Warner's Pond Watershed Management Plan

Warner's Pond
Concord, Massachusetts

PREPARED FOR:
Town of Concord
Division of Natural Resources
141 Keyes Road
Concord, Massachusetts 01742

PREPARED BY:
ESS Group, Inc.
100 Fifth Avenue, 5th Floor
Waltham, Massachusetts 02451

Supported in part from Concord Community Preservation Act funds

Revised May 25, 2012

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ESS Project No. C574-000

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1.0 INTRODUCTION

ESS Group, Inc. (ESS) has prepared this Watershed Management Plan for Warner's Pond on behalf of the Town of Concord's Division of Natural Resources (DNR) and the Warner's Pond Stewardship Committee (WPSC). This Plan was supported in part from Concord Community Preservation Act funds. The objective of this Watershed Management Plan is to provide the Town of Concord (Town) with a framework that can be used to guide future management decisions related to Warner's Pond.

This Watershed Management Plan provides background information on existing conditions within Warner's Pond and its watershed, collates previous studies and reports, identifies the key environmental issues that are negatively impacting the pond, prioritizes issues for remediation, and offers recommendations for the pond's future management. ESS worked with Aquatic Control Technologies, Inc. (ACT), a plant control company familiar with the pond, to develop realistic cost estimates for several of the in-pond plant control options considered as part of the recommendations.

1.1 Warner's Pond Description and History

Warner's Pond was created in the 1800s by damming Nashoba Brook less than a mile downstream of its confluence with Fort Pond Brook to operate a saw mill, then a pail factory. In 1895, a fire destroyed the factory, and Ralph Warner sold it to the West End Land Company. The dam has since grown and been rebuilt several times for various purposes, including operation of David Loring's Lead Pipe Works from 1819 to 1854 (WPSC, 2011). Most recently, in 2008, the dam was reconstructed due to safety concerns about aging and failing structural components.

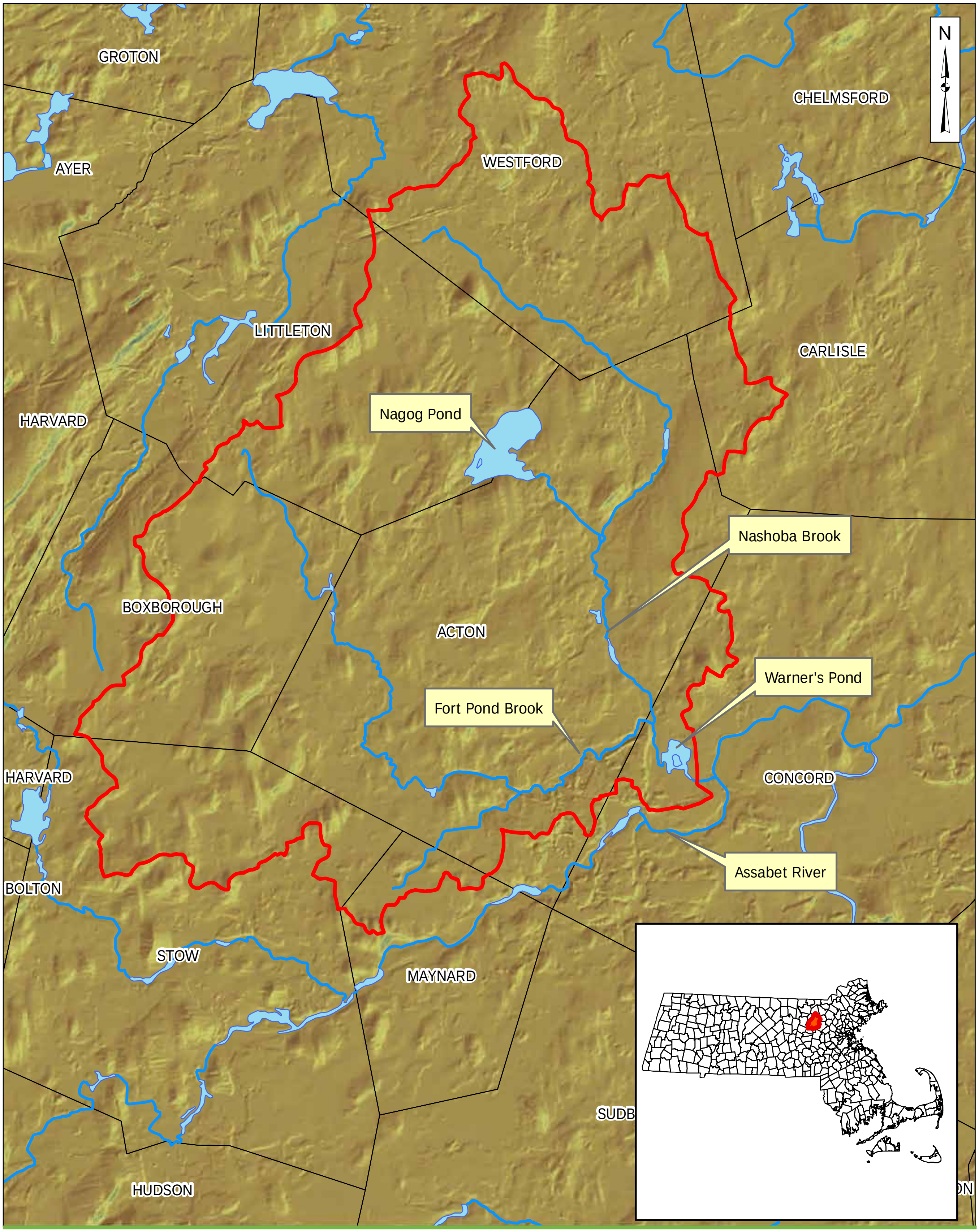
Since the late 1890s, Warner's Pond has been a significant Town natural resource and popular recreation area. Its ecosystem has provided habitat for numerous species of aquatic plants and animals and this continues today.

However, since at least the 1980s, the pond has undergone eutrophication (a process where waterbodies receiving excessive nutrients experience excessive plant growth) and sediment deposition, leading to a decreased use by canoeists, kayakers, and fishermen, as well as diminished ecological value from the establishment of several non-native invasive plants, Exotic, invasive species of plants dominate the pond today, and open water areas are dwindling, Sediments have increased so that some areas are impassable by kayakers and canoeists.

Warner's Pond is relatively shallow and occupies approximately 48 acres (54 acres, if islands are included) fully within the town of Concord, Massachusetts. The pond is fed by an approximately 47-square-mile watershed (Figure 1), which is located primarily outside of Concord and includes portions of the towns of Acton, Boxborough, Carlisle, Littleton, Stow and Westford (Figure 1). The two tributaries that flow into the pond, Nashoba Brook and Fort Pond Brook, merge just upstream of the pond inlet on the western shore (Figure 2). Water discharges into the pond through a broad delta of emergent wetlands on the western shore. Given the size of the pond's watershed and the volume of water contained in the streams feeding the pond, the water entering the pond flushes through the pond relatively rapidly. Water leaves the pond via its outlet at the southeast corner of the pond (Figure 2).

Another consequence of the large watershed to pond ratio is that much of Warner's Pond has filled in with sediments that have made the pond shallower and more susceptible to excessive weed growth, particularly from highly invasive exotic plant species such as variable watermilfoil (*Myriophyllum heterophyllum*), fanwort (*Cabomba caroliniana*), and water chestnut (*Trapa natans*). Sediment and excess nutrients are transported to the pond from its tributaries as well as from the nine stormwater outfalls that discharge directly to the pond or adjacent wetlands around its perimeter. The sediment accumulation, excess nutrients in the water column, and dense growths of exotic aquatic plants have led to a seriously degraded condition in the pond over time. These degraded conditions have diminished the ecological value of the pond with regard to its ability to support fish and wildlife populations typical of

Location: G:/GIS-Projects/Warners-Pond-Concord/00-mxd/Report/watershed.mxd



WARNER'S POND WATERSHED MANAGEMENT PLAN

Warner's Pond Watershed

environmental consulting
& engineering services

Scale: 1" = 8,500' (1.6 miles)

0 8,500 Feet

Watershed boundary

Source: 1) MassGIS, Shaded Relief, 2005
2) MassGIS, Hydrology, 2000

Figure
1

Location: G:/GIS-Projects/Warners-Pond/00-mxd/Report/Locus.mxd

WARNER'S POND WATERSHED MANAGEMENT PLAN

Warner's Pond Locus

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Scale: 1" = 1000'

0 1,000 Feet

Source: 1) MassGIS, USGS Topo Quads

Figure 2

healthier open water habitats. The poor water quality and increased weed growth are also impairing the pond's ability to serve the community with regard to recreational opportunities.

Over the last 13 years, some components of Warner's Pond have been evaluated in an effort to rehabilitate the pond from the effects of excessive sediment and nutrient loading as well as invasive plant growth. This Watershed Management Plan builds on previous studies of Warner's Pond and provides further detail on basic characteristics, the impairments to the pond, and prioritized short- and long-term management recommendations to improve water quality, biological condition, and recreational opportunities.

In 1999, ACT conducted a survey of aquatic plants as well as water and sediment depth and quality (ACT, 1999). The major conclusion from the survey was that excessive sedimentation had facilitated nuisance-level aquatic macrophyte growth in Warner's Pond. In particular, the report noted the establishment of exotic invasive and aggressive native macrophyte beds, particularly at access points in the pond.

Concurrent with the ACT evaluation of Warner's Pond in 1999, New England Environmental, Inc. (NEE) conducted an evaluation of habitat and wildlife use of Warner's Pond. NEE documented that the pond once supported a rainbow trout population, but lost this species as the pond warmed and became a warm-water fishery. No rare or endangered flora or fauna were identified at Warner's Pond during NEE's survey or in any of the documents NEE evaluated from previous surveys. NEE recommended a major restoration effort to improve water quality and habitat in Warner's Pond.

Four years later, ACT conducted a similar study to assess change in Warner's Pond and documented the spread of invasive macrophyte beds throughout the pond (ACT, 2003 and 2004). As a result, aquatic weed harvesting and hydro-raking were implemented to manage water chestnut and fanwort. Following this activity, it was determined that the aquatic weed harvester, or hydrorake, should not be used where variable watermilfoil was also present due to its ability to spread by fragmentation. Volunteer efforts to hand-harvest water chestnut (and thus prevent spreading species that propagate through fragmentation) began in 2004 and continue into the present day.

In June 2007, Geosyntec conducted water quality sampling for the Town in Warner's Pond (Geosyntec, 2007). The motivation for this evaluation was to evaluate two potential sources of pollution inputs to the pond: 1) the area surrounding a 30-inch storm drain outfall to Warner's Pond and 2) water in the vicinity of the old Town dump along Laws Brook Road in West Concord. This study was not able to confirm either source as a definite cause of water quality impairment in Warner's Pond.

Currently, Warner's Pond continues to suffer from high sedimentation and nutrient loading rates, which have accelerated the natural process of pond eutrophication. The excessive growth of exotic and nuisance macrophyte species at the pond impairs recreational uses and both benefits from and contributes to the filling of the pond with sediment in the long term.

2.0 METHODS AND APPROACH

The studies and data collection supporting the current analysis of the Warner's Pond system were conducted between January and December 2011 and included a review of existing data and reports, Geographic Information Systems (GIS) mapping, field data collection, data analysis, and computer modeling. The specific methods and approach that was used to complete each task are described in the following sections.

2.1 Quality Assurance Project Plan Development

ESS developed a Quality Assurance Project Plan (QAPP) for the Warner's Pond Assessment and Restoration Project (Attachment A). A QAPP is a document that is submitted for review by independent authorities to ensure that the data being collected as part of the scientific studies will meet specific data quality objectives and are able to be consistently repeated in future trials. By ensuring that the data collected are valid and repeatable, it ensures that the work performed for this project will be of a quality that will allow the project to qualify for future consideration by state and federal grant programs for pond restoration.

This project's QAPP included plans for the data collection, analysis, and quality control protocols covering all data generating aspects of the project. The QAPP was submitted to the Massachusetts Department of Environmental Protection (MassDEP) and US Environmental Protection Agency (US EPA) for review on February 11, 2011. ESS did not receive comments on the QAPP from MassDEP or US EPA. However, prior correspondence with MassDEP and US EPA indicated that it would be approvable, as long as standard methods were adhered to within the QAPP. Therefore, there is no evidence that the QAPP developed for this project would be considered unacceptable in its draft form.

2.2 Review of Previous Studies

ESS reviewed a number of existing reports and studies, as presented in Table 1 below.

Table 1. Summary of Previous Studies and Reports Reviewed by ESS

Report/Study	Date	Author	Brief Description
Warner's Pond Fisheries Report	July 1983	MA Division Fisheries & Wildlife	Summary of fish population assessment in Warner's Pond
1997 Satellite-Based Monitoring of Massachusetts Lakes & Ponds	December 1997	Organization for the Assabet River	1997 Field data on Warner's Pond; includes aquatic vegetation maps, chlorophyll a data, correlation of lake and pond conditions with satellite imagery
Warner's Pond Management Plan	September 1999	ACT	Provides data on existing conditions and management recommendations for Warner's Pond
Wildlife and Habitat Assessment, Warner's Pond	November 1999	New England Environmental	Attachment to Management Plan; includes biological assessment and management recommendations for Warner's Pond
Updated Aquatic Vegetation Survey and Management Recommendations	October 2003	ACT	Update to 1999 ACT study; includes plant map, water quality results and updated management recommendations.
Project Completion Report for Nuisance Aquatic Plant Management Program at Warner's Pond	January 2005	ACT	Summary of plant surveys and harvesting and hydro-raking efforts to remove invasive weeds during the summer of 2004
Water Quality Sampling Results in Warner's Pond	July 2007	Geosyntec Consultants	Summary report of water quality sampling from stormwater outfall and area near old town dump
Warner's Pond Narrative	Provided to ESS in 2011	Warner's Pond Stewardship Committee	Summary of Warner's Pond characteristics, history, environmental issues and management

ESS conducted its own brief research review to compile additional studies and existing data available on Warner's Pond and its watershed. These sources included the following:

- Massachusetts Year 2010 Integrated List of Waters. April 2010. Prepared by MassDEP, Division of Watershed Management.
- Various presentations and status reports on the Warner's Pond outlet dam rehabilitation project, 2006 to 2008.

In addition to these reports and previous studies, the following digital photographs, GIS shapefiles, maps and figures were also provided by the Town of Concord and WPSC.

- Town of Concord GIS Shapefiles – Provided by Town of Concord Division of Natural Resources in January 2011. Shapefiles used in this study included orthophotos, stormwater outfalls, storm drain lines and catch basins.
- Digital photographs – Provided by Mr. Charlie Simpson, WPSC. Photographs include views of dense floating aquatic vegetation, aerial photo, historic photos of the pond, recreational photos and flooding over the outlet dam during March 2010 floods.
- Concord Board of Health septic system records for homes on streets that border Warner's Pond.

ESS compiled additional information on current watershed and pond features from the most recent USGS topographic maps and Massachusetts Geographic Information System (MassGIS) data.

2.3 Bathymetry and Isopach Survey

A bathymetric (water depth) and isopach (unconsolidated sediment depth) survey was completed at Warner's Pond on January 28, 2011. The purpose of the survey was to collect data to assess the feasibility of pond management options including dredging and drawdown. Prior to conducting the survey, 17 transects were laid out in representative areas throughout the pond as outlined in the QAPP (Figure 3 and Attachment A). Evenly spaced water depth sampling stations were placed along each transect using a GIS in a manner to accurately characterize depth contours across the pond. The sampling stations were uploaded onto a sub-meter accurate Trimble Differential Global Positioning System (DGPS) so that ESS scientists could navigate to each sampling station in the field during the survey.

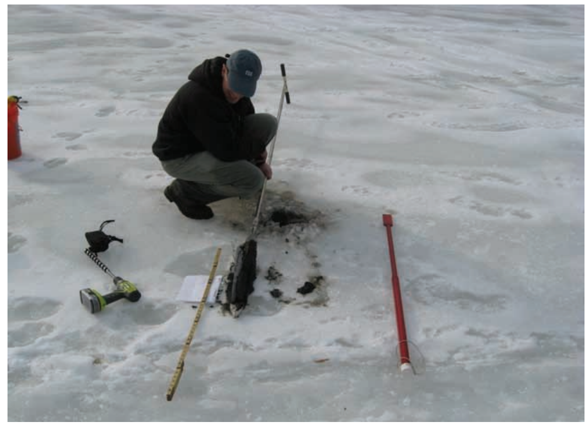
The pond was covered in approximately 16 inches of ice during the time of the survey. A datum measurement was taken at the pond outlet with water surface 5.5 feet below the top of the concrete spillway. Using maps and a DGPS, ESS navigated to each sampling station and used an ice chipper and battery-powered drill to create a hole through the ice. An extendible carbon steel tile probe was extended through the hole to collect two measurements: water depth and total depth. Total depth was obtained by pushing the tile probe into soft sediments until "refusal" at a harder underlying substrate was reached. Data was recorded in field notebooks and used to create figures using a GIS.

Extending tile probe into sediment to measure depth.

2.4 Sediment Sampling

Sediment quality is often used as an indicator of long-term nutrient or contaminant contributions from the watershed to a waterbody. In addition, sediment samples are collected to document physical characteristics and identify levels of potential contaminants that could pose challenges for pond dredging. The characterization of sediments is part of a screening process designed to reveal the severity of sediment contamination, if present, and to aid in the development of future management strategies.

An initial round of sediment sampling at Warner's Pond was completed on February 17, 2011. Prior to collecting sediment, the locations of 12 sediment core locations were plotted using GIS (Figure 4). The coordinates of the 12 sediment core locations were uploaded to a DGPS to navigate to locations in the field. The sediment core locations were selected to characterize the areas of Warner's Pond that are under consideration for dredging and to evaluate any effect of the former landfill at the southwestern corner of the pond on sediment quality. Sample sediment cores were recovered from the pond bottom using an extendible Russian peat corer. ESS photographed each sediment core (Attachment B) and characterized the core color and texture.



View of a sediment core extracted with the peat corer.

A total of four sediment samples (SC1, SC2, SC3, SC4) was composited from three individual sediment cores (SC1-1, SC1-2, SC1-3, etc.) and submitted to the laboratory for analysis. Compositing was accomplished by homogenizing each set of cores with a stainless steel spoon in a stainless steel bowl. Volatile organic compounds (VOCs) were sampled from individual cores prior to compositing, in order to avoid sample loss through volatilization.

Bulk physical and chemical analysis was conducted on the four composite samples. Sediment samples were analyzed for the following parameters: arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), polynuclear aromatic hydrocarbons (PAHs), extractable petroleum hydrocarbons (EPH), percent ash and ASTM grain size analysis per American Society for Testing and Materials (ASTM) standards.

Based on the results of the initial round of sampling, an additional composite sample was collected from the pond at SC-2 on September 2, 2011 to re-test the total chromium and hexavalent chromium levels.

2.5 Sediment Loading and Water Quality Sampling

An initial watershed reconnaissance survey was conducted on March 18, 2011 to identify potential sites to sample to assess sediment and nutrient loading within the Warner's Pond watershed. The reconnaissance was also used to verify that the proposed tributary and point source outfall water quality sampling locations first identified during the development of the QAPP were appropriate for sampling.

Prior to conducting the reconnaissance, maps of land use within the watershed and orthophotos were reviewed to identify areas within the watershed with higher potential to contribute sediment and nutrients to Warner's Pond (Figure 5). After completing the desktop review, targeted areas of the watershed were investigated for potential sediment/nutrient sources and water quality sampling locations (Attachment C). Where obvious pollution sources were observed, the area was described, a GPS position was collected, and photographs taken. These locations included road cuts at bridge crossings, stormwater outfalls, areas with large impervious surfaces, agricultural areas adjacent to pond tributaries, and commercial development along tributary banks (Attachment C). ESS also examined all stormwater outfalls previously identified by the Town around the pond to determine best access for sampling (Figure 6). During the watershed reconnaissance, ESS visited the Town of Acton Planning Department to gather existing data on the locations of catch basins and stormwater outfalls in Acton. According to the Acton Planning Department, comprehensive stormwater infrastructure data for the town is not available in hard-copy or GIS format (March 18, 2011). The Acton Engineering Department was contacted and confirmed that town-wide data is not available though it is currently being developed in an electronic format.

The results of the watershed reconnaissance were used to finalize sediment and nutrient loading point and non-point source sampling locations (Figure 7). Dry and wet weather sampling was completed on September 2 and September 22, 2011, respectively. During dry weather, water quality samples were collected within the pond and at pond tributaries. Samples were not collected from targeted outfalls because no dry weather discharge was observed from these outfalls. During wet weather sampling, water quality samples were collected from pond tributaries and five of the eight targeted outfalls. Samples were not collected from the remaining three outfalls because they were not observed to be flowing during the storm.

2.6 Hydrologic Budget and Nutrient Load Modeling

Data generated during field and desktop assessments was used to develop a hydrologic budget and nutrient load model for Warner's Pond. The nutrient model is a key component of a Watershed Management Plan because nutrient levels influence water quality (e.g., clarity, algal production, etc.) within Warner's Pond. The results of the nutrient model are used to gain an understanding of how the pond is affected by the surrounding watershed and allow management to effectively target those areas of the watershed that will benefit most from restoration efforts and thus be likely to yield the greatest success toward restoring water quality.

Determining a pond's hydrologic budget is the first step toward modeling its nutrient load because all water being delivered to the pond carries some quantity of nutrients. A hydrologic budget models water inflow into the pond, storage capacity within the pond and water outflow from the pond based on the hydrologic cycle. Sources of water inflow include precipitation onto the pond surface, as well as the associated overland runoff, direct stream flow from tributaries, and groundwater seepage along the margins of the pond. Evapotranspiration, groundwater recharge, and direct outflow via a stream outlet all lead to losses of water from the pond. The difference between the sum of the inflows and sum of the outflows determines the storage volume of the pond at a given point in time.

The following sources were used to develop a hydrologic budget for Warner's Pond :. The general pond characteristics, which include acreage, circumference, volume, and watershed size, were calculated using a combination of GIS data and field parameters collected by ESS. Streamflow inputs from the two tributaries to the pond (Nashoba Brook and Fort Pond Brook) were calculated using the online streamflow modeling application, Streamstats[1]. An estimate of the rate of groundwater movement into the pond was based on averages obtained for southern New England ponds of similar morphometry. Data on average precipitation were collected from local weather stations and regional estimates, including the 30-year normals for Boston and Worcester (www.wunderground.com).

The hydrologic model, water quality sampling results (see Attachment A for methods), and sub-watershed land use data were used to model the nutrient load to Warner's Pond. The nutrient budget for a pond models the level of nutrients entering, circulating within, and exiting the pond system. The nutrient level is expressed as a nutrient "load", which is the total mass of the nutrients entering over a given time period (typically expressed as kg/year). A nutrient budget model was developed for Warner's Pond for both phosphorus and nitrogen (Attachment D). Since phosphorus is viewed as the nutrient that controls

[1] Available at: http://water.usgs.gov/osw/streamstats/massachusetts.html

productivity in this freshwater system, greater emphasis was placed on the phosphorus load modeling results.

The model approach for this study began with a nutrient load estimate based on the land use export coefficient approach (Reckhow, 1980). This estimate was then calibrated using limnological modeling techniques based on pond features, watershed hydrology, and field data collected at Warner's Pond. The inputs to the nutrient model include data on watershed land use, parameters from the hydrologic model, and the results of water quality sampling.

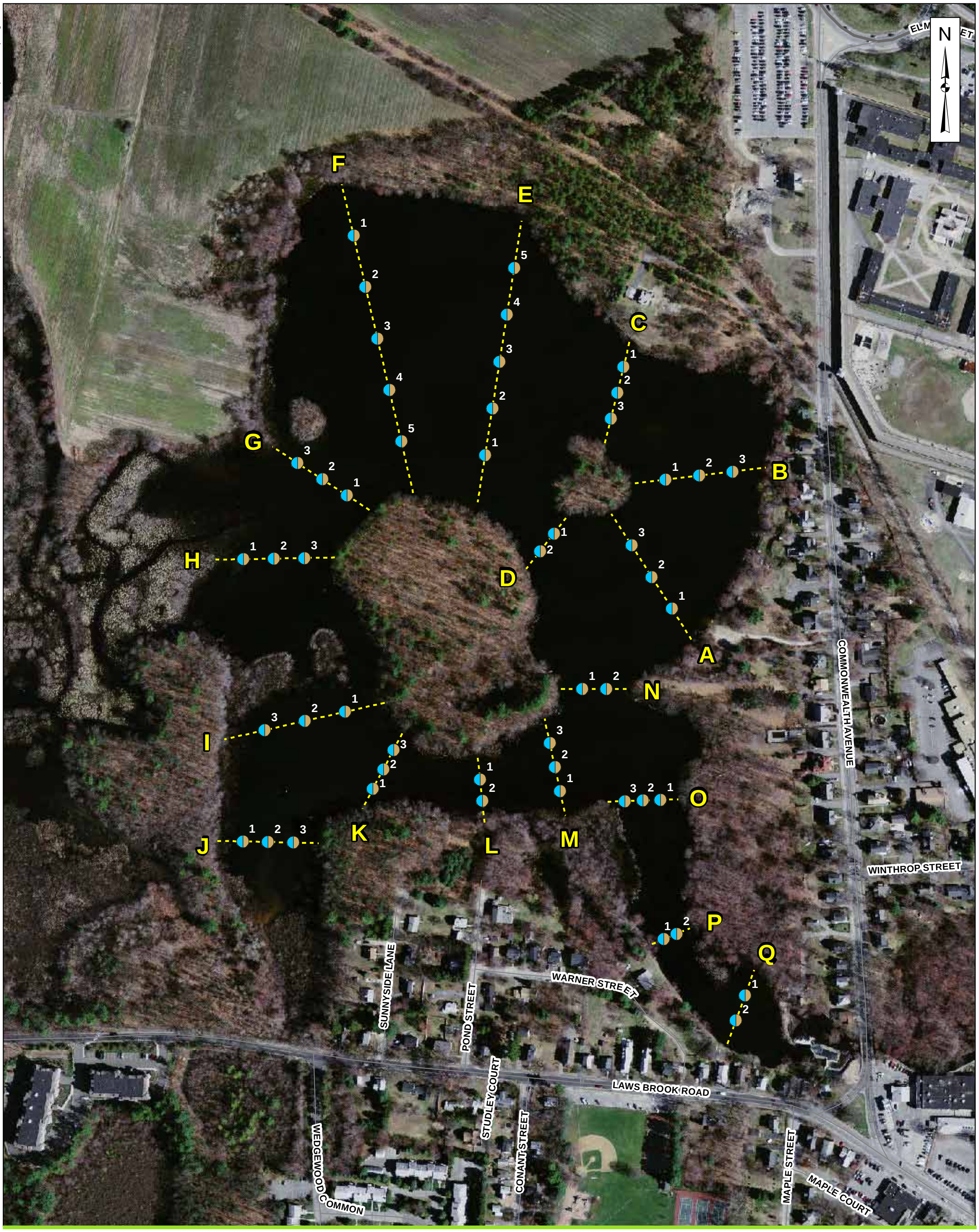
Existing GIS data was first used to determine the acreage of the various land uses which occur within the three primary sub-watersheds of Warner's Pond, which include the Nashoba Brook sub-watershed, the Fort Pond Brook sub-watershed, and the watershed that immediately surrounds the pond (Attachment D). Each land use contributes a different nutrient load based on its propensity to generate nutrient runoff. Developed areas contribute the highest nutrient loads while forested areas and wetlands contribute the lowest nutrient loads. The total nutrient load contributed from each sub-watershed will depend on the acreage of each land use within the watershed and the nature of the route that runoff from the drainage area must travel to reach the pond.

Hydrologic parameters were used to model characteristics of Warner's Pond that influence how nutrients move through the system. These characteristics include the mean depth (pond volume/pond area), flushing rate (number of times/year that the total volume of water in the pond is renewed), areal water load (volume of water entering a pond in a year divided by the pond surface area) and settling velocity (rate at which a particle drops from the water column) (Attachment D). These metrics are subsequently used to refine the nutrient model for the pond.

Water quality data were used to model the concentration of phosphorus and nitrogen flowing into and out of the pond. These data were also used to calibrate the estimated nutrient load entering from the individual sub-watersheds that was calculated earlier using the GIS land-use based approach. Septic inputs, while potentially present, were not incorporated into the model. According to the Board of Health, most of the homes around Warner's Pond are sewered, with the exception of a few on Wright Road and Laws Brook (see Figure 12). The nutrient load inputs were then used to calculate a phosphorus and nitrogen load entering the pond under several different in-pond models (Dillon and Rigler, 1974; Oglesby and Schaffner, 1978; Jones, Rast and Lee, 1979; Kirchner and Dillon, 1975; Vollenweider, 1968 and 1975; Reckhow, 1977; Larsen-Mercier, 1976; Bachmann, 1980; Jones-Bachmann, 1976) (Attachment D). The individual model results were averaged to obtain a final estimate of the phosphorus and nitrogen load entering Warner's Pond.

Once the nutrient loads for the existing conditions were calculated, the effect these loads have on chlorophyll *a* concentration, total phosphorus concentration, and Secchi depth (water clarity) within the pond was determined. The modeled nutrient inputs were also used to determine the permissible load and critical load for Warner's Pond. 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). Once the nutrient load rises above the permissible load, water quality will begin to deteriorate until nutrient loading increases to a level above the critical load at which point the rate of deterioration will slow since the pond is saturated with nutrients – a state of advanced eutrophication.

Location: G:/GIS-Projects/Warners-Pond-Concord/00-mxd/Report/Sampling.mxd



WARNER'S POND WATERSHED MANAGEMENT PLAN

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Scale: 1" = 400'

0 400 Feet

Source: 1) MassGIS, Orthos, 2008

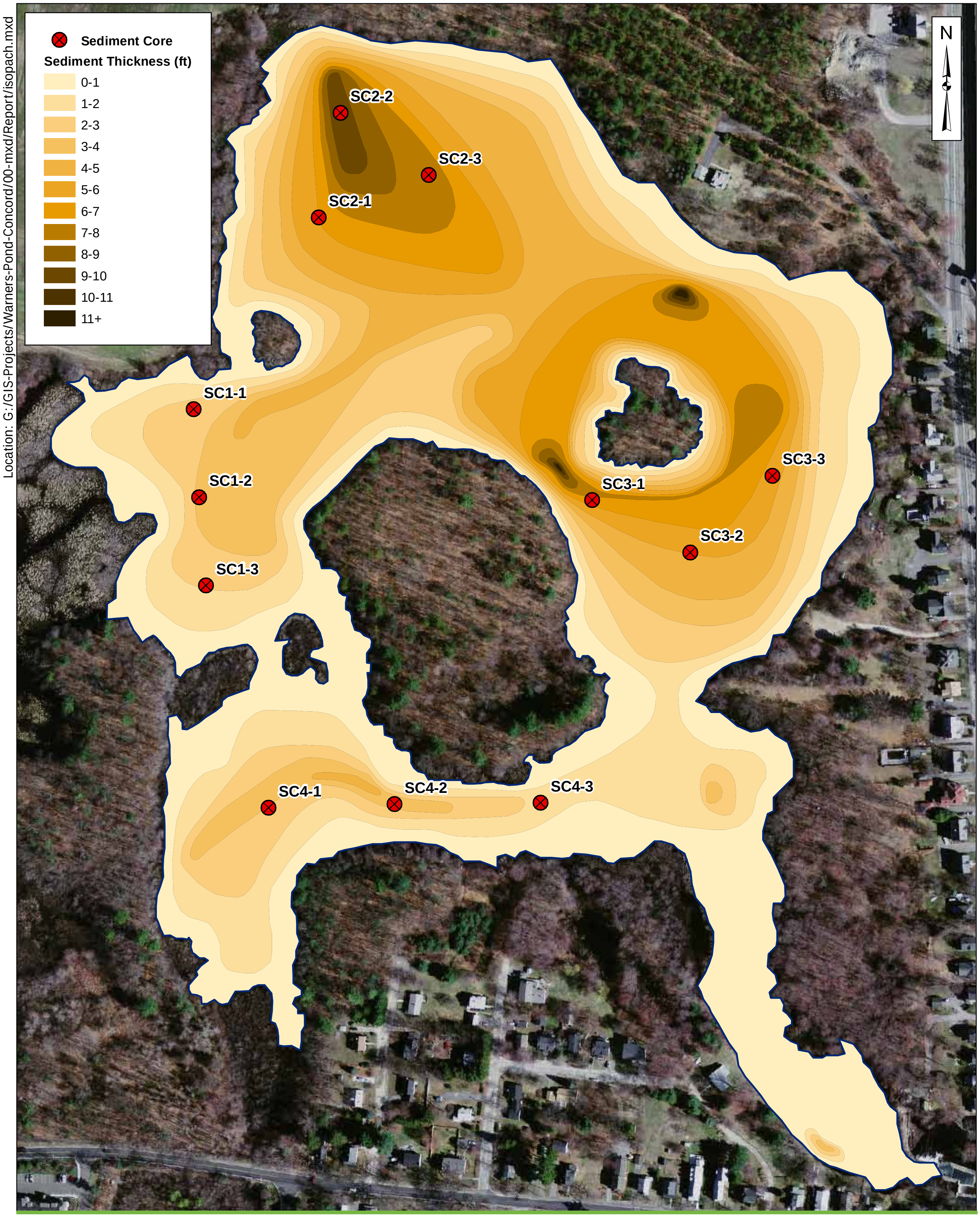
Legend

Bathymetry/Sediment Sampling Locations

Sampling Transects

Bathymetry and Sediment Thickness Sampling Transects

Figure 3



WARNER'S POND WATERSHED MANAGEMENT PLAN

Warner's Pond Isopach Map and Sediment Sampling Locations

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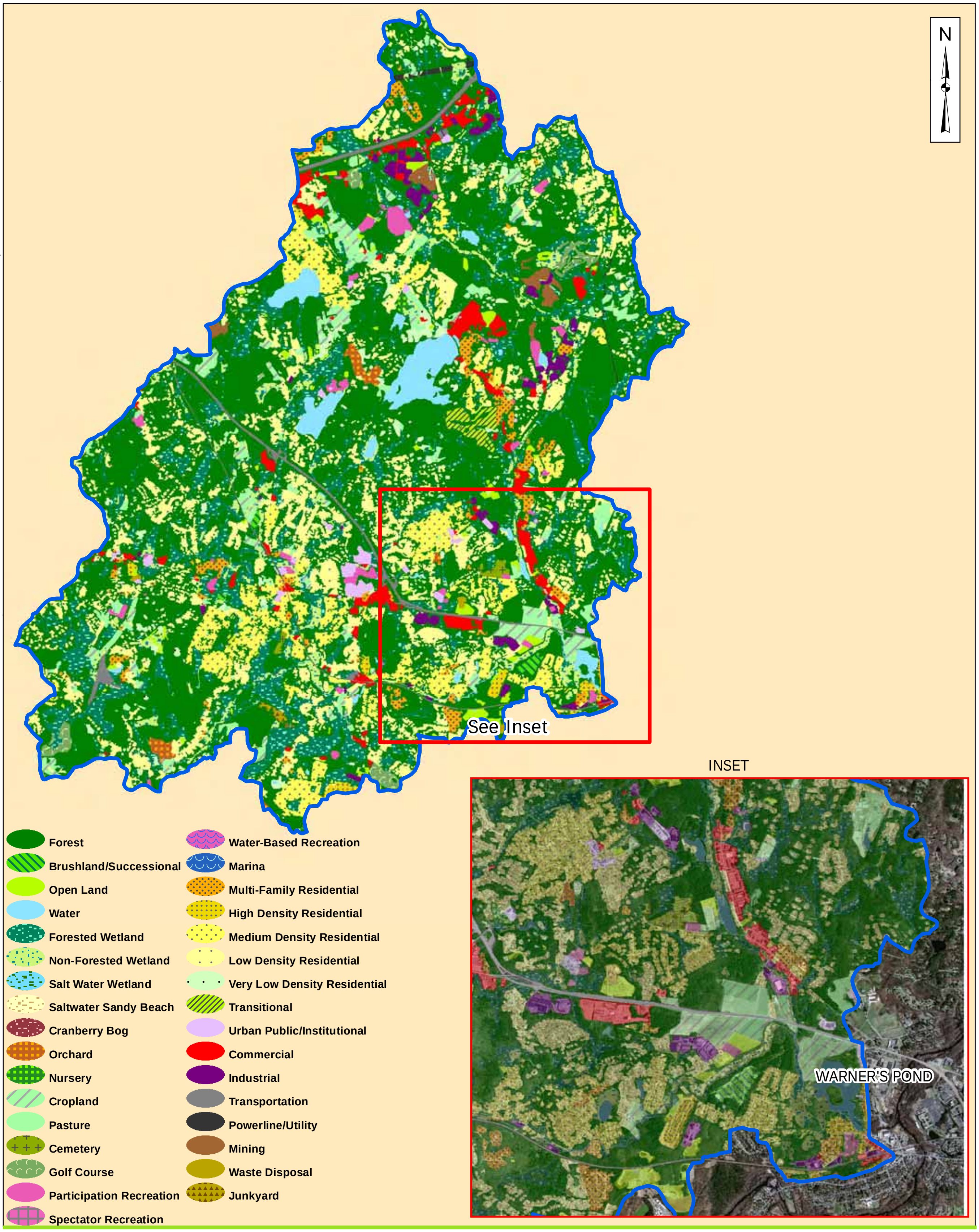
Scale: 1" = 300'

0 300 Feet

Source: 1) MassGIS, Color Orthophotos, 2008

Figure 4

Location: G:/GIS-Projects/Warners-Pond-Concord/00-mxd/Report/LandUse.mxd



WARNER'S POND WATERSHED MANAGEMENT PLAN

Watershed Land Use

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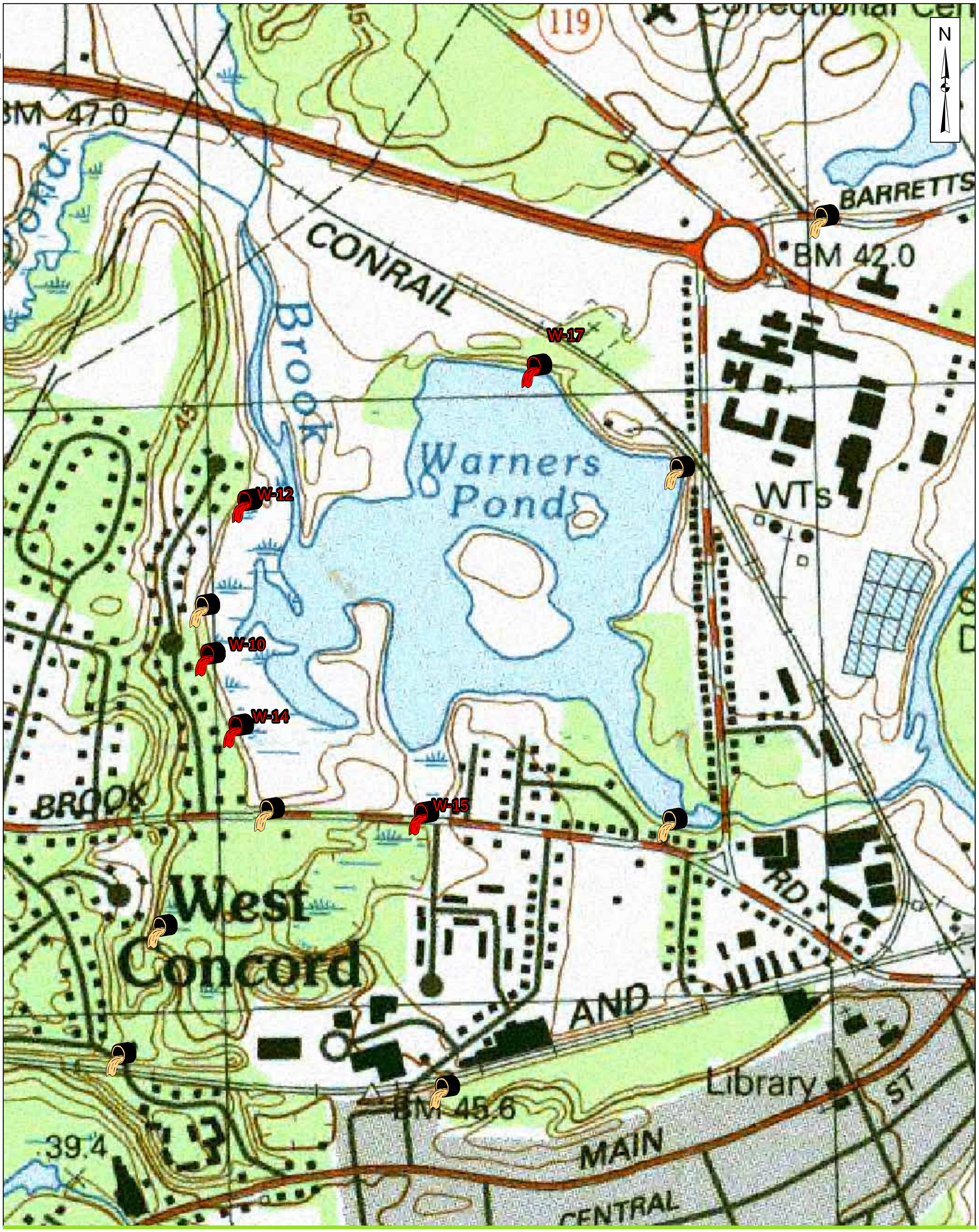
Scale: 1" = 9,000'

0 1 Miles

Source: 1) MassGIS, Color Orthos, 2008
2) MassGIS, Land Use, 2005

Figure 5

Location: G:/GIS-Projects/Warners-Pond-Concord/00-mxd/Report/Point_source.mxd



WARNER'S POND WATERSHED MANAGEMENT PLAN

Point Source Discharge Locations

Scale: 1" = 750'

0 750 Feet

Source: 1) MassGIS, USGS Topos, 1987-1988
2) Town of Concord, Outfall Locations

Legend

Sampled

Not Sampled

Figure 6

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Location: G:/GIS-Projects/Warners-Pond/00-mxd/Report/WQ_Sampling.mxd

Site ID	Location
WP-1	Nashoba Brook Inlet
WP-2	Fort Pond Brook Inlet
WP-3	Pond Outlet
WP-4	Coles Brook
WP-5	Nashoba Brook
WP-S/B	In-Pond Sample

Outfall ID	Location
W-10	Wright Road
W-12	Wright Road
W-14	Wright Road
W-15	Law's Brook Road
W-17	Route 2

WARNER'S POND WATERSHED MANAGEMENT PLAN

Final Water Quality Sampling Locations

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Scale: 1" = 1500'

0 1,500 Feet

Source: 1) MassGIS, USGS Topos, 1987-1988

Legend

Outfall Sample Location

Tributary & In-Pond Samples

Final Location (TSS & Nutrients)

Final Location (Nutrients only)

Figure 7

3.0 RESULTS

The results of each component of the study are presented in the following sections. Results include data collected from previous studies, field collection, desktop review, and limnology modeling.

3.1 Quality Assurance/Quality Control

The project was conducted in substantial compliance with the QAPP developed for the project. All water quality data are deemed valid based on the laboratory's stringent QA/QC procedures (Attachment A). In addition, all of the water quality sample results were inside the normal range of expected values.

The few deviations from the QAPP are described below.

- GeoLabs, Inc. laboratory analysis for total phosphorus for dry weather samples collected on September 1, 2011, did not meet the target detection limit of 0.005 mg/L. The total phosphorus detection used by the laboratory was 0.200 mg/L. ESS requested that the samples be reanalyzed to meet the lower detection limit. The samples were reanalyzed 36 days after collection, which is outside the hold time of 28 days to meet the target detection limit. This option was preferable to using the original results as nearly all of the total phosphorus samples had a "no detect" at the 0.200 mg/L level. The original results were not suitable for use in the nutrient model and instead, the reanalyzed total phosphorus results were used in nutrient modeling calculations.
- The wet weather sampling event captured the first flush of a storm which was forecast to produce greater than 0.25 inches of rain in accordance with the QAPP. The 24-hour storm total of the storm sampled was approximately 0.40 inches. However, according to online weather records (available at www.weatherunderground.com) from the nearest weather station in Bedford, Massachusetts, the majority of the rain in the storm fell the next day, after the samples were collected. There was a period of very light to no precipitation near the end of the time period when ESS was collecting samples. Five of the outfalls that had been targeted for sampling were flowing during the sampling event. However, there was no longer any flow at outfall W-23, which had been targeted for sampling. Therefore, W-23 and the other two remaining outfalls targeted for sampling were not sampled during this event. Despite the lower than anticipated rainfall during the sampling time period, ESS believes the sampled storm still provides reliable data on a smaller storm event and captured the essential first flush period of the storm.
- The laboratory results for hexavalent chromium sediment re-sampling submitted on September 2, 2011, did not meet the target detection limit. The result was that hexavalent chromium was not detected at a detection limit (33.3 mg/kg) that was just above the MCP Method 1 Soil Standard of 30 mg/kg. In accordance with standard methods where laboratory results are above the target detection limit (due to matrix interference or excessive moisture content), the actual value is presumed to be half the laboratory detection limit (in this case, 16.65 mg/kg).

All other field sampling protocols developed for bathymetry, sediment sampling, water quality sampling and biological assessments were completed without deviations from the QAPP.

3.2 Summary of Previous Studies and Existing Conditions

ESS reviewed the previous reports, studies, datasets, and correspondence described in Section 2.2 to develop an understanding of the current conditions in Warner's Pond and how the system has changed through the years. The historic information on Warner's Pond can be used to set realistic restoration goals that are consistent with conditions previously found in the pond.

3.2.1 Biological Resource Assessment

Over the last 12 years, various components of Warner's Pond have been evaluated by the Town to address the effects of excessive sediment and nutrient transport to the pond. Some of the reports presented in Section 2.2 include studies that provide a biological assessment of the pond. These studies were reviewed and provide the baseline for the following biological assessment that ESS conducted during site visits to the pond during the summer of 2011.

The earliest assessment of fisheries within Warner's Pond reviewed was the report prepared by the Massachusetts Division of Fisheries and Wildlife (MassWildlife) in 1983. MassWildlife used gill nets and a shock boat to collect fish within the pond. The fish collected are shown in Table 2).

These results document that warm-water species are dominant within the Warner's Pond fisheries community (except for the stocked rainbow trout). Additionally, red-breasted sunfish (*Lepomis auritus*), pickerel (presumably the redfin pickerel, *Esox americanus americanus*), banded sunfish (*Enneacanthus obesus*), and fallfish (*Semotilus corporalis*) were also observed by MassWildlife in Nashoba Brook and may occur on a transient basis within or at the margins of Warner's Pond. ESS observed bluegill, pumpkinseed, and yellow perch in Warner's Pond in 2011.

View of scrub-shrub wetlands that fringe large areas of Warner's Pond. Water willow is dominant.

Table 2. Fish Species Observed in Warner's Pond

Common Name	Scientific Name
American eel[1]	*Anguilla rostrata*
Golden shiner[1]	*Notemigonus crysoleucas*
White sucker[1]	*Catostomus commersoni*
Rainbow trout[1]	*Oncorhyncus mykiss*
Bluegill[1,2]	*Lepomis macrochirus*
Pumpkinseed[1,2]	*Lepomis gibbosus*
Largemouth bass[1]	*Micropterus salmoides*
Black crappie[1]	*Pomoxis nigromaculatus*
Yellow perch[1,2]	*Perca flavescens*
White perch[1]	*Morone americana*
Yellow bullhead[1]	*Ameiurus natalis*
Brown bullhead[1]	*Ameiurus nebulosus*

†Source: 1. MassWildlife, 1983; 2. ESS, September 2012

The report prepared by the Organization for the Assabet River in 1997 includes plant map results, chlorophyll *a*, and Secchi depth data. The report indicates that the pond was considered eutrophic based on sedimentation levels and excessive aquatic plant growth in the pond.

In 1999, ACT conducted a survey of aquatic plants as well as a study of water and sediment depth/quality (ACT, 1999) (Table 3).The major conclusions from the survey described excess sedimentation facilitating nuisance level aquatic macrophyte growth in Warner's Pond. Additionally, the report noted that exotic and native invasive species were present throughout much of the pond. Exotic aquatic macrophyte species included variable watermilfoil, water chestnut, and fanwort. Additionally, purple loosestrife was observed growing along the margins of Warner's Pond, particularly adjacent to water willow beds on the western side. Four years later, ACT conducted a similar study to document any changes in the condition of Warner's Pond (ACT, 2003 and 2004) (Table 3). The most alarming results indicated that the invasive plants identified in 1999 were spreading rapidly throughout the pond. Fanwort, for example, had increased its cover by 20%, its biomass by 38% and accounted for 54% of all macrophyte growth in the pond (ACT, 2003).

Dense aquatic plant growth just south of Scout Island. Fanwort is visible just below the water surface.

Concurrent with the ACT evaluation of Warner's Pond in 1999, NEE conducted an evaluation of habitat and wildlife use of Warner's Pond (NEE, 1999). The findings in this habitat evaluation are all consistent with the conditions that ESS observed during its assessment of the pond in 2011. NEE described four distinct ecological communities at the pond:

1. Shallow marsh on the western side of the pond
2. A scrub-shrub/emergent marsh (water willow marsh) at the inlet of the pond
3. Open water habitat in the eastern and northern sections of the pond
4. Upland habitat on islands within the pond

The locations and descriptions of these communities in the NEE report are generally consistent with observations made by ESS during the summer field assessment. The most significant observable change is that the scrub-shrub/emergent wetland, which had formerly been limited to the pond inlet and western shoreline, has spread to other areas of the pond. These scrub-shrub/emergent wetlands, which are comprised primarily of water willow (*Decodon verticillatus*), now occur on the southern pond shoreline and areas bordering Scout Island.

Although a fish survey was not conducted as part of this study, ESS believes that, based on the habitat present in Warner's Pond and water quality conditions, the fish community likely remains similar to the community that has been previously documented. The NEE report lists the same warm-water species that were observed during the MassWildlife survey in 1983. NEE noted that the pond once supported a rainbow trout population; however, this species was lost as the pond warmed and warm-water species began to dominate. No rare or endangered flora or fauna were identified at Warner's Pond during NEE's survey or in any documents NEE evaluated from previous surveys.

A major restoration effort was suggested by NEE to restore Warner's Pond water quality. Two approaches (aquatic weed harvesting and hydro-raking) to manage water chestnut and fanwort were implemented in 2004 by the Town at NEE's recommendation. It was later determined that the aquatic weed harvester should not be used where invasive variable watermilfoil was also present, due to its ability to fracture and re-root from cuttings, which is also probably true for fanwort growth as this plant also is known to spread through vegetative fragmentation. Grassroots efforts began in 2004 to hand-harvest water chestnut in areas where variable watermilfoil also occurred, and continues pond-wide.

Currently, Warner's Pond continues to suffer from high sedimentation rates and nutrient inputs due to its large, densely developed watershed. These sediment and nutrient inputs accumulate within the pond and ultimately contribute to the excessive growth of exotic and nuisance macrophyte species, which can degrade open water habitat and impair recreational uses.

The most recent invasive macrophyte treatment program was conducted using the Sonar and Sonar One herbicide formulations during the 2011 growing season. ACT applied these formulations three times in 2011 to control the growth of non-native invasive fanwort and variable watermilfoil (Attachment E). A pre-treatment survey was conducted by ACT on May 20, 2011, which included both plant cover and biovolume mapping from pre-determined sampling locations (Figure 1 in Attachment E). ACT documented numerous macrophyte species in the pond, as well as filamentous green algae and the macroalgal species stonewort (*Nitella sp.*).

ESS and ACT conducted a late season, post-treatment vegetation survey to characterize the aquatic plant community in Warner's Pond and to assess the effects of the Sonar treatment. The Sonar treatment area was limited to the northern and eastern portions of the pond (Figure 2 in Attachment E). A total of 18 different plant species was observed growing within and along the margins of Warner's Pond during the September 2, 2011 post-treatment survey (Table 3).

The two surveys completed in 2011 generated different plant lists as well as somewhat contrasting areas of aquatic macrophyte cover and biovolume. This is due to the effects of seasonality (most aquatic macrophytes do not fully develop until mid- to late summer) and the implementation of a Sonar herbicide treatment between the two surveys.

Table 3. List of Aquatic Plant Species Observed in Warner's Pond[†]

Common Name	Scientific Name
Burreed*[2]	*Sparganium sp.*
Canadian waterweed[1,4,5]	*Elodea canadensis*
Coontail[1,2,3,4,5]	*Ceratophyllum demersum*
Curly-leaf Pondweed[4]	***Potamogeton crispus***
Duckweed[1,2,3,5]	*Lemna sp.*
Eurasian watermilfoil[4]	***Myriophyllum spicatum***
Fanwort[1,2,3,4,5]	***Cabomba caroliniana***
Flatstem pondweed[2,3,4,5]	*Potamogeton zosteriformis*
Floating pondweed[1,2,3,4,5]	*Potamogeton natans*
Humped bladderwort[5]	*Utricularia gibba*
Bladderwort[4]	*Utricularia sp.*
Little floating heart[5]	*Nymphoides cordata*
Mudplantain*[5]	*Heteranthera sp.*
Pickerelweed*[1,2,3,5]	*Pontederia cordata*
Pond water-starwort[1,2,3,4,5]	*Callitriche sp.*
Purple loosestrife*[1,2,3,4,5]	*Lythrum salicaria*
Ribbon-leaf Pondweed[1,2,3]	*Potamogeton epihydrus*

Common Name	Scientific Name
Smartweed[4,5]	*Polygonum sp.*
Thin-leaf Pondweed[2,3]	*Potamogeton pusillus*
Water willow*[1,2,3,4,5]	*Decodon verticillatus*
Variable watermilfoil[1,2,3,4,5]	***Myriophyllum heterophyllum***
Water chestnut[5]	***Trapa natans***
Watermeal[1,2,3]	*Wolffia sp.*
Watershield[1,5]	*Brasenia schreberi*
White water lily[1,2,3,4,5]	*Nymphaea odorata*
Yellow water lily[1,2,3,4,5]	*Nuphar lutea variegata (=N. variegatum)*

†Source: 1. ACT, August 1999; 2. ACT, September 2003; 3. ACT, September 2004; 4. ACT, May 2011; 5. ESS, September 2011
*Emergent species
Exotic invasive species noted in bold

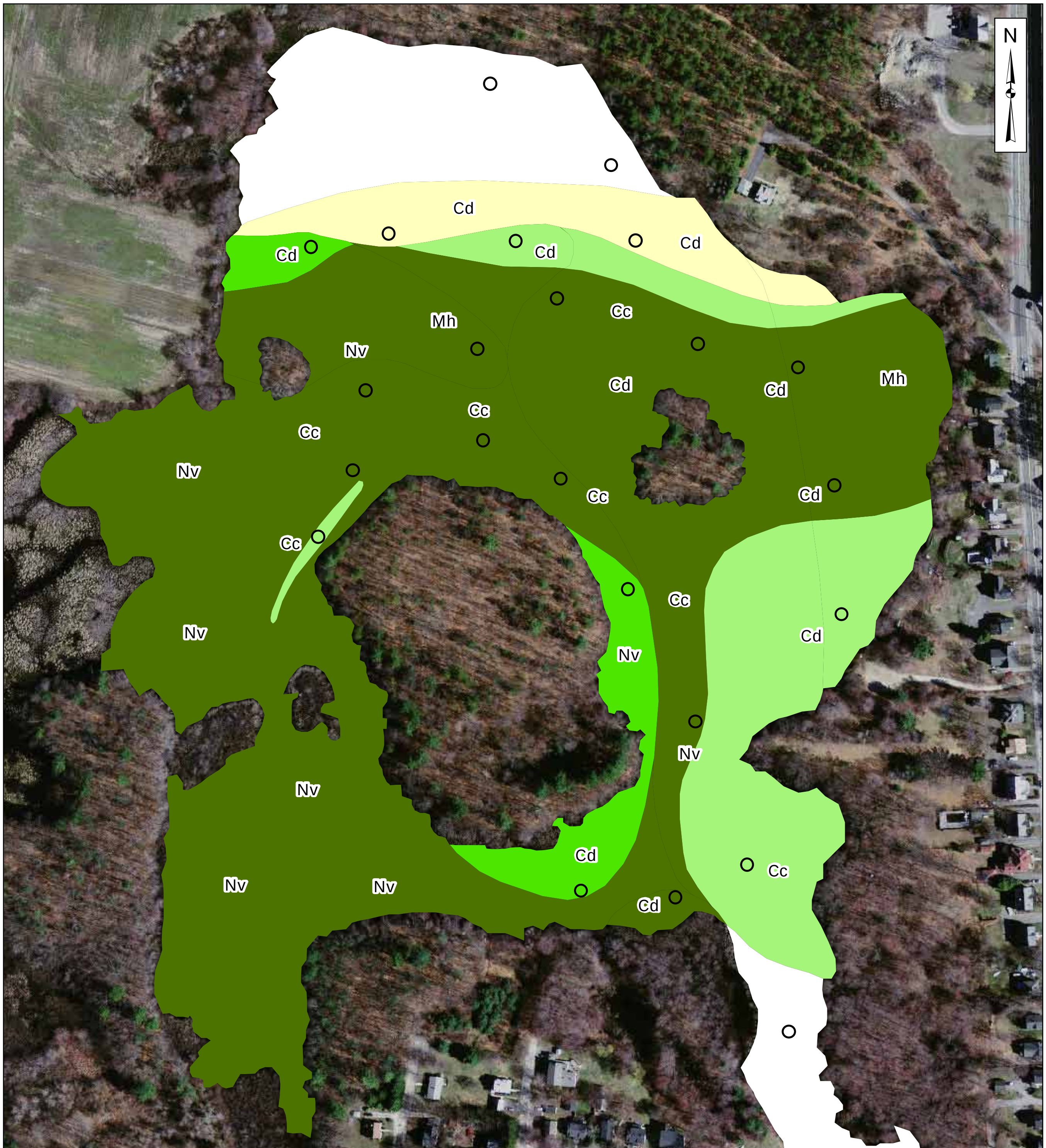
Although the overall number of different plant species observed was relatively high, nearly all of the aquatic plant cover within the pond consisted of fanwort or coontail. This includes southwestern portions of the pond dominated by water lily species, where fanwort and variable watermilfoil were also present as subdominant species. The majority of the other species observed was found at a few limited locations along the shorelines of the southeastern outlet of the pond.

Plant cover, or the percent of an area covered by plants, was highest in the western and southwestern portions of the pond, which had not been targeted by the Sonar treatment (Figure 8). Plant cover was also very high to the north and northeast of Scout Island where swift-moving water through the pond was likely to have limited herbicide contact time and thus appeared to be less effective in these areas. The Sonar treatment was highly effective in the northern and eastern portions of the pond where fanwort, variable watermilfoil and coontail showed signs of chlorosis and had dropped out of the water column due to decay.

Biovolume, or the percentage of the water column occupied by plants, was greatest in the western and southwestern areas of the pond, which were not treated with Sonar (Figure 9). The low biovolume in the northern and eastern portions of the pond reflect the effectiveness of the treatment in some of these areas. The field survey results suggest that there will be a lasting effect of the herbicide treatment going into the 2012 growing season. However, based on the overall densities and coverage of invasive aquatic macrophytes observed during the survey in untreated portions of the pond, these nuisance species will continue to impact the overall ecological integrity of Warner's Pond.

Despite the presence of aquatic invasive species, Warner's Pond provides habitat for birds, warm-water fisheries, reptiles, amphibians, invertebrates and aquatic mammals. The pond is fringed by the extensive scrub-shrub/emergent wetland system near the inlet and along the southern shoreline. These wetlands provide ideal habitat for a variety of waterbirds and likely offer an important feeding area for migratory waterfowl (NEE, 1999). The dense vegetation within the wetlands and shallow water provide foraging, cover, and nesting habitat for avian species. A compilation of bird species observed by NEE and ESS in aquatic, wetland, and upland habitats of the pond and adjacent areas is provided in Table 4.

Location: G:/GIS-Projects/Warners-Pond-Concord/00-mxd/Report/Plant-Cover.mxd



Dominant Aquatic Plant Species, Warner's Pond, September 2, 2011.

Scientific Name	Common Name	Symbol
*Cabomba caroliniana**	Fanwort	Cc
Ceratophyllum demersum	Coontail	Cd
*Myriophyllum heterophyllum**	Variable-leaf milfoil	Mh
Nuphar lutea variegata	Yellow water lily	Nv

*Exotic invasive

WARNER'S POND WATERSHED MANAGEMENT PLAN

Warner's Pond Plant Cover
September 2, 2011

ess group
environmental consulting & engineering services

Scale: 1" = 300'

0 300 Feet

Source: 1) MassGIS, Color Orthophotos, 2008
Note: The symbols on this map represent only the dominant species in each area. Additional species were present and a full species list is provided in the text.

○ Plant Cover Sample Location

Plant Cover
- 0%
- 1% - 25%
- 26% - 50%
- 51% - 75%
- Greater than 75%

Figure 8

WARNER'S POND WATERSHED MANAGEMENT PLAN

Warner's Pond Biovolume
September 2, 2011

ess group
environmental consulting
& engineering services

Scale: 1" = 300'
0 300 Feet

Source: 1) MassGIS, Color Orthophotos, 2008

Biovolume Sample Location
0%
1% - 25%
26% - 50%
51% - 75%
Greater than 75%

Figure 9

Table 4. List of Avian Species Observed using Warner's Pond and its Shoreline Habitats

Common Name	Scientific Name
Belted Kingfisher[1]	*Megaceryle alcyon*
Canada Goose[1,2]	*Branta canadensis*
Double-crested Cormorant[1]	*Phalacrocorax auritus*
Chimney Swift[1]	*Chaetura pelagica*
Eastern Kingbird[1]	*Tyrannus tyrannus*
American Goldfinch[1]	*Spinus tristis*
Great Blue Heron[1,2]	*Ardea herodias*
Least Flycatcher[1]	*Empidonax minimus*
Green Heron[1]	*Butorides virescens*
Mallard[1]	*Anas platyrhynchos*
Mute Swan[2]	*Cygnus olor*
Red-tailed Hawk[2]	*Buteo jamaicensis*
Song Sparrow[1]	*Melospiza melodia*
Spotted Sandpiper[1]	*Actitis macularius*
Wood Duck[1]	*Aix sponsa*
Downy Woodpecker[1]	*Picoides pubescens*
Mourning Dove[1]	*Zenaida macroura*
Gray Catbird[1]	*Dumetella carolinensis*
Northern Flicker[1]	*Colaptes auratus*
Cedar Waxwing[1]	*Bombycilla cedrorum*
Black-capped Chickadee[1]	*Poecile atricapillus*

Source: 1. NEE, April to August 1999; 2. ESS, September 2012

Reptiles and amphibians were not directly observed by ESS at Warner's Pond. However, NEE (1999) reported painted turtle (*Chrysemys picta*) and green frog (*Rana clamitans*) observations. Appropriate breeding, foraging, and overwintering habitat is readily available for both species and they are likely to be common at Warner's Pond.

Aquatic macroinvertebrates, including the terrestrial stages of some species, were observed at Warner's Pond by NEE (1999) and ESS. In addition to several dragonfly and damselfly (Odonata) species, other aquatic worms, insects, crustaceans, snails, and native eastern elliptio freshwater mussels (*Elliptio complanata*) are also present and an important part of the pond community. No rare aquatic macroinvertebrate species were observed.

Although not observed during the survey, the scrub-shrub/emergent and shallow marsh wetlands on the eastern and southern sides of the pond may also provide habitat for muskrats (*Ondatra zibethicus*), beavers (*Castor canadensis),* and mink *(Mustela vison)*. Muskrats may forage to some extent on freshwater mussels in Warner's Pond, as evidenced by the presence of empty mussel valves along portions of the pond shoreline.

In sum, Warner's Pond provides valuable wildlife habitat through the diversity of wetland and open water habitats that occur within the pond. The mix of water depths, variety of water flow regimes, and extensive scrub-shrub/emergent wetland system that border the pond are ecological assets. However, the excessive sediment and nutrient load to the pond have fostered the aggressive expansion of aquatic and emergent plant species that will continue to encroach upon areas of open water habitat. Over the long run, the pond will continue to fill in with sediment and gradually transition into a scrub-shrub/emergent wetland through the process of succession. This will limit the pond's future ecological value as open water habitat and its recreational value to the community.

3.2.2 Recreational Resource Assessment

Warner's Pond has provided recreational opportunities to West Concord residents and visitors for over 160 years. In this time, recreational access and activities have taken many forms. Descriptions of activities documented in the Warner's Pond brochure and are summarized in the following paragraphs,

Historic photo of Scout Island. A bridge that once ran to the island is just visible in background.

In the 1890s, a bridge connected the mainland with Scout Island (then the Isle of Pines), the largest island in the pond. At this time, the Isle of Pines was subdivided into 34 lots for summer cottages. In 1944, ownership of the island was transferred to the Boy Scouts Troop 33 of West Concord and, owing to the use of the island by Boy and Girl Scouts for camping, nature study, cooking and sports, it eventually became known as Scout Island.

The Warner's Pond shoreline was historically used for swimming access by town residents and even inmates from the state reformatory on Commonwealth Avenue. At least four separate swimming areas have been established at one time or another at the pond. A picnic area, playground, and rental boats were also available for summer recreation in previous years.

Historic winter recreational activities included ice skating and hockey. Community ice skating parties were sometimes held in the evenings after Christmas. Residents would bring their old Christmas trees down to the pond and burn them in a bonfire. The light of bonfire would provide enough illumination by which to ice skate.

Ice cutting was also popular in the past at Warner's Pond. Each year, cut ice was stored in ice houses near the state reformatory until these houses burnt down. Mink and muskrat trapping and fishing were also historically practiced.

The current trajectory of the pond's condition appears to be threatening some of these recreational activities as the area of open water habitat shrinks and access to the pond has become more limited.

However, restoration plans could enhance these recreational activities at Warner's Pond if implemented in the near future. The primary pond recreational goals include the following:

- Continue to maintain and improve the pond's fishing opportunities.
- Clear select areas of water lilies and dense exotic aquatic vegetation to provide greater access to Scout Island and other areas of the pond.
- Address the excess sediment and nutrients in the pond.
- Improve the existing boat launch access off Commonwealth Avenue so that it can better accommodate recreational activities throughout the year. This could include adding new gravel and maintaining a relatively deep and weed free boating access channel near the launch that would allow boats to more easily access open water areas of the pond.
- Maintain primitive boat landings on Scout Island and Pond Street to allow for easier access.

The primary concern of residents in the area has been the gradual loss of open water habitat to aggressive aquatic plant growth, particularly of invasive exotic species such as fanwort, variable watermilfoil, and water chestnut. Water lilies, although native, have also developed extensive beds in the pond and often grow alongside fanwort and variable watermilfoil. Some of the recreational goals (i.e., access to Scout Island, boat launch improvement) are dependent on maintaining a large portion of the pond as open water habitat. These goals will need to be balanced with interests to maintain the ecological value of the shallow marsh habitat that occurs in significant portions of the pond, particularly on its western margins.

3.3 Bathymetry

Results of water depth surveys were used to create a bathymetric map for the pond (Figure 10). Warner's Pond was found to be shallow (generally less than 4 feet deep) in the western bays near the inlet. The deepest point in Warner's Pond is at a hole in the northern portion of the pond, where the depth is 12 feet. The total volume of water in the pond is estimated to be approximately 7,214,000 cubic feet (or about 54 million gallons) with a mean water depth of 3.4 feet (Attachment D).

Water flows through Warner's Pond relatively rapidly resulting in a high flushing rate for the pond. Field observations indicate that the dominant flow path leads from the inlet, to the north of Scout Island and then down to the outlet (Figure 10). There is less flow in the deeper pools and coves within the pond. The variety of depths and flow regimes provide aquatic habitat diversity.

3.4 Isopach Map and Sediment Quality

The thickness of soft pond sediments was measured along transects throughout Warner's Pond in order to generate a sediment isopach map (Figure 4). The thickest sediments were found in small pockets located around the small island in the northeast section of the pond. Additionally, deep soft sediment layers were also found in the northwestern corner of the pond where sediment thickness reached 9 feet deep. Sediment thickness averaged 2.8 feet across the entire pond. However, soft sediments in the southeast basin of Warner's Pond near the outlet were generally very thin (less than 1 foot). The total volume of soft sediments in Warner's Pond was estimated to be 5,934,000 cubic feet (220,000 cubic yards) which is a volume that is slightly less than that of the overlying water volume.

An assessment of overall sediment quality in Warner's Pond was conducted on February 17, 2011. The purpose of the analysis was to assess the feasibility of incorporating dredging as a management option for the pond. Results of the analysis provide insight into regulatory issues related to dredge spoils, should dredging be pursued as a management action. This study included analysis of bulk physical properties and a quantitative assessment of sediment chemical parameters.

Sediment core sample from Warner's Pond.

The color and texture of each sediment core collected was documented during the sampling effort. In addition, each sediment core was photographed (Attachment B). The majority of the sediment cores collected consisted of a dark brown, organic muck mixed with silt. A few of the sediment cores were dark, brown, organic mucks mixed with greater percentages of sand and clay. Refusal during sediment core collection was reached at either an underlying sand or clay layer.

A summary table of sediment chemistry results is provided (Attachment F). Sediment chemistry data was compared to the Massachusetts Contingency

Plan (MCP) Method 1 Soil Standards (Attachment F). These standards consider the potential risk of harm resulting from direct exposure to the hazardous constituent of the soil. The MCP defines three different soil types (S-1, S-2, & S-3), generally based on the potential for exposure to that soil. To be conservative, the lowest concentration level was used to evaluate the Warner's Pond sediment quality data. It should be noted that the MCP Method 1 standards apply to upland soils and thus are not directly applicable to the pond sediments. However, the MCP Method 1 standards will apply to any sediment dredged from the pond and would be used to determine whether the sediment is safe for beneficial reuse or how the sediment could be disposed.

Sediments collected near the inlet to Warner's Pond (composite sample SC-1 from the western basin) were below MCP Method 1 Soil Standards for all analytes evaluated. Similarly, in the eastern basin (composite sample SC-3) and southern basin (composite sample SC-4), each of the tested analytes were also below MCP Method 1 Soil Standards. This suggests that sediments in these basins are relatively free of contaminants of concern.

Sediments collected from the northern basin (composite sample SC-2) on February 17, 2011 exceeded the MCP Method 1 Soil Standards for chromium. Chromium occurs in two valence states, trivalent and hexavalent. Trivalent chromium is an essential element and is considered much less toxic than hexavalent chromium, both for acute and chronic exposure. Sediments from this area were re-sampled on September 2, 2011 and analyzed for hexavalent chromium to determine whether the observed exceedance was due to this valence state or the less toxic trivalent state. The results of the re-sampling effort indicate that the hexavalent chromium was not detected and that dredging is a feasible option (Attachment F).

Physical testing indicated that pond sediment was primarily fine sand according to the Unified Soil Classification System (Table 5). The north (SC-2), east (SC-3), and southern (SC-4) basins of Warner's Pond had "medium sand" as the dominant grain size in their sediments. The western basin (SC-1) near the pond inlet was primarily "fine sand" according to the Unified Soil Classification System.

Table 5. Unified Soil Classification System for Warner's Pond Sediments

Sample ID	Fines (Clay or Silt)	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel
SC-1	15.9	49.9	26.2	7.7	0.3
SC-2	17.1	29.3	39.7	13.0	0.9
SC-3	14.2	32.9	44.1	8.6	0.2
SC-4	11.1	31.2	40.3	17.1	0.3

The sieve analysis results, which are the basis of the Unified Soil Classification System, are presented in Table 5. Less than 1% of the sediment collected was greater than 4.75mm in diameter (fine gravel) (Passing #4) (Table 4 and 5). The smallest size fraction (fines) (Passing #200), ranged from 11% of the bulk dry-weight at SC-4 to 17% at SC-2.

Table 6. Results of Sieve Analysis for Sediment Sample, Warner's Pond

Sample ID	Sieve Analysis ASTM C 136, ASTM C 117							
	Percent Passing #4 (% by Wt.)	Percent Passing #10 (% by Wt.)	Percent Passing #20 (% by Wt.)	Percent Passing #40 (% by Wt.)	Percent Passing #60 (% by Wt.)	Percent Passing #80 (% by Wt.)	Percent Passing #100 (% by Wt.)	Percent Passing #200 (% by Wt.)
SC-1	99.7	92.0	77.2	65.8	59.1	53.3	49.4	15.9
SC-2	99.1	86.1	62.4	46.4	37.0	31.9	29.8	17.1
SC-3	99.8	91.2	66.8	47.1	36.6	31.0	28.2	14.2
SC-4	99.7	82.6	55.9	42.3	34.1	29.0	26.1	11.1

3.5 Sediment Loading and Water Quality Results

The results of the watershed reconnaissance described in Section 2.5 were used to identify locations with high, medium, and low potential to contribute sediment and nutrients to Warner's Pond (Figure 11 and Attachment C). The tributary and point source sampling locations were relocated as needed to target areas with the greatest potential to contribute sediment and nutrients to Warner's Pond.

Based on the reconnaissance, the primary sediment loading hotspot occurs along the reach of Nashoba Brook from downstream of Concord Road to the point at which Nashoba Brook turns south from Route 119/2A (Figure 11 and Attachment C). Numerous commercial and light industrial businesses line Nashoba Brook along Route 119/2A with little to no vegetative buffer along the banks of the brook. A dam just downstream of Concord Road in Acton impounds Nashoba Brook to form Ice House Pond. Although there are additional sources of sediment and nutrients from commercial development upstream of Ice House Pond, most of these upstream sediments are likely trapped behind the dam and do not reach Warner's Pond. Sampling location WP-5 was relocated downstream of Ice House Pond from its original location further upstream in order to better target the high priority sediment source locations along Route 119/2A (Figure 7).

Development along Fort Pond Brook, the other major tributary to Warner's Pond, is generally lighter. Drainage from commercial and residential development in West Acton and South Acton likely contributes sediment to Fort Pond Brook. Fort Pond Brook runs alongside the large impervious parking area of the Acton MBTA commuter rail parking lot, which is another potential sediment source. Another large impervious area associated with a facility at the corner of Hosmer Road and Route 2 is another potential sediment source to Coles Brook, which discharges to Fort Pond Brook.

ESS consulted the Town for additional information on sediment and nutrient loading sources to Warner's Pond. According to Concord Board of Health records, most of the homes on the streets that border Warner's Pond are on Town sewer. The exceptions are the homes on Wright Road and a small section of Laws Brook Road, which are primarily on septic systems (Figure 12). Failed septic systems may contribute to the nutrient load to the pond.

The majority of the stormwater outfalls along the perimeter of Warner's Pond that were examined during the watershed reconnaissance discharge to emergent and scrub-shrub wetlands that ring the western shoreline of the pond. Outfalls W-10, W-11, W-12 and W-14 all drain road runoff from Wright Road; however, bordering wetlands likely trap and attenuate much of the sediment load being discharged from these outfalls (Figure 7). Outfall W-15 drains runoff from Law's Brook Road which also discharges to a bordering wetland within Warner's Pond (Figure 7). Outfall W-17 was a high priority for sampling as it discharges runoff from Route 2 directly to Warner's Pond. One mapped outfall near the state prison could not be located and according to correspondence received from the Town, the outfall is likely buried.

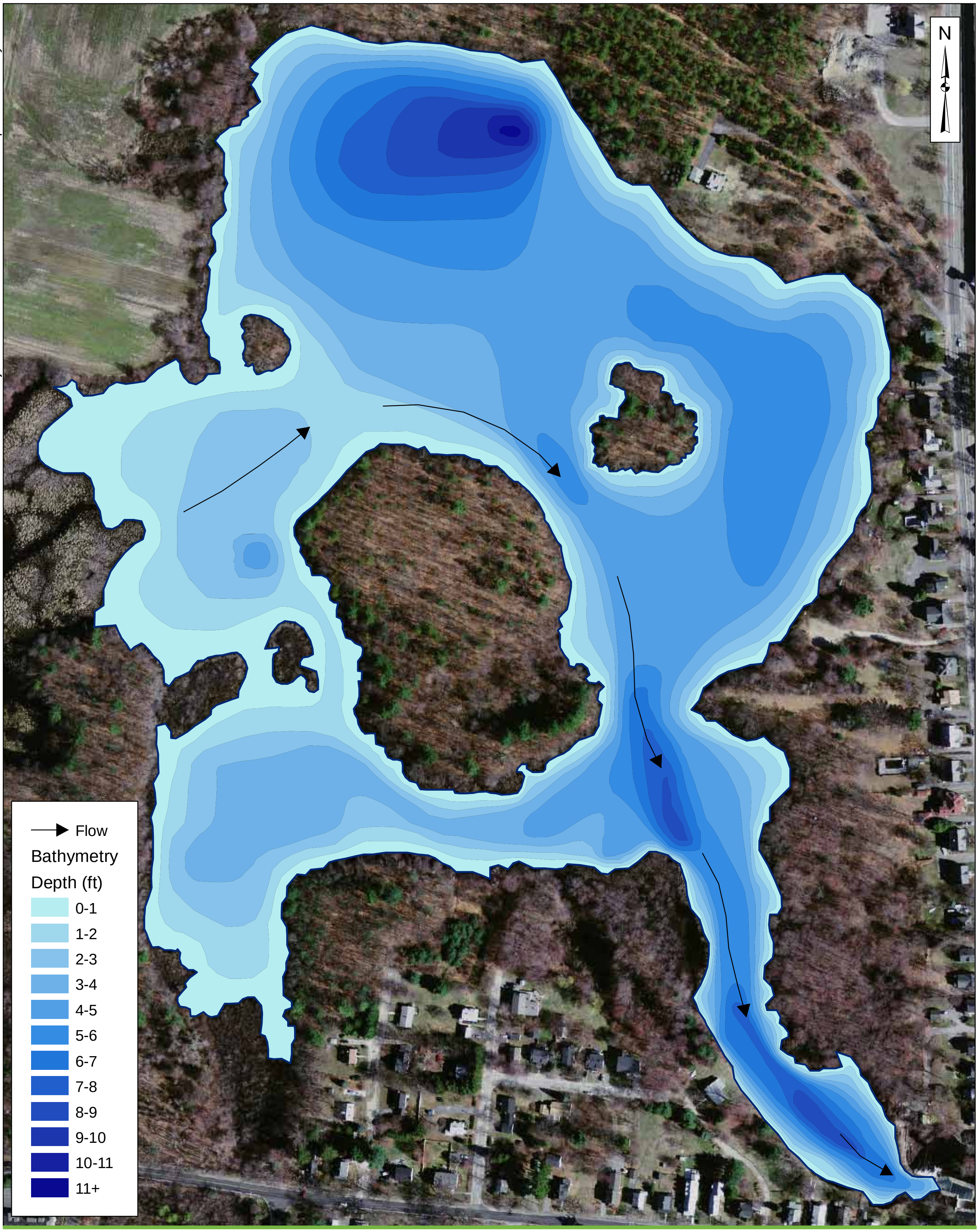
During dry weather sampling, total phosphorus levels were elevated (>0.02 mg/L) at all locations except the Warner's Pond surface site (Table 7). This result indicates that dry weather phosphorus levels contribute significantly to the excess nutrient load in Warner's Pond. The total suspended solid (TSS) levels, which are an indicator of sediment load, were all below the threshold of concern of 10 mg/L. The highest turbidity level was observed at WP-5, which was identified as a sediment loading hotspot during the watershed assessment.

Measuring flow from outfall and stormwater discharging to a catch basin on Wright Road during wet weather sampling.

It should also be noted that flow at the Warner's Pond outlet (WP-3) and Nashoba Brook sites (WP-2 and WP-5) was greater during dry weather than during the wet weather sampling, which may have been due to the timing of dry weather sampling, which occurred soon after Hurricane Irene. Although Irene itself did not produce extreme rainfall amounts over eastern Massachusetts (e.g., less than two inches fell in Boston), it capped off a wetter than average August and extended a period of relatively high stream flows. It is unlikely that this significantly skewed TSS and nutrient values. This is due to the tendency of sediment and nutrient transport to be higher at a given discharge during rising flows than when flows are receding. Given the several days of dry weather between Irene and dry weather sampling, Coles Brook, Nashoba Brook, and Fort Pond Brook were likely receding at the time of sampling. All other parameters fell within the range of expected values for dry weather sampling.

During wet weather sampling, total phosphorus levels were elevated (>0.02 mg/L) at Coles Brook and at all of the outfalls sampled (Table 7). The TSS level at WP-5 was elevated at 9 mg/L; WP-5 was identified as a sediment loading hotspot during the watershed assessment. Turbidity and TSS at two outfalls on Wright Road were also very high. Given the high total phosphorus levels observed during dry weather flow, we would expect to see even higher levels in the tributaries during wet weather flow. However, as described in Section 3.1, the stormwater samples were collected at the beginning of the storm after relatively little rain had fallen. In contrast to streams, water concentrates faster at outfalls, where turbidity and TSS were at levels that are more consistent with what is expected during a storm. Samples collected from tributaries later in the storm would likely have had higher levels of sediment after a greater volume of stormwater discharged to these waterbodies. Although nutrients and TSS were high in the outfalls on Wright Road, their relative contribution to the pollutant load in the pond is very low given the low flows that discharge from these outfalls, which were all well under 1 cubic-foot/second (cfs) (Table 7).

Location: G:/GIS-Projects/Warners-Pond-Concord/00-mxd/Report/bathmetry.mxd



WARNER'S POND MANAGEMENT PLAN

Warner's Pond Bathmetry

ess group
environmental consulting
& engineering services

Scale: 1" = 300'

0 300 Feet

Source: 1) MassGIS, Color Orthophotos, 2008

Figure 10

Location: G:/GIS-Projects/Warners-Pond-Concord/00-mxd/Report/Wtrshd_Assessment.mxd

ess group
environmental consulting & engineering services

WARNER'S POND WATERSHED MANAGEMENT PLAN

Watershed Assessment Results

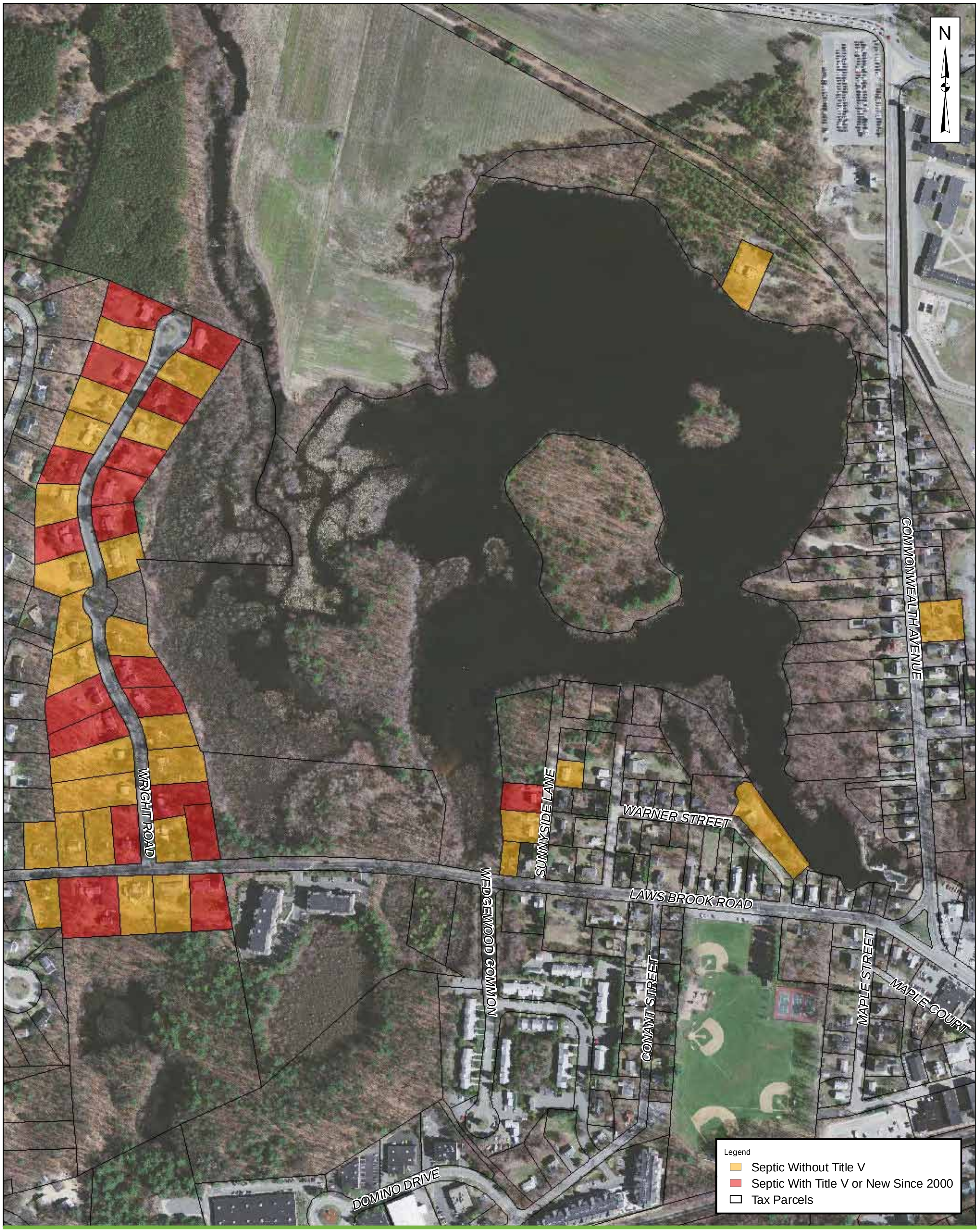
Scale: 1" = 3000'

0 3,000 Feet

Source: 1) MassGIS, Orthophotos, 2008

Figure 11

Location: G:/GIS-Projects/Warners-Pond-Concord/00-mxd/Report/Septic Status.mxd



WARNER'S POND WATERSHED MANAGEMENT PLAN

1 inch = 500 feet

0 125 250 500 Feet

environmental consulting & engineering services

Source: 1) MassGIS, Color Orthophotos, 2008
2) MassGIS, L0 Tax Parcel Data, 2008
3) Concord Board of Health, 2012

Septic System Status in Vicinity of Warner's Pond

Figure 12

Table 7. Results of Dry and Wet Weather Water Quality Sampling (Values of concern are indicated by yellow shading)

Date	Sample ID and Location	Temperature (°C)	pH	Conductivity (µS)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat)	Total Kjeldahl Nitrogen (mg/L)	Nitrate-N (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)	Secchi Depth (meters)	Streamflow (cfs)
Sept. 1, 2011 Dry Weather	WP-1: Fort Pond Brook Inlet	21.8	6.9	279.7	3.11	7.53	86.0	0.866	0.14	0.06	ND[2]	NA	22.0
	WP-2: Nashoba Brook Inlet	21.1	6.8	394.9	1.24	8.24	92.7	0.726	0.47	0.05	ND[2]	NA	20.0
	WP-3: Warner's Pond Outlet	22.0	6.7	286.9	1.15	6.41	73.3	0.956	0.17	0.04	ND[2]	NA	75.0
	WP-4: Coles Brook	18.9	7.0	982.0	2.19	7.57	81.7	0.692	1.00	0.04	ND[2]	NA	4.5
	WP-5: Nashoba Brook off Route 2A	21.2	6.8	387.5	6.44	7.40	82.9	0.855	0.39	0.04	ND[2]	NA	30.0
	WP-S: Warner's Pond surface	20.3	6.7	318.6	1.09	6.50	71.2	0.833	0.23	0.01	NA	1.25	NA
	WP-B: Warner's Pond bottom	19.3	6.4	313.2	1.65	2.29	26.9	1.150	0.24	0.06	NA		NA
Sept. 22, 2011 Wet Weather*	WP-1: Fort Pond Brook Inlet	17.2	6.2	405.3	1.20	5.82	58.3	0.612	0.35	ND[1]	ND[2]	NA	28.1
	WP-2: Nashoba Brook Inlet	17.2	6.2	473.0	2.34	7.21	74.9	0.553	0.88	ND[1]	ND[2]	NA	12.5
	WP-3: Warner's Pond Outlet	17.2	6.1	418.2	1.42	7.66	81.2	0.596	0.47	ND[1]	ND[2]	NA	36.0
	WP-4: Coles Brook	16.5	6.2	1,143.0	4.59	7.62	73.3	0.489	0.93	0.33	ND[2]	NA	5.3
	WP-5: Nashoba Brook off Route 2A	17.2	6.2	472.0	0.91	8.58	89.2	0.665	0.87	ND[1]	9	NA	21.0
	Outfalls												
	W-10: Wright Road	16.9	6.0	130.4	7.30	6.87	71.5	1.480	0.84	0.18	6	NA	0.001
	W-12: Wright Road	16.7	6.1	36.1	11.61	5.48	56.4	1.380	0.37	0.14	51	NA	0.003
	W-14: Wright Road	17.0	5.8	71.5	15.27	7.41	76.5	1.280	2.50	0.22	24	NA	0.025
	W-15: Law's Brook Road	16.0	5.9	764.0	8.67	4.61	45.9	0.910	0.85	0.10	5	NA	0.128
	W-17: Route 2	17.5	6.3	635.0	2.86	7.42	78.1	0.984	5.10	0.03	ND[2]	NA	0.090

ND[1] = Total phosphorus detection limit 0.01 mg/L
ND[2] = TSS detection limit 4.00 mg/L
NA = Not applicable
*Samples collected during first flush of storm, which was of sufficient intensity for wet weather sampling. However, the number of samples collected was limited by the short duration of the first pulse of this storm.

The TSS levels collected during water quality sampling were used to estimate the relative contribution of the main tributaries and nearby outfalls to the overall suspended sediment load to Warner's Pond (Figure 13). Not surprisingly, outfalls (W-10 to W-17) contribute less than 1% of the load, even though their TSS concentrations were higher than the tributaries (Table 7). The total sediment load from the sampled tributaries and outfalls was estimated to be approximately 108 to 162 cubic yards (cy)/year. There is approximately 65 to 98 cy/year of sediment leaving the pond via the pond outlet. This results in net in-pond deposition of approximately 43 to 64 cy/year, or about five ten-ton dump trucks full of sediment per year.

Due to the large watershed of Warner's Pond, much of it outside the Town boundaries, exhaustively documenting sediment and nutrient hotspots was not practical as part of this study. However, it is anticipate that the National Pollutant Discharge Elimination System (NPDES) general permit for Municipal Separate Storm Sewer Systems (MS4s) will provide a systematic process for finding and eliminating hotspots at the municipal level throughout most of the watershed.

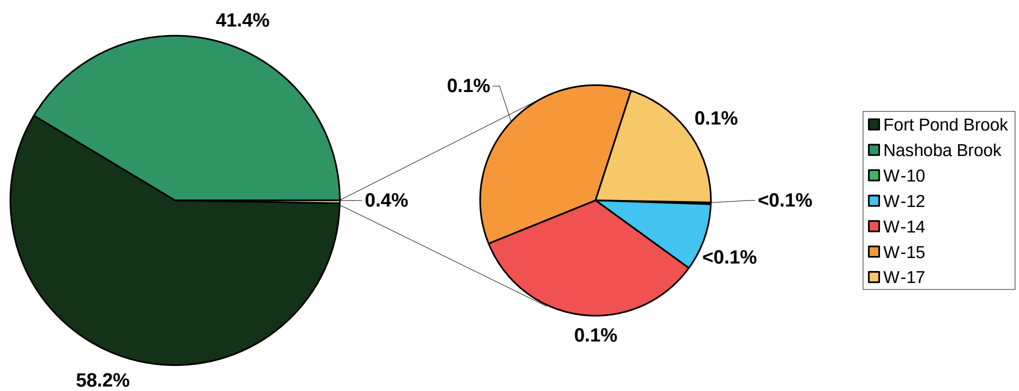


Figure 13. Relative Contribution of Sediment from Tributaries and Storm Water Outfalls

3.6 Hydrologic Budget and Nutrient Load Modeling

The results of the hydrologic budget and nutrient load modeling for Warner's Pond are presented in Attachment D.

The average annual precipitation for Warner's Pond is estimated to be 45.79 inches. This value was used for precipitation inputs during the hydrologic modeling for Warner's Pond. Estimated average water input to Warner's Pond from surface water tributaries, groundwater, and direct precipitation is 86.4, 0.01 and 0.17 cfs, respectively, for a total average annual flow of approximately 86.6 cfs (Attachment D). This average annual value for flow will vary appreciably among seasons and weather conditions. Surface water flow contributes significantly (99%) to the total pond inflow, while groundwater inflow and direct precipitation to the pond surface contribute the remaining 1% combined. The surface water flow can be further divided into dry weather flows (40%) and wet weather flows (60%). A summary of key hydrologic parameters for Warner's Pond is presented in Table 8.

Table 8. Summary of Warner's Pond Hydrology

Element	Value
Watershed Area	29,849 acres
Pond Area	49 acres
Pond Circumference	15,225 feet
Pond Volume	7.21 million cubic feet
Average Groundwater Seepage Inputs	0.012 cfs
Average Direct Precipitation	0.172 cfs
Average Surface Water Inputs	86.433 cfs

Based on total pond volume (7.2 million cubic feet) and the estimated flow through the system, average detention time was calculated to be 0.949 days (0.0026 years). Since detention time represents the duration of time necessary to exchange the volume of water in the pond one time this means that the water entering Warner's Pond is retained for less than a day's time, on average. Flushing rate is the inverse of detention time and represents the number of times per year the pond volume is replaced; for Warner's Pond the flushing rate is nearly 379 times per year. This is an extremely high flushing rate but is not unexpected given the large watershed to pond area ratio (approximately 612:1). The flushing rate indicates that water moves through Warner's Pond very quickly and in many regards, it is more appropriate to view the pond functioning as a large, wide pool within a river system rather than a pond.

A calculation of minimum nutrient load was made by multiplying the volume of the pond by its flushing rate and the average concentration of the nutrient observed during this study. The minimum phosphorus and nitrogen loads delivered to Warner's Pond were determined to be 24.99 $g/m^2/yr$ (4,930 kg/yr) and 504.58 $g/m^2/yr$ (99,547 kg/yr), respectively, based on the in-pond nutrient concentrations observed during the study (Attachment D).

The actual load of phosphorus or nitrogen will exceed the estimated minimum load as a consequence of loss processes that reduce the in-pond concentration over time. A more detailed and realistic estimate of nutrient loading can be obtained by using a combination of actual field data and in-pond modeling theory, e.g., Vollenweider, 1975 and Reckhow, 1977). Nutrient loads are calculated based on nutrient values measured within the pond and hydraulic features of the system. Based on this approach, the predicted phosphorus load necessary to achieve the values found in Warner's Pond ranges between 22.80 g/m2/yr (4,498 kg/yr) using the Vollenweider (1975) model and 27.96 g/m2/yr (5,516 kg/yr) using the Reckhow (1977) model (Table 9). The average predicted phosphorus load for all models was 24.99 g/m2/yr (4,930 kg/yr). The nitrogen load necessary to achieve the observed in-pond concentrations was estimated to be 529.35 g/m2/yr (104,434 kg/yr) (Bachmann 1980) in this manner (Table 9).

As described in Section 2.6, 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 pond which were calculated from the hydrologic budget. The modeling results indicate that the existing conditions for phosphorus in Warner's Pond greatly exceed the permissible load and critical load. The average of phosphorus loads estimated for the pond through the in-pond models (4,930 kg/yr) is much greater than the permissible level of 393 kg/yr and the critical level of 785 kg/yr. This indicates that the phosphorus levels in Warner's Pond are much higher than desirable and at levels that would likely result in algal blooms and poor water clarity throughout the growing season. Given this understanding, it is actually beneficial that Warner's Pond has an extremely high flushing rate since any significant algal blooms that might otherwise occur are more likely to be rapidly flushed through the system.

Similar loading limits for nitrogen have not been established, owing to the less predictable relationship between nitrogen, pond hydrology, and primary productivity. Although nitrogen data are very useful in understanding in-pond conditions and processes, phosphorus is the logical target of management actions aimed at maintaining water quality conditions in Warner's Pond.

Table 9. Summary of Warner's Pond Nutrient Loading Models

Nutrient	Model Output	Value
Phosphorus	Minimum Load	4,486 kg/yr
	Model Average Load	4,930 kg/yr
	Permissible Load	393 kg/yr
	Critical Load	785 kg/yr
Nitrogen	Minimum Load	99,547 kg/yr
	Bachmann (1980) Load	104,434 kg/yr

The land use based model developed for the three major sub-basins in the Warner's Pond watershed included Fort Pond Brook, Nashoba Brook, and the area immediately surrounding Warner's Pond (Table 10). This modeling demonstrates that the portion of the watershed located primarily in Concord contributes only approximately 5% of the total phosphorus load and 3% of the nitrogen load to Warner's Pond. When considered in light of the in-pond nutrient load modeling results, which indicate that more than an 80% reduction in phosphorus loading is necessary, even eliminating all sources of phosphorus in Town would not be nearly enough to bring Warner's Pond phosphorus back below the critical load.

The nutrient model results guided the management recommendations to focus on in-pond techniques as opposed to watershed-wide techniques as described in Section 4.0 and Section 5.0. The modeling results demonstrate that even an 80% reduction in the phosphorus load to Warner's Pond will still mean in-pond levels will be well above the critical load and the water quality issues associated with these high levels. Therefore, constructing stormwater BMPs throughout the watershed, developing vegetated buffers, and implementing other phosphorus-load reducing techniques within the watershed are likely to be important but of low value. Given the size of the watershed and the fact that the watershed spans multiple towns, in-pond techniques for management are likely to provide a more economical and meaningful approach than a watershed-wide approach that would require watershed-wide agreement.

Table 10. Average Annual Nutrient Load by Land Use within the Warner's Pond Watershed Sub-basins*

Sub-basin	Land Use Classification	Acres	Percentage of Phosphorus Load	Percentage of Nitrogen Load
Fort Pond Brook	Cropland and Pasture	653.1	6%	6%
	Currently Developed (Residential/Commercial)	4363.2	76%	38%
	Forest	7562.7	10%	40%
	Open/Cleared Land	210.0	0%	1%
	Transportation	195.2	3%	2%
	Water	282.5	0%	0%
	Wetland	2656.7	5%	14%
	Sub-basin Contribution (%)		**52%**	**53%**

Sub-basin	Land Use Classification	Acres	Percentage of Phosphorus Load	Percentage of Nitrogen Load
Nashoba Brook	Cropland and Pasture	574.3	6%	6%
	Currently Developed (Residential/Commercial)	3633.2	77%	38%
	Forest	6777.3	11%	43%
	Open/Cleared Land	414.9	1%	3%
	Transportation	97.3	2%	1%
	Water	386.9	0%	0%
	Wetland	1575.0	3%	10%
	Sub-basin Contribution (%)		**43%**	**44%**
Warner's Pond	Cropland and Pasture	54.1	14%	16%
	Currently Developed (Residential/Commercial)	145.9	73%	43%
	Forest	151.6	6%	27%
	Open/Cleared Land	3.1	0%	1%
	Transportation	10.0	5%	3%
	Water	46.3	0%	0%
	Wetland	55.6	3%	10%
	Sub-basin Contribution (%)		**5%**	**3%**

*Export coefficients based on median value predicted by Reckhow (1980), Lin (2004), Rast and Lee (1978)

4.0 MANAGEMENT GOALS

The Town is seeking ways to improve the pond's overall ecological value and management actions means to implement recreational improvements that will not decrease the ecological values that currently exist at the pond. The Town has expressed an interest in the following:

- Maintaining or improving water quality
- Controlling exotic/invasive species
- Preserving native plant species within the pond and its adjacent wetlands to the greatest extent feasible
- Maintaining high quality wildlife habitat value

Given the number of issues currently affecting Warner's Pond, including excessive aquatic weed growth, excessive sediment accumulation, and excessive nutrient and sediment loading, a wide range of management options need to be considered and evaluated to maintain or improve in-pond conditions.

A review of each of the management options with regard to their ability to achieve the defined management objectives, as defined above, is presented below.

5.0 SHORT AND LONG-TERM MANAGEMENT OPTIONS AND RECOMMENDATIONS

This section presents the range of options for improving water quality and/or reducing aquatic weed growth within Warner's Pond based on the goals stated in Section 4.0. Prioritized recommendation summaries are provided in Table 11 the reasoning behind these recommendations is provided in greater detail within the sub-sections.

Approval from the Natural Resources Commission will be required in order to implement any approach in Warner's Pond. If two or more approaches are combined into one filing, the required permitting efforts should be easily combined at little additional cost. Any management recommendations involving manipulation of the water level in Warner's Pond would need to be approved by and coordinated with the dam owner (Concord Public Works).

Table 11. Management Options Assessed and Listed by Priority for Action

Priority	Approaches	Issue(s) Addressed	Primary Pros	Primary Cons	Cross-reference
Recommended Short-term Actions					
1	Herbicide (Fluridone)	Fanwort control	Works quickly and provides control for two or more seasons	Limited effectiveness in Warner's Pond due to high flushing rate and extent of fine sediments– will likely require reapplications	Section 5.1.1
2	Herbicide (2,4-D)	Variable watermilfoil control	Works quickly and provides control for two or more seasons	• May require setbacks to prevent migration into adjacent wells • Requires less contact time to be effective than fluridone but can still be affected by flushing rate	Section 5.1.1
3	Mechanical Control (Hand Harvesting)	Water chestnut control	Effective and can be done by volunteers	Infestations can quickly re-emerge if not diligent. Annual removal of water chestnut prior to seed set is required	Section 5.1.2
		Control of small or shoreline infestations of other species			
4	Biological Control (Loosestrife Beetles)	Purple loosestrife control	Inexpensive with no anticipated collateral damage to desirable native species	• Population requires time and contiguous areas of purple loosestrife to become established. May need to reintroduce if population flags • Eradication not feasible through biological control alone	Section 5.1.3
5	Bottom Sealing	Local macrophyte control	Immediately effective in eliminating macrophyte growth	Numerous drawbacks, most notably the high cost. Best over very small areas (<1 acre).	Section 5.1.4
6	Drawdown	Shallow-water macrophyte control	May achieve good control in shallow waters at minimal operating cost	• Effectiveness limited by weather • Reduces or eliminates winter recreation activities and fish habitat • May impact downstream waters	Section 5.1.5
7	Hydroraking or Rotovation	Water lily control	Best way to quickly control water lilies and create open water habitat	• Encourages spread of vegetatively reproducing species (less of a problem in Warner's Pond due to nearly pond-wide establishment of invasive exotics) • Expensive	Section 5.1.6

Priority	Approaches	Issue(s) Addressed	Primary Pros	Primary Cons	Cross-reference
Recommended Long-term Actions					
1	Control Nutrient and Sediment Loading	Water quality	Addresses underlying problems at the source (i.e., in the watershed)	• Does not address internal (in-pond) recycling of nutrients • Warner's Pond watershed is so large, with so many nutrient and sediment sources that sensible improvements in water quality will require lots of time, expense, and regional coordination to achieve	Section 5.2.1
2	Dredging	Shallow water depth	Addresses multiple in-pond problems and lasts for decades	• Expensive • Lengthy permitting process • Reduces or eliminates access to the pond during dredging	Section 5.2.2
		Thick sediment deposits			
		Overall macrophyte control			
Options Assessed but not Currently Recommended					
	Aeration and/or Destratification				Section 5.3.1
	Plant Competition				Section 5.3.2
	Chemical Sediment Treatment				Section 5.3.3
	Dilution and/or Flushing				Section 5.3.4
	Shading Dye		See text for details		Section 5.3.5
	Herbicides (Excluding Fluridone and 2,4-D)				Section 5.1.1
	Biological Controls (Excluding loosestrife beetles)				Section 5.1.3
	Nutrient Inactivation				Section 5.3.6

5.1 Short-term Management Recommendations

5.1.1 Chemical Treatment (Herbicides) – Selected formulations recommended only as short-term or interim approach

Herbicides remain a controversial aquatic weed control measure in many communities because of their association with pesticides, which is generally perceived to be negative. However, as we learn more about the various negative impacts that can be associated with alternative physical and biological management options, chemical control measures continue to be used as part of many balanced pond management plans.

Although no herbicide is completely safe or harmless, a premise of federal pesticide regulation is that the potential benefits derived from use outweigh the risks when registered herbicides are applied according to label recommendations and restrictions. Current herbicide registration procedures are far more rigorous than in the past and the ability of qualified and licensed applicators to target applications of herbicides further improves the relative safety of using these chemicals for nuisance aquatic plant control. Each of the herbicides evaluated in this Plan present some degree of risk with regard to potential toxicity to non-target organisms and temporary recreation restrictions would be needed for herbicide applications at Warner's Pond.

Where exotic aquatic plants infestations have become extensive and well-established (as with fanwort in Warner's Pond), pondwide herbicide treatment is usually the most effective initial control option. Chemical treatment will also be the most cost effective means by which to immediately achieve the goal of reducing aquatic weed biomass.

As herbicides can only be applied by state licensed herbicide applicators, this is not an option that pond residents can undertake themselves. It should also be noted that herbicide treatment alone would not provide for long term, sustainable control of nuisance aquatic plant growth. However, when integrated with other management strategies as part of a comprehensive plan which includes watershed and in-pond level approaches, herbicides can play a valuable role in managing nuisance growth.

Costs for permitting an herbicide treatment are typically low but could be somewhat high if there is significant opposition to this management approach. Permits could be denied, appealed, or rigorously conditioned, the last of which could add cost both through constraints on the treatment process and monitoring expenses.

<u>Herbicide Control of Fanwort</u>

Fluridone – Systemic Herbicide: In Warner's Pond, fanwort is the dominant species of concern and the only herbicides which are effective on fanwort are fluridone (tradename Sonar) and the more recently available flumioxazin (tradename Clipper). Fluridone was applied in the pond as a slow-release pellet formulation during the summer of 2011. Although the results of this treatment did show effective control in many areas, the high flushing rate of Warner's Pond make the use of fluridone extremely challenging since it is imperative to maintain a target concentration throughout the treatment area for a minimum of a three week period to achieve the desired level of control. Fine sediments also make pelletized treatment difficult, since pellets in mucky areas may sink below the sediment-water interface thereby precluding the maintenance of effective in-water fluridone levels. It may be possible to re-apply fluridone pellets to the targeted management zone (Figure 14) to control fanwort as needed going forward if this approach is still desired. Costs for this approach are likely to be on the order of $1,000 per acre or about $8,000 for controlling fanwort within the targeted management zone between Scout Island and the public access point (allowing for some overtreatment beyond the 6.1 acre targeted zone to occur to get the desired results within the target zone). Although the effectiveness of fluridone treatments could last as long as five years under ideal conditions, treatments in Warner's Pond would likely need to be repeated more frequently – every other year or at least every third year.

Flumioxazin – Contact Herbicide The herbicide, flumioxazin is a much faster acting contact herbicide that can achieve results in less than 24 hours. This would theoretically allow for it to be applied selectively to specific larger beds of fanwort (or variable watermilfoil) while avoiding areas of the pond where weed control may not be desired. Flumioxazin is currently approved for use by the US EPA and registered in 46 states including five of the six New England states; unfortunately, Massachusetts is not yet one of these states. Therefore, flumioxazin cannot currently be recommended for Warner's Pond.

Herbicide Control of Variable Watermilfoil

Variable watermilfoil could be effectively managed through the use of herbicides. The three most effective herbicides for targeting variable leaf milfoil in Warner's Pond are presented below.

Diquat dibromide – Contact Herbicide**:** For Warner's Pond one of the most immediate approaches for controlling variable watermilfoil growth would be with the contact herbicide known as diquat (trade name Reward). As a contact herbicide, diquat can clear large areas of weeds in a very short time. Treatment of the milfoil beds throughout the entire pond (in excess of 20 acres of treatment) could be performed at a cost of approximately $8,000 to $10,000 per treatment (including permitting) and would clear the pond of most milfoil. Because diquat is a contact herbicide, it does not typically kill rooted portions of aquatic vegetation and follow-up applications would be needed to control growth each year. Additionally, diquat is not selective and would also likely reduce the biovolume of native plants. A pond-wide diquat program would likely need to be phased in at least three partial-pond treatments in order to avoid excessive nutrient release and oxygen demand due to the decaying plant material.

The use of the contact herbicide diquat is not ideal, particularly since the costs would not decrease significantly on an annual basis. This approach would not be recommended as anything more than a very short-term solution to the problem at hand. If other techniques to control the milfoil on a pond-wide basis prove to be ineffective or difficult to permit, a diquat treatment program targeting the 6.1-acre targeted management area (Figure 14) could be performed at an annual cost of about $3,000.

Triclopyr – Systemic Herbicide**:** The dicot selective systemic herbicide known as triclopyr (Renovate OTF) is a growth regulating herbicide that would be an option for achieving longer term control of the variable leaf milfoil problem because systemic herbicides are able to kill the roots of the plants as well. A joint study by the U.S. Army Corps of Engineers (USACE) and the state of New Hampshire showed triclopyr to be very effective in controlling variable leaf milfoil when the targeted dose was maintained for a period of at least 12 hrs (Getsinger et al., 2003). One of the most recent and comprehensive investigations on the effects of triclopyr on variable leaf milfoil showed that it provided "good" control across a broad range of concentrations (Netherland and Glomski, 2008). However, in a recent Rhode Island application in Lake Mishnock in 2007 and 2008 (Aquatic Control Technology, 2008), triclopyr did not prove to be as effective at lower doses and although control at higher doses was achieved, the additional cost to attain these higher concentration levels resulted in a treatment program that was not cost effective.

One of the major benefits of using an herbicide such as triclopyr as compared to diquat is the ability to be selective for dicots such as milfoil while having much less to no impact on most natives such as lilies and pond weed (*Potamogeton*) species. This represents a much more sustainable solution and is protective of the necessary native plant species and habitat they afford to pond biota.

One drawback of triclopyr is the longer (two to four days is ideal) contact period required for maximum effect. A poorly planned or executed treatment might not achieve appreciable improvement over large areas of the pond given the high flushing rates observed for Warner's Pond. This may be countered by drawing the pond down slightly in advance of the treatment and this may result in better control.

Additionally, triclopyr treatments are comparatively expensive. Costs to treat Warner's Pond with triclopyr are likely to be on the order of $1,000 per acre. A treatment program targeting variable milfoil beds in the targeted management area of the pond would be expected to require cost of approximately $8,000 plus permitting costs. Treatment should be expected to last for at least two years, perhaps even three, but additional efforts would also be required to address milfoil growth in non-treatment areas. Alternatively, the costs for a nearly whole pond treatment using triclopyr would be expected to exceed $30,000.

Given that triclopyr is relatively fast acting the treatments would need to be performed in a phased approach with no more than half of the pond being treated at a given time to minimize the potential for nuisance algal blooms or fish kills due to low oxygen levels.

2,4-D – Systemic Herbicide: The granular form of the systemic herbicide known as 2,4-D (trade name Navigate) is likely to be the most effective herbicide to combat variable leaf milfoil (Netherland and Glomski, 2008) and is also the most economical given its ability to achieve multiple years of control. Like triclopyr, 2,4-D is a growth regulating herbicide that is selective for dicots, which means that it will be effective on milfoil while having less impact or no impact on desirable plant species such as the native pond weeds and water lilies. The real advantage of using 2,4-D over triclopyr is that it has been shown to be the most effective herbicide at controlling variable leaf milfoil and it can be applied at about half the cost of triclopyr (assuming an application rate of 100 lbs/acre or $500/acre). Therefore, assuming treatment of the 6.1-acre targeted management area plus an allowance for overtreatment, using 2,4-D could achieve two to three years of variable milfoil control in Warner's Pond for a cost of about $4,000.

Of the three herbicide treatment options discussed above for variable watermilfoil, the one that makes the most sense from an economic perspective is the use of 2,4-D since the cost per acre is relatively modest and the effects are more specific to the target plant and will last for more than one year. A major drawback to this herbicide is the potential for the herbicide to migrate through soils and negatively impact wells adjacent to a pond. This option would need to be evaluated with homeowners that may have wells around the pond. If a private well were determined to be in use, it would be necessary to establish setbacks from the pond shore for treatment to minimize the potential for treated water to be drawn into the wells. ESS recommends that the nature of the wells that could potentially be drawing water from Warner's Pond first be investigated by a qualified hydrogeologist and, if necessary, by a human health and environmental risk assessor, to assist in determining the fate and transport potential of 2,4-D so that specific setbacks, if any, can be recommended and included as part of the permitting conditions. Costs for this critical step are likely to be on the order of $4,000 to $5,000. In areas where a setback is required but milfoil control is still required, diquat may be used as long as this option has been included in the permitting application and approved.

Total costs for an herbicide program which included a treatment with 2,4-D to control variable watermilfoil within the targeted management zone (Figure 14) and the use of slow-release fluridone within the same area to control fanwort, along with the necessary investigations, permitting, and monitoring would be on the order of $17,000 for up to three years of control. Costs could escalate if there is any significant opposition to herbicide treatment by watershed stakeholders.

Given the results from the recent attempts to manage fanwort through the use of fluridone, which is the only herbicide currently registered in Massachusetts that is known to be effective against fanwort, it is recommended that other techniques (discussed below) may be more cost effective and appropriate for use over the long-term. If weed growth is not effectively managed through other methods and the fanwort eventually returns to dominate the pond's aquatic plant community within the targeted management zone, then the use of herbicides would be worth considering further, particularly if flumioxazin is approved for use in the state since this herbicide would effectively combat both fanwort and variable watermilfoil.

Herbicide Control of Other Species

Exotic species of emergent plant growths in Warner's Pond could be controlled with the herbicide glyphosate (trade name Rodeo) on a selective basis, if needed. This is not currently recommended, as most of the emergent plant cover consists of native species that do not present a significant detriment to use of the pond by wildlife or enjoyment of the pond for recreation. Purple loosestrife is probably best managed through a combination of biological controls (Section 5.3) and manual removal (Section 5.11). Evidence of leaf damage indicates purple loosestrife is already being devoured by *Galerucella* spp. beetles.

Other species that should be managed at Warner's pond include exotic water chestnut (which has been hand harvested by the Town and WPSC for several years), and if desired, native water lilies. Water chestnut is best managed through mechanical harvesting rather than herbicides. Water lilies are best controlled through hydro-raking or rotovation. These methods are discussed below in Sections 5.10 and 5.11

5.1.2 Macrophyte Harvesting – Recommended for Small Scale Control Only

Macrophyte harvesting covers a wide range of techniques, including mechanical harvesting and hand pulling. Mechanical harvesting, which involves cutting and pulling aquatic plants from a specially-equipped watercraft, is most effective in the short term. As mechanical harvesting simply sets plants back for the season, its use should be reserved for scenarios where there is an immediate but temporary need for widespread reduction of nuisance plant cover.

Mechanical harvesting is not currently a recommended management option for Warner's Pond because it is relatively expensive, typically results in only single season control and may not be physically feasible given the shallow water in many areas of the pond. Furthermore, the dominant plants of concern are milfoil and fanwort which both spread through vegetative fragmentation, therefore using a harvester may actually encourage the spread or re-colonization of these weeds over time.

The simplest form of harvesting is hand pulling of selected plants, which is recommended with approval from the NRC. Depending on the depth of the water at the targeted site, hand pulling may involve wading, raking, snorkeling, or SCUBA diving. Hand pulling often involves collection of pulled plants and fragments in a mesh bag or container that allows for transport and disposal of the vegetation. In deeper water, frequent trips to the surface are necessary to dispose of full bags. The intensive nature of this work limits its application to small areas, typically much less than one acre in size. Hand pulling can directly confirm removal of entire individual plants, typically resulting in longer control of plant growth in targeted areas.

In a small pond like Warner's Pond, hand pulling will be most appropriately used to manage or control the growth and spread of water chestnut since these plants are readily managed by the removal of the flowering portion of the plant which spreads across the pond surface and contains the seed head. Water chestnut should be monitored closely and hand harvested annually to ensure that its levels are kept in check. Harvesting should occur in early summer before the seeds mature and drop from the plants to ensure that new growth will not occur from these seeds. Over time, this effort should deplete the seed bank within the pond's sediment and the overall plant densities may decline or be eliminated.

Hand pulling would also be a feasible and a reasonably cost-effective method of aquatic plant control over select areas where weed-free access is desired. Hand pulling is most effective as a "clean-up" control method to be used in conjunction with other methods, especially where aquatic plant beds are particularly dense or extensive.

5.1.3 Biological Control – Recommended on a Limited Basis for Purple Loosestrife Control

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 significant level of control is observed.

Eurasian watermilfoil (*Myriophyllum spicatum*) is the only submergent plant that has been shown, at least experimentally, to be able to be controlled using "watermilfoil weevils" (*Euhrychiopsis 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 pond by placing infested water milfoil strands within the targeted water milfoil beds of the pond. The best results are usually achieved in controlling watermilfoil in ponds with dense, monotypic stands of Eurasian watermilfoil with several years being required to measure a positive effect. Because Eurasian watermilfoil is not known to be established in Warner's Pond, the water milfoil beetle approach would not be appropriate.

Purple loosestrife (*Lythrum salicaria*) may sometimes be controlled using loosestrife beetles (*Galerucella spp*.). Adult beetles tend to stay within a small territory, especially when beetle density is low, which makes natural dispersal of populations very slow (NCERA-125, 2008). Consequently, loosestrife beetles work best as a control method where contiguous stands of purple loosestrife occur. Where purple loosestrife is present in small patches along shorelines, hand harvesting is likely to be the best control method. As with the watermilfoil weevil, larvae play the biggest role in actual control of the plant. While the damage from adults is mostly limited to superficial leaf damage, larvae can kill back shoots by burrowing into the stem. It may take several years for loosestrife beetle populations to grow to a sufficient density to make a measurable difference in purple loosestrife cover. Additionally, loosestrife beetles are unlikely to eradicate purple loosestrife infestations. This highlights one of the primary drawbacks of biological control using specialist herbivores, namely that a host population of the undesirable plant must be maintained in order to prevent the herbivore population from collapsing.

Adult loosestrife beetles can be obtained (with a permit) at a cost of $275 to $300 for 1,000 beetles. It is recommended that release of adult beetles be limited to areas with significant contiguous infestations, which primarily occur along the shallow western margins of the pond. Isolated purple loosestrife infestations along the remaining shoreline would be best controlled by manual removal (Section 5.11).

Biological controls for the other plant species are almost unknown. An herbivorous fish (*Ctenopharyngodon idella*, the grass carp) has been used for general macrophyte control on an experimental basis in smaller ponds in Connecticut and New York, but has not shown a preference for any one species, and is not approved in Massachusetts. Stocking of grass carp is therefore not recommended at Warner's Pond.

5.1.4 Bottom Sealing – Recommended for Use over Small Areas

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. They may have positive side effects such as creating more edge habitat within dense plant assemblages and minimizing turbidity generation from fine bottom sediments. Benthic barriers are best used for providing control of milfoil, fanwort, and other nuisance growth on a localized basis. They are likely to be of most use in heavily used areas near shore and in the vicinity of the Warner's Pond access off Commonwealth Avenue or other shoreline structures.

Barrier materials have been commercially available for decades and a variety of solid and porous are available. However, deployment and maintenance of benthic barriers continues to be difficult and this limits their utility over the full range of weed bed sizes.

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 if desired. However, keeping barriers in place is desirable for preventing recolonization by nuisance species.

The ability of vegetative fragments to recolonize porous benthic barriers such as fiberglass screening has made them less useful for combating infestations by milfoil or fanwort on any but the smallest scale, as sheets must be removed and cleaned regularly, often yearly. Solid barriers have been more useful, although the gas released during decomposition in the sediments below can cause the barrier to billow, necessitating the use of anchors or vents that can reduce the lifespan of the barrier.

Problems associated with benthic barriers include long-term integrity of the barrier, billowing caused by trapped gases, accumulation of sediment on top of barriers, and growth of plants on porous barriers. Benthic barriers are also non-selective, which means all plants in the treatment area are killed, including desirable native plants. By smothering bottom sediments, barriers can also impact the benthic macroinvertebrate community within the treatment area, which may locally reduce food sources for some fish. Another drawback of benthic barriers is that recolonization from adjacent plant beds can occur quickly, once the barrier has been removed. Additional effort, such as hand harvesting, might be necessary for two growing seasons or more.

Cost and labor are the main factors limiting the use of benthic barriers in most ponds, and would be prime deterrents in Warner's Pond. The cost per installed square foot is on the order of $2.00, leading to an expense approaching $90,000 per acre. Bulk purchase and use of volunteer labor can greatly decrease costs, but use over large areas of nuisance vegetation is highly unlikely.

Benthic barriers could be useful by the Town or private landowners to address nuisance plant growth along small shoreline areas, where deployment and any subsequent maintenance would be relatively simple. A small installation immediately offshore from the public access point would be worth considering even with the use of other management approaches.

5.1.5 Water Level Control (Drawdown) – Recommended

Drawdown involves lowering the water level of a pond to expose shallow bottom sediments and associated plants (both native and non-native) to drying and/or freezing. It is most effective against species that reproduce mainly by vegetative means, including fanwort and variable watermilfoil. Drawdown is less effective on species that reproduce primarily by seed (such as the invasive exotic species water chestnut and curly-leaf pondweed) and may expand beds of these species. Under some circumstances, drawdown may also encourage the spread of purple loosestrife in hydrologically connected wetlands. In Warner's Pond, this would primarily be a concern in the water willow dominated wetlands on the western margin of the pond, where purple loosestrife is already present.

Ponds with rapid drop-offs to great depths tend to benefit most from drawdown. Due to the shallow bathymetry of much of Warner's Pond, drawdown is only likely to provide limited control of aquatic invasive plant growth. Although drawdown can be conducted at any time, the interaction of drying and freezing that occurs with winter drawdown is usually most effective. Environmental restrictions and recreational uses also limit the appropriate window for drawdown to the winter period. In Massachusetts, winters are often variable in their intensity and the ideal winter condition of very cold weather with limited snow cover (which insulates the plants) is not likely to be achieved any more frequently than every other year.

"Ice rip" is a drawdown technique that focuses on physical removal of rooted aquatic plants by managing ice cover to literally "rip" the plants, including roots, from shallow areas. This technique is not recommended for Warner's Pond as variable watermilfoil and fanwort spread primarily by fragments (not roots) and it is unlikely to be more effective than a standard drawdown program. Additionally, the rapid induced fluctuation of water levels and ice cover may exacerbate shoreline or downstream erosion, suspend bottom sediments and associated nutrients that are lifted with the ice, negatively impact bottom-dwelling fauna, disrupt hibernating reptiles and amphibians along the margins of the pond, reduce the safety of winter recreation activities on the ice, or compromise the dam.

In order to effectively drawdown a pond, there must be an adjustable discharge structure that allows the water level to be safely controlled. The water level must be drawn down to a sufficient depth (typically at least 3 feet) and for a long enough period of time to allow bottom sediments to at least partially de-water. Aside from the practical feasibility of performing a drawdown, the potential impacts on winter recreation (primarily ice fishing and skating) should also be considered.

If drawdown is pursued as a management strategy, a drawdown feasibility study would first need to be developed that would identify potentially sensitive habitats or biota that may be present within the pond, its downstream waters, or within hydrologically connected wetlands. The drawdown feasibility study would also examine the feasibility of drawdown with regard to controlling hydraulics (related to the amount of water Warner's Pond can hold, how much would be lost during the drawdown, and limitations concerning where the water goes downstream), flooding, and impacts to downstream and hydrologically connected wetland resources (e.g., drying) and would be used to establish a current baseline condition as well as to support permitting.

A Drawdown Operations Plan would need to be developed, inclusive of all hydrologic calculations, to guide dam operators on methods for managing the drawdown timing, the release rate, and the magnitude of drawdown. The Drawdown Operations Plan will also provide protocols for monitoring the system to ensure protection of biota within pond and associated waters while also achieving a better level of control on the targeted milfoil and fanwort. Given the substantial amount of relevant data already collected under the current study, the costs for performing the drawdown feasibility study and preparing the Drawdown Operations Plan are likely to be on the order of $8,000.

Once this information has been determined and the Drawdown Operations Plan is developed, it will then be necessary to file a Notice of Intent application with the NRC. Assuming that a Drawdown Operations Plan is developed, filing a permit to conduct a drawdown at Warner's Pond is likely to cost between $3,000 and $4,000 to prepare and file based upon the nature of the impacts and the supporting studies.

Given that Warner's Pond has a recently improved outlet control structure and has recently conducted a minor drawdown for a weed control project, a drawdown of up to 3 feet to manage aquatic vegetation should not be difficult to permit. Figure 15 depicts what the surface of the pond would look like under a 3-foot drawdown scenario. A greater target depth of up to 5 feet could be envisioned for the pond and would be more likely to control weed growth in the shallower portions of the pond due to more intense dewatering. However, a 3 foot drawdown would likely be favored by permitting authorities in order to reduce impacts to fish, amphibians, reptiles, and invertebrates such as freshwater mussels, which are all present at Warner's Pond.

Drawdown typically reduces habitat volume, access to spawning areas, and availability of dissolved oxygen, among other parameters, each of which is an important factor in the success of fish populations and should be considered prior to drawdown implementation. Overwintering amphibians may also be sensitive to fluctuating water levels during drawdown if it exposes them to dry or freezing conditions. Additionally, invertebrate species, especially those that are slower moving, may be desiccated or frozen if drawdown occurs too rapidly. Therefore, ESS would not recommend a drawdown greater than 3 feet without additional study, in light of concerns over potential impacts to fish and wildlife.

If drawdown were determined to be feasible and could be successfully permitted, impacts to aquatic resources in the pond would need to be monitored annually as a permit condition, which could cost $5,000/year. Monitoring for potential impacts due to drawdown should focus on the mollusk population, water quality, wildlife habitat, and changes to hydrologically connected wetland plant communities. Such a drawdown program has been successfully implemented at Nabnasset Lake in Westford, Massachusetts for over 10 years. ESS has worked with the local lake association to monitor the lake and its hydrologically connected wetlands and found little or no permanent impact to sensitive non-target species.

5.1.6 Hydroraking and Rotovation – Recommended only for limited control of water lilies

Hydroraking uses a backhoe-like machine mounted on a barge to remove plants directly from pond sediments. Depending on the attachment used, plants are scooped, scraped, or raked from the bottom and deposited on shore for disposal. Rotovation is essentially underwater rototilling of pond sediments. Rotating blades cut through roots, shoots, and tubers, dislodging and expelling them from their growing locations. Some operations are also outfitted to collect some or most of the rotovated plant materials. Both hydroraking and rotovation are most useful for local control of water lilies and other plants with large rhizomes or tubers, as these methods can physically remove or destroy the bulky portions of the plant.

Hydroraking has been previously attempted at Warner's Pond. It proved to be an effective approach at managing water lilies in selected areas but would not be recommended against vegetatively reproducing species such as milfoil and fanwort. The primary disadvantage of hydroraking and rotovation is that they spread invasive plants that reproduce via vegetative fragmentation. However, this is not currently a major deterrent in Warner's Pond due to the fact that variable watermilfoil and fanwort appear to have colonized all available habitats in the pond. Fragment barriers could be deployed around management areas prior to hydroraking or rotovation to reduce escape of vegetative fragments. If dredging proves to be too costly to implement in the near term, continuing with a hydroraking program within the targeted management zone (Figure 14) may be an appropriate alternative to maintaining some open water habitat within the pond. Costs to perform hydroraking vary depending upon a number of factors, but based on first hand experience at this pond previously it is estimated that costs will be on the order of $7,000 per acre, plus permitting costs. This would need to be repeated periodically, perhaps every three to five years, to maintain desired conditions.

5.2 Long-term Management Recommendations

5.2.1 Control Nutrient and Sediment Loading – Recommended for Long-term Improvement

Nutrient loading analysis indicates that the phosphorus load to Warner's Pond is far beyond the critical level, suggesting that it will continue to be a eutrophic water body under current conditions. This condition is due primarily to the large relative size of the pond's watershed in relation to the size of the water body itself. The system receives a significant fraction of the nutrients from surface flows including storm water runoff being delivered to the pond via its tributaries.

An educational program for watershed residents, particularly those living close to Warner's Pond and the other ponds in its watershed should be developed. Initial education and outreach should focus on items that individual residents could implement easily and at minimal to no cost. These actions include minimizing the impact of yard care (particularly fertilization), pet waste management, maintaining or planting buffers at the pond margins, and other small behavioral changes that would improve the pond's water quality. Development of a full-color tri-fold brochure would be a good way to raise awareness among Concord residents. Brochures could potentially be made available at the Commonwealth Avenue access location and/or distributed to watershed residents at minimal cost by mailing out with water bills or other regular Town correspondence.

Development and redevelopment within the watershed should incorporate LID storm water techniques to prevent further deterioration. This may now be implemented in Concord through enforcement of the newly adopted stormwater regulations; but gaining improvements within the other towns that comprise the majority of the watershed may be more challenging. While implementation of other watershed BMPs should be considered whenever possible, the amount of phosphorus that would need to be removed to bring water quality in Warner's Pond below the critical load threshold is extremely large and achieving needed reductions in such a large watershed would be very difficult. Therefore, while controlling nutrient and sediment loading is recommended as an ongoing effort to maintain or improve water quality watershed-wide, the primary focus for management of Warner's Pond should be on in-pond management.

5.2.2 Dredging – Recommended as Suitable Long-Term Option for Targeted Area

Dredging works as a plant control technique when either a light limitation is imposed through increased water depth or when enough soft sediment is removed to reveal a less hospitable substrate for plant growth (e.g. hard bottom or other nutrient-poor substrate). Light limitation through increased depth is possible in Warner's Pond, particularly since water clarity is already relatively poor. It may not be necessary to dredge the entire pond to achieve a satisfactory level of plant control, but it would be necessary to do a thorough job in any area where control is to be achieved or greater depths are desired.

Dredging in Warner's Pond could be an effective long-term control technique for nuisance aquatic plants within the targeted management area (Figure 14), but will be costly. The challenges of a project of this type are not unreasonable. The key factor influencing the approach and costs for moving forward with a dredge program at Warner's Pond will be the ability to draw down the pond to allow for dredging within the drained basin to occur using conventional excavation equipment. This is most likely an environmentally sound and feasible approach if conducted during the winter months when wetland areas associated with the pond would be dormant. This approach would allow for sediment to be dewatered within the basin itself by pulling the sediment up to the margins of the pond to allow water to drain back into the main portion of the basin. Given that Warner's Pond has a significant amount of water flowing through the system it may not be possible to entirely dewater the targeted work area without advanced water management techniques such as temporary coffer dams or the creation of channels to route the flow of water around the work area.

Geotubes used to dewater hydraulically dredged material

If conventional "dry" dredging is not determined to be feasible for Warner's Pond due to equipment access issues or water management concerns, hydraulic dredging would be a viable alternative. Hydraulic dredging is generally more expensive than conventional dredging for limited projects and it would require a larger and more sophisticated containment area to dewater the sediment as it is removed from the pond.

Alternatively, advanced dewatering techniques such as the use of Geotubes (geotextile fabric for dewatering) or a belt-filter press machine could be used instead but these would add additional costs over traditional dewatering containment. All of these external sediment dewatering options will require land adjacent to the pond to be made available for the dewatering process. The town's public access lot would be adequate space for the use of a belt-filter press machine, but a larger area would be required for either the use of the Geotubes (>1.0 acres) or a standard dewatering basin (> 2 acre). Pumping material to the open land adjacent to the prison to the north east of the pond that would be acceptable; however, the ability to use this location has not been investigated as part of this study.

The amount of material to be removed and the type of disposal or reuse will also have a significant impact on the cost of dredging. Environmental permitting for dredging projects is moderately complex and will require up to a year before the project could receive all required approvals. Federal (USACE 404), state (MEPA Certificate and 401 Water Quality Certificate) and local permits (Notice of Intent filed for Order of Conditions from the DNR) are all required, and would necessitate considerable advance information and review time.

With an estimated soft sediment volume of approximately 220,000 cubic yards in Warner's Pond, the cost of a dry or hydraulic dredging project for the entire pond would likely run between $5,000,000 and $8,000,000 (including permitting and design) for removal of all of the soft sediments, although not all sediments would necessarily need to be removed to achieve light limitation throughout the pond. Costs could increase if sediment cannot be reused or disposed of in the immediate vicinity of the pond.

A more realistically scaled project designed to deepen the critically important area between Scout Island, Pond Street, and the Commonwealth Avenue public access to a maximum depth of 12 feet (the depth needed to provide aquatic macrophyte control through light limitation) would yield a dredge volume of approximately 30,000 cubic yards over the 6.1-acre targeted area depicted in Figure 14. Costs to dry dredge this volume of material would likely range between $550,000 and $800,000 with permitting and design costs likely to add an additional $75,000 to this total.

If dry dredging is not feasible, hydraulic dredging for a similar scale project would range between $725,000 and $1,100,000 plus up to an additional $100,000 for permitting and design depending on the method of dewatering selected.

Chemical content of the material to be dredged is an important consideration in determining the feasibility of reuse or disposal. Disposal costs could vary greatly depending on whether the material can be beneficially reused. If the material removed from the pond is clean, which we believe it will be based on our analysis, it is useful as a soil amendment. It is possible that the material may potentially be sold to local garden suppliers or landscape businesses which would make the project more economically feasible. However, material that is not suitable for beneficial use would need to either be amended with clean material (potentially from within the basin) to dilute the concentrations to suitable levels or trucked to a site for disposal. Either of these options would increase the cost of the project and, depending upon the level of implementation, could potentially make dredging a less cost effective option.

Based on the sediment sampling results obtained as part of this study (Attachment F), sediment is suitable for upland reuse currently, or at a minimum would only need to be amended slightly prior to stockpiling or beneficial use. MassDEP will make a final determination on suitable reuse options for the material as part of the permitting process.

If dredging is considered to be a viable long-term option, the next steps would be:

1. Assessment of specific scope and extent of dredge program including possible funding options.
2. Additional chemical and physical analysis of the sediments in areas targeted for dredging. The cores collected as part of the current study were valid for assessing sediment quality over a large portion of the pond. However, for permitting purposes, one core will need to be collected specifically from the target dredge area for each 1,000 cubic yards of sediment proposed to be dredged. The level of effort will be based on the final volume of material to be dredged. Assuming a total of 30,000 cubic yards, 30 cores (forming 10 composite samples) will need to be collected.
3. Development of an engineering design for submission to permitting authorities.
4. Initiation of the permitting process including an Environmental Notification Form filing for MEPA (Massachusetts Environmental Policy Act) review, filing a local Notice of Intent under the Wetlands Protection Act, filing for a Section 401 Water Quality Certificate from MassDEP, and seeking a U.S. Army Corps of Engineers Section 404 Permit for dredging.

These four activities might be expected to cost up to $50,000 for Warner's Pond given the work already completed as part of this study, but are essential if dredging is to be pursued as a management option. Additional design costs would include final engineering design following the permitting process (incorporating any accepted changes resulting form these reviews) along with the development of a bid specification package for the project.

Assuming the estimated sediment accumulation rate of 43 to 64 cy/year derived in Section 3.5 and a dredge volume of 30,000 cubic yards in the targeted management area, refill could be expected to take several hundred years. Using a conservative estimate of a 100-year project lifespan, the annualized dredging cost of a conventional dredging project would be $5,500 to $8,000 per year, not including permitting. This estimate is based entirely on measured TSS load and could be higher or lower depending on pond circulation patterns, in-pond algae and macrophyte production, and the occurrence of catastrophic weather events.

5.3 Options Considered but not Recommended

5.3.1 Aeration and/or Destratification – Not Recommended

Aeration and/or destratification (or circulation) is used to treat problems with high algal growth and low oxygen concentrations that may occur in smaller ponds. Air diffusers, aerating fountains, and water pumps are typical types of equipment that may be installed to increase circulation in a pond. The cost of purchasing, installing, and maintaining pond circulation equipment becomes substantial as pond size increases. Likewise, the effectiveness of the equipment tends to decline with pond size as it is difficult to achieve sufficient circulation in large ponds.

This approach is not currently recommended for Warner's Pond, primarily because sedimentation and excessive aquatic plant growth (rather than planktonic algal growth) are the targets for restoration of the pond. Additionally, Warner's Pond's high flushing rate would minimize the effects of any aeration since the aerated water would quickly pass downstream.

5.3.2 Plant Competition – No Recommended Actions Identified

The presence of a healthy, native plant community can often suppress the spread of invasive aquatic species. A plant competition biocontrol technique seeks to supplement native species through seeding and planting disturbed or bare areas before they can be colonized by invasives. The overall goal of the technique is to maximize spatial resource use by desirable species to keep out undesirable invasive species (Wagner, 2004).

The advantages of this approach are that it uses natural processes to control aquatic invasives, may be self-perpetuating after an initial establishment period of several years, and can be easily integrated with other approaches. It is likely to be most effective after elimination of an invasive plant community through an initial herbicide treatment or mechanical removal followed by native species plantings.

There are several challenges associated with the plant competition approach which makes its long-term effectiveness uncertain. Periodic natural disturbances within a plant community provide continual opportunities for recolonization by invasives, which would require ongoing effort with supplemental native plantings (Wagner, 2004). The use of seeding or planting native vegetation is also still experimental and these native species may not become established quickly enough to prevent invasion by exotics.

Costs for implementing this approach will vary depending on the species and area being planted and are largely unknown, but estimates of more than $5,000 per acre would not be unexpected. Though it might be useful as a trial approach to determine the feasibility of establishing a viable native plant plot within the pond following treatment with herbicide to document the growth and expansion of a replacement plant community, plant competition is not recommended for widespread use in Warner's Pond because of its high initial cost and the fact that it is still largely experimental and would most likely involve multiple years of ongoing labor to supplement native plants.

5.3.3 Chemical Sediment Treatment – Not Recommended

This management option consists of adding compounds to alter sediment features and thereby limit plant growths or control chemical exchange reactions. Although compounds such as alum and iron(III) chloride have been shown to have some effect on internal nutrient cycling, these compounds must be expertly applied and buffered to be effective while avoiding fish kills. New products, such as lanthanum-modified bentonite clay (trade name Phoslock), might be expected to achieve similar results. However, given the overwhelming load of phosphorus (far larger than the critical load) and sediment from external sources and the expense of conducting a chemical sediment treatment in Warner's Pond, this action is unlikely to result in a cost-effective and long-term reduction in phosphorus or aquatic macrophyte growth. Therefore, chemical sediment treatment is not recommended.

5.3.4 Dilution or Flushing – Not Recommended

Dilution and flushing involve increasing the flow rate so as to dilute or remove concentrations of nutrients or other pollutants in the pond. It requires an appropriate outlet structure and must take into account the potential downstream impacts of increased flow and "flushing" of nutrients. Due to the relatively large ratio of flow to pond volume, Warner's Pond naturally flushes at a rapid rate. Large additional inputs of clean water would need to be continually supplied to effectively dilute the concentration of phosphorus in Warner's Pond. Additionally, pond sediments are believed to hold a large amount of nutrient that would sustain aquatic plant growth, through root uptake, well into the future even if significant dilution or flushing could be achieved. Therefore, dilution and flushing are not recommended.

5.3.5 Shading Dye – Not Recommended

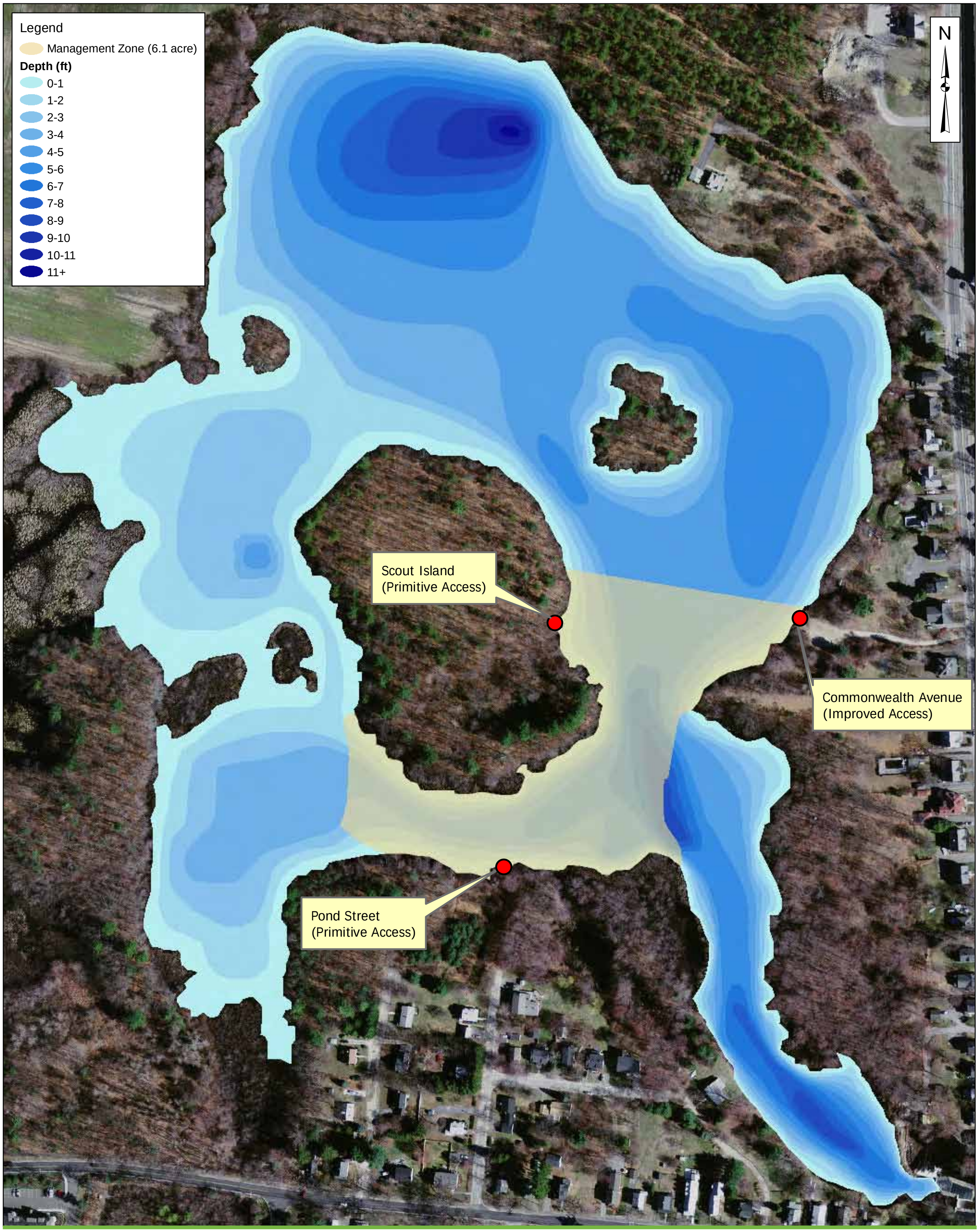
Dyes are used to limit light penetration and therefore restrict the depth at which rooted plants can grow. In essence, they mimic the effect of light inhibition that might be expected during periods of high turbidity or prolonged ice and snow cover. Natural periods of low light are an important variable in determining plant composition and abundance, and use of dyes can produce similar effects. They are only selective in the sense that they favor species tolerant of low light or with sufficient food reserves to support an extended growth period (during which time the plant could reach the euphotic zone). Dyes tend to reduce the maximum depth of plant growth, but are relatively ineffective in shallow water (less than 6 ft or 1.8 m deep). Dyes are unlikely to make a significant difference in plant growth within shallow bodies of water like Warner's Pond. Additionally, maintaining a high concentration of dye in the pond would be impossible, given its very high flushing rate. Therefore, the use of shading dye is not currently recommended.

5.3.6 Nutrient Inactivation – Not Recommended

Nutrient inactivation typically targets dissolved phosphorous (the form most readily available to plants and algae) and involves the addition of alum (aluminum sulfate) or similar aluminum based compounds that bind to this phosphorous to allow it to settle into the pond sediments. In its simplest form, nutrient inactivation is conducted by applying alum directly to the pond as a single dose. More sophisticated nutrient inactivation programs involve proportional injection of alum into stormwater sources or tributaries so that phosphorous is inactivated before it even enters the pond.

Nutrient inactivation is typically used to control algae blooms and improve water clarity. These are not considered to be key target issues for the shallow waters of Warner's Pond, where nuisance growth of aquatic plants and accumulated sediment are the primary problems. An alum dosing system designed to target the incoming phosphorus would be effective, if sized appropriately, at managing the phosphorus content in the waters of the pond; however such a system would be extremely expensive to run given the large volume of inflows that the pond receives. Therefore, nutrient inactivation is not recommended for Warner's Pond.

Location: G:/GIS-Projects/Warners-Pond-Concord/00-mxd/Report/Plant-Cover.mxd



WARNER'S POND WATERSHED MANAGEMENT PLAN

Scale: 1" = 300'

0 300 Feet

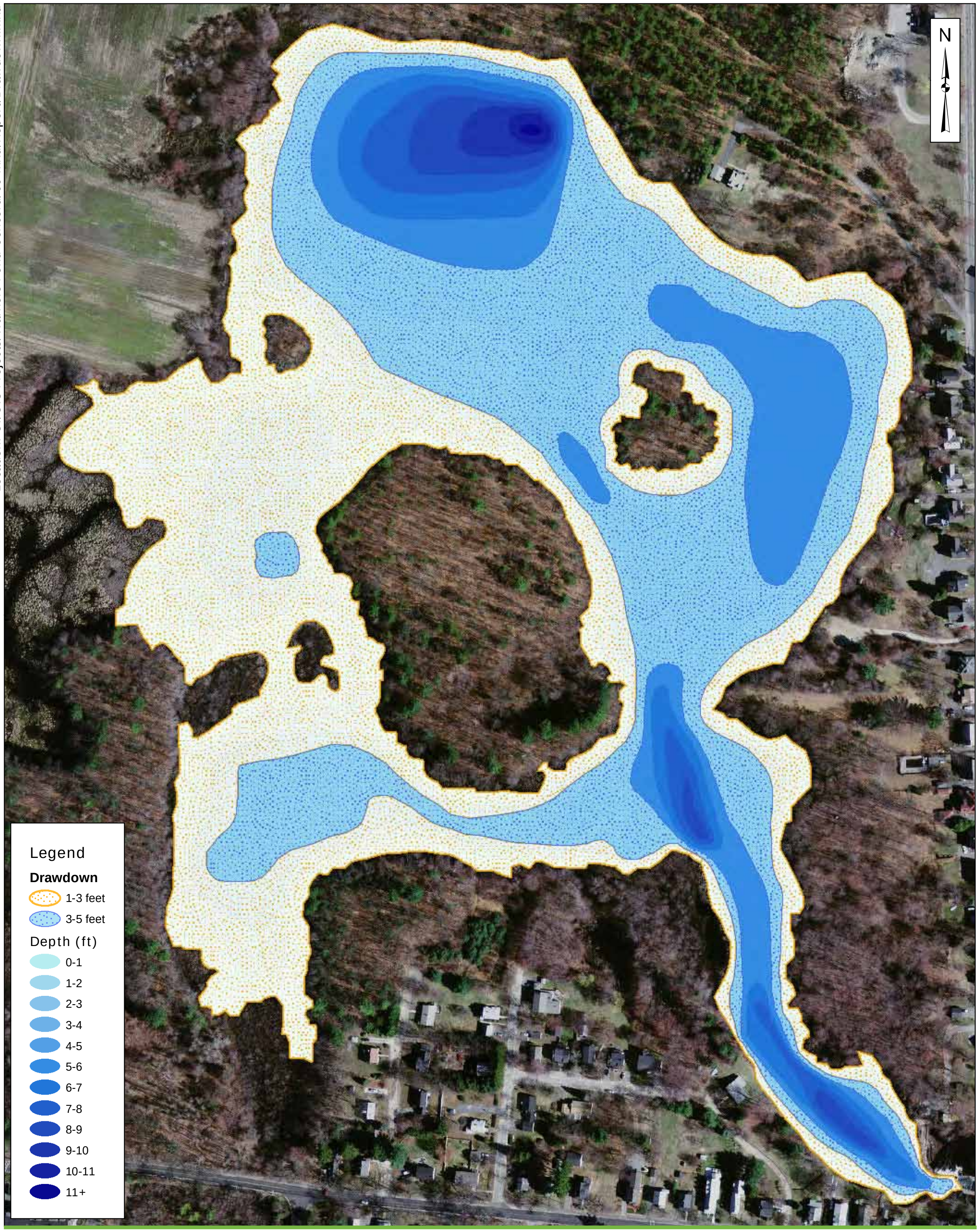
Source: 1) MassGIS, Color Orthophotos, 2008

ess group
environmental consulting
& engineering services

Warner's Pond
Proposed Management Zone

Figure
14

Location: G:/GIS-Projects/Warners-Pond-Concord/00-mxd/Report/Drawdown.mxd



WARNER'S POND WATERSHED MANAGEMENT PLAN

Warner's Pond
Areas Exposed Using Drawdown

ess group
environmental consulting
& engineering services

Scale: 1" = 300'

0 300 Feet

Source: 1) MassGIS, Color Orthophotos, 2008

Figure
15

6.0 IMPROVE PUBLIC ACCESS

Some improvement to the public's ability to access Warner's Pond can be achieved through modest improvements to the existing public access point on Commonwealth Avenue along the pond's eastern shoreline. Such improvements might include the addition of gravel to solidify the parking area, improved signage at the pond or other amenities such as a bench, picnic table, or trash receptacle. Management of weed beds at this location to improve pond access for watercraft should be focused on creating "boating channels" rather than removing all vegetation. Leaving some weed beds intact will provide habitat preferred by larger warmwater game fish, such as largemouth bass, near the access point. This should help to maintain or improve fishing opportunities from shore.

Whatever improvements are made to the actual parking configuration layout or surfacing would require local permitting to be filed through the Natural Resources Commission. Other amenities could be included in this permitting effort for public discussion purposes as well; however, it should be kept in mind that these types of improvements often require maintenance costs (e.g. trash disposal) or periodic replacement due to wear and tear. These structural improvements to this access area, if kept to the modest level envisioned, are likely to cost on the order of $8,000 to $15,000 for design, permitting and construction at the Commonwealth Avenue site.

Creation of a new public access at the end of Pond Street is not recommended. The Commonwealth Avenue access point should be the focus of primary improvements given that this facility is already available and in use. However, the Pond Street area could be improved as a primitive access by maintaining and pruning back vegetation along a defined trail system leading to the pond. Such minor improvements would allow for occasional use by non-motorized boats (canoe or kayak) or shoreline fishing if also combined with a limited shoreline vegetation management program. Likewise, Scout Island could also be similarly maintained to have a primitive but defined access point with selective vegetation clearing, as needed. Having defined and maintained areas for access by boats is actually a wise approach as this will reduce the potential for impacts to shoreline vegetation along other areas of the pond and, if sites are properly maintained, they will also offer a safer access and egress from the pond.

Establishing a Town swimming dock or beach is not currently recommended, due to water quality concerns and budgetary limitations. In addition to the capital improvements this would entail, the liability, maintenance and monitoring costs for public swimming areas are high.

7.0 MONITORING PROGRAM

A cost-effective monitoring program would provide continuous background data for the purpose of tracking the effectiveness of any future management practices at Warner's Pond. Because water quality in Warner's Pond is already failing to meet the stated objectives, the water quality monitoring program should focus on tracking in-pond 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 levels would be the key variable in this regard, along with easily measured field parameters (pH, dissolved oxygen, temperatures, conductivity, turbidity, and clarity [Secchi depth]). 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, often with multiple sample dates in each year. Evaluation of management techniques would be more immediate, allowing comparisons between pre- and post-management periods. A program could be custom designed to fit within an appropriate budget, but a cost of between $5,000 and $8,000 per year should be dedicated in order to include some level of water quality and plant community assessment along with a review of data by a qualified expert. Monitoring plant cover in the pond should be performed on an annual basis to track expansion of variable watermilfoil and fanwort as well as to direct harvesting efforts for water chestnut as well as to support early detection of any new aquatic invasive species that may spread into Warner's Pond. Plant monitoring also allows evaluations of implemented management actions to be made and strategies adjusted, as necessary.

8.0 SUMMARY OF MANAGEMENT RECOMMENDATIONS AND CONCLUSION

The most critical management action identified through this study is the need to address invasive aquatic weed growth, particularly the extremely dense fanwort and variable watermilfoil present throughout much of the pond. In addition, water chestnut is also an invasive that demands continued attention as it can quickly get out of control if left unmanaged. Purple loosestrife, while problematic and undesirable in surrounding wetlands and shorelines, does not directly impact in-pond recreational opportunities. However, management of this species should be included for ecological reasons. Water quality is very poor, characterized by extreme nutrient loading due to the large volume of nutrient-rich water being delivered to the pond by its extensive watershed. Given this, water quality conditions are beyond a level where active management would make significant improvements. However, this aspect of management should not be overlooked when it comes to developing a comprehensive pond management program.

To address water quality issues in the watershed ESS recommends:

1. Implement an education program for watershed residents, particularly those living close to Warner's Pond and the other ponds in its watershed, about the benefits of proper yard care (fertilization being a key focus), pet waste management, maintaining buffers along stream corridors, and other behavioral changes that can be adopted to make improvements in the pond's water quality.

   Educational costs can vary widely depending upon the level of implementation. A typical program to develop a watershed specific, tri-fold brochure focused on the above topics can be created specifically for Warner's Pond watershed residents for less than $3,000. Some towns have opted to distribute brochures with utility bills or other town mailings for very little additional cost. The 319 Non-Point Source Pollution grant program used to fund a portion of the costs for education as part of a comprehensive project to reduce NPS pollution within the watershed; however, this program may not fund such projects in this watershed going forward due to recent regulatory changes to the program.

2. Additional safeguards for protecting future water quality can also be provided through improvements to the watershed's storm water infrastructure. The addition of storm water detention and infiltration facilities at key runoff locations could greatly reduce the phosphorus reaching the pond and would also be able to significantly reduce bacterial contamination as well. There are numerous storm water BMPs currently in the watershed, although most of these may not be adequately maintained or have been designed to remove water from roadways quickly rather than encouraging infiltration. Going forward it should be encouraged that development and improvements to highway infrastructure be designed incorporate infiltrating chambers to the outflows or other LID features such as grassed swales, rain gardens, detention ponds, etc. Opportunities for enhancing storm water infiltration for developed properties in the watershed should be identified systematically. A study to evaluate the watershed to identify the sites that may be superior candidates for retrofitting with LID or other storm water management techniques would be expected to cost on the order of $30,000 to $40,000.

To address public access at Warner's Pond, ESS recommends:

3. Public access to Warner's Pond can be improved through modest improvements to the existing public access point on Commonwealth Avenue along the pond's eastern shoreline. Such improvements might include the addition of gravel to solidify the parking area, improved signage at the pond or other amenities such as a bench, picnic table, or trash receptacle. These structural improvements to this access area, if kept to the modest level envisioned, are likely to cost $8,000 to $15,000 for design,

permitting, and construction at the Commonwealth Avenue site. Additional maintenance costs would be associated with keeping the area clean and providing trash removal services.

Restoration of Warner's Pond in a manner that is comprehensive and long lasting will require additional investment. Based on our findings in this study and on the previously reported management efforts in this regard, ESS is recommending the following actions be taken to address invasive plant management objectives:

4. For fanwort and variable watermilfoil, herbicides are likely to be the most effective option available at Warner's Pond over the short-term and are recommended as the most appropriate means by which to get the system back to a level where the invasive species can be managed through more sustainable options. Presently, these exotic species occupy over 20 acres of the pond at varying densities.

   Fluridone pellets (trade name Sonar) may be applied to the targeted management zone to control fanwort as needed going forward. Costs for this approach are likely to be on the order of $1,000 per acre or about $8,000 for controlling fanwort within the targeted management zone between Scout Island and the public access point (allowing for some overtreatment beyond the 6.1-acre targeted management area to occur to get the desired results within the target zone). Given the difficulty in achieving ideal herbicide contact times at Warner's Pond, this approach would likely need to be repeated every other year, or at least every third year, until other longer term management actions can be implemented.

   Variable watermilfoil may be controlled with the granular form of the systemic herbicide known as 2,4-D (trade name Navigate). 2,4-D will achieve two to three years of variable milfoil control in Warner's Pond for a cost of about $4,000 for the targeted management area. There are no known public or private supply wells around the perimeter of the pond. However, if a private well were determined to be in use, it would be necessary to establish setbacks from shore to minimize the potential for treated water to be drawn into the wells. We recommend that the nature of the wells that could potentially be drawing water from Warner's Pond first be investigated by a qualified hydrogeologist and, if necessary, by a human health and environmental risk assessor, to assist in determining the fate and transport potential of 2,4-D so that specific setbacks, if any, can be recommended and included as part of the permitting conditions. Costs for this critical step are likely to be on the order of $4,000 to $5,000 for Warner's Pond. In areas where a setback is required but milfoil control is still required, diquat may be used as long as this option has been included in the permitting application and approved.

   Assuming permits are issued without significant complication, total costs for an herbicide program which include a treatment with 2,4-D to control variable watermilfoil within the targeted management zone and the use of slow-release fluridone within the same area to control fanwort, along with the necessary investigations, permitting, and monitoring would be on the order of $25,000 for up to three years of control.

5. Hand harvesting is a cost-effective means of controlling water chestnut growth in Warner's Pond. Plants can be easily identified and pulled by volunteers to save on cost. Water chestnut should be harvested annually in early summer (i.e., prior to seed maturation) to ensure that its levels are kept in check. With persistence, it may be possible to deplete the water chestnut seed bank in Warner's Pond to the point that growths of this plant are effectively eliminated. However, annual monitoring would still be recommended to identify and control any re-infestations due influx of seeds from any upstream sources. While hand harvesting will be most effective for water chestnut control, it may also be used on a small scale to supplement other control methods in invasive watermilfoil and fanwort beds.

6. Purple loosestrife may be controlled using loosestrife beetles. Adult loosestrife beetles can be obtained (with a permit) at a cost of $275 to $300 for 1,000 beetles. Beetle release should focus on contiguous infestations primarily occur along the shallow western margins of the pond. Isolated purple loosestrife infestations along the remaining shoreline would be best controlled by manual removal.

7. Benthic barriers can be used on a localized basis if herbicide use is not welcome or within critical areas that must remain weed free such as at the public access point. Barrier material could be placed at the public access for an estimated cost of between $10,000 and $20,000 depending upon the area to be managed. Although permits are likely to be required, very little long-term environmental impact can be expected from such a management approach. This approach also does not address the weed issue on a basin-wide basis or within a broader area that might be envisioned to benefit broader recreational uses such as boating or fishing.

8. Winter pond level drawdown has been the active management approach used by a number of lake and pond associations within the state for many years to manage nuisance weed growth. It can be very effective for controlling fanwort and milfoil if performed correctly and the approach is well suited to Warner's Pond. Although no rare species are known to inhabit Warner's Pond, sensitive wildlife, including turtles, frogs, and freshwater mussels are present. Therefore, drawdown will need to be properly designed, timed and implemented to provide the greatest impact on the target species and the least impact on native plants, fish, and wildlife.

   Drawdowns are often perceived to be "free" and to have little or no environmental impacts; however, this is often not the case. Furthermore, drawdown will never be able to control nuisance weeds in the deeper areas of the pond. "Extreme" drawdowns conducted at Warner's Pond were implemented previously to make repairs or to replace the dam and not specifically for aquatic weed control. Current environmental protection requirements (state and federal) would generally prohibit an extreme drawdown due to the negative impacts on fish and wildlife as well as to the hydrologically connected wetlands. A targeted drawdown that could prudently be recommended based on the data collected as part of this study would be no more than 3 feet below normal pool elevation.

   If done correctly, drawdowns typically require some level of assessment of the baseline conditions, such as provided in this Pond Management Plan, as well as some drawdown specific assessments and calculations. ESS is recommending that a drawdown feasibility study be performed to address some of the outstanding issues and to develop the necessary Drawdown Operations Plan, inclusive of all hydrologic calculations.

   Cost to perform a drawdown feasibility study and develop a Drawdown Operations Plan, given that a substantial amount of information is now available in this Pond Management Plan, are expected to be on the order of $8,000. The cost for filing this permit application is likely to range between $3,000 and $4,000 plus filing fees. It is also likely that a monitoring program will be required as a permit condition, which could cost on the order of $5,000 per year to execute.

9. If dredging is considered to be a viable long-term option, the next steps would be to assess the specific scope and extent of dredge program including possible funding options, conduct additional chemical and physical analysis of the sediments in areas targeted for dredging, develop an engineering design for submission to permitting authorities, and initiate the permitting process including an Environmental Notification Form filing for MEPA (Massachusetts Environmental Policy Act) review, filing a local Notice of Intent under the Wetlands Protection Act, filing for a Section 401 Water Quality Certificate from MassDEP, and seeking a U.S. Army Corps of Engineers Section 404 Permit for dredging. These four activities might be expected to cost up to $50,000 for Warner's Pond given the work already completed as part of this study, but are essential if dredging is to be pursued as a management option. These steps are also beneficial to preparing the project to be "shovel

ready" to take advantage of funding opportunities that may arise within the town or at the state or federal levels. Additional design costs would include final engineering design following the permitting process (incorporating any accepted changes resulting form these reviews) along with the development of a bid specification package for the project.

In order to restore Warner's Pond in a manner that is comprehensive and will be long-lasting the cost will be significant. However, with proper planning and by being ready to take advantage of funding opportunities as they arise, it can be done in a reasonable amount of time. The work performed to date to gain control of the fanwort and milfoil populations should be followed-up through continued management efforts to ensure that the progress made to date is not wasted effort. Additionally, maintaining diligence regarding the control of water chestnut through hand-pulling or harvesting is also essential.

Given the extensive costs associated with implementing a long-term program for full control of the weed problem in the pond, ESS has offered a solution that targets maintenance of a critical area of open water habitat that will allow for acceptable levels of recreational use of the pond while also maintaining less disturbed areas elsewhere in the pond that can continue to serve the ecological needs of local wildlife populations. It is likely that interim measures will be required in order to meet the short-term objectives of keeping the pond safe for recreational use and to maintain a level of quality with regard to aquatic habitat value. Therefore, it is recommended that a drawdown program be considered for the near-term to assist in managing weed growth around the perimeter of the pond, assuming that the required permits can be obtained. A longer-term recommendation is to pursue dredging as a means of permanently enhancing the open water habitat within the southern end of the pond between Scout Island and the Commonwealth Avenue access point.

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Attachment A

Warner’s Pond Quality Assurance Project Plan
(Electronic Version Only)

www.essgroup.com

DRAFT Quality Assurance Project Plan

FOR WARNER'S POND WATERSHED MANAGEMENT PLAN
CONCORD, MASSACHUSETTS

PREPARED FOR	Town of Concord Division of Natural Resources 141 Keyes Road Concord, Massachusetts 01742
PREPARED BY	ESS Group, Inc. 888 Worcester Street, Suite 240 Wellesley, Massachusetts 02482

Project No. C574-000

February 11, 2011

www.essgroup.com

ESS Group, Inc.

QUALITY ASSURANCE PROJECT PLAN (QAPP)

For the

Warner's Pond Watershed Management Plan

February 11, 2011

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APPENDICES

1.0 DISTRIBUTION LIST AND PROJECT PERSONNEL SIGN-OFF SHEET

The distribution list and project personnel sign-off sheet is encompassed on the Title and Approval Page, located at the front of this document.

2.0 PROJECT ORGANIZATION

ESS Group, Inc. (ESS) has been contracted by the Town of Concord (Town) to assist with the development of a watershed management plan. Carl Nielsen will be the ESS Project Manager and also serve as the project internal Quality Assurance (QA) Officer. The Project Manager will be responsible for coordinating all field and laboratory efforts as well as serving as a direct contact for all parties involved with the project. Responsibilities of the QA Officer will be primarily associated with ensuring that personnel serving the project are properly trained in all appropriate procedures relating to sample collection and data generation. The QA Officer will regularly verify that the items described in this Quality Assurance Project Plan (QAPP) are being followed. Additionally, the QA Officer will verify conformance with project reporting deadlines and data quality objectives, and ensure that project deliverables satisfy contract provisions.

This QAPP will direct field and laboratory activities for the Warner's Pond Watershed Management Plan. ESS will conduct all field sample collection activities, as appropriate. GeoLabs, Inc. (GeoLabs), a Massachusetts certified laboratory, will provide analytical services for all sediment bulk chemical and water quality parameters (except those analyzed in the field by ESS personnel). GeoTesting Express will provide analytical services for bulk physical sediment samples.

The project organizational chart (Figure 1) describes the principal officials and investigators associated with the project and illustrates the pathways of communication that will be utilized.

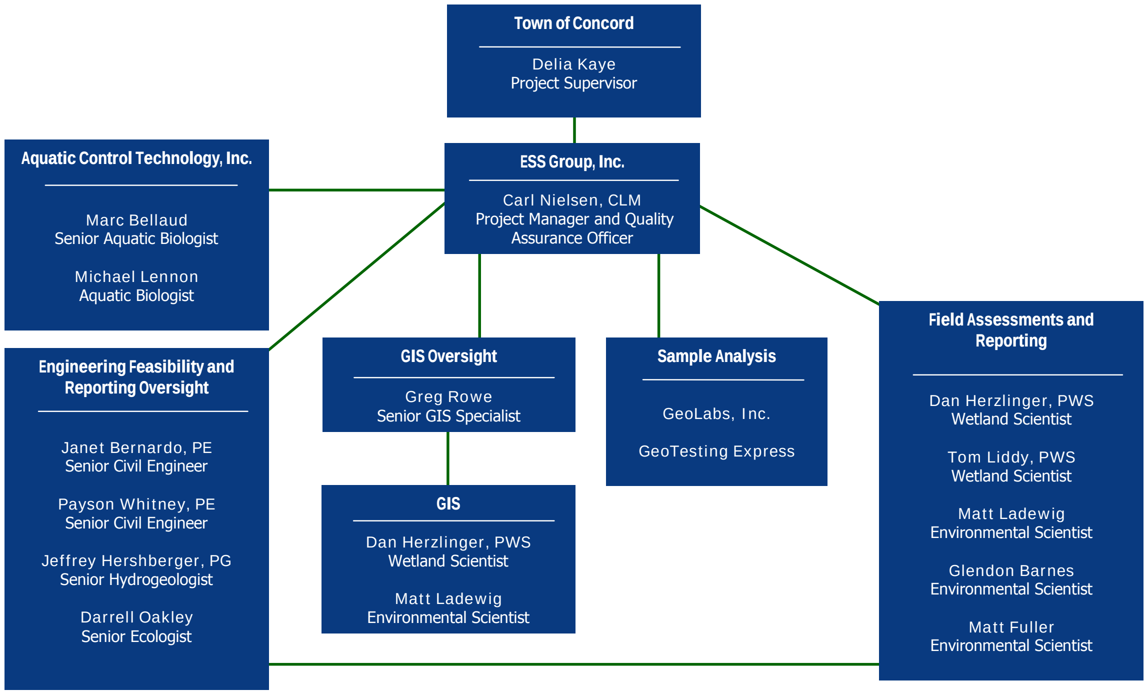


Figure 1. Organizational Chart for Warner's Pond Watershed Management Plan

2.1 Communication Pathways

For all work requested by the Town, Carl Nielsen of ESS will serve as Project Manager and will coordinate all field and office work to ensure that it meets the standards established for the project and that work is performed in a timely manner. Mr. Nielsen will also act as Quality Assurance Officer and will review fieldwork, lab reports, and client deliverables for acceptability. Mr. Nielsen will ensure that all involved personnel are properly trained in appropriate protocols and will review reports for accuracy and completeness. In addition, Mr. Nielsen will provide regular progress updates to Delia Kaye, the Project Supervisor from the Town, and will be responsible for meeting all project requirements. Mr. Nielsen will serve as the primary point of contact for the entire project.

Field data collection will be conducted by Dan Herzlinger, Matt Ladewig, Glendon Barnes, Tom Liddy and Matt Fuller of ESS. They will be responsible for conducting all field work at Warner's Pond and developing reports. These staff will report directly to Mr. Nielsen.

Senior ESS staff including Janet Bernardo, Payson Whitney, Jeffrey Hershberger, and Darrell Oakley may assist Mr. Nielsen with reporting oversight and engineering feasibility on the project. They will coordinate with the field data collection team, as needed, and report to Mr. Nielsen.

GIS data management and mapping will be overseen by Greg Rowe of ESS. He will ensure that all GIS work completed is accurate and appropriately presented.

Given their experience with Warner's Pond from past projects, Marc Bellaud and Michael Lennon of Aquatic Control Technology, Inc. (ACT) will provide prior data reports completed by ACT at Warner's Pond and be available for consultation on this project. They will communicate directly with Mr. Nielsen.

2.1.1 Modifications to the QAPP

In the event that the QAPP requires substantial modification, Carl Nielsen will contact the Project Supervisor from the Town before proceeding with any further project activities. The organizational chart (Figure 1) describes the principal officials and investigators associated with the project and illustrates the chain of communication and authorization.

2.2 Personnel Responsibilities and Qualifications

A summary of personnel responsibilities and resumes for each member of the ESS project team is presented in Appendix A.

2.3 Special Training Requirements/Certification

The Project Team has extensive experience in water quality and sediment sampling, aquatic plant and bathymetry mapping, watershed water quality modeling, and pond and watershed management. Carl Nielsen is a Certified Lake Manager (CLM) and has over twenty years of experience in limnology and lake management. Additionally, Dan Herzlinger and Tom Liddy are Professional Wetland Scientists (PWS) with training in identification and mapping of aquatic plants.

No special training or certification courses were specifically attended in preparation for this project. However, ESS staff received training in limnological field methods, including bathymetry mapping, sediment sampling, water quality sampling, and macrophyte identification from previous academic study, routine participation at conferences on the subject of lake management, as well as during informal ESS in-house training associated with a variety of similar projects throughout New England. Additional in-house training will be provided for ESS staff as necessary.

3.0 PLANNING/PROJECT DEFINITION

3.1 Project Planning Meetings

Initial scoping of this project was defined by the Town in its Request for Proposals for this project. A project "kick-off" meeting was held on January 24, 2011 in order to clarify project goals and contract details.

3.2 Problem Definition/Site History and Background

Warner's Pond is a relatively shallow, 54-acre waterbody formed by damming the Nashoba Brook. The pond has a very large watershed (approximately 47 square miles) spread across seven different towns (Figure 2). Watershed land use ranges from agricultural lands and forest to commercial and industrial areas (Figure 3). As an impoundment, Warner's Pond has filled in over time with sediments from the watershed and may ultimately need to be restored via dredging if it is to retain its character as an open water system. Over time, shallow systems such as Warner's Pond become susceptible to excessive weed growth and this often includes invasive species.

Weed growth is now perceived to be at nuisance levels in Warner's Pond and the depth of the pond is impacted by accumulated sediments from its watershed. The nuisance vegetation partly results from the shallowness of the pond, which allows light penetration to the pond bottom so that aquatic vegetation grows well.

In order to provide the town with management recommendations for Warner's Pond, ESS will review existing and readily available information covering many of the critical physical, chemical, and biological aspects of Warner's Pond and its watershed. This information will be used to supplement data collected by ESS and provide a context for sufficiently documenting the pond's present condition, establishing a set of baseline data, and forming the basis for analysis and management recommendations. The data will form the basis of the Watershed Management Plan that focuses on methods to reduce nuisance aquatic macrophyte growth and meet state Class B Surface Water Quality Standards.

Work will be conducted under the guidance of this QAPP, which is compatible with the Environmental Protection Agency (EPA) and Massachusetts Department of Environmental Protection (MassDEP) guidelines and developed specifically for the Warner's Pond project. All laboratory water quality and sediment analysis will be performed by a Massachusetts certified laboratory.

4.0 PROJECT DESCRIPTION AND SCHEDULE

This project is designed to establish a set of baseline data, covering key physical, chemical and biological aspects of Warner's Pond and its watershed. These data will be used to develop a watershed management plan to ensure the future protection of the pond. To this end, ESS will conduct the following:

1. Develop a Quality Assurance Project Plan – Prepare and submit a QAPP to MassDEP and US EPA for approval
2. Meetings – Attend initial kick-off meeting and an additional meeting to present findings of the Draft Report
3. Develop Watershed Management Report – Use readily available existing and field-collected data to create a summary of the pond's historical and current condition.
4. Conduct a Bathymetric Survey - Determine the pond's water depth contours, and measure soft sediment distribution.
5. Conduct Sediment Sampling - Determine the quality of the pond sediments that may affect ecological health.

6. Document Nutrient Loading in the Warner's Pond Watershed – Sample surface water in Warner's Pond and its watershed for nutrients. Develop hydrologic and nutrient budgets for the pond.

7. Document Sediment Loading in the Warner's Pond Watershed - Sample surface water in Warner's Pond and its watershed for sediments. Develop sediment budget for the pond.

8. Sample Point Source Water Quality – Identify and sample point sources discharging to the pond with an emphasis on quantifying these sources of pollution.

9. Assess Biological Resources – Conduct an assessment of aquatic macrophytes with an emphasis on documenting invasive species. Document wetlands and critical habitats of rare species that could be impacted by management activities at Warner's Pond. Update the Wildlife and Habitat Assessment Report completed by New England Environmental, Inc in 1999.

10. Identify Recreational Uses – Document current and historic public recreational uses of the pond.

11. Develop Watershed Management Plan - Provide short- and long-term management recommendations for the preservation of Warner's Pond, based on data gathered in support of this project.

In order to successfully achieve the goals and objectives stated above, ESS will complete project tasks according to the project schedule (Table A). The project began January 24, 2011 and will be completed by January 24, 2012.

Table A. Project Schedule

		2011																								2012	
Task	Deliverable	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		Jan	
Develop QAPP	Draft and finalize approved QAPP		■	■	■																						
Meetings	Initial startup meeting and final meeting with presentation to review the study findings and recommendations for Warner's Pond.		■																		■	■	■	■			
Develop Watershed Management Report from Existing Data	Summarize the pond's historical and current condition. Describe both past and present, recreational/community use and ecological condition.																	■	■	■							
Document Nutrient Loading	Provide a detailed narrative, data tables, and GIS figures documenting the hydrologic and nutrient budgets.						■	■	■	■	■	■	■	■	■	■	■	■	■								

		2011																								2012	
Task	Deliverable	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		Jan	
Document Sediment Loading	Provide detailed narrative, data tables, GIS figures documenting the sediment load to Warner's Pond.						■	■	■	■	■	■	■	■	■	■	■	■	■								
Point Source Discharge	Provide detailed narrative, data tables, GIS figures documenting the sediment load to Warner's Pond from point source drainage lines along pond's perimeter and within its watershed.						■	■	■	■	■	■	■	■	■	■	■	■	■								
Bathymetric Survey	Information will be used to create GIS maps of sediment depth contours in one-foot increments and to estimate the quantity of soft sediments contained in the pond.		■	■	■	■																					
Sediment Sampling	Tables describing sediment chemistry, sediment core logs, core photographs, and GIS maps depicting core locations.		■	■	■	■	■	■	■																		
Assess Biological Resources	Narrative, tables, and a series of GIS maps documenting wildlife, habitat and macrophyte conditions in Warner's Pond.													■	■	■	■	■	■								
Identify Recreational Resources	Summarize the historic and current recreational use at the pond and define the vision that town residents and stakeholders have for the future of the pond.						■	■	■	■	■	■	■														
Short and Long-Term Recommendations	Prepare and draft study report that focuses on various management options for controlling aquatic vegetation, increasing water depth, and improving aquatic habitat.																	■	■	■	■						
Develop a Final Watershed Management Plan	Draft and final lake management plan for Warner's Pond with cost estimates for permitting.																			■	■	■	■	■	■	■	■

5.0 TECHNICAL DESIGN FOR FIELD SAMPLING

5.1 Bathymetry

Warner's Pond will be surveyed via sonar, marked rod, and/or weighted line at a minimum of 50 points along appropriately spaced transects to determine the lake's maximum depth and define the water depth contours (bathymetry) (Figure 4). Measurements will be made at points along appropriately spaced transects and data will be recorded using a Trimble XT GPS with sub-meter accuracy. This information will be incorporated into the assessment of Warner's Pond's hydrologic and nutrient budgets. Information generated will also be used to produce figures depicting the water depth contours. ESS personnel will follow the SOGs for the creation of a GIS map (Appendix B), to conduct an assessment of the bathymetry of Warner's Pond.

During the bathymetry survey, ESS staff will also measure soft sediment depth in the pond for the purposes of updating the map of the existing unconsolidated sediment thickness (isopach) as reported in the prior baseline assessment and management plan completed by ACT in 1999 (Figure 4). As with bathymetry, measurements will be made at points along appropriately spaced transects and recorded to sub-meter accuracy. Field notes will provide a description of the underlying sediments (i.e. silt, sand, gravel, hardpan, etc.). These data will be used to calculate the volume, average depth, and maximum depth of organic matter. A GIS format map will be prepared depicting sediment depths throughout the pond.

5.2 Sediment Sampling

ESS will collect four composite sediment samples representative of the organic bottom material. Each of the four composite samples will be comprised of three distinct sediment cores that will be homogenized for analysis. However, volatile organic compound (VOC) samples will be extracted prior to homogenization, in order to avoid volatilization of the samples. ESS personnel will collect sediment samples from Warner's Pond in a manner consistent with the SOGs for Collection of Sediments from Freshwater Environments (Appendix B). The sediment samples collected will reflect bottom characteristics in the pond and be analyzed as described below.

Cores obtained by ESS will be logged, photographed, and sampled by ESS in the field in order to obtain and track representative samples for delivery to the appropriate laboratory. ESS will deliver the sediment samples to GeoLabs, where they will be analyzed for bulk physical and chemical characteristics, as required for 401 Water Quality Certification.

- *Bulk Physical Analysis*: Bulk physical analysis will be performed by GeoTesting Express on recovered sediment. The analyses will include: Gradation Analysis, Moisture Content, Ash Content, and Organic Content.

- *Bulk Chemical Analysis*: Bulk chemical analysis will be performed by GeoLabs on recovered sediment. A total of 4 composite samples will be analyzed from the 12 cores collected at the pond (i.e., three cores will be composited for each sample). Samples will be obtained for VOCs before homogenizing. Then each remaining sample will be mixed thoroughly to create a composite sample representative of the three cores. These will be analyzed for metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc), polychlorinated biphenyls (PCBs), and extractable petroleum hydrocarbons (EPHs) with polynuclear aromatic hydrocarbons (PAHs). The list may be modified based on the history of land use within the watershed and the potential for additional contaminants.

Detection limits for this testing will be set at a level appropriate for material removal, storage, and disposal as specified under "Regulations for Water Quality Certification for Dredging, Dredged Materials Disposal, and Filling in the Waters of the Commonwealth" and sufficient to complete an application for an Army Corps of Engineers 404 Permit.

Sample material will be preserved in accordance with the specific requirements of the laboratory methods used to analyze each sample.

5.3 Water Quality

(a) In-Pond Water Quality: ESS will sample the pond at one location, the deepest part of Warner's Pond (Figure 5). This location will be sampled once during dry weather and samples will be taken from the surface water as well as near the bottom of the pond. This proposed sampling program results in a total of 1 collection date with 2 water quality samples.

The following parameters will be measured in the field: dissolved oxygen, water temperature, specific conductance, pH, turbidity, and Secchi transparency. ESS personnel will follow the SOGs outlined in Appendix B to analyze these parameters in the field. Water samples will be field collected and analyzed in the lab for nutrients (total phosphorus, nitrate nitrogen, and total Kjeldahl nitrogen [TKN]). As a quality assurance/quality control (QA/QC) measure of field sampling activities, duplicate samples will be incorporated into the sampling program at random to represent at least 5% of the total number of samples.

(b) Tributary and Outlet Water Quality: Water quality sampling will also occur following the above-described schedule (once during dry weather) at the pond's outlet at Commonwealth Avenue and at four upstream tributary locations, including one at each of the pond's major inlets (Nashoba and Fort Pond Brooks) as well as upstream on Coles Brook and Conant Brook (Figure 5). Two alternate sampling stations have also been proposed on Fort Pond Brook and Nagog Brook, in case the primary stations are not reasonably accessible. In addition to the surface water parameters listed above for the pond sampling, flow rate will be calculated at the outlet and tributary sampling locations. The total suspended solids (TSS) will be included in the laboratory analysis in addition to the nutrient parameters listed for in-pond water quality sampling. Secchi disk transparency will not be measured at the outlet and tributary sampling locations. For the sampling of surface water from the tributaries and outlet of Warner's Pond, ESS personnel will follow a streamlined approach comparable to that outlined in the Standard Operating Guidelines (SOGs) for the acquisition of surface water samples (Appendix B). As a QA/QC measure of field sampling activities, duplicate samples will be incorporated into the sampling program at random to represent at least 5% of the total number of samples.

All dry weather sampling will be conducted following a period of at least 72 hours with less than 0.10 inches of precipitation.

(c) Point Source Water Quality: Point sources of nutrients and sediment to the pond include storm water discharge pipes and outlets along the pond shoreline as well as those located along the banks of the tributaries to the pond within its watershed. In a watershed such as this, there are likely to be a large number of such discharges. ESS has created a GIS map depicting all known point-source discharge pipes near the pond from available sources from the Town of Concord (Figure 6). Based on our initial screening analysis, ESS will select up to eight representative outfall pipes to be sampled as part of this analysis (Figure 6). ESS will select sites that capture the greatest discharges into the pond. The locations of each outfall will be recorded using a Trimble XT GPS unit with sub-meter accuracy. These sources will be investigated during dry weather for the purpose of locating potential sources, and then sampled during dry weather (if flowing). This assessment will be used to identify which of these larger systems is disproportionately contributing to nutrient or sediment loading into the system and then work to develop management recommendations for these drain lines based on what we know of their contributing land uses.

ESS personnel will follow a streamlined approach comparable to that outlined in the SOGs for the acquisition of surface water samples (Appendix B). Water quality parameters to be assessed will include total phosphorus, nitrate nitrogen, total Kjeldahl nitrogen, and TSS. ESS will also measure specific conductance, salinity, turbidity, temperature, dissolved oxygen and pH in the field. All dry weather sampling will be conducted following a period of at least 72 hours with less than 0.10 inches of precipitation.

(d) Storm Water Quality: In addition to the dry weather sampling, ESS will collect samples during one storm event at each of the four upstream tributary locations, the downstream outlet and up to eight point source outfalls. ESS personnel will follow a streamlined approach comparable to that outlined in the SOGs for the acquisition of surface water samples (Appendix B). ESS will measure the following parameters at storm water quality locations: flow rate, dissolved oxygen, pH, temperature, turbidity, and specific conductance. Water samples will be field collected and analyzed in the lab for nutrients (total phosphorus, nitrate nitrogen, and TKN), and TSS.

Wet weather sampling will focus on collecting the more heavily polluted "first-flush" samples. Wet weather storm water quality sampling efforts will target a rainfall event forecasted to produce at least 0.25 inches, and following at least 72 hours of weather with less than 0.10 inches of precipitation. Weather data, forecasts and precipitation totals will be tracked for the Warner's Pond watershed through an Internet weather service (www.intellicast.com or equivalent service) and the National Oceanic and Atmospheric Administration database (National Climatic Data Center).

Storm flow and base flow data from these collections will be incorporated into hydrologic and nutrient budget models. As a QA/QC measure of field sampling activities, duplicate samples will be incorporated into the sampling program at random to represent at least 5% of the total number of samples.

5.4 Biological Assessments

(a) Fish and Wildlife (Wildlife and Habitat Assessment Report Update): The ESS Team will review the previous report and prepare a summary updating the findings of that report based on the current status of the pond. ESS will focus on updating the descriptions of the baseline condition for fish, wildlife, plants and the wetland resources within and supported by the Warner's Pond system.

(b) Macrophytes: An inventory of the aquatic plant community will be conducted for the purpose of describing species composition and abundance during the period of peak development (July to August). All plant species encountered will be identified using the most current taxonomic keys. Taxonomic keys used to identify plants include: *A Guide to Aquatic Plants in Massachusetts* (New England Aquarium, 1999), *Aquatic and Wetland Plants of Northeastern North America* (Crow and Hellquist, 2000) and a series produced by the New Hampshire Agricultural Experiment Station (Crow and Hellquist, 1982).

ESS will assess aquatic macrophyte cover and community composition in the pond from a boat. If conditions warrant, ESS will also employ the use of an underwater camera to aid in underwater plant mapping. This approach achieves results similar to the results that may be obtained by a diver. The data collected from this study will an update to conditions previously documented in the pond and evaluate the potential costs of various plant management techniques for Warner's Pond. In the completion of this macrophyte survey, ESS personnel will follow a streamlined approach comparable to that outlined in the SOGs for the creation of an aquatic plant map (Appendix B).

Maps depicting the distribution of plant cover and plant bio-volume will be created in GIS format as data layers. Using GIS, the acreage of Warner's Pond covered by aquatic plants will be determined. The maps created by ESS will be compared with previous mapping done on Warner's Pond.

(c) Natural Heritage and Endangered Species Program: It may be necessary to document existing wetlands, rare species, and critical habitats that may be affected by any form of pond management. ESS will investigate and describe major wetland areas associated with or adjacent to Warner's Pond. ESS will create a GIS map describing the type and location of rare species or critical habitat (if any) within the immediate location of Warner's Pond. ESS will use this data to describe potential impacts which may result from management activities.

6.0 ANALYTICAL PROCEDURES

Water quality samples (in-pond, tributary/outlet, and storm water) and sediment quality samples will be collected in the field by ESS personnel using the appropriate containers and preserved as required by the lab. All field sampling will follow a streamlined approach comparable to that outlined in the SOGs for the acquisition of surface water samples, pond bathymetry, and the sampling of sediment (Appendix B).

Water quality parameters to be tested by ESS personnel in the field will include the following: flow rate, pH, specific conductance, turbidity, dissolved oxygen, and temperature. All field meters will be calibrated in accordance with their respective operator's manual prior to fieldwork and as needed while in the field. In order to avoid cross contamination, field equipment will be rinsed prior to each measurement using de-ionized water or surface water from the next station. A flow probe will be the preferred flow rate-measuring device for this study; however, time of travel flow measurements may be conducted if equipment malfunctions in the field or if flow is too slow or the stream is too shallow to be accurately characterized by the flow probe. Water quality and flow will be assessed in the field using instrumentation in accordance with the SOGs provided in Appendix B.

Water quality parameters to be tested (by GeoLabs) will include: nitrate nitrogen, total Kjeldahl nitrogen, total phosphorus, and total suspended solids.

Sediment quality parameters to be tested by GeoLabs will include: arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, PCBs, PAHs, EPH, and VOCs. Sediment quality parameters to be tested by Geo Testing Express will include: percent water, gradation analysis, ash content, and organic content.

The laboratory testing programs for sediment quality and water quality are summarized in Table B below.

Table B. Water and Sediment Quality Sampling/Laboratory Parameters (for all samples)

Parameter	Sample Matrix	Number of Samples (dry/wet)	Minimum Volume Needed	Sample Container	Sample Preservation	Maximum Hold Time (Hours)	EPA #
Total Phosphorus *	Water	7/13	1000ml	Amber Glass	H_2SO_4, Ice	28 days	365.2
TKN *	Water	7/13	1000ml	Plastic	H_2SO_4, Ice	28 days	351.3
Nitrate nitrogen *	Water	7/13	250ml	Plastic	Ice	48	353.3
TSS *	Water	7/13	250ml	Plastic	Ice	7 days	160.2
Arsenic	Sediment	4	100g	Amber Glass	Ice	6 months	6010B
Cadmium	Sediment	4	100g	Amber Glass	Ice	6 months	6010B
Chromium	Sediment	4	100g	Amber Glass	Ice	6 months	6010B
Copper	Sediment	4	100g	Amber Glass	Ice	6 months	6010B
Lead	Sediment	4	100g	Amber Glass	Ice	6 months	6010B
Mercury	Sediment	4	100g	Amber Glass	Ice	28 days	7471A
Nickel	Sediment	4	100g	Amber Glass	Ice	6 months	6010B
Zinc	Sediment	4	100g	Amber Glass	Ice	6 months	6010B
VOCs	Sediment	4	100g	VOA Vial	Methanol, Ice	28 days	8260
PCBs	Sediment	4	100g	Amber Glass	Ice	7 days	8082
PAHs	Sediment	4	100g	Amber Glass	Ice	14 days	8270
EPH	Sediment	4	100g	Amber Glass	Ice	14 days	MassDEP EPH Method
Gradation Analysis	Sediment	4	1,000g	Plastic Bag	None required	Indefinite	ASTM D 422-63
% water	Sediment	4	100g	Amber Glass	Ice	14 days	160.3
% organic content	Sediment	4	100g	Amber Glass	Ice	7 days	160.4
% ash content	Sediment	4	100g	Amber Glass	Ice	7 days	160.4

*Does not include field duplicates or dry-weather point source sampling. Duplicates will be collected at a 5% rate for water quality samples.

The laboratories (GeoLabs and GeoTesting Express), routinely analyze duplicate samples for each analytical batch, as part of their internal QA/QC program. Additionally, water quality field duplicates will be collected at a 5% overall rate for this project. Given the large number of samples being collected on any given date, internal checks on the validity of field data will be possible as well and ESS will evaluate data as it is received from the lab. If any data is questionable, ESS will contact the lab immediately to determine whether the problem is due to a transcription error or, if necessary, have the lab re-run the sample test.

Table C summarizes the parameters to be measured in the field with respective EPA methods. Specific conductance, dissolved oxygen, temperature, pH and flow rate will be measured directly in the water column, where possible. Turbidity will be collected in glass or plastic containers and measured immediately in the field. Duplicate measurements will be collected at a 5% rate for quality control (QC) purposes.

Table C: Water Quality Sampling / Field Parameters

Parameter	Flow Rate	Specific Conductance	Dissolved Oxygen	Turbidity	pH	Temperature
Sample Matrix	Water	Water	Water	Water	Water	Water
Number of Samples*	18	20	20	20	20	20
Sample Container	Instrument	Instrument	Instrument	Instrument	Instrument	Instrument
Hold Time	In Field	In Field	In Field	In Field	In Field	In Field
EPA Number	-	120.1	360.1	180.1	150.1	170.1
Expected Range of Field Measurements	0.3 – 100 cfs	0 to 1,500 µS	0 to 15 mg/L 0 to 150 % Sat.	0 to 1000 NTU	4 - 10 SU	-2 to 30 °C
Precision	0.1 cfs (Expected)	1% full scale	0.01 mg/L 0.1 % Sat.	0.01 NTU (Expected)	0.1 SU	0.1 °C
Accuracy	± 0.1 cfs (Expected)	± 1 % full scale	± 0.3 mg/L ± 2 % Sat.	± 2 %	± 0.1 SU	± 0.2 °C

*Does not include field duplicates or dry-weather point source measurements.

7.0 QUALITY CONTROL REQUIREMENTS

QC requirements are the system of technical activities that measure the performance of a process and will be utilized for field and laboratory analysis. Information on QC protocols followed in this project is provided in previous sections. A summary of quality controls to be utilized in the present study is provided in the following sections.

7.1 Bathymetry Mapping

By ensuring that the field bathymetry mapping plan is followed by navigating to pre-determined sampling locations using sub-meter accurate GPS and creating GIS figures using SOGs (Appendix B), ESS will be certain to collect and report bathymetry data that are representative of the actual water depths in Warner's Pond.

7.2 Sediment Sampling

By ensuring that the field sampling plan is followed, proper sampling techniques are used, proper analytical procedures are followed, and that sample holding times are not exceeded, ESS will be certain to collect and report water quality data that are representative of actual sediment conditions. All sediment cores will be logged and photographed at the time of collection.

7.3 Water Quality Sampling

By ensuring that the field sampling plan is followed, proper sampling techniques are used, proper analytical procedures are followed, and that sample holding times are not exceeded, ESS will be certain to collect and report water quality data that are representative.

The in-pond water sampling program has been designed to provide data representative of TKN, nitrate nitrogen, and total phosphorus in the pond. In addition, water quality parameters including temperature, Secchi disk depth, turbidity, pH, and dissolved oxygen will be measured in the field.

The storm water sampling program has been designed to provide data representative of TKN, nitrate nitrogen, total phosphorus and TSS in dry and wet weather stream and storm drain flow. It is expected that TSS, TKN, total phosphorus and field parameters measured will fluctuate in response to changes in stream discharge. Consequently, ESS will attempt to collect a wet weather sample from each stream sampling location and a wet weather sample from each outfall sampling location to provide data from each site. If dry weather flow is observed at selected outfalls, a dry weather sample will also be collected at these locations.

All equipment used in the field efforts will be calibrated, and data will be recorded in a consistent fashion. Duplicate field measurements of a single sample will be performed at a rate of approximately 5% and should agree within 10%. In general, if a discrepancy of greater than 10% is observed between the sample and its duplicate, the piece of equipment will be recalibrated and the sample will be reassessed.

7.4 Biological Assessments

Plants that cannot be easily identified within the field due to either condition or development stage will be sampled and transported back to the lab in plastic bags for identification and/or verification using appropriate taxonomic keys, dissecting microscopes, and consultation with other ESS plant experts. This will ensure that identifications made are as accurate as possible.

7.5 Laboratory Analyses

The accuracy, precision, and sensitivity of laboratory analytical data are critical to achieving the QC acceptance criteria of the analytical protocols. With respect to parameters tested in the laboratory, QC requirements for precision, accuracy, and measurement range will be implemented according to GeoLabs' Quality Assurance Plan and GeoTesting Express' Quality Assurance Plan.

Duplicate water quality samples for lab analysis will be collected at a rate of 5% and should agree within 20%. In general, if a discrepancy of greater than 20% is observed between the sample and its duplicate, ESS will request that the lab reanalyze the sample for the analyte in question.

8.0 DATA VALIDATION AND MANAGEMENT

Carl Nielsen, the Project Manager, will be in charge of ensuring the proper collection of data and preparation of tables and figures for the entirety of the project. The data will be compiled in Microsoft

Excel and the narrative will be written in Microsoft Word format. Other data files (e.g., photos) will also be made available to the Town.

8.1 Field Data

A permanently bound notebook with waterproof pages will be maintained for field sampling. All entries into the notebook will be made with indelible ink or pencil. Corrections will be made using a single line through the mistake with the initials of the individual who made them. Entries will include sampling location, time, date, weather conditions, personnel, parameters to be measured and associated data, as well as any problems encountered during sampling. Copies of data sheets will be checked regularly by the Project QA Officer and will be made available for review upon request.

8.2 Laboratory Data

Analytical results will be recorded in a laboratory notebook, specific for each instrument and method. The automated analytical equipment will have computer generated analytical runs and any problems associated with the analytical runs will be flagged and noted. If any corrective action is taken, it will be noted in narrative in the instrument notebook.

The laboratory will provide ESS with the following deliverables:

- Sample data results for all field samples
- Internal and field duplicate sample results, as applicable
- A case narrative of any deviations from QA/QC criteria and observations about the samples that potentially affect sample or data quality (i.e., missed holding times, broken or leaking bottles, and reference standards or check standards outside criteria, etc.).

The following deliverables will not be required, but will be maintained by the laboratory as applicable and will be made available upon request:

- All raw data
- Duplicate laboratory recoveries and acceptance limits
- Matrix spike/matrix spike duplicate results and acceptance limits
- Method/reagent blank results
- Calibration standards/reference standards/LFB reports
- Copies of instrument logbooks
- Copies of internal chains of custody

All reports will be generated in digital form and available as hard copy, as needed.

9.0 REPORTING

A draft report will be prepared and submitted to the Town for review and comment. In the draft report, ESS will provide a brief narrative of methodologies used and analytical results obtained. Tables and figures will also be provided to summarize the findings of the water quality, nutrient loading, sediment loading, point source discharge, sediment core, bathymetry, and biological resource evaluations. Results will be presented in a comprehensive final report, which will incorporate the comments of the Town. The Final Report will be a Pond and Watershed Management Plan with recommendations of corrective actions and their respective estimated costs for restoring or protecting water resources found to be associated with major sources of water quality impairment. Estimates of costs for permitting various alternatives within the watershed management plan will also be included in the final report. A summary of historical conditions and past recreational use of Warner's Pond will also be included in the final report. Finally, ESS will prepare and deliver a presentation of the data and significant findings of this study at the direction of the Town. One electronic copy of the presentation will also be provided in CD-ROM format for future use.

10.0 DATA ACQUISITION REQUIREMENTS

This section describes protocols associated with data obtained from external sources (i.e., not collected during sampling). A range of readily available data and reports will be used to create a summary of the Warner Pond's historical and current condition. This will include review of reports completed by ACT as well as information compiled by the Warner's Pond Steering Committee and external GIS data layers available through MassGIS and the Town to describe and summarize current and historical recreational use, community use, and ecological conditions. These data will supplement data collected by direct field-based sampling and will be used to help develop recommendations for the restoration of the pond.

11.0 ASSESSMENT AND RESPONSE ACTIONS

The Quality Assurance Officer will provide oversight for each field data collection effort to ensure that protocols described in this QAPP are being followed. This duty includes ensuring that field equipment is properly calibrated, data are recorded in a consistent manner, and samples arrive at laboratories in a timely fashion.

The Project Manager will review the final report to ensure that appropriate methodology is adhered to and reported data is within the accepted range for each parameter. Any "outlier" data discovered will be reported in the final report, and potential sources of error will be described.

12.0 QUALITY MANAGEMENT REPORTS

Quality management reports serve to ensure that ESS and the review agency Town are regularly informed on the project status. To accomplish this goal, ESS will maintain regular contact with the Town, subconsultants and vendors, either through telephone, email, or in-person meetings.

13.0 VERIFICATION AND VALIDATION REQUIREMENTS

Data review, validation, and verification provide methods for determining the usability and limitations of data, as well as a standardized data quality assessment. ESS will be responsible for reviewing laboratory reports for completeness, correctness, and adherence to QC requirements. The Project Manager from ESS will review data received from the laboratories, to assess the data against applicable acceptance criteria. The laboratories conducting the analyses will conduct internal data verifications before submitting the data to ESS.

14.0 VERIFICATION AND VALIDATION PROCEDURES

All field notebook entries, chain-of-custody forms, and other records will be reviewed by the ESS Project Manager for completeness and correctness. Analytical data provided by the laboratories will be reviewed and validated internally to provide information on whether data are acceptable. The ESS Project Manager will be responsible for reviewing the laboratory reports and data packages, as well as data entries and transmittals, for completeness and adherence to QC requirements.

Results of the verification and validation processes will be presented in the project's final report.

15.0 LITERATURE CITED

Crow, G.E. and Hellquist, C.B. 1982. Aquatic Vascular Plants of New England. New Hampshire Agricultural Experiment Station, University of New Hampshire, Durham, New Hampshire.

Crow, G.E. and Hellquist, C.B. 2000. Aquatic and Wetland Plants of Northeastern North America. University of Wisconsin Press, Madison, Wisconsin.

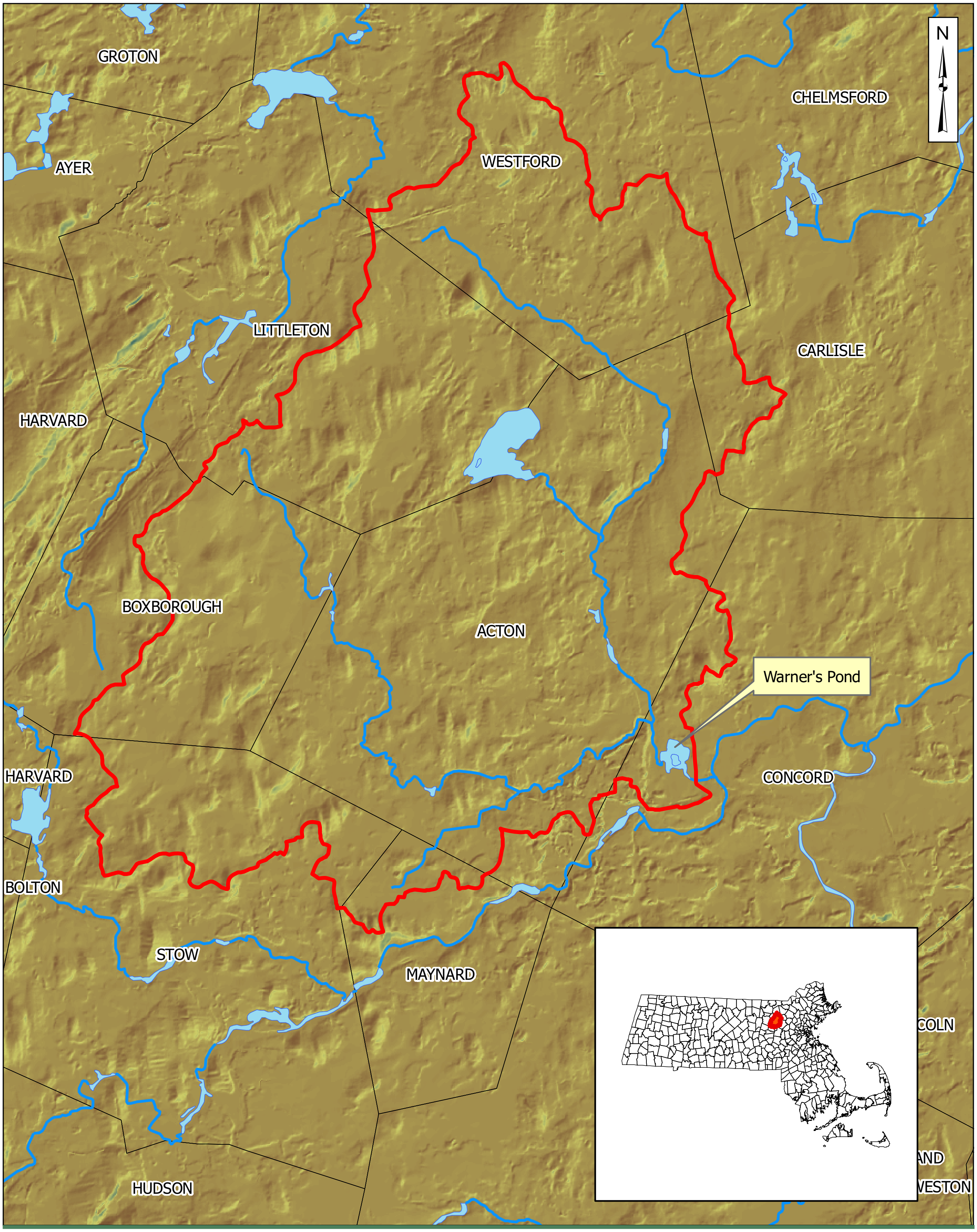
Intellicast. Daily precipitation data for central Massachusetts. http://www.intellicast.com.

National Climatic Data Center. Weather station specific daily surface data. http://nndc.noaa.gov

New England Aquarium, 1999. A Guide to Aquatic Plants In Massachusetts. New England Aquarium, Central Wharf, Boston, Massachusetts.

Figures

Location: G:/GIS-Projects/Warners-Pond-Concord/00-mxd/Watershed.mxd



ESS Group, Inc.

Engineers
Scientists
Consultants

WARNER'S POND QAPP
Concord, Massachusetts

Scale: 1" = 8,500' (1.6 miles)

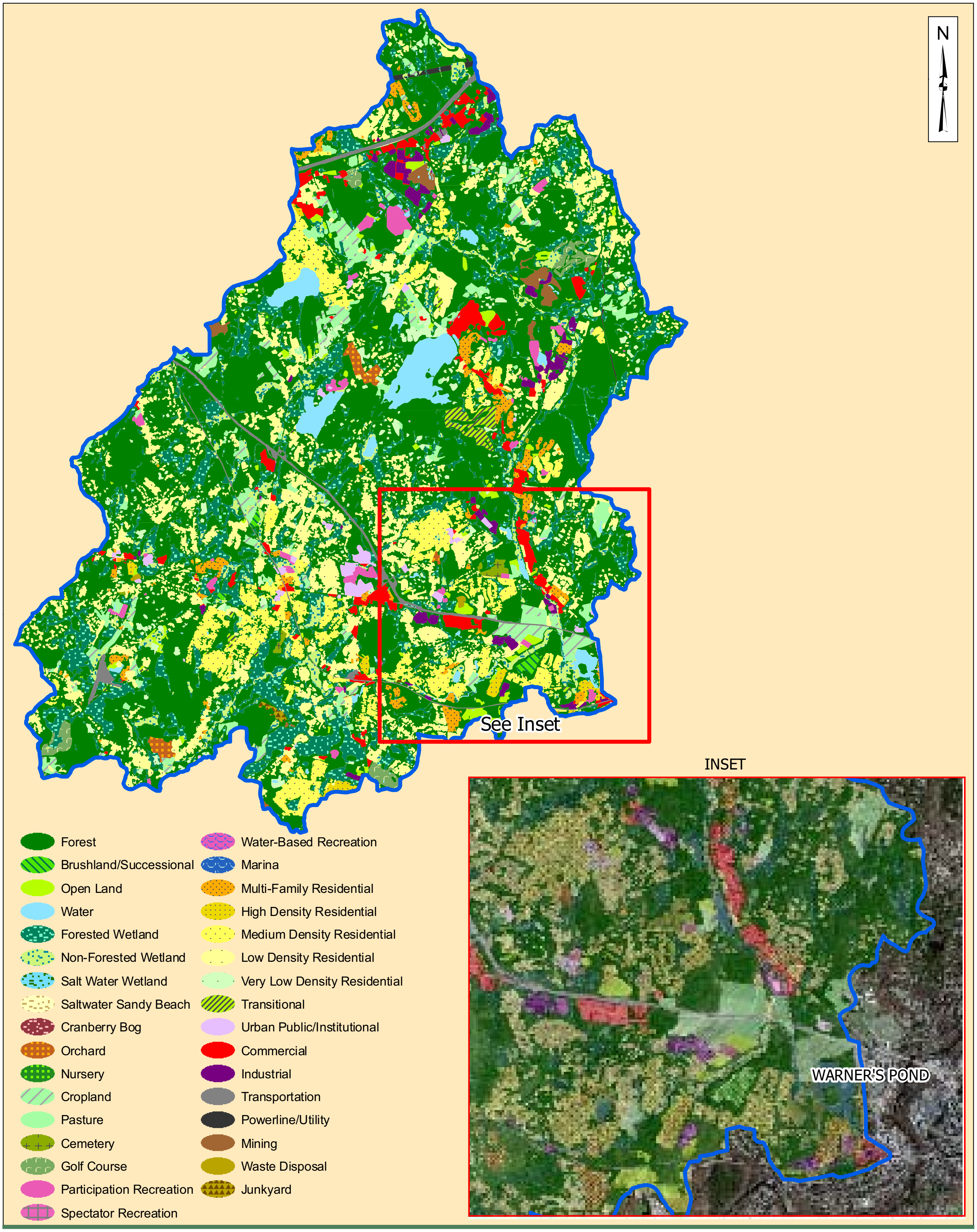
0 1 Miles

Source: 1) MassGIS, Shaded Relief, 2005
2) MassGIS, Hydrology 2000
3) ESS, Watershed Boundary, 2011

Warner's Pond Watershed

Figure 2

Location: G:/GIS-Projects/Warners-Pond-Concord/00-mxd/LandUse.mxd



ESS Group, Inc.

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WARNER'S POND QAPP
Concord, Massachusetts

Scale: 1" = 9000'

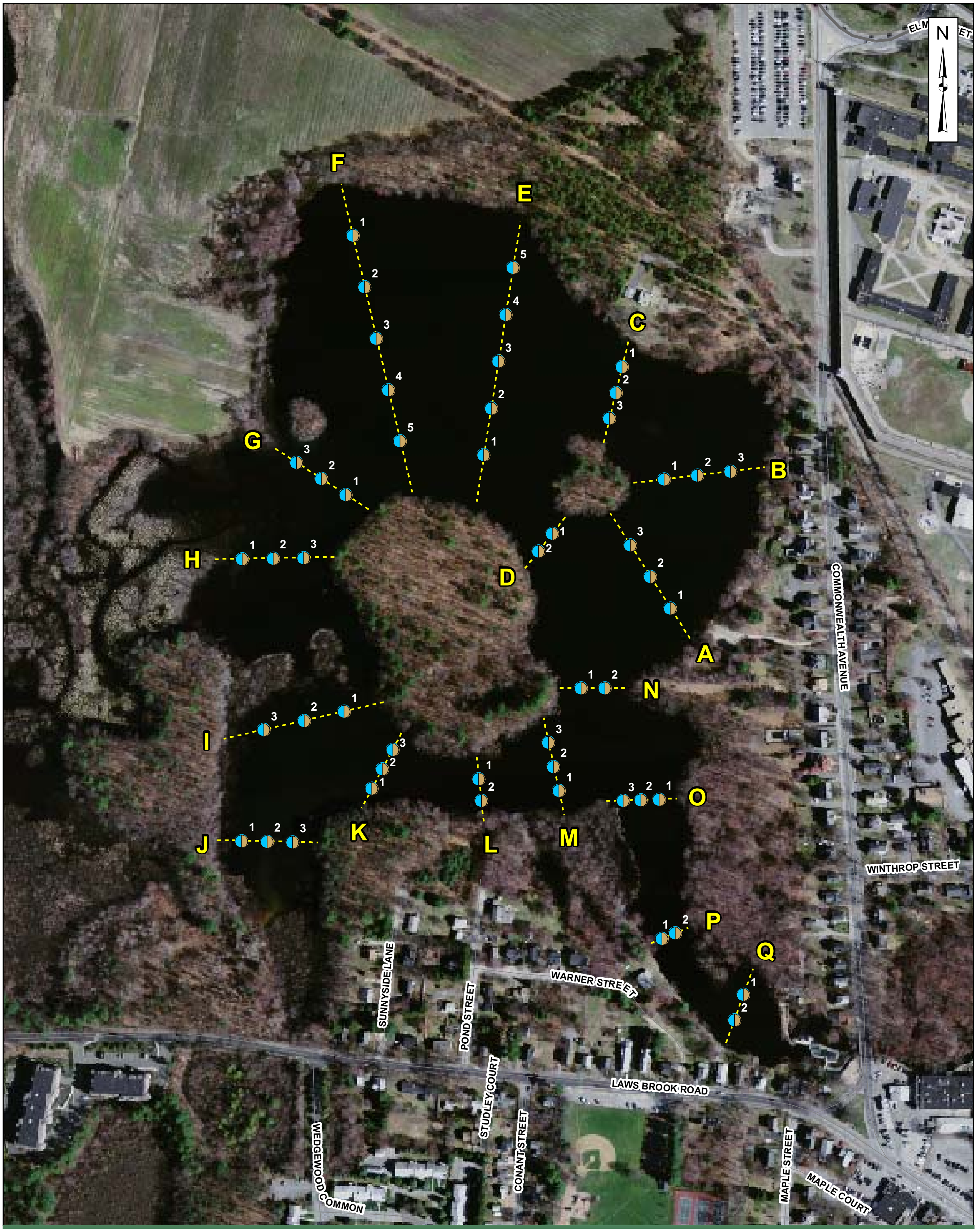
0 1 Miles

Source: 1) MassGIS, Color Orthos, 2008
2) MassGIS, Land Use, 2005

Watershed Land Use

Figure 3

Location: G:/GIS-Projects/Warners-Pond/00-mxd/Sampling.mxd



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WARNER'S POND
WATERSHED MANAGEMENT PLAN
Concord, Massachusetts

Scale: 1" = 400'

0 400 Feet

Source: 1) MassGIS, Orthos, 2008
2) ESS, Transect & Sampling Locations, 2011

Bathymetry & Sediment Depth Sampling Locations

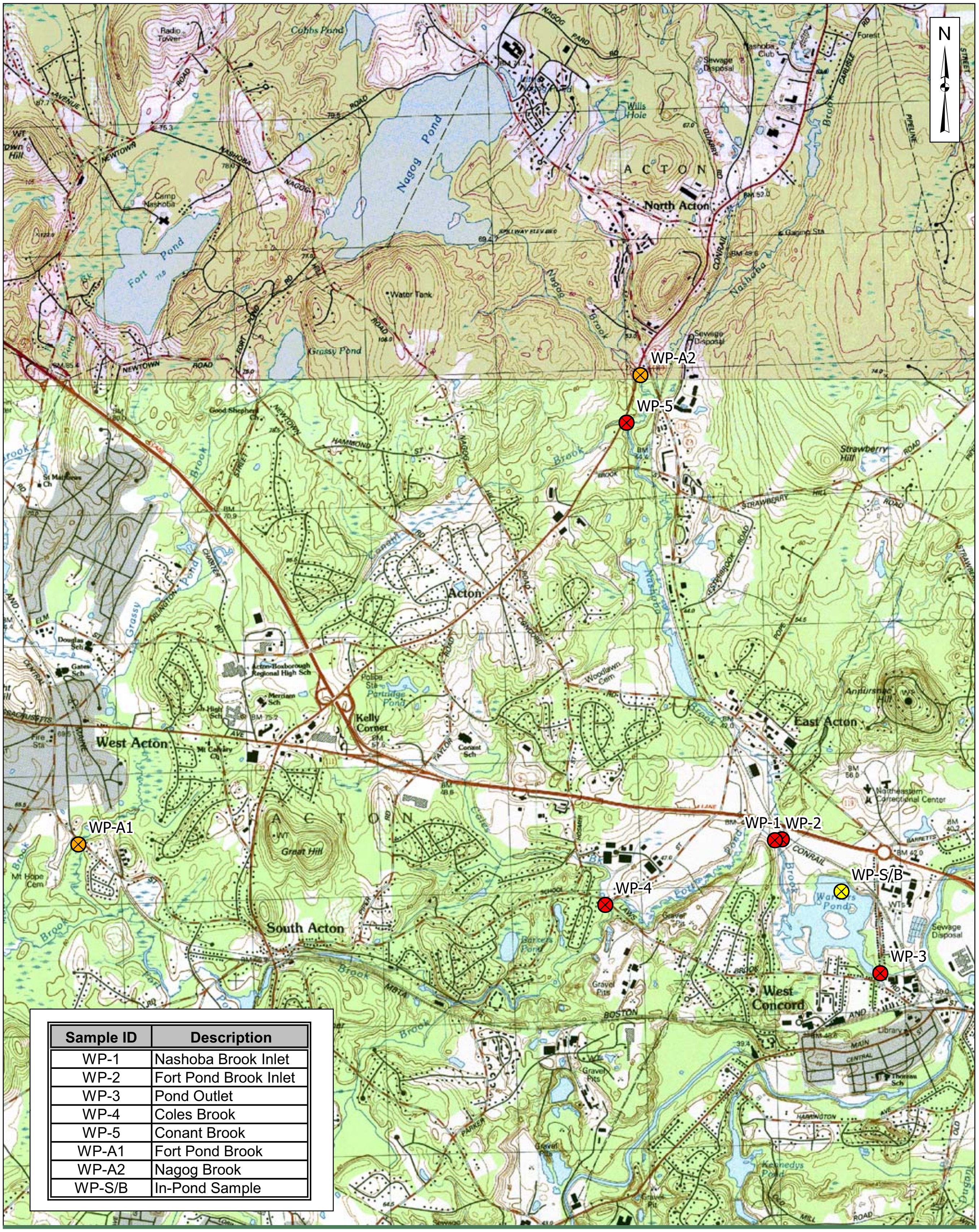
Legend

Proposed Bathymetry/Sediment Sampling Locations

Proposed Transects

Figure 4

Location: G:/GIS-Projects/Warners-Pond-Concord/00-mxd/QAPP_Sampling.mxd



Sample ID	Description
WP-1	Nashoba Brook Inlet
WP-2	Fort Pond Brook Inlet
WP-3	Pond Outlet
WP-4	Coles Brook
WP-5	Conant Brook
WP-A1	Fort Pond Brook
WP-A2	Nagog Brook
WP-S/B	In-Pond Sample

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WARNER'S POND QAPP
Concord, Massachusetts

Scale: 1" = 3500'

0 3,500 Feet

Source: 1) MassGIS, USGS Topos, 1987-1988
2) ESS, Sampling Locations, 2011

Sample Locations

- Proposed Location
- Proposed Location (Nutrients only)
- Alternative Location

Proposed Nutrient & TSS Sample Locations

Figure 5

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WARNER'S POND QAPP
Concord, Massachusetts

Scale: 1" = 750'

0 750 Feet

Source: 1) MassGIS, USGS Topos, 1987-1988
2) Town of Concord, Outfall Locations

Legend

Known Outfalls

Point Source Discharge Locations

Figure 6

Appendix A

Qualifications

ESS Group, Inc.

Carl D. Nielsen, CLM
Vice President and Senior Water Resources Scientist

EXPERIENCE

ESS Group, Inc. - January 1998 to Present
Years of Prior Related Experience - 8

EDUCATION

MS, Fisheries and Wildlife, University of Missouri - Columbia, 1994
BA, Biology, Colgate University, 1990
Tufts University, Water Quality Modeling for TMDLs, 40-hr. Workshop, 2001

SUMMARY OF PROJECT EXPERIENCE

Mr. Nielsen has over 20 years of experience in the assessment and evaluation of marine and freshwater ecosystems. Mr. Nielsen uses his knowledge of water chemistry and biology to go beyond basic assessments that just identify whether a waterbody is meeting the regulatory standards. Mr. Nielsen has worked extensively in identifying and understanding the ecology of most aquatic organisms including aquatic plants, algae, zooplankton, aquatic invertebrates, fish, reptiles and amphibians. By understanding the ecological needs of the organisms present in an aquatic system Mr. Nielsen is able to tailor management recommendations and mitigation strategies that are appropriate and viewed favorably by the community and most permitting authorities. Mr. Nielsen is also actively involved in the restoration of aquatic systems and has worked to improve water quality and aquatic habitat conditions in numerous lake and river systems throughout New England. As part of these efforts, Mr. Nielsen regularly uses water quality data collected to develop customized scientific watershed models to assist in locating sources of pollution and to evaluate the potential effectiveness of a variety of watershed management strategies. Mr. Nielsen has been Senior Project Scientist for more than 150 aquatic resource studies which have been performed for numerous clients including: federal, state and local governments, municipal water districts, local lake and watershed associations, industrial facilities, property developers, major corporations, utilities, golf courses, ski areas, and airports. Mr. Nielsen's representative project experience includes:

- Massachusetts Department of Conservation and Recreation – Dredging Design, Permitting, and Construction Oversight for Robinson Pond Restoration, Agawam, Massachusetts. Mr. Nielsen is the project manager and principal scientist responsible for the restoration of Robinson Pond in Robinson State Park. Mr. Nielsen has designed the initial baseline assessments, sediment sampling program, and is overseeing the engineering design for the pond's restoration which includes dredging. Mr. Nielsen is also overseeing all permitting on this project. The 2,000 cubic yard restoration project that was recommended, designed, and permitted by ESS was completed by MassDCR in June of 2010 under the direct oversight by ESS and Mr. Nielsen.

- Town of Hopedale – Dredging Feasibility Assessment, Hopedale Pond, Hopedale, Massachusetts. Mr. Nielsen is the project manager and principal scientist for an extensive pre-dredging evaluation of Hopedale Pond, a 35 acre mill pond in Hopedale, MA that is suffering the effects of eutrophication and in-filling from its watershed. A goal of the study is to evaluate the quantity and quality of sediment in the pond as well as to assess the nutrient, bacteria, and other water quality issues related to ongoing inputs from its watershed. The results of the study will be used to provide the town with management recommendations for restoring this pond to its former condition through dredging. Management recommendations will include a detailed description of existing sources of pollution from its watershed and conceptual engineering designs for solving these issues on a site-by-site basis. The Best Management practices (BMPs) that ESS will be recommending will be designed to be economical yet effective. A focus of the ESS strategy will be to implement or retro-fit Low Impact Design (LID) techniques into the existing watershed landscape.

- Town of Brookfield – Non-Point Source Pollution Remediation at Quaboag and Quacumquasit Ponds, Brookfield, Massachusetts. Responsible for managing a project to assist the Town of Brookfield in carrying out the variety of tasks associated with a large 319 Non-Point Source Grant that they received from EPA through the State of Massachusetts. The project included structural BMP design and implementation, public educations, evaluations of a flow barrier device for nutrient management, and a pilot program to evaluate the effectiveness of using artificially created boating channels to manage people's perception of weeds at their lake rather than lake-wide herbicide application.

- Vespera, Inc. – Darrow Pond Baseline Assessment, Nutrient Modeling and Long-Term Management Plan, East Lyme, Connecticut. Responsible for design and implementation of a pond study to establish baseline conditions at a pond in East Lyme, CT that was downgradient of an innovative Low Impact Development (LID) consisting of over 1,200 acres and 600 individual residences. Mr. Nielsen was responsible for modeling the benefits of LID vs. standard design runoff management practices and making additional recommendations for further enhancing the projects ability to infiltrate runoff and treat pollutants. The project is still currently in the permitting process.

- Northeast Retail Management Co. LLC – Nutrient and Stormwater Loading Analysis for Inland Wetlands Commission, East Hampton, CT Responsible for designing a storm water management plan to make a proposed 3 acre development site net-neutral with regard to phosphorus load to Lake Pocatopaug in pre- and post-development site conditions. This was achieved through the use of a custom-designed stormwater infiltrations system with multiple removal processes built into the stormwater "treatment train". The project received approval from the Inland Wetlands Commission.

- Wilcox & Barton, Inc. – Water Quality and Biomonitoring Surveys and Ongoing Monitoring Reporting to Inland Wetlands Commission in Support of Major Retail Development, Guilford, Connecticut. Mr. Nielsen was responsible for designing and implementing a comprehensive biomonitoring program in Spinning Mill Brook adjacent to the construction site for a 155,000 square foot retail development. Work included sampling the fish community, benthic invertebrate community, aquatic habitat, and water quality. Work has been performed for two-baseline years of assessment and is likely to continue annually throughout the construction and operation of the proposed development.

- Massachusetts Department of Conservation and Recreation – Dredging Design and Permitting, Farm Pond, Carlisle, Massachusetts. Mr. Nielsen is the project manager and principal scientist responsible for the restoration of Farm Pond in Great Neck State Park. Mr. Nielsen has designed the initial baseline assessments, sediment sampling program, and is overseeing the engineering design for the pond's restoration which includes dredging. Mr. Nielsen is also overseeing all permitting on this project. Sediment from the pond will be re-used on the state park property as a landscape amendment.

- Glendale Power Station - Housatonic River Freshwater Mussel Survey, Stockbridge, MA. Mr. Nielsen designed and implemented a comprehensive survey for rare mussels for the Glendale Power Station in Stockbridge, MA in support of a Federal Energy Regulatory Commission (FERC) re-licensing of their hydro-power facility on the Housatonic River. Field survey was performed in the bypass channel of the hydro-power station on the Housatonic River. In addition, Mr. Nielsen was responsible for filing a Rare Animal Observation Form with the Massachusetts Natural Heritage and Endangered Species Program when evidence of a state-listed mussel species was found in the channel. Summarized the findings of the survey in a report supporting the FERC application.

- Gomez and Sullivan - Housatonic River Freshwater Mussel Survey; South Lee, MA. Mr. Nielsen designed and implemented a field survey for freshwater mussels in the bypass channel of a hydro-powered paper mill on the Housatonic River in support of a Federal Energy Regulatory Commission (FERC) re-licensing effort. No rare or endangered mussels were found in the initial survey. Mr. Nielsen summarized the findings of the survey in a report to the client which was included in the FERC application.

- United States Army Corps of Engineers (USACE) – Mill Pond Pre-Dredging Assessment, Littleton, Massachusetts. Mr. Nielsen was responsible for designing and implementing an assessment of the biological resources of Mill Pond in order to support the USACE with the dredging of Mill Pond. Work by Mr. Nielsen included the assessment of fish and macroinvertebrates in Mill Pond and its tributaries (Reedy Meadow Brook and Beaver Brook) which are all located within the Merrimack River watershed. Fish sampling was performed using boat and back-pack electo-shocking equipment.

- Walpole Country Club - Dredging Feasibility Assessment for Allen Pond, Walpole, Massachusetts. Mr. Nielsen was responsible for designing and overseeing a comprehensive investigation of issues pertaining to sediment transport and deposition at Allen Pond on the Walpole Country Club property in Walpole, MA. Work included storm water sampling, in-pond sediment coring for physical and chemical analysis, age dating of sediment cores, water quality assessment, and recommendations for long-term management of the pond. Following the initial work it was determined that a gravel operation upstream of the course was responsible for a large portion of the sediment that had been deposited within the pond. Mr. Nielsen is now overseeing the dredging design, permitting, and construction efforts to restore the ecological and aesthetic value to the pond.

- Massachusetts Executive Office of Environmental Affairs (EOEA) - Water Budget Study, Massachusetts statewide. Project manager for preparing water budget reports for 74 watersheds and over 300 individual towns in Massachusetts. The Water Budgets Study includes completing water budget assessments for all basins and communities in Massachusetts and evaluating the potential impacts on streamflow. Mr. Nielsen is responsible for the development of basin and community reports that document the water budget results, present associated summary tables and figures/maps. The reports will be developed using a number of document templates that are programmed to interface with the water budgets database using macros. This will enable these electronic reports to be “living documents” that are readily updatable as new data become available.

- Winchester Country Club – Lake Sediment Assessment for a Water Withdrawal Permit, Winchester, Massachusetts. Mr. Nielsen conducted an evaluation of sediment quality in the Upper Mystic Lake adjacent to the Winchester Country Club (WCC) with regard to its potential impact to the quality of groundwater withdrawn from a proposed irrigation well located adjacent to Upper Mystic Lake. Mr. Nielsen designed and oversaw the implementation of the sediment and porewater sampling program at Upper Mystic Lake. Mr. Nielsen also oversaw a risk evaluation of the potential for groundwater withdrawn through sediments of Upper Mystic Lake to mobilize metals contained in the sediments. The predicted groundwater concentrations (and the predicted groundwater concentrations within the source area) were also compared to the MADEP GW-1 (drinking water) standards and GW-3 standards. All of the predicted groundwater concentrations were found to be less than both the MADEP standards. The predictions were confirmed by the results of the groundwater sampling from the existing test well which showed that groundwater concentrations continue to be compliant with the MADEP GW-3 standards. Based on the results of the sediment, surface water, and groundwater sampling program; the analytical modeling performed to predict interstitial pore water concentrations within the lakebed sediments; and groundwater concentrations at the proposed irrigation well indicated that is unlikely that the impaired sediment quality identified within Upper Mystic Lake will have a significant adverse impact on the water quality within the proposed irrigation well.

- Massachusetts Executive Office of Environmental Affairs (EOEA) and the Pioneer Valley Planning Commission (PVPC), Westfield River Watershed Action Plan. Project Manager assisting PVPC with the development of the Watershed Action Plan (WAP) for the Westfield Watershed. Specifically the development of the Water Quality projects section including proposed scope of works for the following priority projects (1) Develop and Implement Water Quality Monitoring Program; (2) Fish Restoration/Remove Migration Barriers; and (3) Build out Analysis for Barnes Aquifer Zone II. Mr. Nielsen attended the public forum during the early stages of the development of the WAP to solicit comments.

- Town of Hull, Massachusetts – Straits Pond Monitoring and Management Plan – Hull, Massachusetts. Mr. Nielsen worked to prepare Notice of Intent (NOI) for a larvicide application for controlling midges in a Straits Pond, a coastal pond in Hull, Massachusetts. Mr. Nielsen also prepared a MassDEP approved QAPP for pre- and post-larvicide application midge assessment based on a sampling designed that he developed. The sampling program included an assessment of midge densities at numerous locations within the pond along with the associated habitat and water quality parameters at each location. Management recommendations developed focused on efforts designed to control the degree of midge infestation and aquatic plant and algae growth that was detrimentally affecting the overall habitat quality of this tidally influenced pond. Mr. Nielsen received a Certificate of Appreciation from the President of the Straits Pond Watershed Association following a presentation made to the Town regarding this project.

- Town of Norton, Massachusetts. Diagnostic and Feasibility Assessment for Management of Lake Winnecunnet, Norton, Massachusetts. Mr. Nielsen was responsible for conducting an assessment of Lake Winnecunnet and its watershed which are located within a Massachusetts ACEC (Area of Critical Environmental Concern). The deep-water habitat associated with the lake is threatened by the invasive and exotic plant *Cabomba caroliniana* (fanwort) which has spread throughout the lake to the detriment of native plants and potentially native fauna. The need to manage this situation while protecting the potentially rare or threatened species that exist within the lake required extensive survey of the lake shoreline, the major tributaries to the lake (Canoe River and Mulberry Meadow Brook), and the lake outlet (Snake River). Mr. Nielsen conducted a survey of freshwater mussels, aquatic macroinvertebrates, minnows and young-of-the-year fish, aquatic and semi-aquatic plants, reptiles, and amphibians. Based on these detailed surveys, Mr. Nielsen developed a comprehensive lake and watershed management plan for the Town.

- Town of Rindge, NH – Hydrologic and Nutrient Budget Analysis for Lake Monomonac, Rindge, New Hampshire. Mr. Nielsen was responsible for using existing data to model the potential impacts to Lake Monomonac from a proposed residential subdivision within its watershed. To do this, Mr. Nielsen first had to establish the hydrologic and nutrient budget for the lake and then determine how this would change due the to the proposed development's features. Based on this analysis, the development was found to be a minimal impact to the lake. Best Management Practices (BMPs) were proposed that could be incorporated into the proposed project's design to further minimize the potential for impact.

- Town of Westford, Massachusetts. Baseline Characterization, Drawdown Feasibility Assessment, and Long-term Monitoring Program for Nabnasset Lake, Westford, Massachusetts. Mr. Nielsen is serving as Project Manager and lead scientist in an investigation of the baseline characteristics of Nabnasset Lake and a hydrologically-linked wetland system known as Shipley Swamp. The purpose of the investigations was to determine the nature of impacts that could be anticipated as a result of a proposed winter lake drawdown for the purpose of controlling nuisance aquatic plants. As part of the baseline assessments, Mr. Nielsen established numerous plant monitoring plots within the wetland, biological monitoring stations within the wetland and lake, and established aquatic plant transects within the lake. These stations are currently being monitored annually to determine the response to drawdown (if any) to allow for immediate management actions to be taken as necessary to prevent significant damage from occurring to the ecosystem. Mr. Nielsen also prepared and filed a Notice of Intent for the control of nuisance aquatic plants at Nabnasset Lake by lake drawdown.

- Massachusetts Department of Conservation and Recreation – Assessment and Permitting for In-lake Weed Control at Lake Cochituate, Massachusetts. Mr. Nielsen prepared Notices of Intent for submittal to the Towns of Framingham, Wayland, and Natick, Massachusetts for the control of nuisance aquatic vegetation at Lake Cochituate. Proposed measures included the use of herbicides, hand-pulling, diver suctioning, milfoil weevils, water circulation, and benthic barriers to control milfoil and curly-leaf pondweed in the lake.

- Massachusetts Department of Conservation and Recreation – Assessment and Permitting of Management Activities (Hydro-raking) at Ruggles Pond, Wendell, Massachusetts. Mr. Nielsen prepared a Notice of Intent for the removal of white water lily (*Nymphaea odorata*) and other nuisance aquatic plants by hydro-raking at Ruggles Pond. Conducted aquatic plant mapping and wildlife habitat evaluations at the pond to quantify the growth of nuisance aquatic plants and assess potential impacts from proposed hydro-raking activities on the aquatic community.

- Massachusetts Department of Conservation and Recreation – Diagnostic/Feasibility Assessment of Big Pond, Otis, Massachusetts. Mr. Nielsen designed and conducted an investigation of Big Pond and its watershed to gather baseline information on water quality, stormwater quality, macroinvertebrate community composition, aquatic and wetland plants, fish, and wildlife. Mr. Nielsen made recommendations for monitoring and preserving the ecological integrity of this relatively healthy aquatic system.

- Town of Hinsdale, Massachusetts – Diagnostic/Feasibility Assessment of Ashmere Lake and Plunkett Reservoir, Hinsdale, Massachusetts. The Hinsdale lakes are located in a Massachusetts ACEC (area of critical environmental concern). Mr. Nielsen designed and carried out an assessment of the physical, chemical and biological characteristics of these lakes which included water quality assessment, fish and wildlife evaluations, rare/threatened/endangered species investigations, and wetland plant assessments. The work served as the basis for making recommendations for controlling nuisance aquatic vegetation within the lakes while minimizing the potential to cause adverse effects on sensitive or rare species common to the ACEC and their watersheds.

- Neponset River Watershed Association - Neponset River Flow Stressed Stream Habitat Assessment & Fish Passage Evaluations, Boston, Massachusetts. Mr. Nielsen evaluated streamflow augmentation and instream habitat restoration alternatives and recommended enhancements that would restore habitat for macroinvertebrates and a target list of freshwater fish species in six sub-watersheds draining to the East Branch of the Neponset River, a tributary to Boston Harbor. Mr. Nielsen served as the macroinvertebrate expert on a team designated as the "trio of experts" (a fisheries biologist, macroinvertebrate specialist, and stream hydrologist) charged with assessing 12 selected stream reaches within the study area during a variety of flow regimes. Mr. Nielsen was responsible for preparing the final report.

- Town of Deering, New Hampshire - Hydrologic and Nutrient Loading Analysis for Deering Reservoir, Deering, New Hampshire. Mr. Nielsen evaluated the potential impact to Deering Lake from two proposed residential sub-divisions to be constructed within the Deering Lake watershed. Town officials and local residents expressed concern over the potential for these developments, as well as future developments, to result in excessive nutrient loading to the lake and contribute to a subsequent decrease in water quality. Deering Lake is classified by New Hampshire Department of Environmental Services (NHDES) as an oligotrophic (low productivity) waterbody. Mr. Nielsen's hydrologic and nutrient loading analysis aided the Town in protecting the quality of the lake and will serve as the basis for evaluating whether the proposed developments, as well as future developments, are compatible with maintaining current in-lake conditions. The modeling effort and report were reviewed and approved by NHDES.

- Town of Deering, New Hampshire – Watershed Build-out Analysis. As a follow-on to the above-described project, Mr. Nielsen conducted a watershed build-out analysis of the Deering Reservoir watershed under 5 different proposed zoning by-law changes. Mr. Nielsen provided the scientific foundation for decisions related to land use planning and future development within the watershed. Evaluations focused on understanding the effect of several development constraints that might be imposed through zoning restrictions including a select number of combinations of minimum lot sizes, wetland setback requirements, and road frontage distances. This assessment was conducted in a manner consistent with standard engineering practices and used U.S. EPA's published guidelines for nutrient load analysis. This approach ensured that the analysis was reliable and defendable. This approach has been used by Mr. Nielsen for more than 30 different watershed systems in New England including many state and municipally funded projects.

- Confidential Client, Hopkinton, Massachusetts – Critical Review of a Proposed 40B Development, Hopkinton, Massachusetts. Responsible for conducting a critical review of a proposed 40-unit 40B housing development in the Town of Hopkinton, Massachusetts. Development of the proposed project site was heavily constrained by Certified Vernal Pool wetlands located on site. However, nitrogen loading from the proposed wastewater treatment system was found to not be a serious threat to the health of these wetlands as previously suspected. Recommendations focused on the implementation of several appropriate BMPs that would be compatible with the proposed development. A monitoring program for the wetland and its tributary was also proposed to ensure their protection. The development is under review at the current time, although it is expected that Mr. Nielsen's recommendations will be incorporated into the project design.

- Jones River Watershed Association – Review of Proposed 40B Development, Pembroke, Massachusetts. Responsible for conducting a critical review of a proposed 44-unit 40B housing development in the Town of Pembroke, Massachusetts. Development of the proposed project site was heavily constrained by Class A wetlands located on site. Nitrogen loading from the proposed wastewater treatment system was found to be a serious threat to the health of these wetlands as well as to the City of Brockton's surface water supply to which they drained. Recommendations focused on the implementation of several appropriate BMPs that would be compatible with the proposed development. A monitoring program for the wetland and its tributary was also proposed to ensure their protection. The development is under review at the current time, although it is expected that Mr. Nielsen's recommendations will be incorporated into the project design.

- Massachusetts Department of Environmental Protection – Chicopee River Watershed Stormwater Assessment. Mr. Nielsen assisted the MassDEP and the Chicopee River Watershed Team by developing a program for locating and assessing the condition of over 300 storm water structures within the rural portions of the Chicopee River Watershed. Assessment included Global Position System (GPS) location of the structures and documentation of over 20 descriptive features of each drain pipe, catch basin, or retention device. Water quality sampling was conducted on storm drains that were observed to be flowing during dry weather in order to assist the state in identifying illicit storm drain hook-ups. All data collected was incorporated into a Geographical Information Systems (GIS) database along with a photograph of each structure. Mr. Nielsen subsequently prepared presentations to educate local communities and highway departments on the findings of the study and to provide them with guidance on how to better manage their storm drainage systems. All data was provided to each town as an interactive computer file on CD-ROM to serve as a basis for tracking management actions.

- Massachusetts Department of Environmental Protection – Shawsheen River Watershed Stormwater Assessment. Mr. Nielsen worked with the Shawsheen River Watershed Team and the Merrimack River Watershed Council (MRWC) to design and conduct a basin-wide storm water assessment program. The purpose of the program was to collect water quality and habitat data for use in a bacteria Total Maximum Daily Load (TMDL) model for the watershed. The TMDL model is currently being implemented and is expected to assist the state and local communities in prioritizing and addressing storm water related water quality problems and to ultimately meet state water quality standards.

- Murtha Cullina, LLP – Macroinvertebrate and Stream Habitat Evaluation, Danbury, Connecticut. Mr. Nielsen was responsible for designing and implementing a biomonitoring program that was prompted in response to claims by the State of Connecticut that activities at an industrial site may have resulted in an impact to the Still River as it flowed through the site. In order to respond to these concerns Mr. Nielsen conducted an investigation of benthic macroinvertebrates, water quality and surrounding stream habitat in several reaches of the Still River bracketing the discharges associated with the site. Although storm water runoff was observed to alter turbidity and temperature, the similarity of the various macroinvertebrate population statistics calculated indicated that the observed influence of the site's runoff was not of a magnitude that was translating into an impact on the macroinvertebrate community. Recommendations were made as to how the storm water structures at the site might be modified to improve retention of sediment and further cool storm water runoff prior to being discharged to the river.

- Town of Charlton, MA - Little Nugget Lake Diagnostic/Feasibility Assessment, Charlton, Massachusetts. Mr. Nielsen designed and coordinated a diagnostic and feasibility study of Little Nugget Lake and its watershed in order to determine why aquatic vegetation had recently expanded in the pond to nuisance levels and to recommend appropriate management actions. Management for the pond included a limited herbicide treatment of selected weed beds and education of watershed residents through the design and distribution of an educational brochure.

- Aquarion Water Company – Biological Survey in Response to Fish Kill, Easton, Connecticut. ESS responded quickly to design and conduct a biological (fish and macroinvertebrates) assessment of numerous sites upstream and downstream of a reported chlorine spill downstream of a water supply reservoir managed by Aquarion Water Company. Work was initiated immediately following reports of a fish kill in order to characterize the true nature of impacts to Mill River and to develop an appropriate remedial response. Although work on this project is ongoing, initial results seem to indicate that the effects of the spill on the macroinvertebrate community was minimal and that a natural recovery of the stream would be expected within a very short period of time. ESS recommended that baseline macroinvertebrate data be collected for other key streams within the watershed so that any future problems within the water supplier's watershed could be easily evaluated.

- Aquarion Water Company –Fish and Fish Habitat Survey, Kent, Connecticut. ESS responded to design and conduct a biological (fish and macroinvertebrates) assessment of sites upstream and downstream of a release of sediment from an impoundment in the water supply drainage system managed by Aquarion Water Company. The sediment was released as a result of construction activities associated with a dam removal project and the sediment was believed to have impacted one of the few native trout spawning habitats in Connecticut. Mr. Nielsen characterizes the true nature of impacts and developed an appropriate remedial response. The scope of work was coordinated directly with CTDEP fishery staff.

- Rhode Island Department of Environmental Management – Statewide Biomonitoring of Rhode Island's Wadeable Streams, Rhode Island. Mr. Nielsen is currently responsible for managing and conducting a long-term biomonitoring program for wadeable streams of Rhode Island. The purpose of the program is to provide the Rhode Island Department of Environmental Management (RIDEM) with benthic macroinvertebrate and stream habitat data from selected streams within the state's two main eco-regions. The biological data collected is being used to fulfill the state's 305(b) reporting requirements and to provide a greater understanding of the relationship between the macroinvertebrate community and stream habitat. ESS collected and analyzed macroinvertebrate data according to the US EPA's Rapid Bioassessment Protocol, which allows for predictions and or inferences to be made on aquatic ecosystem quality from a relatively "rapid" assessment of the prevailing macroinvertebrate community composition. A total of up to 50 stream segments are assessed each year during the contract period. Once samples are collected from the field, Mr. Nielsen and other ESS staff process the samples and identify the macroinvertebrates to the lowest practical taxonomic level, typically Genus, and perform a comprehensive statistical analysis of the results. Yearly data reports are being provided to RIDEM during the contract period. Mr. Nielsen also provided a multi-year data trend analysis along with recommendations for future monitoring and stream restoration as part of the comprehensive final report. This contract began in 2002 and has been renewed for the period from 2006-2013.

- Town of Littleton – Dredging of Mill Pond, Littleton, Massachusetts. Mr. Nielsen is overseeing the civil engineering group at ESS that is providing engineering services for dredging approximately 200,000 cubic yards of nutrient rich soft sediments from four interconnected basins that comprise Mill Pond. The dredging project is being conducted to restore pond depth and to control excessive aquatic plant growth thereby enhancing the recreational and aesthetic value of the pond. ESS is preparing a complete construction bid package for the pond restoration project. The work entails establishing the dredging limits, evaluating acceptable dredge methods, evaluate sediment dewatering requirements, siting of a public boat launch, site access/egress, construction sequencing, and preparation of construction bid documents. An integral part of the project is the construction of a five-acre nutrient/sediment detention system proposed at the outfall of the pond's largest tributary. The constructed wetland system is being designed to trap suspended sediments and remove nutrients through biological uptake prior to reaching the pond.

- Burncoat Pond Watershed District - Burncoat Pond, Towns of Leicester and Spencer, Massachusetts. Designed and coordinated a diagnostic and feasibility study of the Burncoat Pond and its watershed in order to determine why aquatic vegetation had recently expanded in the pond to nuisance levels and to recommend appropriate management actions. Recommend management for the pond included the implementation of a controlled winter drawdown of the pond and education of watershed residents.

- Massachusetts Department of Environmental Protection – Westport River Watershed. Work for the Westport River focused on addressing Non-Point Source (NPS) pollutant loading, particularly fecal coliform and *E. coli* bacteria loading from agricultural runoff, road runoff, and other potential sources within the watershed. Mr. Nielsen worked to assess loading within the watershed and to develop specific Best Management Practices (BMPs) to address identified sources. BMPs are included recommendations for behavioral modification through education as well as engineering design for structural solutions such as infiltration basins, vegetated swales, or detention facilities. Mr. Nielsen worked closely with the Buzzards Bay Watershed Team and the Westport River Watershed Alliance (WRWA) to assess key storm drain discharges and tributaries within the watershed with the goal of confirming specific sources of bacteria loading. The project also relied on existing data and efforts by the Team and the WRWA so that cost savings could be achieved. The project received a 319 NPS Grant from MassDEP and the major BMPs have been implemented successfully.

- RIDEM, EPA and Tetra Tech, Inc. - Mashapaug Pond TMDL, Providence, Rhode Island. Mashapaug Pond has been identified as impaired by excess nutrients and low levels of dissolved oxygen. The Mashapaug Pond watershed is densely developed with a mix of residential, commercial and industrial land uses. The EPA recently agreed to provide federal funding to support the development of a nutrient TMDL for Mashapaug Pond that is to serve as a pilot project for the rest of the region. Mr. Nielsen was responsible for overseeing the design of the study which included the preparation of a Quality Assurance Project Plan (QAPP) and the implementation of the water quality, aquatic plant, groundwater quality and quantity, and fish tissue sampling programs. The goal of this project was to collect water quality data sufficient for developing a TMDL for the pond. The nutrient TMDL was prepared for RIDEM and subsequently approved by US EPA Region 1. This work also supported the preparation of a bacterial TMDL for the waterbody.

- Lake Wickaboag Preservation Association – Lake Wickaboag, W. Brookfield, Massachusetts. Designed and implemented an evaluation of the quantity and quality of accumulated sediments within this large recreational waterbody. The lake has a long history of algal problems, which have been regularly controlled through copper sulfate treatment rather than by assessing the source of the nutrients that are causing the algal blooms. Concern was also raised that the copper may be accumulating to toxic levels in the sediments of the lake. Consequently, sediment quality was evaluated to determine its potential to influence in-lake water quality and to assess its potential to adversely affect the aquatic biota.

- Massachusetts Department of Environmental Protection - Narragansett/Mount Hope Bay and Ten Mile River Watersheds NPS Assessment, Massachusetts & Rhode Island. Coordinated and performed watershed level water quality assessment to identify significant sources of non-point source (NPS) pollution, prioritize these sources, and design a management plan to protect and improve water quality in the Narragansett/Mount Hope Bay and Ten Mile River Watersheds. Prepared and developed MassDEP approved QAPP. Applied P8 modeling program to the study watersheds, thus enabling the prediction of future pollutant loading within the watersheds based on projected population growth estimates. Results from the P8 model will aid in the identification of specific regions most suitable for the implementation of best management practices.

- Town of Sandwich - Shawme Ponds Septic Leachate Study, Sandwich, Massachusetts. Responsible for designing and implementing a groundwater sampling program for Upper and Lower Shawme Pond, waterbodies which were suspected to be influenced by infiltration of septic leachate from adjacent shoreline homes. Groundwater seepage quantity and quality was assessed through the use seepage meters and littoral interstitial porewater (LIP) samplers. Data analysis revealed that nutrient loading via groundwater is a significant annual source of nutrient to the ponds and therefore, management recommendations emphasized increased septic system maintenance, innovative septic system technologies and continued monitoring of in-pond conditions.

- Town of Stoughton, Massachusetts. Diagnostic/Feasibility Study for Ames Long Pond, Stoughton, Massachusetts. Responsible for designing and conducting a comprehensive diagnostic/feasibility assessment of Ames Long Pond and its watershed. The evaluation included an assessment of in-pond water and sediment quality, storm water runoff, groundwater quantity and quality, and a vegetation survey of pond. Management recommendations focused on reducing the growth of nuisance aquatic plants and decreasing the nutrient loading to the pond through in-pond and watershed level management actions.

- Massachusetts Department of Environmental Protection – Non-point Source Water Quality Modeling, Chicopee Watershed, Massachusetts. Developed and implemented a program for analyzing Non-point Source (NPS) pollutant loads to the Quaboag River watershed, a sub-watershed of the Chicopee River watershed. The program relied on GIS land use data, P8 computer modeling, and in-field water quality testing to evaluate over 30 sub-watersheds with respect to average annual nitrogen and phosphorus loads. All sampling was conducted in accordance with a project specific Quality Assurance Project Plan (QAPP). Information generated from the models was used to predict future pollutant loading within the Quaboag River watershed that could result based on currently projected population growth estimates. The information generated was used to effectively prioritize and target management actions throughout the watershed to improve water quality.

- Town of Wrentham – Multi-Lake Diagnostic/Feasibility Assessment, Wrentham, Massachusetts. Responsible for designing and conducting an assessment of the physical, chemical and biological characteristics of Lake Pearl, Lake Archer and Mirror Lake in

Wrentham, Massachusetts in order to determine the cause of lake eutrophication. A key concern was the potential for the groundwater entering these lakes to be contaminated by septic systems within their watersheds. The investigation focused on answering this question through the use of seepage meters (to measure groundwater quantity) and littoral interstitial porewater sampling (to measure groundwater quality). Results from this study were used to evaluate the potential benefits of installing sewer lines through portions of the watershed.

- Town of Wayland – Biological Assessment of Heard and Mill Ponds, Wayland Massachusetts. Designed and implemented a diagnostic/feasibility assessment of Heard and Mill Ponds in Wayland, Massachusetts for the purpose of determining effective treatment methods for the control of nuisance aquatic weed growth, and in particular the exotic species water chestnut (*Trappa natans*). Methods of treatment will rely on mechanical harvesting within key areas of the ponds to ensure that the natural plant community will not be disrupted and can continue to provide valuable habitat to fish and wildlife.

- Lake Monomonac Association, Drawdown Feasibility Assessment, Winchendon Springs, Massachusetts and Rindge, New Hampshire. Conducted a feasibility assessment of Lake Monomonac to ascertain the potential effectiveness of lake drawdown as a method for controlling the nuisance aquatic weed variable leaf milfoil (*Myriophyllum heterophyllum*). Based on the potential impacts of drawdown on the surrounding wetlands and the relatively small area of actual plant infestation, drawdown was not recommended as an appropriate control method at the time.

- Town of Ayer – Diagnostic Feasibility Assessment of Spectacle Pond, Ayer and Littleton, Massachusetts. Designed and Implemented a diagnostic/feasibility assessment of Spectacle Pond in Littleton, Massachusetts for the purpose of determining effective treatment methods for the control of nuisance aquatic weed growth, and in particular the exotic species fanwort (*Cabomba caroliniana*). Two possible methods of treatment were recommended. One feasible method was chemical treatment of the pond with flouridone at a dose specific to the control of fanwort. This precision approach will ensure that the natural plant community will not be disrupted and will continue to provide valuable habitat to fish and wildlife. As second, non-chemical alternative that was recommended was to control nuisance plant beds through the use of hydro-raking equipment in selected areas.

- Norton Company – Pre-Dredging Evaluation of Two Industrial Ponds, Worcester, Massachusetts. Designed and implemented an evaluation of the quantity and quality of accumulated sediments within two industrial ponds located on Norton Company property. Sediment quality was satisfactory for upland disposal. Recommendations made specified the dredging methodology to be used, permitting needs, and overall project costs.

- American Ref-Fuel – Wankinco River Monitoring Program, Carver, Massachusetts. Designed and implemented a sampling program to assess impacts to the Wankinco River from an adjacent landfill. Sampling program focused on both longitudinal and latitudinal differences in water quality and sediment quality within the river channel. Program was reviewed and accepted by the MassDEP. Implementation is ongoing.

- Massachusetts Department of Environmental Protection – Aquatic Habitat Evaluation, French and Quinebaug Watersheds, Massachusetts. Developed and implemented a watershed-wide aquatic habitat assessment program to identify potential problems within the watersheds and to serve as baseline data for future monitoring efforts. Aquatic habitat monitoring was conducted in a manner consistent with MassDEP's Method

004 Aquatic Habitat Assessment Protocol at 50 sites within the two watersheds. Aquatic invertebrates and water quality data were collected and assessed at 10 key sites. All sampling was conducted in accordance with a project specific Quality Assurance Project Plan (QAPP). All information was incorporated into a GIS database and provided to MassDEP as an interactive CD-ROM for use by the French and Quinebaug Watershed Team.

- Massachusetts Department of Environmental Protection – Sediment and Water Quality Assessment, Deerfield Watershed, Massachusetts. Developed and implemented a program for assessing sediment quality behind six impoundments located within the Deerfield Watershed in order to make recommendations regarding potential effects on aquatic biota or human health. In addition, an assessment of fecal coliform contamination was conducted throughout the watershed at more than 20 sites during multiple dry weather and wet weather conditions. All sampling was conducted in accordance with a project specific Quality Assurance Project Plan (QAPP). The water quality data collected, in conjunction with GIS land use data and in-field reconnaissance, was used to identify potential pollutant sources and make recommendations for future management actions.

- Town of Dartmouth – Nuisance Aquatic Vegetation Management Plan – Lake Noquochoke, Dartmouth, Massachusetts. Conducted an assessment of the physical, chemical, and biological conditions within each of the five basins of Lake Noqochoke and the associated watershed for the purposes of recommending measures for controlling excessive aquatic plant growth. Recommendations for plant control were tailored specifically to meet the needs and goals for each of the lake's five basins. Recommendations included herbicides, hydro-raking, and dredging, as well as measures for improving factors within the watershed which have been affecting conditions within the lake.

- Quacumquasit Lake Association – Eurasian Milfoil Transport Study, Brookfield Massachusetts. Designed an on-going study to document the quantity of Eurasian Milfoil being transported into Quacumquasit Lake from an adjacent waterbody during flow reversals within an inter-basin connector resulting from large rain events. This innovative management technique is designed to minimize the spread of Eurasian Milfoil, a highly invasive exotic weed. Directly responsible for training Lake Association volunteers to implement the required field work associated with this project. Data collected will be used to build a case for closing the existing flow barrier between the two lakes during times of summer flow reversals.

- Town of Hopkinton - Storm Water Management Plan, Hopkinton, Massachusetts. Assessed conditions within and downgradient of a relatively new area of property development within the town of Hopkinton. Storm water runoff from the area was reported to carry an excessive sediment load, and evidence at the site showed erosional damage associated with many storm water structures at the site. As part of this project, the recommended solutions were incorporated into the Town of Hopkinton by-laws.

- Town of Wellesley - Multi-Year Limnological Monitoring of Morses Pond, Wellesley, Massachusetts. Project manager for the multi-year monitoring of in-lake conditions at Morses Pond, a 103-acre lake within a highly urbanized setting. Investigations to date have revealed infestation of the pond by Water Chestnut (*Trapa natans*), an exotic plant that can grow to nuisance levels. Additionally, algal blooms within the pond have become a concern. On-going monitoring and management recommendations are required to ensure proper protection of the Town's public beach.

- White Lily Pond Association – Aquatic Plant Community and Water Quality Assessment of White Lily Pond, Otis, Massachusetts. Performed a multi-year evaluation of in-lake conditions at White Lily Pond for the purpose of providing management recommendations. The project was undertaken in order to assess the severity of the pond's aquatic vegetation problem and to provide baseline physical, chemical, and biological conditions of the pond.

- Quaboag and Quacumquasit Lake Association – Summary Report and Grant Application Assistance, Sturbridge, Massachusetts. Responsible for the synthesis of several decades worth of reports and data with the goal of gaining a better understanding of the chemical and biological changes that have occurred in two lakes during the previous 25 years. The primary goal of the study was to better understand how past management actions have altered the quality of each lake, and most importantly to provide a foundation for future management decisions and for securing potential funding for management actions.

- City of New Haven – Impact Assessment of a Proposed Water Diversion from the Mill River, New Haven, Connecticut. Provided third party review of a report entitled "Lake Whitney Water Treatment Plant Environmental Evaluation", dated January 1999. This report was prepared by an environmental study team contracted to the South Central Connecticut Regional Water Authority to evaluate potential impacts and propose mitigation associated with the withdrawal of up to 15 million gallons per day of water from Lake Whitney. The area of evaluation included the Mill River system below Eli Whitney Dam, much of which flows through East Rock Park, a significant resource located in an urbanized area of New Haven. The third party evaluation was prompted in response to concern by the City of New Haven and members of the community over decreased flows and reduced water quality in Mill River below the Eli Whitney Dam.

- Town of Littleton – Fish Sampling and Tissue Analysis for PCB's, Littleton, Massachusetts. Responsible for performing an assessment to determine the potential risk to human health posed by PCB's reported from Mill Pond. The fish population was sampled from the pond and tissue samples from both large game fish (bass and pickerel) and large bottom feeding fish (sucker and bullhead) were analyzed for PCB's. Although one fish had accumulated PCB's in its tissue, the levels detected were well below the human health benchmark. Dredging of the pond sediments to remove the contaminated sediments and reduce aquatic plant growth is part of the long-term pond restoration program.

- Bethlehem Steel, U.S. Steel, and Butler Manufacturing - Roof Runoff Testing, Northeastern Massachusetts. Storm water runoff from zinc-aluminum alloy roofs was collected from seven buildings of differing ages during a single storm event. First-flush storm water was sampled using inexpensive, automated sampling devices that were custom designed for this project. Testing revealed that zinc contamination of the storm water decreases rapidly over the course of a storm event and also decreases substantially with increased age of the roof material.

- Down Island Golf Club, LLC - Lagoon Pond and Sengekontacket Pond Nutrient Loading Impact Assessment, Oak Bluffs, Massachusetts. Responsible for providing both surface water and groundwater impact assessments as part of the comprehensive environmental consulting and engineering services that ESS provided for a private 18-hole golf course development project. Assessments included in-pond sampling as well as controlled on-site turf plot studies. Data collected as part of these investigations was used to develop a balanced nitrogen loading budget for the entire project site. This approach was used to develop a program of short-term and long-term nitrogen loading off-sets from within the watershed resulting in a net reduction in overall nitrogen loading within the each watershed as a result of the proposed program.

- AES Enterprise – Aquatic Habitat Impact Assessment, New Britain and Southington, Connecticut. Downstream resources associated with the New Britain Water Supply System were evaluated by Mr. Nielsen as part of a water diversion permit application for a proposed power generating plant in the Town of Southington, Connecticut. Mr. Nielsen designed studies to determine impacts associated with the withdrawal of four million gallons per day (gpd) of water for evaporative cooling and ultimately the discharge of over 100,000 gpd of cooling water back into the Quinnipiac River. Fish, aquatic invertebrates, water chemistry and habitat were assessed to determine means by which the water supply system could be operated to deliver the required volume of water while minimizing environmental impacts associated with the project.

- Massachusetts Department of Environmental Protection – Determination of Sources of Water Quality Impairment, Westfield Watershed, Massachusetts. Designed and implemented a watershed-wide pollutant source identification program for the Westfield River Watershed. The main stem of the Westfield River is threatened by poor water quality; the sources of this pollution were determined through an extensive sampling program. The project included water quality sampling of both dry and wet weather conditions at over 40 stations, as well as habitat, aquatic invertebrate and periphyton analysis. Impaired sub-basins within the watershed were identified and solutions for identified pollutant sources were recommended. The report included an extensive database presented in GIS format for the purposes of illustrating patterns in water quality for each sampled parameter.

- Goose Pond Maintenance District - Defined Baseline Conditions, Lee/Tyringham, Massachusetts. Performed a study of the physical, chemical, and biological features of Goose Pond and its watershed for the Goose Pond Maintenance District. The project was undertaken to generate information that could provide a basis for management decisions regarding this relatively pristine waterbody.

- Lake Boon Commission - Nutrient Study of Lake Boon, Hudson/Stow, Massachusetts. Performed a study of the physical, chemical, and biological features of Lake Boon and its watershed for the Lake Boon Conservation Commission. The study was conducted in response to perceived increases in eutrophication and aquatic plant abundance within the lake. It was determined that high levels of nutrients were entering the lake from storm water and groundwater sources. Recommendations focused on improving storm water quality through implementation of BMPs and improving groundwater quality through increased septic system maintenance. Recommendations for nuisance plant control focused on a combination of chemical control and lake drawdown. Subsequently designed and implemented an evaluation of the potential ecological impacts that may occur as a result of the proposed drawdown. Impacts to reptiles, amphibians, aquatic invertebrates and non-target plant species were assessed.

- Town of Groton - Pre-dredging Survey of Thompson Mill Pond, Groton, Massachusetts. Conducted a study of Thompson Mill Pond's sediment quantity and quality in preparation for a dredging program. It was determined that the sediment was of a quality that could be properly disposed without undue risk of contaminating downstream resources or areas adjacent to the disposal area.

- **Town of Littleton - Watershed Management Plan for Mill Pond, Littleton, Massachusetts.** Conducted an assessment of the physical, chemical, and biological conditions within Mill Pond and its watershed for the purposes of recommending measures for controlling excessive aquatic plant growth. Recommendations focused on plant control through dredging and a reduction of the sediment and nutrient load from sources within the watershed. Currently, Mr. Nielsen is working with the Town and the US Army Corps of Engineers to permit and implement the recommendations made during this study which included dredging of >200,000 cubic yards of material, creating public access, and creating a wetland system at the major inlets to the pond to reduce pollutants associated with storm water flows.

- **Town of Westwood - Diagnostic/Feasibility Study for Perry Crouse Pond, Westwood, Massachusetts.** Performed a study of the physical, chemical, and biological features of Perry Crouse Pond to assess methods for reducing plant growth within the pond. Recommendations for the immediate future focused on physical removal of water lily root masses and chemical treatment of nuisance species. Dredging was the primary long-term solution for maintaining open water within the relatively shallow pond.

- **National Science Foundation - Investigation of the Effects of Artificial Shading on the Macroinvertebrate and Periphyton Communities, New Hampshire.** A study of stream shading on several tributaries in the Hubbard Brook Experimental Forest in New Hampshire was designed as part of a National Science Foundation grant. Macroinvertebrate communities were not significantly different between shaded and non-shaded stream segments. This unexpected result was due to low nutrient levels being the limiting factor controlling primary productivity rather than light levels. Information from this study was used as part of a broader study researching the effects of clear-cutting practices by the forest industry.

- **Major Property Developers - Invertebrate Community Assessment, Braintree and Wilmington, Massachusetts.** Examined several stream systems in Braintree and Wilmington, Massachusetts for two confidential developers to determine the relative permanence of several stream tributaries as defined under the Massachusetts Riverways Protection Act (MRPA). Both systems had invertebrate populations that would typically occur in streams defined as temporary and consequently suggested that these streams should not be subject to the 100-foot buffer zone as specified under the MRPA.

- **Conservation Commission - Baseline Survey, North Attleborough, Massachusetts.** Investigated a segment of the Ten Mile River between Whitings Pond and Fall Pond in North Attleborough, Massachusetts to document existing conditions. Duties included the collection of sediment cores from the river, habitat evaluation, and an assessment of the macroinvertebrate community. Information gathered was used to evaluate the feasibility of dredging selected portions of the river.

- **Massachusetts Highway Department - Environmental Oversight, South Hadley, Massachusetts.** Provided environmental oversight for the Massachusetts Highway Department during the demolition of the old Route 116 bridge in South Hadley, Massachusetts. The primary concern of this program was the Shortnose Sturgeon (*Acipenser brevirostrum*) spawning beds located approximately 200 yards downstream of the demolition area. Duties included the implementation of the QA/QC program, preparation of monthly reports and a final report describing all water quality monitoring data, and reporting any environmental concerns and corrective actions that were implemented as a result of this oversight.

- Massachusetts Department of Environmental Protection, Office of Watershed Management - Major Fishery Inventory, Massachusetts and Vermont. Responsible for the fish collection portion of a carefully planned research investigation by the MassDEP/OWM on the development of numeric biocriteria for possible promulgation in its Surface Water Quality Standards. Sampling sub-ecoregions included 26 reference sites, 15 impaired sites, and eight quality control sites throughout Massachusetts and Vermont. Fish were collected using standard back-pack electrofishing procedures.

- PG&E - Athens Generating Project, Athens, New York. Coordinated an extensive investigation of the Hudson River in association with a proposed water intake and discharge pipeline extending from shore, through a tidal flat, and into the river channel. This effort involved biological, chemical, physical, and historical characterizations of an area that would be subject to dredging for the purpose of a pipeline installation. Investigated the invertebrate and aquatic plant communities associated with near shore habitats at the site in order to locate possible rare or endangered species and further characterize the level of impact. Coordinated the collection of core samples along the proposed pipeline path for the purpose of describing the physical and chemical characteristics of the sediment within the dredge path. Supervised a marine archaeology survey at the site including magnetic, sonar, and visual location of items of potential historical interest.

- Town of Wellesley - Phosphorus Inactivation Pilot Study, Wellesley, Massachusetts. Mr. Nielsen was responsible for implementing a pilot program for the inactivation of phosphorus in Bogle Brook, a tributary to Morses Pond, in Wellesley, Massachusetts. The program was designed to assess the capability for reducing peak loads believed to be largely responsible for observed algal blooms, low water clarity, and related water quality and use impairment in Morses Pond. Multiple storm events were treated with either aluminum or calcium compounds in response to rising flows. Treatments were determined to have been reasonably effective in relation to small storms, with aluminum sulfate being the most effective. Other responsibilities included all aspects of the permitting process and assisting with the design, construction and operation of the storm water treatment system.

- City of Gardner - Diagnostic/Feasibility Study, Gardner, Massachusetts. Managed the diagnostic/feasibility study of Parker Pond and its watershed in Gardner, Massachusetts. The study determined that increased levels of nutrients entering the pond during storm events must be decreased, diverted, or removed to improve water quality. Additionally, dredging of in-lake sediment was recommended to increase depth and control rooted macrophytes.

- City of Peabody - Diagnostic/Feasibility Study, Peabody, Massachusetts. Supervised and performed a diagnostic/feasibility study for Crystal Lake and Elginwood Pond in the City of Peabody, Massachusetts. Sediment accumulations throughout the system were negatively impacting most forms of recreation. Dredging coupled with in-stream sediment removal systems were recommended.

- Massachusetts Department of Environmental Management - Diagnostic/Feasibility Study, Boston, Massachusetts. Supervised a diagnostic/feasibility study of Chandler Pond in Boston, Massachusetts. Evaluation of the hydrologic budget and nutrient loading to the system revealed significant sediment and phosphorus loading during storm events. Management recommendations included plans to divert or reduce the quantity of first-flush storm water entering the pond and subsequent dredging of the sediment accumulations currently within the pond.

- Woodridge Lake Property Owners Association - Diagnostic/Feasibility Study, Goshen, Connecticut. Performed a diagnostic/feasibility study of Woodridge Lake and its watershed in Goshen, Connecticut to evaluate existing conditions to provide a basis for management decisions. Management recommendations included a harvesting program taylored to the specific growth and reproduction cycles of the plant species creating nuisance conditions within the lake.

- Towns of Pembroke and Duxbury - Diagnostic/Feasibility Study, Pembroke and Duxbury, Massachusetts. Supervised a diagnostic/feasibility study of Lower Chandler Mill Pond that was prompted by concerns over plant nuisances and perceived loss of recreational utility. Information gathered was used to provide input on appropriate management of the pond and as a basis for guiding future management decisions. Management recommendations included plans to perform a lake drawdown and/or combine the drawdown with an herbicide application for maximum effectiveness.

- Massachusetts Highway Department - Ecological Monitoring Investigation, Taunton, Massachusetts. Examined five stream systems along the Route 44 corridor near Taunton, Massachusetts to document existing conditions in order to assess potential environmental impacts associated with a proposed highway expansion. This investigation included an evaluation of water chemistry, physical habitat, fish community composition, algal community composition, and macroinvertebrate community composition.

- National Parks Service - Baseline Survey, Missouri. Investigated baseline characteristics of Big Spring, the second largest spring system in the United States, for the Ozark National Scenic Riverways branch of the National Parks Service. Work focused on differences in substrate use by macroinvertebrates, temporal changes in the aquatic plant bed, and storm water discharge monitoring. Habitat throughout the system was mapped via GPS and the HABSIM protocol. The study was prompted by proposed lead mining within Big Spring's recharge area.

- Bigelow Nursery - Water Quality Assessment, Massachusetts. Provided bacterial source detection and remedial recommendations for a plant nursery holding pond. The study was prompted as a result of a reportedly high level of effluent contamination to the Wachusett Reservoir, an Outstanding Resource Water, in Massachusetts. Results of the investigation strongly suggested that the effluent was being contaminated by animal rather than human sources.

- Anchorage International Airport (ANC) - Storm Water Pollution Prevention Plan, Anchorage, Alaska. Responsible for developing an airport-wide Tenant Storm Water Pollution Prevention Plan (SWPPP) that was to be implemented by tenants operating under several different SIC codes. The SWPPP custom-tailored best management practices for each of the 80 tenants at the airport. The SWPPP was easy to understand and implement while maintaining its function of providing guidance for effective storm water protection efforts.

- Federal Express - Site Investigations, States of Colorado, Connecticut, Florida, Georgia, Massachusetts, Montana, New Mexico, Texas, Wyoming, and Tennessee. Managed and implemented and inspection program for over 90 package distribution facilities, owned or operated by Federal Express, requiring coverage under the National Pollution

Discharge Elimination System (NPDES) regulations for industrial storm water management. Prepared Storm Water Pollution Prevention Plans (SWPPP) and recommendations for bringing each facility into compliance under NPDES guidelines. Facilities were located in the states of Colorado, Connecticut, Florida, Georgia, Massachusetts, Montana, New Mexico, Tennessee, Texas, and Wyoming.

- Massachusetts Highway Department - Storm Water Pollution Prevention Plan. Project manager responsible for the development and implementation of a Storm Water Pollution Prevention Plan as specified under the NPDES program, for a Massachusetts Highway Department Salt Depot and Maintenance Facility. Prepared recommendations for bringing the facility into compliance under NPDES guidelines and to the satisfaction of the local Conservation Commission.

- Auto Salvage Yard Operators - Site Investigations, Massachusetts. Project manager responsible for the development and implementation of Storm Water Pollution Prevention Plans and storm water monitoring programs, as specified under the NPDES program, for several Massachusetts auto salvage yards. Prepared recommendations for bringing each facility into compliance under NPDES guidelines.

- Carter and Burgess - Watershed Modeling, Dallas, Texas. Provided technical support for a diagnostic/feasibility study of White Rock Lake in Dallas, Texas. Watershed analysis and hydrologic and nutrient budget modeling was performed on a large, multi-year database. Information provided was used to facilitate management decisions with the purpose of advancing a large-scale dredging restoration program for the lake.

- Portland Water District - Periphyton Colonization Study, Portland, Maine. Assisted in the design and implementation of an experimental investigation to detect changes in periphyton quantity and quality among three distinct shoreline segments in Sebago Lake, the primary water supply for Portland, Maine. The intent of the study was to use periphyton as a reflection of water quality over an extended period of time to evaluate conditions along gradients of shoreline development and water depth. It was demonstrated that it was possible to detect nearshore impacts in a system that exhibited no discernible degradation in offshore water quality. Nearshore periphyton monitoring was recommended as a viable early warning method for detecting future offshore impact.

- Cambridge Water District - Watershed Monitoring Plan, Cambridge, Massachusetts. Assisted in developing and implementing a monitoring plan to gather the data necessary to evaluate watershed contributions to the Cambridge water supply under wet weather conditions. Information gathered was used to maintain the best possible water quality in the reservoirs of the District. Over 25 monitoring stations were established and equipped with passive first-flush sampling devices designed for each station.

- Aquatic Control Technologies - Lake Dye Study, East Brookfield, Massachusetts. Supervised and performed a rhodamine dye study at North Pond in East Brookfield, Massachusetts to describe patterns of water movement within the 450-acre lake. The movement of the dye plume was tracked with a boat and flourometer over a three-day period. Information gathered during the study was used to make recommendations on the feasibility of various herbicidal treatment techniques.

RECENT PROJECTS - DESCRIPTIONS PENDING

- Town of West Brookfield, Massachusetts – Tributary and Groundwater Assessment for Wickaboag Pond, West Brookfield, Massachusetts.

- Wickaboag Pond Association – Diagnostic/Feasibility Assessment of Wickaboag Pond, West Brookfield, Massachusetts.

- Town of West Brookfield, Massachusetts – Sediment Sampling and Pre-Dredging Feasibility Assessment for Wickaboag Pond, West Brookfield, Massachusetts

- New England Interstate Water Pollution Control Commission (NEIWPCC) – Mashapaug Pond Storm Water Evaluation, Providence, Rhode Island.

- Indian Lake Association – Aquatic Plant Replacement Pilot Study, Indian Lake, Worcester, Massachusetts.

- Town of Chelmsford – Pre-Dredging Feasibility Assessment of Crooked Spring Pond, Chelmsford, Massachusetts.

- Merrimack River Watershed Council – Wellhead Protection Planning and Pollutant Source Investigation, Chelmsford, Massachusetts.

- Town of Lee, Massachusetts – Diagnostic/Feasibility Assessment of Laurel Lake, Lee, Massachusetts.

- Town of Walpole, MA – Diagnostic/Feasibility Assessment and Design of a Educational Boardwalk Access for Cobb's Pond, Walpole, Massachusetts.

- Aquarion Water Company – Biological and Stream Habitat Surveys Supporting Dam Repair, Redding and Seymour, CT

- PureGen One, LLC. – Development of Offshore and Nearshore Biological and Sediment Sampling Program for Carbon Sequestration Project in Coastal New York and New Jersey.

PROFESSIONAL REGISTRATIONS AND AFFILIATIONS

- North American Lake Management Society – Certified Lake Manager (CLM)
- New England Chapter – North American Lake Management Society
- North American Benthological Society
- Northeast Aquatic Plant Management Society
- NAUI Open Water SCUBA Diver Certification
- American Heart Association – CPR and First Aid

PUBLICATIONS

- Fuller, R.L., B.P. Kennedy and C. Nielsen. 2004. Macroinvertebrate responses to algal and bacterial manipulations in streams. Hydrobiologia 523:113-126.

- Nielsen, C. D. and D. L. Galat. 1996. Substrate association by macroinvertebrates in a large, cold-water springbranch. University of Missouri- Columbia.

- Schubert, A. L. S., C. D. Nielsen, and D.B. Noltie. 1993. Habitat use and gas bubble disease in southern cavefish (*Typhlichthys subterraneus*). International Journal of Speleology 22(1-4): 131-143.

PRESENTATIONS

- The Benefits of Bio-monitoring for Watershed Assessment. Charles River Watershed Association's Annual Brown-bag Presentation Series. June 19th, 2007.

- Lake Management and the 319 Grant: How to Make Your Grant Application Rise Above the Rest. January 27th, 2007. Annual Meeting of the Massachusetts Coalition of Lakes and Ponds.

- DNA Ribotyping as a Tool for Bacterial Source Tracking: A Narraganset Bay Watershed Case Study. April 2003. New England Association of Environmental Biologists Annual Conference.

- How to Develop and Implement a Lake and Watershed Management Program. December 2002. Town of Walpole Lakes and Ponds Committee.

- The Quaboag River watershed non-point source pollution assessment, a modeling approach. April 2001. New England Association of Environmental Biologists Annual Conference.

- Water Quality and Sediment Quality within the Deerfield River Watershed. March 2001. 2nd Annual Deerfield River Watershed Conference.

- Innovative watershed study design – Techniques for locating sources of non-point source pollution. April 2000. Environmental Protection Agency – Region 1.

- An investigation of the sources of non-point source pollution affecting water quality within the lower Westfield River watershed. March 2000. 6th Annual Westfield River Symposium.

- Impaired Waters. April 1999. 5th Annual Westfield River Symposium.

- Differences in substrate use by macroinvertebrates of a large, cold-water springbranch. February 1993. 42nd Annual Meeting of the North American Benthological Society.

- Seasonal variation in macroinvertebrate and fish assemblages in a thermally constant aquatic system. 1993. George Wright Society (National Park Service).

- The aquatic plant and fish communities of Big Spring. 1992. Ozark National Scenic Riverways (National Park Service).

Jeffrey G. Hershberger, PG
Senior Project Manager/Senior Hydrogeologist

EXPERIENCE

ESS Group, Inc. – March 1998 to Present
Years of Prior Related Experience – 9

EDUCATION

MS, Geology, University of Massachusetts, 1992
BS, Geology, Juniata College, 1985

SUMMARY OF PROJECT EXPERIENCE

Mr. Hershberger's professional experience includes over 20 years of environmental consulting focusing on the assessment of impacts to soil and groundwater resources, hydrogeologic investigations and water supply feasibility evaluations, permitting and development. His experience emphasizes evaluation and quantification of hydrogeologic processes as related to groundwater flow and contaminant transport, aquifer remediation, aquifer yield, capture zone modeling for remedial design and wellhead protection, analysis of the fate and transport of contaminants in the subsurface, and development of conceptual site models of hydrogeology and contaminant distribution. Mr. Hershberger has significant experience at CERCLA National Priority List (NPL) sites as the technical lead or project manager for the RI/FS, Pre-Design and Remedial Action Implementation work phases at sites throughout New England. Project management experience also includes site investigations and feasibility evaluations under various state regulations, complex field investigation and sampling programs and water supply development and groundwater resource assessments. Mr. Hershberger's representative water supply and hydrogeologic investigation project experience includes:

- Winchester Country Club – Lake Sediment Assessment in Support of WPA Permitting, Winchester, Massachusetts. Mr. Hershberger was the Task Manager and Hydrogeologist for an evaluation of sediment quality in the Upper Mystic Lake with regard to its potential impact on the quality of groundwater withdrawn from a proposed irrigation well located adjacent to the lake. Mr. Hershberger assisted in the design of the field sampling program, performed analytical modeling of the projected capture zone of the proposed pumping well and coordinated a contaminant fate and transport and risk evaluation of the potential for groundwater withdrawn through sediments of Upper Mystic Lake to mobilize metals contained in the sediments from upstream industrial properties and state- and federally-listed disposal sites. All of the predicted groundwater concentrations were found to be less than the applicable MassDEP standards and other applicable risk thresholds. The predictions have been confirmed by the results of ongoing groundwater sampling from the existing supply well.

- Town of Sharon – Hydrogeologic Evaluation of Potential Municipal Water Supply Sites, Sharon, Massachusetts. Mr. Hershberger serves as the Project Manager and Hydrogeologist for the ongoing evaluation of potential water supply sites within the Town of Sharon, Massachusetts. The initial phase of the project consisted of the desktop evaluation of five potential well sites using the Massachusetts Department of Environmental Protection (MassDEP) Site Screening Criteria. Based on the results of the initial phase and discussions with the Superintendent of Public Works and various Town boards, four locations were proposed for further evaluation. The second phase, including test drilling and aquifer testing to develop comparable hydraulic data for each site, is currently underway. As the project has progressed, field investigations have been performed to assess additional potential water supply sites. To support local decisions, Mr. Hershberger also developed and presented a matrix providing a summary of the information collected for each potential site and ranking the sites relative to each other to support decision-making by the Town representatives. Based on the findings, the town has decided to move forward with state and local permitting of a new groundwater source.

- Club Motorsports, Inc – Potable Water Supply Investigation and Permitting, Valley Motorsports Park, Tamworth, New Hampshire. Project Manger for the development of the potable water supply source(s) for proposed road course on 230-acres. Responsible for obtaining the necessary permit approvals from the NHDES and design and implementation of technical and field assessments. Mr. Hershberger also prepared for and represented project information at public meetings and hearings before the Tamworth Conservation Commission and Planning Board.

- MADEP SARSS Program - New Source Approval of a Replacement Municipal Water Supply Source, Holbrook, Massachusetts. Mr. Hershberger served as the Project Manager/Field Manager for New Source Approval. The reactivation of the Donna Road aquifer under Operable Unit 4 of the Record of Decision for the Baird and McGuire Superfund site is anticipated to replace the 0.31 million gallons per day of municipal water lost due to the contamination of the South Street Wellfield. Field activities included: extensive surveying of surrounding land uses; installation of numerous exploration, observation, and monitoring wells; geophysical and bedrock fracture trace and fracture fabric analyses; installation of pilot production well(s); discharge water and groundwater sampling; and performance of a long-term aquifer pumping test. Project work also included temporary road design; preparation of draft bylaws and wellhead protection district documents; delineation of the zone of contribution (Zone II) of the proposed supply well; and preparation of documents to satisfy Massachusetts Division of Water Supply guidelines and regulations. Division of Water Supply approval of the source and the Zone II delineation was received in May 1994.

- Town of Littleton – Zone II Delineation, Littleton, Massachusetts. Mr. Hershberger served as the Task Manager and hydrogeologist for the delineation of the Zone II area for the Spectacle Pond municipal supply well. The Zone II delineation was approved by the MassDEP.

- Confidential Client - Extensive Overburden and Bedrock Aquifer Exploration to Provide Process Water for the Proposed AG-Energy Cogeneration Facility. Mr. Hershberger served as the Task Manager and field geologist. A hydrogeologic and geotechnical investigation was also performed for a proposed surface water intake structure in the St. Lawrence River as an alternative water supply for the cogeneration facility.

- Private Residential Developer – Hydrogeologic Investigation to Support Major Groundwater Discharge Permit Application, Cotuit, Massachusetts. Mr. Hershberger serves as the Project Manager and Senior Hydrogeologist for the performance of a hydrogeologic investigation of a property in Cotuit, Massachusetts. The investigation was being performed to support the application for a Major Groundwater Discharge Permit for a combined wastewater treatment facility to serve a proposed 124-unit residential development. Mr. Hershberger designed and directed the subsurface investigation of the property and the groundwater modeling of the hydraulic impact of the proposed groundwater discharge. Technical activities also included evaluation of nitrogen loading and development of a water quality monitoring program. Work included presentation of findings at Town of Hyannis Zoning Board of Appeals hearings.

- Cat Island LLC - Environmental Impact Assessment and Hydrogeologic Investigation, Cat Island Beach Resort, Cat Island, The Bahamas. Mr. Hershberger was directly responsible for the assessment of baseline and proposed groundwater conditions and associated mitigation measures in support of the preparation of the Environmental Impact Assessment (EIA), and Environmental Management Plan (EMP) for the proposed Cat Island Beach Resort. Mr. Hershberger also provided senior technical leadership during the completion of subsurface investigations on the property in support of groundwater quality investigations and design of intake wells for the proposed reverse osmosis water treatment facility.

PROFESSIONAL CERTIFICATIONS AND AFFILIATIONS

- Professional Geologist Registration, Pennsylvania (PG-002185-G; inactive)
- Professional Geologist Registration, New Hampshire (No. 276)
- National Groundwater Association - Association of Groundwater Scientists and Engineers
- American Water Works Association and New England Water Works Association
- OSHA Hazardous Materials for Hazardous Waste Site Workers (40-hour training in accordance with 29 CFR 1910.120[e]), 1989, and annual refresher training
- Rhode Island Water Resources Board, Water Allocation Program Advisory Committee, Out-of-Basin Transfer Committee Member, 2003-2004
- Town of Upton, Water and Wastewater Advisory Committee, member, 2003-2008
- Town of Upton, Enterprise Fund Committee, member, 2008-2009

PROFESSIONAL TRAINING

- NGWA, 1991, Analysis and Design of Aquifer Tests
- NGWA, 1994, Groundwater Flow and Mass Transport Modeling
- NGWA, 1996, Natural Attenuation for Remediation of Contaminated Sites
- U.S. EPA, 2000, Advances in Innovative Ground-Water Remediation Technologies
- NEWWA, 2000, Integrated Water Resource Management and Conservation
- LSP Association, 2002, Principles and Field Techniques for Characterizing Contaminant Migration in Fractured Rock
- NEWWA, 2003, Water Wars – Are There Peaceful Solutions?
- NEWMOA, 2004, What Regulators Want: The Conceptual Site Model Approach
- NGWA, 2005, Focus Conference on Eastern Regional Ground Water Issues
- NEWWA, 2006, Why Water Suppliers Should Care About Stormwater Management
- Fractured Rock Educational Services, 2007, Hydrogeology of Fractured Rock – Characterization, Monitoring, Assessment and Remediation
- NEWMOA, 2008, Remediation of Chlorinated Solvent Sites
- U.S. EPA/TIO, 2008, A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems
- ITRC, 2009, In-Situ Bioremediation of Chlorinated Ethene – DNAPL Source Zones
- ESTCP (DOD), 2009, FAQs Regarding Management of Chlorinated Solvents in Soil and Groundwater

PUBLICATIONS AND PRESENTATIONS

- Hydrogeology and Water Resources of Shelburne and Colrain, Massachusetts, Masters Thesis, University of Massachusetts, 1992

- Finney, D.F., Hershberger, J.G., and Nangeroni, P.E., *Use of Angled Drilling Techniques to Characterize Fractured Crystalline Bedrock and Minimize Migration of Suspected Non-Aqueous Phase Liquids (NAPL)*, Proceedings - 2004 U.S. EPA/NGWA Fractured Rock Conference: State of the Science and Measuring Success in Remediation, September 13-15, 2004.

- “Maximizing Water Use Potential Through Cost Efficient Hydrogeologic Studies”, 8th Annual Regional Turfgrass Conference & Show, Providence, Rhode Island, March 9, 2005.

ESS Group, Inc.

Janet Carter Bernardo, PE
Senior Civil Engineer

EXPERIENCE

ESS Group, Inc. – July 1997 to Present
Years of Prior Related Experience – 8

EDUCATION

BS, Civil Engineering, University of Lowell, 1984
Numerous professional seminars and conferences

SUMMARY OF PROJECT EXPERIENCE

Ms. Bernardo is a registered Professional Civil Engineer (PE) with technical and management experience in civil site design. As a Project Engineer and Manager, Ms. Bernardo has managed and participated in numerous site designs and permitting projects, including industrial, office, retail, commercial, and residential properties. These projects include zoning analysis, building and parking layouts, traffic analysis, stormwater management, drainage and utility design, subsurface disposal system design, construction details, specifications and construction administration. She is also experienced in local and state permitting and has served as the reviewing consultant for various Massachusetts communities. Ms. Bernardo is currently a board member on the Needham Conservation Commission and the Needham Community Preservation Committee. Her representative project experience includes the following:

- Covanta of SEMASS, L.P. – Rochester, MA. Senior Civil Engineer responsible for preparation of an Application for Site Plan Approval for a renewable fuels demonstration project and an administration building at the SEMASS Resource Recovery Facility in Rochester, Massachusetts. Design included stormwater management in compliance with the MassDEP Stormwater Management Policy, grading, parking and access roadway configuration, and utility connections.

- Stormwater Authority – West Brookfield, MA. Senior Civil Engineer responsible for designing a stormwater management system in compliance with the MassDEP Stormwater Management Policy to improve the runoff characteristics of the Wickaboag Valley Road stormwater prior to it discharging to Lake Wickaboag. Assisted the West Brookfield Stormwater Authority with design options, construction drawings and cost estimate for the preferred stormwater management system.

- Astoria Energy – Astoria, NY. Civil Engineer responsible for preparation of the Stormwater Pollution Prevention Plan (SWPPP) for a major electric generating facility located in Astoria, New York. The 23 acre facility is expanding from a 500 MW facility to a 1000 MW facility.

- Pioneer Valley Energy Center – Westfield, MA. Senior Project Manager and Civil Engineer responsible for providing civil/site engineering services related to the construction of a 400 MW combined-cycle power facility that will generate economical energy for the Town of Westfield and the surrounding communities. The project involves the application to the State Energy Facility Siting board as well as the preparation of an Environmental Impact Report, and application for numerous state and local permits. Responsibilities included site layout, grading, access roadway design, construction traffic analysis, interconnects, and stormwater management in compliance with the MassDEP Stormwater Management Policy for the 36-acre parcel.

Paul Finger Associates – Residence at Sudbury Commons, Sudbury, MA. Project Manager and Senior Engineer responsible for subsurface disposal system design, utility coordination, grading, and stormwater management for the redevelopment of a retail center to a 20-unit affordable housing complex.

- Church of Latter-Day Saints – Meetinghouse, Cambridge, MA. Senior Civil Engineer providing layout, drainage and utility connections for a proposed Stake to be located on a 24,000 square foot parcel. Responsibilities included meeting with the City Engineer and Department of Public Works as well as coordinating between the various utility companies, the owner, and the architect. Construction plans, details, and specifications provided to the architect for inclusion in the building documents.

- Town of Andover – Stormwater Peer Review, Andover, MA. Senior Civil Engineer providing ongoing peer review services to the Andover Planning Board and the Andover Conservation Commission. Responsibilities include evaluating the adequacy and appropriateness of the proposed stormwater management design in accordance with the local regulations, MassDEP Stormwater Management Guidelines, and sound engineering practice.

- LKQ/Route 16 Auto Parts – Salvage Facility, Webster, MA. Project Manager and Senior Engineer for the development of a stormwater management plan required per a MassDEP Consent Order in compliance with the MassDEP Stormwater Management Policy for an 18-acre auto salvage facility.

- Aggregate Industries – Recycled Asphalt Plant, Chelmsford, MA. Designed stormwater management plan in compliance with the MassDEP Stormwater Management Policy, the Chelmsford Conservation Commission, and the Environmental Protection Agency Multi-Sector NPDES permit.

- W/S Development Associates LLC – Retail Shopping Center, Wareham, MA. Professional Engineer of Record responsible for reviewing site layout, grading, drainage, and utility design for a 750,000 square foot retail and restaurant community style open air shopping center located at the interchange of Route 28 and Interstate 195.

- Harold Simansky – Residence Condominiums, Brookline, MA. Project manager providing the civil engineering services related to the relocation of a historic Victorian house located in Brookline, Massachusetts. Project included development of five residential condominiums and an underground garage connected to the existing Victorian house relocated on the same parcel.

- Bentley College – Residence Halls, Waltham, MA. Engineer of Record responsible for reviewing site layout, grading, drainage, and utility design for the development of two, three-story residence halls for the housing of 120 students.

- Winchester Country Club – Maintenance Facility, Winchester, MA. Senior Engineer responsible for the layout, utility connections, and stormwater management plan for the maintenance facility buildings and accessory areas.

- W/S Development Associates LLC – Retail Shopping Center, Mansfield, MA. Senior Civil Engineer responsible for reviewing site layout, grading, drainage, and utility design for a 395,000 square foot retail and restaurant community style open air shopping center located at the interchange of Route 140 and Interstate 495.

- Interior Stone – Mixed Use Commercial/Industrial Facility, Waltham, MA. Engineer of Record responsible for reviewing site layout, grading, drainage, and utility design for the redevelopment of a parcel of land within a flood plain for use as a Commercial/Industrial facility.

- Metals Recycling LLC - Wetland and Upland Restoration, Johnston, RI. Responsible for a four-acre wetland and upland restoration/creation project on the Woonasquatucket River. The project involved the restoration of a highly degraded site by contouring and planting existing retention basins and wetlands to create one large functional wetland/marsh. The grading of the adjacent uplands was completed to function as an upland meadow. Construction inspections and post construction monitoring were completed in accordance with the RIDEM Consent Order.

- R.M.D., Inc. – Supermarket Complex, Chelmsford, MA. Evaluated a proposed stormwater management design which included an infiltration system beneath a proposed parking lot with an overflow system designed to discharge to River Meadow Brook. Numerous public hearings were attended to discuss findings and to verify the final approved design was in compliance with the local and state regulations.

- TVGC, Inc. – The Down Island Golf Club, Oak Bluffs, Martha's Vineyard, MA. Provided civil/site-engineering services related to a Rees Jones designed private 18-hole championship golf course development project located on a 119-acre tract of land on Martha's Vineyard. The design included driveway access and parking design, traffic analysis, drainage analysis, subsurface disposal system design, and site grading. Coordination between the golf course architect, building architect, and landscape architect were part of the engineering duties associated with the filing of the MEPA ENF and DEIR. Directly involved with the preparation of the traffic and wastewater sections of the DEIR.

- Ramapo Energy Limited Partnership – Power Plant, Ramapo, NY. Senior Civil Engineer responsible for providing civil/site engineering services related to the Ramapo Energy Facility located in Rockland County, New York. Responsibilities included site layout, grading, access roadway design, construction traffic analysis, interconnects, and drainage analysis and design for the 60-acre parcel. Direct participation in the preparation of the New York Article X submittal including the Traffic, Stormwater, Wastewater, and Solid Waste sections. Expert Witness testimony provided during Article X review process.

- Town of Hopkinton – Stormwater Drainage Analysis, Hopkinton, MA. Project Manager and Senior Civil Engineer responsible for the data research, drainage analysis, design recommendations, and Subdivision Regulation revisions for the Town of Hopkinton Planning Board in regards to the White Oak Estates subdivision, Spring Street, and the Whitehall Reservoir.

PROFESSIONAL CERTIFICATIONS

- Massachusetts Registered Professional Engineer - No. 34700
- Massachusetts Soil Evaluator - certified in July 1995
- Massachusetts System Inspector (Septic) - certified in March 1995
- New Hampshire Subsurface Disposal Designer - No. 1340
- New Hampshire Registered Professional Engineer – No. 11865
- New York Registered Professional Engineer – No. 078701-1

ESS Group, Inc.

Payson R. Whitney, III, PE
Senior Civil Engineer

EXPERIENCE

ESS Group, Inc. – October 1998 to Present
Years of Prior Related Experience – 4

EDUCATION

BS, Civil Engineering, Lehigh University, 1994

SUMMARY OF PROJECT EXPERIENCE

As a Civil/Coastal engineer and Project Manager, Mr. Whitney has more than 14 years of experience in a wide range of public and private sector projects, including project design and management activities in civil/site engineering, coastal permitting/shoreline assessment, and the planning and permitting of electrical transmission projects. He has managed several large-scale projects involving multidisciplinary staff and subconsultants. Mr. Whitney's engineering design and management experience includes recreational facility planning and design, dredging design, roadway design, site layout and design, site drainage analysis, transportation analysis, design reviews for project specifications and plans, reviewing third party plan sets, preparing and reviewing construction documents and shop drawings, construction consultation, and preparation of construction budget estimates. Mr. Whitney's representative project experience includes the following:

Coastal Services/Dredging/Environmental Permitting

- Winchester Country Club – Irrigation Supply and Pond Restoration Project, Winchester, MA. Project Manager and Engineer responsible for permitting, design, and construction of an irrigation supply project. This project involved construction of an irrigation water supply well and associated appurtenances, dredging and lining of an existing on-site pond to provide adequate storage for irrigation water, installation of approximately 2,500 feet of piping and electrical feeds, and installation of a pump station. The pond restoration aspect of the project involved a dredging program to mechanically dredge sediments that had accumulated since the Pond was constructed in the 1950's, and to provide for additional water storage capacity. Approximately 6,000 cubic yards of material was dredged from Morton's Pond.

- Walpole Country Club - Allen Pond Restoration Project, Walpole, MA. Engineer-of-record for the dredging and dewatering design of Allen Pond at the Walpole Country Club. The goal of the restoration project is to remove excessive sedimentation and limit the long-term excessive growth of nuisance and invasive species by dredging approximately 23,000 cubic yards of sediment from the pond and converting an area of BVW from shallow to deep marsh. The proposed project will reduce the overall sediment that has accumulated in the pond, restore pond depth/storage capacity (current capacity is approximately 1.8 million gallons, which would increase to approximately 4.6 million gallons) and reduce proliferation of nuisance and invasive species.

- Massachusetts Department of Conservation and Recreation (DCR) — Robinson Pond Dredging, Agawam, MA. Engineer-of-record for the dredging and dewatering design of Robinson Pond in Robinson State Park and Farm Pond in Great Brook Farm State Park. DCR proposes to remove excess sediment that has resulted from many years of infilling in order to improve wildlife habitat, enhance storage capacity, improve water quality, and limit the pioneer spread of invasive species. Once completed, water quality will improve, wildlife habitat will be enhanced through greater diversity of depth zones, and the ponds ability to limit nonpoint source pollution will increase. The project will remove approximately 3,000 cubic yards of material through dry-dredging, after DCR draws down the pond by opening the gate valve outlet structure and shutting off groundwater well inputs. Work includes preparing and reviewing the designs and site plans necessary to support the Notice of Intent application to the Agawam Conservation Commission, 401 Water Quality Certification application to MassDEP, and the Section 404 Army Corps application.

- Massachusetts Department of Conservation and Recreation (DCR) — Farm Pond Dredging, Carlisle, MA. Engineer-of-record for the dredging and dewatering design of Robinson Pond in Robinson State Park and Farm Pond in Great Brook Farm State Park. DCR proposes to remove excess sediment that has resulted from many years of infilling in order to improve wildlife habitat, enhance storage capacity, improve water quality, and increase storage capacity for fire protection. Once completed, water quality and clarity will improve with reduced algae blooms and wildlife habitat will be enhanced through greater diversity of depth zones. The project will remove approximately 3,300 cubic yards of material through dry-dredging, after DCR draws down the pond via the existing outlet. Work includes preparing and reviewing the designs and site plans necessary to support the Notice of Intent application to the Agawam Conservation Commission, 401 Water Quality Certification application to MassDEP, and the Section 404 Army Corps application.

- Littleton Water Department – Mill Pond Restoration, Littleton, MA. Project Manager responsible for performing and overseeing design efforts related to the restoration of Mill Pond (a four basin, 54 acre pond system). This project includes dredging of approximately 220,000 cubic yards of soft sediment, removal of nuisance pond vegetation, creation of a 12.5-acre constructed wetland system to remove total suspended solids (TSS) from contributing streams prior to entering the pond, and construction of public access facilities. This project has received several state and federal grants, and is currently being undergoing environmental assessment review by the U.S. Army Corps of Engineers for possible further federal funding to enhance fish habitat. Provided technical support to preparation of an Environmental Assessment/Environmental Restoration Report in USACE format.

- TransÉnergie U.S., Ltd. – Cross Sound Cable Project, New Haven, CT to Brookhaven (Shoreham), NY. Responsible for planning, directing, and overseeing dredging design/construction oversight for the Cross Sound Cable Project that crosses Long Island Sound between New Haven, Connecticut and Brookhaven, New York. Responsible for designing and managing a 12,000 cubic yard hydraulic dredging operation at the Shoreham landfall to facilitate cable embedment. During design, alternatives for hauling dredged material from the dredging area to upland disposal facilities and an adjacent beach for beach nourishment were evaluated for cost, schedule, and environmental impacts.

- Yankee Fleet, Inc. – Conceptual Vessel Berthing Facility Design, Gloucester, MA. Provided project design engineering and permitting support for the development of a vessel berthing facility to accommodate a commercial fishing and whale-watch fleet in Gloucester, Massachusetts. Responsibilities included site planning and design efforts, including 18,000 cubic yards of dredging with upland disposal, grading and reuse, and for environmental impact assessments. Also responsible for planning and executing a marine geotechnical sampling program for characterization of sediments to be dredged. Also provided engineering support for the preparation of local and state permit applications including local Wetland Permit Application and MEPA review documents.

Civil/Site Engineering

- Siemens Energy, Inc. – Civil/Site Engineering for Electrical Converter Station, The Hudson Project, Ridgefield, NJ. Project manager responsible for the preliminary civil/site design of a proposed back-to-back electrical converter station as part of The Hudson Project. ESS is prepared civil/site design plans for Siemens Energy, Inc. to provide to Hudson Transmission Partners (HTP) to support their preparation of permit applications associated with the Ridgefield, New Jersey Converter Station Facility to the New Jersey Meadowlands Commission (NJMC) and New Jersey Department of Environmental Protection (NJDEP).

- Starwood Tiverton LLC – The Villages on Mount Hope Bay, Tiverton, RI. Project manager for ESS services beginning in Phase 3 of construction of the project, which involves mixed-use redevelopment of a 98 acre waterfront site formerly utilized as a bulk fuel oil storage facility. Supervised preparation of designs for field changes including site entrance layouts and stormwater management structures. Supervised engineering services required to support continued regulatory permitting activities with CRMC.

- Prolerized New England – Site Modernization Project, Everett, MA. Project Manager responsible for civil/site and stormwater management design for the ongoing modernization of a 33-acre metals shredding and recycling facility. The modernization includes the replacement of the existing site buildings with new, relocated buildings; the replacement of the existing metals shredder with a new, more modern unit; and the replacement and/or upgrade of existing utilities and stormwater management systems. The stormwater management system uses an innovative system of open drainage channels and water quality units to manage stormwater that is heavily laden with solids from the facility's operations. In addition, the majority of the site will be paved with fiber reinforced concrete. In some areas, the design provided for the harvesting of captured stormwater for reuse as cooling water or dust suppression on site. The majority of the site has been reconstructed, and ESS is providing ongoing design support for the remaining portions of the site.

- Schnitzer Northeast – Non-Ferrous Material Processing Facility, Everett, MA. Project Manager for civil/site design and stormwater management improvements for a planned state of the art non-ferrous scrap metal material recycling facility. Supervising design of site layout, grading, utilities, and stormwater management. The stormwater management system will use an innovative system of open drainage channels and water quality units to manage stormwater that is heavily laden with solids from the facility's operations.

- Winchester Country Club – Stormwater Improvements, Winchester, MA. Project Manager and Engineer to evaluate flooding on a portion of the golf course, which appeared to be caused by runoff from an adjacent town roadway. Developed a hydrologic and hydraulic model to evaluate the roadway drainage system and its potential impacts. The results indicated that the municipal roadway drainage system was overwhelmed during significant storm events. This inadequate roadway drainage, coupled with an inefficient design for capture of roadway runoff and sedimentation in a portion of the roadway drainage system, were the cause of the flooding. Developed a number of recommendations for drainage system improvements, which were presented to the Town of Winchester on behalf of WCC, and were implemented by the Town to address flooding on the course. Supervised design of a detention basin that was constructed by WCC in coordination with Town drainage improvements.

- Whitney Atwood Norcross Associates, Inc. – Boston Fire Training Academy Simulator Facility, Moon Island, Quincy, MA. Project Manager for civil/site design and the design of stormwater management improvements for the proposed Simulator Facility. The project entails the construction of a “Burn Building”. The Burn Building is used to simulate fires in urban settings for training purposes for fire fighting, containment, and rescue. Engineering services included preparation of preliminary engineering designs to support regulatory permitting efforts, preparation of construction document, and review of contractor submittals during construction. Construction of the facility was completed in July 2008.

- Down Island Golf Club, Inc. – Down Island Golf Club, Oak Bluffs, MA. Project manager and provided project engineer services for civil/site engineering and stormwater management components of the proposed Down Island Golf Club in Oak Bluffs, Massachusetts. The project entailed design of an 18-hole, par 72 woodlands type golf course and its appurtenances. Responsible for engineering of site driveway, parking areas, golf course management facility, and stormwater management systems; as well as coordination with the golf course and building architects. Supported preparation of local Site Plan Review application and MEPA Draft Environmental Impact Report.

PROFESSIONAL REGISTRATIONS AND AFFILIATIONS

- Professional Engineer Registration, Commonwealth of Massachusetts, No. 41706, 2001
- Professional Engineer Registration, State of Rhode Island, No. 8551, 2006
- Engineer-In-Training, Commonwealth of Pennsylvania, 1994
- Master Design Certificate for Low Impact Development, State of Rhode Island, No. 1106011, 2006
- Boston Society of Civil Engineers Section - ASCE (BSCES)—Board of Government Member (1999-2000)
- BSCES Waterways, Ports, Coastal & Ocean Technical Group—Chairman (1999-2000)

RELEVANT PUBLICATIONS/PRESENTATIONS

- *Use of Marine Remote Sensing Data for Submarine Cable Route Planning and Siting*, Whitney, P.R.; Natale, C.J.; and Nash, J.P., Marine Technology Society/IEEE Oceans 2000 Conference, Providence, Rhode Island, September 2000.

Darrell Oakley, PWS
Senior Ecologist

EXPERIENCE

ESS Group, Inc. – August 2004 to Present
Years of Prior Related Experience – 10

EDUCATION

BA, Biology (concentration in Environmental Science), Colby College, 1994
Certificate in Native Plant Studies, New England Wildflower Society, (anticipated completion 2011)

SUMMARY OF PROJECT EXPERIENCE

Mr. Oakley is a Senior Ecologist with a diverse background and sixteen years of experience in environmental consulting. He specializes in wetland delineation and wetland mitigation; habitat assessment; on-site identification of flora and fauna species; rare, threatened, and endangered species surveys; and endangered species mitigation. Mr. Oakley has completed numerous state and federal environmental applications, including Environmental Impact Statements and state and federal wetland submittals in the New England and mid-Atlantic regions. His project experience includes wind power development, commercial and residential projects, airport site development, local and regional sewer projects, federal government facility siting, railroad projects, gas pipeline installation, power plant siting, fiber optic installation, watershed protection, water diversion, highway and bridge construction, and remedial investigations for hazardous waste sites. Mr. Oakley's representative project experience includes:

- Town of Hopedale – Dredging Feasibility Assessment, Hopedale Pond, Hopedale, Massachusetts. Mr. Oakley is the assistant project manager and senior ecologist for an extensive pre-dredging evaluation of Hopedale Pond, a 35 acre mill pond in Hopedale, MA that is suffering the effects of eutrophication and in-filling from its watershed. A goal of the study is to evaluate the quantity and quality of sediment in the pond as well as to assess the nutrient, bacteria, and other water quality issues related to ongoing inputs from its watershed. The results of the study will be used to provide the town with management recommendations for restoring this pond to its former condition through dredging. Management recommendations will include a detailed description of existing sources of pollution from its watershed and conceptual engineering designs for solving these issues on a site-by-site basis. The Best Management practices (BMPs) that ESS will be recommending will be designed to be economical yet effective. A focus of the ESS strategy will be to implement or retro-fit Low Impact Design (LID) techniques into the existing watershed landscape.

- Massachusetts Department of Conservation and Recreation – Dredging Design and Permitting, Farm Pond, Carlisle, Massachusetts. Mr. Oakley is the assistant project manager and senior ecologist responsible for the restoration of Farm Pond in Great Neck State Park. Mr. Oakley is overseeing the engineering design and permitting for the pond's restoration which includes dredging. Sediment from the pond will be re-used on the state park property as a landscape amendment.

- Massachusetts Department of Conservation and Recreation – Dredging Design and Permitting, Robinson Pond, Agawam, Massachusetts. Mr. Oakley is the assistant project manager and senior ecologist responsible for the restoration of Robinson Pond in

Robinson State Park. Mr. Oakley is overseeing the engineering design and permitting for the pond's restoration which includes dredging.

- Town of Norton, Massachusetts. Diagnostic and Feasibility Assessment for Management of Lake Winnecunnet, Norton, Massachusetts. Mr. Oakley contributed to the assessment of Lake Winnecunnet and its watershed. The lake is part of a Massachusetts ACEC (Area of Critical Environmental Concern). The deep-water habitat associated with the lake is threatened by the invasive and exotic plant *Cabomba caroliniana* (fanwort), which has spread throughout the lake to the detriment of native plants and potentially native fauna. The need to manage this situation while protecting the potentially rare or threatened species that exist within the lake required extensive survey of the lake shoreline, the major tributaries to the lake (Canoe River and Mulberry Meadow Brook), and the lake outlet (Snake River). Mr. Oakley surveyed the adjoining wetlands, open water habitats, and shoreline to determine baseline conditions. Mr. Oakley also surveyed the lake and adjoining habitats for rare species, which could be affected by lake management. The results of the survey were used to help develop a comprehensive lake and watershed management plan for the Town.

- Department of Conservation and Recreation, Neponset Salt Marsh Restoration – Boston, Massachusetts. Mr. Oakley supported DCR in implementing the 20-acre Neponset Salt Marsh Restoration project. Mr. Oakley reviewed and approved project changes, provided construction oversight, and assisted the DCR Resident Engineer and Project Manager in completing the project.

- Siasconset Beach Preservation Fund, Lighthouse Beach Shore Protection and Bank Stabilization Project – Nantucket, Massachusetts. Delineated wetlands and providing environmental permitting assistance for an innovative proposed shore protection project consisting of a new beach dewatering system, high-tech sand fence, vegetative bank stabilization, and bank drainage improvements. The project is intended to protect the historic Sankaty Lighthouse, public infrastructure, and numerous houses from coastal storm damage.

- Wannacomet Water Company – Nantucket, Massachusetts. The Wannacomet Water Company (Wannacomet) proposed the installation of new wells and a 2,000,000 gallon storage tank on the North Pasture site on the island of Nantucket, Massachusetts. Nantucket has the highest concentration of state-listed rare species in the Commonwealth of Massachusetts. Mr. Oakley was brought in to navigate Wannacomet through the extensive rare species survey requirements and regulatory hurdles. The North Pasture is within Priority Habitat and near Estimated Habitats for 26 state-listed species ([reptile] spotted turtle; [bird] long-eared owl, northern harrier; [moths] chain dot geometer, barrens buckmoth, southern ptichodis, a noctuid moth, barrens daggermoth, straight lined mallow moth, spiny oakworm, pink sallow, coastal swamp metarranthis moth, pine sallow, coastal swamp metarranthis moth, pine barrens zale, Melsheimeri sack bearer, coastal heathland cutworm, and Gerhards's underwing moth; [plants] broom crowberry, Nantucket shadbush, eastern silvery aster, Mattamuskeet panic-grass, St. Andrews cross, New England blazing star, sandplain blue eyed grass, lion's foot, and bushy rockrose). Mr. Oakley conducted extensive surveys on the North Pasture over two years for plants, moths, and birds, in order to document rare species on the site. He conducted daytime and overnight moth surveys, plant surveys during important flowering periods, and searches for nesting Northern Harriers and Long-eared Owls.

Gregory A. Rowe
GIS Analyst

EXPERIENCE

ESS Group, Inc. – October 1999 to Present
Years of Prior Related Experience – 3

EDUCATION

MS, Environmental Studies, University of Charleston/Medical University of South Carolina
BS, Marine Affairs, Minor, Fishery Science and Technology, Minor, Political Science, University of Rhode Island

SUMMARY OF PROJECT EXPERIENCE

Mr. Rowe has more than ten years experience operating and developing geographic information systems (GIS). Mr. Rowe manages the development, oversight, and integration of GIS at ESS. In this role, Mr. Rowe is responsible for GIS project design and management, staff training and hiring, software evaluations, and development of GIS formats and templates. Mr. Rowe has been primarily involved in creating, designing and utilizing resources to support a wide variety of ESS projects specifically in the energy and ecological markets. GIS has been vital to ESS in developing and achieving specific analysis in permitting and design efforts on projects. Mr. Rowe's representative ecological project experience includes:

- Town of Littleton – Dredging of Mill Pond, Littleton, MA. The goal of the restoration project is to dredge and control excessive aquatic plant growth in Mill Pond to enhanced recreational and aesthetic value of the Pond. Responsible for GIS analysis of watershed delineation, wetlands analysis and classification, public access siting, and dredging limits.

- Town of Deering, New Hampshire, Hydrologic and Nutrient Loading Analysis for Deering Reservoir, Deering, NH. Purpose of project was to evaluate the potential impact to Deering Lake from two proposed residential sub-divisions to be constructed within the Deering Lake watershed. Responsible for a GIS analysis based on hydrologic and nutrient loading of the Reservoir. The results served as the basis for evaluating whether the proposed developments, as well as future developments, are compatible with maintaining current in-lake conditions.

- Massachusetts Environmental Office of Environmental Affairs, Statewide Water Budgets and Report Development Project, Massachusetts. Responsible for collaborating with federal, state, and municipal agencies in developing an automated GIS tool to assess water budgets for all basins and communities in Massachusetts with the Charles River Watershed Association. The purpose of the project is to evaluate potential human impacts on stream flow. The water budget model accounts for regulated human derived water inputs and outputs as well as irrigation loses and total recharge loss from impervious area. The budget analyzes the data at the sub-basin level (HUC-14) on a monthly basis. The model will be able to perform the sub-basin analysis, create maps showing impact, and summarize the results by table with only a click of a few buttons. The final product of the project will be 350 municipal and 74 watershed customized reports.

- Massachusetts Department of Conservation and Recreation – Assessment and Permitting for In-lake Weed Control at Lake Cochituate, Massachusetts. Purpose of the project was to map, evaluate, and propose cost efficient techniques for controlling milfoil and curly-leaf pondweed in Lake Cochituate. Responsible for analyzing cross-section field data taken by GPS and creating vegetation maps depicting the largest concentrations of aquatic weed cover.

- Massachusetts Department of Conservation and Recreation – Assessment and Permitting of Management Activities (Hydro-Raking) at Ruggles Pond, Wendell, Massachusetts. Purpose of the project was to map, evaluate, and propose cost efficient techniques for controlling white water lily *(Nymphae odorata)*. Responsible for analyzing cross-section field data taken by GPS and creating vegetation maps depicting the largest concentrations of aquatic weed cover as well as wildlife habitat cover.

- Club Motorsports, Inc., 401 Water Quality Certificate and Baseline Monitoring, Tamworth, New Hampshire. Purpose of project is to obtain local and state permits for a proposed road course (private racetrack) on a 230 acre site. Responsible for desktop GIS assessment of environmental, geologic, and cultural factors to support permitting efforts.

- Rhode Island Department of Environmental Management, Woonasquatucket River Greenway Project, Providence, RI. Purpose of project was to create a GIS management tool for making regulation recommendations to the state and City regulations affecting the Woonasquatucket River corridor. Responsible for implementing a GIS analysis of land use and zoning classifications to identify potential brownfield properties along the Woonasquatucket River Corridor.

- Naval Station Newport, Storm Drain Outfall Mapping, Newport, RI. Conducted a storm drain outfall survey on Naval Station property using a Global Positioning System (GPS) unit. The survey was performed in conformance with Rhode Island Pollutant Discharge Elimination System guidelines to allow identification of outfall pipe locations in the field and to create an interactive GIS database that would allow the Naval Station to track the condition and maintenance activities of the storm water structures.

- Naval Station Newport, Illicit Discharge Tracking, Newport, RI. Illicit discharge detection is being completed as part of Naval Station Newport's Phase II Storm Water Management Plan (SWMP) in order to comply with the Rhode Island Pollution Discharge Elimination System (RIPDES) regulations as required by the Environmental Protection Agency (EPA) under the Clean Water Act. Responsible for developing and implementing a program methology to track illicit discharges across the site. Process included examining historic stormwater infrastructure, GPS field verification surveys, stormwater infrastructure mapping utilizing GIS technology, flow monitoring, and dye testing for confirmation.

- Town of Hull, Nantasket Beach Coastal Storm Damage Reduction Project Beach Nourishment/Sandfill Material Transportation Study, Hull, MA. Purpose of the project was to constructing a 50 foot wide sand fill berm seaward of the existing seawall to protect the beach from storm damage. Responsible for completing a GIS transportation study to determine the most economic and feasible method to deliver sand by trucks or barges from upland sources to the Nantasket Beach Reservation while assessing environmental and cultural receptors.

- Walker's Farm Salt Marsh Restoration, Barrington, RI. The Walker's Farm restoration project involved government agencies, non-governmental organizations and private sector businesses working to return historic salt marsh conditions to a 45-acre site that was altered by a number of roads and dam structures restricting salt water entering the marsh. Responsible for developing a GIS delineated wetland coverage of the site utilizing GIS/GPS technology, aerial photography and field reconnaissance to assist in the restoration process.

- Massachusetts Department of Environmental Protection (MADEP), Chicopee River Watershed, MA. Purpose of project was to assist MassDEP and the Chicopee River Watershed Team by developing a program for locating and assessing the condition of over 300 storm water structures within the rural portions of the Chicopee River Watershed. Responsible for creating and managing a GIS database assessing location of the structures by Global Position System (GPS). These locations included documentation of over 20 descriptive features and photographs of each drain pipe, catch basin, or retention device. Water quality sampling was conducted on storm drains that were observed to be flowing during dry weather in order to assist the state in identifying illicit storm drain hook-ups. All data was provided to each town as an interactive computer file on CD-ROM to serve as a basis for tracking management actions.

- Massachusetts Department of Environmental Protection, Shawsheen River Watershed. Purpose of project was to work with the Shawsheen River Watershed Team and the Merrimack River Watershed Council (MRWC) to design and conduct a basin-wide storm water assessment program. Responsible for developing a GIS project assessing water quality and habitat data for use in a bacteria Total Maximum Daily Load (TMDL) model for the watershed. The results of the TMDL model is expected to assist the state and local communities in prioritizing and addressing storm water related water quality problems and to ultimately meet state water quality standards.

- Massachusetts Watershed Initiative, Water Quality and Habitat Assessment, French and Quineboag Watershed, MA. Purpose of project was to provide an interactive GIS CD analyzing habitat quality to managers at the Executive Office of Environmental Affairs/MADEP. Created the CD containing more than 50 sample locations containing physical/chemical parameters and photos for each site, as well as linking historical data from the MassDEP. Land use data from MassGIS was also used to identify possible sources of pollution and impacts on habitat quality.

- Massachusetts Watershed Initiative, Nonpoint Source Pollution Assesssment, Ten Mile and Narragansett/Mount Hope Bay Watersheds, Southeastern MA. Objective of project was to identify significant resources of non-point source (NPS) pollution, prioritize these resources, and design a management plan to protect and improve water quality in the watersheds. Created a GIS database project analyzing land use, soils, and other environmental conditions using water quality modeling techniques and qualitative means to determine which sub-basins were contributing significant nutrient and bacteria loads to each water body reach/segment of the watersheds. The final GIS project was used by town managers and local officials to prioritize and address nutrient and bacteria levels impacting the different watershed communities.

- Massachusetts Executive Office of Environmental Affairs (EOEA), Mattfield River Watershed Nonpoint Source Pollution Assessment, Southeastern MA. Purpose of project was to assess local capacity to manage nonpoint source pollution in five southeastern Massachusetts towns. Responsible for creating and managing a GIS database identifing significant resources of non-point source (NPS) pollution, prioritizing these resources, and assisting in the design a management plan to protect and improve water quality in the watershed.

- Lake Wickaboag Preservation Association, Lake Wickaboag, West Brookfield, MA. Purpose of project was to assess the long history of problems related to algal blooms and to evaluate the quantity and quality of accumulated sediments in the Lake. Responsible for creating a GIS bathymetry map of the lake based on a GPS/Secchi-disk survey. Sediment quality was then evaluated to determine its potential to influence in-lake water quality and to assess its potential to adversely affect the aquatic biota.

- Massachusetts Department of Environmental Protection (MADEP), Non-point Source Water Quality Modeling, Quaboag River Watershed, Central MA. Assisted in the development and implementation of a program analyzing Non-point Source (NPS) pollutant loads to the Quaboag River watershed. Responsible for a GIS program analysing statistics on land use data, P8 computer modeling, and in-field water quality testing to evaluate over 30 sub-watersheds with respect to average annual nitrogen and phosphorus loads. Information generated from the models was used to predict future pollutant loading within the Quaboag River watershed that could result based on currently projected population growth estimates. The information generated was used to effectively prioritize and target management actions throughout the watershed to improve water quality.

- RIDEM, EPA and Tetra Tech, Inc. – Mashapaug Pond TMDL, Providence, RI. The EPA funded the development of a nutrient TMDL for Mashapoag Pond to serve as a pilot project for the Region due to the heavy residential, commercial and industrial uses in the surrounding watershed. Responsible for GIS development of a bathymetric map for the Pond as well as analyzing plant communities within the Pond.

- Newport Housewrights, Eelgrass Monitoring Project, Jamestown, RI. Project included conducted monitoring events for a three-year seagrass monitoring project to document the impacts of a residential dock facility and associated boating activities on an eelgrass bed. Responsible for creating a georeferenced base map for collecting and analyzing data on the density and distribution of eelgrass, canopy height, epiphytic coverage and wasting disease.

- Massachusetts Department of Environmental Protection (MADEP), Aquatic Habitat Evaluation, French and Quinebaug Watersheds, MA. Assisted in the development and implemention of a watershed-wide aquatic habitat assessment program to identify potential problems within the watersheds and to serve as baseline data for future monitoring efforts. Responsible for creating a GIS database of 50 sites analyzing aquatic invertebrates and water quality data for the watersheds. All sampling was conducted in accordance with a project specific Quality Assurance Project Plan (QAPP). All information was provided to MassDEP as an interactive GIS CD-ROM for use by the French and Quinebaug Watershed Team.

- Massachusetts Department of Environmental Protection (MADEP), Sediment and Water Quality Assessment, Deerfield Watershed, MA. Assisted in the development and implemention of a program assessing sediment quality behind six impoundments located within the Deerfield Watershed in order to make recommendations regarding potential effects on aquatic biota or human health. In addition, an assessment of fecal coliform contamination was conducted throughout the watershed at more than 20 sites during multiple dry weather and wet weather conditions. All sampling was conducted in accordance with a project specific Quality Assurance Project Plan (QAPP). Responsible for creating a GIS project analyzing water quality data, land use data and in-field reconnaissance to identify potential pollutant sources and make recommendations for future management actions.

- Massachusetts Department of Environmental Protection (MADEP), Determination of Sources of Water Quality Impairment, Westfield Watershed, MA. Assisted in the design and implementation of a watershed-wide pollutant source identification program for the Westfield River Watershed. Responsible for GIS creation and anaylsis of water quality sampling of both dry and wet weather conditions at over 40 stations, as well as habitat, aquatic invertebrate and periphyton analysis. Impaired sub-basins within the watershed were identified and solutions for identified pollutant sources were recommended. The report included an extensive database presented in GIS format for the purposes of illustrating patterns in water quality for each sampled parameter.

- Massachusetts Department of Conservation and Recreation – Assessment and Permitting for In-Lake Weed Control at Lake Cochituate, MA. Purpose of the project was to prepare Notices of Intent for submittal to three towns in Massachusetts for the control of nuisance aquatic vegetation. Responsible for GIS analysis and mapping of milfoil and curlyleaf pondweed concentrations based on field surveys done by ESS staff using GPS.

- Massachusetts Department of Conservation and Recreation – Diagnostic/Feasibility Assessment of Big Pond, Otis, MA. Purpose of project was to make recommendations for different types of monitoring to preserve the ecological integrity of the aquatic system. Responsible for developing a baseline GIS project for the Big Pond watershed. This included sample data for water quality, stormwater, macroinvertebrate community composition, and aquatic/wetland plants.

COMPUTER SKILLS

- ArcGIS 9.X & Extensions
- ArcView (Versions 3.X) & Extensions
- Autodesk Land Desktop & 3D Civil
- Autodesk Viz (Visualization software)
- Metadata (FGDC)
- Avenue Programming Language (GIS)
- Adobe (Photoshop & PageMaker)
- Global Positioning Systems (GPS) – Pathfinder Office
- C.A.M.E.O. – Computer Aided Management of Emergency Operations
- Windows Operating Systems (Microsoft Office)
- Programming (SAS, Maple V, and C/C++)

ESS Group, Inc.

Glendon H. Barnes
Environmental Scientist

EXPERIENCE

ESS Group, Inc. – May 2008 to Present
Years of Prior Related Experience – 3

EDUCATION

JD, Vermont Law School, 2005
MSEL, Vermont Law School, 2006
Certificate of Advanced Studies, GIS, University of Denver, 2000
BA, Environmental Science, Boston University, 1998
Sea Education Association (SEA) Program, 1998

SUMMARY OF PROJECT EXPERIENCE

Ms. Barnes brings a wide range of skills including experience with regulatory, legal and zoning research, geographic information systems mapping, and data collection. She has hands-on experience with water sampling, aerial mapping, Hyperspectral data collection, and use of Light Detection and Ranging (LIDAR) technology. During her undergraduate education she had the opportunity to assess the health and population status of invertebrate marine wildlife, inventory temperate rain forest flora and perform aquatic bacterial quantifications. In law school she worked closely with municipalities, gaining valuable knowledge of zoning and permitting regulations. Ms. Barnes's relevant experience includes:

- Office of the Vermont Secretary of State, Montpelier, VT. Researched regulations and recent case law to update the *Guide to Municipal Land Use*, distributed to Vermont municipalities as a baseline zoning regulation guide.

- Alaska State Forest – GIS/Field Lead, Southeast AK. Responsible for aerial LIDAR data collection and processing, ground truthing methods, and occasional progress update presentations to the client. Oversaw field crew of one to five people and trained additional field crew members in data collection, processing and analysis.

- New York Regional Interconnect – High Voltage DC Transmission Line, NY. Conducted research, evaluation and write up of local ordinances and local laws of towns crossed by a proposed alternative routing of a 400 kV direct current transmission project. This research was conducted to supplement an Article VII filing to the New York Public Service Commission.

- Bayonne Energy Center, LLC – Bayonne Energy Center Project, NJ (Bayonne) to NY (Brooklyn). Assisted in the review, preparation and submission of Article VII and U.S. Army Corps of Engineers applications for the construction of a 345 kV submarine electric cable from Bayonne, NJ routed through Upper New York Bay and making landfall at the existing ConEd Gowanus substation in Brooklyn. Assisted in research and preparation of sections discussing water quality and sediment transport, land use, topography, geology and drafted sections involving coastal consistency with state and federal management regulations and local ordinances.

- Rhode Island Department of Environmental Management – Statewide Biomonitoring and Habitat Assessment of Rhode Island's Wadeable Streams, RI. Assisted in the collection of benthic macroinvertebrates from numerous stream sites as part of an ongoing monitoring program.

- Hudson Transmission Energy Project – NY/NJ. Performed Coastal Zone Management regulatory research.

- Cape Wind Renewable Energy Project – Nantucket Sound, MA. Researched and prepared alternatives analysis, project timeline and response to public comments regarding cultural and historic resources, drafted Section 106 briefing document and U.S. Coast Guard/Minerals Management Service response letter.

- Town of Hull – Hull Wind Offshore Expansion, Hull, MA. Conducted benthic habitat field research for developing siting and feasibility analysis, performed visual assessment data collection and participated in project development meetings for a proposed four-turbine array in waters off Nantasket Beach. Assisted in the drafting of the Avian Risk Assessment and drafted response to public comments regarding visual impacts.

- Upstate New York Power Corp. – Hounsfield Transmission Line Project, Upstate NY. Assisted in a local law and town ordinance review and drafted a section for the Article VII Application to the State of New York for a proposed 39-mile transmission line.

- Areva NP – Nine Mile Point Proposed Unit 3 Nuclear Reactor, Scriba, NY. Assisted in drafting of cultural section for combined construction and operating license application for submission to the U.S. Nuclear Regulatory Commission by UniStar Nuclear Energy LLC, regarding an additional proposed 1,600 MW nuclear reactor. Performed visual field data collection and assisted in write up of visual impacts assessment.

- Deerfield Wind LLC – 45 MW Deerfield Wind Project, Searsburg and Readsboro, VT. Working in conjunction with the U.S. Forest Service, assisted in analysis and drafting of recreational impact section of Environmental Impact Statement. The project would be an expansion of an existing wind project, operating on a privately held ridgeline in Green Mountain National Forest lands.

- Town of Sharon Well Installation – Sharon, MA. Performed permit requirement research, assisted with costing of permitting and performed wetland delineation field work for preparation of a proposal to the Town of Sharon for the installation of test wells and construction of town drinking water well.

- Robinson Pond Dredging Project – Agawam, MA. Assisted in the preparation of a 401 Water Quality Certification application.

- Berkeley Green II, LLC. – RiverGreen Technology Park, Everett, MA. Assisted in preparation of Chapter 91 License application, Expanded Environmental Notification Form and Supplemental Environmental Impact Report for the development of a state-of-the-art technology park to be located on a remediated former brownfield site.

- Confidential Energy and Carbon Sequestration Project – Northeast U.S. Performed desktop regulatory and locational visibility research and Coastal Zone Consistency for facility siting and permitting for a 750 MW energy facility that involves offshore carbon sequestration on the Outer Continental Shelf.

- Winchester Country Club – Winchester, MA. Assisted in the preparation of a renewal of a Massachusetts Water Use Permit.

- Laidlaw Berlin BioPower, LLC – Proposed Biomass Facility, Coos County, NH. Assisted in the preparation of an Application for Certificate of Site and Facility for a proposed 66 MW biomass power plant.

- Wilcox and Barton – Guilford Commons Monitoring Program, Guilford, CT. Assisted in field work including habitat assessment, water quality sampling and biomonitoring at three sites along Spinning Mill Brook to establish baseline conditions in the stream prior to completion of new storm and waste water systems on the Guilford Commons property.

- BayCorp Holdings – Proposed Anaerobic Digester Facility, MA. Performed local zoning ordinance and permit review and research of possible towns in Massachusetts for the location of a proposed anaerobic digester facility that would recycle organic waste product into fuel and compost.

- Bare Cove Marina – Chapter 91 License Review, Hingham, MA. Performed Chapter 91 Waterways License review and research to determine permitting history of a marina in Hingham Harbor.

- DeNunzio Development – Proposed Commercial Development, Everett, MA. Performed Chapter 91 Waterways License review and research to determine historic shoreline and interpret Chapter 91 Regulatory applicability.

PROFESSIONAL REGISTRATIONS AND AFFILIATIONS

Admitted to the Vermont Bar – 2008
Admitted to the Washington D.C Bar – 2008
Member of the Washington D.C. Bar Association, Environmental Section

ESS Group, Inc.

Matthew R. Fuller
Environmental Scientist

EXPERIENCE

ESS Group, Inc. – August 2010 to Present
Years of Prior Related Experience – 6

EDUCATION

MS, Zoology, University of Wisconsin-Madison, 2009
BS, Biology, Cornell University, 2006

SUMMARY OF PROJECT EXPERIENCE

Mr. Fuller has more than 6 years of experience working in aquatic ecology. He has specialized in ecological evaluation of food webs and trophic interactions within streams, lakes and wetlands. Mr. Fuller is familiar with freshwater and marine benthic invertebrate taxonomy, hydrologic and water quality analysis, and aquatic plant community assessment. Additionally, Mr. Fuller excels at statistical analysis and environmental modeling for the evaluation of large and complex data sets associated with a variety of ecological projects. Mr. Fuller's representative research and experience includes:

- Rhode Island Department of Environmental Management – Statewide Biomonitoring and Habitat Assessment of Rhode Island's Wadeable Streams. Mr. Fuller has been involved in the collection and analysis of water quality and benthic data for this state-wide freshwater biological assessment program. Work performed by Mr. Fuller was compliant with the project's Quality Assurance Project Plan (QAPP) as approved by USEPA and RIDEM. The program is a multi-year assessment of all of the waters of the state and the data reports prepared by the ESS team are used to support the state's routine water quality reporting requirements (305 (b) Assessment) to USEPA.

- The Louis Berger Group, Inc. – Stream Biomonitoring and Habitat Assessment, South Kingstown, RI. Mr. Fuller was responsible for implementing the annual sampling program which includes assessment of five stream reaches to monitor water quality and aquatic habitat conditions in surface waters adjacent to a landfill remediation site. Mr. Fuller assessed basic water quality and stream habitat conditions in the field and collected, identified, and reported the results of benthic macroinvertebrate samples according to protocols established by RIDEM.

- Massachusetts Water Resources Authority – Aquatic Invasive Macrophyte Surveys, MA. Mr. Fuller identified and quantitatively assessed macrophyte cover/biovolume at several reservoirs in eastern Massachusetts. This effort was made to complete a survey of aquatic invasive macrophytes at source and emergency reservoirs managed by MWRA and the Massachusetts Department of Conservation and Recreation (DCR). The primary purpose of this survey was to update comprehensive baseline surveys of aquatic macrophytes completed in 2006 and 2007. Small watercraft outboard motor operation was necessary while conducting this field work.

- Town of Wellesley – Annual Water Quality Monitoring and Aquatic Plant Assessment, Wellesley, MA. Conducted annual aquatic plant and water quality data collection at Morses Pond. Water quality data have been used by ESS to guide decisions regarding the need to perform chemical treatments to manage the more severe algal blooms.

- Cape Wind Associates, LLC – Cape Wind Offshore Renewable Energy Generation and Submarine Cable Project, Nantucket Sound, MA. Assisted with the drafting and editing of responses to agency requests concerning avian impacts of the wind farm and assisted with the statistical design of the pre- during and post-construction monitoring plan. The project involves the siting, permitting, and construction of up to 130 wind turbines, an offshore electric service platform, as well as the submarine cable transmission link, and the upland cable interconnection with New England's power grid. Once completed, the project will be the largest offshore wind power generation facility in the United States and among the largest worldwide.

- Bayonne Energy Center – New York Landfall, Gowanus Bay, Brooklyn, NY. Independent Environmental Inspector for construction activities associated with the installation of a new submarine transmission line from Bayonne, New Jersey to Brooklyn, New York. He also provided inspection services, documented any environmental compliance issues and prepared daily written inspection reports during all in-water construction activities associated with the installation of the New York landfall. The project entails the construction of a 512 MW electric generating plant in Bayonne, NJ. The plant will be connected to the New York electrical grid via a 6.5 mile long, 345 kV submarine electric transmission cable with an interconnection at the ConEdison Gowanus substation in Brooklyn.

- Quaboag and Quacumquasit Lake Association – Aquatic Invasive Weed Control Pilot Study, Lake Quacumquasit, East Brookfield, Brookfield, and Sturbridge, MA. Assisted with a pilot study of cost-effective, small-scale treatments for control of invasive aquatic weeds. Project tasks were primarily field sampling and monitoring of the in situ experimental treatments.

- KeySpan and Northeast Utilities – Long Island Submarine Cable Replacement Project, Norwalk, CT to Northport, NY. Sorted marine benthic samples under a New York State Department of Environmental Conservation approved protocol to monitor the impacts, if any, to marine benthic invertebrates in the vicinity of several abandoned cable segments. This biomonitoring was a small part of the larger effort to replace several high voltage submarine power transmission cables connecting Connecticut and Long Island. Statistical analysis of four years of monitoring data was also conducted to evaluate major changes in community composition over time as well as differences between directly impacted sites and reference sites.

- Pepco Holdings, Inc. – Mid-Atlantic Power Pathway Project, Chesapeake Bay, MD. Sorted marine benthic samples to establish a baseline benthic invertebrate community along a proposed route for a submarine high voltage transmission cable extending from the western shore of Chesapeake Bay in Calvert County, Maryland to Dorchester County, Maryland.

- University of Wisconsin-Madison, Dept. of Zoology and Center for Limnology; Rocky Mountain Biological Laboratory – Beaver Pond Morphology As a Tool for Predicting Changes in Downstream Reaches, Madison, WI and Gothic, CO. Surveyed beaver ponds across the Colorado Rocky Mountains to evaluate simple morphological parameters of beaver ponds that predict changes downstream of the pond. Survey sampling included benthic invertebrates, water chemistry, hydrology, geomorphology and GIS data.

- Nyanza Project; Kigoma, Tanzania; Cornell University Ithaca, NY – Deforestation and Season Alter Tropical Benthic Macroinvertebrate Communities of East Africa. Characterized and compared stream macroinvertebrate communities of forested and deforested catchments bordering Lake Tanganyika during wet and dry seasons. Also assisted other researchers with water chemistry, hydrology and geomorphology sampling. Operation of small motorized watercraft was necessary to reach sampling sites.

- EcoQuest New Zealand – A Study of Aquatic Macroinvertebrates on Mount Maungatautari, Kaiaua, New Zealand. Characterized and compared stream macroinvertebrate communities along a forest-pasture interface at the border of Maungatautari Scenic Reserve, a mainland island reserve. This study was conducted during the construction of a predator-proof fence being built around Mt. Maungatautari in order to exclude invasive mammalian pests that destroy native plants and out-complete native animals in the reserve. Stream invertebrate communities were characterized within the forest for future comparison when mammalian pests are eradicated. The comparison between forest and pasture was conducted to determine what major community shifts were associated with the new fence culverts in addition to the upland habitat transition.

- Cornell University – Game Farm Road Soccer Field Construction Monitoring, Ithaca, NY. Sampled and identified stream benthic invertebrates before, during and after construction of two practice soccer fields adjacent to Fall Creek to determine impacts of construction on stream benthos. During construction, sedimentation sensitive taxa were reduced, but post-construction results suggest that these taxa were able to reestablish themselves once the initial impact was mitigated by a few high flow events.

- Technician – Siena College, Loudonville, NY and Asa Wright Nature Center Trinidad, West Indies. Supported work of Principal Investigators to evaluate nutrient fluxes through a tropical foodweb as part of a larger ongoing project to determine links and feedbacks between evolution and ecosystem processes.

PROFESSIONAL REGISTRATIONS AND AFFILIATIONS

- Member, American Water Resources Association
- Member, Ecological Society of America
- Member, North American Benthological Society
- Member, Rocky Mountain Biological Laboratory
- Reviewer, Hydrobiologia

PUBLICATIONS

- Fuller, M.R. and B.L. Peckarsky. (in press) Ecosystem engineering by beavers affects mayfly life histories. (in press for Freshwater Biology)

- Fuller, M.R. and B.L. Peckarsky. (in revision) Does the morphology of beaver ponds alter food webs of downstream reaches? (in revision for Hydrobiologia)

- Fuller, M.R., O'Reilly, C.M., and A.S. Flecker. (in prep) Deforestation and season alter tropical benthic macroinvertebrate communities of East Africa. (in preparation for submission to Journal of the North American Benthological Society)

- Fuller, M.R. (in review) Spoonhead sculpin, deepwater sculpin, mottled sculpin, chain pickerel and bowfin life history reports. (in review for John Lyons' rewrite of George C. Becker's 1983 Fishes of Wisconsin online book).

- Fuller, M.R. and E. Maroni. 2005. A study of aquatic macroinvertebrates on Mount Maungatautari. EcoQuest Study Abroad Program Directed Research Project Report

PRESENTATIONS

- Fuller, M.R. and B.L. Peckarsky. 2009. Do beaver ponds alter mayfly fitness? North American Benthological Society Annual Meeting No. 57

- Fuller, M.R. and B.L. Peckarsky. 2008. Do beaver ponds alter mayfly fitness? University of Wisconsin-Madison Center for Limnology Seminar

- Fuller, M.R. and B.L. Peckarsky. 2008. All beaver dams are not created equal. Rocky Mountain Biological Lab Graduate Student Summer Seminar Series

- Fuller, M.R. and B.L. Peckarsky. 2008. All beaver dams are not created equal. North American Benthological Society Annual Meeting No.56

- Fuller, M.R. 2008. Biogeochemistry of alpine beaver ponds. University of Wisconsin-Madison Center for Limnology Seminar

- Fulle, M.R. 2007. Groundwater movement around beaver impoundments: Effects on stream biogeochemistry and biology. Rocky Mountain Biological Lab Graduate Student Summer Seminar Series

- Fuller, M.R. 2007. Beaver impoundments as discontinuities of stream networks. University of Wisconsin-Madison Center for Limnology Seminar

- Fuller, M.R., O'Reilly, C.M., and A.S. Flecker. 2006. Benthic macroinvertebrate communities in tropical streams of forested and deforested catchments, Tanzania. North American Benthological Society Annual Meeting No. 54 (poster)

- Fuller, M.R., O'Reilly, C.M., and A.S. Flecker. 2006. Benthic macroinvertebrate communities in tropical streams of forested and deforested catchments, Tanzania. Cornell University Ecology and Evolutionary Biology Senior Honors Thesis Presentation

- Fuller, M.R. and C.M. O'Reilly. 2005. A study of stream macroinvertebrates in forested and deforested catchments bordering Lake Tanganyika. Presentation to the Tanzania Fisheries Research Institute-Kigoma and local government officials

- Fuller, M.R. and E. Maroni. 2005. A study of aquatic macroinvertebrates on Mount Maungatautari. Presentation to the Mount Maungatautari Ecological Land Trust and New Zealand Department of Conservation

SKILLS AND CERTIFICATIONS

- PADI Advance Open Water SCUBA certification
- Fluorometry trained for chlorophyll a analysis
- Spectrophotometer trained for various phosphorus analyses
- Trained in identifying aquatic macroinvertebrates from northeastern United States, Colorado Rockies, New Zealand, East Africa
- Statistical computing within the software "R"
- Proficient in GIS mapping

ESS Group, Inc.

Daniel J. Herzlinger, PWS
Environmental Scientist

EXPERIENCE

ESS Group, Inc. – January 2006 to Present
Years of Prior Related Experience – 3

EDUCATION

MEM, Resource Ecology, Duke University, 2001
BA, Biology, Bates College, 1997

SUMMARY OF PROJECT EXPERIENCE

Mr. Herzlinger is a Professional Wetland Scientist (PWS) with over six years of experience conducting ecological field studies, wetland delineations, environmental permit review/preparation, natural resource site assessments, wildlife habitat evaluations and rare species surveys. Mr. Herzlinger's range of project experience includes the siting and permitting of energy generation facilities and infrastructure, commercial development, lake management and watershed assessments for non-point source pollution. He has expertise in the use of Geographic Information Systems (GIS), sub-meter accuracy Global Positioning Systems (GPS), laser rangefinder and methodology for conducting visual assessments.

Mr. Herzlinger has a strong working knowledge of the Massachusetts Wetlands Protection Act (WPA), Massachusetts Environmental Policy Act (MEPA), Rhode Island Freshwater Wetlands Act, and Section 401 and 404 of the federal Clean Water Act. As a Conservation Agent for the Town of Acushnet, Massachusetts, Mr. Herzlinger served as the Chair of the Town's National Pollutant Discharge Elimination System Phase II Storm Water Committee and assisted drafting a storm water bylaw for the town. He managed over 250 acres of open space in Acushnet and assessed the ecological value of various town-owned parcels. Mr. Herzlinger's representative wetland delineation and permitting experience at ESS includes the following:

- Tiverton Power, LLC – Electric Generating Facility Expansion, Tiverton, RI. Mr. Herzlinger assessed potential impacts to terrestrial ecology and wetlands from the proposed construction of an additional natural gas-fired turbine and associated structures at the facility. He drafted a section on terrestrial ecology and wetlands for the application to the Rhode Island Energy Facilities Siting Board.

- FM Global – Remote Site Expansion, West Gloucester, RI. Mr. Herzlinger conducted a site visit and evaluated potential wetland permitting issues under the Rhode Island Freshwater Wetlands Act for the construction of a new test pad near a perennial stream. He prepared a brief technical memo outlining various permitting options and provided recommendations for proceeding with the project. Based on the recommendations, Mr. Herzlinger delineated jurisdictional wetland resource areas at the site and prepared and filed a Request for Preliminary Determination with RIDEM for the remote site expansion.

- National Grid – Mortimer-Golah Transmission Line Rebuild Project, Monroe County, NY. Mr. Herzlinger was responsible for conducting an ecological assessment and delineation of jurisidictional wetland resource areas under Section 404 of the Clean Water Act and the New York State Freshwater Wetlands Act. The project involved the delineation of over 25 wetlands along a 10-mile transmission line route. The results of the delineation will be used to prepare a New York State Article VII application and a filing with the U.S. Army Corps of Engineers.

- Arkwright, Inc. – Fiskeville, RI. Mr. Herzlinger delineated wetland resource areas at the Arkwright property in accordance with guidelines established in the Rhode Island Freshwater Wetlands Act, using the three-parameter approach.

- Toray America, Inc. – North Kingstown, RI. Assisted the project manager to delineate wetland resource areas at the Toray Plastics factory. Wetland resource areas were delineated in accordance with guidelines established in the Rhode Island Freshwater Wetlands Act. Prepared and filed a Request to Verify Wetland Edge with the Rhode Island Coastal Resources Management Council.

- State Line Scrap, Inc. – Storm Water Improvements, Attleboro, MA. Mr. Herzlinger delineated jurisdictional wetland resource areas under the Massachusetts WPA and City of Attleboro Wetlands Protection Ordinance at the State Line Scrap facility for a proposed storm water improvement project. Mr. Herzlinger is currently preparing the Notice of Intent for the project to be filed with the Attleboro Conservation Commission and Massachusetts Department of Environmental Protection.

- Massachusetts Department of Conservation and Recreation – Pond Dredging, Agawam and Carlisle, MA. Mr. Herzlinger delineated jurisdictional freshwater wetland resource areas under the Massachusetts WPA at Robinson Pond, in Robinson State Park. He prepared and filed Environmental Notification Forms and Notices of Intent for the proposed dredging of Robinson Pond as well as Farm Pond in Carlisle, Massachusetts. He presented projects to regulators at MEPA site visits and local Conservation Commission hearings. Mr. Herzlinger was responsible for preparing the Request for 401 Water Quality Certifications to the Massachusetts Department of Environmental Protection and the Section 404 U.S. Army Corps of Engineers applications for each pond. Dredging will be conducted to restore aquatic habitat and water quality within the ponds.

- Housatonic River Natural Resource Damage Fund – Housatonic River Enhanced Public Access Project, MA. Mr. Herzlinger assisted the project manager in partnership with the Housatonic Valley Association to perform an initial screening of 40 potential sites for enhanced public access to the Housatonic River in western Massachusetts. The screening was based on land availability as well as physical, hydrological, and natural resource constraints. Mr. Herzlinger conducted rare species surveys, evaluated access constraints and collected data on stream profiles, streambed composition and substrate characteristics. He conducted field surveys for the presence of Jefferson and Four-toed Salamanders, which are listed as species of special concern in Massachusetts. Mr. Herzlinger delineated jurisdictional wetland resource areas at five high priority sites and prepared the Notices of Intent under the Massachusetts WPA for construction of canoe launches at each of these five sites. Mr. Herzlinger presented the project before the Conservation Commissions of the towns in which the canoe launch sites will be located.

- Indian Ridge Country Club – Golf Course Drainage Improvements, Andover, MA. Mr. Herzlinger was responsible for delineating jurisdictional wetland resource areas under the Massachusetts WPA and Andover Wetlands Protection Bylaw at the Indian Ridge Golf Course for a proposed drainage improvement project. Mr. Herzlinger provided the Indian Ridge Golf Course with a technical memo summarizing the results of the delineation and permitting implications for the proposed drainage improvements.

- EMI Chelsea – Energy Generating Facility, Chelsea, MA. Mr. Herzlinger conducted field work to determine the extent of state and federal wetland resource areas present on this six-acre site along the Chelsea River. He flagged coastal resource areas at the site that fall under jurisdiction of the Massachusetts WPA. Mr. Herzlinger prepared and filed a Request for Determination of Applicability for initial site work for the proposed energy generating facility.

- Plymouth EDF – Rare Species and Habitat Mapping, Plymouth, MA. Mr. Herzlinger completed a survey of a 1,000-acre parcel to assess natural communities at the site and evaluate constraints on development based on the presence of rare natural communities and species. He mapped the location of rare natural communities and produced GIS figures delineating sensitive areas based on the field assessment.

- Walpole Country Club – Regulatory Permitting and Engineering Design Services Allen Pond, Walpole, MA. Mr. Herzlinger delineated wetland resource areas adjacent to a 3.5-acre pond in accordance with the Massachusetts WPA and U.S. Army Corps of Engineers, Wetland Delineation Manual (1987) for dredge work. He assisted with the Wildlife Habitat Evaluation conducted in accordance with Appendix B of the *Massachusetts Wildlife Habitat Protection Guidelines for Inland Wetlands*. Mr. Herzlinger assisted the project manager to prepare Notice of Intent and MEPA review applications for proposed dredge work at Allen Pond. He prepared the Request for 401 Water Quality Certification and Section 404 Army Corps application for the project.

- Town of Wellesley – Wellesley Department of Public Works, On-Call Wetland Delineations, Wellesley, MA. Mr. Herzlinger flagged jurisdictional wetland resource areas under the Massachusetts WPA using the three-parameter approach for two road improvement projects. He prepared a brief technical summary delineation report for inclusion in a Notice of Intent application filed by the Wellesley Department of Public Works.

- Westfield Land Development Company – Pioneer Valley Energy Center, Westfield, MA. Mr. Herzlinger assisted the Project Manager with wetland permitting and field delineation associated with the Pioneer Valley Energy Center. The project involves the permitting and construction of a generating facility capable of generating up to 400 MW of power and a 2.5-mile natural gas pipeline to connect the Generating Facility to the WG&E gas delivery system. Mr. Herzlinger was responsible for preparing portions of the Electric Facilities Siting Board, Abbreviated Notice of Resource Area Delineation and Draft Environmental Impact Report applications. Mr. Herzlinger assisted with the preparation of the Notice of Intent for the generating facility, gas pipeline and water interconnection.

- Berkley Investments – River Green Technology Park, Everett, MA. Mr. Herzlinger assisted with the delineation of jurisdictional wetland resource areas under the Massachusetts WPA at a brownfield site along the Mystic River in Everett, Massachusetts. Wetlands were delineated in accordance with the WPA and the U.S. Army Corps of Engineers wetland delineation manual (1987). The site was formerly used for construction of airplane engines. Vegetation and soils were disturbed from previous site use which presented a challenging delineation.

- SEMASS – Facility Expansion, Rochester, MA. Delineated jurisdictional wetland resource areas under the Massachusetts WPA using the three-parameter approach. Inland bank and bordering vegetated wetlands were delineated to evaluate potential permitting needs for a facility expansion.

PROFESSIONAL REGISTRATIONS AND AFFILIATIONS

- Society of Wetland Scientists - Professional Wetland Scientist

- Member of Society of Wetland Scientists
- Association of Massachusetts Wetland Scientists – Full Voting Member

ESS Group, Inc.

Matthew D. Ladewig
Environmental Scientist

EXPERIENCE

ESS Group, Inc. – September 2006 to Present
Years of Prior Related Experience – 3

EDUCATION

MS, Aquatic Resource Ecology and Management, University of Michigan, 2006
BA, Geography, University of Illinois at Urbana-Champaign, 2000

SUMMARY OF EXPERIENCE

Mr. Ladewig possesses a broad range of skills useful in bioassessment, monitoring, modeling, and management of aquatic ecosystems. He has conducted numerous fish and wildlife surveys in a wide variety of environments. Mr. Ladewig's understanding of hydrology, geomorphology, and ecology allow him to make holistic evaluations of lakes, ponds, streams, and their watersheds. He draws upon this knowledge and experience to develop sound approaches for monitoring and managing aquatic invasive species. Mr. Ladewig also has extensive expertise in freshwater and marine macroinvertebrate identification and is certified by the North American Benthological Society as a Level II EPT Taxonomist. His analytical skills are anchored by a strong background in Geographic Information System (GIS) software, statistical analysis, and data management.

Mr. Ladewig's representative work experience includes the following:

- Sand Dam Reservoir Association (SDRA) – Vegetation Monitoring and Long-term Lake Management Plan, Glocester, RI. Conducted survey of aquatic macrophytes at Sand Dam Reservoir to monitor growth of invasive variable-leaf milfoil and assess the health and diversity of native plants in the lake. Developed a prioritized long-term lake management and monitoring plan to help SDRA control their plant management costs through a more sustainable strategy.

- Massachusetts Water Resources Authority (MWRA) – Aquatic Invasive Macrophyte Surveys, MA. Managed field effort and reporting tasks for a comprehensive survey of aquatic macrophytes at ten source and emergency reservoir areas jointly managed by MWRA and the Massachusetts Department of Conservation and Recreation (DCR). This survey provided the first comprehensive update to baseline macrophyte surveys completed in 2006 and 2007. Developed aquatic macrophyte monitoring and management plan that included an assessment of climate change impacts on macrophyte communities in the MWRA/DCR reservoirs. Compiled the first comprehensive field guide to the aquatic macrophytes of the entire MWRA/DCR reservoir system.

- Northeast Utilities – Long Island Submarine Cable Replacement Project, Norwalk, CT. Collected infaunal grab samples and oversaw diver collection of epifaunal samples as part of the submarine cable post-construction monitoring program conducted under a Connecticut Department of Environmental Protection approved protocol. Provided quality assurance/quality control and identified and enumerated benthic macroinvertebrates from these samples. Assisted with data analysis and reporting for 24-month and Final Summary Reports to monitor the impacts, if any, to benthic and shellfish resources near the submarine replacement cables.

- Pepco Holdings, Inc. – Mid-Atlantic Power Pathway Project, Chesapeake Bay, MD. In accordance with protocols tailored to meet the standards of the Maryland Department of Natural Resources, collected vibracore and benthic grab samples from numerous locations along a proposed high voltage submarine transmission cable route in Chesapeake Bay and the Choptank River. Provided quality assurance/quality control and taxonomic identification of benthic macroinvertebrates from 40 grab samples. Analyzed data and completed report detailing the baseline benthic macrofaunal assessment. This assessment was included in the Environmental Review Document filed with the state of Maryland for project permitting.

- Quaboag and Quacumquasit Lake Association (QQLA) – Aquatic Invasive Weed Control Pilot Study, Lake Quacumquasit; East Brookfield, Brookfield, and Sturbridge, MA. Conducts pilot study of cost-effective, small scale treatments for control of invasive aquatic weeds. In response to persistent invasive weed problems at Quaboag Pond and Lake Quacumquasit, ESS developed a long-term plant management plan for QQLA. As an initial management step, a pilot study will be conducted to investigate the success of several low-cost alternatives to lakewide herbicide treatment. Experimental treatments will be feasibility tested in aquaria trials. Treatments with the greatest likelihood for success will be studied in-situ using enclosures to isolate dense weed beds of invasive Eurasian milfoil (*Myriophyllum spicatum*) and fanwort (*Cabomba caroliniana*). Field testing will allow ESS to provide QQLA with a toolbox of small-scale management actions that can be used to control weed growth in key recreational areas at minimal cost.

- Town of Wellesley – Phytoplankton and Water Quality Monitoring of Morses Pond, Wellesley, MA. Conducted monitoring of in-lake conditions at Morses Pond, a 103-acre lake within a highly urbanized setting. Responsibilities included water quality sampling and collecting Secchi disk readings and phytoplankton samples. Also provided rapid turnaround screening level identification of phytoplankton samples to detect incipient algae blooms that could impact recreational use at the pond. Analyzed water quality and phytoplankton data for final reporting.

- Providence Water – Limnological Studies of Ponaganset and Regulating Reservoirs; Glocester and Scituate, RI. Conducted bathymetric and aquatic macrophyte mapping surveys of two reservoirs in the City of Providence's public water system as part of a limnological study to address water quality issues. These issues stem mainly from concerns over aquatic invasive species (AIS), land use density in the watershed, and shoreline encroachment.

- Northern Rhode Island Conservation District – Development of Lake Management Plans for Bowdish Lake and Smith and Sayles Reservoir; Glocester, RI. Prepared a Quality Assurance Project Plan (QAPP) for field surveys, including aquatic macrophyte mapping. Field data collected during this effort were integrated with existing data on the lakes and their watersheds and used to prepare separate lake management plans for Bowdish Lake and Smith and Sayles Reservoir. Once approved these will be among the first lake management plans in the state. A comprehensive short and long term management strategy was developed to maintain the high water quality in each lake while controlling the growth of aquatic invasive weeds, including variable-leaf milfoil (*Myriophyllum heterophyllum*) and fanwort (*Cabomba caroliniana*).

- Confidential Client – Permitting of Private Dock; Hingham, MA. Led a field survey of shellfish and macroalgae at the site of a proposed dock, in accordance with protocols approved by the town Conservation Commission.

- Club Motorsports, Inc. – Valley Motorsports Park; Tamworth, NH. Led the pre-construction wet weather water quality sampling field effort to support the permitting and construction of a recreational and instructional driving course. In order to comply with the low reporting limits required at the site by New Hampshire water quality regulations, samples were collected in accordance with the EPA 1669 clean sampling method.

- The Louis Berger Group, Inc. – Stream Biomonitoring and Habitat Assessment; South Kingstown, RI. Led the field sampling effort at five stream reaches to monitor the water quality and aquatic habitat conditions in surface waters adjacent to a landfill remediation site. Assessed basic water quality and stream habitat conditions in the field and collected, processed, and reported the results of benthic macroinvertebrate samples according to RIDEM protocols. Results of the biomonitoring and habitat assessment efforts will allow the client to track impacts or improvements to surface waters downgradient of the site of interest.

- Rhode Island Department of Environmental Management (RIDEM) – Characterization of Buckeye Brook Biological Impairment; Warwick, RI. Collected and identified quantitative macroinvertebrate samples from six sites in the Buckeye Brook system and one reference site used in the annual statewide biomonitoring program for wadeable streams. Also collected and analyzed results of quantitative periphyton and particulate organic matter samples. Buckeye Brook is on the Rhode Island 303(d) list for biodiversity, *Enterococcus*, and fecal coliform impairments. Results of the study are being used to help identify potential sources of contamination within this highly urbanized watershed.

- Pawtuxet River Authority and Watershed Council – Tiogue Lake Assessment; Coventry, RI. Conducted plant mapping, water quality, wildlife, and invertebrate surveys and analysis in Tiogue Lake. The results of these surveys were used to assess the general condition of Tiogue Lake with regard to water quality, nuisance vegetation, and other aquatic life, and provide the Town of Coventry and the Tiogue Lake Association with management recommendations that are compatible with both wildlife and continued recreation at the lake.

- Confidential Client – NYS Article VII Application, NY. Completed an assessment of existing benthic resources in Lake Ontario for a proposed power transmission project between a proposed wind farm on Galloo Island and the town of Mexico, New York. As part of this assessment, identified and enumerated benthic macroinvertebrates from baseline benthic samples collected along the Proposed Subaquatic Route in Lake Ontario. Additionally, assisted with the drafting of several sections of the New York Article VII application, including discussions of hydrology, wetlands, biological resources, and vegetation clearing. This was used, along with other studies, to identify potential impacts of the 51 mile, 230 kV electric transmission line and associated substations.

- Town of Hull - Hull Wind Offshore Expansion; Hull, MA. Identified and enumerated macroinvertebrates from benthic samples collected in the Proposed Project Area as part of the baseline monitoring effort. Also completed analysis of targeted benthic samples in areas with the potential to support surf clam beds. Data from these efforts were summarized in a technical report on the baseline benthic resources. This project, which is being developed as a public/municipal/academic partnership between the Town of Hull Massachusetts, the Massachusetts Technology Collaborative, and the University of Massachusetts Renewable Energy Research Laboratory, will be the first community-based offshore project in New England and is being used as a model for the U.S. Department of Energy National Offshore Wind Energy Collaborative.

- Town of Hopedale – Diagnostic/Feasibility Study of Hopedale Pond; Hopedale, MA. Led seepage survey of Hopedale Pond shoreline to evaluate potential groundwater sources of bacteria and nutrients. Also assisted with collection of dry weather surface water samples within the pond and at strategic locations within the watershed. Drafted Canada goose management recommendations as part of the Diagnostic/Feasibility Study in order to reduce the potential for problems related to Canada goose overpopulation, including nutrient pollution, fecal contamination, and general incompatibility with public uses at the pond. Additionally, developed a Canada goose pilot study to assess and evaluate the success of management options as they are adopted by the town.

- Confidential Client – Stream and Pond Monitoring Program; Guilford, CT. Conducts field work including habitat assessment, water quality sampling and biomonitoring at three sites along Spinning Mill Brook, as well as plant and bathymetry mapping of a small pond in line with the stream. The biomonitoring design employs quantitative methods for sampling macroinvertebrates, periphyton and fish within the brook. Baseline conditions have been established for the stream and will permit the evaluation of post-construction water quality, sedimentation and biological conditions in Spinning Mill Brook, as needed.

- KeySpan and Northeast Utilities - Long Island Submarine Cable Replacement Project; Norwalk, CT to Northport, NY. Assisted in the design and execution of a post-construction benthic macroinvertebrate monitoring program. Collected and analyzed water quality and benthic samples under a New York State Department of Environmental Conservation (NYSDEC) approved protocol to monitor the impacts, if any, to biological resources in the vicinity of several abandoned cable segments. The Project was granted the Certificate of Environmental Compatibility and Public Need from the Connecticut Siting Council and the New York State Coastal Consistency Concurrence and was successfully installed.

- Massachusetts Department of Conservation and Recreation, Lakes and Ponds Program – Sampling, Design and Permitting Services to Support Dredging at Robinson Pond and Farm Pond; Agawam and Carlisle, MA. Assisted with the design and implementation of a sediment sampling plan for two small ponds on state-managed land. The principal objectives of this project were to assist the client in obtaining the necessary environmental permits for dredging and onsite disposal as well as prepare the final engineering drawings for each pond.

- Massachusetts Department of Conservation and Recreation, Lakes and Ponds Program – Quagga and Zebra Mussel Education, Monitoring and Outreach; Western MA. Managed project designed to help prevent the spread of invasive quagga and zebra mussels into the waters of western Massachusetts. Also presented a workshop to volunteers on methods of collection, preservation, and screening of early life stage samples. The approach of this project was multifaceted and incorporated education, monitoring and outreach activities. On the monitoring front, volunteers were trained to collect and process samples using kits developed by ESS that focus on early life stage detection. The project team also developed educational materials, including brochures for outreach to boaters and anglers as well as metal signs for posting at strategically targeted water bodies. A concerned citizen relied on information in the educational brochure to detect the first occurrence of zebra mussels in the state.

- Housatonic River Natural Resource Damage (NRD) Fund – Enhancement of Housatonic River Public Access; Western MA. Assessed hydrologic, geomorphic, and biological conditions at potential public access points along the Housatonic River to select five sites (from a total of 41 locations) for construction of public access improvements.

Conducted cross section surveys and discharge measurements at sites with the highest priority for public access. Also assessed high priority locations for the presence of rare, threatened, and endangered fish, mussel, and invertebrate species and their habitats. The assessment was based mainly on feasibility of access, ecological constraints and distance to the nearest existing river access point. Each site has been permitted and is ready for construction.

- Walpole Country Club – Sampling, Design and Permitting Services to Support Dredging at Allen Pond; Walpole, MA. Collected sediment cores for analysis of grain size distribution, physical properties and chemical constituents to support permitting of dredging in Allen Pond. The principal objectives of this project are to assist the client in obtaining the necessary environmental permits for dredging and onsite disposal as well as prepare the final engineering drawings for the pond.

- Rhode Island Department of Environmental Management (RIDEM) – Statistical Analysis of Biomonitoring Data. Managed project examining the statistical relationships between biological condition, stream habitat and relative abundance of taxa for sites sampled statewide during the 2002 to 2006 period. Results from this analysis will be used to guide classification of surface water bodies into designated use categories for reporting to the U.S. Environmental Protection Agency.

- Confidential Client – Environmental Impact Assessment for Cat Island Beach Resort; Cat Island, Bahamas. Conducted biological and water quality surveys of the aquatic and marine habitats adjacent to the proposed Cat Island Beach Resort. Also assisted with avian surveys of the terrestrial, wetland and shoreline habitats on the property. Researched and developed language in relevant sections of the environmental impact assessment to reflect the conditions observed during field surveys.

- Rose Island Hotel Company – Environmental Monitoring for Rose Island Resort; Rose Island, Bahamas. Collects water quality, sediment, phytoplankton and benthic samples in accordance with the environmental monitoring plan (EMP) for the pre-construction, construction and operation phases of a mixed-use development project. Also identifies and enumerates marine invertebrate species from benthic samples collected in the shallow coastal waters surrounding the property.

- C. Webb and Associates, LLC. - Darrow Pond Baseline Assessment; East Lyme, CT. As part of a baseline assessment, provided quality control and taxonomic identification for macroinvertebrate samples collected from tributaries and the outlet of Darrow Pond. Also conducted baseline water quality data collection in parallel sampling effort with the Connecticut Department of Environmental Protection (CTDEP). A goal of this study was to identify the baseline water quality condition in the pond prior to completion of a clustered development near the pond that incorporates Low Impact Development (LID) principles.

- Aquarion Water Company – Stream Biomonitoring; Redding and Seymour, CT. Responsible for quantitative macroinvertebrate sample collection and stream habitat assessment at six sites on two wadeable streams. In response to water quality issues, baseline data were collected at strategic locations within the source watershed.

- Central Beach Fire District – West Pond Restoration Program; Charlestown, RI. Developed content of an educational brochure concerning the removal of several acres of exotic common reed (*Phragmites australis*). Aquatic vegetation control is planned in order to remove exotic weeds, enhance wildlife habitat and maintain the recreational assets of West Pond.

- Jacobs Pond Estate Condominium Trust – Water Quality Impact Assessment; Jacobs Pond, Norwell, MA. Deployed seepage meters to estimate groundwater flow at four shoreline segments. Also extracted groundwater water quality samples with a Littoral Interstitial Porewater sampler. Pollutant concentrations for each shoreline segment were evaluated to identify areas contributing excessive levels of nutrients or bacteria.

- Town of Westford – Baseline Characterization, Drawdown Feasibility Assessment, and Long-term Monitoring Program for Nabnasset Lake, Westford, MA. Assisted with an aquatic plant survey of Nabnasset Lake. The purpose of this investigation was to monitor the impacts, if any, of annual winter lake drawdowns for the purpose of controlling nuisance aquatic plants.

- Confidential Client – Submarine Cable Installation; Lower Hudson River, NY and NJ. Identified and enumerated macroinvertebrates from 10 benthic samples collected in the lower Hudson River estuary. Summarized data in a report on baseline benthic resources in the Project area for Article VII submission.

- Aquarion Water Company — Midge Larvae Monitoring and Management Recommendations; Bucklin Point, East Providence, RI. Conducted an invertebrate monitoring effort in order to identify non-biting midge larvae "hot spots" in the mud flats of the area of concern. Monitoring involved sampling set locations within the mud flats several times throughout the season for midge larvae. The focus of this study was to develop site-specific management recommendations and assist the Narragansett Bay Commission with community outreach activities.

- Massachusetts Department of Conservation and Recreation – Ponkapoag Golf Course, Water Supply Development and Ecological Monitoring; Canton, MA. Conducts biological surveys for several state-listed butterflies, damselflies and dragonflies. Monitors water levels in Ponkapoag Pond and Bog in compliance with an Order of Conditions and Water Level Monitoring Plan issued by the Canton Conservation Commission. These efforts are conducted to preserve the fragile ecosystem of an Atlantic white cedar/emergent/scrub-shrub wetland.

- United States Navy – Storm Water Drainage Map Updates; Naval Station Newport, RI. Performed field verification of storm water structures using a GPS unit with sub-meter accuracy. Coordinated the incorporation of these field-verified updates into Computer-aided Design (CAD) files of the overall storm water drainage plan for Naval Station Newport. Also contributed to drafting of the final report.

- City of New Haven – Monitoring Report Review for Water Diversion from the Mill River; New Haven, CT. Project manager for third party review of annual environmental monitoring reports concerning the Lake Whitney Water Treatment Plant. Meets with members of the Environmental Study Team to evaluate the monitoring program on an annual basis. The reports generated by the monitoring program focus largely on the aquatic macroinvertebrate community and are prepared by an environmental study team contracted to the South Central Connecticut Regional Water Authority to monitor the impacts associated with the withdrawal of up to 15 million gallons per day of water from Lake Whitney. The area of evaluation includes the Mill River system below Eli Whitney Dam, much of which flows through East Rock Park, a significant resource located in an urbanized area of New Haven. The third party evaluation was prompted in response to concern by the City of New Haven and members of the community over decreased flows and reduced water quality in Mill River below the Eli Whitney Dam.

- United States Navy – Illicit Discharge Tracking; Naval Station Newport, RI. As part of the illicit discharge tracking and elimination program, conducted GPS-aided field tracking of dry-weather flow from storm water outfalls within the Station boundaries. Supported the project with GIS storm water feature mapping, outfall sampling and report writing. Additionally, helped coordinate updates to the overall storm drainage system map for the Station. Illicit discharge detection was completed as part of Naval Station Newport's Phase II Storm Water Management Plan (SWMP) in order to comply with the Rhode Island Pollution Discharge Elimination System (RIPDES) regulations as required by the Environmental Protection Agency (EPA) under the Clean Water Act.

- Rhode Island Department of Environmental Management (RIDEM) - Statewide Biomonitoring and Habitat Assessment of Rhode Island's Wadeable Streams. Responsible for the annual collection and identification of macroinvertebrates from 50 sites across the state of Rhode Island. Analyzes the habitat, water quality and macroinvertebrate community data and summarizes the results in report form for submission to the U.S. Environmental Protection Agency as part of Rhode Island's 305(b) reporting requirements. Additionally, participated in an August 2007 review of Rhode Island's stream biomonitoring program. The purpose of this multi-year program is to provide RIDEM with benthic macroinvertebrate and stream habitat data from selected streams within the state's two main eco-regions. The biological data collected are being used to provide a greater understanding of the relationship between the macroinvertebrate community and stream habitat.

- Massachusetts Executive Office of Environmental Affairs - Statewide Water Budgets & Report Development Project; MA. Prepared GIS figures for towns within various watersheds and assisted with report discussions of wastewater recharge and water transfers. The purpose of the project is to evaluate potential human impacts on stream flow. The water budget model accounts for regulated human derived water inputs and outputs as well as irrigation loses and total recharge loss from impervious area. Data are analyzed at the sub-basin level (HUC-14) on a monthly basis. Results are calculated on a seasonal basis (Summer/Winter).

- Town of Brookfield - Watershed Nonpoint Source Assessment; Brookfield, MA. Assisted with collection of discharge and water quality data at targeted sites throughout the Quabog Pond watershed. The results of the monitoring and watershed assessment were used to design and implement Best Management Practices (BMPs) to address non-point source pollution in Quaboag Pond.

- Winchester Country Club (WCC) - Stream Biomonitoring; Winchester, MA. Completed all macroinvertebrate identification, statistical analysis and report writing for the monitoring of Herbert Meyer Brook following completion of an irrigation improvement project in 2003. Compared a stream reach within the zone of potential impact to a control reach upstream. Also compared these data to baseline data collected prior to construction and operation of the small well supplying water for irrigation. No significant impacts of well operation to the stream biota were identified.

- Gomez and Sullivan - Housatonic River Freshwater Mussel Survey; Glendale Power Station, Stockbridge, MA. Assisted with a field survey for mussels in the bypass channel of a hydro power station on the Housatonic River. In addition, was responsible for filing a Rare Animal Observation Form with the Massachusetts Natural Heritage and Endangered Species Program when evidence of a state-listed mussel species was found in the channel. Summarized the findings of the survey in a report to the client for compliance with Federal Energy Regulatory Commission (FERC) relicensing procedures.

- Gomez and Sullivan - Housatonic River Freshwater Mussel Survey; South Lee, MA. Assisted with a field survey for mussels in the bypass channel of a hydro-powered paper mill on the Housatonic River. No rare or endangered mussels were found in the initial survey. Summarized the findings of the survey in a report to the client.

- ARCADIS, Inc. - Wetland Biomonitoring; Staten Island, NY. Responsible for project management, macroinvertebrate taxonomy and reporting of samples collected annually from a landfill wetland.

- Vespera, Inc. - Darrow Pond Baseline Assessment, Nutrient Modeling and Long-Term Management Plan; East Lyme, CT. Collected baseline water quality data on Darrow Pond and assisted with technical writing for the diagnostic and feasibility study and data reports

- University of Michigan, School of Natural Resources and Environment – Study of Disturbance and its Effects on *Glossosoma* and the Structure of Macroinvertebrate Communities in Coldwater Streams; ME and MI. Assisted with the sorting, identification and enumeration of quantitative macroinvertebrate samples taken over several years from multiple coldwater streams in Maine and Michigan. These efforts are part of an ongoing study to investigate community dynamics related to pathogen-induced disturbance in streams dominated by the caddisfly genus *Glossosoma*.

- University of Michigan, School of Natural Resources and Environment - Muskegon River Habitat Mapping and Hydraulic Modeling; MI. Instrumental in the execution of all stages of a major river habitat mapping and modeling project, including the collection of field data, development of GIS maps, and hydraulic modeling (using HEC-RAS and HEC-GeoRAS modeling software). These accomplishments allowed other researchers to couple fish and invertebrate models with six years of modeled hydraulic output.

- University of Michigan, School of Natural Resources and Environment - Estimation of Sediment Transport Rates on the Lower Muskegon River; MI. Collaborated with state agencies and citizen groups to complete a sediment transport study on the lower Muskegon River and three major tributaries. Spearheaded organization and execution of field sampling campaigns, lab processing and data analysis. Developed a model of annual suspended sediment and bedload transport rates across the sub-watershed.

- University of Michigan, School of Natural Resources and Environment - Quantitative Assessments of Fish and Invertebrate Communities in the Muskegon River Watershed; MI. As an integral member of a multidisciplinary team, collected and processed hydrologic, geomorphic, chemical and biological data on wadeable tributaries and navigable segments of the Muskegon River in Michigan. In addition to operating portable and boat-mounted electrofishing equipment, helped deploy minnow traps, fyke nets and a smolt trap to estimate fish abundance and migration. Deployed standard quantitative sampling equipment (including zooplankton tow nets, Hess samplers and Ponar grab samplers) to estimate abundance and biomass of macroinvertebrates and flux of larval fish and zooplankton. Provided taxonomic identification of fish and macroinvertebrates in the field as a regular part of this work.

- US Geological Survey - Coastal Freshwater Wetland Management Study; Ottawa National Wildlife Refuge, OH. Conducted fieldwork on the Crane Creek/Lake Erie wetlands of the Ottawa National Wildlife Refuge. As part of this project, operated towed barge and small watercraft electrofishing units to help characterize the seasonal movements of fish in the freshwater estuary system. Surveyed diked pools and unmanaged wetlands using a laserplane and survey-grade GPS unit.

PROFESSIONAL REGISTRATIONS AND AFFILIATIONS

- North American Benthological Society: Level II Ephemeroptera, Plecoptera and Trichoptera (EPT) Certified Macroinvertebrate Taxonomist for Eastern North America
- Coastal and Estuarine Research Federation
- Rhode Island Natural History Survey

PRESENTATIONS

- Ladewig, M.D. and C.D. Nielsen. The Ups and Downs of Winter Lake Drawdown as Part of a Long-term Invasive Weed Control Program in a Massachusetts Lake. New England Association of Environmental Biologists 34th Annual Meeting. March 2010. Newport, RI.

- Nielsen, C.D. and M.D. Ladewig. Boating Channel Pilot Study: Feasibility versus Acceptance. North American Lake Management Society 29th Annual Symposium. November 2009. Hartford, CT.

- Nielsen, C.D. and M.D. Ladewig. Got Swarms? Successful Management of the Non-biting Midge Population in Seekonk River, Rhode Island. Estuarine Research Federation 2007 Conference, November 2007. Providence, RI.

- Ladewig, M.D. and C.D. Nielsen. The Benefits of Biomonitoring for Watershed Assessment. Charles River Watershed Association. June 2007. Weston, MA.

- Riseng, C.M., M.J. Wiley, B. Sparks-Jackson, M. Ladewig and S.R. David. Assessment of the Interacting Effects of Channel Unit Substrate and Hydraulics on Benthic Standing Stock in the Lower Muskegon River, Michigan. North American Benthological Society 53rd Annual Meeting, June 2006. Anchorage, AK.

- Ladewig, M.D. and M.J. Wiley. Estimation of Sediment Transport Rates in the Lower Muskegon River, Michigan. 48th Annual Conference of the International Association for Great Lakes Research, May 2005. Ann Arbor, MI.

MARC D. BELLAUD
Senior Aquatic Biologist

PROFESSIONAL HISTORY

Aquatic Control Technology, Inc. - 16 years with firm
New Hampshire Wildlife Federation
Science Center of New Hampshire

EDUCATION

University of Vermont
B.S. in Biological Sciences 1992

PROFESSIONAL REGISTRATIONS & AFFILIATIONS

NEAPMS – Northeast Aquatic Plant Management Society; Immediate Past-President, President 2008, VP/President Elect 2007, Director 2004-2006
NALMS – North American Lake Management Society
APMS – Aquatic Plant Management Society
NEAEB – New England Association of Environmental Biologists
NYSAMA – New York State Aquatic Managers Association; current Director
Commercially Certified Aquatic Pesticide Applicator – CT, MA, NH, NY, RI & VT

TECHNICAL SPECIALTIES / FIRM RESPONSIBILITIES

- Lake and Watershed Assessment Studies
  - Baseline Biological Surveys and Aquatic Vegetation Mapping
  - Preparing Aquatic Vegetation Management Plans
  - Water Quality Monitoring
  - Limnological Investigations
  - Limited Dredging and Drawdown Feasibility Studies
  - Algal Identification and Enumeration Studies
- Account Manager for Vermont, New Hampshire, New York and Rhode Island Contracts
- Permitting and Compliance Reporting for all Pond/Lake/Wetland Restoration Projects at Local, State and Federal Levels
- GPS and GIS Coordinator
- Supervisory Chemical Applicator
- Business Development

REPRESENTATIVE PROJECT EXPERIENCE

- Saratoga Lake – Saratoga Springs, NY – developed and performed demonstration Sonar herbicide treatments in 2000 and 2003. Utilized GPS and GIS technology to provide real-time navigation with sub-meter accuracy. Performed detailed aquatic plant surveys in treatment plots. Prepared Long-Term Aquatic Vegetation Management Plan and initiated 3-year plan to selectively treat Eurasian watermilfoil beds lake-wide in 2007 Sonar herbicide applied in 2007 and Renovate OTF herbicide applied in 2008. ACT 2000-2008.

- Mount Auburn Cemetery – Watertown/Cambridge, MA – performed limited dredging feasibility studies of three ponds. Permitted and served as project manager for a dry-dredging project of one pond in 1998 and a hydraulic dredging operation and major wetland replanting effort on second pond in 1999. Coordinating annual water quality monitoring and restoration program. Developed alum treatment program to maintain desirable water clarity. ACT 1997-2008.

- Twin Lakes – Salisbury, CT – performed aquatic vegetation survey in 1999. Developed 2001 Sonar herbicide treatment program in West Twin Lake and 2003-2008 Reward herbicide treatment program in the Twin Lakes system. Completed comprehensive aquatic plant surveys and water quality monitoring. ACT 1999-2008.
- Lake Morey – Fairlee – conducted comprehensive aquatic plant survey in 2006 and developed Long-Term Integrated Milfoil Management Plan. Performed Renovate OTF and Renovate 3 treatment program in 2007 and Renovate OTF treatment in 2008. ACT 2006-2008.
- Congamond Lake – Southwick, MA & West Suffield, CT – developed Sonar herbicide treatment program to control non-native Eurasian watermilfoil growth in 2001, and completed comprehensive pre and post-treatment vegetation monitoring program and coordinated subsequent non-native aquatic plant control efforts with Reward herbicide. ACT 2000-2008.
- Charles River Lakes District – Newton & Waltham, MA – assisted with fieldwork and preparation of a Survey of the Aquatic Plant Community. ACT & Fugro 1994. Served as project manager for water chestnut removal program. ACT 1995-2002.
- Onota Lake – Pittsfield, MA – developed Sonar herbicide treatment program to control non-native Eurasian watermilfoil growth in 1999, and completed comprehensive pre and post-treatment vegetation monitoring program and coordinated subsequent milfoil control efforts. ACT 1999-2002.
- Pachaug Pond – Griswold, CT – performed fieldwork and prepared report for the Development of an Aquatic Vegetation Management Plan. Project partially funded by CT DEP. ACT 1999-2002.
- Briggs Marsh – Little Compton, RI – designed and permitting herbicide application program to control *Phragmites australis* growth in a salt marsh and initiated a restoration plan. ACT 1996-2007.

GUEST LECTURES

- North American Lake Management Society (NALMS)
- Northeast Aquatic Plant Management Society (NEAPMS)
- Massachusetts Association of Conservation Commissions (MACC and LAPA West)
- Massachusetts Congress of Lakes and Ponds, Inc. (COLAP)
- New York Federation of Lake Associations (FOLA)
- Connecticut Federation of Lake Associations
- Cornell Cooperative Extension Marine Program
- Putnam County, NY Water Quality Strategy Committee
- New London County, CT Soil & Water Conservation District
- New Canaan, CT Environmental Commission
- UMass Cranberry Station

Michael C. Lennon
Aquatic Biologist

PROFESSIONAL HISTORY

Aquatic Control Technology, Inc. - 6 years with firm
SePro Corporation
Cascadia Consulting Group
MA Department of Environmental Protection

EDUCATION

Bates College
B.A. in Environmental Studies 2000

PROFESSIONAL REGISTRATIONS & AFFILIATIONS

NEAPMS – Northeast Aquatic Plant Management Society
NALMS – North American Lake Management Society
Commercially Certified Aquatic Pesticide Applicator – CT, MA & NH

TECHNICAL SPECIALTIES / FIRM RESPONSIBILITIES

- Lake and Watershed Assessment Studies
  - Baseline Biological Surveys and Aquatic Vegetation Mapping
  - Preparing Aquatic Vegetation Management Plans
  - Water Quality Monitoring
  - Limnological Investigations
  - Limited Dredging and Drawdown Feasibility Studies
  - Algal Identification and Enumeration Studies
  - Zooplankton Identification and Enumeration Studies
- Account Manager for Massachusetts, New York, Connecticut and Rhode Island Projects
- Permitting and Compliance Reporting for Pond/Lake/Wetland Restoration Projects at Local and State Levels
- GPS and GIS Coordinator
- Chemical Applicator

REPRESENTATIVE PROJECT EXPERIENCE

- Neponset Reservoir – Foxborough, MA – Comprehensive aquatic plant surveys and water quality monitoring, algal enumeration and zooplankton analysis, in cooperation with ENSR-AECOM – 2007-2010
- Golden Hills – Saugus, MA – Developed and implemented Non-Native Plant Management Plan for three recreational waterbodies in the Golden Hill Area of Critical Environmental Concern (ACEC).
- Shelter Harbor Golf Club – Conducted comprehensive water quality monitoring, algal enumeration and zooplankton analysis - 2005-2009.

- Developed and conducted Comprehensive Data Point Intercept Surveys on eight Open Water Reservoirs for Massachusetts Water Resources Authority (MWRA) 2006 & 2007. (Chestnut Hill Reservoir, Fells Reservoir, Framingham Reservoir, Norumbega Reservoir, Spot Pond, Sudbury Reservoir & Weston Reservoir)
- Twin Lakes – Salisbury, CT – Completed comprehensive aquatic plant surveys and water quality monitoring, algal enumeration and zooplankton analysis - 2004-2010.
- Congamond Lake – Southwick, MA & West Suffield, CT – Completed comprehensive pre and post-treatment vegetation monitoring program and coordinated subsequent non-native aquatic plant control efforts with Reward herbicide. 2005-2010.
- Melrose, MA - Conducted annual water quality and vegetation monitoring for Ell Pond, Swains Pond and Towners Pond 2004-2009.

APPENDIX A
Contractor Employee Responsibility by Task

Task	Assigned Employee(s)/Title(s)
I: Develop QAPP	Carl Nielsen, Matt Ladewig, Dan Herzlinger, Matt Fuller
II: Meetings	Carl Nielsen, Dan Herzlinger, Matt Ladewig, Marc Bellaud, Michael Lennon
III: Develop Watershed Management Report for Pond Based on Existing Data	Carl Nielsen, Matt Ladewig, Jeff Hershberger, Darrel Oakley, Janet Bernardo, Dan Herzlinger
IV: Document Nutrient Loading in Watershed	Carl Nielsen, Matt Ladewig, Dan Herzlinger, Greg Rowe, Matt Fuller, Glendon Barnes, Jeff Hershberger
V: Document Sediment Loading in Watershed	Carl Nielsen, Matt Ladewig, Dan Herzlinger, Greg Rowe, Matt Fuller, Glendon Barnes, Jeff Hershberger
VI: Point Source Discharge	Carl Nielsen, Matt Ladewig, Dan Herzlinger, Greg Rowe, Matt Fuller, Glendon Barnes, Janet Bernardo
VII: Bathymetric Survey	Carl Nielsen, Matt Ladewig, Dan Herzlinger, Greg Rowe, Matt Fuller, Glendon Barnes
VIII: Sediment Sampling	Carl Nielsen, Matt Ladewig, Dan Herzlinger, Matt Fuller, Glendon Barnes
IX: Assess Biological Resources	Carl Nielsen, Matt Ladewig, Dan Herzlinger, Matt Fuller, Glendon Barnes, Darrell Oakley
X: Identify Recreational Resources	Carl Nielsen, Matt Ladewig, Dan Herzlinger, Payson Whitney
XI: Short and Long-Term Recommendations	Carl Nielsen, Matt Ladewig, Dan Herzlinger, Matt Fuller, Glendon Barnes, Payson Whitney, Darrell Oakley, Jeff Hershberger
XII: Watershed Management Plan	Carl Nielsen, Matt Ladewig, Dan Herzlinger, Matt Fuller, Glendon Barnes, Payson Whitney, Darrell Oakley, Jeff Hershberger

Appendix B

ESS Standard Operating Guidelines

ESS Group, Inc.

ESS GROUP, INC. STANDARD OPERATING GUIDELINES
FOR THE CREATION OF A BATHYMETRY MAP

1.0 INTRODUCTION

1.1 Purpose and Applicability

This Standard Operating Guideline (SOG) provides basic instructions for the mapping of depth contours within standing waterbodies. The methods outlined below are intended (1) to standardize depth measurement techniques used by ESS Group field personnel; (2) to standardize the recording of depth measurements to ensure the creation of an accurate bathymetry map.

2.0 RESPONSIBILITIES

2.1 Project Manager

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.

2.2 Field Personnel

The field personnel are responsible for taking accurate depth measurements at documented locations throughout the waterbody. The field personnel are also responsible for recording the number of depth measurements that will best characterize the bathymetric contours of the waterbody, i.e. steep contour areas with coves will be more thoroughly characterized than shallow contour areas with no coves.

3.0 REQUIRED MATERIALS

The following materials are necessary for the creation of a bathymetry map:

- Boat
- Depth Probe
- Measuring Pole 10ft in length. Marked off in 1ft increments
- Enlarged outline of the waterbody on write-in-the-rain paper
- Global Positioning System (GPS) unit (optional)
- Field note book
- Historical bathymetric maps for the waterbody (optional)

4.0 METHOD

4.1 Depth Measurement Procedure

- A number of transects will be drawn on the map of the waterbody to act as a guide in the collection of depth measurements. The number and location of transects selected will depend on the size and shape of the waterbody, with the aim of thoroughly characterizing the bathymetric contours within it. Historical bathymetric maps can be used (if available) to guide in the selection of transect locations so that areas requiring more thorough characterization can be identified.

- The boat will be driven along each transect, at appropriately spaced points along the transect the boat will be stopped and a measure of the depth of the water at that point will be recorded.

- The number of depth measurement points will depend on the rate of change in depth as the boat is moved along each transect, i.e. the steeper the slope of the waterbody bottom, the more depth measurements will be taken in order to illustrate incremental changes in depth (i.e. 1ft, 2ft or 5ft increments).

- Each depth measurement point along the transect will be numbered and marked onto the map in order to later link depth data with location information. Locations may be estimated based on landmarks and shoreline morphometry or more precisely mapped using a Global Positioning Systems (GPS). The depth at each point will also be noted with its associated transect and point number in the field note book.

- At each measurement point when the depth is 10ft or less, a measuring pole will be used to measure the exact depth of the water in feet. At depths greater than 10ft a sonar depth probe will be used. This approach minimizes the possibility of plant growth interfering with sonar measurements.

4.2 Creation of Bathymetry Maps

- In the office, depth measurements recorded from throughout the waterbody will be linked with the transects and measurement point locations drawn onto the outline map.

- The known depths at known locations throughout the water body will then be used as a guide (or base) for the drawing of contour lines onto the outline map, thus illustrating incremental changes in water depth either in 1ft, 2ft or 5ft increments depending on the overall depth of the water body.

5.0 QUALITY CONTROL

At each depth measurement point, no matter which depth equipment is being used, a couple of measurements will be taken in very close proximity to each other to make sure the readings are the same, in case of rocks, plants, or other obstacles on the bottom are affecting the measurement at one specific point. In instances where the measurements are slightly different, the average depth will be recorded.

6.0 DOCUMENTATION

Depth measurements will be recorded in field note books associated with location information in the form of transect numbers and depth measurements points, by ESS personnel. The locations of transect lines and depth measurement points will be recorded on a write-in-the-rain map outline of the waterbody. Any unanticipated site specific information, which requires ESS field personnel to deviate from the above SOG will be reported in an ESS field notebook. Documentation for recorded data must include a minimum of the following:

- Date of survey
- Weather conditions
- Signature or initials of person performing the survey
- Depth measurement point locations
- Comments/Observations

7.0 TRAINING/QUALIFICATIONS

To properly complete an assessment of depth contours within a waterbody, the analyst must be familiar with the measurement and data collection protocols as stated within this SOG and must have confidence in the use of depth measurement equipment.

ESS Group, Inc.

ESS GROUP, INC. STANDARD OPERATING GUIDELINES
FOR MEASUREMENT OF SPECIFIC CONDUCTANCE

1.0 INTRODUCTION

1.1 Purpose and Applicability

These Standard Operating Guidelines (SOG) provide basic instructions for routine calibration and operation of a variety of specific conductance meters. Although this meter measures additional parameters (e.g., temperature, TDS), this SOG addresses specific conductance measurement only (other capabilities are outlined in the appropriate SOG and manufacturer's individual instrument manuals). This SOG is designed specifically for the measurement of specific conductance in accordance with EPA Method 120.1 and Standard Method 2510 B which address specific conductance measurements of drinking, surface, and saline waters, domestic and industrial wastes, and acid rain.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) or laboratory Quality Assurance Manual (OAM) and may include duplicate or replicate measurements or confirmatory analyses.

2.0 RESPONSIBILITIES

The analyst is responsible for verifying that the specific conductance meter is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOG and the project plan.

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.

3.0 REQUIRED MATERIALS

The following materials are necessary for this procedure:

- Specific conductance meter
- Specific conductance meter manufacturer's instruction manual
- Deionized water
- KCI standard at concentration that approximates sample concentrations
- Lint-free tissues
- National Institute of Standards and Technology (NIST)-traceable thermometer
- Calibration sheets or logbook

- Laboratory or field data sheets or logbooks

4.0 METHOD

4.1 Sample Handling, Preservation, and General Measurement Procedures

- Specific conductance measurements should be taken soon after sample collection since temperature changes, precipitation reactions, and absorption of carbon from the air can affect the specific conductance. If specific conductance measurements cannot be taken immediately (within 24 hours), samples should be filtered through a 0.45 μm filter, stored at 4°C and analyzed within 28 days.

- Report results as specific conductance, μmhos/cm at 25°C.

- As temperature can affect the specific conductance measurements obtained, record both the specific conductance and the temperature of the sample. The Cole-Parmer Portable Conductivity Meter and YSI Model 55 has the ability to compensate for temperature.

- Secondary standards may be purchased as a solution from commercial vendors. These standards should not be used after their expiration dates as provided by the manufacturer. An expiration date of one year should be used if the manufacturer does not supply an expiration date or if the standards are prepared from various salts (e.g., KCI).

4.2 Calibration and Measurement Procedures

- The specific conductance meter must be calibrated daily (or the calibration checked) before any analyses are performed.

- Set up the instrument according to the manufacturer's instructions.

- Rinse the probe with deionized water and dry with a lint-free tissue.

- Dip the probe into the calibration standard. Immerse the probe tip beyond the upper steel band. Stir the probe gently to create a homogenous sample.

- Record the stabilized specific conductance reading of the standard and the temperature. Enter the calibration mode (according to manufacturer's instructions) and change the value on the primary display to match the value of the calibration standard. The meter can be adjusted to ± 20% from the default setting. If the measurement differs by more than ± 20%, the probe should be cleaned or replaced as needed. If the meter does not have automatic temperature compensation (ATC), correct all measurements to 25°C by adding 2% of the reading per degree if the temperature is below 25°C or by subtracting 2% of the reading per degree if the temperature is above 25°C.

- An additional check may be performed, if required by the project plan, by placing the probe into an additional KCI standard. This standard should be from a different source than the standard used for the initial calibration. This standard should read within 5% of the true value.

- Verify the calibration every 15 samples and at the end of the day. Recalibrate or replace the instrument if the check value is not within 15% of the true value.
- The probe will be rinsed with deionized water and wiped gently with a lint-free tissue between sample analyses.
- The meter must be recalibrated following any maintenance activities and prior to the next use.
- Conductivity data may be post calibrated using any of a variety of calibration data including, but not limited to field calibration points, manufacturer calibration data, and analytical results from samples collected during field deployment of the sensors. The decision criteria for post calibration, and the technique used will be specified in the project plan, and will be consistent with the manufacturer's recommendations.

4.3 Troubleshooting Information

If there are any performance problems with any of the specific conductance meters which result in inability to achieve the acceptance criteria presented in Section 5.0, consult the appropriate section of the meter instruction manual for the checkout and self-test procedures. If the problem persists, consult the manufacturer's customer service department immediately for further instructions.

4.4 Maintenance

- Instrument maintenance should be performed according to the procedures and frequencies required by the manufacturer.
- The probe must be stored and maintained according to the manufacturer's instructions.
- If an instrument with ATC is being used, the meter should be checked annually for accuracy with an NIST thermometer.

5.0 QUALITY CONTROL

- The meter must be calibrated daily before sampling and recalibrated every 12 hours, and will not be used for sample determinations of specific conductance unless the initial check standard value is within 5% of the true value.
- Duplicate measurements of a single sample will be performed at the frequency specified in the project plan. In the absence of project-specific criteria, duplicate measurements should agree within 10%.
- The temperature readout of the meter will be checked against an NIST traceable thermometer at least quarterly. If the difference is greater than 0.2°C, the instrument manufacturer will be consulted for instructions. Temperature measurements will be compensated for any difference with the reference thermometer.
- Some agencies may require the analysis of USEPA Water Pollution (WP) performance evaluation samples. These performance evaluation samples will be analyzed as required.

6.0 DOCUMENTATION

- All specific conductance meter calibration, temperature check, and maintenance information will be recorded on the daily calibration sheet (an example is presented as Figure 1). Specific conductivity data may be recorded on the appropriate laboratory or field data sheets or logbooks.
- Calibration documentation must be maintained in a thorough and consistent manner. At a minimum, the following information must be recorded:
    - Date and time of calibration
    - Signature or initials of person performing the measurement
    - Instrument identification number/model
    - Expiration dates and batch numbers for all standards
    - Reading for standard before and after meter adjustment
    - Readings for all continuing calibration checks
    - Temperature of standards (corrected for any difference with reference thermometer)
    - Comments
- Documentation for recorded data must include a minimum of the following:
    - Date and time of analysis
    - Signature or initials of person performing the measurement
    - Instrument identification number/model
    - Sample identification/station location
    - Temperature (corrected for any difference with reference thermometer) and conductance of sample (including units and duplicate measurements) Note: show all calculations for converting instrument reading to μmhos/cm if the instrument provides readings in any other units. Useful conversions are: 1 mS/m = 10 μmho/cm or 1 μmho/cm = 0.1 mS/m.
    - Comments

7.0 TRAINING/QUALIFICATIONS

To properly perform specific conductance measurements, the analyst must be familiar with the calibration and measurement techniques stated in this SOG. The analyst must also be experienced in the operation of the meter.

Certain state certification programs require that specific conductance measurements be taken in the field by, or in the presence of, personnel that are qualified under the certification program.

8.0 REFERENCES

Standard Methods for the Examination of Water and Wastewater, 17th Edition, 1989.

Methods for the Chemical Analysis of Water and Wastes, EPA 600/4-79-020, Revised 1983.

ESS GROUP, INC. STANDARD OPERATING GUIDELINES
FOR MEASUREMENT OF DISSOLVED OXYGEN

1.0 INTRODUCTION

1.1 Purpose and Applicability

These Standard Operating Guidelines (SOG) provide basic instructions for routine measurement of dissolved oxygen using a polarographic sensor equipped dissolved oxygen meter with a digital read-out such as the YSI Model 55 Handheld Dissolved Oxygen System. Measurements are made in accordance with EPA Standard Methods that addresses dissolved oxygen measurement of drinking, surface, and saline waters, and domestic and industrial wastes.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) or laboratory Quality Assurance Manual (QAM) and may include duplicate or replicate measurements or confirmatory measurements.

2.0 RESPONSIBILITIES

The analyst is responsible for verifying that the dissolved oxygen measuring device is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOG and the project plan.

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.

3.0 REQUIRED MATERIALS

The following materials are necessary for this procedure:

- Dissolved oxygen meter with digital read-out device
- Manufacturer's instruction manual for the instrument
- YSI Model 5775 Standard Membrane Kit with KCl solution and O-rings
- NIST-traceable thermometer
- Laboratory or field data sheets or logbooks

4.0 METHOD

4.1 Sample Handling, Preservation, and General Measurement Procedures

To achieve accurate dissolved oxygen measurements, samples should be analyzed *in situ*. Measurements in flowing waters should be made in relatively turbulent free areas. Measurements in standing waters will require probe agitation to create water movement around the probe.

4.2 Calibration and Measurement Procedures

To accurately calibrate the YSI Model 55, you will need to know the approximate altitude of the region in which you are located and the approximate salinity of the water you will be analyzing. Fresh water has a salinity of approximately zero. Seawater has an approximate salinity of 35 parts per thousand (ppt). If uncertain, measure salinity with an appropriate device.

- Ensure that the sponge inside the instrument's calibration chamber is wet then insert the probe into the chamber. Turn the instrument on and wait for readings to stabilize (approximately 15 minutes).
- To calibrate, enter the calibration menu by pressing and releasing both the up and down arrow keys at the same time. Enter the altitude (in hundreds of feet) at the prompt by using the arrow keys to increase or decrease the altitude (example: 12 = 1,200 feet). Press enter when correct altitude is shown.
- The meter should display CAL in the lower left of the display with the calibration value in the lower right of the display and the current D.O. reading (before calibration) should be on the main display. Once the D.O. reading is stable, press ENTER. Enter the salinity at the prompt by using the arrow keys. Press ENTER when finished and the instrument will return to normal operation.
- Calibration should be performed at a temperature within ± 10°C of the sample temperature. Verify the calibration every 15 samples and at the end of the day.
- If erratic readings occur, replace membrane as per the manufacturer's manual. The average replacement interval is two to four weeks.
- Replace the membrane as per the manufacturer's manual if bubbles appear (>1/8 inch diameter), or if the membrane becomes damaged, wrinkled, or fouled.
- Avoid contact with any environment which contains substances that may attack the probe materials (e.g. acids, caustics, and strong solvents).
- The meter must be re-calibrated following any maintenance activities and prior to the next use.

4.3 Troubleshooting Information

If there are any performance problems with the dissolved oxygen-measuring device, consult the appropriate section of the instruction manual for the checkout and self-test procedures. If the problem persists, consult the manufacturer's customer service department immediately for further instructions.

4.4 Maintenance

Instrument maintenance for meter-type dissolved oxygen measuring devices should be performed according to the procedures and frequencies required by the manufacturer.

5.0 QUALITY CONTROL

Duplicate measurements of a single sample will be performed at the frequency specified in the project plan. In the absence of project-specific criteria, duplicate measurements should agree within ± 0.2 mg/L.

The temperature readout of the meter will be checked regularly (at least weekly) against a NIST-traceable thermometer. If the difference is greater than 0.5°C, the instrument manufacturer will be consulted for instructions. Temperature measurements will be compensated for any difference with the reference thermometer.

6.0 DOCUMENTATION

All dissolved oxygen meter calibration, checks, and maintenance information will be recorded on the daily calibration sheet or logbook. Dissolved oxygen data may be recorded on the appropriate laboratory or field data sheets or logbooks.

- Calibration documentation must be maintained in a thorough and consistent manner. At a minimum, the following information must be recorded:
  - Date and time of calibration
  - Signature or initials of person performing the measurement
  - Instrument identification number/model
  - Expiration dates and batch numbers for all standard solutions
  - Readings for all continuing calibration checks
  - Comments
- Documentation for recorded data must include a minimum of the following:
  - Date and time of analysis
  - Signature or initials of person performing the measurement
  - Instrument identification number/model
  - Sample identification/station location

- o Dissolved oxygen, both in mg/L and percent saturation (corrected for any difference with reference thermometer) and temperature of sample (including units and duplicate measurements)
- o Comments

7.0 TRAINING/QUALIFICATIONS

To properly perform dissolved oxygen measurements, the analyst must be familiar with the calibration and measurement techniques stated in this SOG. The analyst must also be experienced in the operation of the meter.

Certain state certification programs require that dissolved oxygen measurements in the field be taken by, or in the presence of, personnel that are qualified under the certification program.

8.0 REFERENCES

Standard Methods for the Examination of Water and Wastewater, 21st Edition, 2005.

Methods for the Chemical Analysis of Water and Wastes, EPA 600/4-79-020, Revised 1983.

ESS Group, Inc.

ESS GROUP, INC. STANDARD OPERATING GUIDELINES FOR MEASUREMENT OF FLOW RATE

1.0 INTRODUCTION

1.1 Purpose and Applicability

These Standard Operating Guidelines (SOG) provide basic instructions for routine measurement of flow rate in bodies of running water. The two techniques under consideration are the Time of Travel Method and the Global Flow Probe Procedure.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) or laboratory Quality Assurance Manual (QAM) and may include duplicate or replicate measurements or confirmatory measurements.

2.0 RESPONSIBILITIES

The analyst is responsible for verifying that the instrumentation is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOG and the project plan.

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.

3.0 REQUIRED MATERIALS

The following materials are necessary for the Global Flow Probe Procedure:

- Global Flow Probe FP101, Global Water, Gold River, CA
- LCD computer display
- Radio Shack 675 HP or equivalent batteries
- Manufacturer's instruction manual for the instrument
- Laboratory or field data sheets or logbooks

The following materials are necessary for the Time of Travel Method:

- A neutral buoyancy floating object, such as a cracked ping-pong ball
- Twine or other heavy-duty string material
- Water proof yard-stick to measure stream depth

- Stop-watch
- Permanent marker (e.g., sharpie)
- Laboratory or field data sheets or logbooks

4.0 METHOD

4.1 General Measurement Procedures For Global Flow Probe Procedure

To achieve accurate flow measurements samples must be analyzed in the field. Flow measurements may be taken in small and large streams, rivers and within pipes.

- The average velocity of stream flow multiplied by the cross-sectional area is equal to the flow rate (Q=VxA). The cross sectional area is determined manually by measuring the depth of the water at several points across the channel. The cross section in square feet times the average velocity in feet per second gives the cubic feet per second (c.f.s.).
- When sampling within round pipes, one needs only to measure the water depth and then refer to the tables in the Global Flow Probe Instruction Manual to determine the cross-sectional area.

4.2 Calibration and Measurement Procedures for Global Flow Probe Procedure

The Flow Probe is set up and calibrated at the factory. The calibration sequence is entered automatically when the batteries are changed or by holding down both Right and Left buttons simultaneously for 8 seconds. Calibration should be checked annually.

- To change between English and Metric units and to enter the calibration sequence, hold down both Left and Right buttons simultaneously for 8 seconds. The Left button scrolls between English “mi” and Metric “km”.
- To check the calibration push the Right button to “CAL”. For “mi” calibration set Probe calibration to 33.31. For “km” calibration set Probe calibration to 1603. The Left button increases the number when the arrow points up and decreases the number when the arrow points down.
- The Flow Probe computer has a simple 2 – button operation. The Right button changes between Function and the Left button picks the Option. Pushing both buttons simultaneously for 1 second zeros the displayed value.
- By pushing the Right button you may scroll through the following functions. Velocity Function: “V” is instantaneous velocity to the nearest 0.1 feet per second. Push the Left button to scroll between “AV” (average velocity) and “MX” (maximum velocity) which reads out to the nearest 0.01 feet per second. Stop Watch / Clock Function: Push the Left button to start and stop watch.
- Make sure the prop turns freely and point the prop directly into the flow with the arrow on the bottom of the probe pointing down-stream.

- Press the Right button until the “V” for velocity appears and select the desired velocity parameters to be measured by pushing the Left button. Average velocity readings “AV” must be collected for flow rate measurements (c.f.s.).
- Put the probe at your measuring point and press both Right and Left buttons simultaneously and release to re-zero and begin recording. Hold in the flow for several seconds until you have steady average velocity.
- When sampling in small streams and within pipes, the probe should be moved slowly and smoothly along a vertical plane throughout the flow to ensure that the probe evenly samples the cross-sectional area of the flow.
- When sampling larger streams and rivers divide the stream into subsections (e.g. 2-3 feet in width). At the center of each subsection, insert the probe and sample vertically from the surface to the bottom smoothly to obtain a vertical average velocity profile. The Average Velocity times the Area of the subsection is the Flow for the subsection. Add all the subsection flows to obtain the Total Stream Flow.
- Repeat procedure three times in at least three different locations, recording data in field notebook. The flow rate should be calculated as an average of the three measurements taken at different locations within the channel or pipe.
- Calculate discharge (Q) from the measured data, as follows:
    - Measure and calculate the cross-sectional area of your flow stream in square feet and multiply this by the average velocity in feet / second to obtain discharge in cubic feet per second (c.f.s.).
    - Cross-sectional area (ft^2) x AV (ft/sec) = Q (ft^3/sec)

<u>4.3 Calibration and Measurement Procedures for the Time of Travel Method</u>

- To measure travel time, the length of time taken for the floating object to travel 3 feet will be measured as follows:

1. Select an appropriate stream cross section with relatively uniform and uninterrupted flow
2. Securely attach 3 feet of string to floating object (i.e., cracked ping-pong ball)
3. Release floating object in the water and activate timer
4. Record time (T) from when the floating object is released to the time when the string goes taut, indicating that the object has traversed 3 feet
5. Repeat procedure three times at three different locations, recording data in a field notebook. The flow rate should be calculated as an average of the three measurements taken at

different locations within the stream channel. Flow rate = 3 feet/T (seconds) = X feet / second

6. Measure stream average width and average depth at sampling location

- Calculate discharge (Q) from the measured data, as follows:

1. Calculate cross-sectional area (A) of the stream, by multiplying average width and average depth

2. Select a coefficient or correction factor (C): 0.8 for rocky bottom streams, 0.9 for muddy bottom streams. The coefficient allows correction for the fact that water travels faster at the surface than at the stream bottom, due to resistance from bottom materials

3. $Q = \frac{A*C*L}{T}$ Where L= 3 feet and T= time of travel (seconds)

   Units of Q are typically cubic feet per second

4.4 Troubleshooting Information for Global Flow Probe Procedure

If there are any performance problems with the Global Flow Probe, consult the appropriate section of the instruction manual for the checkout and self-test procedures. If the problem persists, consult the manufacturer's customer service department at (916) 638-3429 immediately for further instructions.

4.5 Maintenance for Global Flow Probe Procedure

Instrument maintenance for the Global Flow Probe should be performed according to the procedures and frequencies required by the manufacturer.

5.0 QUALITY CONTROL

5.1 Quality Control for Global Flow Probe Procedure

The Global Flow Probe calibration should be checked annually to ensure that the Flow Probe is operating up to factory specifications.

5.2 Quality Control for the Time of Travel Method

To ensure a quality measurement, a minimum of three times of travel measurements will be obtained and recorded at each sampling point. An average value will be used to measure flow rate / discharge.

6.0 DOCUMENTATION

6.1 Documentation for Global Flow Probe Procedure

All Global Flow Probe calibration, checks, and maintenance information will be recorded on the daily calibration sheet or logbook. Flow data may be recorded on the appropriate laboratory or field data sheets or logbooks.

- Calibration documentation must be maintained in a thorough and consistent manner. At a minimum, the following information must be recorded:
    - Date and time of calibration
    - Signature or initials of person performing the measurement
    - Instrument identification number/model
    - Readings for all continuing calibration checks
    - Comments
- Documentation for recorded data must include a minimum of the following:
    - Date and time of analysis
    - Signature or initials of person performing the measurement
    - Instrument identification number/model
    - Sample identification/station location
    - Flow Rate in cubic feet per second (c.f.s.), average water velocity and maximum water velocity
    - Comments

6.2 Documentation for the Time of Travel Method

- All data will be recorded in a field logbook. Documentation for recorded data must include a minimum of the following:
    - Date, time and location of measurement
    - Time of travel and distance traveled
    - Comments, if any

7.0 TRAINING/QUALIFICATIONS

- To properly perform Global Flow Probe measurements, the analyst must be familiar with the calibration and measurement techniques stated in this SOG. The analyst must also be experienced in the operation of the meter.

  Certain state certification programs require that flow measurements in the field be taken by, or in the presence of, personnel that are qualified under the certification program.

- No special training is required to implement the Time of Travel Method; however, the analyst must be familiar with the calibration and measurement techniques stated in this SOG.

8.0 REFERENCES

Volunteer Stream Monitoring: A Methods Manual. EPA 841-B-97-003, November 1997.

Global Flow Probe Instruction Manual.

ESS Group, Inc.

ESS GROUP, INC. STANDARD OPERATING GUIDELINES FOR MEASUREMENT OF pH

1.0 INTRODUCTION

1.1 Purpose and Applicability

These Standard Operating Guidelines (SOG) provide basic instructions for routine calibration and operation of a variety of pH meters, including the YSI Model 55, Hydac Multimeter Probe and the pHep pH Testers. Although these meters may measure additional parameters (e.g., temperature, specific conductivity, etc.), this SOG addresses pH measurement only (other capabilities are outlined in the appropriate SOG and manufacturer's individual instrument manuals). This SOG is designed specifically for the measurement of pH in accordance with EPA Method 150.1 and Standard Method 4500-H B which address electrometric pH measurements of drinking, surface, and saline waters, domestic and industrial wastes, and acid rain.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) or laboratory Quality Assurance Manual (QAM) and may include duplicate or replicate measurements or confirmatory analyses.

2.0 RESPONSIBILITIES

The analyst is responsible for verifying that the pH meter is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOG and the project plan.

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.

3.0 REQUIRED MATERIALS

The following materials may be necessary for this procedure:

- pH meter
- pH meter manufacturer's instruction manual
- Deionized water
- 4.0, 7.0, and 10.0 buffer solutions
- Lint-free tissues
- Mild detergent

- 10% hydrochloric acid
- National Institute of Standards and Technology (NIST)-traceable thermometer
- Calibration sheets or logbook
- Laboratory or field data sheets or logbooks

4.0 METHOD

4.1 Sample Handling, Preservation, and General Measurement Procedures

- To achieve accurate pH measurements, samples should be analyzed in the field (preferably within 15 minutes), or as soon as possible after collection. Sample should be collected in plastic or glass containers.

- After measuring a sample containing oily material or particulate matter, the electrode must be cleaned by carefully wiping with a lint-free cloth, or washing gently in a mild detergent, followed by a deionized water rinse. If this does not suffice, an additional rinse with 10% hydrochloric acid (followed by deionized water) may be needed.

- As temperature can affect the pH measurements obtained, both the pH and the temperature of the sample must be recorded. Both the Hydac Multimeter and the pHep Tester that will be used in this study have the ability to compensate for temperature.

  Calibration must include a minimum of two points that bracket the expected pH of the samples to be measured. Calibration measurements must be recorded in logbook.

- Primary standard buffer salts available from NIST can be purchased and are necessary for situations where extreme accuracy is required. Secondary standard buffers may be purchased as a solution from commercial vendors and are recommended for routine use. Buffers should not be used after their expiration dates as provided by the manufacturer. An expiration date of one year should be used if the manufacturer does not supply an expiration date or if the buffers are prepared from pH powder pillows, etc.

- When using the meter in the laboratory, always place the buffer/sample beaker on the magnetic stirrer, and make sure the stirring bar is rotating during measurements. Rinse the stirring bar as well as the beaker between buffers/samples.

  EXCEPTION: Do not use the magnetic stirrer for acid rain samples. It is crucial not to induce dissolved gases into the sample to be absorbed or desorbed, as this will alter the pH. Stir the sample gently for a few seconds after introducing the electrode, then allow the electrode to equilibrate prior to recording temperature and pH readings.

- When the meter is being used in the field, move the probe in a way that creates sufficient sample movement across the sensor; this insures homogeneity of the sample and suspension of solids. If sufficient movement has occurred, the readings will not drift (<0.l pH units). Rinse the electrode with deionized water between samples and wipe gently with a lint-free tissue.

- When measuring the pH of hot liquids, wait for the liquid to cool to 160°F or below.
- Fluctuating readings may indicate more frequent instrument calibrations are necessary.

4.2 Calibration and Measurement Procedures

- The pH meter must be calibrated daily before any analyses are performed. The meter should be re-calibrated every 12 hours or at the frequency specified in the project plan.
- Connect the electrode to the meter. Choose either 7.0 and 10.0 (high range) or 4.0 and 7.0 (low range) buffers, whichever will bracket the expected sample range. Place the buffer in a clean glass beaker. If the pH is being measured in a laboratory, place the beaker on the magnetic stirrer and place the stirring bar in the beaker. Measure and record the temperatures of the buffers using a calibrated thermometer or automatic temperature compensation (ATC).
- Place the electrode into the 10.0 buffer or into the 7.0 buffer.
- Adjust the instrument calibration according to the manufacturer's instructions. Discard the buffer and rinse the beaker and stirring bar thoroughly with deionized water.
- Refill the beaker with the 7.0 buffer or the 4.0 buffer. Rinse the electrode, gently wipe with a lint-free tissue, and place it in the selected buffer solution. If the pH is being measured in a laboratory, place the beaker on the magnetic stirrer and place the stirring bar in the beaker. Continue adjusting the instrument calibration according to the manufacturer's instructions. Record the electrode slope (if provided by the instrument) on the calibration sheet (an acceptable slope is between 92 and 102 percent). Measure and record the temperature of the buffer using a calibrated thermometer or ATC. Discard the buffer and rinse the beaker and stirring bar thoroughly with deionized water.
- An additional check may be performed, if required by the project plan, by placing the electrode into an additional buffer solution. This buffer should be from a different source than the buffers used for the initial calibration. This buffer should read within +0.2 pH units of the buffer's true pH value.
- Verify the calibration every 15 samples and at the end of the day. Recalibrate the instrument if the check value varies more than 0.2 pH units from the true value.
- The electrode will be rinsed with deionized water and wiped gently with a lint-free tissue between sample analysis.
- Recalibrate the instrument if the buffers do not bracket the pH of the samples.
- The meter must be re-calibrated following any maintenance activities and prior to the next use.

4.3 Troubleshooting Information

If there are any performance problems with any of the pH meters which result in the inability to achieve the acceptance criteria presented in Section 5.0, consult the appropriate section of the meter instruction manual for the checkout and self-test procedures. If the problem persists, consult the manufacturer's customer service department immediately for further instructions.

4.4 Maintenance

- Instrument maintenance should be performed according to the procedures and frequencies required by the manufacturer.
- The electrode must be stored and maintained according to the manufacturer's instructions.
- If an instrument with ATC is being used, the device should be checked on a quarterly basis for accuracy with an NIST thermometer.

5.0 QUALITY CONTROL

- Duplicate measurements of a single sample will be performed at the frequency specified in the project plan. In the absence of project-specific criteria, duplicate measurements should agree within ±0.l pH units.
- The temperature readout of the meter will be checked annually against an NIST-traceable thermometer. If the difference is greater than 0.2°C, the instrument manufacturer will be consulted for instructions. Temperature measurements will be compensated for any difference with the reference thermometer.
- Some regulatory agencies may require the analysis of USEPA Water Supply (WS) or Water Pollution (WP) performance evaluation samples. These performance evaluation samples will be analyzed as required.

6.0 DOCUMENTATION

- All pH meter calibration, temperature check, and maintenance information will be recorded on the daily calibration sheet (Figure 1). pH data may be recorded on the appropriate laboratory or field data sheets or logbooks.
- Calibration documentation must be maintained in a thorough and consistent manner. At a minimum, the following information must be recorded:
    - Date and time of calibration
    - Signature or initials of person performing the measurement
    - Instrument identification number/model
    - Expiration dates and batch numbers for all buffer solutions

- Reading for pH 7.0 buffer before and after meter adjustment
- Reading for pH 4.0 or 10.0 buffer before and after meter adjustment
- Readings for all continuing calibration checks
- Temperature of buffers (corrected for any difference with reference thermometer), including units
- Comments

▪ Documentation for recorded data must include a minimum of the following:

- Date and time of analysis
- Signature or initials of person performing the measurement
- Instrument identification number/model
- Sample identification/station location
- Temperature (corrected for any difference with reference thermometer) and pH of sample (including units and duplicate measurements)
- Comments

7.0 TRAINING/QUALIFICATIONS

To properly perform pH measurements, the analyst must be familiar with the calibration and measurement techniques stated in this SOG. The analyst must also be experienced in the operation of the meter.

Certain state certification programs require that pH measurements in the field be taken by, or in the presence of, personnel that are qualified under the certification program.

8.0 REFERENCES

Standard Methods for the Examination of Water and Wastewater, 17th Edition, 1989.

Methods for the Chemical Analysis of Water and Wastes, EPA 600/4-79-020, Revised 1983.

ESS Group, Inc.

ESS GROUP, INC. STANDARD OPERATING GUIDELINES
FOR THE CREATION OF AN AQUATIC PLANT MAP

1.0 INTRODUCTION

1.1 Purpose and Applicability

This Standard Operating Guideline (SOG) provides basic instructions for the mapping of aquatic plants present within standing waterbodies. The methods outlined below are intended to, (1) standardize plant mapping techniques used by ESS Group, Inc. (ESS) field personnel; and (2) standardize recording of field data to assure the creation of an accurate plant map.

2.0 RESPONSIBILITIES

2.1 Project Manager

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the survey in accordance with this SOG and the project plan.

2.2 Field Personnel

The surveyors are responsible for identifying dominant aquatic plant beds within the waterbody, establishing the locations of the beds using GPS, noting the percentage of plant cover and biovolume throughout the waterbody, keeping a species list of all plants identified within the waterbody and collecting clearly marked samples of all those plants unidentifiable in the field.

3.0 REQUIRED MATERIALS

The following materials are necessary (unless otherwise noted) for the creation of a plant map:

- Boat
- Long handled grappling rake
- Throw grappling rake (for deeper waters)
- Aquascope
- Plant keys
- Enlarged outline of the waterbody on water resistant paper
- Water resistant field notebook
- Small see-through plastic bags
- Indelible marker
- Cooler

- Ice
- GPS unit (Trimble GeoExplorer 2005 series recommended)
- Underwater camera (Optional – useful in deeper waters)

4.0 METHOD

4.1 Aquatic Plant Survey and Sample Collection

A number of transects will be drawn on the map of the waterbody to act as a guide for the survey. The number and location of transects selected will depend on the size and shape of the waterbody, with the aim of thoroughly characterizing the plants within it.

The boat will be driven along each transect; at pre-determined points along each transect, anchor will be dropped and a detailed survey of the aquatic plants will be carried out in the immediate area. The number of points surveyed along each transect will depend on the bathymetry and plant diversity in the survey area, with the aim of characterizing changes in the composition, cover and biovolume of plant beds. Each point sampled along each transect will be numbered and recorded on the site map in order to link plant survey data with location information. Alternatively, records may be added electronically in the field, if this function is supported by the GPS unit used.

At each survey point a grappling rake will be used to sample aquatic plants from within the water column and the floor of the waterbody for closer identification.

Each plant present within each sample will be identified *in situ* (using keys if necessary) and recorded in the species list for the waterbody. The dominant plant at each transect point will be noted with its associated transect and point number in the field notebook.

If identification of certain plants is not possible in the field, a generous sample of these plants will be stored with a little water in a plastic bag clearly labeled with the associated transect and point number in indelible ink. All such sample bags will be stored in a cooler filled with ice to preserve the quality of the samples, and transported back to the lab for identification using a dissecting microscope, if necessary. Unknown plants will be assigned a code number (e.g. UK1) to use as species identification for future transects and sampling locations.

4.2 Assessment of Percentage Plant Cover and Percentage Plant Biomass

At each survey point ESS field personnel will use general observation as well as an Aquascope to estimate the percentage plant cover (i.e. the percentage of the bottom covered by plants, which is a factor of plant density). A simple code system will be used whereby percentage “ranges” are assigned an integer: i.e. 0 = 0%; 1 = 1%-25%; 2 = 26%-50%; 3 = 51%-75%; 4 = 76%-100%. At each survey point the estimation of plant cover will be recorded with the associated transect and point number in the field notebook. All estimations of plant cover and biomass are made by the same field personnel to ensure consistency.

In addition to plant cover, biovolume will be estimated by ESS field personnel at each survey point, using both general observation as well as an Aquascope (or underwater camera for deeper water). The percentage of biovolume represents that percentage of the water column that is occupied by plants; biovolume is a factor of water depth, plant height, and plant density. As noted above, a simple code system will be used to assign integers as estimations of percent biovolume. At each survey point the estimation of biovolume will be recorded with the associated transect and point number in the field notebook. All estimations of plant cover and biomass are made by the same field personnel to ensure consistency.

Assessment of both plant cover and biovolume will be made along the length of each transect with general observation and an Aquascope. In increased water depths or under turbid conditions, the grappling rake will be used to assess these measurements. The bottom of the waterbody will be scraped in order to estimate plant cover and biovolume. At depths greater than 16ft, the grappling rake will not be effective and the plant cover and biovolume will be assumed to be 0%.

4.3 Creation of Plant Maps

Upon completion of the field survey, dominant plant beds identified within the waterbody will be linked with associated transects and survey point locations to create a dominant aquatic plant distribution map.

Percentage plant cover and plant biovolume “code numbers” will be linked with the transects and survey point locations drawn onto the outline map to create maps that illustrate the percentage cover and percentage biomass of aquatic plants in every part of the waterbody.

5.0 QUALITY CONTROL

Dominant species as well as unidentifiable plants (unknowns) will be sampled *in situ* and transported back to the lab in plastic bags. Identification checks with other plant keys and consultations with ESS plant experts will be made to confirm species identification.

6.0 DOCUMENTATION

All observed and sampled plants will be recorded by ESS personnel in field notebooks in the form of a species list. Dominant plants will be also be associated with location information in the form of transect numbers and survey points. Transect lines and survey points will be recorded on a map outline of the waterbody that has been printed on water resistant paper (e.g. Rite-in-the-Rain). Any unanticipated site-specific information, which requires ESS field personnel to deviate from the above SOG will be reported in an ESS field notebook. Documentation for recorded data must include a minimum of the following:

- Survey date
- Weather conditions
- Signature or initials of person performing the survey
- Plant survey transect and point locations

- Comments/observations

Additionally, survey point data may be added electronically in the field using a GPS unit.

7.0 TRAINING/QUALIFICATIONS

To properly complete an assessment of plants within a waterbody, the analyst must be familiar with the sampling protocols as stated in this SOG, must have confidence in the use of plant keys and must have familiarity with the aquatic plants of the area in question.

ESS Group, Inc.

ESS GROUP, INC. STANDARD OPERATING GUIDELINES
FOR MEASUREMENT OF TURBIDTY WITH A SECCHI DISC

1.0 INTRODUCTION

This Standard Operating Guideline (SOG) provides basic instructions for the routine measurement of water clarity in lakes and ponds with a Secchi disc. Water clarity is a function of the number of particles in the water (algae, sediment, etc) and the color of the water, which both have an impact on the depth of light penetration. The transparency of the water column can be used as an indicator of water body productivity, with certain exceptions (e.g., naturally sediment laden waterbodies). Generally, the more productive a system is the more algae in the water column, and the lower the transparency. Water transparency can also be affected by erosionally suspended particles which are related to water depth and wave action. Thus on any given day the turbidity of a water body may be affected by its productivity, the season, wind speed and level of sunlight. The methods outlined below are intended (1) to standardize the use of a Secchi disc in the measurement of turbidity; (2) to standardize recording of field data to assure proper documentation of weekly, monthly and seasonal patterns in turbidity.

2.0 REQUIRED MATERIALS

The following materials are necessary for the measurement of turbidity with a Secchi disc:

- Weighted Secchi disc with attached length of rope marked off in one tenth of a meter increments with indelible ink.
- Field data sheets

3.0 METHODS

- A location will be selected from which to measure turbidity, this location will stay constant throughout the study.
- The date, weather conditions, and personnel conducting the measurement will be recorded on the field sheet.
- The Secchi disc will be lowered slowly into the water by the rope so that the weight enters the water first and the disc follows, flat side parallel to the water surface.
- The disc will continue to be lowered through the water column until it is no longer visible.
- A note will be made of the depth of the disc at this point in tenths of a meter by reading where the surface of the water touches the rope.
- The disc will then be slowly raised until it is just visible again.
- Once again a note will be made of the depth of the disc at this point.
- An average of these two depths will be calculated to give the “Secchi depth”, i.e. a measure of the turbidity of the water.

4.0 DOCUMENTATION

Secchi depth data will be reported on field data sheets for every day that a measurement is taken. Documentation for recorded data must include a minimum of the following:

- The date
- The time
- Weather conditions
- Signature or initials of person performing the measurement
- Depth measurements and average Secchi depth
- Field comments/observations on anything that may influence the Secchi depth measurement that day.

ESS GROUP, INC. STANDARD OPERATING GUIDELINES
FOR COLLECTION OF SEDIMENTS FROM FRESHWATER ENVIRONMENTS

1.0 INTRODUCTION

1.1 Purpose and Applicability

These Standard Operating Guidelines (SOGs) provide basic instructions for the collection of bottom sediments from freshwater environments. Collections are to be performed in accordance with methodologies generally accepted by the Massachusetts Department of Environmental Protection (MADEP). Laboratory analysis of sediment samples should be performed by a state certified laboratory with the detection limits for analysis specified on the project's Chain of Custody.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements may be defined in a site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) and may include duplicate or replicate measurements or confirmatory measurements.

2.0 RESPONSIBILITIES

Field personnel are responsible for verifying that all sampling equipment is in proper operating condition prior to use and for implementing the sampling procedures in accordance with this SOG and any specific project plan.

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.

3.0 REQUIRED MATERIALS

The following materials may be necessary for this procedure:

- Sediment coring or grab sampling device
- Stainless steel mixing bowl
- Stainless steel mixing spoon or tool
- Nitrile gloves
- Alconox
- Pre-cleaned sample jars provided by laboratory
- Pencil and labeling marker or pen
- Field data sheets or logbooks

- GPS receiver and/or map of target waterbody to record sample locations

4.0 METHOD

Field personnel are to collect sediment cores or grabs in accordance with the instructions provided with each specific sampling device deployed. Nitrile gloves should be worn at all times during these procedures. At each sampling location, a pre-cleaned grab sample dredge or corer is to be deployed, typically from a boat. All equipment is to be decontaminated using alconox and fresh water before the collection of each discrete sample. If specified by the project plan, samples may be composited in a pre-cleaned stainless steel mixing bowl and mixed thoroughly with a pre-cleaned stainless steel spoon before being transferred to the glass sampling jars provided by the laboratory. However, volatile organic compound (VOC) samples should be collected from cores prior to compositing.

The sample jar should be labeled with the sample identification, date, and any other project specific requirements. This information should be recorded in a field book at the time of sampling along with other essential information such as water depth, sample coordinates (or the location should be mapped on a figure at the time of sampling), and any other general notes on the nature of the sediment collected.

5.0 QUALITY CONTROL

Duplicate field samples or split samples may be collected if specified by the project plan. Once samples have been retrieved and placed into jars, the samples should be kept on ice or refrigerated until the laboratory can analyze them. Specific sample volumes, holding times, and detection limits for each parameter to be analyzed (Table 1) should be adhered to unless the project plan has outlined project-specific requirements.

TABLE 1. SEDIMENT ANALYSIS

Parameter	Volume Needed (ml)	Sample Container	Sample Preservation	Maximum Hold Time (hours)	Detection Limits (mg/Kg)	EPA #
Arsenic	100 g	Amber Glass	Ice	6 months	0.5	200.7
Cadmium	100 g	Amber Glass	Ice	6 months	0.1	200.7
Chromium	100 g	Amber Glass	Ice	6 months	1.0	200.7
Copper	100 g	Amber Glass	Ice	6 months	1.0	200.7
Lead	100 g	Amber Glass	Ice	6 months	1.0	200.7
Mercury	100 g	Amber Glass	Ice	6 months	0.02	245.1
Nickel	100 g	Amber Glass	Ice	6 months	1.0	200.7
Zinc	100 g	Amber Glass	Ice	6 months	1.0	200.7
PCBs	100 g	Amber Glass	Ice	7 days	0.01	8082
PAHs	100 g	Amber Glass	Ice	7 days	0.02	8270

Parameter	Volume Needed (ml)	Sample Container	Sample Preservation	Maximum Hold Time (hours)	Detection Limits (mg/Kg)	EPA #
EPH	100 g	Amber Glass	Ice	14 days	25	418.1
VOCs	100 g	Amber Glass	Methanol, Ice	7 days	0.1	EPA/ACE 8260
% Organic Content	100 g	Amber Glass	Ice	7 days	1.0%	160.4
% Ash Content	100 g	Amber Glass	Ice	7 days	1.0%	160.4
Grain Size Analysis (Sieve and Hydrometer)	1,000 g	Plastic Bag/Glass	None Required	Indefinite	0.1%	ASTMD 2216
% Water	100 g	Amber Glass	Ice	14 days	1.0%	160.3

6.0 DOCUMENTATION

Documentation for recorded data must include a minimum of the following:

- Date and time of collection and analysis
- Signature or initials of person performing the collection or measurement
- Sample identification/station location
- Pertinent comments

7.0 TRAINING/QUALIFICATIONS

To properly perform sediment collections, the field personnel must be familiar with the techniques stated in this SOG and experienced in the operation of the sampling equipment.

8.0 REFERENCES

MADEP Interim Policy # COMM-94-007

MADEP 2002. Technical Update: Freshwater Sediment Screening Benchmarks for Use under the Massachusetts Contingency Plan. May 2002.

ESS Group, Inc.

ESS GROUP, INC. STANDARD OPERATING GUIDELINES
FOR THE ACQUISITION OF SURFACE WATER

1.0 INTRODUCTION

1.1 Purpose and Applicability

This Standard Operating Guideline (SOG) provides basic instructions for the routine acquisition of surface water. The methods outlined below are intended (1) to standardize water sample collection methods used by ESS Group, Inc. (ESS) field personnel; (2) to ensure that samples delivered to the laboratory represent field conditions as accurately as possible; (3) to standardize recording of field data to assure proper documentation of sample collection; (4) to minimize cross contamination between sampling sites.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) or laboratory Quality Assurance Manual (QAM) and may include duplicate or replicate measurements or confirmatory analyses.

2.0 RESPONSIBILITIES

2.1 Project Manager

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.

2.2 Field Personnel

The analyst is responsible for verifying that the sampling bottles are appropriately sanitized and contain the appropriate preservative for the desired laboratory analyses. Sample bottle caps should be securely in place to ensure that no contamination has occurred and that preservative has not been released.

3.0 REQUIRED MATERIALS

The following materials are necessary for the acquisition of surface water:

- Rubber gloves
- Labeled sampling container provided from contracted laboratory, which is appropriately sanitized and contain the appropriate preservative for the desired analyses
- Laboratory or field data sheets or logbooks
- List of sites or locations of each site to be sampled

4.0 METHOD

4.1 Sample Handling, Preservation, and General Measurement Procedures

- Unless noted otherwise, surface water samples will be collected via direct grab methods.
- Upon entering a sampling location, ESS field personnel shall minimize disturbance to upstream waters and shall always sample water from the undisturbed upstream region. In addition, when wading in waterbodies, field personnel will try and disturb as little bottom sediment as possible.
- Sample collection shall precede the measurement of physical field parameters (such as turbidity, conductivity, dissolved oxygen, etc.) in order to minimize the risk of sediment disturbance and/or contamination.
- Clean rubber gloves shall be worn at each sampling location. Gloves shall be rinsed with distilled water prior to subsequent sample collection. When sampling multiple sites on the same date, gloves may be rinsed in the immediate downstream reaches of the waterbody to be sampled, before sample collection, in order to minimize the risk of cross-contamination. When warranted by the sensitivity of the laboratory analyses under investigation or at the Clients request, new, sterile rubber gloves shall be worn at each different sampling location.
- In absence of a project specific sampling protocol, grab samples are to be collected from beneath the water surface (at approximately 8 to 12 inches beneath the surface or mid-way between the surface and the bottom if the waterbody is shallow, (EPA 1997)). Samples will be collected at an appropriate distance from the stream bank or lake shoreline and away from submerged obstacles. For small streams (i.e., 10-20 feet wide with a maximum depth of less than 2 feet) the appropriate distance to collect a sample would be the center, while within larger streams the sample would be taken at a location where water depth is 2-3 feet.
- When collecting samples, ESS field personnel shall stand downstream of the desired sampling location, hold the bottle near its base and plunge it below the water surface with the opening (mouth) downward. The opening of sample bottles shall always be directed away from field personnel in an upstream direction.
- Sample containers with preservatives should not be used to collect surface water samples. If using containers with preservatives, a pre-cleaned container of similar type should be used to collect the sample with subsequent transfer to the preserved container.
- ESS personnel shall leave an approximate 1-inch air space (except for dissolved oxygen and BOD samples) in sample bottles, so that bottles may be shaken (if needed) before analyses (EPA, 1997).
- ESS personnel shall place sample bottles and temperature blanks (if required by QAPP or QAM) in a cooler filled with ice (if required by QAPP or QAM).

- The testing or analytical method and sample containers, preservation technique, and sample volumes should be selected in consultation with the laboratory to ensure that the samples obtained will provide the desired results.

5.0 QUALITY CONTROL

5.1 Field Duplicates

Field duplicate measurements of a single sample will be performed at the frequency specified in the project plan. Collection of duplicates will adhere to the surface water acquisition methods described above. Field duplicates will be collected immediately following initial sample collection.

6.0 DOCUMENTATION

Surface water quality field data will be reported in field notebooks by ESS personnel. Surface water quality laboratory data will be reported by contracted laboratories on official laboratory letterhead. Any unanticipated site-specific information, which requires ESS field personnel to deviate from the above SOG will be reported in an ESS field notebook. Documentation for recorded data must include a minimum of the following:

- Date and time of analysis
- Signature or initials of person performing the measurement
- Sample identification/station location
- Comments/observations

7.0 TRAINING/QUALIFICATIONS

To properly perform the acquisition of surface water, the analyst must be familiar with the sampling protocols as stated in this SOG.

8.0 REFERENCES

EPA, 1997. Volunteer Stream Monitoring: A Methods Manual. United States Environmental Protection Agency. Office of Water. EPA 841-B-97-003.

ESS Group, Inc.

ESS GROUP, INC. STANDARD OPERATING GUIDELINES
FOR MEASUREMENT OF TEMPERATURE

1.0 INTRODUCTION

1.1 Purpose and Applicability

These Standard Operating Guidelines (SOG) provide basic instructions for routine measurement of temperature using any high quality mercury-filled thermometer or thermistor with analog or digital read-out device such as the Hydac Multimeter Probe and YSI Model 55. Multimeter instruments used for temperature measurement may measure additional parameters (e.g., dissolved oxygen, conductivity, pH, etc.). This SOG addresses temperature measurement only (other capabilities are outlined in the appropriate SOG). This SOG is designed specifically for the measurement of temperature in accordance with EPA Method 170.1 and Standard Method 2550 B which address thermometric temperature measurement of drinking, surface, and saline waters, and domestic and industrial wastes.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) or laboratory Quality Assurance Manual (QAM) and may include duplicate or replicate measurements or confirmatory measurements.

2.0 RESPONSIBILITIES

The analyst is responsible for verifying that the temperature measuring device is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOG and the project plan.

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.

3.0 REQUIRED MATERIALS

The following materials are necessary for this procedure:

- Thermometer or thermistor with analog or digital read-out device
- Manufacturer's instruction manual for the instrument
- National Institute of Standards and Technology (NIST)-traceable thermometer
- Laboratory or field data sheets or logbooks

4.0 METHOD

4.1 Sample Handling, Preservation, and General Measurement Procedures

To achieve accurate temperature measurements, samples should be analyzed immediately upon collection (preferably within 15 minutes). Samples should be collected in glass or plastic containers.

4.2 Calibration and Measurement Procedures

- ESS-owned temperature measuring devices will, at a minimum, be checked annually as described in Section 5.0. The device will be checked against an NIST-traceable thermometer and the necessary compensation made for the difference in temperature between the two. Rental equipment will be checked by the manufacturer and documentation provided to ESS.
- Immerse the thermometer or temperature measuring device into the sample.
- Swirl and take a reading when the value stabilizes.
- Record the temperature reading to the nearest 0.50 for a thermometer or 0.10 for digital meter-type instruments. Compensate for any difference with the NIST-traceable thermometer.
- Temperature data may be post-calibrated using any of a variety of calibration data including, but not limited to, field calibration points, manufacturer calibration data, and analytical results from samples collected during field deployment of the sensors. The decision criteria for post calibration, and the technique used, will be specified in the project plan, and will be consistent with the manufacturer's recommendations.

4.3 Troubleshooting Information

If there are any performance problems with any of the meter-type temperature measuring devices, consult the appropriate section of the meter instruction manual for the checkout and self-test procedures. If the problem persists, consult the manufacturer's customer service department immediately for further instructions. If a performance problem exists with the thermometer, discard the thermometer and replace it.

4.4 Maintenance

Instrument maintenance for meter-type temperature measuring devices should be performed according to the procedures and frequencies required by the manufacturer.

5.0 QUALITY CONTROL

The temperature measuring devices will, at a minimum, be checked against an NIST-traceable thermometer at the frequency stated in Section 4.2.1. This verification procedure will be performed as follows:

- Immerse the thermometer or temperature sensor and the NIST-traceable thermometer into a sample.

- Allow the readings to stabilize.
- Record the readings and document the difference.
- Label the thermometer or temperature sensor with the correction value/adjustment and the date the accuracy check was performed.
- Compensate for the difference when sample measurements are taken.

Duplicate measurements of a single sample will be performed at the frequency stated in the project plan. In the absence of project-specific criteria, duplicate measurements should agree within $\pm$ 0.50C or approximately $\pm$ 1.00F.

6.0 DOCUMENTATION

- Records for checking the accuracy of the thermometer or temperature measuring device (where applicable) will include:
  - Date
  - Thermometer or meter-type temperature measuring device checked
  - Reference thermometer number
  - Readings for reference thermometer and thermometer being checked
  - Adjustment made for difference in readings
  - Initials of analyst
- Documentation for recorded data must include a minimum of the following:
  - Date and time of analysis
  - Signature or initials of person performing the measurement
  - Thermometer ID # or instrument identification number/model
  - Sample identification/station location
  - Temperature of sample (including units and duplicate measurements) compensated for any difference with the reference thermometer if applicable
  - Comments

7.0 TRAINING/QUALIFICATIONS

To properly perform temperature measurements, the analyst must be familiar with the calibration and measurement techniques stated in this SOG. The analyst must also be experienced in the operation of the meter.

Certain state certification programs require that temperature measurements in the field be taken by, or in the presence of, personnel that are qualified under the certification program.

8.0 REFERENCES

Standard Methods for the Examination of Water and Wastewater, 17th Edition, 1989.

Methods for the Chemical Analysis of Water and Wastes, EPA 600/4-79-020, Revised 1983.

ESS GROUP, INC. STANDARD OPERATING GUIDELINES
FOR MEASUREMENT OF TURBIDITY

1.0 INTRODUCTION

1.1 Purpose and Applicability

These Standard Operating Guidelines (SOG) provide basic instructions for routine measurement of turbidity using a nephelometric turbidity meter with a digital read-out device such as the LaMotte 2020 Turbidimeter. Measurements are made in accordance with EPA Method 180.1 that addresses nephelometeric turbidity measurement of drinking, surface, and saline waters, and domestic and industrial wastes.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) or laboratory Quality Assurance Manual (QAM) and may include duplicate or replicate measurements or confirmatory measurements.

2.0 RESPONSIBILITIES

The analyst is responsible for verifying that the turbidity measuring device is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOG and the project plan.

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.

3.0 REQUIRED MATERIALS

The following materials are necessary for this procedure:

- Turbidity meter with digital read-out device
- Manufacturer's instruction manual for the instrument
- Turbidity tubes
- Mild detergent
- Lint-free cloth
- Distilled water
- Nephelometric Turbidity Unit (NTU) calibration standards (1.00 NTU and 10.0 NTU)
- Laboratory or field data sheets or logbooks

4.0 METHOD

4.1 Sample Handling, Preservation, and General Measurement Procedures

To achieve accurate turbidity measurements, samples should be analyzed immediately upon collection (preferably within 15 minutes). Samples should be collected in glass or plastic containers.

4.2 Calibration and Measurement Procedures

- Select a turbidity standard in the range of the samples to be tested (1.00 NTU or 10.0 NTU). Fill a turbidity tube with the standard, cap, and wipe the tube with the clean lint-free cloth.
- Place the sample into the turbidity meter such that the indexing arrow on the turbidity tube is aligned with the indexing arrow on the meter face. Close the lid and press the "READ" button. If the displayed value is not the same as the value of the standard (within 2%), continue with the calibration procedure.
- Follow the calibration procedures outlined by the manufacturer's manual.
- Verify the calibration every 15 samples and at the end of the day. Recalibrate the instrument if the check value varies more than 2% from the true value.
- The turbidity tubes will be rinsed with deionized water and wiped gently with a lint-free tissue between sample analysis.
- Recalibrate the instrument with the appropriate NTU standard if the standard is not of the same order of magnitude as the samples being tested.
- The meter must be re-calibrated following any maintenance activities and prior to the next use.
- Record the turbidity reading to the nearest 0.01 NTU for measurements less than 11 NTU and to the nearest 0.1 for measurements greater than 11 NTU but less than 110 NTU. For values greater than 110 NTU record to the nearest 1 NTU.

4.3 Troubleshooting Information

If there are any performance problems with any of the meter-type turbidity measuring devices, consult the appropriate section of the meter instruction manual for the checkout and self-test procedures. If the problem persists, consult the manufacturer's customer service department immediately for further instructions.

4.4 Maintenance

Instrument maintenance for meter-type turbidity measuring devices should be performed according to the procedures and frequencies required by the manufacturer.

5.0 QUALITY CONTROL

- The turbidity measuring tubes will, at a minimum, be checked against NTU calibration standards at the frequency stated in Section 4.2. This verification procedure will be performed as follows:
  - Insert the turbidity tube with distilled water into the turbidity meter.
  - Press “READ”.
  - Record the readings and document the difference.
  - Label each turbidity tube with its corresponding turbidity correction value.
  - Record the adjustment and the date the accuracy check was performed in a logbook.
  - Compensate for the difference when sample measurements are taken.
- Duplicate measurements of a single sample will be performed at the frequency stated in the project plan. In the absence of project-specific criteria, duplicate measurements should agree within $\pm$ 2% for readings below 100 NTU and $\pm$ 3% for readings above 100 NTU.

6.0 DOCUMENTATION

All turbidity meter calibration, checks, and maintenance information will be recorded on the daily calibration sheet or logbook. Turbidity data may be recorded on the appropriate laboratory or field data sheets or logbooks.

- Calibration documentation must be maintained in a thorough and consistent manner. At a minimum, the following information must be recorded:
  - Date and time of calibration
  - Signature or initials of person performing the measurement
  - Instrument identification number/model
  - Expiration dates and batch numbers for all standard solutions
  - Reading for 1.00 NTU standard before and after meter adjustment
  - Reading for 10.0 NTU standard before and after meter adjustment
  - Readings for all continuing calibration checks
  - Comments
- Documentation for recorded data must include a minimum of the following:
  - Date and time of analysis

- o Signature or initials of person performing the measurement
- o Instrument identification number/model
- o Sample identification/station location
- o Turbidity of sample (including units and duplicate measurements)
- o Comments

7.0 TRAINING/QUALIFICATIONS

To properly perform turbidity measurements, the analyst must be familiar with the calibration and measurement techniques stated in this SOG. The analyst must also be experienced in the operation of the meter.

Certain state certification programs require that turbidity measurements in the field be taken by, or in the presence of, personnel that are qualified under the certification program.

8.0 REFERENCES

Standard Methods for the Examination of Water and Wastewater, 17th Edition, 1989.

Methods for the Chemical Analysis of Water and Wastes, EPA 600/4-79-020, Revised 1983.

Appendix C

Lab Standard Operating Protocols And Quality Assurance Plans

GEOLABS, INC.

COMPREHENSIVE LABORATORY QUALITY ASSURANCE PLAN

Version 20, April 1, 2010

45 JOHNSON LANE
BRAINTREE, MA 02184
(781) 848-7844

Authorized Signatures:

Charles Morrow, Laboratory Director

David Kahler, President

Mark Perkins, Quality Assurance Manager

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1.0 INTRODUCTION

GeoLabs, Inc. is an environmental and analytical chemistry laboratory with a strong commitment to providing quality services for government, commercial and industrial clients with water, air, soil and hazardous material analytical needs. GeoLabs provides these services to national, regional and local clients and is committed to providing superior quality work. GeoLabs, Inc. is a corporation registered in the Commonwealth of Massachusetts. Corporate headquarters is located in a 12500 square foot facility in Braintree, MA, 10 miles south of Boston. GeoLabs' is staffed by over 25 professionals, including Chemists, Environmental Scientists, and other technical specialists.

1.1 Statement of Policy

GeoLabs recognizes that our achievement of excellence in analytical services depends on the accuracy and precision of the data we provide to our clients. As a result, we have developed a Quality Assurance/Quality Control (QA/QC) program which ensures that standardized, proper protocols are followed and documented for each sample analyzed. As a NELAP certified laboratory we are committed to compliance with the NELAC standards.

1.2 QA/QC Considerations

The complex task of producing high-quality data can be grouped into several QA/QC considerations:

- Samples must remain undisturbed and representative of sampled conditions until they are analyzed.
- Care must be taken that samples are properly preserved.
- Proper analytical procedures must be followed.
- Analytical equipment must be in proper working order.
- Procedures to determine acceptability of QC data must be formalized.
- Raw data must be "reduced" to usable, comparable formats.
- Procedures for dealing with unusual results/circumstances must be in place.
- All of the above items must be documented appropriately.

With these considerations in mind, GeoLabs has developed specific, uniform procedures for every step of sample handling, analysis, data management and review. While adapted to our own internal needs, these procedures are consistent with the QA/QC requirements of government agencies.

By our definition, those procedures concerned with the accuracy and precision of each sample analyzed fall into the QC category. These are usually single procedures which are performed in conjunction with analysis that are used to quantify the success of analysis. In the GeoLabs plan these include:

- Instrument calibration criteria
- Reagent and standard preparation
- Replicate/spike/blank protocols
- Determination of detection limits

QC activities associated with the procedures above are individually tailored to each instrument and analytical method and are described in the Standard Operating Procedure for each method.

QA, on the other hand, is the composite of all activities involved with the production of valid information. Documentation, review and procedural updating are key elements of GeoLabs' plan which includes the following:

- Method selection and updating
- Chain of Custody
- Sample log-in and identification
- Sample storage and integrity
- Analysis scheduling (to minimize sample holding time)
- Documentation of sample preparation and analysis activities
- Documentation of standard and reagent receipt and preparation
- Calculation of results
- Data review
- Preparation of final reports
- QA performance audits and system audits
- Personnel training
- Safety

Periodic reviews of the entire QA plan are performed at least once a year prior to the annual internal audit to ensure that appropriate QA procedures are established and initiated in a timely manner. Each employee has clearly defined QA/QC responsibilities while responsibility for QA plan updating and auditing of the QA system rests with GeoLabs' Quality Assurance Officer.

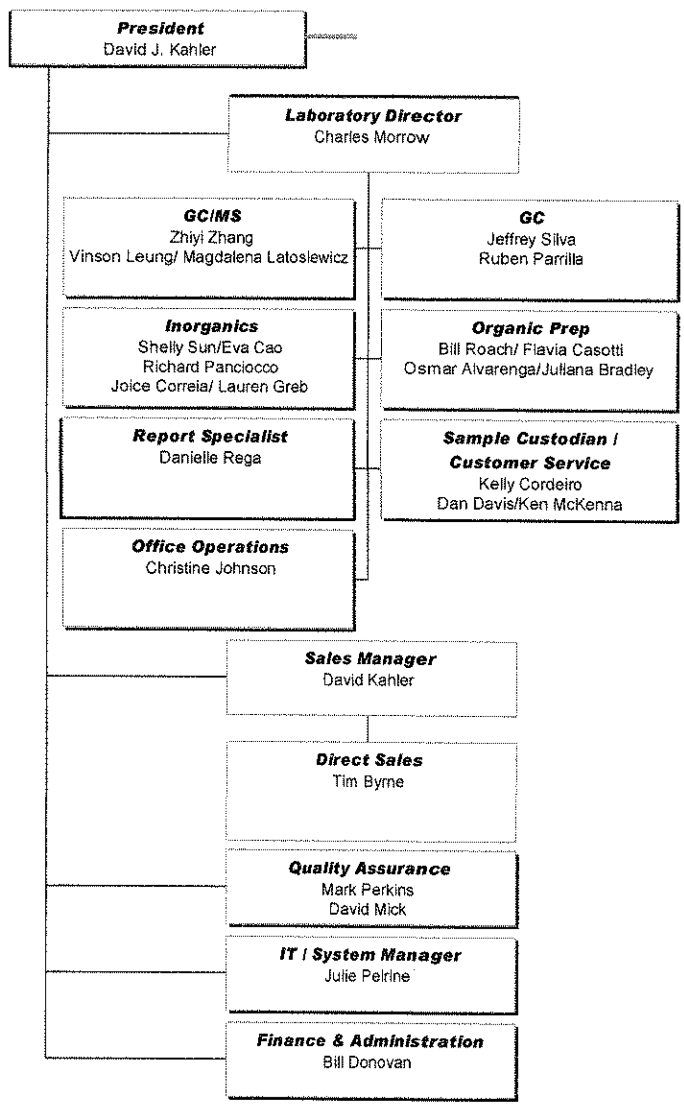
This document details all of the QA procedures followed by GeoLabs staff. Several other documents exist as supplements to this one. These documents include the Standard Operating Procedures specific to each method. The Standard Operating Procedures include detailed QC requirements for each analysis.

1.3 Intended Use of The Quality Assurance Plan

The intended use of the GeoLabs QA Plan is to maintain the quality of each analysis and to insure that the laboratory results are accurate and are presented in a clear and concise manner to our customers. It is understood and recognized that clients will often be using GeoLabs' analysis data for reporting purposes to the appropriate regulatory agency. The environmental assessment of a potential remediation site is based almost completely on the final results generated by a state certified laboratory; therefore, it is imperative to ensure that all analytical methods are conducted under controlled conditions. Controlled conditions can be maintained only by implementing and enforcing a formal QA/QC program that guarantees analytical data can withstand the most vigorous scrutiny.

2.0 Organization of the Laboratory

Laboratory services are organized into individual disciplines: inorganic/wet chemistry, volatile organics, semi-volatile organics, metals, TPH/pesticides/PCBs, EPH/VPH, and volatiles in air analyses. Each discipline is responsible for its work output and quality. The Laboratory Director oversees all laboratory operations including the enforcement of quality control procedures as well as solving any technical problems that may arise in the laboratory. Qualification and continuing education/training documentation for all employees is maintained by the Laboratory. This section describes the specific roles and responsibilities that accompany positions at GeoLabs.



2.1 Sample Custodian/Project Coordinator

- Reports to the Laboratory Director
- Inspects all coolers, samples, and Chains of Custody upon receipt.
- Confirms proper sample preservation of non-volatile aqueous samples by measuring and recording temperature and pH, as required
- Corrects preservation where necessary and makes appropriate note on Chain of Custody
- Informs client of any abnormalities
- Brings any abnormalities or unfamiliar requirements/tests to the attention of the Lab Director
- Assigns unique sample number, and maintains the log-in data base.
- Labels sample containers with unique sample numbers.
- Maintains a thorough knowledge of sampling receipt protocol.
- Monitors work flow
- Assembles and reviews project data for completeness
- Prepares sample bottles for delivery to clients

2.2 Chemist

- Reports to the Laboratory Director
- Performs extractions, digestions, concentrations and analyses according to the approved methodology.
- Documents each step legibly, completely, and accurately.
- Retains responsibility for the analysis and/or preparation of applicable quality control samples.
- Responsible for the documentation and reporting of applicable quality control data for control charts and method detection limit studies.
- Clearly documents and reports all instances of failed quality control procedures associated with samples.
- Operates all equipment according to the specifications of the manufacturer and the approved methodology.
- Maintains a thorough understanding of the QA Plan, QC criteria, and accepted laboratory practices.

2.3 Instrument Analyst

- Reports to the Laboratory Director
- Maintains, calibrates and operates instruments.
- Performs sample analyses according to approved methodology.
- Documents each step completely, legibly, and accurately.
- Retains responsibility for the analysis and/or preparation of applicable quality control samples.
- Responsible for the documentation and reporting of applicable quality control data for control charts and method detection limit studies.
- Clearly documents and reports all instances of failed quality control procedures associated with samples.
- Operates all equipment according to the specifications of the manufacturer and the approved methodology.
- Performs necessary calculations.
- Reviews data for correctness
- Maintains a thorough understanding of the QA Plan, QC criteria and accepted laboratory practices..

2.4 System Manager/Office Manager

- Reports to the President
- Responsible for in-house computer maintenance and troubleshooting

- Orders supplies and equipment for the laboratory
- Provides computer support to office and laboratory
- Performs data backup and archiving functions

2.5 Report Specialist

- Reports to the Laboratory Director
- Performs data review for completeness
- Requests corrections by laboratory if necessary
- Produces final deliverable reports
- Submits final deliverable reports to the Quality Assurance Manager for review.

2.6 Financial Manager

- Reports directly to the President
- Serves as company CFO
- Serves as company Human Resource Manager

2.7 Quality Assurance and Safety Manager

- Reports directly to the President
- Maintains reference material on quality assurance procedures and requirements.
- Prepares and updates the QA Plan, in-house SOPs, QC criteria and QC protocols in strict accordance with approved methodology and/or regulations
- Monitors laboratory compliance with the QA Plan
- Arranges for and conducts internal audits on the entire quality system annually
- Prepares yearly report to management on deficiencies in the quality system and monitors corrective action
- Recommends new QA program implementation when necessary
- Produces in-house warning and control limits from QC data supplied by chemists/analysts
- Serves as the laboratory point of contact for the exchange of QA/QC information
- Performs review of final deliverable packages before submittal to Lab Director
- Prepares and updates the Laboratory Chemical Hygiene Plan
- Provides initial employee training on GeoLabs safety policies and procedures
- Does not routinely analyze samples.

2.8 Laboratory Director

- Reports directly to the President
- Maintains a well-versed technical understanding of analytical methodology for the evaluation of laboratory operations
- Has responsibility for the administrative oversight and overall operation of the laboratory, including defining minimum qualifications, experience and skills necessary for all technical employees. Establishes training guidelines and policies for new personnel. Annually reviews all laboratory personnel to ensure continued technical proficiency.
- Works to ensure the implementation of the quality system
- Directs all aspects of laboratory operations to ensure the timely completion of all obligations
- Monitors the progress of sample analysis
- Assists both the client and laboratory in resolving any difficulties that may arise during a project
- Authorizes use of data which exceeds normal QC criteria, but due to extenuating circumstances retains validity

- Reviews all data generated by the laboratory
- Certifies the content of final deliverable packages prior to release with a dated signature
- Retains ultimate responsibility for the quality of data generated and reported by the laboratory

2.9 President

- Retains ultimate responsibility for the company
- Initiates new programs as desired
- Coordinates laboratory services directly with clients

2.10 Relationships

As GeoLabs is a small company many of its relationships are open and informal. All staff are aware of technical and quality issues in their areas and are free to suggest ways of improvement or to point out potential problems. A great degree of cross-training exists among the office/login staff and among the laboratory staff. As necessary, responsibilities are assumed by other members of the team.

2.11 Ethics Policy

GeoLabs realizes the importance of ethical behavior on the part of all its employees. GeoLabs utilizes training at the time of initial employment to ensure that its employees are aware of what is involved in ethical behavior with respect to the laboratory environment. Employees sign a "Statement of Understanding" indicating that their questions have been satisfactorily answered and that they understand the issues involved. Annual ethics and integrity training is required under NELAC and will be scheduled by the President at the beginning of the calendar year. Statement of Understanding is kept in each employee's personnel file.

Management is always available to answer questions concerning particular situations.

GEOLABS ETHICS POLICY

It is GeoLabs' responsibility to ensure training of personnel in their ethical and legal responsibilities. The responsibility for training and/or delegation of training responsibilities to someone with the knowledge and experience necessary shall rest with the Laboratory Director. It is GeoLabs' responsibility to insure that employees are free from any commercial, financial, and other undue pressures, which may affect the quality of their work. If such pressures are encountered by an employee, it is their responsibility to notify the Laboratory Director and/or Quality Assurance Manager. These issues are then brought to the attention of the President for action. All complaints will be discussed seriously and monitored by management to ensure compliance.

Below are the criteria that will be used by GeoLabs to determine what constitutes an improper, unethical, or illegal action.

Improper Actions: Improper actions are defined as deviations from GeoLabs standard operating procedure specified analytical practices and may be intentional or unintentional.

Unethical or Illegal actions: Unethical or illegal actions are defined as a gross deviation from GeoLabs standard operating procedure specified analytical practices, combined with the intent to conceal the deviation. The difference between poor analytical judgement and fraud may be assessed in the documentation of intent within laboratory records. Gross deviations from specified procedures will be investigated for potential fraud, and findings of fraud will be dealt severe penalties.

Examples of Improper/Unethical/or Illegal Practices:

- Improper use of manual integrations to meet calibration or method QC criteria (e.g., peak shaving or peak enhancement are considered improper, unethical, or illegal actions if performed solely to meet QC requirements).
- Time travel of analyses to meet method requirements (e.g., intentionally resetting a computer system's or instrument's date and/or time to make it appear that a time/date requirement was met).
- Falsification of results to meet method requirements.
- Reporting of results without analyses to support (e.g., dry-labbing).
- Selective exclusion of data to meet QC criteria (i.e., initial calibration points dropped without technical or statistical justification.)
- Misrepresentation of laboratory performance by presenting calibration data or QC limits within data reports which are not linked to the data set reported, or QC control limits presented within any document which are not indicative of historical laboratory performance or used for batch control.
- Notation of matrix interference as basis for exceeding acceptance limits (typically without implementing corrective actions) in interference-free matrices (e.g., Method Blank or Laboratory Control Samples).
- Unwarranted manipulation of computer software (e.g., improper background subtraction to meet ion abundance criteria for GC/MS tuning, chromatographic baseline manipulations).
- Improper alteration of analytical conditions (e.g., modifying EM voltage, changing GC temperature program to shorten analytical run time) from standard analysis to sample analysis.
- Misrepresentation of QC samples (e.g., adding surrogates after sample extraction, omitting sample preparation steps for QC samples, over-spiking or under-spiking).
- Reporting the results from the analysis of one sample for those of another.
- Any misrepresentation of practices or procedures used within our company, to any internal or external auditor, by any employee of GeoLabs.

To avoid any miscommunication the basis for manual integrations on QC data shall be clearly documented within the analytical record. Peer review and/or review by the Laboratory Director shall also be documented. All changes in data shall be clearly marked to show who made the change, date changed, and why changed.

An in-depth data audit will be conducted on 5% of all final reports produced. This data review shall include a check of all data for any data integrity issues. All possible data integrity issues will be clearly noted on a Quality Finding Report and forwarded to the President and Laboratory Director. An evaluation will be made regarding the extent of the infraction. A decision will be made by management of training needs or possible penalties.

A proactive program for the detection of improper, unethical, or illegal actions will be included in our yearly technical review. This will include the audit of laboratory records, calibration data, computer back-up records, and manual integrations.

Instances of fraud in the laboratory will result in the dismissal of the guilty party and prompt notification of any affected client or agency.

STATEMENT OF UNDERSTANDING:
I am aware of GeoLabs' Ethics Policy. I have read the document and any questions I may have had on the issues involved have been answered to my satisfaction. I agree to abide by this policy.

Signed: Print Name: Date:

3.0 DOCUMENTATION, DOCUMENT CONTROL, DATA BACKUP AND PROTECTION

Laboratory documentation, such as the Quality Assurance Plan, Chemical Hygiene Plan, and Standard Operating Procedures are perhaps the most important aspect of proper laboratory practices. These documents are controlled by the Quality Assurance Manager. Revision control is implemented through the following philosophy: minor changes/corrections to existing versions are documented within the software by use of revision tracking. Major changes require a new version number and retirement of the previous version. Previous versions will be marked with the initial and final dates of use. Implementation of an historical library of documents was begun in 1999. Hard copy and electronic versions are archived.

Report formats, including appropriate RDLs and method references, are controlled by the Report Specialist in conjunction with the Quality Assurance Manager. Reports are generated within our Khemia Omega LIMS system.

The record keeping system allows historical reconstruction of all laboratory activities that produced the resultant sample analytical data. The history of the sample is understood through the documentation. All documentation entries must be signed or initialed by responsible staff. The reason for the signature or initials must be clearly indicated in the records, such as "sampled by", "prepared by", or "reviewed by".

The laboratory shall retain on record all original observations, calculations and derived data, calibration records and a copy of the test report for a minimum of ten years.

Documentation Control and Archival Practices:

Type of Document	Stored
Final Report	Paper version filed with all associated data (instrument reports, calculations, chain of custody, etc.). All are stored on-site. Electronic files associated with the report are archived and stored in two geographically separated locations on external hard drives.
Instrument Data Files	Electronic data files are archived nightly and stored in two geographically separated locations on external hard drives
Quality Control Data	Paper copies of batch quality control data are kept in each analytical area. Electronic files are archived as mentioned above.
Log books	Log books are issued by the QA manager and are archived by the chemist. Copies of appropriate pages are included with reports.
IDCs, MDL Studies	Kept on file in QA office method specific files.
Control Charts	Control Charts can be viewed from within our LIMs system based on entered QCdata.

Backup Procedures

All important data files from networked computers are archived daily to a server. The servers are achived on a quarterly basis to an external hard drive, which is kept off-site.

4.0 REVIEW OF ALL REQUESTS, TENDERS AND CONTRACTS

All new work is initiated by the Laboratory Director who delegates responsibilities for the new work according to available resources. Affected staff members meet prior to initiation of new work in order to determine if appropriate facilities and resources are available. The plan for any new testing shall be reviewed and approved by the Laboratory Director before commencing such work. If the review uncovers any potential conflicts, deficiencies, inappropriate accreditation status, and/or inability to perform the work, the laboratory shall notify the client. In cases where differences exist between the request/tender and contract they shall be resolved prior to starting work.

The review shall document that facilities and resources are organized to efficiently perform the work, including subcontracted work. The record of contract review includes pertinent discussions with the client regarding their requirements and results submitted during the contract period. For routine reviews of ongoing work a date and a signature of the laboratory official responsible for the contract is sufficient. For any new testing requirements, the designated official shall ensure that standard operating procedures and demonstration of capability to perform those tests prior to reporting results are available. The SOP's shall be under document control and a Demonstration of Capability statements shall be on file.

Clients are notified immediately in situations where the laboratory cannot conform to the contract and if there is a change in laboratory accreditation status.

5.0 SAMPLE RECEIPT, CUSTODY AND LABORATORY OPERATIONS

5.1 Sample Containers

GeoLabs supplies new bottles for sample collection. GeoLabs customers are supplied with appropriate sample containers in order to maintain the integrity of each sample in accordance with EPA sampling protocols. Requests for sample bottles are generally made by telephone from the prospective client and are assembled by the sample custodian. Containers are supplied with labels, preserved if appropriate, and packed in coolers for delivery by GeoLabs' courier. A Chain of Custody form is supplied to the customer with the bottle shipment. The containers are then shipped by the appropriate method to the client. Approximately 95% of the sample bottles are hand delivered to the client by the GeoLabs' courier. Trip blanks (containers filled with laboratory DI water) are shipped or hand-delivered with sampling bottles at random to monitor "trip" conditions. Customers may also request trip blanks.

Metals analysis grade 1:1 nitric acid, 1:1 sulfuric acid and 1:1 hydrochloric acid are supplied by the laboratory. Clients can request to have in-house preserved bottles dropped off by the laboratory courier. The sample custodian preserves the requested bottles in the laboratory before delivery.

Records of container shipments, purchase orders, shipping documents, and related paperwork are maintained by office personnel. Shipping documents may include manufacturer's lot numbers, certification statements, point of origin, shipping dates and specific quantities. The date of physical receipt of all bottle shipments are written in indelible ink directly on the shipping invoice. The shipping invoice is also initialed by the individual who accepted the delivery.

Sample containers, preservation and holding times are documented in Appendix C.

5.2 Chain of Custody

All samples received by the Laboratory must be accompanied by a properly filled out Chain of Custody. An example of GeoLabs' Chain of Custody is given at the end of this section. The Chain of Custody form identifies the client's samples, special conditions, and the tests to be performed. Chain of custody forms contain all of the information referred to by "Test Methods for Evaluating Solid Wastes; Physical and Chemical Methods", SW-846, (U.S. EPA, 1982b). Specifically:

Client's name, address, phone and fax numbers.
Person to contact with questions.
Name of project and billing information
Expected turn-around time
Special instructions
Client sample identification
Date and time of sampling, initials of person taking sample, if more than one
Type of sample
Type of container
Number of containers
Preservative
Tests desired
Space for lab pH and temperature of sample when received
Signature of client or clients agent
Signatures of all intermediate recipients of the samples

All incoming samples are checked to verify sample integrity, i.e. samples are on ice, no headspace for VOAs, have been preserved properly, and complete documentation and identification are present. A temperature check, by use of a non-contact infrared thermometer, is performed on all samples at time of receipt, and recorded on the chain of custody. In addition, the tests requested are reviewed and the submitted sample volumes, container types and preservation are verified to make sure that they are appropriate for the testing requested. Should there be any question concerning whether the laboratory can perform the requested test, the issue is addressed with the Laboratory Director or the QA Manager before the samples are accepted.

5.3 Sample Receipt and Storage

Chains of Custody are inspected by login personnel to ensure that the chains are correctly filled out and that the tests requested are appropriate. A temperature check is performed on all samples and included on the chain of custody. The pH of samples is determined by transferring a small amount of sample by disposable pipette onto a wide range pH paper and the result is included on the chain of custody (excluding volatile, soil, and Oil and Grease samples).

Login personnel, office personnel cross-trained for login, the Lab Director, QA Manager, and President may all accept samples.

Unique sequential sample numbers are given to each sample. These sample numbers are recorded in ink directly on the original Chain of Custody. These numbers are written on all sample containers (both the jar and the cap) in indelible ink. All samples received at GeoLabs are logged into the LIMS. This data base, along with the Chain of Custody, serves as the reference for each sample in terms of the sample number, client's name, sample type, analyses requested, date received, date collected, and appropriate comments. In addition, as required by the Massachusetts DEP, a hand-written log of samples received, lab identification numbers assigned and test requested is maintained. Each entry is initialed by the person entering the data. After a set of samples has been numbered and entered into the computer, copies of the Chain of Custody are distributed to each analytical department that will be involved in the analysis, and to the accounting department. A project folder is prepared with client name, sample numbers and internal due date. The Chain of Custody remains in this folder until project completion.

Samples are stored in accordance with the guidelines in Appendix C and Section 4.9 of this manual. Several refrigerators and freezer units are used to segregate samples from analytical standards. Analytical standards for volatile, semi-volatile and pesticides/PCB analyses are stored separately in three refrigerator/freezer units. Samples and extracts are kept in refrigerator units. These refrigerators are monitored daily to insure a constant temperature of 4° ± 2° C. Provision has been made for isolated storage for volatile organic samples. All volatile organic samples, including duplicates, field blanks, and trip blanks, are stored together in the same refrigerator and maintained at 4.0° ± 2° C. All other samples are excluded from the volatile organic refrigerator. Upon receipt, samples are placed in a secure storage area to which only the Laboratory Personnel have access. After an analyst has removed an appropriate aliquot of the sample, any remaining sample is returned to the storage area. The analyst is responsible for maintaining proper custody of the sample aliquot and extracts.

5.4 Holding Time Confirmation

Holding time confirmation is verified from the Chain of Custody supplied with the sample. The Sample Custodian reviews the chain and makes note of the sampling date, sampling time and the date samples were received by the laboratory. The holding time is then calculated from the actual time of sample collection and correlated with the recommended EPA holding time specified in Appendix C of this manual. Samples that are rejected due to hold time violations are documented by writing "Holding Time Exceeded" in ink in the comments section of the chain of custody sheet. The client is contacted and a new sample is requested. In some cases where there is limited sample, the client may request that the analysis be performed despite the holding time issue. These exceptions are noted on the Chain of Custody and in the Final Report.

5.4.a Protocol For Sample Rejection

The following deficiencies are grounds for sample rejection:

1. Incomplete or poorly filled out chain of custody form.
2. Lack of collection dates and collection times
3. Sample supplied without chain of custody form(s)
4. Lack of authorized signatures
5. Samples collected and stored by client that are beyond EPA holding times
6. Samples that are collected and stored in vessels that are not within EPA specifications. Examples: VOA samples received in plastic containers or TPH samples contained in propylene bottles.
7. Broken or damaged sample containers resulting in the loss of sample integrity.
8. Samples that contain insufficient sample volume or weight for a given analysis.

In all cases, where there is a perceived problem with a sample or with the chain, the client is notified and the problem and potential solutions are discussed. At the client's request, GeoLabs will proceed with an analysis, but will note the problem in the Final Report

5.5 Laboratory Documentation

Many documents facilitate the traceability of data, if necessary, through each step of sample handling to provide valid evidence should such data become the subject of testimony. These documents include the laboratory logbooks, laboratory data records, correspondence, reports, sample tags, chain of custody records, bench sheets, and instrument reports. Entries into these documents are initialed by the responsible individuals and reviewed, where appropriate. These documents (or copies of the appropriate pages) are kept with the Final Report for each project.

Laboratory documentation involves three general categories:

- Sample flow
- Analytical activities (e.g. instrument calibration, reagents etc.)

• Data reduction

Sample flow documentation is summarized below and the remaining two items will be discussed in detail in subsequent sections.

All references to a sample are made using the GeoLabs sample identification number, and all beakers, containers, etc. are marked similarly, unless clearly impossible. In the latter case, apparatus numbers are cross-referenced with sample numbers in the analyst's notebook. The following list describes the records associated with sample handling at GeoLabs:

1. The Chain of Custody documents the history of the sample. The Chain of Custody form also provides the analysts with the necessary information to complete each test.
2. The LIMS is the basic reference for information on all samples received by GeoLabs.
3. Sample numbers affixed to each container are unique to that sample and continuously increment as samples are received.
4. A daily Job Track is maintained in the LIMS to keep a running log of all work in progress. Information is organized according to client, collection date, analysis due date, report due date, sample numbers, and appropriate comments.
5. As work on the sample progresses, instrument reports and related raw data are maintained in a project folder.
6. A new chain of custody is initiated when a sample is sent to a subcontract laboratory for analysis. GeoLabs' sample number is used as the sample identifier and GeoLabs is listed as the client in order to maintain the confidentiality of our client. This chain of custody shall also indicate the state regulatory criteria that must be followed by the subcontracted laboratory. When samples are sent to local subcontract labs for analysis, GeoLabs' courier delivers the samples and maintains the custody record. When samples are shipped, they are sent via Fed-ex, carefully packaged, and the shipping number is used for sample tracking.

5.6 Forms

Master copies of forms are maintained in an active computer data base and hard copies are stored in separate files that are accessible by the laboratory staff. When additional laboratory forms are required, a hard copy is obtained from the filing system and reproduced.

5.7 Storage of Hard Copy

Hard copies of laboratory reports are filed and indexed sequentially by their LIMS generated identification number and are stored in file cabinets. Each laboratory report is accompanied by all bench sheets, calculations, quantification reports, chromatograms, correspondence relating to laboratory activities for the project, and chain of custody sheets. Hard copies are maintained on-site for ten years after which they will be disposed of. All documents will be retained for a minimum of ten years.

5.8 Final Reports

Hard copies are generated by the Reports Specialist using our LIMS system. When all analyses are complete, the project folder is assembled by the Sample Custodian and given to the Reports Specialist. The Reports Specialist verifies that the appropriate testing has been performed and provides a review of the data for completeness. The appropriate parameters are checked against the analysis raw data to verify correct entry into the LIMS by the analysts. The report is then printed, proofread and submitted to the Quality Assurance Officer for initial review. Calculations are checked for accuracy and detection limits are confirmed. All data points on the completed reports are compared with the data points on the bench sheets. The report is then submitted to the Laboratory Director for final review. Approval is documented with the Laboratory Directors signature and forwarded to the Report

Specialist for distribution. The final report and a copy of the chain of custody form are e-mailed to the customer. Final reports may also be faxed or e-mailed at the client's request.

Reports for all Massachusetts DEP reportable work for potable and non-potable water will include a copy of our Massachusetts DEP certified parameter list.

All samples submitted for reporting under a program that requires that a certified laboratory perform such testing, and for which Geolabs does not hold current certification, will be sub-contracted to a certified laboratory. All reported analysis which is sub-contracted will be clearly labeled with the sub-contractors laboratory ID number.

5.9 Analysis Scheduling

Some samples and analyses are sensitive to sample storage time. Priority is given to time-sensitive samples. Such priority is initiated and tracked through the LIMS functions. More routine analyses are performed according to the individual analyst's overall job schedule, always with the report due date in mind. The flow of samples which require several steps of processing prior to final analysis is scheduled by the Extractions Supervisor.

5.10 Sample Storage and Disposal

Prior to analysis, samples are stored so as to preclude alteration in any way from their condition as received. After receipt, samples are stored for 30 days, in case analyses must be rerun. The chemical integrity of the samples is maintained by the addition of appropriate preservatives at the time of collection and maintaining appropriate physical conditions such as low temperature.

GeoLabs, Inc.

Environmental Laboratories
45 Johnson Lane
Braintree, MA 02184
Office: 781-848-7844Fax: 781-848-7811

Turnaround Time

RUSH: 24hrs ☐ 48hrs ☐ 72hrs ☐

STANDARD:
5 Days____
Rush
Approved
By:_______

Page____of__

SPECIAL INSTRUCTIONS

Client:
Address:
Phone:
Fax:
Contact:

Project Number:
Project Location:
Purchase Order #:
Collected By:

SAMPLE ID	COLLECTION		SAMPLE LOCATION	CONTAINER		MATRIX	COMP	GRAB	PRES	GeoLabs SAMPLE NUMBER	ANALYSES REQUESTED									LABpH Temp
	DATE	TIME Sampledd by		TYPE	QUANT															

CONTAINER CODES:
A = Amber
B = Bag
G = Glass
P = Plastic
S = Summa Canister
O = Other
V = VOA

MATRIX CODES:
GW = Ground Water
WW = Wastewater
DW = Drinking Water
SL = Sludge
S = Soil **A** = Air
O = Oil
OT = Other

PRESERVATIVE CODES:
1 = HCl 7 = ICE
2 = HNO_3
3 = H_2SO_4
4 = $Na_2S_2O_3$
5 = NaOH
6 = MeOH

Relinquished By: *Date/Time*	*Relinquished By:* *Date/Time*
Relinquished By:	*Received By:*
Relinquished By:	*Received By GeoLabs:*

GEOLABS CHAIN OF CUSTODY

6.0 Analytical Procedures

Many procedures performed at GeoLabs are highly specific to a particular type of analysis or instrument. All such procedures are maintained on file in our laboratories and are accessible to all chemists. All analyses are performed in accordance with EPA, NIOSH, MA DEP, Standard Methods or ASTM protocols. Standard Operating Procedures (SOPs) for each analysis are maintained on file. The SOPs contain all instructions, references, deviations from methods, and contingency measures. SOPs are updated whenever changes in the methodology are made.

6.1 Glassware

Inorganic/Metals Laboratory

Glassware is washed with detergent (Liquinox for inorganics, Citranox for metals), rinsed with hot tap water and then rinsed three times with distilled, deionized water (15 Mohm resistivity or higher) (DI). Glassware used in trace metals analysis is also rinsed with a 1:1 nitric acid-water mixture followed by a thorough rinsing with distilled, deionized water. Separate glassware is reserved for use in the analysis of phosphorous. Glassware is then covered and stored in the area where it will be used

Organic Laboratory

Glassware is washed with Liquinox detergent, rinsed with hot tap water and then distilled water. The glassware is then allowed to air dry and is stored in laboratory drawers and cabinets. Certain glassware is baked out in muffle furnaces or drying ovens. Volumetric glassware is never baked. When ready for use, the chemist rinses the glassware with the appropriate solvent for the test being performed.

6.2 Reagent Preparation and Storage

Solvents used in the preparation of reagents and standards include distilled, deionized water and high purity organic solvents (glass-distilled, pesticide grade or re-distilled, when necessary). When new shipments of reagents are received by the laboratory, all shipping invoices and associated papers are placed into files which are arranged alphabetically by manufacturer. Lot numbers are recorded in the Chemical Receipt book. When reagents and solvents are received they are labeled with the receipt date. When they are opened, they are labeled with the "date opened". These notations are made on the product label using indelible ink.

All reagent solutions used are prepared from Analytical Reagent Grade (AR) chemicals or higher purity grades, as required by the stated method. The preparation of all reagent solutions is documented in the appropriate laboratory notebook, including source, weights and dilutions. Each reagent solution is clearly labeled with the composition, concentration, date prepared, initials of preparer, expiration date, and special storage requirements if any.

Reagent solutions are stored in appropriate glass, plastic or metal containers. Reagents are stored under conditions designed to maintain their integrity (refrigerated, dark, etc.). Shelf life is listed on the label and the reagent is discarded after it has expired. Dry reagents such as sodium sulfate and silica gel are baked at 400°C and rinsed with solvent prior to use for organic chemical analyses. See Table 5.1, Reagent and Standard Storage.

6.3 Training

At GeoLabs, great effort is made to maintain a staff of scientists of exceptional quality. The Laboratory Director certifies that personnel with appropriate educational and/or technical background perform all tests for which the laboratory is accredited. During the interview process, the Laboratory Director reviews each prospective employees educational experience, basic technical background, and/or prior professional experience, to insure that they are capable of understanding and following the methodology that will be their responsibility. Upon hiring a new analyst, and upon change of positions of existing employees, GeoLabs will proceed with a training program to acquaint that individual with any unfamiliar analytical procedures, in-house practices and our QA/QC requirements. Employees are provided a certification statement that ensures that they have read, understand and agree to follow this QA Plan, the latest version of the Standard Operating Procedures that relate to their job function, and the laboratory Chemical Hygiene Plan. Employees will also be provided with our Ethics Policy, which will describe their ethical and legal responsibilities.

The performance of the individual is evaluated after a 90-day trial period. Each new employee is expected to be completely familiar with the QA Plan, Chemical Hygiene Plan, and applicable SOPs by the end of that period. In addition to their supervisor, the Laboratory Director and QA Manager are available to the new analyst at any time to discuss all of GeoLabs in-house procedures and requirements. For all technical staff involved with the testing of environmental samples a Demonstration of Capability is required, the results of which will be kept on file.

In addition to this initial training, all employees of GeoLabs are urged to attend short courses available from instrument manufacturers, professional groups, seminars and other methods of improving employee performance and knowledge.

Continued proficiency will be documented on a yearly basis by checking analysts results on four consecutive laboratory control samples with acceptable levels of precision and accuracy. If this is not possible, documentation of acceptable performance of a blind sample will be used.

All personnel training records will be kept in a secure centralized file, and maintained by the Quality Assurance Manager. These records will include any documentation of training courses or workshops on specific equipment, analytical techniques or laboratory procedures. This file will also contain all certification statements signed by personnel.

6.4 Safety

The safety of its employees and neighbors is a prime concern of GeoLabs. Safe practices not only ensure individual and environmental protection but also result in better quality work. Hence GeoLabs has a Chemical Hygiene Plan and Emergency Plan which cover the following topics:

- Housekeeping
- Labeling/Signs
- Protective Equipment/Apparel/Personal Habits
- Accident Reporting
- Injuries
- Fires
- Refrigerators/Freezers
- Ventilation
- Emergency Procedures
- Waste Disposal and spill cleanup

6.5 Waste Disposal

Samples are packaged, categorized and disposed of according to the applicable EPA and MA DEP Hazard Class. GeoLabs is considered a small quantity generator, therefore, drinking water samples and non-hazardous wastewater, groundwater and surface water samples with a pH less than 5 or greater than 9 are disposed of by neutralizing to a pH of 5-9 and discharging under our industrial permit. Contaminated soil samples are bulk stored in 17H drums in GeoLabs' hazardous waste storage area for disposal by an approved disposal company. Sample extracts are disposed of in the appropriate waste barrels (i.e. acid/metals waste, organic solvent waste, cyanide waste, mercury waste, , and non-RCRA, non-hazardous soil waste).

Laboratory Waste is separated into seven groups:

1. Acid/Metals Waste: generated during the preparation and analysis of samples and standards for metals analyses, as well as the disposal of client samples that contain metals concentrations over regulated levels..
2. Cyanide Waste: generated during the analysis of samples and the preparation of standards for cyanide analysis, the use of cyanide containing reagents for other analyses, and the disposal of cyanide contaminated samples.
3. Waste Oil / Organic Solvent Waste: generated from the analysis of waste oil samples and during the analysis of PCB's, pesticides, volatile and semi-volatile organics, MBAS, TPH, the disposal of organic extracts, and the solvents used for cleaning glassware. (PCBs and pesticides below regulated levels)
4. Soil Waste: generated during the analysis of soil samples. GeoLabs disposes of these samples as a service to our clients to ensure that they are disposed of properly.
5. Stannous Chloride Waste: Generated during the analysis of metals. GeoLabs disposes of stannous chloride waste in a drum located in the hazardous waste storage room.
6. Pyridine Barbituric Acid Waste: Generated by Wet Chemistry during the analysis of reactive cyanides, total cyanides, etc. GeoLabs disposes of pyridine-barbituric waste into the solvent waste drum located in the hazardous waste storage room at a rate of 2 gallon per 53 gallons solvent waste.
7. Poly-Chlorinated-Biphenyl (PCB) Waste: Generated during the extraction of PCBs. Disposed of into a waste drum located in the hazardous waste storage room.

Waste is stored in a special locked waste storage room accessible from outside of building only. Keys to this room are monitored. The waste room and its contents are marked and labeled according to EPA Hazardous Waste Activity Protocols. Waste generated during the course of analyses is initially stored in properly-labeled gallon waste disposal bottles, which are placed in marked cabinets in the laboratory satellite waste areas. Proper labeling includes the use of a hazardous waste sticker with the full chemical name, the start date of the bottle, the EPA waste code number, the in-house number, and the company name. The in-house number is obtained from the "generated waste" log book, in which the labeling information is also entered. Waste is emptied a minimum of once per week or more often if needed into the appropriate waste barrel in the storage room and logged into the generated waste log book. This procedure is performed by an OSHA-trained chemist wearing proper safety clothing. The chemist is always accompanied by a safety observer.

Waste is disposed of by a licensed hauler and taken to licensed waste disposal facilities. These procedures are tracked on Uniform Hazardous Waste Manifest Sheets (EPA Form 8700-22, Rev. 9/94).

TABLE 5.1
REAGENT AND STANDARD STORAGE

Chemical	Method of Storage
Acids (Nitric, Sulfuric, Hydrochloric, Acetic)	Stored in original containers in vented cabinets designed for acid storage.
Organic Solvents	Stored in original containers in vented solvent storage cabinets. All solvents used for VOC analyses are stored separately in the VOC analysis area.
Inorganic Chemicals, Reagents and Standards	Stored in cabinet designated for standard and reagent storage. Cabinet is in temperature controlled area of the laboratory. Certain heat and/or light sensitive reagents are stored according to manufacturer's instructions.
pH Buffers	Stored in designated reagent storage cabinet in a temperature controlled area of lab.
Organic Standards	Stored in designated Refrigerator/freezer, i.e. VOC standards are stored separately from Semi-VOA and PCB standards.

6.6. Chemical Handling Procedures

The following instructions are given to all chemists and others who come in contact with chemicals:

All chemicals used in the laboratory should be handled with care at all times. Gloves, safety glasses and lab coats should be worn at all times while in the laboratory. The following guidelines should be followed:

Any solvent use should take place in the hoods. Solvent vapors are very harmful and should not be inhaled under any circumstances. Carry bottles with two hands. Use care when pouring into squirt bottles. Avoid skin contact. Change gloves immediately if contact occurs. Clean up spills with towels or absorbent. Allow empty bottles to vent before throwing away.

All acid bottles should be carried with two hands, and dispensed or poured in a hood. Always add acid to water, and never the reverse. Use caution to avoid spilling or splattering. If acid gets on gloves or lab coat, change them immediately. Clean up small spills with absorbent or neutralizer. Rinse empty bottles into the acidic rinse water waste before throwing away.

All other hazardous reagents and chemicals should be handled with caution at all times. If you are ever unsure about the hazards of any chemical, obtain the MSDS and read it thoroughly. All MSDS sheets are located in the QA Managers office. If you are still in doubt, ask someone for help to be sure you are handling the chemical properly. Again, ALWAYS wear gloves, safety goggles, and a lab coat. More detailed instructions are given in the Chemical Hygiene Plan.

7.0 CALIBRATION

Calibrations substantiate the precision and accuracy of routine sample analysis. All instruments and equipment must be calibrated and pass the calibration standards set by method quality control before samples can be run with any merit. Calibration criteria can be found in Table 7.3. Reference thermometers and reference weights must be re-calibrated every 5 years as required by MADEP regulations.

7.1 Standard Receipt and Traceability

Standards are received by the chemist in charge of the analysis to be performed and logged into the New Standard Log Book. In the New Standard Log Book, the standard's compounds, the date received, and lot number are entered. The certificate of Analysis is then entered into the appropriate notebook.

Organics Laboratory
Mixed or individual concentrates and neat standards are purchased from certified suppliers in sealed ampoules or vials. Each standard comes with a Lot Analysis Sheet and lot number. The standard is dated and stored as recommended by the manufacturer. Certification and traceability statements are kept in a binder in the appropriate laboratory.

Metals Laboratory
Individual standards are purchased from the supplier. Lot number and expiration dates are on each label. The standard is received by the metals chemist, dated and stored according to the manufacturer's instructions. Records of Certification and Traceability are on the label and therefore kept with the stock standard.

Inorganics Laboratory
Standards are purchased from certified commercial suppliers. Standards and reagents are received by the Inorganic Laboratory chemist. They are dated and stored according to the manufacturers instructions. Only high quality, certified chemicals are purchased. Certification, Lot Analysis and Traceability are on the label.

7.2 Standards Sources, Preparation and Storage

Quantitative reagents are prepared from neat materials or concentrates supplied by certified suppliers, and are standardized or checked against primary standards, check standards, or by other appropriate techniques to ensure the reliability of the reagent. They are prepared using analytical balances, Class A volumetric glassware, with utmost care and proper technique, and are stored in appropriate containers under specific conditions. Working standards are prepared from stock solutions as needed. Working standards can be traced to stock standards by lot number, date and analyst initials. Preparation of working standards is recorded in the analyst's laboratory notebook. Lot number, date of expiration, date of preparation, weight, volumes, chemist name, lab ID number, and solvent type are all recorded in the notebook. The standard container is labeled with the contents, lot number, date of preparation, expiration date, and analysts initials. See Table 6.2 Standard Sources and Preparation.

7.3 Instrument Calibration

See Table 6.3 Instrument Calibration

7.4 Method Calibration Requirements

Method calibration requirements detailed in this manual are based on methodologies established by the U.S. EPA and the State of Massachusetts Department of Environmental Protection.

Given that more stringent calibration methodologies may be required for a given client, GeoLabs will implement, adhere, and follow these new calibration procedures in their entirety. Modifications will be incorporated into all forms and documents utilized in the method calibration process. These modified documents and the modified procedural formats will be recorded, filed, and maintained within the existing method calibration filing system.

7.5 Documentation and Records

Documentation and records of calibration are contained and stored within laboratory notebooks which are maintained by each analyst. Instrument calibrations are conducted before each analysis series within the wet chemistry and metals analysis divisions. Calibrations for the GC/MS instruments are instituted every 12 hours. The GC-FID and GC-ECD units are calibrated as specified by the particular method. A hard copy of each calibration is maintained by the chemist responsible for each instrument.

7.6 Calibration Procedures for GC/Mass Spec

BFB/DFTPP tuning is initiated every twelve hours. Tuning criteria are based on ion abundance criteria, % relative abundance, % relative standard deviation of response factor, base peak and appropriate peak. Acceptance and rejection ranges for the tuning procedure are detailed in the Ion Abundance section of the BFB/DFTPP performance standard forms. If the instrument fails to pass the stated tuning parameters, then a fail tune notation will appear in the status column of the BFB/DFTPP performance standard forms. After tuning, the check calibration standard is injected every 12 hours. A fail tune notation requires the analyst to examine the GC section, MSD section and additional components to determine the cause of failure. Once defined, the cause of the tuning failure is corrected, a notation is then made in the GC/MS operator's laboratory notebook. The operator notes the corrective actions that were required to remedy the tuning failure in the maintenance notebook. The tuning procedure continues to be conducted until tuned status is achieved.

7.7 Method Detection Limit (MDL)/ Limit of Detection (LOD)

The terms Method Detection Limit (MDL) and Limit of Detection (LOD) are interchangeable. LOD's are initially determined in accordance with 40 CFR Part 136, Appendix B. Massachusetts DEP requires that LOD's be prepared and analyzed over a 3 day period, and utilizing all instrumentation used for each specific method. Updating of LOD (MDL) data will be conducted once yearly for all certified analytes or whenever a major change occurs. An LOD will not be necessary for methods where no spiking solutions are available, such as pH. The LOD results must be lower than the Limit of Quantitation (LOQ). Where a multi-level calibration is utilized the LOQ is set at the low standard of the calibration. On other analyses the LOQ will be a value between 2 to 5 times the LOD. Once a LOD is established, it must be verified, on each instrument, by analyzing a quality control sample (prepared as a sample) at approximately 2-3 times the calculated LOD for single analyte methods, and 1-4 times the calculated LOD for multiple analyte methods. The LOD is verified when the QC sample is qualitatively identified. When an LOQ is established, it must be initially verified by the analysis of a low level QC sample at 1-2 times the LOQ, and annually thereafter. A verified LOQ will be one where the recovery of the QC sample is +/- 50%.

Table 7.1

Instrumentation List

Laboratory Equipment

Equipment	Number	Make and Model	Approx. age(yrs)
GC-ECD (2 ECD's)	2	Hewlett Packard 6890	9
GC-FID	2/2	Hewlett Packard 6890/5890	9
GC-FID/PID	1	Hewlett Packard 5890	2-6
GC/MS	4	Hewlett Packard 6890/5973	4-5
Ultrasonic Cleaner	3	Americanbrand/VWR/Fisher	7
ICP	2	Perkin Elmer P400/Leeman	2-7
Graphite Furnace/AA	1	Perkin Elmer Aanalyst 800	3
GC/MS	2	Hewlett Packard 5972/6890 Series GC	2
Air Concentrator with Autosampler	1	Entech	2
Air Canister Cleaning System	1	Entech	2
Air Standard Diluter	1	Entech	2
Tekmar Precept II Autosampler	1	Tekmar	2
CEM Mars X Microwave Extractor	1	CEM	2
Lachat Quik-Chem Flow Injector Analyzer	1	Zellweiger Analytical	2
Analytical Balance	3	DenverInst.Co./MettlerAE160/AE200	3-6
pH Meter	2	Accumet Model 15/Orion EA-920	2-6
Circulating Hot Air Oven	1	Labline 3605-M	6
Muffle Furnace	3	Thermolyne 1400/Lindberg/51848	6-11
Conductivity Meter	1	Cole Parmer 1500-20	8
Hot Water Bath	2	Precision Electric 9818-R30	11
Flash Point Tester	2	Koeler K-14600 /Pensky Martin	6
Vacuum Pump	2	Sklar 100-15/Gast G582GDX	7 & 2
High Speed Centrifuge	1	Damon/IEC HN-S	7
Drying Oven	2	VWR 1360/1305U	8
Visible Spectophotometer	2	Gensys 20 / Hach DR2000	1 / 6
Top Load Balance	4	Ohaus	3-6
Turbovap II Concentrator	3	Zymark	2
Liquid/Liquid 3D Shaker	1	Glas-Col	3
Labline 6 Station Hotplate	3	Labline	6
100 Station Autosampler	1	Centurion from EST	1
51 Station Autosampler	2	Archon from Varian	11
Sample Concentrator	4	Tekmar 3000	6
			6
			6
Orbit Shaker	1	Labline	6
Chiller	2	Neslab CFT-25/75	2-8
Flow thru Cooler	1	Neslab EN-150	6

TABLE 7.2 STANDARD SOURCES AND PREPARATION

Instrument	How Received	Source/ Storage	Preparation from Source	Lab Stock Storage	Preparation Frequency
G C (PCB/Pest)	Neat or 2000 µg/mL	Frozen/ Frozen	Primary Standard prepared from Source Stock	4°C	Semi-Annual or when degradation is apparent
			Working Standard from primary	4°C	Monthly or when degradation is apparent
GC/MS (VOA)	Neat or 2000 µg/mL	Frozen/ Frozen	Primary Standard from Source	4°C	Weekly
			Working Standard from Primary	4°C	Daily
GC/MS (Semi-VOA)	Neat or 2000 µg/mL	Frozen/ Frozen	Primary Standard prepared from Source Stock	4°C	Monthly
			Working Standard from Primary	4°C	Weekly
ICP	1000 mg/L	RT	Primary Standard from Source (20 ppm, then 1-10 ppm range)	0.15% HNO_3 4°C	Annually or as needed
			Working Standard from Primary	0.15% HNO_3 RT	Weekly or as needed
pH Meter	4, 7, 10 Buffer solns	RT	As Received	N/A	Replaced Daily
Visible Spectrometer	Neat	As directed	Stock Standard from Neat	Refrig 4°C	Monthly or as directed by method
			Intermediate Standard from Stock	Refrig 4°C	Weekly or as directed
			Working Standard from Intermediate	N/A	Daily
IR Spectrometer	Neat	Freezer	Stock from Neat Compound	Refrig 4°C	Semi- Annually
			Intermediate Standard from Stock	Refrig 4°C	Monthly
			Working Standard from Intermediate	N/A	Daily
Ion Analyzer	1000 mg/L Solution	As directed	Stock from Source Solution	Refrig. 4°C	Monthly or as directed
Flashpoint Tester	Xylene-99.9%	Solvent Cabinet	Used as Received	N/A	N/A
Turbidimeter	Neat Formazin Solution 100 NTU	As directed	Working Standard from stock	Refrig 4°C	Daily
Conductivity Meter	Neat	RT	Stock Standard from Neat Compound	Refrig 4°C	Monthly
			Working Standard from Stock	Refrig 4°C	Weekly

Table 7.3 Calibration Criteria

Instrument	# Standard Initial Calibration	Accept/Reject Criteria-Initial	Frequency	Accept/Reject Criteria Continuing Calibration	# Standards Continuing Calibration	Frequency
GC (PCB/Pest)	3	%RSD. <10 (608) %RSD <20 (8082,8081A)	Initial and Continuing calibration and after corrective action.	Conc. w/in 15% of known value	1	Initial, every 10 samples, end of sequence
GC/MS (VOA)	5	%RSD. <15% (8260B) %RSD <35% (624)	Initial and Continuing calibration and after corrective action.	Conc. w/in 15% of known value	2	Initial, every 10 samples, end of sequence
GC/MS (SEMI-VOL)	5	%RSD. <25	Initial and Continuing calibration and after corrective action.	Conc. w/in 15% of known value	2	Initial, every 10 samples, end of sequence
ICP	5	Linear Regression correlation coefficient. >0.995	Daily or prior to use or failure of continuing calibration	Conc. w/in 10% of known value	1	Initial, every 10 samples, end of sequence
AAS Graphite Furnace	5	Linear Regression correlation coefficient. >0.995	Daily or prior to use or failure of continuing calibration	Conc. w/in 10% of known value	1	Initial, every 10 samples, end of sequence
pH Meter	2	± 0.01 pH Units	Daily prior to use or failure of continuing calibration	± 0.01 pH Units	2	Initial, every 10 samples, end of sequence
Visible Spectrophoto meter	5	Linear Regression correlation coefficient of >0.995	Daily prior to use or failure of continuing calibration	Conc. w/in 10% of known value	1	Initial and every 10 Samples
Ion Analyzer.	5	Logarithmic correlation coefficient >-0.995	Daily Prior to use or failure of continuing calibration	Conc. w/in 5% of known value	1	Initial, every 10 samples, end of sequence
Specific Conductivity Meter -	2	Conc. w/in 5% of known value (mid-range std.)	Daily prior to use or failure of continuing calibration	Conc. w/in 5% value (std. run at range of samples)	1	Initial, every 10 samples, end of sequence

Instrument	# Standards Initial Calibration	Accept/Reject Criteria-Initial	Frequency	Accept/Reject Criteria Calibration	# Standards. Continuing Calibration	Frequency
Infrared Spectrophoto meter	4	Linear Regression correlation coefficient >0.995	Daily Prior to use or failure of continuing calibration	Conc. w/in 5% of known value	1	Initial and every 10 Samples and end of run
Analytical Balance	3	Low, mid and high range within 0.5mg of true wt.	Daily prior to use	Weight w/in 0.5mg of true wt.	N/A	Daily
Ovens	N/A	± 2 ° C	Daily	N/A	N/A	N/A
Refrigerators	N/A	± 2 ° C	Daily	N/A	N/A	N/A
Flashpoint Tester	1	± 2 ° C	Prior to use	Flash w/in 2 ° C of True Flash	1	Initial and every 10 Samples
Turbidity	4	Linear Regression correlation coefficient of >0.995	Daily prior to use or failure of continuing calibration	Conc. w/in 10% of known value	1	Initial, every 10 Samples, end of run (2 standards)

Table 7.4
Standardization of Solutions

Analysis	Solution	Source of Primary Standard	Frequency of Standardization
C O D	Potassium Acid Phthalate	Commercial Lab Supplier	Daily as Needed
Chloride	$AgNO_3$ (Silver Nitrate) Titrant	Commercial Lab Supplier	Daily as Needed
Cyanide	KCN, Standard	Commercial Lab Supplier	Weekly
Phenols	Phenol Standard	Commercial Lab Supplier	Daily as Needed
Formaldehyde	Formaldehyde Standard.	Commercial Lab Supplier	Daily as Needed
Alkalinity	Sulfuric Acid	Commercial Lab Suppler	Daily as Needed
Hardness	Calcium and Magnesium Standards	Commercial Lab Supplier	Daily as Needed
Sulfide	Iodine Solution, PAO Titrant	Commercial Lab Supplier	Daily as Needed
Residual Cl	PAO Titrant Standard Iodine Titrant	Commercial Lab Supplier	Daily as Needed

8.0 Preventive Maintenance

8.1 Routine Preventive Maintenance

Analytical instrumentation has become increasingly sensitive and sophisticated in recent years and, with the increasing reliance on microprocessors, promises to become even more so in the coming years. While this development allows greater accuracy and precision, lower detection limits, and greater productivity, it also increases the modes of failure which can occur, as well as the difficulty of repairs. Thus, a program of instrument maintenance is necessary to avoid lengthy repair down-time and to ensure optimum functioning.

Preventive maintenance such as lubrication, cleaning, etc. is performed according to the procedures delineated in each instrument manual. See Table 8.1 Preventive Maintenance. Analytical balances are serviced once a year by an NIST certified balance technician. Precision and accuracy data are examined for trends and excursions beyond control limits to determine evidence of instrument malfunction. Upon discovery of a malfunction, test and corrective procedures recommended by the manufacturer's manual are implemented by the analyst. If repair cannot be effected at this stage, the laboratory director is notified and determines the appropriate action. This may involve in-house repair or a service call by a repair technician.

8.2 Maintenance Documentation

All malfunctions detected, as well as corrective action taken, are noted in a log book maintained with each instrument. This includes regularly scheduled preventive maintenance. All maintenance logbooks shall contain an equipment information section that shall include, laboratory identification, manufacturer's name, type identification, serial number (or other identification), date received (if available), date placed in service (if available), current location, condition when received (if available) (e.g. new, used, reconditioned), and the location of manufacturer's instructions if available.

8.3 Contingency Plan

If analysis holding times will be exceeded before repairs can be affected, then samples are sent to a subcontract laboratory with specific instructions on holding times. Rush surcharges will be paid to the subcontract laboratory if sample analyses are approaching holding time limits.

Table 8.1
PREVENTIVE MAINTENANCE

Instrument	Activity	Frequency
Furnace Atomic Absorption		
	Clean furnace windows	Each time
	Check plumbing connections	Each time
	Clean/change graphite tube	Each time/Weekly (usually)
	Check gases	Each time
	Check optics	Each time
	Clean/change graphite platform	Each time/Two weeks
	Clean carbon tube (outside surface)	Each week
	Change carbon tube	6 months (when As, Se run not acceptable)
ICP		
	Clean plasma windows	Weekly
	Check Liquid Argon	Daily
	Check/change pump tubing	Daily/Weekly
	Check nebulizer/change sample tips	Weekly/Monthly
	Check torch/change torch	Daily/Monthly
	Check waste drain	Daily
	Check the tension of the pump	Weekly
	Clean air filters	Monthly
	Change O-rings when change torch	Monthly
Gas Chromatograph		
	Change liners	1 – 3 times per week
	Check/change carrier gas and makeup gas	As necessary
	Change carrier trap	When indicated
	Change septum and O-rings	Weekly
	Clip column	When chromatography loses sensitivity
	Clean ECD	When signal reaches 150 Hz
	Check system for gas leaks	When RTs change/lose sensitivity
	ECD wipe test	Twice a year
	Clean FID	Biweekly
	Check flow rates	Monthly / loss of sensitivity
GC/MS-VOA		
	Check carrier gas and/or purge gas	Daily
	Change carrier gas and/or purge gas	Tank P drops below 500 psi
	Change in-line filters	(None) uses high-grade He
	Check system for gas leaks	Pressure and vacuum gauges daily
VOA		
	Check Purge Trap Connection to GC	Daily
	Change Trap	As needed
MS		
	Clean Source	Six months/or as needed
	Change multiplier	As high voltage limit maxed
	Change pump oil	Semi-annually
GC/MS-Semi-VOA		
	Check carrier gas	Daily
	Change carrier gas	Tank P drops below 500 psi
	Cut off end of capillary column	Whenever column is removed for maintenance
	Check system for leaks	Gauges checked daily instrument fully leak checked if RTs drift
MS		
	Change Filaments	When they burn out
	Clean source	1-2 months
	Change multiplier	As it approaches high voltage limit
	Change pump oil	Annually

Instrument	Activity	Frequency
Analytical Balances		
	Clean pan and compartment	Daily after use
	Check alignment and balance	Daily
	Service Balances (by Cert.Tech)	Annually
	Accuracy check	Daily
Visible Spectrophotometer		
	Check cuvettes for scratches	Daily before use
	Clean cuvettes	Daily before and after use
	Instrument "zero's"	Daily and after 10 samples
	100% transmittance w/DI water	Daily and after 10 samples
	Clean instrument	Daily and after use
	Servicing (by Cert. Tech.)	Annually, calibrated with certified standards semi-annually
pH Meter		
	Electrode stored in neutral solution (pH 7)	Daily when not in use
	Check connections meter electrode	Daily as used
Infrared Spectrophotometer		
	Check cells for scratches, dirt	Daily before use
	Clean cells	Daily before and after use
	Check optics	Semi-annually
Ion Analyzer		
	Check electrode filling solutions	Daily before use
	Check connections meter electrode	Daily before use
Ovens		
	Clean interior and shelves	Weekly or as needed
Fume Hoods		
	Check air flow	Semi-annually by Certified Technician
	Clean surface	Daily after use
	Check vent for obstructions	Semi-annually by Certified Technician
Flashpoint Tester		
	Check Gas Lines	Daily before use
	Check and test thermometer	Daily before use
	Clean cup and gas nozzle	Daily after use

9.0 ANALYTICAL QUALITY CONTROL

Prior to acceptance and institution of any test method, GeoLabs will perform a demonstration of capability, testing the performance of the method in the available clean matrices appropriate to the method. For analytes which do not lend themselves to spiking, the demonstration of capability of will be performed using quality control samples. Results of these demonstrations will be recorded on appropriate Certification Statements and these statements as well as the supporting laboratory results will be kept on file. Such a demonstration of capability will be completed every time there is a significant change in instrument type, personnel or test method. Continuing capability is demonstrated through satisfactory analysis of laboratory control samples.

Paramount to the maintenance of reliability in analytical determinations is the need to control the accuracy and precision of analytical results. GeoLabs employs a procedure for analytical quality control which consists of analyzing check standards, duplicates, and spiked samples corresponding in number from 10% to 20% of the samples analyzed. These analyses are used to prepare control charts defining accuracy and precision. Additionally, specific routines are maintained for instrument calibration, as described in the previous section.

9.1 Laboratory QC Checks

The control tests to validate accuracy and precision include the use of:

- Blanks (DI water and Reagent Blanks): Frequency of 1 in batch of 20 or fewer environmental samples for organics; 1 in batch of 10 or fewer samples analyzed for inorganics and for 608 and 624 analyses.
- Spike solutions: same as above.
- Duplicates: 1 in 10 samples, per matrix or per batch analyzed for inorganics.
- Surrogates: Volatile, semivolatile, PCB/Pesticide and herbicide and Modified 8100, MADEP VPH and EPH analyses - all standards, blanks, samples, and spikes are dosed at the level specified in the method.
- Laboratory Control Spike: Semivolatile, PCB/Pesticide and Herbicide and Modified 8100 analyses - all standards, blanks, samples, and spikes are dosed at the level specified in the method.
- Matrix Spikes: 1 in 20 samples, per matrix/batch analyzed for organics per CMR 310.42.00. (1 in 10 for PCB/Pesticides Method 608 analysis.)
- Matrix Spike Duplicates: 1 in 20 samples, per matrix/batch analyzed for organics.
- Trip Blanks: 1 Trip blank per cooler used for transport of VOCs at client's request.
- Internal Standards: Volatile / semivolatile All samples, standards, blanks, spikes and duplicates are dosed at levels specified in the method.
- Performance Standards: PT samples will be analyzed annually, or more often, depending on regulations.
- Continuing Calibration Standards (CCS): Run initially, after every 10 samples, and at the end of a sample run.
- QC Check Standards: Run at the beginning of each run and run at a frequency of 1 in 10 samples or every 12 hours for GC/MS analysis.
- QC Check Samples: From ERA, run quarterly. Concentrations unknown to analysts.
- QC Degradation Standards for Pesticides each run when samples are run.

These operations are used systematically to determine when an analytical system is out of control and whether such a condition is due to procedural or mechanical problems.

9.2 Routine Methods to Assess Precision and Accuracy

See Table 9.1 QC Methods used to Generate Precision and Accuracy Targets.

$$\text{Matrix Spike Recovery (\%)} = \frac{D_{ms} - D_s}{Q_{ms}} \cdot 100\%$$

where: D_{ms} = detected concentration in the Matrix Spike sample
D_S = detected concentration in the (unspiked) sample
Q_{ms} = Concentration of standard added to the Matrix Spike

Poor recovery in matrix spiked samples does not necessarily represent an analytical system that is out of control. It is possible that unavoidable interferences from the sample preclude efficient recoveries. Evaluation of concomitant surrogate standards can often resolve whether poor recovery is due to a matrix problem or a laboratory problem.

Replicates / Duplicates

Duplicate sampling analyses are performed at a rate of 1 per sample lot or every ten samples. For a pair of data points, the appropriate measure of deviation is either the percent difference:

$$D(\%) = \frac{|d_1 - d_2|}{(d_1 + d_2)/2} \cdot 100$$

where: D = Percent Difference
d_1 = First sample value or first sample matrix spike
d_2 = Second (duplicate) sample value or matrix spike duplicate.

or the Relative Range (R):

$$R(\%) = \frac{d_1}{x} \cdot 100 \text{ or } \frac{d_2}{x} \cdot 100$$

where x = mean of d_1 and d_2

In some cases multiple replicates are run on a sample and the Coefficient of Variation (or Relative Standard Deviation) would be the appropriate statistic to evaluate the dispersion of data around a mean:

$$CV = \frac{S}{x_1}$$

where: CV = coefficient of variation
S = standard deviation
x_i = mean of i replicates (i>2)

Replicate analyses are used in one of two ways, depending on the project requirements. In the simplest case, the replicate results are reported with the other sample results along with the appropriate measure of deviation for each replicate.

Quality Control Charts

Quality Control Charts are used as a visual means of monitoring replicate % differences and spike recoveries. Each analytical method for which spikes are available has control chart data. Control charts are maintained within the LIMS system. New control limits are calculated based on percent recovery of last 30 data points. If a LCS sample result falls outside the control limits (which are the average ±3 standard deviations), the analysis must be stopped until the problem has been identified and resolved. All samples analyzed with the out of control LCS sample must be reanalyzed.

Method Detection Limits

Method detection limits are determined according to procedures outlined in 40 CFR Part 136, Appendix B.

9.3 QC Requirements

If method QC requirements are more stringent than those listed, then GeoLabs will follow the QC requirements as specified and defined in the methods of interest. Line items 1-8 are understood to be minimum requirements for the determination of precision and accuracy. However, this does not imply that only the minimum QC requirements will be satisfied by GeoLabs.

TABLE 8.1 QC METHODS USED TO GENERATE PRECISION AND ACCURACY TARGETS

QC Method	Purpose	Conc. Level	Method Reference
Blanks (DI Water and Reagent)	Monitor Contamination	N/A	All Water and Soil Methods
Trip Blanks	Monitor contamination during sample transport	N/A	All water and soil methods where necessary
Field Blank	Monitor contamination during sampling	N/A	All Water and Soil Methods where necessary
Sample Duplicates or Matrix Spike Duplicates	Precision	Low, Mid, and High Levels	All Water and Soil Methods
Matrix Spike (Organics/Inorganics)	Monitor for unusual matrix effects	Low Level	624, 8260B, 625, 8270C, 608, 8082,8081A
		Mid Level	All other Methods
Surrogates	Accuracy; Monitor samples and QC for processing and/or matrix problems	50 µg/L	624, 8260B
		100 µg/L	Base/Neutrals, 625 and 8270C
		150 µg/L	Acid Extract., 625 and 8270C
		0.5 µg/mL	8082,8081A, 608
QC Check Samples (EPA / ERA Samples)	Accuracy	Varies	Water / Wastewater Methods where necessary
Matrix Spike Duplicates (Organics)	Precision and monitor unusual Matrix Effects	Low, mid, and High Levels	624, 8260B, 625, 8270C, 608, 8082, 8081A
Internal Standards	Calculate Sample Conc. And Monitor unusual Matrix Effects	See Method	624, 8260B, 625, 8270C
Performance Standards PT Samples	Accuracy	Varies	All Certified Testing
Continuing Calibration Standards	Verify continued acceptability of initial calibration	Low and Mid Range	All Water and Soil Methods where necessary
QC Check Standards	Verify Accuracy of Calibration Curve	Low and Mid Range	All Water and Soil Methods where necessary

9.4 Actions Required When There Are QC Exceptions

Individual actions are detailed in the Method SOPs, but in general, deviations from acceptable quality control limits are treated as follows: Contamination detected in blank samples would result in the blank being re-run. Contamination in blank that also appears in samples would be cause to re-run samples as well. Inappropriate surrogate recovery would result in sample re-analysis to determine if there was a matrix interference. If failure can be demonstrated to be due to matrix interference, the analytical results would be used and the final report would make reference to the interference. Failure of batch standards (Lab Control Sample) are a cause for corrective action and the entire batch would be rerun. Data which is to be reported despite a QC exception would be annotated in the final report.

10.0 Data Reduction, Validation and Reporting

10.1 Data Reduction

Upon completion of analysis, the analyst compiles all the raw data and calculates the results in the laboratory notebook or reporting sheet for the specific analysis. All corrections must be made by crossing out, initialing and dating the correction. Associated data for calibration, standards, spikes, blanks and replicates are also assembled. Data reduction calculations are performed on standardized forms tailored to each analysis type to minimize calculation errors and to facilitate review. The individual formulas used to calculate the results are the formulas found in the SOP for each method. Temperature compensation for the conductivity meter and the pH meter is automatically adjusted by a temperature probe and associated IC circuitry. The cell constant for the conductivity meter is equal to 1, therefore, no calculations are required to achieve the analytical result. Calculations completed using internal standards for the volatile and semi-volatile organic analyses are determined by the Standard Response Factor equation found in the Hewlett Packard computer. Linear regression, logarithmic regression and single point reference calculations are performed by the analyst. The entire data package is then organized for validation.

10.2 Data Validation

The data validation audit is concerned with accuracy, precision, completeness, and understandability or legibility. All analytical documentation is examined to insure proper methods were followed and any deviations were documented. Sample log-in documentation is checked for proper holding times and preservation.

The data package is first reviewed for completeness by the Project Manager and then forwarded to the Reports Specialist. The Report Specialist also verifies that all tests and methodology requested have been performed. The Report Specialist reviews their work before submitting it to the QA department to minimize transcription errors. The QA department reviews the data package, checks that QA/QC measures are within limits, checks that transcription for accuracy and verifies selected calculations. The QA department then initials the report as being reviewed and forwards it to the Laboratory Director.

The Laboratory Director focuses primarily on whether the appropriate methods and detection limits were used and on whether all QC criteria have been satisfied, i.e. holding times have been met, QC results fall within accepted limits, sample custody was maintained. The Laboratory Director also reviews correlations among the analyses where appropriate. Documentation on method deviations and QC corrective actions are reviewed to ensure proper resolution. If the Laboratory Director suspects that proper QC has not been maintained or if the methodology has been inappropriately altered, two responses may be implemented. First the analyst will be interviewed in an attempt to resolve any misunderstanding or omissions. Second if the situation remains unresolved, the analyst will be asked to reanalyze the samples using the proper QC and methodology. When the data package is accepted, the Laboratory Director signs it.

On the occasion when exceptional departures from documented policies and procedures are necessary, such departures are authorized by the Laboratory Director. These departures are noted on the appropriate laboratory sheet. When appropriate, reference to the departure would be made in the final report.

The Laboratory Director also reviews the data package for responsiveness of the information to the client's needs. He ensures that all of the required parameters have been examined, that field and laboratory information are in line, i.e. results for field blanks, trip blanks and any blind replicates make sense and that special instructions for methodology, accuracy and handling have been satisfied.

10.3 Data Reporting

Reports are mailed, e-mailed and/or faxed only to clients, by whatever service is suitable for their time schedule. Under severe time problems and if requested by the client, GeoLabs is willing to present the selected results by telephone to the client. However, this is done only with the client's understanding that a validated report is only transmitted in printed form. Clients are contacted within 24 hours of validation by the Laboratory Director if data exceeds the MCL.

10.4 Data Storage

Hard copy laboratory reports as well as all associated back-up data (chromatograms, chain of custody forms, purchase orders, analysis request forms, correspondence relating to laboratory activities for the project, etc.) are filed by order number. These files are kept in the lab office for two years and are then put in storage in a on-site storage warehouse, in file boxes labeled with the order numbers, and kept for at least 8 more years. After 10 years, all information will be discarded unless other action is specifically requested by the client or contract. Laboratory notebook pages, log-in books, and instrument maintenance and calibration information are stored in the laboratory office area for 3 years and are then sent to on-site storage for an additional 7 years. Additionally, all data generated from an instrument run by a computer is stored on data cartridges for 10 years. These records are stored in storage file boxes labeled with the dates and contents.

Should GEOLABS, Inc. cease doing business for any reason, all hard copy data records would be returned to our engineering, municipal and MWRA clients. Other clients would be contacted to determine whether they wished to receive copies. If not, such copies would be destroyed. Records not subject to parsing (log books, electronic files, etc.) would be held by the owner, David Kahler, for a period of 10 years.

10.5 Data Confidentiality

Data generated by GeoLabs is confidential and is distributed only to the client, following the client's instructions on the Chain of Custody . Requests from other interested parties are referred to the client. With permission of the client, copies of a report may be given to third parties.

11.0 Corrective Action

QC decision conditions and corrective responses vary with the types of analyses and checks being performed. See Table 10.1 for specific actions. In addition to the specifics for the QC activities described above, GeoLabs maintains a general systematic resolution procedure for any laboratory deficiency. This can be summarized as follows:

- reagents are examined for age, proper make-up, storage or use
- data are examined for calculation errors
- instruments are examined for faults and calibration
- possible sources of contamination are reviewed
- the entire analytical procedure is reviewed, by the analyst, and if unresolved, by the QA Officer for possible procedural errors

Most often, this systematic approach will resolve any QC discrepancies at one of the steps described. If, however, this fails, the analysis is rerun by re-calibrating the instrument, using newly made reagents, a different method, or if necessary by a different analyst.

The Analysts are responsible for all QC measures that are involved in their analysis methods. Analysts are trained in these procedures during their initial training. These issues are also discussed during their annual review. Most QC decisions can be made by the analysts involved, which may include instrument maintenance, and re-analysis of the sample batch. QC problems not resolved by normal procedures need to be brought to the attention of the Laboratory Director. All corrective actions must be documented in the analytical records. Samples should only be reported if all quality control measures are acceptable. If a quality control measure is found to be out of control, and the data must be reported, the analyst must fully explain the reason for the failed QC in text accompanying the effected data. The text accompanying the data with the failed QC must be transferred to the final report. Should corrective actions affect the results of any client analyses, the effected data would be corrected and the report reissued to the client.

The Laboratory Director, working with the QA Officer, is responsible for initiating and approving corrective actions. Corrective measures may be taken when results from performance evaluation samples and split samples are outside acceptance limits. The Laboratory QA Officer will look at all associated raw data and speak to the analyst and supervisor to try to determine the source of the problem. The step by step procedure outlined above would be followed.

DEP recommended corrective action will be initiated as a result of systems or performance audits, split samples or data validation review.

All deficiencies in the quality system that the quality assurance officer becomes aware of, through either internal or external audits of the laboratory, performance evaluation studies, customer complaints, etc; shall be reported to the Laboratory Director. All corrective actions to such deficiencies shall be documented on a corrective/ preventive action log. Corrective actions taken will be monitored to ensure on-going compliance. Inclusion of prior corrective actions and prior deficiencies noted in external or internal audits will be included in the yearly technical review of the laboratory to monitor on-going compliance. All audit and managerial review findings will be monitored by the Laboratory Director to ensure completion within the agreed time frame.

Customer complaints are infrequent and are dealt with by trying to resolve the matter to the customer's satisfaction. This may simply be a matter of explaining the situation and/or result or modifying our reporting format. Where a complaint raises doubt concerning the laboratory's compliance with the laboratory's policies or procedures, or with the requirements of regulatory standards, including NELAC standards, or otherwise concerning the quality of the laboratory's calibrations or tests, the laboratory ensures that those areas of activity and responsibility involved are promptly audited. Records of the complaint and subsequent action will be maintained by the Quality Assurance Manager.

Table 11.1 Corrective Actions

QC Activity	Acceptance Criteria	Recommended Corrective Action
Initial Instrument Blank	Instrument Response <MDL	Prepare another blank, if same problem, determine cause. Reagents, environment, instrument, syringe, etc.
Initial Calibration	Out of limits	Reanalyze standards and/or remake standards
QC Check Standard	$\pm$ 5% of expected value	Reanalyze standard. Recalibrate and rerun samples from last good continuing calibration. check.
Method Blank	<MDL	Reanalyze Blank. If still positive, determine source of contamination. Check samples for contaminants. If not present in samples check blank glassware and DI water. If present in samples, reprocess sample set
Replicates / Duplicates	Within lab control limits and/or method limits	Reanalyze sample in duplicate, as well as 1 in 3 of samples in set.
Lab Control and Matrix Spikes	Within lab control limits and method limits	Frequent failures to meet the limits for recovery or RPD warrant, investigation and correction by laboratory must be taken.
QC Check Samples	Within Limits Established by Manufacturer (ERA)	Determine cause of problem: analyst error, procedural error, etc. Re-calibrate. Re-run sample.
Surrogates	Within Limits Established by Method and lab control limits	If recovery of surrogate is out of limit range, the sample must be rerun.
Internal Standards	Area counts within established limits	Check for matrix effects, check surrogate recoveries to verify by historical data matrix effect, qualify results. If all samples effected determine source of problem, not added to samples, instrument malfunction, etc. Reanalyze sample set.
Trip Blanks	<MDL	Reanalyze Blank. If still positive, determine source of contamination. Check samples for contamination. If not present in samples check blank glassware and DI water. If present in samples, reprocess sample set.
Continuing Calibration	Within method limits	Maintenance if necessary. Reanalyze and remake standard if necessary.
Tuning (GC/MS)	Within limits established by EPA Method(s). (Every 12 hrs)	Maintenance and/or review of instrumental conditions. Re-analyze and remake BFB/DFTPP standard if necessary.

12.0 Performance and Systems Audits

12.1 Systems Audits

Managerial Review

Periodically, but at least once per year in January, the President, Lab Director, and QA Officer meet to discuss operations and problems. Topics to be discussed include: The suitability of policies and procedures; reports from managerial and supervisorial personnel; the outcome of recent internal audits; corrective and preventive actions; assessment by external bodies; the results of proficiency tests; any changes in the volume and type of work undertaken; feedback from clients; complaints; other relevant factors, such as quality control activities, resources and staff training. All information presented will be reviewed by management and records of review findings and actions will be maintained by the Laboratory Director

Internal System Audits

Beginning in January of each year, the entire laboratory is audited by the QAManager. All areas shall be audited before the end of the first quarter. Completion of the audit will be finalized with a report sent to the President and Laboratory Director for use during their yearly management review. The President will ensure that Geolabs has the proper resources necessary to perform this audit yearly.

This activity involves evaluation of all aspects of our technical operation, including:

- Analytical method employed / adherence to SOPs
- QC precision activities
- QC accuracy activities
- Instrument maintenance
- Documentation
- Traceability of standards and reagents
- Detection of improper, unethical, or illegal practices

Infractions are listed by the QA Manager on a Corrective/Preventive Action Log, with an attached detailed explanation of the finding, and discussed with the Laboratory Director. A written report is also prepared by the QA Manager and given to the appropriate personnel. If infractions are due to individual oversight, the Laboratory Director discusses the problem with the appropriate analysts. If infractions are due to a systematic error or misunderstanding, the QA Officer determines how to implement corrective action. Adoption of such modifications are reflected in an updated Standard Operating Procedure for the method affected. All corrective actions due to findings of an internal audit will be maintained in a Corrective/Preventive Action Log maintained by the Quality Assurance Manager. The QA Manager will prepare an initial report summarizing the findings of the internal audit and listing the corrective actions required and the time frame for the corrective actions to be accomplished. The QA Manager will also track all corrective/preventive actions to show that the corrective actions have been completed.

A proactive program for the detection of improper, unethical, or illegal actions will be included in our yearly technical review. This will include the audit of laboratory records, calibration data, computer back-up records, and manual integrations.

External System Audits

Geolabs is audited by the New York Department of Health under the NELAC guidelines according to their required schedule. The MA DEP also audits GeoLabs according to their Massachusetts regulatory guidelines.

The laboratory will conduct an annual review of its quality system and its testing and calibration activities to ensure its continuing suitability and effectiveness and to introduce any necessary changes or improvements in the quality system and laboratory operations. The review will take account of reports from the Quality Assurance Officer, the outcome of recent internal audits, assessments by external bodies, the results of proficiency tests, any changes in the volume and type of work undertaken, feedback from clients, corrective actions and any other relevant factors. All information presented will be reviewed by management and records of review findings and actions will be maintained by the Laboratory Director.

12.2 Performance Audits

Internal Performance Audits

One internal performance audit is run by the analyst. The analyst checks the calibration curve for every sequence that is run. This is done by using a check standard from a source different from the standards used to generate the original calibration curve. If the check standard does not fall within the acceptable range, corrective actions are taken, e.g. necessary maintenance is done and re-calibration is performed. This procedure is documented in the lab notebook of the chemist. Any maintenance is noted in the maintenance log book for the particular instrument.

External Performance Audits

GeoLabs participates in a WP and WS Proficiency Testing Sample Program for each analyte or interdependent analyte group four times per year. The PT samples are analyzed the same as client samples, according to the detailed instructions, and following all deadlines set by the provider. Only the analyst who performs the testing on a routine basis is allowed to analyze the PT samples. Results of PT sample testing will be directed to the appropriate accrediting departments. The laboratory will not be allowed to discuss any testing results of PT samples, nor have analysis completed by another laboratory. All records of PT sample analysis and results will be kept on file with the Laboratory Director. The laboratory will not knowingly analyze a PT sample from another lab. In the instance of such a receipt of a sample, the primary accrediting authority will be notified within five business days.

In the case of a failed PT sample, a corrective action plan, detailing all corrective actions, and a schedule for further PT sample analysis to remain certified will be sent to the accrediting authority.

FIGURE 12.1

Geo Labs Internal Audit Checklist

Date of Inspection ____________________ Department Inspected:

Inspected By ________________________ Method Inspected:

Deficiency Analyst Audited: ______________________

Deficiency
Equipment
Methodology
Initial Demonstration of Capability
Recent MDL Data
Precision and Accuracy Data
Quality Control Charts
QA Plan
SOPs
Documentation and Record-keeping
Other (specify):

Signature of Inspector ________________________ Date:

Signature of Laboratory Director ________________________ Date:

A copy of this report shall be furnished to analyst and Laboratory Director.

A corrective action reply within two weeks is mandatory. This must include details of corrective action performed or a detailed plan of corrective action. All supporting documentation necessary for validation of response is required.

13.0 Physical Plant

GeoLabs, Inc. is located at 45 Johnson Lane, Braintree, in approximately 12500 square feet. This space is divided into laboratory, office, sample receipt and storage, and storage locations. Laboratories are organized by function and separated to minimize adverse interactions. Hoods, safety showers, eye-wash stations and interim waste storage facilities are located as appropriate in the laboratory areas.

Deionized water is generated on site by a Millipore deionizer system. The conductance of the D.I. water is tested daily for conformance to required standards. Filters are changed as necessary.

Appendix A Approved NELAC Methods (See NYDOH Certificate of Approval for updated certification listings)

Parameter	Method
Metals	
Aluminum	6010B(soil) / 200.7(pw,npw)
Antimony	6010B(soil) / 200.7(npw) / 200.9(pw)
Arsenic	6010B(soil) / 200.7(npw) / 200.9(pw)
Barium	6010B(soil) / 200.7(pw,npw)
Beryllium	6010B(soil) / 200.7(pw,npw)
Boron	6010B(soil) / 200.7(npw)
Cadmium	6010B(soil) / 200.7(pw,npw)
Calcium	6010B(soil) / 200.7(pw)
Chromium	6010B(soil) / 200.7 (pw,npw)
Cobalt	6010B(soil) / 200.7(npw)
Copper	6010B(soil) / 200.7(pw,npw)
Iron	6010B(soil) / 200.7(pw,npw)
Lead	6010B(soil) / 200.7(npw) / 200.9(pw)
Magnesium	6010B(soil) / 200.7(pw,npw)
Manganese	6010B(soil) / 200.7(pw,npw)
Mercury	245.1(npw) / 7471A(soil)
Molybdenum	6010B(soil) / 200.7 (npw)
Nickel	6010B(soil) / 200.7(pw,npw)
Potassium	7610(soil) / 3111B SM19th ed.(pw,npw)
Selenium	6010B(soil) / 200.7 /200.9(pw)
Silver	6010B(soil) / 200.7(pw,npw)
Sodium	7770(soil) / 3111B SM 19th ed. (npw)
Strontium	6010B(soil) / 200.7(npw)
Thallium	6010B(soil) / 200.7 / 200.9(pw)
Tin	6010B(soil) / 200.7(npw)
Titanium	200.7(npw)
Vanadium	6010B(soil) / 200.7(npw)
Zinc	6010B(soil) / 200.7(pw,npw)
Inorganics(Non-Potable Water)[1,2,4]	
Alkalinity (Titrimetric)	2320B
COD	410.4
Chloride	Lachat 10-117-07-1 A
Chromium, hexavalent.	7196A(soil) / 3500Cr-D
Cyanide, Total	4500-CN-E SM 19th ed.
Cyanide, Amenable	4500-CN-G SM 19th ed.
Hardness	2340B SM 19th ed.
Hydrogen Ion (pH)	4500-H B SM 19th ed./ 9045C(soil)
Ignitability/Flashpoint	1010
MBAS	5540C SM 19th ed.
Kjeldahl Nitrogen- Total	4500-NH3 C SM 19th ed.
Nitrate	Lachat 10-107-04-1C

Ammonia	4500 NH3-C SM 19th ed.
Oil and Grease	1664A
Orthophosphate	4500 P-E SM 19th ed.
Phenols	420.1
Phosphorus, Total	Lachat 10-115-01-1-E / 4500-P E SM 19th ed.
Reactivity Cyanide/Sulfide	SW-846 Ch7 Sec.7.3
Residue	
- Total (TS)	2540B SM 19th ed.
- Filterable (TDS)	2540C SM 19th ed.
- Nonfilterable (TSS)	2540D SM 19th ed.
Specific Conductance	120.1
Sulfate	ASTM D516-90
Color	2120B SM 19th ed.
Sulfide (as S)	4500-S F SM 19th ed.
Volatile Organic Compounds (Non-Potable Water)[3,4]	
1,1,1,2-Tetrachloroethane	8260B
1,1,1-Trichloroethane	624 / 8260B
1,1,2,2-Tetrachloroethane	624 / 8260B
1,1,2-Trichloroethane	624 / 8260B
1,1-Dichloroethane	624 / 8260B
1,1-Dichloroethene	624 / 8260B
1,1-Dichloropropene	8260B
1,2,3-Trichlorobenzene	8260B
1,2,3-Trichloropropane	8260B
1,2,4-Trichlorobenzene	8260B
1,2,4-Trimethylbenzene	8260B
1,2-Dibromo-3-Chloropropane	8260B
1,2-Dibromoethane	8260B
1,2-Dichlorobenzene	602 / 624 / 8260B
1,2-Dichloroethane	624 / 8260B
1,2-Dichloropropane	624 / 8260B
1,3,5-Trimethylbenzene	8260B
1,3-Dichlorobenzene	602 / 624 / 8260B
1,3-Dichloropropane	8260B
1,4-Dichlorobenzene	602 / 624 / 8260B
2,2-Dichloropropane	8260B
2-Butanone	8260B
2-Chloroethyl Vinyl Ether	624 / 8260B
2-Chlorotoluene	8260B
2-Hexanone	8260B
4-Chlorotoluene	8260B
4-Isopropyltoluene	8260B
4-Methyl-2-Pentanone	8260B
Acetone	8260B
Acrolein	8260B
Acrylonitrile	624 / 8260B
Benzene	602 / 624 / 8260B

Bromobenzene	8260B
Bromochloromethane	8260B
Bromodichloromethane	624 / 8260B
Bromoform	624 / 8260B
Bromomethane	624 / 8260B
Carbon Disulfide	8260B
Carbon Tetrachloride	624 / 8260B
Chlorobenzene	602 / 624 / 8260B
Chloroethane	624 / 8260B
Chloroform	624 / 8260B
Chloromethane	624 / 8260B
cis-1,2-Dichloroethene	624 / 8260B
cis-1,3-Dichloropropene	8260B
Dibromochloromethane	8260B624 / 8260B
Dibromomethane	8260B
Dichlorodifluoromethane	624 / 8260B
Ethylbenzene	602 / 624 / 8260B
Hexachlorobutadiene	8260B
Isopropylbenzene	8260B
Methyl Tert-Butyl Ether	8260B
Methylene Chloride	624 / 8260B
Naphthalene	8260B
n-Butylbenzene	8260B
n-Propylbenzene	8260B
sec-Butylbenzene	8260B
Styrene	624 / 8260B
tert-Butylbenzene	8260B
Tetrachloroethene	624 / 8260B
Toluene	602 / 624 / 8260B
trans-1,2-Dichloroethene	624 / 8260B
trans-1,3-Dichloropropene	624 / 8260B
Trichloroethene	624 / 8260B
Trichlorofluoromethane	624 / 8260B
Vinyl Chloride	624 / 8260B
Xylenes (Total)	602 / 624 / 8260B
Volatile Organic Compounds (Solid)[4]	
1,1,1,2-Tetrachloroethane	8260B
1,1,1-Trichloroethane	8260B
1,1,2,2-Tetrachloroethane	8260B
1,1,2-Trichloroethane	8260B
1,1-Dichloroethane	8260B
1,1-Dichloroethene	8260B
1,1-Dichloropropene	8260B
1,2,3-Trichlorobenzene	8260B
1,2,4-Trichlorobenzene	8260B
1,2,4-Trimethylbenzene	8260B
1,2-Dibromo-3-Chloropropane	8260B
1,2-Dibromoethane	8260B

1,2-Dichlorobenzene	8260B
1,2-Dichloroethane	8260B
1,2-Dichloropropane	8260B
1,3,5-Trimethylbenzene	8260B
1,3-Dichlorobenzene	8260B
1,3-Dichloropropane	8260B
1,4-Dichlorobenzene	8260B
2,2-Dichloropropane	8260B
2-Butanone	8260B
2-Chloroethyl Vinyl Ether	8260B
2-Chlorotoluene	8260B
2-Hexanone	8260B
4-Chlorotoluene	8260B
4-Isopropyltoluene	8260B
4-Methyl-2-Pentanone	8260B
Acetone	8260B
Acrylonitrile	8260B
Benzene	8260B
Bromobenzene	8260B
Bromochloromethane	8260B
Bromodichloromethane	8260B
Bromoform	8260B
Bromomethane	8260B
Carbon Disulfide	8260B
Carbon Tetrachloride	8260B
Chlorobenzene	8260B
Chloroethane	8260B
Chloroform	8260B
Chloromethane	8260B
cis-1,2-Dichloroethene	8260B
cis-1,3-Dichloropropene	8260B
Dibromochloromethane	8260B
Dibromomethane	8260B
Dichlorodifluoromethane	8260B
Ethylbenzene	8260B
Hexachlorobutadiene	8260B
Isopropylbenzene	8260B
Methyl Tert-Butyl Ether	8260B
Methylene Chloride	8260B
Naphthalene	8260B
n-Butylbenzene	8260B
n-Propylbenzene	8260B
sec-Butylbenzene	8260B
Styrene	8260B
tert-Butylbenzene	8260B
Tetrachloroethene	8260B
Toluene	8260B
trans-1,2-Dichloroethene	8260B

trans-1,3-Dichloropropene	8260B
Trichloroethene	8260B
Trichlorofluoromethane	8260B
Vinyl Chloride	8260B
Xylenes (Total)	8260B

Pesticides(Non-Potable Water / Soil)[3,4]	
p,p'-DDD	608 / 8081A
p,p'-DDE	608 / 8081A
p,p'-DDT	608 / 8081A
Aldrin	608 / 8081A
a-BHC	608 / 8081A
b-BHC	608 / 8081A
g-BHC	608 / 8081A
d-BHC	608 / 8081A
Dieldrin	608 / 8081A
Endosulfan I	608 / 8081A
Endosulfan II	608 / 8081A
Endosulfan Sulfate	608 / 8081A
Endrin	608 / 8081A
Endrin Aldehyde	608 / 8081A
Heptachlor	608 / 8081A
Heptachlor Epoxide	608 / 8081A
Methoxychlor	608 / 8081A
Chlordane	608 / 8081A
Toxaphene	608 / 8081A
PCBs(Non-Potable Water / Soil)[3,4]	
Aroclor 1016	608 / 8082
Aroclor 1221	608 / 8082
Aroclor 1232	608 / 8082
Aroclor 1242	608 / 8082
Aroclor 1248	608 / 8082
Aroclor 1254	608 / 8082
Aroclor 1260	608 / 8082
Semivolatile Organic Compounds (Non-potable Water)[3,4]	
1,2,4-Trichlorobenzene	625 / 8270C
1,2-Dichlorobenzene	8270C
1,3-Dichlorobenzene	8270C
1,3-Dinitrobenzene	8270C
1,4-Dichlorobenzene	8270C
2,3,4,6-Tetrachlorophenol	8270C
2,4,5-Trichlorophenol	625 / 8270C

2,4,6-Trichlorophenol	625 / 8270C
2,4-Dichlorophenol	625 / 8270C
2,4-Dimethylphenol	625 / 8270C
2,4-Dinitrophenol	625 / 8270C
2,4-Dinitrotoluene	625 / 8270C
2,6-Dinitrotoluene	625 / 8270C
2-Chloronaphthalene	625 / 8270C
2-Chlorophenol	625 / 8270C
2-Methylnaphthalene	8270C
2-Methylphenol	8270C
2-Nitroaniline	625 / 8270C
2-Nitrophenol	625 / 8270C
3,3′-Dichlorobenzidine	625 / 8270C
3-Methylphenol	8270C
4-Methylphenol	8270C
3-Nitroaniline	8270C
4,6-Dinitro-2-Methylphenol	625 / 8270C
4-Bromophenyl Phenyl Ether	625 / 8270C
4-Chloro-3-Methylphenol	625 / 8270C
4-Chloroaniline	8270C
4-Chlorophenyl Phenyl Ether	625 / 8270C
4-Nitroaniline	625 / 8270C
4-Nitrophenol	625 / 8270C
Acenaphthene	625 / 8270C
Acenaphthylene	625 / 8270C
Acetophenone	625 / 8270C
Aniline	8270C
Anthracene	625 / 8270C
Benz(a)Anthracene	625 / 8270C
Benzidine	625 / 8270C
Benzo(a)Pyrene	625 / 8270C
Benzo(b)Fluoranthene	625 / 8270C
Benzo(g,h,i)Perylene	625 / 8270C
Benzo(k)Fluoranthene	625 / 8270C
Benzyl Alcohol	8270C
Bis(2-Chloroethoxy)Methane	625 / 8270C
Bis(2-Chloroethyl)Ether	625 / 8270C
Bis(2-Chloroisopropyl)Ether	625 / 8270C
Bis(2-Ethylhexyl)Phthalate	625 / 8270C
Butyl Benzyl Phthalate	625 / 8270C
Carbazole	8270C

Chrysene	625 / 8270C
Dibenz(a,h)Anthracene	625 / 8270C
Dibenzofuran	8270C
Diethyl Phthalate	625 / 8270C
Dimethyl Phthalate	625 / 8270C
Di-n-Butyl Phthalate	625 / 8270C
Di-n-Octyl Phthalate	625 / 8270C
Fluoranthene	625 / 8270C
Fluorene	625 / 8270C
Hexachlorobenzene	625 / 8270C
Hexachlorobutadiene	625 / 8270C
Hexachlorocyclopentadiene	625 / 8270C
Hexachloroethane	625 / 8270C
Indeno(1,2,3-cd)Pyrene	625 / 8270C
Isophorone	625 / 8270C
Naphthalene	625 / 8270C
Nitrobenzene	625 / 8270C
N-Nitrosodimethylamine	625 / 8270C
N-Nitrosodi-n-Propylamine	625 / 8270C
N-Nitrosodiphenylamine	625 / 8270C
Pentachlorophenol	625 / 8270C
Phenanthrene	625 / 8270C
Phenol	625 / 8270C
Pyrene	625 / 8270C
Pyridine	625 / 8270C
Semivolatile Organic Compounds (Solid)[3,4]	
1,1'-Biphenyl	8270C
1,2,4-Trichlorobenzene	8270C
1,2-Dichlorobenzene	8270C
1,2-Dinitrobenzene	8270C
1,3-Dichlorobenzene	8270C
1,3-Dinitrobenzene	8270C
1,4-Dichlorobenzene	8270C
1,4-Dinitrobenzene	8270C
2,3,4,6-Tetrachlorophenol	8270C
2,4,5-Trichlorophenol	8270C
2,4,6-Trichlorophenol	8270C
2,4-Dichlorophenol	8270C
2,4-Dimethylphenol	8270C
2,4-Dinitrophenol	8270C
2,4-Dinitrotoluene	8270C
2,6-Dinitrotoluene	8270C
2-Chloronaphthalene	8270C

2-Chlorophenol	8270C
2-Methylnaphthalene	8270C
2-Methylphenol	8270C
2-Nitroaniline	8270C
2-Nitrophenol	8270C
3,3′-Dichlorobenzidine	8270C
3-Methylphenol/4-Methylphenol	8270C
3-Nitroaniline	8270C
4,6-Dinitro-2-Methylphenol	8270C
4-Bromophenyl Phenyl Ether	8270C
4-Chloro-3-Methylphenol	8270C
4-Chloroaniline	8270C
4-Chlorophenyl Phenyl Ether	8270C
4-Nitroaniline	8270C
4-Nitrophenol	8270C
Acenaphthene	8270C
Acenaphthylene	8270C
Acetophenone	8270C
Aniline	8270C
Anthracene	8270C
Benz(a)Anthracene	8270C
Benzo(a)Pyrene	8270C
Benzo(b)Fluoranthene	8270C
Benzo(g,h,i)Perylene	8270C
Benzo(k)Fluoranthene	8270C
Benzyl Alcohol	8270C
Bis(2-Chloroethoxy)Methane	8270C
Bis(2-Chloroethyl)Ether	8270C
Bis(2-Chloroisopropyl)Ether	8270C
Bis(2-Ethylhexyl)Phthalate	8270C
Butyl Benzyl Phthalate	8270C
Carbazole	8270C
Chrysene	8270C
Dibenz(a,h)Anthracene	8270C
Dibenzofuran	8270C
Diethyl Phthalate	8270C
Dimethyl Phthalate	8270C
Di-n-Butyl Phthalate	8270C
Di-n-Octyl Phthalate	8270C
Fluoranthene	8270C
Fluorene	8270C

Hexachlorobenzene	8270C
Hexachlorobutadiene	8270C
Hexachlorocyclopentadiene	8270C
Hexachloroethane	8270C
Indeno(1,2,3-cd)Pyrene	8270C
Isophorone	8270C
Naphthalene	8270C
Nitrobenzene	8270C
N-Nitrosodimethylamine	8270C
N-Nitrosodi-n-Propylamine	8270C
N-Nitrosodiphenylamine	8270C
Pentachlorophenol	8270C
Phenanthrene	8270C
Phenol	8270C
Pyrene	8270C
Pyridine	8270C

Appendix B: Sample Preparation Table

Sample Preparation Method Number	Description	Matrix	Sample Preparation used for these Methods
3050A	Acid digestion	Soil/Sediment/Sludge	6010B/200.7
3010A	Acid digestion	Aqueous	6010B/200.7
3005A	Acid digestion	Aqueous	6010B/200.7
3510B	Liquid/Liquid Extraction	Aqueous	625, 8270C, 608, 8081A,8082, Modified 8100
3545	Automated Solvent Extraction	Soil/Sediment/Sludge	625,8270C,608,8081A,8082, Modified 8100
3620B	Florisil Cleanup	Soil/Aqueous	608, 8081A
1311	TCLP Extraction		6010B, 7000A/8000 series
1310	EP TOX Extraction	Soil/Solid	6010B, 7000A series

Method References

1. EPA 1983. "Methods for Chemical Analysis of Water and Wastes." EPA-600/4-79-020, EPA, EMSL, Cincinnati, OH.
2. "Standard Methods for the Examination of Water and Wastewater." 19th edition, American Public Health Assoc., Washington, D.C., 1995.
3. Code of Federal Regulations, 40 CFR, Part 136, Appendix A. Revised July, 1996.
4. EPA 1996. "Test Methods for Evaluating Solid Waste", SW-846 3rd edition. U.S. EPA Offices of Solid Waste and Emergency Response, Washington, D.C.
5. EPA. 40 CFR Part 261, Appendix II, July, 1990.
6. EPA. 40 CFR Part 136, Appendix B, July 1, 1993. MDL determination achieved by following the procedure outlined in 40 CFR Part 136 Appendix B.
7. MADEP VPH/EPH Method, MADEP, 1998.
8. QuikChem Methods, Lachat Instruments., Milwaukee, WI.

Appendix C: Sample Preservation and Handling

RECOMMENDED SAMPLE CONTAINERS, PRESERVATION and HOLDING TIMES					
Category	**Methods**	**Minimum Quantity**	**Recommended Container(s)**	**Required Preservation**	**Holding Time**
Volatile Organic Analyses					
Aqueous Samples					
Volatile Organics	601/602 624/502.2 524.2	40 mL	2 x 40 mL Glass Vials w/Teflon septum caps	Cool to 4°C Adjust pH <2 w/HCl Remove Chlorine	14 Days
Acrolein & Acrylonitrile	603	40 mL	2 x 40 mL Glass Vials w/Teflon septum caps	Cool to 4°C Adjust pH 4-5 w/HCl Remove Chlorine	14 Days
Solid Samples					
Volatile Organics	8010/8020 8260B	10 g	1 x125 mL Glass Vial w/Teflon septum cap	Cool to 4°C	14 Days
Acrolein & Acrylonitrile	8030	10 g	1 x125 mL Glass Vial w/Teflon septum cap	Cool to 4°C	14 Days
Semivolatile Organics Analyses					
Aqueous Samples					
Semivolatile	625	1 L	2 x1L Amber Glass Bottle w/Teflon liner	Cool to 4°C Remove Chlorine w/ $Na_2S_2O_3$	7 Days
PAHs	610 8270C	1 L	2 x1L Amber Glass Bottle w/Teflon liner	Cool to 4°C Remove Chlorine w/ $Na_2S_2O_3$	7 Days
Solid Samples					
Semivolatile Organics	8270C	30 g	Glass Jar w/Teflon liner	Cool to 4°C	14 Days
PAH	8100 8270C	30 g	Glass Jar w/Teflon liner	Cool to 4°C	14 Days

Category	Methods	Minimum Quantity	Recommended Container(s)	Required Preservation	Holding Time
Pesticide and Herbicide Analyses					
Aqueous Samples					
Organochlorine Pesticides & PCBs	608 508	1 L	2 x 1L Amber Glass Bottle w/Teflon liner	Cool to 4°C Adjust pH 5-9, Remove Chlorine w/ $Na_2S_2O_3$	7 Days
Organophosphorus Pesticides	614/8140	1 L	2 x 1L Amber Glass Bottle w/Teflon liner	Cool to 4°C Adjust pH 6-8 Remove Chlorine w/ $Na_2S_2O_3$	7 Days
Herbicides	615/8150	1 L	2 x 1L Amber Glass Bottle w/Teflon liner	Cool to 4°C Remove Chlorine w/ $Na_2S_2O_3$	7 Days
EDB and DBCP	504/8011	40 mL	2 x 40 mL Glass Vials w/Teflon septum caps	Cool to 4°C Adjust pH <2 w/HCl Remove Chlorine w/ $Na_2S_2O_3$	14 Days
Solid Samples					
Organochlorine Pesticides & PCBs	8081/8082	30 g	Glass Jar w/Teflon liner	Cool to 4°C	14 Days
Organophosphorus Pesticides	8140	30 g	Glass Jar w/Teflon liner	Cool to 4°C	14 Days
Herbicides	8150	30 g	Glass Jar w/Teflon liner	Cool to 4°C	14 Days
EDB and DBCP	8260B	10 g	1 x 125 mL Glass Vial w/Teflon septa cap	Cool to 4°C	14 Days
Hydrocarbon Analyses					
Aqueous Samples					
Hydrocarbon Fingerprint (GC/FID)	8100 Modified	1 L	2 x 1L Amber Glass Bottle w/Teflon liner	Cool to 4°C Adjust pH <2 w/H_2SO_4	7 Days
TPH/DRO	418.1/8100M 8100	1 L	2 x 1L Amber Glass Bottle w/Teflon liner	Cool to 4°C Adjust pH <2 w/H_2SO_4	28 Days
Oil and Grease	1664A	1 L	2 x 1L Amber Glass Bottle w/Teflon liner	Cool to 4°C Adjust pH <2 w/H_2SO_4 or HCl	28 Days
Gasoline Range Organics	8015	40 mL	2 x 40 mL Glass Vials w/Teflon septa caps	Cool to 4°C Adjust pH <2 w/HCl	14 Days

Category	Methods	Minimum Quantity	Recommended Container(s)	Required Preservation	Holding Time
Solid Samples					
Hydrocarbon Fingerprint (GC/FID)	8100 Modified	30 g	Glass Jar w/Teflon liner	Cool to 4°C	14 Days
TPH/DRO	418.1/ 8100M	30 g	Glass Jar w/Teflon liner	Cool to 4°C	14 Days
Oil and Grease	1664A	30 g	Glass Jar w/Teflon liner	Cool to 4°C	14 Days
Gasoline Range Organics	8015	10 g	1 x 125 mL Glass Vial w/Teflon septa cap	Cool to 4°C	14 Days
Metals Analyses					
Aqueous Samples					
Total Metals (except Mercury)	200.7/200.9 6010B/7000's	100 mL	Plastic Bottle	Cool to 4°C Adjust pH to <2 w/HNO_3	180 Days
Dissolved Metals (except Mercury)	200.7/200.9 6010B/7000's	100 mL	Plastic Bottle	Filter First Cool to 4°C Adjust pH to <2 w/HNO_3	180 Days
Total Mercury	245.1 7470A	100 mL	Plastic Bottle	Cool to 4°C Adjust pH to <2_w/HNO_3	28 Days
Dissolved Mercury	245.1 7470A	100 mL	Plastic Bottle	Filter First Cool to 4°C Adjust pH <2 w/HNO_3	28 Days
Drinking Water Lead & Copper Rule	200.9 200.7	1 L	1 x 1 L Plastic Bottle	Cool to 4°C	180 Days
Chromium, Hexavalent	218.1-5	200 mL	Plastic Bottle	Cool to 4°C	24 Hours
Solid Samples					
Total Metals (except Mercury)	6010B 7000's	2 g	Glass Jar w/Teflon liner	Cool to 4°C	180 Days
Total Mercury	7471	0.6 g	Glass Jar w/Teflon liner	Cool to 4°C	28 Days

Category	Methods	Minimum Quantity	Recommended Container(s)	Required Preservation	Holding Time
Hazardous Waste Characterization Analyses					
Solid Samples					
TCLP Volatile Organics	1311 8260B	150 g	2 x 125 mL Glass Vial w/Teflon septum cap	Cool to 4°C	14 Days
TCLP Metals, Semi-Volatiles, Pesticides and Herbicides	1311/6010B 7000's/8081A 8150	300 g	Glass Jar w/Teflon liner	Cool to 4°C	28 Days 14 Days
Ignitability	1010 Modified	100 g	Plastic or Glass Jar	Cool to 4°C	None
Corrosivity	9045	20 g	Plastic or Glass Jar	Cool to 4°C	None
Reactivity	SW-846	20 g	Plastic or Glass Jar	Cool to 4°C	None
Paint Filter	9095	100 g	Plastic or Glass Jar	Cool to 4°C	None
Conventional Physical Properties Analyses					
Aqueous Samples					
Color	2120B	20 mL	Plastic or Glass Bottle	Cool to 4°C	48 Hours
Conductance	120.1	100 mL	Plastic or Glass Bottle	Cool to 4°C	28 Days
Hardness	130.1-2	100 mL	Plastic or Glass Bottle	Cool to 4°C Adjust pH <2 w/HNO_3	180 Days
Odor	140.0	200 mL	Glass Bottle Only	Cool to 4°C	24 Hours
pH	4500-H-B	25 mL	Plastic or Glass Bottle	None	Immediately
Solids, Total Dissolved (TDS)	2540C	100 mL	Plastic or Glass Bottle	Cool to 4°C	7 Days
Solids, Total Suspended (TSS)	2540D	100 mL	Plastic or Glass Bottle	Cool to 4°C	7 Days
Solids, Total (TS)	2540B	100 mL	Plastic or Glass Bottle	Cool to 4°C	7 Days
Solids, Total Volatile (TVS)	160.4	100 mL	Plastic or Glass Bottle	Cool to 4°C	7 Days
Solids, Settleable (SS)	160.5	100 mL	Plastic or Glass Bottle	Cool to 4°C	48 Hours
Turbidity	180.1	100 mL	Plastic or Glass Bottle	Cool to 4°C	48 Hours

Category	Methods	Minimum Quantity	Recommended Container(s)	Required Preservation	Holding Time
Conventional Inorganic Analyses					
Aqueous Samples					
Acidity	305.1	100 mL	Plastic or Glass Bottle	Cool to 4°C	14 Days
Alkalinity	2320B	100 mL	Plastic or Glass Bottle	Cool to 4°C	14 Days
Bromide	320.1	100 mL	Plastic or Glass Bottle	None	28 Days
Chloride	L10-117-07-1 A	50 mL	Plastic or Glass Bottle	None	28 Days
Chlorine, Total Residual	330.1-5	200 mL	Plastic or Glass Bottle	None	Immediately
Cyanide	4500-CN-E,G	500 mL	Plastic or Glass Bottle	Cool to 4°C Adjust pH >12 w/NaOH Remove Sulfide	14 Days
Fluoride	340.1-3	300 mL	Plastic Bottle Only	None	28 Days
Iodine	345.1	100 mL	Plastic or Glass Bottle	Cool to 4°C	24 Hours
Nitrogen, Ammonia	4500-NH3 C	400 mL	Plastic or Glass Bottle	Cool to 4°C Adjust pH <2 w/H_2SO_4	28 Days
Nitrogen, Total Kjeldahl	4500-NH3 C	500 mL	Plastic or Glass Bottle	Cool to 4°C Adjust pH <2 w/H_2SO_4	28 Days
Nitrogen Nitrate plus Nitrite	353.1-3	100 mL	Plastic or Glass Bottle	Cool to 4°C Adjust pH <2 w/H_2SO_4	28 Days
Nitrogen, Nitrate	L10-107-04-1-C	100 mL	Plastic or Glass Bottle	Cool to 4°C	48 Hours
Nitrogen, Nitrite	354.1	50 mL	Plastic or Glass Bottle	Cool to 4°C	48 Hours
Orthophosphate	4500P-E	50 mL	Glass Bottle Only	Filer (0.45υm) Cool to 4°C	48 Hours
Oxygen, Dissolved	360.1	300 mL	Glass Bottle Only	None	Immediately
Phosphorous, Total	L10-115-01-1-E	50 mL	Glass Bottle Only	Cool to 4°C Adjust pH <2 w/H_2SO_4	28 Days
Silica	370.1	50 mL	Plastic Bottle Only	Cool to 4°C	28 Days
Sulfate	D516-90	50 mL	Plastic or Glass Bottle	Cool to 4°C	28 Days
Sulfide	4500-S-F	500 mL	Plastic or Glass Bottle	Cool to 4°C Adjust pH >9 w/ NaOH, 2 mL Zinc Acetate	7 Days

Category	Methods	Minimum Quantity	Recommended Container(s)	Required Preservation	Holding Time
Conventional Organic Analyses					
Aqueous Samples					
Biochemical Oxygen Demand (5 Day BOD)	405.1	1 L	Plastic or Glass Bottle	Cool to 4°C	48 Hours
Chemical Oxygen Demand (COD)	410.1-4	50 mL	Plastic or Glass Bottle	Cool to 4°C Adjust pH <2 w/ H_2SO_4	28 Days
Organic Carbon, Total (TOC)	415.1	25 mL	Plastic or Glass Bottle	Cool to 4°C Adjust pH <2 w/H_2SO_4	28 Days
Phenolics	420.1-3	500 mL	Glass Bottle Only	Cool to 4°C Adjust pH <2 w/H_2SO_4	28 Days
Surfactants (MBAS)	5540C	250 mL	Plastic or Glass Bottle	Cool to 4°C	48 Hours
Bacterial Analyses					
Aqueous Samples					
Coliform Total and Fecal		100 mL	Whirlback Bag **OR** Sterilized Bottle	Cool to 4°C Remove Chlorine w/ Na_2S	6 Hours

Appendix D: Certifications and accreditations

Geolabs Inc. maintains certifications or accreditations with numerous states. At the time of this QA Plan revision, the laboratory has accreditations or certifications with the following organizations:

Organization	Certificate Number
Massachusetts DEP	M-MA-015
New York DOH NELAP	11796
Pennsylvania DEP NELAP	68-03417
New Jersey DEP NELAP	MA-009
Connecticut DPH	PH-0148
Rhode Island DOH	LA000252
Maine DHHS	2010018
New Hampshire ELAP-NELAP	250809

The certificates and parameter lists for each state may be found on the Geolabs website (www.geolabs.com) and in the QA office.

Technical Information

Reference Number: ASTM D 2216 – latest revision

Test Method Title: Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock Mass

Test Property: Moisture content

Test Specimen Size: As per test method based on maximum particle size

Number of Test Specimens: 1 or, as required by other testing representative based on type of sample:

Undisturbed: mix sample by hand or take random samples throughout test sample, combine and mix

Disturbed: take a representative cross-section of material for test

Test Equipment:
Oven capable of maintaining 60 or 110 ±5 °C
Balance readable to 0.01 gram with 200 gram capacity or readable to 0.1 grams with >200 gram capacity
Numbered specimen containers
Dessicator

Standard Operating Procedure

1. Determine and record mass of a clean, dry specimen container.

2. Select a representative test specimen based on largest particle size. Place moist test specimen into container. Determine and record mass of container and moist test specimen using proper balance based specimen size.

3. Place the container with moist specimen in the oven at 110 °C (unless highly organic, in which case use 60°C). Dry material to constant mass.

4. Once specimen has dried to constant mass, remove from oven and place into desiccator. Allow to cool to room temperature (or until container can be held comfortably in hands).

5. Measure and record mass of dried specimen and container with the same type of balance used to measure the before drying mass.

6. Calculate the moisture content of the material as follows:

$w = [(M_{cws} - M_{cs}) / (M_{cs} - M_c)] \times 100$

where:
w = moisture content, %
M_{cws} = mass of container and wet specimen, g
M_{cs} = mass of container and dry specimen, g

M_c = mass of container, g

7. Report: sample identification, moisture content of specimens to the nearest 0.1% or 1 % based on sample size used, description of material, temperature of drying oven if other than 110 °C, size and amount of material (if any) that was excluded from the test specimen.

Technical Information

Reference Number: ASTM D 2974

Test Method Title: Standard Test Method for Moisture, Ash and Organic Matter of Peat and Other Organic Soils

Test Property: Moisture content, ash content and organic matter

Test Specimen Size: Method A: at least 50 g

Number of Test Specimens: 1 (representative sample obtained by quartering; obtained quickly to avoid loss of moisture)

Test Equipment: Drying oven capable of maintaining 110 ± 5 °C, muffle furnace capable of maintaining 440 °C, balance readable to 0.01 grams with 500 gram capacity, numbered specimen porcelain containers, desiccator

Standard Operating Procedure

METHOD A

1. Determine and record mass of a clean, dry specimen porcelain container to the nearest 0.01 g.
2. Select a representative test specimen by quartering and selecting at least 50 g. Break up soft lumps with a spoon. Record mass to nearest 0.01 g.
3. Place the container with moist specimen in the oven at 105 °C. Dry material to constant mass.
4. Once specimen has dried to constant mass, remove from oven and place into desiccator. Allow to cool to room temperature (or until container can be held comfortably in hands).
5. Measure and record mass of dried specimen and container with the same type of balance used to measure the before drying mass.

METHOD C

6. Place oven dried specimen and porcelain container into a muffle furnace. Bring the temperature in the muffle furnace to 440 °C. Keep specimen in furnace until a constant mass is achieved.
7. Cool specimen and container in a desiccator then measure and record the mass to the nearest 0.01 g.
8. Calculate the moisture content of the material as follows:

$$w = [(A - B) \times 100] / B$$

where:

w = moisture content, %

A = mass of as-received test specimen, g

B = mass of oven dried test specimen, g

9. Calculate the ash content as follows:

   Ash content, % = 8 x 100) / B
   where:
   C = mass of ash, g
   B = mass of oven dried test specimen, g

10. Calculate the amount of organic matter as follows:

    Organic matter, % = 100.0 - D
    where:
    D = ash content, %

11. Report: results for organic matter and ash content to nearest 0.1%, furnace temperature used for ash content determinations, how moisture contents are determined (oven-dried mass), moisture content (oven-dried mass) to nearest 1% (below 100%), nearest 5% (between 100 and 500%), nearest 10% (between 500 and 1000%), or nearest 20% (over 1000%).

Technical Information

Reference Number:	ASTM D 422-latest revision
Test Method Title:	Test Method for Particle Size Analysis of Soils
Test Property:	Grain Size Analysis
Test Specimen Size:	Passing #10 sieve: 115 g sandy soils, 65 g silty or clayey soils Retained on #10 sieve: see test standard (based on largest particle size)
Number of Test Specimens:	1 representative sample obtained by quartering, mixing or splitting
Test Equipment:	Hydrometer (ASTM) Sedimentation Cylinder Stirring Apparatus (blender) Dispersion Cup Drying containers Balance readable to 0.01 gram for material passing #10 sieve or 0.1% of mass for material retained on #10 sieve Thermometer readable to 0.5 ºC Various sieves 250 mL beaker Drying oven capable of maintaining a temperature of 110 ± 5 ºC Dispersing agent mixture (40 g/L of Sodium Hexametaphosphate solution) Mechanical sieve shaker Distilled Water Spray Bottle Wash pan

Standard Operating Procedure

Sampling

1. Collect a representative sample and perform a moisture content test in accordance with ASTM D 2216.

2. Collect another representative sample to be used for the particle size analysis. Base specimen size on test standard (based on largest particle size). Record specimen wet weight.

Splitting / Washing sample on #200 sieve

3. Add 125 ml of dispersing agent into sample container. Stir well and allow to soak for at least 16 hours.

4. Rinse sample into dispersion cup and use stirring apparatus (blender) to further disperse sample for 1 minute.

5. Wash the test specimen from the dispersion cup, using distilled water, over the No. 200 sieve into a container. Be sure to collect all washings in the container. Use only 800 ml of distilled water for the washing operation.

6. Transfer the portion retained on the No. 200 into a tare and place in a drying oven.

7. Wash the minus No. 200 sieve material into a Sedimentation cylinder.

Sieve analysis of portion retained on #200 sieve

8. Separate the portion retained on #200 sieve into a series of fractions using various sieve sizes ranging from 3 inch to #200. Set up in mechanical shaker and shake for 10 minutes. Determine the mass retained on each sieve by weighing and recording mass to nearest 0.1 % of sample mass.

Hydrometer analysis of portion passing #200 sieve

9. Add distilled water to the1000 mL point. Place a rubber stopper over the open end and turn the cylinder upside down and back for a period of 1 minute (should be 60 turns per minute). Set the cylinder down, remove stopper and wash any adhering soil into the cylinder. Begin to take and record hydrometer readings at the following intervals: 2, 5, 15, 30, 60,120, 240 and approximately 1440 minutes. After each reading, the temperature of the solution should be recorded.

10. Calculations: Use initial moisture content and initial wet weight of test specimen to calculate initial dry weight of test specimen. Use reporting software to enter data and calculate % passing and retained for each sieve size and hydrometer readings.

11. Report: sample identification, sample description, percentage passing or retained on each sieve fraction (tabular and graphical).

Attachment B

Sediment Core Photographic Log

SC-1 A
February 17, 2011

SC-1 B
February 17, 2011

SC1-2 A
February 17, 2011

SC1-2 B
February 17, 2011

SC1-3 A
February 17, 2011

SC1-3 B
February 17, 2011

SC1-3 C
February 17, 2011

SC2-1 A
February 17, 2011

SC2-1 B
February 17, 2011

SC2-1 C
February 17, 2011

SC2-2 A
February 17, 2011

SC2-2 B
February 17, 2011

SC2-2 C
February 17, 2011

SC2-3 A
February 17, 2011

SC3-1 A
February 17, 2011

SC3-2 A
February 17, 2011

SC3-2 B
February 17, 2011

SC3-2 C
February 17, 2011

SC3-2 D
February 17, 2011

SC3-3 A
February 17, 2011

SC3-3 B
February 17, 2011

SC3-3 C
February 17, 2011

SC4-1 A
February 17, 2011

SC4-2 A
February 17, 2011

SC4-3 A
February 17, 2011

SC2-1 A
September 2, 2011

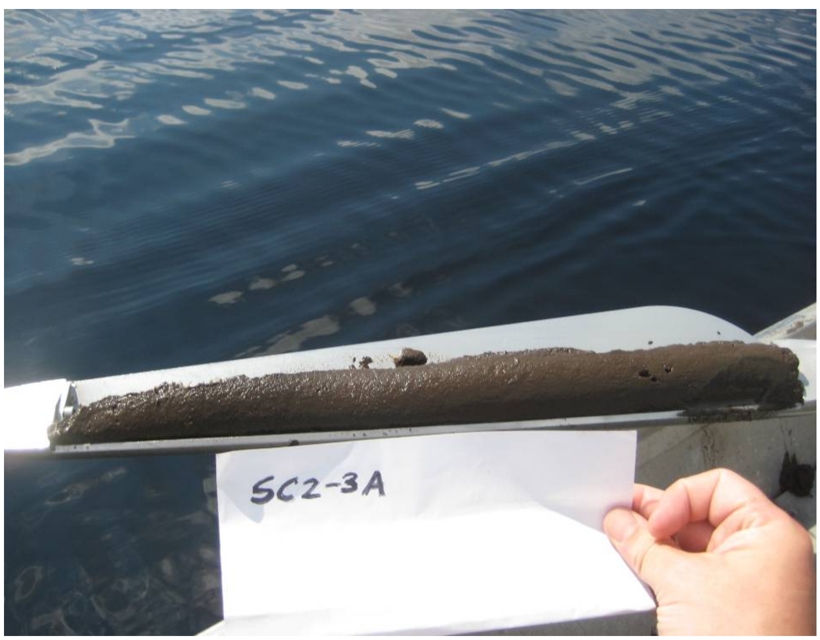
SC2-1 B
September 2, 2011

SC2-1 C
September 2, 2011

SC2-2 A
September 2, 2011

SC2-2 B
September 2, 2011

SC2-2 C
September 2, 2011



SC2-3 A
September 2, 2011

Attachment C

Watershed Assessment Results

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Attachment D

Hydrologic Budget and Nutrient Load Model

www.essgroup.com

Warner's Pond Water Quality Sampling Locations & Watershed Assessment Results

Tributary Assessment/Sampling Locations

SITE	W-19, Fort Pond Brook (Sampling Station ID = WP-1)
LOCATION	Access off Route 2 East. Pull-off available at railroad track crossing or further down Route 2.
DESCRIPTION	Fort Pond Brook inlet at Route 2. Sample just upstream of confluence with Nashoba Brook. High potential to contribute sediment to Warner's Pond from upstream sources.

SITE	W-20, Nashoba Brook (Sampling Station ID = WP-2)
LOCATION	Access off Route 2 East. Pull-off available at railroad track crossing or further down Route 2. Same access point as W-19.
DESCRIPTION	Nashoba Brook inlet at Route 2. Sample just below Route 2 bridge crossing and upstream of junction with Fort Pond Brook. High potential to contribute sediment to Warner's Pond from upstream sources.

SITE	W-16, Warner's Pond Outlet (Sampling Station ID = WP-3)
LOCATION	Access from Law's Brook Road.
DESCRIPTION	Outlet of Warner's Pond, just upstream of the dam. Access from open grassy area.

SITE	WP-4A, Coles Brook just upstream of confluence with Fort Pond Brook (Sampling Station ID = WP-4)
LOCATION	Access from Law's Brook Road.
DESCRIPTION	Coles Brook discharges to Fort Pond Brook at corner of Law's Brook Road and School Street. Coles Brook watershed drains portions of Route 2, and very large impervious surface area associated with Adesa Corporation facility at Route 2 and Hosmer Road. Two stormwater outfalls discharge to Coles Brook at this location. Sample downstream of bridge and outfalls. High potential to contribute sediment.

SITE	W-21, Nashoba Brook at unnamed bridge crossing (Sampling Station ID = WP-5)
LOCATION	An unnamed street that leads to Teamworks facility crosses Nashoba Brook at this location. The street is just south of Weatherbee Road.
DESCRIPTION	Highest potential sediment load occurs from this location up to the dam at Concord Road. Numerous businesses on Rt 2A line river bank with little buffer. Landscaping business at this location; other light industrial and commercial businesses upstream.

Non-Point Source Assessment/Sampling Locations – Stormwater Outfalls

Sample ID	Photo	Description and Notes
W-10		• Access from small open space area on east side of Wright Road and walk south • W-10 drains catch basins on Wright Road • Flow during dry weather survey from melting snow • Slightly turbid • Discharges to scrub-shrub wetland
W-11		• Access from small open space area on east side of Wright Road and walk north • 24" RCP with historic stone headwall • Discharges to scrub-shrub wetland • Low flow from snow melt during dry weather survey
W-12		• Access from end of Wright Road and follow trail east behind homes • 24" RCP with historic stone headwall • Discharges to scrub-shrub wetland • Slight flow from snow melt during dry weather survey
W-14		• Park at Warner's Woods and access from Law's Brook Road • Follow pond shoreline up through woods • 24" RCP with historic stone headwall • High dry weather flow during survey • No odors or sheens detected to suggest illicit connection; flow likely due to groundwater and snowmelt

W-15		• Access on Law's Brook Road, park at Warner's Woods visitor spot • 2 outfalls – one 12" RCP, one 36" Corrugated Metal pipe • Drains road runoff
W-17		• Access from prison parking facility, walk along treeline and follow trail past cemetery through woods to outfall • 36" RCP with low flow during dry weather survey from snowmelt • Slight sheen on water • See AECOM figure of drainage • Drains Rt 2 runoff – discharges directly to pond with no wetland buffer • See GeoSyntec Report for past results • High priority sampling location
W-23		• Outfall drains catch basins along Weatherbee Road • Light industry nearby • No flow during dry weather survey but likely runs during wet weather

Selection of Other Key Areas Investigated During Watershed Assessment

Location ID	Photo	Description and Notes
W-1		• Road cut along Route 111 • Sediment from road discharges to Guggins Brook, a tributary of Fort Pond Brook • Culvert under road is blocked
W-1A		• Fort Pond Brook at Central Avenue, West Acton • Road cut with moderate sediment deposition on the roadway
W-3		• Catch basins along Route 111 in West Acton • Moderate sediment deposition on the roadway • Catch basins likely drain to Fort Pond Brook
W-6		• Pratt Brook crossing at Main Street near south Acton • Moderate sediment deposition on the roadway • Large impervious surfaces associated with parking area adjacent to brook and car dealership further north

W-7		• Fort Pond Brook at Main Street in South Acton • Large parking area at the commuter rail station is located in proximity to the brook, a potential sediment source
W-9		• Catch basins along Wright Road discharge sediment load from the street to Warner's Pond via the outfalls on the pond's western shore
W-13		• 12" Corrugated Plastic Pipe outfall that drains road runoff from Laws Brook Road • Outfall discharges to forested area and not directly into Warner's Pond; sediment load attenuated by forested buffer • Not recommended for water quality sampling
W-18		• Agricultural fields along Route 2 and School Street • Potential source of nutrient loading to Warner's Pond

W-22	 	• Eastern bank of Nashoba Brook along Route 2A/Route 119 • This stretch of brook is a sediment-loading hotspot; there are numerous businesses and parking lots along the bank with little forested buffer • Steep eroding banks in this area likely contribute heavy sediment load
W-23		• Weatherbee Road Crossing of Nashoba Brook near Route 2A • Numerous business and light industrial areas contribute sediment to the brook along this reach
W-24		• Nashoba Brook at Concord Road with view of dam downstream of Ice House Pond • A proportion of the sediment within the brook likely settles out in front of the dam

W-25		• Nashoba Brook at Brook Street • Road cuts on upstream and downstream side of the brook at this location with moderate sediment load in the roadway • Heavy commercial development to east on Rt 2A/Route 119
W-26		• Example of some of the commercial development along Route 2A/Route 119 located to the east of Nashoba Brook • Although this area is a potential source of sediment, much of it is likely attenuated before it reaches the pond given the distance to the pond and presence of dams downstream
W-28		• Nagog Brook at Route 27 • Newly installed box culvert • Surrounding area is less developed than southern portion of the watershed • Light sediment deposition on the roadway
W-30		• Conant Brook at Nagog Road • Rural area of the watershed • No catch basins on the roadway • Surrounding area has no obvious sources of sediment loading to Warner's Pond

W-32		• Grassy Pond Brook at Arlington Street • Large church parking area adjacent to the brook is a potential sediment source

Location: G:/GIS-Projects/Warners-Pond/00-mxd/Wtrshd_Assessment.mxd

WARNER'S POND WATERSHED MANAGEMENT PLAN
Concord, Massachusetts

ess group
environmental consulting & engineering services

Scale: 1" = 3000'

0 3,000 Feet

Source: 1) MassGIS, Orthophotos, 2008
2) ESS, Watershed Assessment Results, 2011

Legend

Assessment Locations

Sediment Source Potential

- Low
- Medium
- High
- Pond Watershed

Watershed Assessment Results

Figure 1

Warner's Pond - HYDROLOGIC ASSESSMENT

									Source:
Watershed for Warner's Pond =		29,848.9	acres		1,300,219,222	SF	47	mi2	ESS delineation based on MassGIS USGS topos
Pond Area		48.8	acres		2,123,595	SF	197,288	meters2	ESS, 2011, calculation in GIS
Area of Watershed - Pond Area		29,800.2	acres		1,298,095,627	SF			
Lake Circumference		15,224.7	feet						ESS, 2011, calculation in GIS
Lake Volume		7,213,848.5	cubic feet				204,273.5	meters3	ESS, 2011, calculation based on GIS and field data
Area influenced by seepage		152,247.4	ft2	=	14,144	m2			ESS estimate derived from pond circumference
Groundwater (data)		2	l/m2/day	=	0.071	cf/m2/day			ESS estimate based on unpublished data
				=	998.6	cf/day			Calculation
				=	0.012	cfs			Calculation
Annual PPT/yr		45.79	inches						Mean of Worcester/Logan Airport 30 year records
Annual PPT - ET	30.68	2.56	ft/yr		0.17	cfs			Precip on pond minus regional ET
Runoff (watershed)	15.11	1.26	ft/yr		51.83	cfs			Calculation
Base Flow (Streams) as measured during dry weather - Average =					34.60	cfs			Sum of Nashoba and Fort Pond Brook estimates
		Nashoba Brook	16.0						StreamStats, D60 Flow, modeled at Nashoba Brook downstream of Rt.2
		Fort Pond Brook	18.6						StreamStats, D60 Flow, modeled at Fort Pond Brook downstream of Rt.2

	Ground	PPT	Surfacewater	Total
Dry	0.012	0.000	34.600	34.612
Wet	0.000	0.172	51.833	52.005
Total	0.012	0.172	86.433	86.616 cfs

Estimated range of total annual input into lake:
(1.5 to 2 cfs/sq mi of watershed) =
69.96 to 93.28 cfs

Warner's Pond, Concord, Massachusetts - Existing Conditions

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	58	Enter Value	
L	Phosphorus Load to Lake	g P/m2/yr	From hydro & sub-watershed model	22.75	Enter Value	Assumes 100%
TPin	Influent (Inflow) Total Phosphorus	ppb	From data	39	Enter Value	
TPout	Effluent (Outlet) Total Phosphorus	ppb	From data	40	Enter Value	
I	Inflow	m3/yr	From data	77348431	Enter Value	
A	Lake Area	m2	From data	197288.4	Enter Value	
V	Lake Volume	m3	From data	204273.5	Enter Value	
Z	Mean Depth	m	Volume/area	1.035405		
F	Flushing Rate	flushings/yr	Inflow/volume	378.6514		
S	Suspended Fraction	no units	Effluent TP/Influent TP	1.025641		
Qs	Areal Water Load	m/yr	Z(F)	392.0577		
Vs	Settling Velocity	m	Z(S)	1.061954		
R	Retention Coefficient (from TP)	no units	(TPin-TPout)/TPin	-0.025641		
Rp	Retention Coefficient (settling rate)	no units	((Vs+13.2)/2)/(((Vs+13.2)/2)+Qs)	0.017864		
Rlm	Retention Coefficient (flushing rate)	no units	1/(1+F^0.5)	0.048878		

THE MODELS

NAME	FORMULA	PREDICTION CONC. (ppb)	PREDICTION LOAD (g/m2/yr)
Mass Balance	TP=L/(Z(F))*1000	58	
(minimum load)	L=TP(Z)(F)/1000		22.74
Kirchner-Dillon 1975	TP=L(1-Rp)/(Z(F))*1000	57	
(K-D)	L=TP(Z)(F)/(1-Rp)/1000		23.15
Vollenweider 1975	TP=L/(Z(S+F))*1000	58	
(V)	L=TP(Z)(S+F)/1000		22.80
Reckhow 1977 (General)	TP=L/(11.6+1.2(Z(F)))*1000	60	
(Rg)	L=TP(11.6+1.2(Z(F)))/1000		27.96
Larsen-Mercier 1976	TP=L(1-Rlm)/(Z(F))*1000	55	
(L-M)	L=TP(Z)(F)/(1-Rlm)/1000		23.91
Jones-Bachmann 1976	TP=0.84(L)/(Z(0.65+F))*1000	49	
(J-B)	L=TP(Z)(0.65+F)/0.84/1000		27.12
Average of Model Values		56	
(without mass balance)			24.99
Reckhow 1977 (Anoxic)	TP=L/(0.17(Z)+1.13(Z(F)))*1000	51	
(Ra)	L=TP(0.17(Z)+1.13(Z(F)))/1000		25.71
From Vollenweider 1968			
Permissible Load	Lp=10^(0.501503(log(Z(F)))-1.0018)		1.99
Critical Load	Lc=2(Lp)		3.98

LOAD ANALYSIS

MODEL	ESTIMATED LOAD (kg/yr)	ESTIMATED LOAD (mg/L)
Phosphorus		
Mass Balance (no loss)	4486	
Kirchner-Dillon 1975	4568	
Vollenweider 1975	4498	
Reckhow 1977 (General)	5516	
Larsen-Mercier 1976	4717	
Jones-Bachmann 1976	5350	
Model Average		
(without mass balance)	4930	0.0637
Reckhow 1977 (Anoxic)	5071	
Permissible Load	393	0.0051 Permissible Conc.
Critical Load	785	0.0101 Critical Conc.

PREDICTED WATER CLARITY

PREDICTED CHL AND WATER CLARITY

MODEL	Value
Mean Chlorophyll (ug/L)	
Dillon and Rigler 1974	24.7
Jones and Bachmann 1976	28.7
Oglesby and Schaffner 1978	29.0
Modified Vollenweider 1982	26.5
"Maximum" Chlorophyll (ug/L)	
Modified Vollenweider (TP) 1982	87.1
Vollenweider (CHL) 1982	86.4
Mod. Jones, Rast and Lee 1979	92.9
Secchi Transparency (M)	
Oglesby and Schaffner 1978 **(Avg)**	1.1
Modified Vollenweider 1982 **(Max)**	3.2

ADDENDUM FOR NITROGEN

SYMBOL	PARAMETER	UNITS	DERIVATION	VALUE		
TN	Lake Total Nitrogen Conc.	ppb	From data or model	1287	Enter Value	
L	Nitrogen Load to Lake	g N/m2/yr	From data or model	504.75	Enter Value	Assumes 100%
C	Coefficient of Attenuation	fraction/yr	2.7183^(0.5541(ln(F))-0.367)	18.58767		

NAME	FORMULA	PREDICTION CONC. (ppb)	PREDICTION LOAD (g/m2/yr)
Mass Balance	TN=L/(Z(F))*1000	1287	
(minimum load)	L=TN(Z)(F)/1000		504.58
Bachmann 1980	TN=L/(Z(C+F))*1000	1227	
	L=TN(Z)(C+F)/1000		529.35

MODEL	ESTIMATED LOAD (kg/yr)	ESTIMATED LOAD (mg/L)
Nitrogen		
Mass Balance (no loss)	99547	
Bachmann 1980	104434	1.35 (check - av in pond nitrogen concentration - mg/L)

Average Annual Nutrient Load by Land Use within the Warner's Pond Watershed

Sub-basin	Land Use Classification	Acres	P load rate (kg/ha/yr)	P Load rate (kg/acre/yr)	Phosphorus Load (kg/yr)	Percentage of Phosphorus Load	N load rate (kg/ha/yr)	N Load rate (kg/acre/yr)	Nitrogen Load (kg/yr)	Percentage of Nitrogen Load
Fort Pond Brook	Cropland and Pasture	653.1	0.50	1.24	806.9	6%	5.0	12.35	8069.0	6%
	Currently Developed (Residential/Commercial)	4363.2	1.00	2.47	10781.3	76%	5.0	12.35	53906.6	38%
	Forest	7562.7	0.08	0.19	1401.5	10%	3.0	7.41	56061.2	40%
	Open/Cleared Land	210.0	0.10	0.25	51.9	0%	3.0	7.41	1556.9	1%
	Transportation	195.2	1.00	2.47	482.4	3%	5.0	12.35	2412.0	2%
	Water	282.5	0.00	0.00	0.0	0%	0.0	0.00	0.0	0%
	Wetland	2656.7	0.10	0.25	656.5	5%	3.0	7.41	19694.1	14%
	Preliminary Total Annual Nutrient Load				14180.5				141699.8	
	Attenuation Coefficient (% of load reaching lake)				20%				39%	
	Sub-basin Contribution (%)				52%				53%	
	Adjusted Total Annual Nutrient Load				2836.1				55262.9	
Nashoba Brook	Cropland and Pasture	574.3	0.50	1.24	709.5	6%	5.0	12.35	7095.1	6%
	Currently Developed (Residential/Commercial)	3633.2	1.00	2.47	8977.5	77%	5.0	12.35	44887.6	38%
	Forest	6777.3	0.08	0.19	1256.0	11%	3.0	7.41	50239.5	43%
	Open/Cleared Land	414.9	0.10	0.25	102.5	1%	3.0	7.41	3075.9	3%
	Transportation	97.3	1.00	2.47	240.5	2%	5.0	12.35	1202.7	1%
	Water	386.9	0.00	0.00	0.0	0%	0.0	0.00	0.0	0%
	Wetland	1575.0	0.10	0.25	389.2	3%	3.0	7.41	11675.4	10%
	Preliminary Total Annual Nutrient Load				11675.3				118176.2	
	Attenuation Coefficient (% of load reaching lake)				20%				39%	
	Sub-basin Contribution (%)				43%				44%	
	Adjusted Total Annual Nutrient Load				2335.1				46088.7	
Warner's Pond	Cropland and Pasture	54.1	0.50	1.24	66.8	14%	5.0	12.35	668.4	16%
	Currently Developed (Residential/Commercial)	145.9	1.00	2.47	360.6	73%	5.0	12.35	1802.8	43%
	Forest	151.6	0.08	0.19	28.1	6%	3.0	7.41	1123.7	27%
	Open/Cleared Land	3.1	0.10	0.25	0.8	0%	3.0	7.41	22.7	1%
	Transportation	10.0	1.00	2.47	24.8	5%	5.0	12.35	124.0	3%
	Water	46.3	0.00	0.00	0.0	0%	0.0	0.00	0.0	0%
	Wetland	55.6	0.10	0.25	13.7	3%	3.0	7.41	412.1	10%
	Preliminary Total Annual Nutrient Load				494.8				4153.5	
	Attenuation Coefficient (% of load reaching lake)				50%				70%	
	Sub-basin Contribution (%)				5%				3%	
	Adjusted Total Annual Nutrient Load				247.4				2907.5	

Notes: Phosphorus export coefficients based on median value predicted by Reckhow (1980), Lin (2004), Rast and Lee (1978)

Attachment E

2011 Project Completion Report
SONAR Herbicide Treatment at Warner's Pond

www.essgroup.com

2011 Project Completion Report
SONAR Herbicide Treatment Program at Warner's Pond
Concord, Massachusetts

Report Prepared by: Aquatic Control Technology, Inc.
11 John Road
Sutton, MA 01590

Report Prepared for: Bill Straub P.E., CMA Engineers
Delia Kaye, Director, Concord Division of Natural Resources
William J. Renault, Jr. P.E., Town Engineer, Concord Public Works, Engineering Division

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Introduction

In 2010 a treatment program using Sonar AS & Sonar One herbicides was conducted at Warner's Pond to control growth of non-native, invasive fanwort (*Cabomba caroliniana*) and variable watermilfoil (*Myriophyllum heterophyllum*). The Project Completion Report for the 2011 Sonar Herbicide Treatment Program follows. This report will serve to document the herbicide application process and the observed response of the targeted weeds. Attached to this report are several figures and supporting documentation that further help to explain the project and the observed results.

All work performed at Warner's Pond in 2011 was conducted in accordance with the Order of Conditions (OOC) issued by the Concord Natural Resources Commission (DEP # 137-895), Water Quality Certification – DEP File # 137-895, U.S. Army Corp of Engineers Permit # 2006-2088 and the License to Apply Chemicals issued by the MA DEP – Office of Watershed Management (# 11202).

A chronology of this past year's management and brief description of events follows.

2011 Program Chronology

- DEP License to Apply Chemicals Issued 5/19/11
- Early Season Vegetation Survey 5/20/11
- Initial Sonar Application 6/3/11
- Collection of FasTEST Immunoassay samples 6/22/11
- First Follow-up Sonar Application 7/7/11
- Collection of FasTEST Immunoassay samples 7/26/11
- Mid-Treatment Inspection 7/26/11
- Second Follow-up Sonar Application 8/10/11
- Late Season Vegetation Survey 9/2/11

Pre-Treatment Survey

A pre-treatment survey of Warner's Pond was conducted on May 20, 2011 to document pre-treatment aquatic plant composition and distribution. The survey methodology used was consistent with surveys performed in 1999, 2003 and 2004 and utilized the same transects and data points established in 1999. In total eight transects and 66 data points were surveyed.

The following information was recorded at each data point: water depth, sediment type, overall cover index, biovolume, dominant aquatic plant species and present aquatic plant species. Plant cover and the percent area occupied by plants was estimated in two-dimensions using a semi-quantitative scale. Cover index was assigned as follows: areas with no plants were assigned a value of 0; areas were assigned 1 where plant coverage was approximately 1-25%; 2 for 26-50%; 3 for 51-75% coverage and 4 for 76-100% coverage. Overall biovolume was estimated based on the relative volume of each plant of the community at each point. The biovolume index ranges from 0-4 according to the following breakdown: 0 – no plants, 1 – plants generally low-growing within a foot of the bottom, 2 – plants generally half-way through the water column, 3 – plants within 1-2 feet of the surface, 4 – plants just below or at the surface.

A map depicting transect and data point locations (Figure 1) as well as the data collected on 5/20/11 are attached to this report. This data was provided to the Town in advance of the initial Sonar application in 2011. A formal discussion of the data and the data collected during the post treatment survey performed by ESS Group and ACT, Inc. will be presented in a separate report prepared by ESS Group.

Pre-Treatment Conditions

At the time of the pre-treatment survey (5/20/11) plant growth in the pond was fairly advanced but had not topped-out allowing for good access to most areas of the pond. Fourteen different aquatic species were identified during the course of the survey (see attached Field Data), however the vegetative composition was generally dominated by three species namely fanwort, variable watermilfoil and coontail (*Ceratophyllum demersum*).

Fanwort was the most widely distributed plant in the pond and was documented at 45 (68%) of the 66 surveyed data points. In most locations growth of fanwort was secondary in abundance to cover of coontail and/or variable watermilfoil. Coontail was the most abundant plant in the pond and formed a dense blanket throughout the shallower areas of the pond. While it was only the dominant species at 19 of the 37 locations where documented, coontail cover was dense throughout the northern, "open water" portion of the pond. Variable watermilfoil was also well distributed and was recorded at 31 (47%) of the data points surveyed. At the time of the survey growth both coontail and variable watermilfoil was more advanced than the observed fanwort growth and was in most areas within only a few inches to a foot of the surface; fanwort by contrast was lower growing and was generally only visible with the use of an underwater camera system. Cover of curlyleaf pondweed was also advanced at the time of the survey and was the only species that was growing to the top of the water column. Growth of curlyleaf pondweed was low-density and was typically tertiary of quaternary in abundance but was well distributed and was identified at 25 (38%) of the surveyed data point locations.

Cover of other aquatic plants was fairly limited however other species of note include: flat-stem pondweed (*Potamogeton zosteriformis*) which was documented at 25% of the data point locations; white waterlily (*Nymphaea odorata*) at 35%; and, yellow waterlily (*Nuphar variegatum*) at 30%.

Treatment Summary

Consistent with the proposed treatment scope provided to the Town on March 4, 2011 the 25 acre "open water" area of Warner's Pond was treated with Sonar (active ingredient fluridone) herbicide for control of fanwort (*Cabomba caroliniana*) and variable watermilfoil (*Myriophyllum heterophyllum*). Sonar effectively controls both species at low concentrations (<20 ppb) provided that herbicide contact-time with the targeted plants is maintained for 60-90 days. Two formulations of Sonar herbicide [SonarOne (pellet) - EPA Reg. No. 67690-45 and

Sonar AS (liquid) – EPA Reg. No. 67690-4] were applied on three separate occasions. A map depicting the extent of the treatment area is attached to the end of this report (Figure 2)

A complete summary of the treatment program is provided below:

Herbicide Applications:

Date	Product Applied	Estimated Concentration (ppb) applied	Comments
6/3/11	SonarOne – 300 lbs.	50 ppb in treatment area ~33 ppb lakewide	• Water level estimated to be 0.5-1.0-foot above normal/full pool • Fanwort and milfoil plants had 3-4 feet of new growth at the time of the initial treatment
7/7/11	SonarOne – 180 lbs Sonar AS – 5.0 qts.	50 ppb in treatment area ~33 ppb lakewide	• Considerable rainfall and outflow occurred between 1st and 2nd treatments • Small amount of chlorosis (whitening) noticeable on fanwort and white waterlily
8/10/11	SonarOne – 110 lbs Sonar AS – 3.0 qts.	30 ppb in treatment area ~20 ppb lakewide	• Considerable chlorosis evident on fanwort and milfoil, but plants remain upright in the water column • Waterlilies showing signs of chlorosis, but plants were still viable • Pondweeds and all emergent species (pickerelweed, rushes, cattails, woody shrubs, etc) seen in adjacent wetlands were not showing any signs of chlorosis
TOTALS	SonarOne – 590 lbs Sonar AS – 8.0 qts.	130 ppb in treatment area ~86 ppb lakewide	• Totals for all three applications

Herbicide applications were conducted by Aquatic Control using an airboat. The SonarOne pellet formulation was applied using a calibrated spreader mounted on the bow of the airboat. The Sonar AS liquid formulation (used during the 7/7/11 & 8/10/11 applications) was diluted with pond water and injected subsurface through weighted hoses using a calibrated pumping system. The treatment area was preloaded into a GPS unit that was used for real-time navigation during each treatment to insure that the herbicide was applied accurately. The GPS treatment track recorded during the initial application on 6/3/11 is depicted in Figure 2 attached to this report.

Prior to all applications notification of the treatment was submitted to the Town and posters warning of the temporary water restrictions to be imposed following treatment were posted along the shoreline of the pond.

FasTEST Immunoassay samples were collected twice during the course of the treatment to help assist in the timing and dosing of subsequent Sonar applications. Sample Site 1 was located in the open-water area at the north end of the pond. Sample Site 2 was located between the boat launch and Boy Scout Island. FasTEST samples were collected by ACT, Inc. and shipped to the SePRO Laboratory in Whitakers North Carolinian via overnight mail for analysis. Results from the FasTEST samples were used to guide timing of subsequent Sonar applications to ensure that lethal concentrations of fluridone were maintained in the pond for a minimum of 60 days. Results from the four samples collected at Warner's Pond in 2011 are below. Laboratory reports from SePRO are attached.

Warner's Pond FasTEST Results:

Warner's Pond	6/22/2011	7/26/2011
Sample Site 1	8.4 ppb	4.9 ppb
Samples Site 2	11.5 ppb	3.3 ppb

Results/Discussion

Fanwort and milfoil plants in the treatment area showed signs of fluridone exposure soon after the initial treatment and clorosis or bleaching was evident at the time of the first FasTEST sample collection on 6/22/11. While both fanwort and variable watermilfoil plants in the treatment area remained in the water column well into early August, chlorosis persisted and progressed throughout the summer. By the time of the final application fanwort in the pond was bleached white in the upper 6-10 inches of the plant and variable watermilfoil had collapsed out of the water column. Coontail was slow to develop signs of fluridone exposure but was exhibiting some slight chlorosis at the time of the second FasTEST sample collection on 7/26/11. This slow progression is typical with coontail and has been observed at many other waterbodies treated with fluridone.

By the time of the post-treatment survey conducted on 9/2/11, fanwort, variable watermilfoil and coontail were all heavily impacted in the treatment area and only low-density, severely damaged coontail existed within the designated 25-acre treatment area. While fanwort and variable watermilfoil were visible and even abundant outside the treatment area, especially west of Boy Scout Island, little to no growth was found within treated areas. Some thinning of waterlilies (*Nymphaea* & *Nuphar*) was evident in the treated portion of the pond and what remained floating showed signs of chlorosis (yellowing around their edges); however and estimated 50% of the waterlilies remained. Waterlily coverage outside of the treatment areas appeared untouched by treatment save for some slight discoloration in some of the waterlily pads towards the edge of the treated area.

Overall the treatment performed in 2011 appears to have provided excellent control of both fanwort and variable watermilfoil in the designated treatment area, while also providing suppression and thinning of the native coontail and waterlily growth. We would expect to see nuisance-level fanwort control throughout the 2012 and possibly the 2013 seasons within the treated areas. Variable milfoil often recovers more rapidly following treatment with Sonar herbicide, but control through the 2012 season is anticipated. The native waterlily and coontail growth usually recovers more rapidly than the invasive fanwort and milfoil, but thinned-out populations of these plants should persist throughout the 2012 season.

Warner's Pond will continue to suffer from problematic aquatic weed growth. The presence of fanwort in the western (inflow) portion of the pond, high water flows, and mucky bottom sediments will limit the duration of control that can be achieved using Sonar (fluridone) herbicide. Herbicides with a faster mode of action may be more appropriate for partial pond treatments in the future.

Enclosures: Data Point/Transect Map
Field Survey Data – 5/20/11
DEP License to Apply Chemicals
2011 Treatment Map
FasTEST laboratory reports
Photo-documentation

Warners Pond
Concord, Ma

Data Point Locations

FIGURE:	SURVEY DATE:	MAP DATE:
1	5/20/11	7/5/11

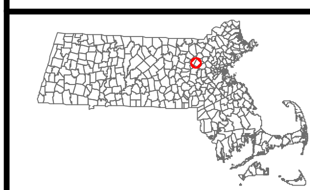
Legend:

● Data Point Locations surveyed on 8/6 & 8/9/99 and 5/20/11

N

0 62.5 125 250 Feet

AQUATIC CONTROL TECHNOLOGY, INC.
11 JOHN ROAD
SUTTON, MASSACHUSETTS 01590
PHONE: (508) 865-1000
FAX: (508) 865-1220
WEB: WWW.AQUATICCONTROLTECH.COM



Transect Number & Sampling Point	Water Depth	Sediment Type	Cover Index	Biovolume	Cd	Mh	Pc	Cc	Pz	Ny	Nu	Poly	Dec	U	Ni	Fa	Cal	Ec
A 1	4.5	M/S	2	2	D		X	X		X			X					
2	9	M	0	0														
3	11	M	0	0														
4	10.5	M	0	0														
5	7.3	M	1	3	D	X	X	X		X								
6	5	M	2	3	D	X	X	X		X								
B 1	4.5	M	3	4	X	D	X	X		X								
2	5	M	2	2	X	D	X				X							
3	9.1	M	0	0														
4	7.8	M	1	2	D	X	X											
5	6.1	M	2	2	X	X	D	X										
6	9.5	M	0	0														
7	6.5	M	2	1	X		X	D		X								
C 1	3.5	M	2	3		X		X				X	D					
2	4	M	2	2	X	X		X	X	X		X						
3	4	M	3	3	D	X	X	X	X		X							
4	5.5	M	3	2		D	X	X	X									
5	5	M	3	3	X	D	X	X	X		X							
6	5.5	M	4	3	D		X	X			X							
7	6.5	M	2	2	D		X	X										X
8	6	M	2	1	D			X										X
9	6.5	M	3	2	D		X	X										
10	5.5	M	2	2	D	X	X	X	X									
D 1	3.5	M/S	3	2		D				X								
2	3.5	M	4	2		D			X		X							
3	4.5	M/S	3	3		X		D	X	X	X							
4	6	M	2	1		X		D	X									
5	5	M	3	2	D	X	X	X	X						X			
6	5	M	4	3	D	X			X		X							
7	3	M/S	2	2	D	X		X	X		X							
8	5.5	M	3	2	D		X	X										
9	5.3	M	3	2	D		X	X			X						X	
10	6	M	3	2	D	X	X											
E 1	3.5	M	3	2		X		X			D				X	X		
2	4.5	M	3	3	X	X		X	X	X	D				X	X		
3	4.5	M	4	3		D		X			X							
4	4	M	3	3				X		X	X	X	D					

Transect Number & Sampling Point	Water Depth	Sediment Type	Cover Index	Biovolume	Cd	Mh	Pc	Cc	Pz	Ny	Nu	Poly	Dec	U	Ni	Fa	Cal	Ec
5	4	M	2	2	X	D		X	X									
6	5.5	M	3	2	X	D		X										
7	6	S	3	2	D													
8	6	M	2	2	D	X	X			X								
F 1	3.5	M	1	1				X		X	X	X	D					
2	2	M	3	2				X		D	X							
3	4	M	3	3				X	D	X								
4	2.5	M	2	2						X	X	X	D					
5	3.2	M	2	1	D			X										X
6	6.1	M	2	1	X		X	D			X							
7	7.5	M	2	1				D										
G 1	4	M	2	2				X		D								
2	4.5	M	3	3		X		X		D	X							
3	2.5	M	3	2				X		D				X				
4	4.5	M	3	3		X		D	X	X				X				
5	4.8	M	3	3	X	X		D	X	X	X			X				
6	4.5	M	4	3	X	X		D		X	X			X				
7	5	M	4	3	X	D	X	X										
8	5.5	M	2	2	X			D										
9	5	M	1	1	X		X	D	X	X								
H 1	7	R/S	0	0														
2	4	M	3	2	X		X	D		X								
3	6	M/S	1	1											D			
4	7	S/G	1	1	X		X	D										
5	8	S/G	0	0														
6	8.5	S/G	0	0														
7	5	9	1	1	X										D			
8	4	R/G	0	0														
Average	5.4		2.2	1.8														

	Cd	Mh	Pc	Cc	Pz	Ny	Nu	Poly	Dec	U	Ni	Fa	Cal	Ec
Present	18	21	24	33	16	19	18	5	1	4	3	2	1	3
Dominant	19	10	1	12	1	4	2	0	4	0	2	0	0	0
Total	37	31	25	45	17	23	20	5	5	4	5	2	1	3
% frequency	56%	47%	38%	68%	26%	35%	30%	8%	8%	6%	8%	3%	2%	5%

Cd: Ceratopohyllum demersum
Mh: Myriophyllum heterophyllum
Pc: Potamogeton crispus
Pz: Potamogeton zosteriformis
Ny: Nymphaea odorata
Nu: Nuphar variegatum
Poly: Polgonum sp.
Dec: Decadon sp.
U: Utricularia sp.
Ni: Nitella sp.
Fa: Filamentous algae
Cal: Callitriche
Ec: Elodea canadensis
Pn: Potamogeon natans (observed, not at data point)
Ms: Myriophyllum spicatum (observed, not at data point)

MassDEP

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

Central Regional Office • 627 Main Street, Worcester MA 01608 • 508-792-7650

DEVAL L. PATRICK
Governor

TIMOTHY P. MURRAY
Lieutenant Governor

RICHARD K. SULLIVAN JR.
Secretary

KENNETH L. KIMMELL
Commissioner

LICENSE
TO
APPLY CHEMICALS
FOR CONTROL OF
NUISANCE AQUATIC VEGETATION

Applicant:	TOWN OF CONCORD
License No.:	11202
Name of Lake:	WARNERS POND
PALIS Number:	
Location of Lake:	CONCORD

AUTHORITY FOR ISSUANCE

Pursuant to the authority granted to the Department of Environmental Protection, by Massachusetts G.L.c. 111, s5E, the following license is hereby issued to **GERALD N. SMITH, PRESIDENT, AQUATIC CONTROL TECHNOLOGY, INC.** (hereinafter called the "licensee"), authorizing the application of chemicals for the control of nutrients, algae or aquatic plants to **WARNERS POND, CONCORD** such authorization being expressly conditional on compliance by the licensee with all terms and conditions of the license hereinafter set forth. This license shall become effective on the date of the Director's signature and shall expire nine months from the date of issuance.

[signature]

for David Ferris, Director
Division of Watershed Management
Department of Environmental Protection

19 May 11
Date

Transmit Number:	X236911	Record Number:	

A. Application Condition(s)

CHEMICAL NAME	MAXIMUM WEIGHT or VOLUME	MAXIMUM APPLICATION RATE/ACRE	MAXIMUM TREATMENT in ACRES
SONAR ONE	675 POUNDS	27 POUNDS	25
SONAR AS	16.875 QUARTS	0.675 QUARTS	25
3 TREATMENTS			

B. Proposed Date(s) of Treatment:

The proposed date(s) of treatment are: 05/01/2011; 06/01/2011; 07/01/2011
Changes to proposed treatment dates are acceptable for the period May through November when the above chemicals are applied according to manufacturer's label directions in an environmentally responsible fashion.

C. Application Report
By December 31 of the year of this treatment the licensee shall submit a written report to the Department certifying the treatment date, application rate, and the total weight/volume for each chemical used in the treatment, in accordance with requirements of Section I.A. of this license.

D. Modification of Application Conditions
The licensee shall not apply chemicals in a manner contrary to, or inconsistent with, the application conditions set forth in Section I.A. of this license without the prior written approval of the Department.

II. GENERAL CONDITIONS

A. The licensee is hereby notified that chemical treatments to control aquatic nuisances in public or private lakes and ponds of the Commonwealth involve the alteration of wetland resource areas protected under both Massachusetts G.L.c. 131, s40, the Wetlands Protection Act and 310 CMR 10.00, Massachusetts Wetlands Protection Regulations.

B. The licensee is hereby notified that issuance of this license does not in any way constitute the Department's approval of the chemical treatment as it relates to the provisions of the Wetlands Protection Act.

C. The licensee shall obtain either a final Order of Conditions or a negative Determination of Applicability from the
CONCORD Conservation Commissions
prior to application of chemicals authorized under this license.

D. Shoreline areas of the lake or pond must be posted with signs warning the general public of any water use restrictions stated on the chemical label for a minimum of one week. This is especially important at bathing beaches and other areas of common access. These signs shall clearly state that the chemical treatment is being conducted pursuant to a license issued by the Department of Environmental Protection, "DEP." A new sign shall be posted for each treatment event.

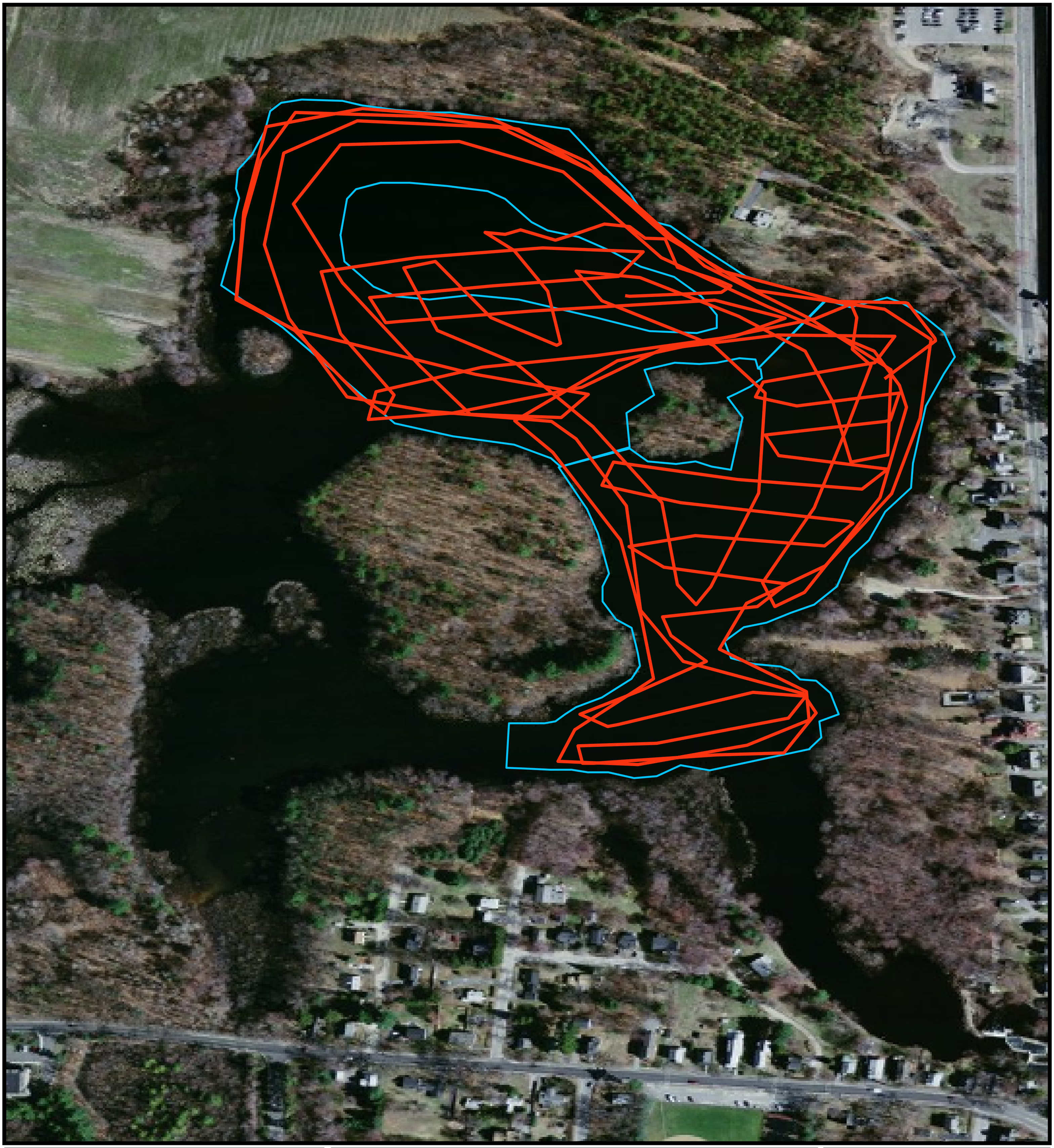
E. The Department may require the licensee to cease application of chemicals to a body of water at any time following the issuance of a license if the Department determines that the chemical treatment will be ineffective, or will result in unreasonable restrictions on current water uses, or will produce unnecessary adverse side effects on nontarget flora or fauna.

F. Chemical applications shall be performed in accordance with the manufacturer's label directions, existing pesticide use laws, and any conditions imposed by other local or state agencies.

G. Chemical treatments shall only be performed by an applicator currently licensed by the Massachusetts Department of Food and Agriculture Pesticide Bureau in the aquatic weed category.

H. Issuance of this license does not release the licensee from liability resulting from the use of chemicals or from negligent or reckless application of chemicals specified in Section I.A. of this license.

I. Electronic notification of treatment must be made to the Massachusetts Division of Fisheries and Wildlife (richard.hartley@state.ma.us and colleen.hubbard@state.ma.us) and the Massachusetts Department of Environmental Protection (robert.kubit@state.ma.us). Notification that the treatment was performed or postponed shall be made within 24 hours of treatment. The notification message should include waterbody, town, license number and chemicals used.



Warners Pond
Concord, Ma

2011 Treatment Area

FIGURE:	SURVEY DATE:	MAP DATE:
2	--	11/22/11

Legend:

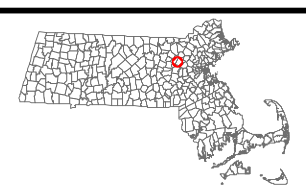
2011 Treatment Area (~25 acres)

GPS Treatment Track - 6/3/11

N

0 250 500 1,000 Feet

AQUATIC CONTROL TECHNOLOGY, INC.
11 JOHN ROAD
SUTTON, MASSACHUSETTS 01590
PHONE: (508) 865-1000
FAX: (508) 865-1220
WEB: WWW.AQUATICCONTROLTECH.COM



SRTC

SePRO Research & Technology Campus

SePRO

Chain of Custody D078C7DA-5

Customer Company

Customer Contact

Company Name:	Aquatic Control Technology, Inc.	Contact Person:	Gerald N
Address:	11 John Road	E-mail Address:	gnsmith@aquaticcontroltech.com
City:	Sutton	Phone:	
State:	MA 01590-2509	Fax:	

Payment Information

Payment Type:	Invoice	Card Number/Expiration Num:	

Waterbody Information

Waterbody:	Warners Pond	Waterbody Size (acres):	48.00
Depth Average:	5.00		
Target Plants			

Sample Information

Sample Site ID	Date Treated	Date Sample Collected	Sample Location	Products	Acres Treated	Rate	Active	Result
1	06/03/2011	06/22/2011	treated area	Sonar One	25	40	Fluridone	**8.4 ppb**
2	06/03/2011	06/22/2011	ramp	Sonar One	25	40	Fluridone	**11.5 ppb**

Laboratory Information

Date Received:	6/27/2011	Date Analysis Performed:	6/27/2011
Date Results Sent:	6/27/2011	Storage Conditions	Analyzed Immediately

SRTC

SePRO Research & Technology Campus

SePRO

Chain of Custody 17F425AA-1

Customer Company

Customer Contact

Company Name:	Aquatic Control Technology, Inc.	Contact Person:	Gerald N
Address:	11 John Road	E-mail Address:	gnsmith@aquaticcontroltech.com
City:	Sutton	Phone:	
State:	MA 01590-2509	Fax:	

Payment Information

Payment Type:	Invoice	Card Number/Expiration Num:	

Waterbody Information

Waterbody:	Warners Pond	Waterbody Size (acres):	48.00
Depth Average:	5.00		
Target Plants	Fanwort,		

Sample Information

Sample Site ID	Date Treated	Date Sample Collected	Sample Location	Products	Acres Treated	Rate	Active	Result
1	07/07/2011	07/26/2011	treated area	Sonar A.S., Sonar One	25	20	Fluridone	**4.9 ppb**
2	07/07/2011	07/26/2011	ramp	Sonar A.S., Sonar One	25	20	Fluridone	**3.3 ppb**

Laboratory Information

Date Received:	8/4/2011	Date Analysis Performed:	8/5/2011
Date Results Sent:	8/5/2011	Storage Conditions	Analyzed Immediately

Warner's Pond 2011 Sonar Herbicide Treatment Program

Pre-treatment: Waterlily cover near Boy Scout Island

Pre-treatment: Submersed weed growth

During treatment: boat ramp looking north

During treatment: chlorosis evident on fanwort

Post-treatment: boat ramp looking north

Post-treatment: decomposing coontail growth

Attachment F

Sediment Quality Results

Sediment Quality at Warner's Pond, February 17, 2011

Analyte	CAS Number	SC1 Result	SC2 Result	SC3 Result	SC4 Result	MCP[1]	BUD[2]	Lined Landfill[3]
Metals - mg/kg-dry								
Arsenic	**7440-38-2**	3.68	8.81	6.45	ND (1)	20	11	40
Cadmium	**7440-43-9**	ND (1)	ND (1)	ND (1)	ND (1)	2	0.8	30
Chromium (total)		15.8	**44.1 (1)**	23.6 (1)	23.4 (1)	30	11	1000
Copper (analyzed wet)	**7440-50-8**	ND (1)	ND (1)	ND (1)	ND (1)	1000	NR	NR
Lead	**7439-92-1**	27.1 (1)	66.3 (1)	34.5 (1)	34.0 (1)	300	19	2000
Mercury	**7439-97-6**	ND (1)	ND (1)	ND (1)	ND (1)	20	8.7	10
Nickel	**7440-02-0**	6.93	13.9	7.85	9.4	20	7.2	NR
Zinc	**7440-66-6**	33.1 (1)	128 (1)	70.1 (1)	44.3 (1)	2500	280	NR
Ash - %								
Ash		85.6 (1)	55.0 (1)	74.7 (1)	65.1 (1)	NR	NR	NR
EPH Ranges - mg/kg-dry								
Adjusted C11-C22 Aromatics		93.7 (1)	153 (1)	ND (1)	ND (1)	1000	480	NR
C09-C18 Aliphatics		ND (1)	ND (1)	ND (1)	ND (1)	1000	780	NR
C19-C36 Aliphatics		ND (1)	140 (1)	ND (1)	ND (1)	3000	3000	NR
Unadjusted C11-C22 Aromatics		93.7 (1)	153 (1)	ND (1)	ND (1)	1000	48	NR
1-Chlorooctadecane (%REC)		52.2 (1)	57.7 (1)	59.8 (1)	63.6 (1)	NR	NR	NR
o-Terphenyl (%REC)	**84-15-1**	72.8 (1)	60.8 (1)	58.9 (1)	72.7 (1)	NR	NR	NR
EPH Target Analytes - mg/kg-dry								
Acenaphthene	**83-32-9**	ND (1)	ND (1)	ND (1)	ND (1)	4	3.9	NR
Acenaphthylene	**208-96-8**	ND (1)	ND (1)	ND (1)	ND (1)	1	1.1	NR
Anthracene	**120-12-7**	ND (1)	ND (1)	ND (1)	ND (1)	1000	0.001	NR
Benzo(a)Anthracene	**56-55-3**	ND (1)	ND (1)	ND (1)	ND (1)	7	3.7	NR
Benzo(a)pyrene	**50-32-8**	ND (1)	ND (1)	ND (1)	ND (1)	2	0.66	NR
Benzo(b)fluoranthene	**205-99-2**	ND (1)	ND (1)	ND (1)	ND (1)	7	3.7	NR
Benzo(g,h,i)perylene	**191-24-2**	ND (1)	ND (1)	ND (1)	ND (1)	1000	1000	NR
Benzo(k)fluoranthene	**207-08-9**	ND (1)	ND (1)	ND (1)	ND (1)	70	37	NR
Chrysene	**218-01-9**	ND (1)	ND (1)	ND (1)	ND (1)	70	370	NR
Dibenz(a,h)anthracene	**53-70-3**	ND (1)	ND (1)	ND (1)	ND (1)	0.7	0.66	NR
Fluoranthene	**206-44-0**	ND (1)	ND (1)	ND (1)	ND (1)	1000	1000	NR
Fluorene	**86-73-7**	ND (1)	ND (1)	ND (1)	ND (1)	1000	NR	NR
Indeno(1,2,3-cd)pyrene	**193-39-5**	ND (1)	ND (1)	ND (1)	ND (1)	7	3.7	NR
Methylnaphthalene, 2-	**91-57-6**	ND (1)	ND (1)	ND (1)	ND (1)	0.7	0.66	NR
Naphthalene	**91-20-3**	ND (1)	ND (1)	ND (1)	ND (1)	4	0.66	NR
Phenanthrene	**85-01-8**	ND (1)	ND (1)	ND (1)	ND (1)	10	10	NR
Pyrene	**129-00-0**	ND (1)	ND (1)	ND (1)	ND (1)	1000	1000	NR
Total PAH Target Concentration		ND (1)	ND (1)	ND (1)	ND (1)	NR	NR	100
2,2'-Difluorobiphenyl (%REC)		90.6 (1)	74.5 (1)	78.7 (1)	76.2 (1)	NR	NR	NR
2-Fluorobiphenyl (%REC)	**321-60-8**	62.4 (1)	70.2 (1)	64.6 (1)	62.6 (1)	NR	NR	NR
Other - %								
Total Volatile Solids	**TVS**	14.4 (1)	45.0 (1)	25.3 (1)	34.9 (1)	NR	NR	NR
Polychlorinated Biphenyls - µg/kg - dry								
Aroclor 1016	**12674-11-2**	ND (1)	ND (1)	ND (1)	ND (1)	2000	44	NR
Aroclor 1221	**11104-28-2**	ND (1)	ND (1)	ND (1)	ND (1)	2000	44	NR
Aroclor 1232	**11141-16-5**	ND (1)	ND (1)	ND (1)	ND (1)	2000	44	NR
Aroclor 1242	**53469-21-9**	ND (1)	ND (1)	ND (1)	ND (1)	2000	44	NR
Aroclor 1248	**12672-29-6**	ND (1)	ND (1)	ND (1)	ND (1)	2000	44	NR
Aroclor 1254	**11097-69-1**	ND (1)	ND (1)	ND (1)	ND (1)	2000	44	NR
Aroclor 1260	**11096-82-5**	ND (1)	ND (1)	ND (1)	ND (1)	2000	44	NR
Decachlorobiphenyl Sig 1 (%REC)	**2051-24-3**	76.3 (1)	44.6 (1)	57.3 (1)	49.2 (1)	NR	NR	NR
Decachlorobiphenyl Sig 2 (%REC)		87.7 (1)	53.0 (1)	67.4 (1)	58.8 (1)	NR	NR	NR
Tetrachloro-m-Xylene Sig 1 (%REC)	**877-09-8**	80.6 (1)	40.6 (1)	64.0 (1)	53.4 (1)	NR	NR	NR
Tetrachloro-m-Xylene Sig 2 (%REC)		95.2 (1)	49.5 (1)	76.9 (1)	65.1 (1)	NR	NR	NR
VOCs - µg/kg-dry								
1,1-Dichloropropene	**563-58-6**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
1,2,3-Trichlorobenzene	**87-61-6**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
1,2,4-Trimethylbenzene	**95-63-6**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
1,3,5-Trimethylbenzene	**108-67-8**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
1,3-Dichloropropane	**142-28-9**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
2,2-Dichloropropane	**590-20-7**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
2-Chlorotoluene	**95-49-8**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
2-Methoxy-2-Methylbutane	**994-05-8**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
4-Chlorotoluene	**106-43-4**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
4-Isopropyltoluene	**99-87-6**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
Bromobenzene	**108-86-1**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
Bromochloromethane	**74-97-5**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
Dichlorobenzene, 1,2- (o-DCB)	**95-50-1**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	9000	660	NR
Dichlorobenzene, 1,3- (m-DCB)	**541-73-1**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	1000	660	NR
Dichloroethane, 1,1'-	**75-34-3**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	400	200[2]	NR

Analyte	CAS Number	SC1 Result	SC2 Result	SC3 Result	SC4 Result	MCP[1]	BUD[2]	Lined Landfill[3]
Dichloroethane, 1,2-	**107-06-2**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	100	5	NR
Dichloropropane, 1,2-	**78-87-5**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	100	5	NR
Dichloropropene, 1,3-	**542-75-6**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	10	19	NR
Diethyl Ether	**60-29-7**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
Diisopropyl Ether	**108-20-3**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
Ethyl-t-Butyl Ether	**637-92-3**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
Isopropylbenzene	**98-82-8**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
n-Butylbenzene	**104-51-8**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
n-Propylbenzene	**103-65-1**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
sec-Butylbenzene	**135-98-8**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
tert-Butylbenzene	**98-06-6**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
Tetrahydrofuran	**109-99-9**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
trans-1,2-Dichloroethene	**156-60-5**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	100	92	NR
1,2,4-Trichlorobenzene	**120-82-1**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	2000	660	NR
1,4-Dichlorobenzene	**106-46-7**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	700	660	NR
Hexachlorobutadiene	**87-68-3**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	6000	300	NR
Naphthalene	**91-20-3**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	4000	660	NR
1,1,1,2-Tetrachloroethane	**630-20-6**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	100	25	NR
1,1,1-Trichloroethane	**71-55-6**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	30000	19000	NR
1,1,2,2-Tetrachloroethane	**79-34-5**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	5	5	NR
1,1,2-Trichloroethane	**79-00-5**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	100	5	NR
1,1-Dichloroethene	**75-35-4**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	3	NR	NR
1,2-Dibromo-3-chloropropane	**96-12-8**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
1,4-Dioxane	**123-91-1**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	200	14	NR
2-Chloroethyl vinyl ether	**110-75-8**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
2-Hexanone	**591-78-6**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
4-Methyl-2-pentanone	**108-10-1**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
Acetone	**67-64-1**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	6000	330	NR
Acrylonitrile	**107-13-1**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
Benzene	**71-43-2**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	2000	150	NR
Bromodichloromethane	**75-27-4**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	100	5	NR
Bromoform	**75-25-2**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	100	7	NR
Bromomethane	**74-83-9**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	500	10	NR
Carbon disulfide	**75-15-0**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
Carbon tetrachloride	**56-23-5**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	10000	390	NR
Chlorobenzene	**108-90-7**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	1000	28	NR
Chloroethane	**75-00-3**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
Chloroform	**67-66-3**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	400	5	NR
Chloromethane	**74-87-3**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
cis-1,2-Dichloroethene	**156-59-2**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	300	13	NR
Dibromochloromethane	**124-48-1**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	5	5	NR
Dibromomethane	**74-95-3**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
Dichlorodifluoromethane	**75-71-8**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
Ethylbenzene	**100-41-4**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	40000	190	NR
Ethylene dibromide	**106-93-4**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	100	5	NR
Methyl Tert-Butyl Ether	**1634-04-4**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	100	140	NR
Methylene chloride	**75-09-2**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	100	NR	NR
Styrene	**100-42-5**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	3000	NR	NR
Tetrachloroethene	**127-18-4**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	1000	NR	NR
Toluene	**108-88-3**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	30000	1300	NR
trans-1,3-Dichloropropene	**10061-02-6**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
Trichloroethene	**79-01-6**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	300	NR	NR
Trichlorofluoromethane	**75-69-4**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	NR	NR	NR
Vinyl Chloride	**75-01-4**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	600	280	NR
Xylenes, Total	**1330-20-7**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	400000	420	NR
1,2-Dichloroethane-D4 (%REC)	**17060-07-0**	117 (1.25)	116 (1.3)	117 (1)	113 (1.67)	NR	NR	NR
4-Bromofluorobenzene (%REC)	**460-00-4**	116 (1.25)	102 (1.3)	111 (1)	114 (1.67)	NR	NR	NR
Dibromofluoromethane (%REC)		106 (1.25)	107 (1.3)	104 (1)	97.2 (1.67)	NR	NR	NR
Toluene-d8 (%REC)	**2037-26-5**	96.1 (1.25)	99.6 (1.3)	95.3 (1)	88.2 (1.67)	NR	NR	NR

Analyte	CAS Number	SC1 Result	SC2 Result	SC3 Result	SC4 Result	MCP[1]	BUD[2]	Lined Landfill[3]
VOC - µg/kg								
Methyl ethyl ketone	**78-93-3**	ND (1.25)	ND (1.3)	ND (1)	ND (1.67)	400	350	NR
PAH - µg/kg								
Acenaphthene	**83-32-9**	ND (1)	ND (1)	ND (1)	ND (1)	20000	3900	NR
Acenaphthylene	**208-96-8**	ND (1)	ND (1)	ND (1)	ND (1)	100000	1100	NR
Anthracene	**120-12-7**	ND (1)	ND (1)	ND (1)	ND (1)	1000000	1000000	NR
Benz(a)anthracene	**56-55-3**	100 (1)	ND (1)	ND (1)	ND (1)	7000	3700	NR
Benzo(a)pyrene	**50-32-8**	90.0 (1)	ND (1)	ND (1)	ND (1)	2000	660	NR
Benzo(b)fluoranthene	**205-99-2**	ND (1)	ND (1)	ND (1)	ND (1)	7000	3700	NR
Benzo(g,h,i)perylene	**191-24-2**	ND (1)	ND (1)	ND (1)	ND (1)	1000000	1000000	NR
Benzo(k)fluoranthene	**207-08-9**	ND (1)	ND (1)	ND (1)	ND (1)	70000	37000	NR
Chrysene	**218-01-9**	ND (1)	ND (1)	ND (1)	ND (1)	70000	370000	NR
Dibenz(a,h)anthracene	**53-70-3**	ND (1)	ND (1)	ND (1)	ND (1)	700	660	NR
Fluoranthene	**206-44-0**	ND (1)	ND (1)	ND (1)	ND (1)	1000000	1000000	NR
Fluorene	**86-73-7**	ND (1)	ND (1)	ND (1)	ND (1)	400000	NR	NR
Indeno(1,2,3-cd)pyrene	**193-39-5**	71.7 (1)	ND (1)	ND (1)	ND (1)	7000	3700	NR
Methylnaphthalene, 2-	**91-57-6**	ND (1)	ND (1)	ND (1)	ND (1)	4000	660	NR
Naphthalene	**91-20-3**	ND (1)	ND (1)	ND (1)	ND (1)	4000	660	NR
Phenanthrene	**85-01-8**	ND (1)	ND (1)	ND (1)	ND (1)	700000	10000	NR
Pyrene	**129-00-0**	ND (1)	ND (1)	ND (1)	ND (1)	1000000	1000000	NR
2-Fluorobiphenyl (%REC)	**321-60-8**	87.1 (1)	94.6 (1)	90.3 (1)	86.9 (1)	NR	NR	NR
Nitrobenzene-D5 (%REC)	**4165-60-0**	109 (1)	112 (1)	120 (1)	125 (1)	NR	NR	NR
Terphenyl-d14 (%REC)	**98904-43-9**	91.6 (1)	98.7 (1)	95.0 (1)	87.7 (1)	NR	NR	NR

Value in parentheses = Dilution Factor
ND: Not Detected
NR: Not Reported

Result exceeds MCP Standard, Soil Cat-1, GW-1
Result exceeds BUD Standard, S-1, GW-1

1: MADEP, 2007. Massachusetts Contingency Plan 310 CMR 40
2: MADEP, 2004. Draft Interim Guidance Document for Beneficial Use Determination Regulations 310 CMR 19.060
3: MADEP, 1997. Reuse and Disposal of Contaminated Soil at Massachusetts Landfills Department of Environmental Protection Policy # COMM-97-001

Sediment Chromium Results from September 2, 2011

Analyte	SC2 Retest Result	MCP[1]	BUD[2]	Lined Landfill[3]
Metals - mg/kg-dry				
Chromium (total)	ND (39.8)	30	11	1000
Hexavalent Chromium	ND (33.3)	30	11	1000

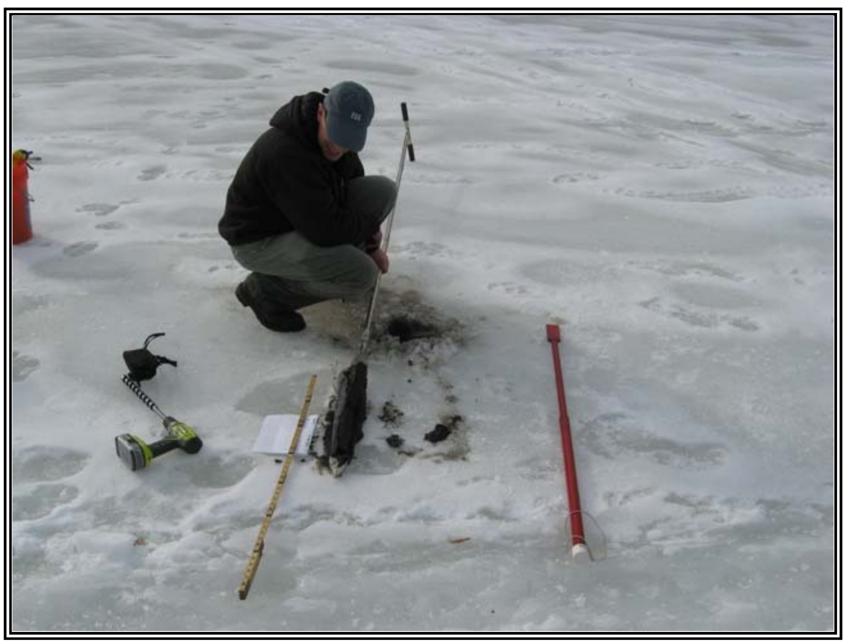
Attachment G

Project Photo Log

Photograph No. 1:
Drilling holes for Bathymetry and sediment depth sampling

Photograph No. 2:
Measuring water and sediment depth with tile probe

Photograph No. 3:
Drilling hole for sediment corer



Photograph No. 4:
Pulling core above ice

Photograph No. 5:
Sediment Core (see Sediment Coring Photographic Log for more detailed photos)

Photograph No. 6:
Mixing composite sample and collecting in lab jar

Photograph No. 7:
Watershed Reconnaissance W-15 culvert at Lawson Brook Road

Photograph No. 8:
Watershed Reconnaissance W-17 off Route 2 at north shore of Warner's Pond

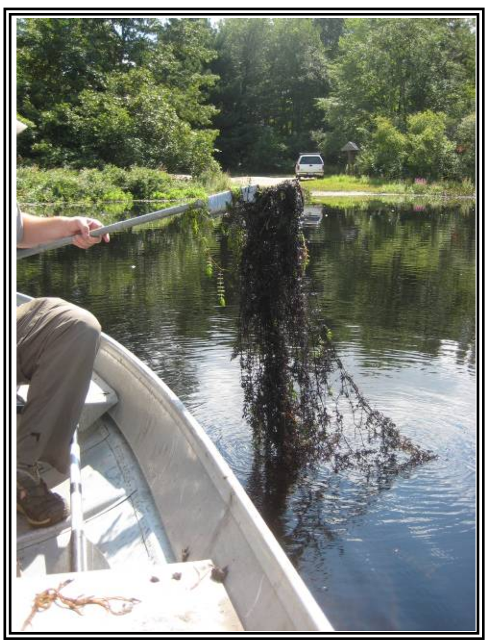
Photograph No. 9:
Stormwater flowing into catch basin

Photograph No. 10:
Stormwater sampling at outfall

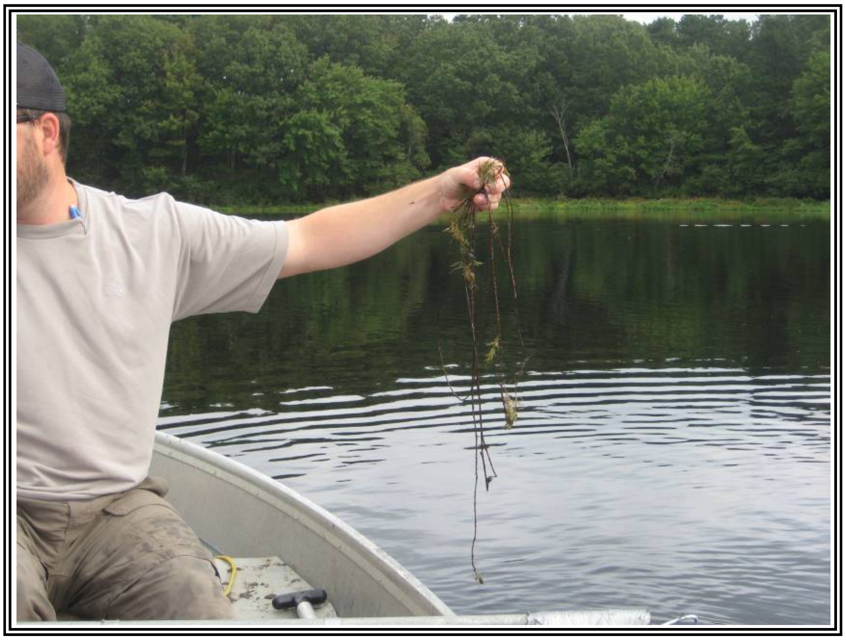
Photograph No. 11:
Warner's Pond west bay on September 2, 2011

Photograph No. 12:
Warner's Pond east bay on September 2, 2011

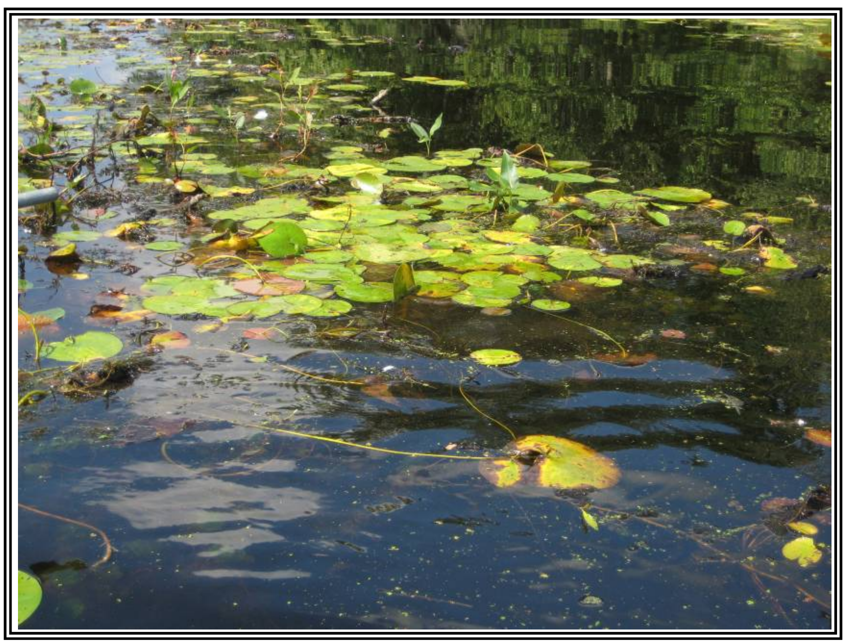
Photograph No. 13:
Warner's Pond east bay access on September 2, 2011



Photograph No. 14:
Plant mapping macrophyte collection in east bay



Photograph No. 15:
Warner's Pond macrophyte identification in east bay



Photograph No. 16:
White water lilies in Warner's Pond on September 2, 2011

Attachment H

Glossary of Pond Terms

7.0 GLOSSARY OF LIMNOLOGICAL TERMS

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.

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: 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.

***E. coli* Bacteria:** Found naturally in the intestinal tracts of warm blooded animals, high levels of this bacteria in water or sludge is an indicator of pollution and possible contamination by pathogens.

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.

Eutrophic: A trophic state (degree of eutrophication) in which a lake or pond is nutrient rich and sustains high levels of biological productivity. Dense macrophyte growth, fast sediment accumulation, frequent algae blooms, poor water transparency and periodic oxygen depletion in the hypolimnion are common characteristics of eutrophic lakes and ponds.

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.

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.

Isopach Map: A map illustrating the depth of sediments within a lake or pond.

Limnology: The study of lakes.

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.

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.

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. Often used interchangeably with metalimnion.

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

TSS: Total suspended solids, a direct measure of all suspended solid materials in the water.

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.