COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Division of Watershed Management, 627 Main Street, Worcester, MA 01608

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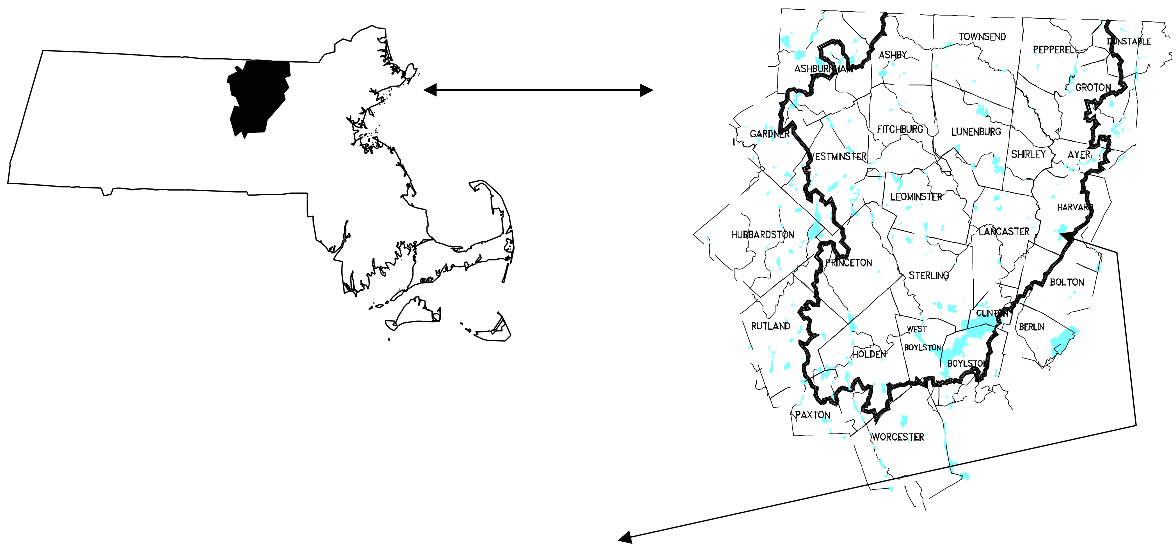
Bare Hill Pond, Harvard, MA. (MA81007) TMDL

DEP, DWM TMDL Report MA81007-1999-001 July, 1999



Location of Nashua Basin, and the Bare Hill Pond in Massachusetts.

Key Feature:	TMDL assessment of a lake with nuisance aquatic plants.
Location:	Harvard, MA - EPA Region 1
Scope/Size:	Watershed 1,082 Ha, Surface area 130. Ha (321 ac)
Land Type:	New England Upland
Land Uses:	Forest 64%, Agriculture 5%, Residential 16%, Other 15%
Pollutants/Stressor:	Noxious Aquatic Plants (Phosphorus TMDL)
Data Sources:	Local, Whitman and Howard, (July 1987)
Data Mechanisms:	Dillon-Rigler Model, Best Professional Judgment
Monitoring Plan:	Massachusetts Watershed Initiative Five-Year Cycle.
Control Measures:	Watershed Management, Septic system maintenance, Macrophyte Management.

Executive Summary

Bare Hill Pond is listed on the Massachusetts 303d list for Nuisance Aquatic Plants and lake water quality may be threatened by high phosphorus loadings. This report, based on the Whitman and Howard (1987) Diagnostic/ Feasibility (D/F) study concludes that the excessive macrophyte growth in the pond is due to both natural conditions associated with flooded shallow areas after the lake was dammed and anthropogenic nutrient enrichment from the pond's watershed. Current plant harvesting operations and winter drawdowns may be sufficient to control macrophytes without the need for additional measures. The D/F study recommends watershed management to control nutrients and sedimentation and also recommended water level manipulation and optimization of plant harvesting to control plant growth. The proposed control effort is predicted to reduce total phosphorus concentrations from 0.044 mg/l to 0.030 mg/l. Because of the limited data available on discrete sources of nutrients within the watershed, a locally organized watershed survey is recommended to target reductions in nonpoint source nutrients and sediments. In many cases the State has limited authority to regulate nonpoint source pollution and thus successful implementation of this TMDL will require cooperative support from the public including lake and watershed associations, local officials and municipal governments in the form of education, funding and local enforcement. Funding support to aid in implementation of this TMDL is available under various state programs including section 319 and the State Revolving Fund Program (SRF) and the Department of Environmental Management's Lakes and Pond fund.

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Introduction

Section 303(d) of the Federal Clean Water Act requires each state to (1) identify waters for which effluent limitations normally required are not stringent enough to attain water quality standards and (2) to establish Total Maximum Daily Loads (TMDLs) for such waters for the pollutant of concern. TMDLs may also be applied to waters threatened by excessive pollutant loadings. The TMDL establishes the allowable pollutant loading from all contributing sources at a level necessary to achieve the applicable water quality standards. The TMDLs must account for seasonal variability and include a margin of safety (MOS) to account for uncertainty of how pollutant loadings may impact the receiving water's quality. This report and attached documents are submitted to the USEPA as a TMDL under Section 303d of the Federal Clean Water Act, 40 CFR 130.7. After public comment and final approval by the EPA, the TMDL will be used by the local Executive Office of Environmental Affairs Basin Team to guide watershed management plans in the basin. In some cases, TMDLs will be used by DEP to set appropriate limits in permits for wastewater and other discharges. Currently, no point source discharges are permitted in the Bare Hill Pond Watershed, however there are discharges downstream and those point source discharges must be consistent with this TMDL.

The proposed Total Maximum Daily Load (TMDL) for Bare Hill Pond is based on a Diagnostic/Feasibility (D/F) Study conducted by Whitman and Howard (1987) and funded under the Massachusetts Clean Lakes Program. (Parts of the D/F are reproduced in Appendix 1). Bare Hill Pond is listed on the Massachusetts 303d list for Nuisance Aquatic Plants and lake water quality may be threatened by high phosphorus loadings. The Executive Summary of the D/F study (Whitman and Howard 1987; see Appendix I) concludes that the excessive weed growth in the pond is due to both natural and anthropogenic nutrient enrichment from the pond's watershed. The study further concluded that septic systems comprise a large percentage of the nutrient inputs. The D/F study recommends watershed management to control nutrients and sedimentation and also recommended water level manipulation and plant harvesting (Appendix I). The proposed control effort is predicted to reduce total phosphorus concentrations from 0.044 mg/l to 0.030 mg/l. Current plant harvesting operations and winter drawdowns may be sufficient to control macrophytes without the need for additional measures. In many cases the State has limited authority to regulate nonpoint source pollution and thus successful implementation of this TMDL will require cooperative support from the public including lake and watershed associations, local officials and municipal governments in the form of education, funding and local enforcement. Additional funding support is available under various state programs including section 319 and the State Revolving Fund Program (SRF) and the Department of Environmental Management's Lakes and Pond fund.

General Background and Rationale

Section 303(d) of the Federal Clean Water Act requires each state to (1) identify waters for which effluent limitations normally required are not stringent enough to attain water quality standards and (2) to establish Total Maximum Daily Loads (TMDLs) for such waters for the pollutant of concern. The TMDL establishes the allowable pollutant loading from all contributing sources at a level necessary to achieve the applicable water quality standards. The TMDLs must account for seasonal variability and include a margin of safety (MOS) to account for uncertainty of how pollutant loadings may impact the receiving water's quality. This report and attached documents are submitted to the USEPA as a TMDL under Section 303d of the Federal Clean Water Act, 40 CFR 130.7. After public comment and final approval by the EPA, the TMDL will be used to guide watershed and lake management plans in the basin and to set appropriate limits in permits for wastewater and other discharges, if any.

Nutrients are a requirement of life, but in excess can create problems. Lakes are ephemeral features of the landscape and over geological time most tend to fill with sediments and associated nutrients as they make a transition from lake to marsh to dry land. However, this natural successional ("aging") process can be and often is accelerated through the activities of humans—especially through development in the watershed. For highly productive lakes with developed watersheds, it is not easy to separate natural succession from "culturally induced " effects. Nonetheless, all feasible steps should be taken to reduce the impacts from cultural activities. The following discussion summarizes the current understanding of how nutrients influence the growth of algae and macrophytes, the time scale used in the studies, the type of models applied and the data collection methods used to create a nutrient budget. A brief description of the rationale for choosing a target load (the TMDL) as well as a brief discussion of implementation and management options is presented.

A detailed description of the current understanding of limnology (the study of lakes and freshwaters) and management of lakes and reservoirs can be found in Wetzel (1983) and Cooke et al., (1993). To prevent cultural enrichment it is important to examine the nutrients required for growth of phytoplankton (algae) and macrophytes. The limiting nutrient is typically the one in shortest supply relative to the nutrient requirements of the plants. The ratio of nitrogen (N) to phosphorus (P) in both algae and macrophyte biomass is typically about 7 by weight or 16 by atomic ratio (Vallentyne, 1974). Examination of relatively high N/P ratios in water suggests P is most often limiting and careful reviews of numerous experimental studies have concluded that phosphorus is the limiting nutrient in most freshwater lakes (Likens, 1972; Schindler and Fee, 1974). Most diagnostic/feasibility studies of Massachusetts lakes also indicate phosphorus as the limiting nutrient. Even in cases where nitrogen may be limiting, previous experience has shown that it is easier, more cost-effective and more ecologically sound to control phosphorus than nitrogen. The reasons include the fact that phosphorus is related to terrestrial sources and does not have a significant atmospheric source as does nitrogen (e.g., nitrates in precipitation). Thus, non-point sources of phosphorus can be managed more effectively by best management practices (BMPs). In addition, phosphorus is relatively easy to control in point source discharges. Finally, phosphorus does not have a gaseous phase, while the atmosphere is a nearly limitless source of nitrogen gas which can be fixed by some types of phytoplankton (the blue-greens, or cyanobacteria) even in the absence of other sources of nitrogen. For all of the reasons noted above, phosphorus is chosen as the critical element to control freshwater eutrophication, particularly for algal dominated lakes or in lakes threatened with excessive nutrient loading.

There is a direct link between phosphorus loading and algal biomass (expressed as chlorophyll a) in algae dominated lakes (Vollenweider, 1976). The situation is more complex in macrophyte dominated lakes where the rooted aquatic macrophytes may obtain most of the required nutrients from the sediments. In organic, nutrient rich sediments, the plants may be limited more by light or physical constraints such as water movement than by nutrients. In such cases it is difficult to separate the effects of sediment deposition, which reduce depth and extend the littoral zone, from the effects of increased nutrients, especially phosphorus, associated with the sediments. In Massachusetts, high densities of aquatic macrophytes are typically limited to depths less than ten feet and to lakes where organic rich sediments are found (Mattson et al., 1998). Thus, the response of rooted macrophytes to reductions in nutrients in the overlying water will be much weaker and much slower than the response of algae or non-rooted macrophytes, which rely on the water for their nutrients. In algal or non-rooted macrophyte dominated systems nutrient reduction in the water column can be expected to control growth with a lag time related to the hydraulic flushing rate of the system. In lakes dominated by rooted macrophytes, additional, direct control measures such as harvesting, herbicides or drawdowns will be required to realize reductions in plant biomass on a reasonably short time scale. In both cases, however, nutrient control is essential since any reduction in one component (either rooted macrophytes or phytoplankton) may result in a proportionate increase in the other due to the relaxation of competition for light and nutrients. In addition, it is critical to establish a Total Maximum Daily Load so that future development around the lake will not impair water quality. It is far easier to prevent nutrients from causing eutrophication than to attempt to restore a eutrophic lake. The first step in nutrient control is to calculate the current nutrient loading rate or nutrient budget for the lake.

Nutrient budgets and loading rates in lakes are determined on a yearly basis because lakes tend to accumulate nutrients as well as algal and macrophyte biomass over long time periods compared to rivers, which constantly flush components downstream. Nutrients in lakes can be released from the sediments into the bottom waters during the winter and summer and circulated to the surface during mixing events (typically fall and spring in deep lakes and during the summer in shallow lakes). Nutrients stored in shallow lake sediments can also be directly used by rooted macrophytes during the growing season. In Massachusetts lakes, peak algal production, or blooms may begin in the spring and continue during the summer and fall while macrophyte biomass peaks in late summer. The impairment of uses is usually not severe until summer when macrophyte biomass reaches the surface of the water interfering with boating and swimming. Also, at this time of year the high daytime primary production and high nighttime respiration can cause large changes in dissolved oxygen. In addition, oxygen is less soluble in warm water of summer as compared to other times of the year. The combination of these factors can drive oxygen to low levels during the summer and may cause fish kills. For these reasons the critical period for use impairment is during the summer, yet the modeling is done on a yearly basis.

There are two basic approaches to estimating current nutrient loading rates: the measured mass balance approach and the landuse export approach. The measured mass balance approach requires frequent measurements of all fluvial inputs to the lake in terms of flow rates and phosphorus concentrations. The yearly loading is the product of flow (liters per year) times concentration (mg/l), summed over all sources (i.e., all streams and other inputs) and expressed as kg/year. The landuse export approach assumes phosphorus is exported from various land areas at a rate dependent on the type of landuse. The yearly loading is the sum of the product of landuse area (Ha) times the export coefficient (in kg/Ha/yr). The mass balance method is generally considered to be more accurate, but also more time consuming and more costly due to the field sampling and analysis. For this reason, the mass balance results are used whenever possible. If a previous diagnostic/feasibility study or mass balance budget is not available, then a landuse export model, such as Reckhow et al., (1980) can be used to estimate nutrient loading.

Once the current nutrient loading rate is established, a new, lower rate of nutrient loading must be established which will restore water quality. This target load or TMDL, can be set in a variety of ways. Usually a target concentration in the lake is established and the new load must be reduced to achieve the lower concentration. This target nutrient concentration may be established by a water quality model that relates phosphorus concentrations to water quality standards, such as the four-foot transparency criterion at Massachusetts swimming beaches. Alternatively, the target concentration may be set based on concentrations observed in background reference lakes for similar lake types and in similar regions. Various models (equations) have been used for predicting productivity or lake total phosphorus concentrations in lakes from analysis of phosphorus loads. These models typically take into consideration the waterbody's water residence time and some factor to account for settling and storage of phosphorus in the lake sediments. Among the more well known metrics are those of Vollenweider (1975), Dillon-Rigler (1974) and Reckhow (1979). The TMDL must account for the uncertainty in the estimates of the phosphorus loads from the sources identified above by including a margin of safety. This margin of safety can either be specifically included, and/or included as part of conservative assumptions used to develop the TMDL.

After the target TMDL has been established, the allowed loading of nutrients is apportioned to various sources which may include point sources as well as private septic systems and various land uses within the watershed. In Massachusetts, few, if any, lakes receive direct point source discharges of nutrients. River impoundments often have upstream point sources, but these will be addressed as part of the appropriate river system. The nutrient source analysis generally will be related to landuse which reflects the extent of development in the watershed. This effort can be facilitated by the use of geographic information systems (GIS) digital maps of the area which can summarize landuse categories within the watershed. The targeted reductions must be reasonable given the reductions possible with the best available technology and Best Management Practices. The first scenario for allocating loads will be based on what is practicable and feasible for each activity and or landuse to make the effort as equitable as possible.

Although the landuse approach gives an estimate of the magnitude of typical phosphorus export from various landuses, it is important to recognize that nonpoint phosphorus pollution comes from many discrete sources within the watershed. Perhaps the most common sources in rural areas are leaching from failed or inadequate septic systems and phosphorus associated with soil erosion. Soils tend to erode most rapidly following soil disturbances such as construction, gravel pit operations, tilling of agricultural lands, overgrazing, and trampling by animals or vehicles. A common problem with erosion in rural areas is erosion from unpaved roads. Soils may also erode rapidly where runoff water concentrates into channels and erodes the channel bottom. This may occur where impervious surfaces such as parking lots direct large volumes of water into ditches which begin to erode and may also result from excessive water drainage from roadways with poorly designed ditches and culverts. Any unvegetated drainage way is a likely source of soil erosion.

Discrete sources of nonpoint phosphorus in urban, commercial and industrial areas include a variety of sources that are lumped together as 'urban runoff' or 'stormwater'. As many of these urban sources are difficult to identify the most common methods to control such sources include reduction of impervious surfaces and treatment of stormwater runoff in detention ponds or other structural controls.

Other sources of phosphorus include phosphorus based lawn fertilizers used in residential areas, parks, cemeteries and golf courses and fertilizers used by agriculture. Manure from animals, especially dairies and other confined animal feeding areas is high in phosphorus. In some cases the manure is inappropriately spread or piled on frozen ground during winter months and the phosphorus can leach into nearby surface waters. Over a period of repeated applications of manure to local agricultural fields, the phosphorus in the manure can saturate the ability of the soil to bind phosphorus, resulting in phosphorus export to surface waters. In some cases, cows and other animals including wildlife such as flocks of ducks and geese may have access to surface waters and cause both erosion and direct deposition of feces to streams and lakes. Perhaps the most difficult source of phosphorus to account for is the phosphorus recycled within the lake from the lake sediments. Phosphorus release from shallow lake sediments may be significant due to the ideal conditions. These conditions include higher microbial activity in shallow warmer waters which can lead to sediment anoxia, the possibility of anoxia and sediment phosphorus release during temporary stratification, wind or power boat caused turbulence which resuspends phosphorus rich sediments and from nutrient 'pumping' by rooted aquatic macrophytes as they extract phosphorus from the sediments and excrete phosphorus to the water during seasonal growth and senescence (Cooke et al., 1993; Horne and Goldman, 1994).

The implementation plan or watershed management plan to achieve the TMDL will vary from lake to lake depending on the type and degree of development. While the impacts from development can not be completely eliminated, they can be minimized by prudent "good housekeeping" practices, known more formally as best management practices (BMPs). Among these BMPs are control of runoff and erosion, well-maintained subsurface wastewater disposal systems and reductions in the use of fertilizers. Activities close to the waterbody and its tributaries merit special attention for following good land management practices. In addition, there are some statewide efforts that provide part of an overall framework. These include the legislation that curbed the phosphorus content of many cleaning agents, revisions to regulations that encourage better maintenance of subsurface disposal systems (Title 5 Septic systems), and the Rivers Act that provides for greater protection of land bordering waterbodies. In addition, there is the public's concern about the environment that is being harnessed to implement remediation and protection plans through efforts associated with the Massachusetts Watershed Initiative and the Basin Teams. In some cases, structural controls, such as detention ponds, may be used to reduce pollution loads to surface waters.

The most important factor controlling macrophyte growth appears to be light (Cooke et al., 1994). Due to the typically large mass of nutrients stored in lake sediments, reductions in nutrient loadings by themselves are not expected to reduce macrophyte growth in many macrophyte-dominated lakes, at least not within a reasonable time frame. In such cases additional in-lake control methods are generally recommended to directly reduce macrophyte biomass. Lake management techniques for both nutrient control and macrophyte control have been reviewed by a Draft Generic Environmental Impact Report (Mattson et al., 1998). The Massachusetts Department of Environmental Protection will endorse in-lake remediation efforts that meet all environmental concerns, however, instituting such measures will rest with communities and the Clean Lakes Program now administered by EPA and, in Massachusetts, the Department of Environmental Management.

Financial support for implementation is potentially available on a competitive basis through both the non-point source (319) grants and the state revolving fund (SRF) loan program. The 319 grants require a 40 percent non-federal match of the total project cost although the local match can be through in-kind services such as volunteer efforts. Other sources of funding include the 604b Water Quality Management Planning Grant Program, the Community Septic Management Loan Program and the DEM Lake and Pond Grant Program. Information on these programs are available in a pamphlet "Grant and Loan Programs – Opportunities for Watershed Protection, Planning and Implementation" through the Massachusetts Department of Environmental Protection, Bureau of

Resource Protection and the Massachusetts Department of Environmental Management (for the Lake and Pond Grant Program).

Since the lake restoration and improvements can take a long period of time to be realized, follow-up monitoring will be essential. This can be accomplished through a variety of mechanisms including volunteer efforts. Recommended monitoring will include Secchi disk readings, lake total phosphorus, macrophyte mapping of species distribution and density, visual inspection of any structural BMPs, coordination with Conservation Commission and Board of Health activities and continued education efforts for citizens in the watershed.

Problem Assessment

Description: Bare Hill Pond, (MA81007) is a 321 acre, municipally-owned pond located in Harvard Massachusetts in the Nashua Basin at approximately 71°35'46"W, 42°29'29"N. Although the pond's shoreline is moderately developed, the lakeshore community maintains a rural atmosphere due largely to the forested environs. The pond has three beaches, one located along the northern shore at the Camp Green Eyrie Girl Scout facility, a town beach off Pond Road at the northeast corner of the lake, and a small, informal beach on Harvard Conservation Commission Land near Thurston's Brook. Public access to the town beach is restricted to Harvard residents but the general public can gain pond access via Harvard conservation land.

According to Whitman and Howard (1987), in colonial times Bare Hill Pond was surrounded by Pasture lands and was roughly 200 acres in size. From 1838, when the pond's dam was built and enlarged to its present size, until 1920, the water level varied depending upon the industries drawing from the pond's water supply. Since 1920, the size and depth of the pond have remained relatively constant. It is not surprising that a majority of the present-day shallow, weedy areas are those inundated after the 1838 pond expansion. It has also been theorized that erosion of enriched soil into the pond from former agricultural areas provided the conditions necessary for some of the aquatic plants to reach nuisance proportions. A chronology of pond management activities provided by the Bare Hill Pond Watershed Management Committee is available in Appendix IV.

Extensive growths of water lilies, milfoil, smartweed and pondweed have hampered boating activities and swimming in certain sections of the pond (Plate 16 in Appendix). The Massachusetts Division of Water Pollution Control (MDWPC) conducted a baseline survey of the pond in 1983. Their findings suggest that the pond is mesotrophic, displaying elevated nutrient levels and moderate hypolimnetic dissolved oxygen concentrations and transparency. However, a more detailed analysis is presented in the Diagnostic/Feasibility report of Whitman and Howard (1987), which concludes that in terms of phosphorus concentrations and macrophyte growth, the pond is eutrophic. The Whitman and Howard (1987) report shows the lake to have very dense or moderately dense aquatic vegetation over about 40-45 percent of the lake area, mostly in protected shallow coves and bays (see Plate 16 and Plate 17 in Appendix I. *Myriophyllum heterophyllum* (Watermilfoil) is the dominant species, followed by *Polygonum sp.* and *Brasenia schreberi.* Recent surveys in 1998 by DEP staff and by ENSR (1998) reported slightly less extensive plant coverage (about 30%), but noted the presence of the non-native water chestnut (*Trapa natans*), as well as Fanwort (*Cabomba caroliniana*) which adds to the problem. The pond was listed on the 1998 Massachusetts 303d list for Nuisance Aquatic Plants (DEP, 1998). The overall goal is to restore the uses of the pond for primary and secondary contact recreation by reducing the nuisance aquatic plant growth. This will be accomplished by a combination of reducing the phosphorus loading to the lake and by direct control of macrophytes.

A detailed study of the nutrient sources and sediment sources was included in the Diagnostic/Feasibility Study of Whitman and Howard (1987). The average total phosphorus concentration at the surface was 0.044 mg/l which is relatively high, yet Secchi disk transparency was greater than expected, ranging from 2.7 to 4 meters with an average of 3.5 meters in the center of the lake. The more recent ENSR (1998) study reported a mid-August surface concentration of 0.05 mg/l with a Secchi disk depth of only 2.0 m (6.5 feet), possibly suggesting that conditions are worsening. The Whitman and Howard (1987) report concludes that the excessive weed growth in the pond is due to favorable habitat conditions such as shallow depths with bottom sediments rich in nutrients and the sustained nutrient enrichment from the pond's watershed. The model used to determine the pond's trophic status was the phosphorus loading model of Dillon and Rigler (1974).

Water Quality Standards Violations: In consideration that the waters listed are a designated Class B water under the Massachusetts Surface Water Quality Standards, the data listed above were judged sufficiently well documented to place the lake on the Massachusetts 303d list for 1998 (DEP, 1998) with Noxious Aquatic Plants listed as the cause for violation of the Water Quality Standards related to impairment of primary and secondary contact recreation and aesthetics. These Water Quality Standards are described in the Code of Massachusetts Regulations under both sections:

> 314CMR 4.05 (3) b: "These waters are designated as a habitat for aquatic life, and wildlife, and for primary and secondary contact recreation...These waters shall have consistently good aesthetic value."
> and 314CMR 4.05 (5) a: All surface waters shall be free from pollutants ......or produce undesirable or nuisance species of aquatic life".

Pollutant/Stressor Sources: The Whitman and Howard (1987) D/F study concluded that phosphorus is most likely the limiting nutrient. It should be noted that light may also limit macrophyte growth in deep water. Two different methods were used to estimate the annual phosphorus load to the pond; these are summarized in the Appendix. The first method used a modified mass balance approach which estimated the phosphorus loading to be 1,213 kg/yr. This estimate included 450 kg/yr loading from the watershed and 763 kg/yr from internal sediment recycling. The second method used landuse maps and "most likely" phosphorus export coefficients (Reckhow et al., 1980) to estimate a phosphorus load of 769 kg/yr from the watershed alone. Both methods are assumed to be valid for this analysis as there has been little growth in human population in the town (only 1.3% from 1980 - 1990 according to census data) due to the recent closing of the nearby Fort Devens, however redevelopment of the area is expected to expected to increase growth. Landuse areas and a detailed breakdown of loading by landuse are presented in Tables 40 and 42 in the Appendix. For purposes of this TMDL, we will rely mainly on the mass balance 'nutrient budget' approach.

The major sources according to the land use analysis were residential area and wastewater (on site septic systems), which accounted for more than half the total from the watershed. A very rough estimate of the load from internal cycling yielded a value of 763 KG P/yr. This was based on taking a mid-range value from the literature that reported a low of -2 mg/m^2/day and a high of 9.6 mg/m^2/day (Whitman and Howard, 1987). Thus, the internal load could be a dominant source, but the estimate is highly uncertain. Given this, DEP re-estimated sediment recycling as described below. Given that reductions on the watershed will eventually impact the internal cycling, watershed management is still fruitful to pursue. The main impact from the internal cycling would be extending the time for noticing improvements in water quality from watershed management efforts.

TMDL Analysis

Identification of Target: There is no loading capacity *per se* for nuisance aquatic plants. As the term implies, TMDLs are often expressed as maximum daily loads. However, as specified in 40 CFR 130.2(I), TMDLs may be expressed in other terms when appropriate. For this case, the TMDL is expressed in terms of allowable annual loadings of phosphorus because the growth of phytoplankton and macrophytes responds to changes in annual rather than daily loadings of nutrients. The target in-lake total phosphorus concentration chosen is based on consideration of the typical concentrations expected in lakes in the region. The phosphorus ecoregion map of Griffith et al. (1994) indicates the lake is in an ecoregion with concentrations of 10-14 ppb, based on spring/fall concentrations, while the phosphorus ecoregion map of Rohm et al., (1995) suggests that typical lakes in this ecoregion would have concentrations between 30 and 50 ppb, based on summer concentrations. Considering the above suggested ranges and that the chlorophyll a concentrations are generally well below 10 ppb (Whitman and Howard, 1987), DEP has set the target TP concentration at 30 ppb. Any value lower than this would be difficult to attain given the forested nature of most of the watershed and a higher value may allow algal blooms, potentially leading to violations of the four-foot transparency standard for swimming. The ENSR report (1998) suggests that due to the high dissolved organic carbon in the lake, as indicated by the color of the water, much of the total phosphorus may be unavailable for growth and that light may also limit algal production despite the relatively high total phosphorus concentrations. Thus, a relatively high phosphorus target is justified in this lake. The 30 ppb target represents a 32 percent a reduction from the current total phosphorus concentration of 44 ppb. Note that the lake already meets the 4-foot transparency requirement for swimming beaches and the proposed reduction in phosphorus loading would likely increase the transparency even more. Following the methods of Whitman and Howard (1987), the Dillon-Rigler model (see below) would estimate that a Total Maximum Daily Load of 538 kg/yr would meet the target of 30 ppb (0.030 mg/l). This target is generally consistent with the Stage I implementation plan of Whitman and Howard (1987) which suggested a 33.5% reduction in phosphorus loading. The lower phosphorus concentrations will lessen the chance of nuisance algal blooms, which may occur as macrophyte biomass is reduced by direct controls.

The many sheltered shallow bays offer an ideal habitat for natural growth of aquatic macrophytes, which provide habitat for fish and wildlife and as such complete elimination of macrophytes is neither possible nor desired. To some extent, the proliferation of aquatic macrophytes in the pond is a natural condition resulting from the availability of shallow, nutrient rich sediments being flooded when the lake was enhanced by a dam. Thus reducing the supply of external phosphorus may not meet the goals of the TMDL without additional management in the lake as discussed below.

Wasteload Allocations, Load Allocations and Margin of Safety:

DEP chose a margin of safety of 5 percent of the total TMDL. In this case, the margin of safety is 538 kg/yr*.05 or 27 kg/yr. Point source loading is zero, which leaves 511 kg/yr for the load allocation to nonpoint sources as indicated in the right side of Table 1. Loading allocations are based on the measured phosphorus budget; not the landuse modeled phosphorus budget.

Obviously the estimate for sediment recycling of phosphorus of 763 kg/yr suggested by Whitman and Howard (1987) is highly uncertain since it was based on the midpoint of a range of literature values. Using the Dillon-Rigler model, DEP estimated a total phosphorus load of 790 kg/yr would coincide with the observed in-lake phosphorus concentration of 0.044mg/l. Given this, the internal sediment phosphorus recycling was then estimated using the mass balance approach as the difference between the total load of 790 kg/yr estimated above, and the measured external watershed loading of 448 kg/yr. Thus, an internal (sediment) recycling load of 342 kg/yr was used in this analysis.

Phosphorus loading allocations for each subbasin and other sources are shown (are rounded to the nearest kg/yr) in Table 1. A map of subbasins is available in Appendix I. No reduction in atmospheric loading is targeted, because this source is impossible to control on a local basis. The reduction of phosphorus loading from wastewater septic systems of 150.8 kg/yr is based on Whitman and Howard (1987) analysis assuming 50% reduction in loading due to increase tank cleaning with 100% participation of homeowners. This represents a 33.5 percent reduction in the watershed loading. This is allocated as a proportional phosphorus loading reduction among the groundwater and stream subwatersheds based on the approximately equal distribution of houses around the watershed. An additional of 4.9 percent in phosphorus loadings due to watershed management will reduce total loadings to the target of 511 kg/yr (a total of 38.4% reduction) as indicated in Table 1. This assumes that internal recycling of phosphorus will be proportionately reduced 38.4%, as the external loading is reduced, although it is expected that reductions in recycling will lag behind reductions in external loading. Note that atmospheric inputs are assumed to be constant at 63 kg/yr.

Table 1. TMDL Load Allocations.

Source	*Current TP Loading (kg/yr)*	*Target TP Load Allocation (kg/yr)*
Atmosphere	63.	63.
Groundwater	50.	31.
Clapp's Brook	61.	38.
Pond Road Subwatershed	71.	44.
Thurston's Brook	43.	26.
Bowers Brook	104.	64.
Sprague Swamp Subwatershed	56.	34.
Sediment Recycling	342.	211.
Total Inputs	790.	511.

The TMDL is the sum of the wasteload allocations (WLA) from point sources (e.g., sewage treatment plants) plus load allocations (LA) from nonpoint sources (e.g., landuse sources) plus a margin of safety (MOS). In this case the TMDL is:

TMDL = WLA + LA + MOS = 0 kg/yr + 511 kg/yr + 27 kg/yr = 538 kg/yr.

Modeling Assumptions, Key Input, Calibration and Validation: No models currently exist to predict a reduction of nuisance aquatic macrophytes as a result of phosphorus controls, therefore, no macrophyte models were used. Control of nuisance aquatic macrophytes is based on established literature and best professional judgment. In-lake nutrient concentrations were modeled to estimate how nutrient management may reduce in-lake nutrient concentrations and reduce the probability of algal blooms in the future. Based on the Dillon-Rigler (1974) model the in-lake total phosphorus concentrations is predicted from:

$$P = P_I * (1\text{-}R)$$

where P_i=(Lp/(Z/T) and R (phosphorus retention=(0.426$e^{-0.271Z/T}$ + 0.574$e^{-0.00949Z/T}$) and Lp (areal loading rate or 790 kg/yr / 1300000 * 1000g/kg)=0.608 g/m^2/yr, Z (mean depth)= 3m, and T(hydraulic retention time)=0.64 to 0.73 years. The predicted total phosphorus averages 0.044 and agrees with the measured average total phosphorus concentration of 0.044 mg/L (44 ppb), because the loading rate, and specifically, the internal loading rate was adjusted as noted above. Note that the loading rate used by Whitman and Howard (1987) of 1213 kg/yr, which included the higher estimate of sediment phosphorus recycling, would result in a predicted lake concentration of 0.064 to 0.074 mg/l.

The Dillon-Rigler model is based on the typical assumptions of a single compartment, fully mixed open system which was calibrated on 13 Canadian lakes. The model was designed for use on algal dominated lakes and may become inaccurate in lakes with large areas dominated by macrophytes such as Bare Hill Pond. Otherwise, Bare Hill Pond falls within the range of the calibration dataset for lake area, mean depth and areal loading of phosphorus. The model was calibrated to spring overturn total phosphorus conditions and the spring values for Bare Hill Pond ranged between 0.03 and 0.05 mg/l, thus the yearly average of 0.044 mg/l is representative of spring conditions. As noted above, for the purposes of this TMDL we estimated the internal loading to be 342 kg/yr.

Seasonality: As the term implies, TMDLs are often expressed as maximum daily loads. However, as specified in 40 CFR 130.2(I), TMDLs may be expressed in other terms when appropriate. For this case, the TMDL is expressed in terms of allowable annual loadings of phosphorus. Although critical conditions occur during the summer season when weed growth is more likely to interfere with uses, water quality in many lakes is generally not sensitive to daily or short term loading, but is more a function of loadings that occur over longer periods of time (e.g. annually). Therefore, seasonal variation is taken into account with the estimation of annual loads. In addition, evaluating the effectiveness of nonpoint source controls can be more easily accomplished on an annual basis rather than a daily basis.

For most lakes, it is appropriate and justifiable to express a nutrient TMDL in terms of allowable annual loadings. The annual load should inherently account for seasonal variations by being protective of the most sensitive time of year. The most sensitive time of year in most lakes occurs during summer, when the frequency and occurrence of nuisance algal blooms and macrophyte growth are usually greatest. Therefore, because the Bare Hill Pond phosphorus TMDL was established to be protective of the most environmentally sensitive period (i.e., the summer season), it will also be protective of water quality during all other seasons. Additionally, the targeted reduction in annual phosphorus load to Bare Hill Pond will result in the application of phosphorus controls that also address seasonal variation. For example, certain control practices such as stabilizing eroding drainage ways or maintaining septic systems will be in place throughout the year while others will be in effect during the times the sources are active (e.g., application of lawn fertilizer).

Implementation

Considering the lack of information on discrete sources of phosphorus to the lake the implementation plan will of necessity include an organizational phase, an information gathering phase, and the actual remedial action phase.

Phosphorus sources can not be reduced or eliminated until the sources of phosphorus are identified. Because many of the nutrient sources are not under regulatory control of the state, engagement and cooperation with local citizens groups, landowners, local officials and government organizations will be needed to implement this TMDL. The Massachusetts Department of Environmental Protection will use the Watershed Basin Team as the primary means for obtaining public comment and support for this TMDL. The proposed tasks and responsibilities for implementing the TMDL are shown in Table 2. The next step will be to release this TMDL for public comment to watershed and lake associations, town conservation commissions and the interested public. Depending on public response, a public meeting will be held to obtain comments on the report, define goals and to organize groups for implementation. The local citizens within the watershed will be encouraged to participate in the information gathering phase. This phase may include a citizen questionnaire mailed to homeowners within the watershed to obtain information on use of the lake, identify problem areas in the lake and to survey phosphorus use and Best Management Practices in the watershed. A similar questionnaire was mailed as part of the Whitman and Howard (1987) study, but with only a 29 percent response rate. In that questionnaire, most residents wanted noise and powerboats limited as well as limitations on shoreline development. The most important part of the information-gathering phase is to conduct a NPS watershed field survey to locate and describe sources of erosion and phosphorus within the watershed following methods described in "A Citizen's Guide to Lake Watershed Surveys. How to Conduct a Nonpoint Source Phosphorus Survey" by Williams, (1997). For this survey volunteers are organized and assigned to subwatersheds to specifically identify, describe and locate potential sources of erosion and other phosphorus sources by driving the roads and walking the streams. Once the survey is completed, the Basin Team will be asked to review and compile the data and make recommendations for implementation. Responsibility for remediation of each identified source will vary depending on land ownership, local jurisdiction and expertise as indicated in Table 3. For example, the lake association may organize a septic tank pumping on a two to three year schedule for all lakeside homeowners. Usually a discount for the pumping fee can be arranged if a large number of homeowners apply together. Farmers can apply for money to implement BMPs as part of the NRCS programs in soil conservation. Town public works departments will generally be responsible for reduction of erosion from town roadways and urban runoff. The conservation commission will generally be responsible for ensuring the BMPs are being followed to minimize erosion from construction within the town. A description of funding sources for these efforts is provided in the Program Background section, above.

The major implementation effort would take place during the year 2000 as part of a rotating 5-year cycle, but would continue in the "off years" as well. The major components will focus on stage I of Whitman and Howard (1987), which involves septic system inspection, maintenance and upgrades as required under Title 5 with the Board of Health as the lead agency. Additional nutrient and erosion control will focus on enforcement of the wetlands protection act by the local Conservation Commission and various Best Management practices supported by the National Resource Conservation Service (NRCS formerly SCS). Best Management Practices (BMPs) for logging are presented in Kittredge and Parker (1995) and BMPs for general nonpoint source pollution control are described in a manual by Boutiette and Duerring (1994), BMPs for erosion and sediment control are presented in DEP (1997). The Commonwealth has provided a strong framework to encourage watershed management through the recent modifications to on-site septic system regulations under Title 5 and by legislation requiring low phosphorus detergents. All of these actions will be emphasized during the outreach efforts of the Watershed Team.

The Department is recommending that the lake be monitored on a regular basis and if the lake does not meet the water quality standards additional implementation measures may be implemented. For example, if phosphorus concentrations remain high after watershed controls are in place, then in-lake control of sediment phosphorus recycling may be considered.

The current TMDL proposes only a 4.9 percent reduction in phosphorus loading from landuse activities (other than septic systems) and this is expected to be easily achieved. As new housing development expands within the watershed, additional measures are needed to control the associated additional inputs of phosphorus. A proactive approach to protecting the lake may include limiting development, particularly on steep slopes near the lake, changes in zoning laws and lot sizes, requirements that new developments and new roadways include BMPs for runoff control and more stringent regulation of septic systems. A map of current (1990) land use for the watershed is shown in Figure 1. Examples of town bylaws for zoning and construction, as well as descriptions of BMPs are presented in the Nonpoint Source Management Manual by Boutiette and Duerring (1994), that was distributed to all municipalities in Massachusetts. Other voluntary measures may include encouraging the establishment of a vegetative buffer around the lake and along its tributaries, encouraging the use of non-phosphorus lawn fertilizers and controlling runoff from agriculture and timber harvesting operations. Such actions can be initiated in stages and at low cost. They provide enhancements that residents should find attractive and, therefore, should facilitate voluntary implementation. The National Resource Conservation Service is an ideal agency for such an effort and the residents will be encouraged to pursue NRCS' aid.

Reducing the supply of nutrients will not in itself result in achievement of the goals of the TMDL and continued macrophyte management is an essential part of the implementation plan. The approach recommended in the ENSR (1998) report is to continue with current winter drawdrown (47 inches) with close monitoring; adjust the harvesting program to increase effectiveness, perform a pilot herbicide treatment; use benthic barriers in the Town swimming area; and seek opportunities to get selected areas dredged at reduced cost. As noted in Appendix IV, the harvester broke twice in 1998 after hitting boulders and thereafter operator set harvester to cut only 2' deep. This may also explain the poor effectiveness of harvesting to control plant growth because the machine was set too shallow. Marking or removing boulders, or restricting harvesting to established channels may be options to allow proper depth of cutting while minimizing breakdowns. A synoptic survey by DEP staff in August of 1998 indicated that roughly 20-30 percent of the pond has dense or very dense macrophytes that are still impairing uses. This is in close agreement to the approximately 30% dense cover reported in ENSR (1998). While this represents an improvement (approximately 50 percent reduction of impaired areas from the 1986 survey), the lake will likely be re-listed on the next 303d list in the year 2000.

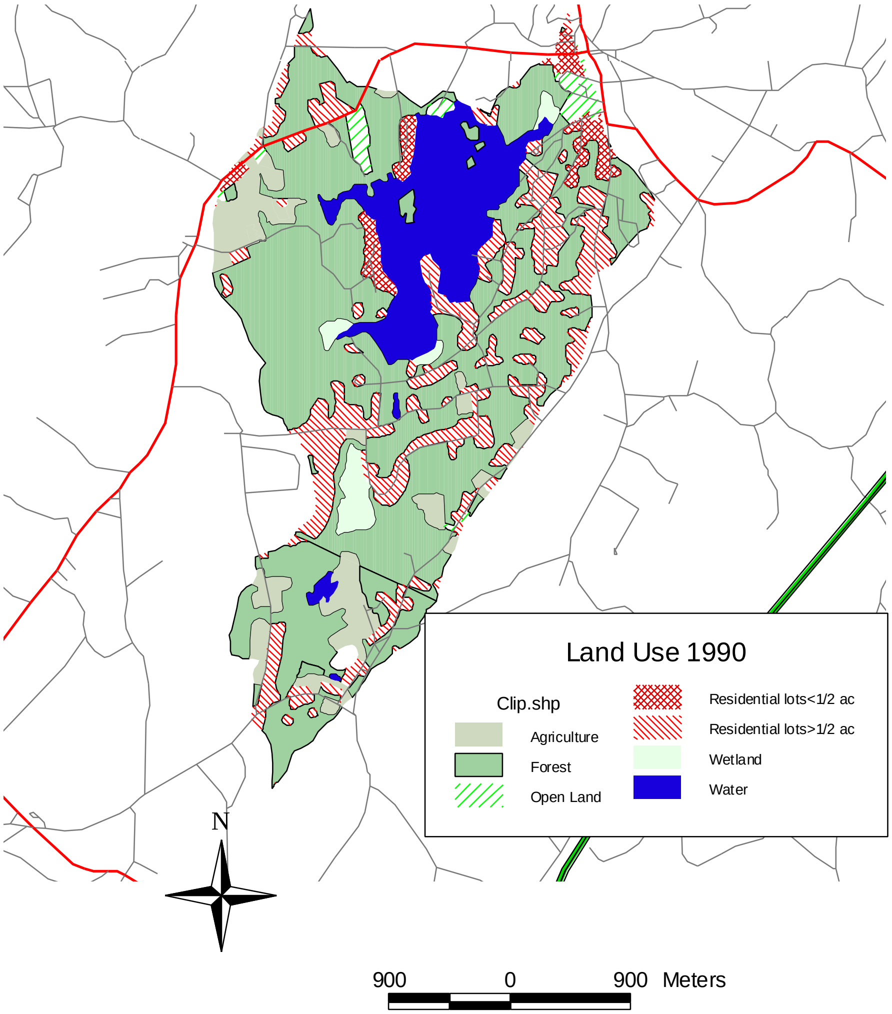

Figure 1. Current (1990) land use in Bare Hill Pond Watershed.

Table 2. Proposed Tasks and Responsibilities

Tasks	Responsible Group
TMDL development	DEP
Public comments on TMDL, Public meeting	DEP and Watershed Team
Response to public comments	DEP
Organization, contacts with Volunteer Groups	Watershed Team
Develop guidance for NPS watershed field survey.	DEP
Organize and implement NPS watershed field survey	Watershed Team and Bare Hill Watershed Association
Compile and prioritize results of NPS watershed surveys	Watershed Team and Bare Hill Watershed Association
Organize implementation; work with stakeholders and local officials to identify remedial measures and potential funding sources.	Watershed Team and Bare Hill Watershed Association
Write grant and loan funding proposals	Bare Hill Watershed Association, Nashua Watershed Associations, Towns, Planning Agencies, NRCS
Organize and implement education, outreach programs	Bare Hill Watershed Association, Nashua Watershed Associations,
Implement remedial measures for discrete NPS pollution	See Table 3 below.
Include proposed remedial actions in the Watershed Management Plan	Watershed Team
Provide periodic status reports on implementation of remedial actions to DEP	Watershed Team
Monitoring of lake conditions	DEP (year 2 of cycle) and Bare Hill Watershed Association (annually)

Table 3. Guide to Nonpoint Source Control of Phosphorus and Erosion

Type of NPS Pollution	Whom to Contact	Types of Remedial Actions
Agricultural		
Erosion from Tilled Fields	Landowner and NRCS	Conservation tillage (no-till planting); contour farming; cover crops; filter strips; etc.
Fertilizer leaching	Landowner and NRCS and UMass Extension	Conduct soil P tests; apply no more fertilizer than required.
Manure leaching	Landowner and NRCS and UMass Extension	Conduct soil P tests; obtain estimate of phosphorus in manure. Apply no more manure than required by soil P test. Install manure holding structure. Do not apply on frozen ground or near surface waters.
Erosion and Animal related impacts	Landowner and NRCS	Fence animals away from streams; provide alternate source of water.
Construction		
Erosion, pollution from development and new construction.	Conservation commission, Town officials, planning boards	Enact bylaws requiring BMPs and slope restrictions for new construction, zoning regulations, strict septic regulations. Enforce Wetlands Protection Act
Erosion at construction sites	Contractors, Conservation commission	Various techniques including seeding, diversion dikes, sediment fences, detention ponds etc.
Resource Extraction		
Timber Harvesting	Landowner, logger, Regional DEM forester	Check that an approved forest cutting plan is in place and BMPs for erosion are being followed
Gravel Pits	Pit owner, Regional DEP, Conservation commission	Check permits for compliance, recycle wash water, install sedimentation ponds and berms. Install rinsing ponds.
Residential, urban areas		
Septic Systems	Homeowner, Lake associations, Town Board of Health, Town officials	Establish a septic system inspection program to identify and replace systems in non-compliance with Title 5. Establish a regular septic system inspection program. Discourage garbage disposals in septic systems.
Lawn and Garden fertilizers	Homeowner, Lake associations	Establish an outreach and education program to encourage homeowners to eliminate the use of phosphorus fertilizers on lawns, encourage perennial plantings over lawns.
Runoff from Housing lots	Homeowner, Lake associations	Divert runoff to vegetated areas, plant buffer strips between house and lake
Urban Runoff	Landowner, Town or city Dept. Public Works	Reduce impervious surfaces, institute street sweeping program, batch basin cleaning, install detention basins etc.
Unpaved Road runoff	Town or city Dept. Public Works	Pave heavily used roads, divert runoff to vegetated areas, install riprap or vegetate eroded ditches.

Other stream or lakeside erosion	Landowner, Conservation Commission	Determine cause of problem; install riprap, plant vegetation.

Water Quality Standards Attainment Statement

The proposed TMDL, if fully implemented, will result in the attainment of all applicable water quality standards, including designated uses and numeric criteria for each pollutant named in the Water Quality Standards Violations noted above.

Monitoring

A synoptic survey of the lake from vantage points on the shoreline was conducted by DEP in August of 1998 and as noted above most of the lake surface (approximately 70-80 percent) was apparently clear of nuisance aquatic vegetation. Monitoring by DEP staff will be continued on a regular basis according to the five-year watershed cycle. Baseline surveys on the lake should include Secchi disk transparency, nutrient analyses, temperature and oxygen profiles and aquatic vegetation maps of distribution and density. At that time the effectiveness in reducing plant cover and reducing total phosphorus concentrations can be re-evaluated and the TMDL modified, if necessary. Additional monitoring by volunteer groups will be encouraged.

Public Participation

As part of the D/F study by Whitman and Howard (1987), there was extensive public participation in all phases of the study and these included public meetings (held June 19, 1985 and Feb. 26, 1986) and a questionnaire distribution (June 4, 1985). Recent meetings with Basin Team members including the Nashua River Watershed Association were held in West Boylston on May 28, 1998. This draft TMDL was announced in the Environmental Monitor for public review and comment on April 7, 1999. After a response to public comments is completed, the TMDL will be submitted to EPA for final approval. The results of a lake management questionnaire returned by the Bare Hill Pond Watershed Management Committee are available in Appendix III.

Public Comment and Reply

A public meeting to obtain comments on the Bare Hill Pond TMDL was announced in the Environmental Monitor and the official comment period was extended to July 25, 1999. The public meeting was held by Dr. M. Mattson and Dr. R. Isaac of the Massachusetts Department of Environmental Protection on June 16, 1999 in the Public Library of the Town of Harvard from 7-9pm. The meeting was attended by 25 people including representatives of the local Selectmen, the Conservation Commission, the Nashua River Watershed Association, the EOEA Basin Team Leader, the U.S.E.P.A. and the Bare Hill Pond Watershed Management Committee along with local residents. Comments from the meeting, as well as comments received in the mail are reprinted in Appendix II along with the Department's Response to Comments.

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Appendix I Reprint of Whitman and Howard (1987).

The following pages are selectively reproduced from Whitman & Howard (1987). Diagnostic/Feasibility Study Bare Hill Pond. Harvard, Massachusetts.

DIAGNOSTIC/FEASIBILITY STUDY
BARE HILL POND
HARVARD, MASSACHUSETTS

FOR THE

BARE HILL POND MANAGEMENT COMMITTEE

JULY, 1987

WHITMAN & HOWARD, INC.
45 WILLIAM STREET
WELLESLEY, MASSACHUSETTS 02181

EXECUTIVE SUMMARY

This study was conducted by Whitman & Howard, Inc. for the Town of Harvard and the Bare Hill Pond Study Committee. Study funding was provided by the Town of Harvard and the Commonwealth of Massachusetts under Chapter 628 "Clean Lakes Program". The study was comprised of two parts, a diagnostic analysis of the pond's current condition and a feasibility section which compared restoration methods. The study's purpose was to describe Bare Hill Pond's morphology, determine the trophic state of the pond and develop reasonable means for improving and protecting water quality for contact and non-contact recreation.

Diagnostic data collected over a twelve (12) month period indicate that the pond's inlets contribute the majority of external nutrients to Bare Hill Pond. Individual wastewater disposal systems comprise a large percentage of this tributary loading to the pond. This nutrient source and nutrients accumulated/recycled from sediments provide for the growth of nuisance aquatic weeds in the pond.

The conclusion of the diagnostic section was that the growth of aquatic weeds in the pond was due to both natural and development oriented influences. The rich sediment material in the bottom of the pond supports the weed growth, while runoff and septic system leachate provide continued nutrient enrichment.

The feasibility section reviewed available methodologies for pond restoration, selected those with reasonable applicability to Bare Hill Pond and evaluated selected alternatives based on environmental, economic and effectiveness criteria. Through this process, the reduction of inlet nutrient levels, water level manipulation and weed harvesting are recommended for reducing the excessive weed growth.

The first stage of pond restoration is recommended to include a program of watershed management and level manipulation and that weed harvesting be continued with improved management of these activities. The continued restoration of the pond should include influent nutrient control at the Beach Area, Bowers Brook, Clapps Brook and Thurston's Brook.

Cost of the above work is expected to be in the range of 87,000 to 965,000. Project time frame is approximately four years with work commencing in the fall of 1988. Restoration funding would be available from the Commonwealth of Massachusetts at a 75 percent level. The town would be required to raise the remainder of necessary funds. No State funding would be available for work on private property or for normal O&M costs.

It should be noted that the pond will not become a "pristine" waterbody as a result of the recommended restoration program. At present, the excessive weed growth in the pond reflects the internal and external nutrient loadings.

The restoration effort is aimed at reducing the external sources and should result in reduction of the eutrophication rate of the pond. Following implementation of restoration alternatives, the pond will still support weeds but density will hopefully be reduced. The goal of the restoration program is to control the nutrient loading sources to the pond and then re-assess the trophic state of the pond to define additional restoration measures, if necessary. Bare Hill Pond will continue to rate as eutrophic due to available nutrients in the sediment.

The proposed restoration components, their costs and a preliminary restoration effort schedule are as follows:

PROJECT COST SUMMARY

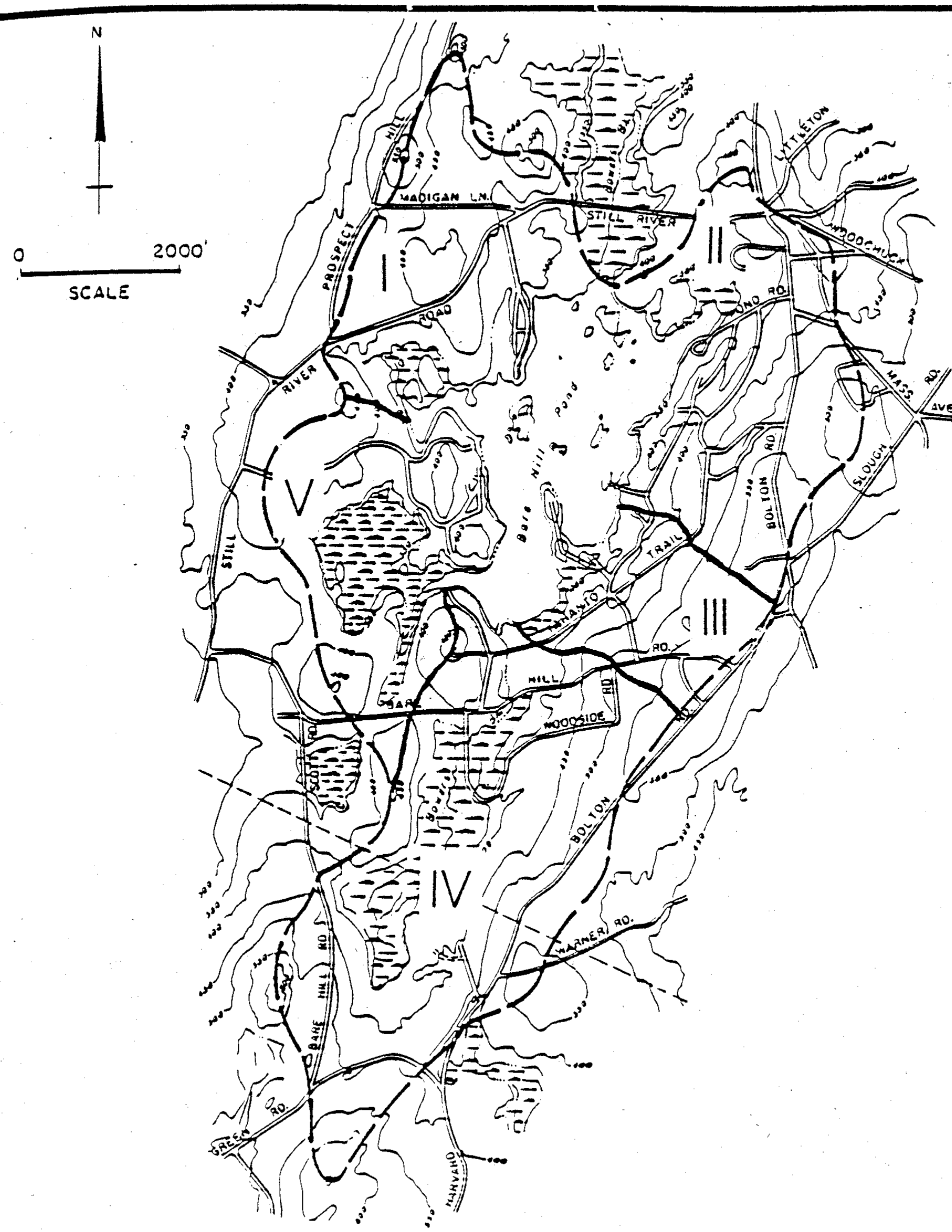
BARE HILL POND - PHASE II - RESTORATION

A. STAGE I: Management and Harvesting

Level Control		$ 15,000
Watershed Management		30,000
Weed Harvesting/Raking (Outside Assistance)		20,000
Contingencies @ 10%		7,000
Consultant Assistance		10,000
Monitoring Program		5,000
	Sub-total	$ 87,000

B. STAGE II: Source Control/Program Management

Inlet Controls		$600,000
Contingencies		150,000
Engineering Design		40,000
Construction Oversight		73,000
Monitoring Program & Report		15,000
	Sub-total	$878,000
	TOTAL PROGRAM COST	$965,000



BARE HILL POND SUBWATERSHEDS

Clapp's Brook Subwatershed (I)
Pond Road Inlet Subwatershed (II)
Thurston's Brook Subwatershed (III)
Bowers Brook Subwatershed (IV)
Sprague Swamp Subwatershed (V)

WHITMAN & HOWARD INC. **WELLESLEY, MASS.**	**PLATE 4**

TABLE 39

BARE HILL POND
HARVARD, MASSACHUSETTS

Nutrient Budget Summary

Source	Total Nitrogen KG/YR (%)	Total Phosphorus KG/YR (%)
Atmospheric Fallout ("Most Likely Values")	1,018.8 (23.1)	63.2 (5.2)
Ambient Groundwater	1,058.4 (24.0)	50.4 (4.2)
Runoff (Surface & Groundwater)		
1) Clapp's Brook Subwatershed	403.44 (9.2)	60.51 (5.0)
2) Pond Road Subwatershed	475.75 (10.8)	71.36 (5.9)
3) Thurston's Brook Subwatershed	347.91 (7.9)	43.49 (3.6)
4) Bowers Brook Subwatershed	723.98 (16.4)	104.18 (8.6)
5) Sprague Swamp Subwatershed	376.34 (8.5)	56.45 (4.7)
Phosphorus Sediment Recycling	N/A	763.0 (62.8)
Total Imputs	4,404.62 (100)	1,212.59 (100)
Total Outflow (Average)	1,660.55	297.76

TABLE 40

BARE HILL POND
HARVARD, MASSACHUSETTS

LAND USE SUMMARY

Land Use Categories	Bare Hill Pond Watershed (Hectares)	(% of Total)
Residential	139.6	(15.6)
Commercial	9.4	(<1)
Open Space	79.4	(8.3)
Agriculture	43.8	(4.6)
Forest	610.3	(64.0)
Wet Land	70.2	(7.4)
	952.7	(100.0)

Note: One Hectare = 2.471 acres

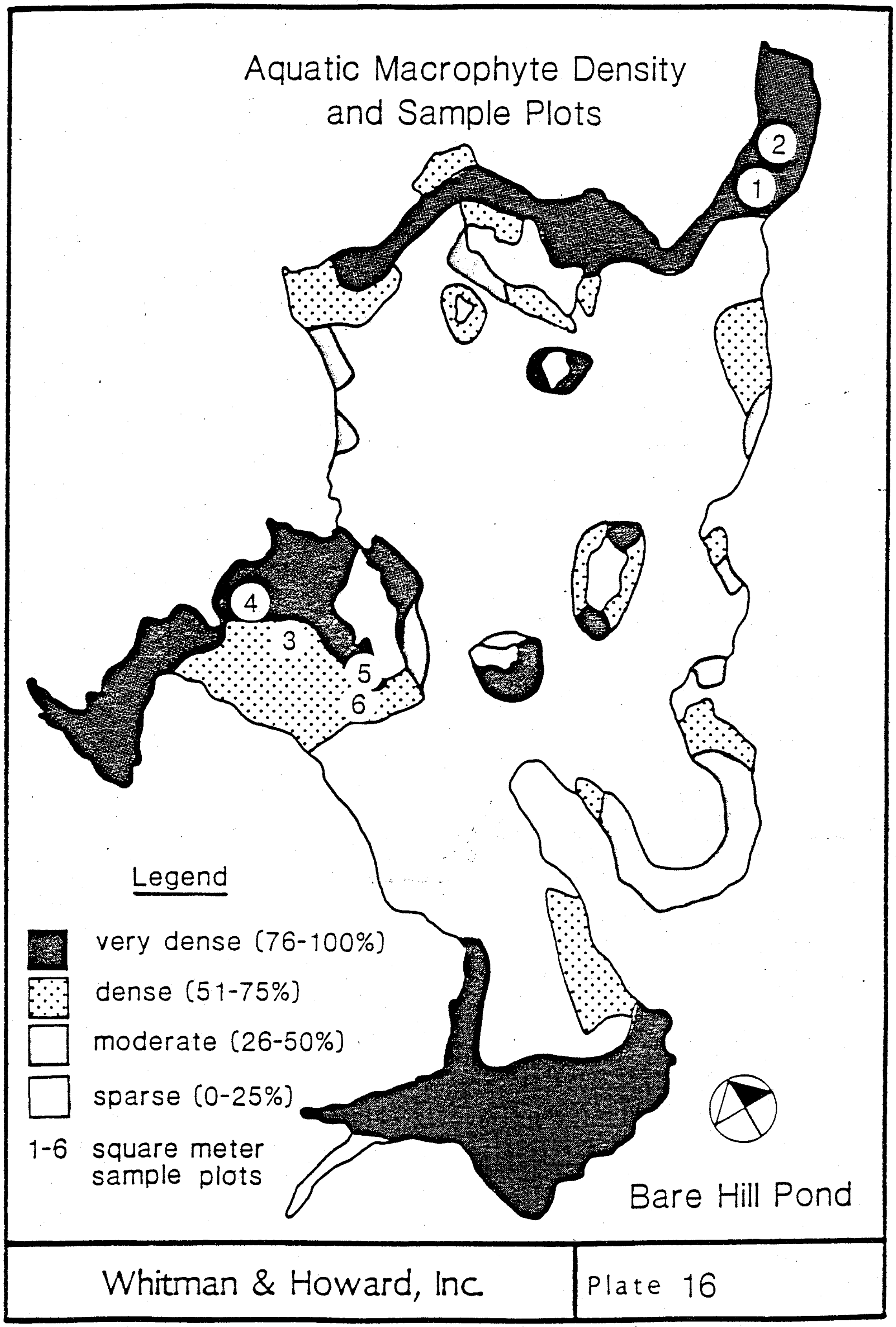
TABLE 42

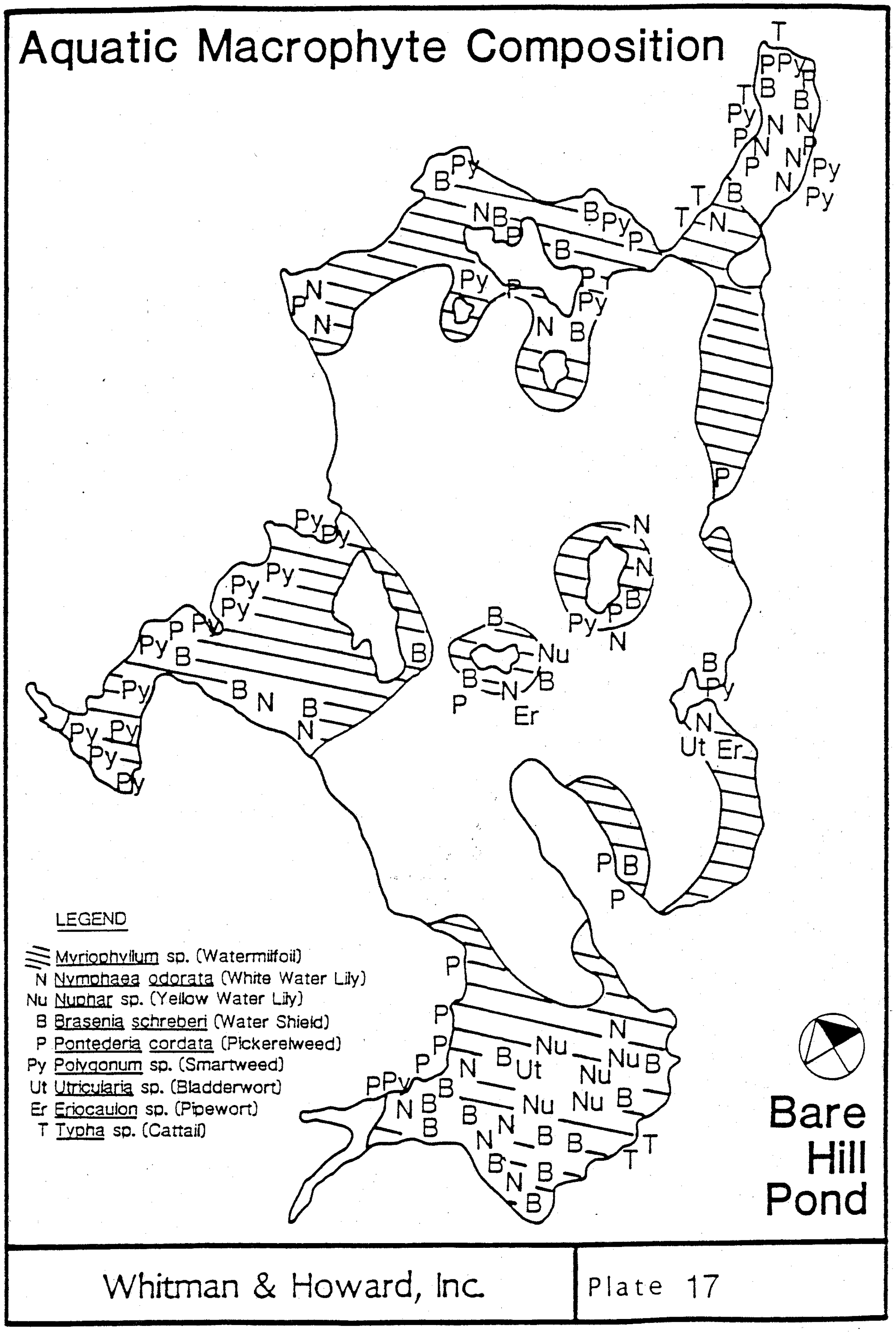
BARE HILL POND
HARVARD, MASSACHUSETTS

MASS PHOSPHORUS LOADING
"MOST LIKELY" VALUES

Land Use	Loading (KG/YR)
Residential	202.4
Commercial	16.0
Open Space	21.4
Agriculture	43.8
Forest	167.8
Atmospheric Fallout	63.2
Wastewater (Most Likely Soil Retention)*	254.2
	768.8
Subwatershed I	74.3
Subwatershed II	134.5
Subwatershed III	42.3
Subwatershed IV	147.2
Subwatershed V	53.1
Atmospheric Fallout	63.2
All Wastewater (Most Likely Soil Retention)*	254.2
	768.8

* See Appendix F


Aquatic Macrophyte Density
and Sample Plots
1
2
3
4
5
6
Legend
very dense (76-100%)
dense (51-75%)
moderate (26-50%)
sparse (0-25%)
1-6 square meter
sample plots
Bare Hill Pond
Whitman & Howard, Inc.
Plate 16



Aquatic Macrophyte Composition
LEGEND
Myriophyllum sp. (Watermilfoil)
N Nymphaea odorata (White Water Lily)
Nu Nuphar sp. (Yellow Water Lily)
B Brasenia schreberi (Water Shield)
P Pontederia cordata (Pickerelweed)
Py Polygonum sp. (Smartweed)
Ut Utricularia sp. (Bladderwort)
Er Eriocaulon sp. (Pipewort)
T Typha sp. (Cattail)
Bare Hill Pond
Whitman & Howard, Inc.
Plate 17

Appendix II Summary of Public Comment and Response.

Comments of Patricia Austin, PE, Metropolitan District Commission:

#1) Introduction – DEP should state specifically who they expect to use this document, what management plans(s) DEP expect(s) to be impacted by this document, and what permits or discharges DEP expects to be set based on this document

Response: These points were added to the introduction.

#2) General Background – This section is longer than the actual assessment of Bare Hill. I suggest shortening this section, and trying to add more information that is specific to Bare Hill Pond in the Problem Assessment section.

Response: As this is a new program, a detailed General Background was deemed necessary. Additional information on Bare Hill Pond and past management activities is now provided in the completed questionnaire in Appendix III.

#3) P. 6, Par 3 – "The Massachusetts Department of Environmental Protection will endorse in-lake remediation efforts…"—this statement may be misleading to the average citizen. I served on the Worcester Conservation Commission for four years. There are many lakes in the city which need restoration measures ranging from herbicide treatment to lake drawdown and week harvesting. I encountered several cases where the Commission did not feel it could permit proposed lake remediation measures and write an order of conditions which was in conformance with the wetlands regulations. This is because there are basic conflicts between intent and conduct of programs within DEP, most notably the Wetlands Program and the Lakes Program. The DEP, DWM staff should work with their DEP colleagues, especially those in the Wetlands Program. to incorporate "environmental concerns" from the beginning of the TMDL process, and be certain that remediation plans are in conformance with, and will be "permittable" by, all groups within DEP.

Response: The Department recognizes the potential for conflicts between the lakes management programs and the wetlands regulations, however each treatment must be evaluated based on local conditions at the lake in question and can not be resolved prior to submittal of a detailed Environmental Notification Form. For example, the local Conservation Commission, which has authority of enforcement of the Wetlands Protection Act, may not permit a lake drawdown in a specific case, yet may approve of it in another case based on local conditions and the specifics of the drawdown. At this point, we do not have detailed information on Bare Hill Pond related to the eight interests of the Wetlands Protection Act.

#4) Problem Assessment – There should be a map with the contributing watershed. The narrative should include land use for pond's watershed, both as a table and a GIS map.

Response: The watershed map (with subwatersheds) from the Whitman and Howard (1987) report is now included in the appendix. The most recent landuse map available (1990) is now included in the report.

#5) Water Quality Standards Violation Discussion—Aren't there more water quality standards than those listed in this section (e.g., Dissolved Oxygen, fecal coliform, etc.). A table which lists the numeral standards, plus the values which have been observed in the lake would be helpful.

Response: Although more Water Quality Standards exist, only water quality standards which are not being met are listed.

#6) Pollutant Sources—This really seems to be the crux of the analysis, yet this report basically says that DEP doesn't know what the source actually is. Is there any additional analysis which can be done to make some more definitive statements? In particular, it seems very important to get more information about the loading due to internal cycling. It is true that in general BMPs to reduce nutrient loading are a good thing. However, they do add costs to any construction project. DEP needs to make a stronger case for benefits these measures will provide, if they expect the community to take on the task of adopting local measure to require additional BMPs.

Response: The sources of phosphorus are largely unknown, and that is why the Department has recommended a Watershed NPS survey as a major piece of the implementation plan. Additional monitoring of lake nutrient levels may help narrow the estimated internal sources of phosphorus. The Department is not requiring any specific BMPs. Specific BMPs will be recommended by the Basin Team after the results of the NPS watershed survey locate specific sources of phosphorus which can be reduced in a cost effective manner.

#7) TMDL Analysis/Waterload Allocation – Overall, this is somewhat confusing and weak argument. There is little data, and much of the data is very old. With the numerical basis so uncertain, would it be better to just recommend some general BMPs for concerned citizens rather than doing the TMDL (i.e., recommend some treatment technology rather than numerical limits)?

Response: The TMDL is based on the Whitman and Howard report of (1987) which is based on a full year of intensive sampling of inlets, the lake and the outlet for nutrients, and water flow estimates. While the data are old, there is little evidence that conditions have changed in the watershed. In fact, total phosphorus concentrations measured last year as reported in the ENSR (1998) report (50 ppb) are not different from the levels reported in the Whitman and Howard (1987) report (44 ppb). In addition, the Federal Clean Water Act section 303d requires a numeric TMDL and recommending general BMPs is not sufficient to comply with the law.

#8) Implementation – It would be useful to have a discussion of the measures recommended by the 1987 D/F study to improve water quality. Have they been implemented? If so, were they successful? If not, why weren't they implemented? Presumably, many of the recommendations in this report are similar to those in the D/F study. Are they more likely to be implemented now than in 1987?

Response: There has been some upgrading of private septic systems to comply with the Title 5 requirements since the D/F study in 1987 (see response to questionnaire in Appendix III). As such, some of the recommended implementation has already been achieved. Apparently, there has been few documented BMPs implemented for NPS pollution in the watershed. As noted in the TMDL report, the Whitman and Howard (1987) report recommended detention ponds that are not recommended here. The Department is now offering increased priority for funding of BMP measures and thus there is a greater likelihood of implementation now than in 1987.

#9) If septic system is a major concern as a pollutant source, this is an area where there have been significant changes since the 1987 report was published. Major revisions were made to Title 5, in large part to bring around improvements to surface water quality. So, there should be some discussion of this (e.g., how many septic systems are actually in the drainage, what percentage can reasonably be expected by upgraded through inspection and transfer; what percentage has been upgraded since 1987 reports, etc.).

Response: As noted above, there have been improvements in the septic systems within the watershed. According to the Harvard Board of Health there are no shared systems in the area, but there are several pumped systems and several tight tanks near the lake. Local Board of Health regulations restrict septic systems 100 feet or more from wetlands. The local Conservation Commission also applies orders of conditions regarding septic system placement for new construction as well. More detailed information on septic systems can be obtained during the watershed survey. Note that the systems may improve in phosphorus retention merely by being pumped and inspected regularly, without the requirement for upgrades unless the system is failing. Thus, all of the systems that can be included in a pump and inspection program are likely to improve regardless of the number of upgrades.

#10) The NPS watershed survey should be included in the report, as an Appendix; and should be ready to present to citizens at the public meeting for the TMDL.

Response: The NPS watershed survey is part of the proposed implementation plan, not part of the draft TMDL to be discussed at the public meeting. A copy of "A Citizen's Guide to Lake Watershed Surveys" by Williams (1997) was delivered to the Nashua River Watershed Association and addition copies will be mailed to the Bare Hill Pond Watershed Management Committee and to the EOEA Basin Team Leader.

#11) It is important to be clear about whether recommendations are to try to improve an existing problem (remediation) or prevent additional loadings to the pond. For instance, bylaws for BMPs in new construction will reduce the additional nutrient loading (theoretically) form new construction relative to similar construction without BMPs, but it will do nothing to reduce the current loading and improve existing conditions.

Response: Because we are proposing a reduction in current loading it is a remediation plan and obviously, a prevention plan as well. While new bylaws for construction can be implemented for prevention, additional measures, such as reducing fertilizer use and implementation of BMPs in road maintenance and agriculture can achieve reductions in current loadings.

#12) Do the authors feel that controls are needed in addition to those by recent regulatory changes at DEP (e.g., Rivers Protection Act establishes protective buffers; title 5 provides more stringent requirements for repair, and siting new systems in sensitive area; stormwater guidance requires stormwater mitigation). In light of all the additional work local boards have taken on in the past few years because of all these new regulations; it would be good for DEP to be more specific in these recommendations for local controls (e.g., exactly what they are, why they are needed, etc.). A table which summarizes existing and recommended controls for Bare Hill Pond would be helpful.

Response: The Department acknowledges the lack of information on what BMPs and other measures have been implemented since the Whitman and Howard (1987) report, that is why the major implementation effort is a local NPS watershed survey to identify which BMPs are in place and which BMPs are still needed. Table 3 provides recommended controls for the types of NPS problems likely to be reported in the NPS watershed survey.

#13) Table 2—Tasks that DEP would like to have Nashua Team conduct should have been submitted to the team when the annual work plans are developed and reviewed. We asked DEP about this when we were developing the plan, and received no requests for assistance on Bare Hill Pond or other lakes in the Nashua watershed. Has DEP discussed tasks and responsibilities with other agencies and groups who are listed in this table (RPAs, NRCS, etc.)?

Response: The Department recognizes that all agencies have ever increasing responsibilities with few additional resources. The types of tasks and responsibilities listed are within the scope of responsibilities of the listed agencies, but it is up to those agencies to decide how best to fulfill those responsibilities. The Department has not discussed the responsibilities of other agencies and is only making recommendations for an implementation plan in this TMDL report.

#14) Monitoring - This states that DEP will monitor the lake on a regular basis, but Warren Kimball said (at the water quality subcommittee meeting) that it was unlikely that Bare Hill Pond would be monitored by DEP. This should be resolved; and should be clearly stated in the report (i.e., either state that DEP will monitor the lake, and when; or state that in fact it is unlikely that DEP will provide any monitoring assistance.).

Response: The Department monitors lakes within a basin such as the Nashua on a rotating five-year cycle. Due to staff and resource limitations, not all lakes will be monitored in each cycle. During which 5 year cycle Bare Hill will be monitored by DEP is unknown at this time.

#15) DEP must resolve their issues regarding the use of volunteer monitoring data. If DEP will not use volunteer data, DEP should not recommend that volunteers collect it. This is very frustrating. The Nashua team has been working with DEP on this issue for at least two years. The team helped DEP get a grant which was supposed to be used to resolve the QA/QC issues that DEP has relative to volunteer data.

Response: The Department welcomes the collection of volunteer data. The Department may use volunteer data which is not quality controlled to screen waters for possible water quality violations and/or to monitor effectiveness of BMPs in surface waters where the Departmental data is collected infrequently, such as Bare Hill Pond. Volunteer data which is not quality controlled can not be used to set official TMDL loadings or waste water discharge permits which are under the regulatory authority of the Department as such data may be challenged in court. The Department has a policy for accepting data for use in TMDL reports which is the same as requirements for the requirements for the water quality 305(b) assessments as stated in DEP DWM (1998): "At a minimum when data are used for making 305(b) assessments DEP requires that an appropriate Quality Assurance Project Plan (QAPP), including a Quality Assurance/Quality Control (QA/QC) plan be attached, that a state certified laboratory (certified in the analytes applicable to the monitoring plan) be used for analysis, that the data management QA/QC be described, and that the information be documented in a citable report."

The Department is sponsoring a research program at the University of Massachusetts Water Watch Partnership in Amherst, Massachusetts to provide assistance to volunteer groups that wish to develop a quality control plan for their volunteer monitoring efforts.

#16) Water Quality Standards Attainment Statement - I think it is unlikely that water quality standards (will be met), based on what has been put forward in this plan.

Response: The Water Quality Standards Attainment Statement is required by the United States Environmental Protection Agency. As noted, the lake already meets most water quality standards and is expected to meet all standards when the plan is implemented.

#17) Appendices – Project Cost Summary - In discussions with the team, DEP often refers to the measures which would improve water quality in the lake as small measures that can be implemented by volunteers. Yet, the table of Project Costs estimates the total program cost for Bare Hill Pond restoration at $965,000. This estimate was made in 1987; so the estimated costs would be considerably more today. Does DEP really think that volunteer efforts will be adequate to restore the pond?

Response: The $965,000 figure includes the Whitman and Howard (1987) estimate of $878,000 for costs associated with the detention ponds. Only $87,000 was projected for weed control, monitoring and associated costs, much of which is already being implemented in Bare Hill Pond. The additional volunteer efforts that the Department is recommending involve the NPS watershed survey and BMPs within the watershed for which there is additional funding potentially available from a variety of sources.

Comments of Jo Anne Carr, EOEA Nashua Basin Team Leader, summarizing comments of Water Quality Sub-committee meeting of April 22, 1999:

#1) I would like to take the opportunity to note that the TMDL should reflect current information, and provide an open process through which the report can be amended. If the development of a TMDL is intended, in part, to be supported by the public, then DEP needs to hear from those most affected, and incorporate information gathered from those stakeholders before distribution of the draft.

> Response: The Department did contact some of the stakeholders to get information prior to writing the draft TMDL. These contacts included participation at prior Nashua Basin Team Water Quality Sub-committee meetings and direct contacts with Gene Marsh of the Bare Hill Pond Committee who provided us with a copy of the recent ENSR report on Bare Hill Pond. In the future, additional efforts will be made to send out questionnaires to local stakeholders prior to preparation of the draft TMDL.

Comments by Section:

Introduction

#2) There needs to be Executive Summary for the general public – noting specific issues and recommendations to Bare Hill Pond. it appears that the report is heavily based on the Diagnostic and Feasibility study from 1987. The information in that study is outdated and may not reflect current lake conditions or recent actions undertaken at the local level.

> Response: An executive summary is now provided. Information on lake conditions and recent actions has been updated (see Appendix III and IV).

#3) It appears that the report is heavily based on the Diagnostic and Feasibility study from 1987. The information in that study is outdated and may not reflect current lake conditions or recent actions undertaken at the local level.

> Response: See response to P. Austin's Comment #7 above and the Questionnaire responses in Appendix III.

#4) There is question and concern with current land-use information. It should be noted clearly what the date of the land-use cover is – and whether any significant changes have occurred in sub-basins.

> Response: Land use information is not used as a basis for the TMDL report. The loading information comes from direct measurements (see response to P. Austin's Comment #7 above).

#5) There should be a map of the Pond's watershed and contributing tributaries showing land-uses and sub-drainage areas (as outlined on Table 1).

> Response: A landuse map is now provided for reference purposes in Appendix I, however, current conditions in the watershed are best assessed by the proposed volunteer NPS watershed survey.

General Background and Rational

#6) This language not "public readable," that is, as a document intended in part, to be distributed to the general public it is very difficult for the lay person to read. A summary of this section should be reflected in the Executive Summary.

Response: An executive summary is now provided.

#7) This narrative regarding phosphorus conditions in lakes in general, states among other things, that perhaps the most difficult source of phosphorus to account for is the phosphorus recycled in lake sediments. There is also a statement that phosphorus released from shallow lake sediments may be significant due to ideal conditions and that the most important factor in managing macrophyte growth is light. Further on, it is asserted that due to the large mass of nutrients stored in lake sediments, reductions in nutrient loadings are not expected to reduce macrophyte growth in a reasonable time frame. This introduction appears to contradict the result of the report, specifically to limit surface water sources of phosphorus inputs as a way to manage plant growth and address the reason for completing a TMDL.

Response: The report is written has two separate objectives: 1)to continue with in-lake treatments to manage macrophyte growth, and 2) to reduce total phosphorus loading in order to protect the lake water quality and prevent algae blooms. As stated, the nutrient reductions are not intended to control macrophyte growth within a reasonable time period.

#8) In this section of the document it states "DEP will endorse in-lake remediation," there is concern that there is inherent conflict within DEP in this statement. DEP Wetlands Section should be closely involved with an specific recommendations and remediation which may be proposed as a result of the TMDL.

Response: See response to P. Austin's comment #3 above.

#9) It is recommended that there be established a "Lake Team" as per the DGEIR for lake management released last winter. The Lake Team would consist of agency and local representatives.

Response: The Draft Generic Environmental Impact Report (dGEIR) on Eutrophication and Aquatic Plant Management in Massachusetts (Mattson et al., 1998) recommends that a Lake Management Technical Review Group be established from EOEA agencies. The report is under final review and it is expected that the review group will be established by EOEA to review and resolve inter-departmental and inter-agency issues on lake management.

Problem Assessment

#10) The growth projections relating to Devens redevelopment are questioned. The growth rate seems quite low.

Response: The section has been reworded.

#11) The DEP/DWM should acknowledge the need for updated information in the report and should also reference current work of the Pond Association (it is noted that there was reference to the recent ENSR report).

Response: The Department acknowledges the need for additional information. The recommended volunteer NPS watershed survey and proposed monitoring should provide additional information. The summary of the activities of the Pond Association is available in Appendix III.

#12) There are questions regarding sampling which may have occurred to support the document and what follow-up monitoring is to be expected. DEP/DWM expects monitoring to occur in "Year 2." DEP/CERO staff have noted that the sampling program does not include lakes (other than Pepperell impoundment) and hasn't at this time planned on sampling Bare Hill Pond.

Response: See response to P. Austin's comment #14 above.

#13) The implementation portion of the report shows that the Pond Association is expected to provide some sampling support. The Team is concerned whether the DEP would actually accept volunteer data. At this time there is no DEP approved QAPP for the Bare Hill Pond Association.

Response: See response to P. Austin's comment #15 above.

#14) There is also concern raised regarding water quality standards for bacteria and whether any water quality violations have occurred.

Response: Water quality sampling for bacteria within public beaches is conducted by the local Board of Health and is not reported to the Department.

<u>TMDL Analysis</u>

#15) The Team recommends further review of land-use allocations in each sub-watershed. It is not readily apparent that the loading limits reflect current land uses.

Response: See response to P. Austin's comment #4.

16) Table 1. **-** Is there any water quality sampling to support these numbers? Reasons why or why not should be documented.

Response: See response to comment #4 above.

<u>Wasteload Allocation</u>

#17) There is concern with the waste load allocation and margin of safety (MOS). How do we know that 5% is adequate for a margin of safety?

Response: As stated in the report, the waste load allocation is zero, as there are no point sources within the watershed. Although the margin of safety is set at 5% of targeted loading, it represents approximately 10 % of the targeted reduction in loading. This level of assurance was considered adequate considering the general nature of the implementation plan. The TMDL can be modified to reduce loading further and increase the margin of safety if future monitoring warrants such action. In addition, setting the margin of safety much higher than 5% at this time would make it increasingly unlikely that the more restrictive loading allocations from nonpoint sources could be achieved in a watershed where the major land use is forest. If the currently proposed TMDL is in fact, adequate, the BMPs required (unnecessarily) by a more stringent TMDL may make the implementation program too costly to be feasible.

<u>Implementation</u>

#18) Concern is raised regarding language with respect to buffer; Harvard may be ahead of the curve on providing buffers from human activities. The report should reflect current land-use policies and bylaws.

Response: Although the Rivers Protection Act restricts construction within a 'buffer' of lakes and streams there are additional ways to increase the effectiveness of such areas by vegetation management as well. For example, a fertilized lawn extending down to the stream could be replaced with a natural ground cover and/or woody plants which would tend to take up nutrients rather than export nutrients to the lake or stream.

#19) There is considerable concern regarding Table 2 Tasks and Responsibilities. Without consulting any of the parties beforehand, there are assumption(s) of capacity and resources to achieve these tasks which are very optimistic. An implementation schedule should be developed with those who are expected to take on this responsibility. The implementation is guaranteed to fail if DEP/DWM simply assigns tasks without consulting potential responsible parties. The Team recommends that Table 2 be revisited by DEP/DWM to develop some realistic actions and responsibilities.

Response: The proposed implementation in the draft was considered as a draft proposal and an email copy was sent to the Basin Team Leader for comment on March 31, 1999, prior to announcement and release of the draft document (no comments on Table 2 were received). While the Department considers the suggested tasks within the general responsibilities of the stakeholders and various agencies, we welcome all comments and discussions with the responsible parties.

#20) The Team recommends that DEP/DWM consult with the Pond Association, gather information from them, revise the draft report accordingly, and then hold a public informational meeting prior to the final revisions of the report.

Response: See response to comment #1 above, and see Appendix III and Appendix IV.

#21) DEP needs to make a presentation on the revised draft, which will include maps of the sub-watershed, orthophotos, and land-uses by sub-drainage area within the sub-watershed. In addition, some explanation on the value of this process for developing TMDLs needs to be made. Will these eventually be enforceable? Why or why not? The people impacted by this report and others as they come out need to understand the implication of a TMDL for their lake or pond.

Response: Orthophotos and land use maps were not used to develop the TMDL (See response to P. Austin's comment #4 above and response to comments #4 and #5 immediately above) although they may be useful during implementation and we will provide them at the public meeting. The TMDLs are enforceable by the state only in regards to areas where the state has authority to regulate, such as for point source discharges and stormwater discharges. Regulations regarding nonpoint discharges from land use (i.e. zoning regulations, and Wetlands Protection Act), construction and private septic systems, etc. are generally enforced by the town and local authorities, not by the state.

#22) It should be noted here that the Nashua Team has over this past year extended an invitation to work more closely with DEP/DWM by arranging meetings for DWM staff to review the strategy for the TMDL and any interim reports. The Team has also offered, early in the process, to bring stakeholder contributions to the drafting of the TMDL. Consistent with that approach, the Team is prepared to assist in arranging a preliminary public meeting on the current draft, and will also assist with a follow-up meeting when the report is revised.

Response: Your comments are noted.

Notes of some General Comments given during public meeting .

#1) Regarding the use of buffer strips, how effective are they?

Response: In terms of total phosphorus retention, the effectiveness of vegetated buffer strips (also called filter strips or field borders) depends on the width of the buffer strip and the slope of the land. Generally, buffer strips should be 25 feet wide on fairly shallow slopes. The Megamanual states that filter strips are 30-50 percent effective at removing sediment and moderately effective against nutrient export (Boutiette and Duerring, 1994).

#2) How do we report wetlands impacts related to the Wetlands Protection Act during lake drawdowns ?

Response: The first place to report problems is with the local Conservation Commission that issued the Order of Conditions for the project.

#3) Is there transport of phosphorus in groundwater to lakes?

Response: Most soils absorb phosphorus and generally, there is little transport of phosphorus in groundwater. However, sandy soils do not absorb phosphorus as well and thus may transport significant amounts of phosphorus. In addition, any soil can become oversaturated with phosphorus if enough loading is applied.

#4) Is remote sensing a good tool for mapping aquatic vegetation?

Response: While satellite remote sensing is not effective at mapping submerged vegetation at this time on the scale that would be useful, aerial photographs may provide valuable documentation of aquatic plant distributions.

#5) Additional local regulation may be difficult to implement unless there is strong evidence that it will be effective.

Response: Studies citing the effectiveness of various Best Management Practices are available in (Boutiette and Duerring, 1994). In some cases it is difficult to estimate effectiveness as it varies depending on circumstances, however, many of the BMPs and development restrictions have additional benefits of reducing erosion, reducing bacteria loading and may save money in the long term.

#6) What are the data requirements for the use of volunteer data in the TMDL process?

Response: See response to Pat Austin's comment #15 above.

#7) Is there a state tax incentive to septic system upgrades?

Response: Yes, there is a personal income tax credit for expenditures to comply with Title 5, however, certain restrictions apply (full details are given on the Massachusetts Department of Revenue web site http://www.state.ma.us/dor/rul%5Freg/tir/97/tir97_12.htm). Briefly, the home must be the principal residence and it must have a failed system. The credit is limited to 40% of expenditures and may be spread over 4 years with a $1,500 limit per year (a credit limit of $6,000 total).

#8) The Bare Hill Pond Committee would like to initiate deeper (8-foot) drawdowns in the winter to control macrophyte growth.

Response: Deeper drawdowns would expose much more of the macrophytes to freezing temperatures and this would be an big improvement in the ability to manage plant growth with little yearly expense. There are many issues to consider when proposing a deeper drawdown. There are structural constraints due to the location of culverts downstream that would appear to limit the depth of drawdowns, however these could be replaced at some expense. Another concern is the sediment that has infilled both in front of the dam and in the channel through the wetland below the dam. This sediment would have to be removed and this would require permits under the Wetlands Protection Act. Of primary concern would be impacts to any shallow public or private wells near the lake that may go dry during a deeper winter drawdown. Such concerns could be addressed with a contingency plan. Such a plan, possibly using a staged drawdown by increasing drawdown depth one foot each year, could be implemented if no serious impacts are observed at each stage. Finally, there are environmental concerns such as increased impacts on hibernating animals in the sediments, dissolved oxygen supplies and fish habitat in the pool in the lake during drawdown, impacts to downstream and upstream wetlands during the drawdown, impacts on any rare species and the impacts associated with refilling and maintaining downstream flow. Since most dense plant growth in Bare Hill Pond occurs in less than eight feet of water, an eight foot drawdown may excessively reduce plant growth and this could impact the 'protection of wildlife habitat' interest of the Wetlands Protection Act. According to the ENSR (1998) report, the lake should refill a 4-foot drawdown within 2 months in the spring. A deeper drawdown would probably take an additional month, which would limit the time of freezing and delay refilling which could impact fish spawning in the early spring. In summary, a somewhat deeper drawdown, perhaps to six feet, would be advantageous for aquatic plant management and might be achieved if approached slowly while addressing all concerns.

Comments taken from the Lake Management Questionnaire filled out by Mark Hastings, Chairman, Bare Hill Pond Watershed Management Committee:

1) Our analysis of previous studies indicates that the level of phosphorus entering the pond through its various inlets is approximately at the same level as the water already in the pond. This indicates that the high levels of phosphorus are attributable factors other than runoff from the watershed. The most likely source of the high phosphorus levels is the rich bottom muck found in most areas of the pond. (The southern end of the pond was actually once a cow pasture.) Given this, and the lack of algae blooms that would be normally expected, it seems safe to conclude that another limiting factor is at work. This factor is most probably the light limiting brown color caused by the presence of organic tannins in the water. The Bare Hill pond Watershed Committee is very concerned that a TMDL report that focuses on the phosphorus levels, will not properly target the main problem in the pond, namely the rooted aquatic plants. We are also concerned that this focus will divert limited resources, and energy away from the primary problem in the attempt to solve a secondary effect that is not a significant contributor to the problem at hand. Furthermore, we worry that this focus will create a legal requirement and financial burden on the taxpayers that will not yield an appreciable, if any, benefit.

We would like to see a TMDL report that could address *all* of the factors adversely affecting the water quality of Bare Hill Pond, with appropriate *priority* given to these factors. Such a report should include clear, quantifiable, objectives and goals. Any remedies recommended should include evidence of the effectiveness of such remedies. (Ex: if a requirement for annual pumping of septic systems recommended, it should be backed up with proven studies demonstrating the effectiveness of such action.)

Response: High levels of phosphorus in inlets as well as the lake would not rule out the watershed as a source, in fact, that would identify the watershed as the main source. As the Whitman and Howard (1987) report noted, the sediments are also a likely source for significant amounts of phosphorus to the lake. While the brown color of the lake water may limit light transmission and reduce the likelihood of algal blooms, it probably won't prevent surface blooms if phosphorus levels increase to higher levels. Many species of blue-green algae for example are buoyant and can float near the surface and thus would not be affected by light limitation. The large increase in total phosphorus concentrations from the 0.010 mg/l level in the early 1970's to about 0.044 to 0.050 mg/l levels observed recently (ENSR, 1998) suggest a large phosphorus increase which may lead to algal blooms and eutrophication. Thus, there is good reason to target phosphorus for control now before additional growth and development in the watershed impacts the water clarity. Therefore, common sense restrictions on building and construction activities, restrictions on phosphorus fertilizers and a septic system pumping and inspection program are warranted and in many cases are already in place. Although effectiveness for each proposed method can not be easily predicted, general effectiveness ranges for a variety of BMPs are noted in the Boutiette and Duerring (1994) report. In addition, the state and federal government are now offering various grant and loan programs which given higher priority to those applications that support TMDLs.

While macrophyte growth is an immediate concern for local residents, it appears that the current management activities and the management plan proposed by ENSR (1998) are adequate to manage the macrophytes. Additionally, if the harvesting is targeted to specific areas to create many channels through the area rather than dispersed across the lake, then the harvester can avoid rocky areas that damage the equipment. By harvesting in established channels and other areas the harvester can target areas repeatedly and harvest deeper, closer to the bottom, which is more effective against regrowth. Hand harvesting of Water Chestnut should be further encouraged particularly if all plants in the pond can be removed before seeds are produced. Over time, the viable seed supply in the sediments should be eliminated and a monitoring program established. As noted in the response to General Comments #8 above, an increase in drawdown depth may also increase effectiveness of macrophyte control in the pond.

Appendix III Response to Lake Management Questionnaire.

Preliminary Lake Management Survey For Municipalities, ConComms and Lake Associations

This information will be used to help develop Total Maximum Daily Load Reports as part of the Federal Clean Water Act requirements under section 303(d). If you are unsure of the accuracy of your answer to any question then add a question mark? and provide a name and phone number that we can call for further information on the subject.

Return to: Dr. Mark D. Mattson, Dept. Environmental Protection, DWM, 627 Main St. 2nd Fl
Worcester, MA 01608 (508) 767-2868 email mark.mattson@state.ma.us

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Type of Waterbody: Lake   Town, Basin Harvard, Nashua Basin   Name: Bare Hill Pond
ID number:81007   Pollutant Stressor: Nuisance aquatic plants
Comments: Information on the pond is summarized in the Whitman and Howard D/F study of 1987 and more recently in the ENSR report of 1998.

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1)Your Name and position title: Phone: email:

Mark D. Hastings   Chairman, Bare Hill Pond Watershed Management Committee   H (978) 456-6943
mhasting@pictel.com
W (978) 623-4928

2)Name of Municipality or Lake or Watershed Association and address:
Bare Hill Pond Watershed Management Committee, Town Hall   14 Ayer Road Harvard Ma, 01451

3)Describe any unique or valuable features of the lake (ownership, historic, water supply, only beach in town, in a park, tourist attraction, rare species etc.)
5 islands, the only town beach, good bass fishing, increasing number of unusual birds and wildlife, historic use as mill pond dating back over 150(?) years.

4)Roughly estimate daily public use (# of people on lake during the day) during summer months for each of the following activities:

a) Boating	b) Fishing	c)Swimming	d)Sightseeing, picnic	e)other
40	20	200		

Also - Canoeing , Sailing , Jet Skis, Water skiing

Canoeing	Sailing	Jet Skis	Water skiing
10	10	0	15

These numbers are estimates based on weekend usage, which is generally higher. It is also an estimate of the total number of people during the day, not merely the number on the lake at any one moment.

5)Does the lake have a dam at the outlet? Yes

If yes, how high? (i.e. how many vertical feet of water does the dam hold back? 4-8 ft.) the dam is designed and built to allow an 8-foot drawdown. At present we are limited to 43 inches due to silting up at the dam and raised culverts and beaver activity below the dam.

Is the lake level adjustable from the dam? (i.e., splash boards, gate, or valve?) and are they in good working order to conduct a drawdown? Yes, we have splash boards to adjust the pond level. They are in good working order except for the silt buildup.

Are annual drawdowns conducted? Drawdowns have been conducted somewhat sporadically the last drawdown was this past winter 1998-99. The next drawdown is planned for the coming winter 1999-2000.

If yes, how many feet? 43 inches

Who owns the dam ? Town of Harvard

6)How many public bathing beaches are present? (where): One, at the north East End of the pond.
There is only one beach that is semi public. My understanding is that it is on private land, but has been made available for the town's use. This beach is located at the end of Pond Road on the pond's northeastern end.

7)How many other beaches (e.g. resorts) are used by public (where): none. There is one parcel of state owned land, and town conservation land on the pond. Otherwise, all land on the pond is privately owned.

8)Are there current problems with swimming in the lake? a) bacteria,   b)transparency <4ft   c) weeds,   d)no serious problems   e)other   Have the beaches been closed last year due to any of above causes? ___
Our Secci disk readings are generally to 3.5 meters +- 0.25 meters. The beach was not closed last year, but there was serious concern that the infestation of variable milfoil in the swimming area might cause a swimmer may to become entangled and drown. A harvester has been used to keep the height of the milfoil down. Results are not completely satisfactory.

9)How many public boat launches are available? (where):
One, adjacent to the town beach.

10)How many other boat launches (e.g. resorts) are used by the public?
None

11)Are there current problems with boating or fishing on lake? a)weeds along shore   b) weeds cover on ____% of lake surface   c)fish kills d) exotic weeds (list)   e)boating noise f) boating turbidity, g) algae blooms h) low oxygen i)no serious problems,
Other problems?   Explain.

a.) weeds exist in several areas of the pond. Predominantly, on the North, South, and West ends of the pond. Additional weed infestations affect the NorthEastern Corner and the town beach.

b.) emergent week cover on about 30 - 40% of the pond – non- emergent weed growth may take this estimate to 50-60%
c.) We have noted occasional minor fish kills. 1-3 fish. This may be a result of sport fishing activity.
d.) We have several exotic weeds (see 12)
e.) boating noise is a minor problem, especially on holiday weekends, or when Jet Ski type boats are used.
f.) boating turbidity does not appear to be a problem, except at the boat ramp when boat owners perform "power loads"

g.) no algae blooms are recorded despite high phosphorus levels. We suspect that the pond color prevents this.
h.) DO studies exist for several years. We do not seem to have a problem in this area.
Other Problems – Inconsiderate boaters producing noise, litter, and urinating into the pond. Violations of boating safety such as drinking and boating. Towing water skiers without a person on board acting as a spotter, is not uncommon. There have been incidents of near misses caused by boats running the wrong way around the pond. This is a particular problem at the end of the peninsula (South end of pond) where visibility is limited. There is also serious concern of a potential accident between swimmers and boats, as swimmers often swim quite far across the lake to reach the islands.

12) Are aquatic weeds a problem in the lake? Yes!
Have the species been identified? Yes – Variable Milfoil, Water Lillies white and pink, Smart Weed, Fanwort, Waterchestnut (Trapa Natans) and others.

13)What is considered to be the major sources of pollution? a)Farms b) urban runoff, c)septic systems d)gravel pits e)unknown e)other
None

14)What type of sewage treatment is used for homes on the lakeshore (within 100 yards) ?: a)private septic b)sewer c)unknown
private septic. There is still reason to believe that there are non -Title 5 compliant systems.

Contact person and phone Nashobe Board Of Health

15)As listed below, what has been done in the past ten years to remedy lake problems? (Roughly estimate money spent and provide contact person):

a) Volunteer or local water quality monitoring; Yes Years 1 Contact: Gene Marsh 978 456 3211

b)Please provide title, year and author of any recent studies or lake management plans:
"Bare Hill Pond Water Quality and Aquatic Plant Evaluation 1998" Ken Wagner of ENSR

c) Describe any in-lake treatments (i.e. harvesting, herbicide, water level drawdown, etc.) and include what kind are being applied, what years were the treatments conducted, details of treatments and approximate cost (continue on back or separate sheet)

Harvard has operated an aquatic weed harvester since 1982(?)
Volunteer Water Chestnut weed pulls have been conducted 3 times a year since 1994
Drawdowns have been used sporadically. The last was this past winter 1998-1999

d)How effective and long lasting was the treatment?
Harvesting – limited effectiveness on Milfoil
Drawdowns – uncertain effectiveness. Highly dependent on the winter temperatures. Most recent drawdown shows some promise.
Volunteer weed pulls – highly effective, but slow. Must maintain effort every year indefinitely.
Herbicides – records suggest that this is highly effective.

e) Work either on shore or in the watershed to reduce pollution entering lake .e.g. new sewer hookups for homes, major sewer repairs, public education, erosion control, BMPs etc.:
Conservation Commission and Board Of Health involved with upgrading of many septic systems. Recent activity on Western side of the pond known as Clinton Shores, Lancaster Shores, Turner Lane, Willard lane.

f) Please identify any other grants or grant applications or future management plans, including sewer, street maintenance etc.:
no grant applications planned at this time. Plan to continue use of harvester, and drawdowns to control weeds. Will possibly reintroduce herbicide program to control weeds.

Other Comments and Concerns:
Our analysis of previous studies indicates that the level of phosphorus entering the pond through its various inlets is approximately at the same level as the water already in the pond. This indicates that the high levels of phosphorus are attributable factors other than runoff from the watershed. The most likely source of the high phosphorus levels is the rich bottom muck found in most areas of the pond. (The southern end of the pond was actually once a cow pasture.) Given this, and the lack of algae blooms that would be normally expected, it seems safe to conclude that another limiting factor is at work. This factor is most probably the light limiting brown color caused by the presence of organic tannins in the water. The Bare Hill pond Watershed Committee is very concerned that a TMDL report that focuses on the phosphorus levels, will not properly target the main problem in the pond, namely the rooted aquatic plants. We are also concerned that this focus will divert limited resources, and energy away from the primary problem in the attempt to solve a secondary effect that is not a significant contributor to the problem at hand. Furthermore we worry that this focus will create a legal requirement and financial burden on the taxpayers that will not yield an appreciable, if any, benefit.

We would like to see a TMDL report that could address *all* of the factors adversely affecting the water quality of Bare Hill Pond, with appropriate *priority* given to these factors. Such a report should include clear, quantifiable, objectives and goals. Any remedies recommended should include evidence of the effectiveness of such remedies. (Ex: if a requirement for annual pumping of septic systems recommended, it should be backed up with proven studies demonstrating the effectiveness of such action.)

Appendix IV Chronology of Activities Provided by Bare Hill Pond Management Committee

BARE HILL POND
Chronology of Activities
Early 1800s to 1999

NOTE: chronology edited and condensed by M. Mattson

Early 1800s: First dam constructed (for downstream water power) (Nourse)

1837: Dam rebuilt, and level raised about 6 feet (Nourse)

Ca. 1930s: Dam modified to current configuration; Earthen dam with concrete gate; two courses of removable wooden planks used for water-level control; Top of dam elevation, 100 feet; legal water level, 98.33 feet; bottom of dam elevation, 90.5 feet; maximum drawdown, 7.88 feet

1956-58: Weed problem became acute

1959: Bare Hill Pond Committee appointed by Selectmen; No Town or state funding available for weed control; Goal of $10,000 set (70% from abutters and 30% from other sources) for 5-year herbicide program to start in 1960

1960: Bare Hill Pond Committee kick-off, open Town meeting; Funds of $7,000-10,000 raised for a 5-year herbicide program; Purchased a small weed cutter; Herbicides applied to all areas of the pond. Silvex herbicide used. Results reported to be "very satisfactory" and pond clear of weeds. No health problems reported.

1960s: Water level lowered to maximum level (about 7.5 feet) for blasting of rocks in pond. This appears to have been the only total drawdown ever conducted with the current dam and was performed prior to Still River Road culvert replacement.

1961-64: Spot treatment of areas using Silvex, effective on weeds; No health problems reported

1965-70 No Bare Hill Pond Committee; No weed removal activities

Ca. 1970s: Square culverts under Still River Road and Underpin Hill Road replaced with five-foot diameter round culverts; elevations of bottoms of new culverts raised approximately 3-4 feet over the bottoms of the replaced culverts, thus creating a maximum drawdown level of 3.5 to 4 feet

1971: (no committee); No weed removal activities; $100 appropriated for pond patrol; Weed coverage had become acute

1972: Bare Hill Pond Study Committee established as subcommittee of the Conservation Commission; $5,000.00 grant received from Ford Foundation and used for planning; Bare Hill Pond Study Committee conducted a 1-day, 10-29-72, trial of a mechanical weed harvester using a harvester belonging to the Bare Hill Pond Association; 2 small areas harvested, in front of the current beach and in front of the current canoe storage location; considered not to be successful due to a 55% rate of effectiveness

1973: Bare Hill Pond Study Committee recommended chemical treatment program, started in 1973; Mass. Department of Environmental Management gave partial treatment; Chemical (probably Kuron and Aquathol) treatment probably conducted, although records not available

1974: Chemical treatment program funded by State Board of Health and completed; used Kuron (0.5 ppm) and Aquathol (0.5 ppm); Study Committee recommendation that chemicals be the primary method to control weeds; Pond weeds started to be "under control"

1975: No weed eradication efforts, either chemical or mechanical; Boston University consultant employed as consultant to committee; Water quality survey conducted by Mass. Division of Water Pollution

1976: Algae was noticed and of concern to the committee; No weed eradication efforts conducted; heavy weed infestation

1977: Area between the dam and 4-Acre Island received 30 gallons of Aquathol (1 ppm) on 6-10-77 and 7-19-77, effective on variable milfoil, by Lycott Environmental Research; South Bay area received 50 gallons of Silver Kuron (2-(2,4,5-????) Trichlorophenoxy) Prupionic Acid) Propylene Glycol on 6-10-77 by Lycott Environmental Research; Results surveyed in July. Aquathol in area near 4-Acre Island showed no variable milfoil eradication; Kuron (0.3 ppm) in South Bay area very effective on all weeds, except bladder wort and smart weed; Water monitoring contract with Boston University terminated; Harvester, owned by the Bare Hill Pond Association, was reconditioned and leased by the Committee for an experiment in the Minister's Island area; result not satisfactory due to the low power of the harvester

1978: Starting in late autumn, 4-foot drawdown conducted; refill started in late December; Area between 4-Acre Island and shoreline, 2 herbicide treatments 6-20-78 and 7-31-78 of Silvex (2,4,5 Trichlorophenoxy) Proponic Acid 4#/gal.; total, 2.6 gals.; the results, variable milfoil killed 100%, but smart weed not affected, by midJuly; Area in south bay, west side, 2 herbicide treatments 6-20-78 and 7-31-78 of 2,4 Dichlorophenoxy Acetic Butoxyethanol Ester (Aqua Kleen), granular, 200 184#/acre each treatment; the results, variable milfoil and water lilies killed but smart weed not affected; Two small areas, Clinton and Lancaster Shores, received one herbicide treatment 6-20-78 of Silvex (2,4,5-TP); the results, variable milfoil and water lilies killed; Area west of Minister's Island, 2 herbicide treatments 7-31-78 and 9-6-78 of 2,4-D, granular, 200#/acre; the results, variable milfoil, white water lilies and water shield killed; bladder wort and yellow water lilies not affected; Total cost of treating all 4 areas: $3,141.00

1979: Started "Shapiro report" to analyze and summarize all data on the pond started; 1978-79 drawdown (completed Feb. 11) quite successful, despite a 4-foot exposure and mild winter weather; 2 high school students employed to pull weeds for 6 weeks; Aquatic Control Technology used Aquamarine Chub to evaluate mechanical harvesting; the results, good on variable milfoil, but less so on smart weed; Reduced weed coverage during year, perhaps due to 1977-78 drawdown; Beach closed two times due to suspected E. Coil bacteria, an indicator of pollution; tests indicated bacteria to be Aeromonas Hydrophica, a harmless naturally occurring organism; No herbicides used; Extensive testing of temperature, transparency, dissolved oxygen, total phosphorous conducted; no indication of adverse trends in 1979; Bliss-Hoffman report over period 1972-74 delivered.

1980: No lasting favorable results from the 1978-79 drawdowns, with the weed condition the same as pre-drawdowns. Conclusion: Drawdown effects limited to 1 year.; A "York" rake was demonstrated and was very effective against smart weed.; $5,000 appropriation to the Bare Hill Pond weed control fund; Aquatic Control Technology conducted a 1-day trial of Aquamarine Chub in the 4-Acre Island, channel and town beach areas; not successful against the targeted weed, smart weed; successful against variable milfoil, but, within 30 days, it had reappeared; Testing of water quality continued, with no adverse trends detected; 2,4-D, at very low dosage (about 2 ppm), used in about 40 acres in the Minister's Island, channel, southwest cove, Thurston Beach and Camp Green Eyrie areas applied by Allied Biological Control Corp. The results: 100% of variable milfoil and water lilies killed, but not effective on smart weed; no adverse effect upon fish or reptiles. No health problems reported.

1981: The 1980 2,4-D herbicide-treated areas in southwest cove and Minister's Island areas clear of weeds; York rake used in swimming areas (cost of $2,000); Aquamarine Chub mechanical harvesting effort around 4-Acre Island in 1980 had no "lay over" effect in 1981; 1980 manual pulling efforts in the swimming and boat launching areas had no "lay over" effect; By 7/81, variable milfoil around Minister's Island and southwest cove had recovered, despite of, or perhaps because of, a very low application of 2,4-D in 1980; In July, 10 acres behind 4-Acre Island had 2,4-D granular at a low dosage applied; the results, very effective on variable milfoil; Shapiro report received

1982: 2,4-D granular applied to about 35 acres in southwest cove; 4 acres treated with Aquathol-K for pond weed; heavy rainfall decreased effectiveness; 4-Acre Island, treated with 2,4-D in 1981, still clear of variable milfoil; Areas in Minister's Island and south cove, not treated in 1981, fully covered with milfoil ???

1983: New harvester (Aquamarine) ordered; Hydro-rake effort (cost of $2,000) with Aquatic Control Technology in area of Town beach; 3/83 Town Meeting resulted in moratorium (Article 16; 238 votes yes; 124 votes, no) restricting the future use of herbicides; Town leased Aquamarine harvester (from July 5 to Sept. 1); harvested about 200 tons (loads) of weeds from over 100 acres; 2 shifts in operation

1984: New (current) harvester delivered, 2 weeks late; 387 tons (loads) harvested; 2nd weed offloading area belonging to an abutter used at the south end of the pond; Aquascreen installed in 8,400 square feet in swimming area at Town beach, very successful as weed control mechanism; $5,000 appropriated at Town meeting for study of Bare Hill Pond (Whitman & Howard study); Battelle Research conducted test for dioxin

1985; Harvesting started 6-14-85; logged 200 hours; removed 690 tons (loads?) of weeds; More Aquascreen added to Town beach. Silt had started to accumulate on screen installed in 1984. The need for cleaning was recognized. (Note: Cleaning of silt was not ever performed, and today the weeds in the screens in the swimming area have serious problems.); Dioxin testing of fish indicated no detectable traces (cost of $5,100) by Battelle, Duxbury, MA

1986: Harvesting started in early 6/86; logged 469 hours; removed 385 tons (loads)

1987: Bare Hill Pond Watershed Management Committee formed (7 members), reporting to Selectmen, replaced Bare Hill Pond Study Committee; Harvesting started in early 6/87; logged 485 hours; removed 250 tons (loads?); Warrant article for herbicide treatment withdrawn at Town meeting; 1983 ban on herbicides reaffirmed at Town meeting; Whitman & Howard diagnostic/feasibility report delivered

1988: Harvesting started in early 6/88; logged 415 hours; removed 127 loads (loads); channel lanes for boating, swimming and access to home fronts kept free of weeds; Drawdown started in 10/88

1989: Drawdown refill started in 3/89; Good climatic conditions during the winter contributed to the good results in the areas exposed by the 50-inch drawdown; Some harvesting activities, but no data on amounts harvested available

1990; Some harvesting activities, but no data on amounts harvested available; Weeds again becoming a problem

1991; No funding available and, therefore, no harvesting activities; Harvester mothballed and transferred from Bare Hill Pond Watershed Committee to Highway Department; Bare Hill Pond Watershed Management Committee joined Mass Water Watch Partnership

1992: No harvesting activities due to lack of funding;Weed situation very serious

1993; New Bare Hill Pond Watershed Management Committee; Funding from private parties, a corporation and the Conservation Commission, used to put harvester back into limited operation; Harvester operated for a total of 5½ weeks; Weed chestnut pull conducted

1994: Water chemistry testing was performed by Mark Hastings. Tests were for temperature, dissolved oxygen, turbidity, pH, acidity and Secchi disk measurements; Water chestnut pull conducted; Harvester in operation by Highway Department, under the operational direction of the Bare Hill Pond Watershed Management Committee; No funds from Town

1995: 4 water chestnut pulls; however, area of weeds increased from about 7,000 square feet to an estimated 49,000 square feet; Weed harvester in limited operation, but decreased volume as compared to 1994, despite increased weed coverage in pond;

1996: Harvester in operation (with reduced output); variable milfoil greatly increased in Clapps Brook/Minister's Island area; 4 water chestnut pulls conducted by volunteers

1997: Total coliform testing by Board of Health, Thurston Brook, very high; Harvester in operation, but essentially not effective; weeds in pond very heavy in all areas less than 8-feet deep

- 1998: New Bare Hill Committee expands recovery program for the pond; $30,000 for harvester restoration appropriated by Town; harvester totally reconditioned; 204.75 hours of harvesting in southwest cove, town beach and boat park; 198 loads harvested; 35% down time due to harvester maintenance; Most harvesting effort conducted in south bay in an effort to evaluate multiple harvesting passes; the results, repeated passes not effective due to rapid weed re-growth (approximately 1 inch per 1-2 days) experienced; The results of this year's harvester efforts, as well as previous year's activities, leads one to conclude that mechanical harvesting (1) has no year-to-year lasting carry-over effect and (2) even with the current year, harvested areas recover as quickly as to be not detectable at the end of the season; (Note: Gene Marsh mentioned that the harvester broke twice after hitting boulders and thereafter the operator set harvester to cut only 2' deep, which may explain the poor control achieved). Harvesting also included 4 water chestnut pulls; while the weeds were not eliminated, the growth was under control and confined to only the Clapps Brook inlet; Drawdown started 11-1-98; reached maximum depth of 43 inches 12-17-98; $12,000.00 appropriated for contract with ENSR, Westborough, MA, to conduct a study of weed mapping and water chemistry; report delivered in 12/98

1999: Started pond refill March 1