICTED CHL AND WATER CLARITY

MODEL	Value
Mean Chlorophyll (ug/L)	
Dillon and Rigler 1974	3.1
Jones and Bachmann 1976	3.6
Oglesby and Schaffner 1978	4.6
Modified Vollenweider 1982	6.8
"Maximum" Chlorophyll (ug/L)	
Modified Vollenweider (TP) 1982	19.5
Vollenweider (CHL) 1982	13.0
Mod. Jones, Rast and Lee 1979	15.7
Secchi Transparency (M)	
Oglesby and Schaffner 1978 (Avg)	3.2
Modified Vollenweider 1982 (Max)	4.7

Permissible Conc.

Critical Conc.

ADDENDUM FOR NITROGEN

SYMBOL	PARAMETER	UNITS	DERIVATION	VALUE
TN	Lake Total Nitrogen Conc.	ppb	From data or model	472.5
L	Nitrogen Load to Lake	g N/m2/yr	From data or model	3.34
C	Coefficient of Attenuation	fraction/yr	2.7183^(0.5541(ln(F))-0.367)	1.065216478

NAME	FORMULA	PREDICTION CONC. (ppb)	PREDICTION LOAD (g/m2/yr)
Mass Balance	TN=L/(Z(F))*1000	472.6	
(minimum load)	L=TN(Z)(F)/1000		3.34
Bachmann 1980	TN=L/(Z(C+F))*1000	317	
	L=TN(Z)(C+F)/1000		4.98