Watershed Management Plan

Webster-Highland Lakes Watershed Partnership

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Executive Summary

During the summer of 2003 and late-summer of 2004, significant outbreaks of nuisance blue-green algae, including cyanobacteria, were observed in Webster Lake, these outbreaks greatly diminished its use for recreational purposes and posed a human health threat. Subsequently, several meetings and workshops were held with New Hampshire Department of Environmental Services (DES) personnel, Webster Lake Association members and municipal officials to try to identify sources of the problem and appropriate corrective measures. In early 2006, DES included Webster Lake on the DRAFT 2006 303(d) list of impaired water bodies due to the reoccurrence of cyanobacteria. Ongoing water quality sampling, conducted by DES personnel and the DES Volunteer Lake Assessment Program (VLAP) monitors, has also revealed occasional elevated levels of turbidity, phosphorus and *E. coli* bacteria, which represent additional water quality concerns.

The document will serve as a planning tool for the members of the Webster-Highland Lakes Watershed Partnership and municipal officials for future planning, scheduling and in seeking additional funding to implement feasible measures that will improve water quality in both Highland and Webster Lake and maintain their primary use as valuable recreational resources for years to come. Although the primary focus of this project is on Webster Lake, as directed by the grant application process submitted by the City of Franklin, the water quality objectives, data analysis, and recommended measures contained in this report may be beneficial and could be applied in the Highland Lake watershed as well, which is located in the neighboring Town of Andover. Approximately 75 % of the Webster Lake watershed, which includes Highland Lake, is located in the Town of Andover.

Both Webster Lake and Highland Lake have been part of VLAP for nearly 20 years. The VLAP volunteers are trained by DES to collect basic limnological measurements and water quality samples on a monthly basis during the summer months. The primary measurements or parameters analyzed include Secchi disk transparency (i.e., water clarity), chlorophyll *a*, and total phosphorus at various depths. As discussed above, these parameters represent the primary limnological indicators for determining in trophic status and monitoring changes.

To improve water quality conditions in Webster Lake, a reasonable goal would be to reduce the existing in–lake phosphorus concentration by 2 to 3 parts per billion (ppb) and maintain an average in-lake phosphorus concentration closer to 11 or 12 ppb, rather than 13 to 15 ppb. This may seem like a minor change but lake water quality conditions, in terms of water clarity and algal productivity, can be substantially different with an average phosphorus concentration closer to 12 ppb as opposed to 15 ppb. The proposed reduction would also buffer against any short-term, episodic influxes similar to those that may have occurred in 2003 and 2004. It may also allow for some future residential growth that will likely occur within the watershed. The existing phosphorus load would need to be reduced by about 94.0 kilograms per year (kg/yr) to lower the in-lake concentration by about 2 ppb and by as much as 140 kg/yr to lower the concentration by 3 ppb. These load reductions represent about 18% and 26% of the estimated existing phosphorus load, respectively, contributed from tributaries and septic systems.

To achieve these phosphorus load reductions, several different phosphorus sources within the watershed and around the Lake would need to be addressed. There is no one particular source where the entire recommended load reduction can be achieved with a simple fix. The existing phosphorus load is generated from many different sources within the watershed including residential development, timber harvesting, roadway runoff, manure spread on hayfields as fertilizer as well as that deposited in pasture areas, stables and pens by livestock. Other sources include shoreline septic systems, pet wastes, storm water runoff, use of detergents, sediment erosion caused by excessive runoff flow, construction activity and wave action, or other sediment disturbances caused by boating activity and internal loading from bottom sediments, to name a few. None of these sources or activities, by themselves, contributes more than 30% of the total phosphorus load entering Webster Lake. For most of these sources, their percentage of the total contribution is estimated to be less than 10 percent, which reinforces the need to initiate a multi-faceted approach to watershed management.

Based on pollutant modeling and previous sampling results, the largest phosphorus load reductions could be achieved through a combination of additional manure management measures and septic system upgrades for shoreline lots around Webster Lake. Manure management measures may include additional fencing in pasture areas to keep cows out of drainage ways that convey storm water runoff and by working with farmers to perhaps modify the timing of manure spreading on hayfields and avoid applications on frozen ground or saturated soils. Although there has been a great deal of improvement in this area over the years, there is still room for improvement. In addition, addressing some of the smaller livestock pens and horse stables or so-called "hobby" farms that exist in residential areas through local ordinances and drainage modifications would also be crucial step in the process.

One of the critical needs will be to continue working with shoreline homeowners to identify and upgrade the few poorly functioning shoreline septic systems that are likely to exist around Webster Lake. Although many shoreline homeowners have upgraded and improved their septic systems over the last 20 years or so, there could be as much as 10 to 15% of shoreline systems that are poorly functioning or failing. Previous estimates indicate that a large majority of the phosphorus attributed to shoreline septic systems is coming from poorly functioning or failing septic systems. Even though shoreline septic systems are estimated to contribute only 15 to 20% of the overall total phosphorus load to Webster Lake, eliminating or upgrading the remaining poorly functioning or failing septic systems could result in a significant reduction in the phosphorus load. A reduction of 5 to 10 % of the overall phosphorus load through septic system improvements could achieve at least half and perhaps more of the 18 to 26 % reduction goal, discussed above, to improve water quality in the lake.

More information is needed to identify exactly where these potentially failing systems are located. The remainder of the load reductions would perhaps come from treatment of road runoff in specific areas, additional maintenance of the existing storm drain system, additional zoning regulation updates to address certain activities such as future residential development, sediment disturbances resulting from timber harvesting and construction activities as well as through a coordinated education and outreach effort that would be updated each year to educate homeowners, lake users and other stakeholders on how their activities may affect lake water quality and promote good land stewardship within the watershed.

1

Introduction

Project Overview

This project was funded by a grant provided by NH Department of Environmental Services (DES) through the Watershed Assistance Grant Program. The Grant application was submitted by the City of Franklin Municipal Services Director, Mr. Brian Sullivan and the Planning/Zoning Administrator, Mr. Richard Lewis in November 2004. The grant award was approved and awarded to the City of Franklin in May 2005.
This project has four major components:

- Establish a Watershed Organization/ Partnership Group
- Conduct Additional Water Quality Monitoring
- Develop a Watershed Management Plan
- Prepare a Public Outreach and Education Plan

Webster Lake is located in the City of Franklin, and is extensively used for recreational activities including swimming, boating and fishing by residents in the area. The Lake is approximately 610 acres in size with a maximum depth of about 39.0 feet (11.9 meters) and an average depth of 17 feet (5.2 meters). Nearly 75% of its watershed is located in the Town of Andover. The Lake's primary water inflow is provided by Sucker Brook, which originates approximately 12 miles upstream at the outlet of Highland Lake located in the Town of Andover. Both lakes were expanded around the turn of the 19^{th} century to store water during spring runoff and then supplement flow to power the Franklin Mills during the drier times of the year. Highland Lake is the smaller of the two, at approximately 212 acres in size, and is slightly shallower with an average depth of 16 feet (5.0 meters).

During the August of 2003 and September of 2004, significant outbreaks of nuisance blue-green algae, including cyanobacteria, were observed in Webster Lake, which greatly diminished its use for recreational purposes and posed a human health threat. These outbreaks prompted several meetings and workshops with DES personnel, Webster Lake Association members and municipal officials to try identify sources of problem and appropriate corrective measures. **Recently, DES included Webster Lake on the DRAFT 2006 303(d) list of impaired water bodies due to the reoccurrence of cyanobacteria.** Ongoing water quality sampling conducted by DES personnel and the Volunteer Lake Monitoring Program (VLAP) monitors, has also revealed occasional elevated levels of turbidity, phosphorus and *E. coli* bacteria, which represent additional water quality concerns. DES has also responded to findings of elevated *E. coli* bacteria levels that have been recently detected in various tributaries discharging to the Lake and particularly Sucker Brook. DES has, as a result, conducted additional water quality sampling in the Sucker Brook watershed over the last three (3) years in an attempt to identify *E. coli* bacteria sources. This information is summarized in this report.

The Webster-Highland Lakes Watershed Partnership was established in late summer-early fall of 2005 to help guide the development of this Watershed Management Plan and prioritize the issues and concerns related to water quality between the various stakeholders within the Webster-Highland Lakes watershed area. The Partnership consisted of municipal officials from both Franklin and Andover, lake association members, DES personnel and other at large community members. With Highland Lake being in the Webster Lake watershed, it was recognized early on in the process that community members of Andover and the Highland Lake Association should be included in the Plan development process. Potential measures that could improve water quality in Webster Lake could also benefit or be directly applicable to the Highland Lake watershed. The members and activities of this Partnership are discussed in greater detail in Section 2.0 of this Report.

In developing a Watershed Management Plan, the Partnership retained the services of a multi-disciplinary, consultant team consisting of Vanasse Hangen Brustlin, Inc (VHB) of Bedford, NH, Hutchins Consulting Services (HCS) of Salisbury, NH and naturesource communications of Boscawen, NH through a competitive bid proposal process. VHB was the lead consultant and was assisted by HCS in evaluating the lake water quality data, pollutant source identification and BMP recommendations for the Watershed Management Plan. naturesource communications assisted in facilitating public meetings and in preparing the educational and outreach component of this Plan. The primary goal of this Watershed Management Plan was to identify measures, based on existing water quality data and other relevant studies that will improve and/or preserve the water quality conditions in Webster Lake and provide an implementation plan to help guide the Partnership in implementing these measures. These measures may consist of storm water treatment measures, additional controls on land use development or activities, in-lake treatments and other management alternatives.

Section 3.0 of this Plan describes the historical and current lake water quality conditions based primarily on a set of indicator limnological parameters measured by volunteer monitors as part of the DES Volunteer Lake Assessment Program (VLAP). Both Webster and Highland Lakes have been monitored for over 20 years. In general, conditions have remained fairly consistent with a few exceptions and some more recent signs of decline in Webster Lake. Section 4.0 provides an assessment of the various possible sources and contributions of phosphorus in the Webster Lake watershed based on existing data. It is important to point out that the development of this Plan and associated recommendations are based primarily on the findings of previous water quality studies and investigations. More recent additional sampling conducted by DES in the Sucker Brook watershed and/or Webster Lake is also included to supplement the data interpretation.

Section 5.0 lists various action goals and recommendations to be considered for water quality improvements. Section 6.0 provides an implementation plan to assist the Partnership in implementing the various options for watershed management and on lake or shoreline activities. Section 7.0 presents an Education and Outreach Plan to outline activities.

To be eligible to receive Section 319 Grants for future implementation of the measures, this Plan was developed to be consistent with EPA's 319 elements listed below:

Nine Minimum Elements to be Included in a Watershed Plan for Impaired Waters Funded Using Incremental Section 319 Funds."

To improve eligibility to receive subsequent EPA or DES Restoration/ Implementation grants, this Watershed Management Plan contains the "Nine Minimum Elements to be Included in a Watershed Plan for Impaired Waters Required for Funded Using Incremental Section 319 Funds." The following lists the Nine Minimum Elements:

1. Identify the causes and/or pollutant sources that need to be controlled,
2. An estimate of the load reductions expected from management measures,
3. A description of nonpoint source management measures that will need to be implemented to achieve the load reductions,
4. An estimate of the amount of technical and financial assistance needed and the potential sources and agencies that may provide this assistance,
5. An information and education component that will enhance public understanding of the project and encourage early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented,
6. Schedule for implementing the nonpoint source management identified in this plan that is reasonably expeditious,
7. A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented,
8. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards,
9. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item 8 immediately above.

This document will serve to guide the Partnership in planning, scheduling and in seeking additional funding to implement feasible measures that will improve water quality in Webster Lake and maintain its primary use as a valuable recreational resource for years to come. The data analysis and recommended measures included in this document may also be directly or indirectly beneficial to protecting and improving water quality in Highland Lake as well.

2

The Webster - Highland Lakes Watershed Partnership

In 2005, members of the Webster Lake and Highland Lake Associations, and staff and citizens of the City of Franklin and the Town of Andover, and the NH Department of Environmental Services initiated a collaborate effort to investigate and address water quality concerns within the lakes' watersheds. This project builds on these efforts and strengthens the Partnership between the area stakeholders by forming the Webster-Highland Lakes Watershed Partnership. It is the continued collaboration of this Partnership that will be key to successful implementation of the water quality protection measures identified in this Plan.

Residents and stakeholders of both communities will need to commit to a unified effort in adopting or implementing the corrective measures identified as part of this project as well as any other future efforts to be successful. For certain measures, adoption or implementation could benefit both communities as they relate to Highland Lake or Webster Lake. Even the measures that may be focused on activities or sources that are physically located downstream of Highland Lake, could be beneficial to Andover residents just in terms of proper environmental stewardship of the land. Partners include:

Laurence Boyett, City of Franklin Planning Board
Don Gould, Town of Andover Planning Board
Sandra Graves, Town of Andover Conservation Commission
Mark Henderson, Webster Lake Association
Helen Johnson, Webster Lake Association
Ron Klemarczyk, FORECO (City of Franklin Forester)
Dick Lewis, City of Franklin
Glenn Morrill City of Franklin Conservation Commission
Brian Sullivan, City of Franklin
Jim Tullis, City of Franklin Planning Board
Bob Welch, Highland Lake Protective Association
Peter Zak, Town of Andover Conservation Commission

To date, the project team met with the Partnership on March 9 and June 13, 2006. During these meetings, Partners discussed water quality data and other information. They identified areas in which further information was required and collaborated to initiate additional water quality monitoring activities including ice-out sampling, conducting storm event monitoring, and producing an algal observation form for lake residents and visitors.

To raise awareness of the Partnership, encourage participation, and to hear stakeholders' concerns, three listening sessions were also conducted; one in Franklin on June 27th and two in Andover on July 11th and August 31, 2006. An Executive Summary of the Draft Watershed Management Plan was handed out and discussed at the latter session. During these listening sessions, nearly 50 participants shared their views, concerns, and suggestions about the most important aspects and pollutant sources that exist within the watershed. These include:

- One of the Plan outcomes should be that the City of Franklin connects Webster Lake waterfront and area residences to the sewer system or the report should evaluate the potential benefits of a possible sewer extension to the Webster Lake waterfront area.
- There could be unintended consequences of higher density development if a sewer extension is proposed for the Webster Lake waterfront area. The Partnership might be more effective if it works directly with owners of failing or failed septic systems vs. connecting them with a new City sewer.
- The newer septic system technologies allow for smaller leach fields, which means they will be closer to the water.
- The issue of a possible sewer line extension could become a political one with neighbors pitted against each other.
- Is it worth it to connect to the sewer if it will address 11% or less of the phosphorus loading into Webster Lake?
- Should there be a survey to determine residents' willingness and ability to pay the capital and ongoing costs to build and maintain a sewer line?
- The plan should focus on the phosphorus loading from Sucker Brook.
- Logging, road, and other runoff are adversely affecting Sucker Brook and its tributaries.
- Winter salt and sand applications on Webster Lake Avenue running into Webster Lake.
- Catch basins are never or not regularly cleaned: water is not running into them and they are not working (some residents are cleaning them themselves).
- A lot of sand and sediment runoff in the catch basins is coming from un-vegetated soils on private property and becomes part of the public (City) liability: Best Management Practices and other systems are needed on private property.
- A windshield survey found 72 locations where runoff directly entered Webster Lake.
- The plan should contain a graphic representation of the correlation between flow and runoff leading to phosphorous loading: this output could be GIS-based and on the Partnership website.
- Should VLAP and other monitoring be changed or increased to gain better data?
- Fireworks on Webster Lake are contributing to phosphorous loading.
- Do dishwasher detergent, dish soap, and laundry detergents adversely affect Webster Lake? Are there phosphorus-free alternatives?
- Will there be a study of current and potential development in the Plan? Will there be a build-out analysis?
- A sandbar has been forming and growing near the Sucker Brook outlet into Webster Lake and could be hindering flushing.
- Do tannins affect water clarity?
- Speed boating and the wakes that result seem to stir up turbidity.
- Should bacteria testing be part of the watershed evaluation?
- There are septic systems that are too close to the shore—how can the NH Department of

Environmental Services allow this?

- There are new private septic system technologies that allow units to be installed even closer to the shore.
- Septic systems are causing phosphorus loading.
- Aren't there technologies to separate grey from black water and enable landowners to have holding tanks vs. septic systems?
- Higher and fluctuating water levels are eroding the shore—there is discussion about lowering the lake level.
- The Town beach area is a lot shallower than it used to be.
- The water is 8″ lower than normal.
- Is the Maple Street dam size adequate to maintain the desired water level (is its size appropriate with increasing levels of development)?
- The effects if downstream surging from the Maple Street dam should be analyzed.
- Management of dams in needs to be more carefully monitored and coordinated between the two lakes because of the effect of flows and releases on Chance Pond Brook.
- There should be more analysis and management of Mill Pond.
- There should be a statistical analysis of precipitation patterns for the spring vs. summer in comparison to changes in water quality.
- The geomorphology of watershed tributaries should be analyzed—some have changed course or are eroding because of fluctuating flows.
- There has been a great deal of vegetation removal along Tilton Brook near the power lines.
- The Partnership should explore ordinances to require storm water detention and/or retention on sites vs. culverts and other direct flow to water bodies.
- Currently culverted water needs to be slowed down.
- Riparian protection zones should be considered in local ordinances.
- Steeps slopes should be taken into consideration to gauge the appropriateness of logging and development operations.
- Recent Maple Street logging activities have caused silt to deposit into the lake and woody debris to be discharged into the tributaries and the lake; a delta has formed at the mouth of the affected tributary.
- Blue-green algae do not currently seem to be a major issue but some anticipate that they could become a concern.
- Is there a relationship between increasing water temperatures coupled with additional nutrient loading—could this trigger blue-green algal growth?
- Oxygen levels have decreased.
- There is more in-lake native vegetation.
- The lakes should consider working with the Lake Host Program.
- Increasing boat traffic seems to increase shorefront erosion—can no wake zones or reduced speed limits be applied?
- Some would like to maintain the summer lake level year-round.
- Fireworks discharge has increased on the lake and goes on for many days—does this impact water quality?
- Grass clippings are flowing into water bodies.
- Unsecured docks are on the move in the lake(s).
- Traffic from launching and retrieving bob houses has caused erosion on the shore.
- The number of bob houses has increased.

Stakeholder input garnered during these listening sessions provided the Partnership with valuable local knowledge and serves as a record of observations and concerns in the Webster-Highland Lakes watershed and further informed discussions and decisions on water quality issues and management recommendations.

3

Existing Lake Water Quality Conditions and Possible Goals for Improvement

Lake Water Quality and the Eutrophication Process

Lake water quality conditions are often described in terms of trophic status and are typically categorized as either in an oligotrohic, mesotrophic or eutrophic state, terms that are used to describe the lake biological productivity. Lakes categorized as oligotrophic have low algal productivity and usually limited rooted aquatic plant growth, low phosphorus levels, clear water and adequate dissolved oxygen throughout the water column. Oligotrophic lakes are generally viewed as ideal for recreational purposes and aesthetic values. In New Hampshire, they are often larger and deeper than most lakes and may have limited development in the watershed on a relative basis. Eutrophic lakes are generally smaller and shallower with mucky, organic bottoms, extensive rooted plant growth, algae blooms that cause reduced water clarity and have depleted dissolved oxygen at depth. These lakes are not well suited for recreational uses. Mesotrophic lakes fall somewhere in between oligotrophic and eutrophic and exhibit water quality characteristics are on average are somewhere between the two categories.

Eutrophication is caused by increased nutrient inputs, particularly phosphorus in most freshwater lakes. Nutrient enrichment can occur naturally through the natural erosion of sediments and through atmospheric deposition. It can also result from human activity within the watershed or around the lake. Human-induced eutrophication is often referred to as "cultural eutrophication" and associated nutrient enrichment can often stimulate or increase the level of lake biological productivity. Land use activities can significantly alter the amount of nutrients entering a lake. Studies have shown that the nutrient export from agricultural land and residential development, especially that of phosphorus, can be more than 5 and 10 times greater than that from forested lands, respectively (DES 1996; MeDEP 1992). Other activities that contribute to eutrophication include the use of fertilizers, faulty or inadequate septic systems, the discharge of detergent-laden water, erosion caused by excessive runoff flow or wave action, fecal matter from pets, livestock or waterfowl, dumping of organic matter (i.e. lawn clippings, leaves, etc.) and the disturbance of bottom sediments, to name a few.

As mentioned earlier, lake water quality conditions generally decline as algal production increases. The decline in water quality relates to reduced water clarity and often an increased abundance of floating algae and/or rooted plants. These changes initially represent more of nuisance and detract from the aesthetic appeal for recreational uses. Eventually, however, if conditions worsen, toxic forms of blue-green algae (cyanobacteria) may become abundant, which can be toxic to pets and humans if sufficient quantities are ingested. Additionally, where there are increased nutrient inputs, especially if they relate to manure spreading or generated by faulty septic systems, pet or waterfowl wastes, there may be an increased presence of harmful bacteria such as *E. coli* bacteria, which increases the human health risk.

Table 3.1 presents DES' Lake Classification Scheme to Determine the Tropic Status (i.e. level of biological productivity) for a given lake.

Table 3.1
NH DES Lake Classification Scheme to Determine Trophic Status

Category	Total Phosphorus Concentration (mg/)	Secchi disk Transparency (meters)	Chlorophyll (ug/l)	Dissolved Oxygen (mg/l)	Rooted Plant Abundance
Oligotrophic	< 0.010	≥ 4.0	≤ 4	> 1 throughout water column	Sparse to scattered
Mesotrophic	0.010 -0.020	2.0 – 4.0	4- 15	< 1 in less than ½ of hypolimnion volume	Along most of shoreline
Eutrophic	≥ 0.020	≤ 2.0	≥ 15	< 1 in more than ½ of hypolimnion volume	> 1/3 of lake surface area
NH Median Value	0.011	3.3	4.4	na	na

Source: DES's Layman's Guide for Measuring a Lake's Trophic Status

These limnological parameters are all interrelated but are primarily driven by the in-lake phosphorus concentration. As in-lake phosphorus concentrations increase, then algal productivity will also increase resulting in higher chlorophyll *a* concentrations and lower transparency readings (as measured by a lower Secchi disk depth). Each 1.0 ppb increase in chlorophyll *a* concentrations, generally results in a 1.0 to 1.5 foot decrease in transparency reading due to increased abundance of algae. As the algal biomass dies and sinks to the bottom, this causes greater oxygen demand due to decomposition. As the oxygen demand increases, a greater portion of the hypolimnion will become anoxic (i.e., without oxygen).

The eutrophication process is typically a slow, gradual process that may require thousands of years to produce measurable or distinct changes in limnological conditions. On the other hand, lake productivity can sometimes sharply increase on a temporary basis in response to some distinct periodic event associated with some major runoff event, erosion issue or some infrequent major discharge of phosphorus. The lake algae growth may increase dramatically for a relatively short period of time and then return back to more mestrophic or oligotrophic conditions. Thus, it is extremely important to maintain a long-term record of limnological conditions to be able to distinguish these short-term episodic events from long term water quality conditions.

It is much easier to prevent the eutrophication from advancing further through proper management controls than it is to try to reverse the progression once conditions have become apparent.

Often times, a lake may become more vulnerable to periodic nuisance algal bloom as its trophic state moves from oligotrophic levels toward eutrophic levels. Eventually, a relatively small increase in phosphorus can sometimes be enough to push a lake into an apparent higher productivity level, in a relatively short time frame even though the actual average trophic condition has not changed significantly. The old adage, "An Ounce of Prevention is Worth a Pound of Medicine" definitely applies to Watershed Management as well. It is much easier to prevent advancing trophic conditions through proper management controls than it is to try to reverse the advancement, once trophic conditions have become apparent. It also is generally much more expensive to reverse the trend that it does to try to prevent it.

Historical Limnological Data Since 1986

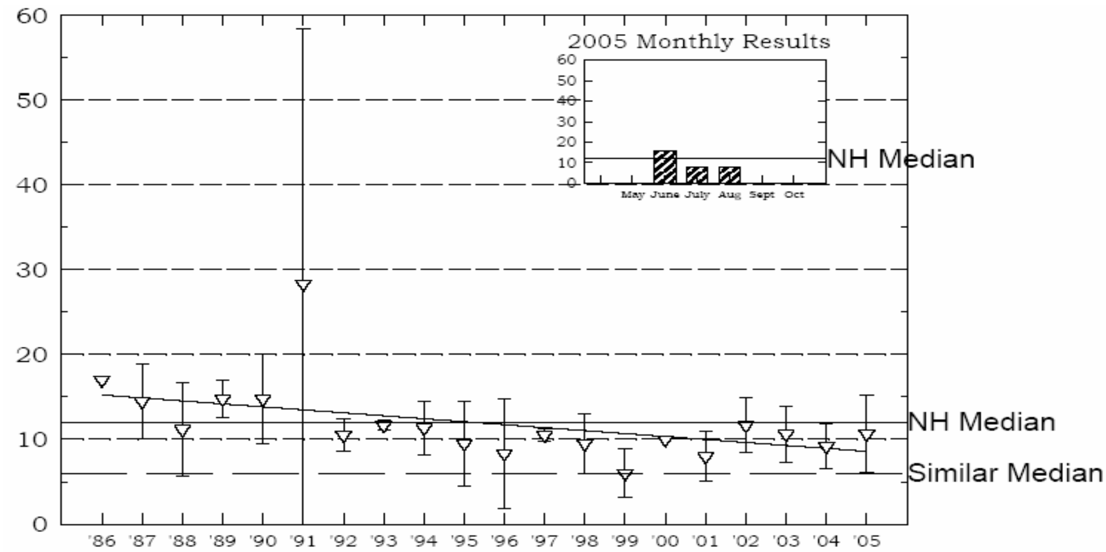
Both Webster and Highland Lake have been part of the DES Volunteer Lake Assessment Program (VLAP) for approximately 20 years. The VLAP volunteers are trained by DES to collect basic limnological measurements and water quality samples on a monthly basis during the summer months. The primary measurements or parameters analyzed include Secchi disk transparency (i.e., water clarity), chlorophyll *a*, and total phosphorus at various depths. As discussed above, these parameters represent the primary limnological indicators for determining in trophic status and monitoring changes. The following provides an overall assessment and discussion of trends for the 20 years of data collected in Webster Lake:

- **Phosphorus Concentrations in Webster Lake**

Total Phosphorus Concentrations in the Epilimnion

Figure 3-1 presents the maximum, minimum and average total phosphorus concentrations observed for each summer season in the epilimnion (upper water layer) of Webster Lake since 1986. Since 1992, the summer epilimnetic total phosphorus concentrations have averaged between 6 and 12 parts per billion (ppb). The maximum concentration during that time period was no greater than 15 ppb. Prior to 1992, the average concentrations were generally higher and closer to 15 ppb or slightly higher in one year. The maximum concentrations during the pre-1992 period were generally in the 18-20 ppb range and in one year, 1991, the maximum concentration was 59 ppb. This high level is an anomaly and was likely either due to a contaminated or unrepresentative sample or a reporting error. The trend line in Figure 3.1-1 indicates a declining trend in epilimnetic total phosphorus levels which suggests that nutrient loading may also be gradually declining. The 2005 Annual VLAP Report has reported that this declining trend is statistically significant. The historical average concentration is estimated to be 11.9 ppb based on the mean of the seasonal average concentrations for all 20 years and this would be very close to the median epilimnetic concentration of 12 ppb for all NH lakes in the VLAP system. However, in lakes with similar volumes and mean depth, the median epilimnetic phosphorus concentration is estimated to be 6.0 ppb which is significantly lower than that calculated for Webster Lake. Based on DES guidelines for lake trophic status classification, the seasonal average phosphorus concentrations would place Webster Lake in the low to mid "mesotrophic" category.

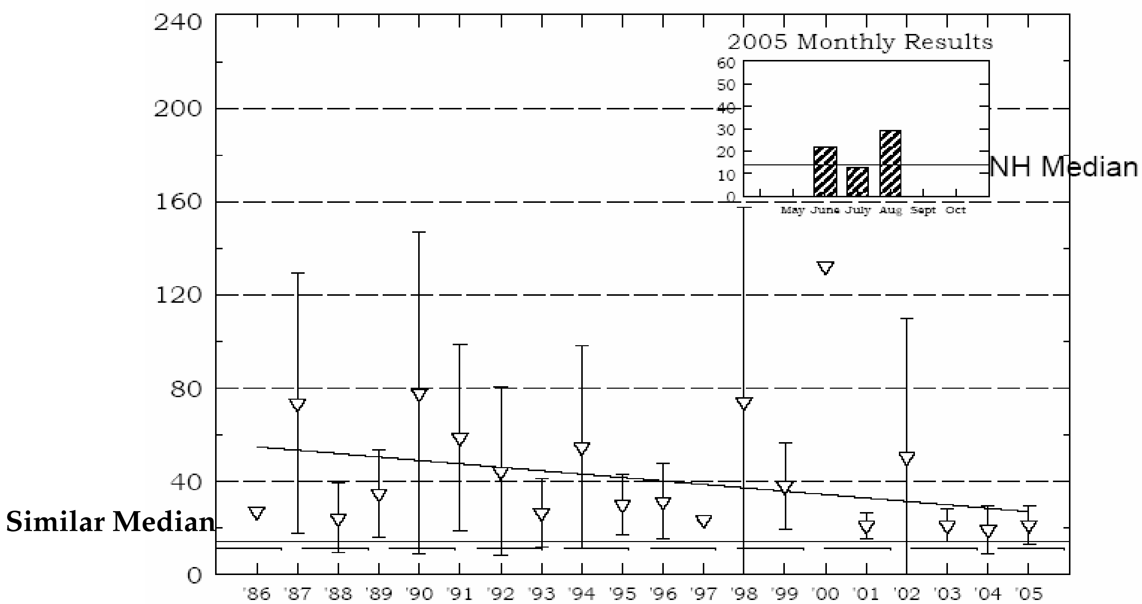
Figure 3.1-1
Historical Total Phosphorus Concentrations (ug/l) in the Epilimnion of Webster Lake



The historical total phosphorus levels in the hypolimnion (deep water layer) have generally been much higher and consistently above the median level observed in other NH Lakes for the entire period of record. Average concentrations (taken at mid-depth of the hypolimnion) ranged from low of around 20 ppb in 2001, 2003, 2004 and 2005 to highs of 80 and 130 ppb in 1990 and 2000, respectively. Maximum concentrations have exceeded 100 ppb in 7 out of the 20 years in the database. The higher phosphorus levels in the hypolimnion are due in large part to the anoxic conditions that are prevalent at depth. Phosphorus tends to be released from bottom sediments and organic matter in low oxygen environments. As stated earlier, as algae dies and sinks to the bottom, the decomposition of this material consumes oxygen and can contribute to anoxic conditions. Organic loading from other sources such as decaying aquatic plants tributary sources may also create an oxygen demand in deeper lake waters.

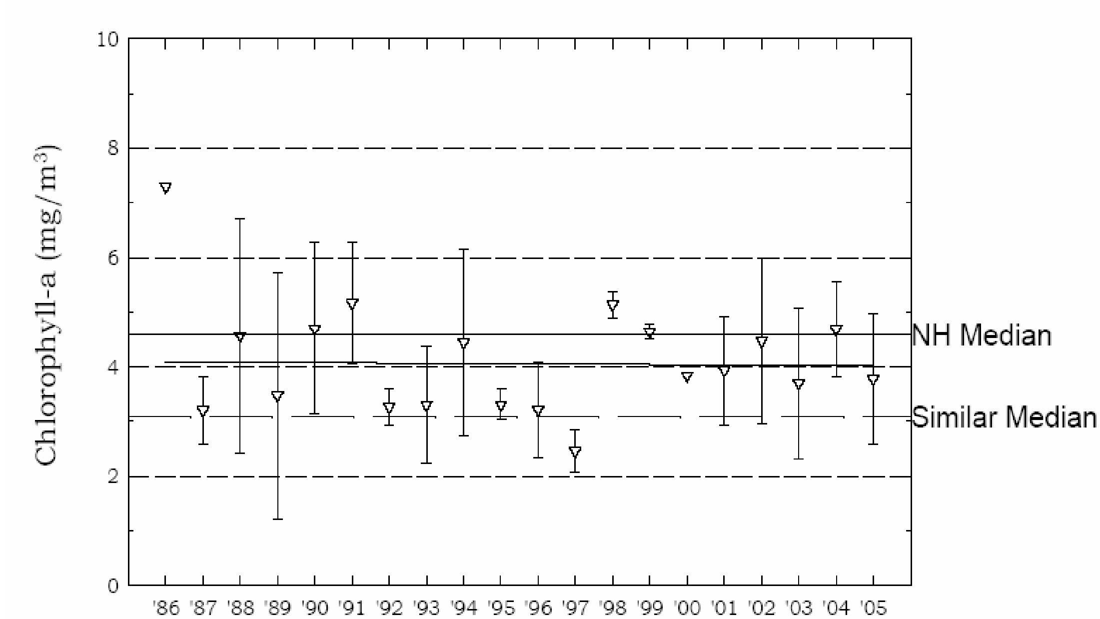
Similar to the epilimnetic phosphorus concentrations, the data show that phosphorus concentrations in the hypolimnion were considerably higher in the late 1980's and early 90's. Importantly, phosphorus levels in both the epilimnion and the hypolimnion show statistically significant declining trends. Interestingly enough, the phosphorus concentrations in both the epilimnion and hypolimnion were relatively low from a historical perspective in the summers of 2003 and 2004 when the nuisance algal blooms were observed. This may suggest that other factors or very localized conditions may have contributed to the algae blooms in Webster Lake may that may not be entirely reflected in the available phosphorus data measured in the middle of the Lake.

Figure 3-2
Historical Total Phosphorus Concentrations (ug/l) in the of Hypolimnion of Webster Lake



Chlorophyll *a* Concentrations

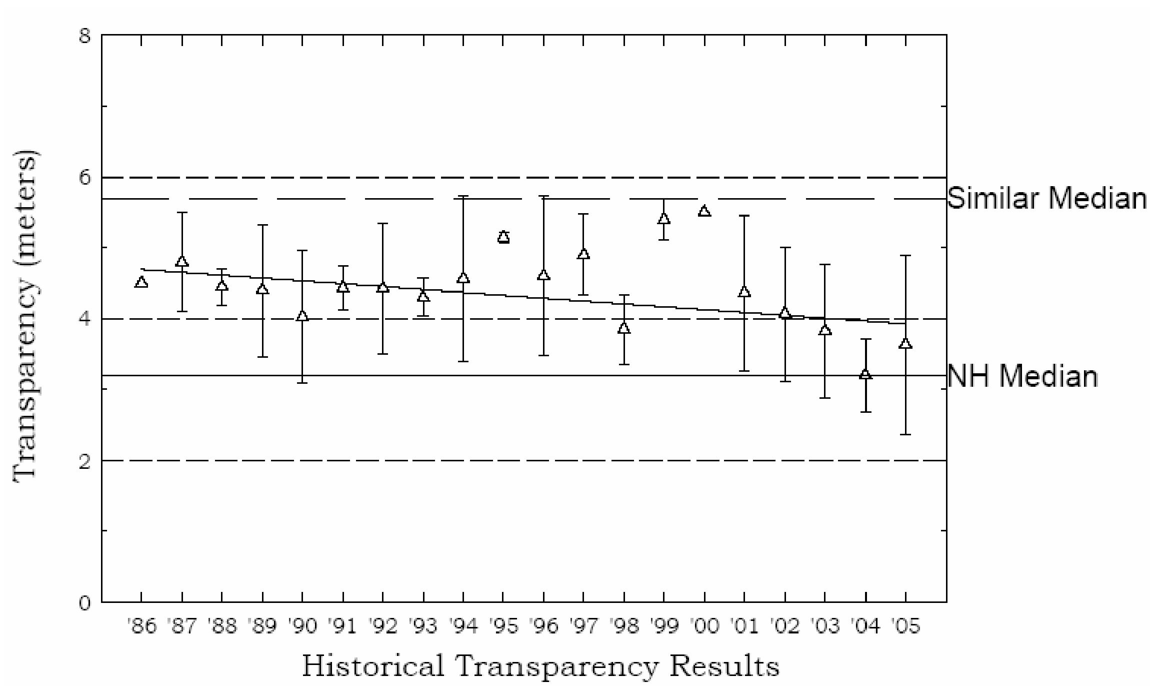
Chlorophyll *a* is a measure of the chlorophyll content of algae and is well correlated to water quality and trophic state. DES guidelines indicate chlorophyll *a* levels less than 4 ppb are indicative of oligotrophic or "good" conditions (0-5 ppb) while values in the 4-15 ppb range indicate mesotrophic conditions or "more than desired" levels. In Webster Lake, chlorophyll *a* concentrations have historically averaged between 3 and 5 ppb for the summer months, with recent maximum values almost always less 6 ppb. These average levels would result in a "good" classification, somewhat better than the NH median of 4.6 ppb. Even so, some of the maximum values exceed the "good" category, and while not at "nuisance" levels (>15 ppb), they would place occasional Webster Lake chlorophyll *a* values at "more than desired" levels. There is no statistically significant trend in the long-term chlorophyll *a* data which suggests that concentrations are neither increasing nor decreasing. Given the natural variability of phytoplankton activity, this is not unexpected.



- **Secchi Disk Transparency**

The historic summer Secchi disk readings have generally averaged around 4 to 5.5 meters (13 to 18 feet). According to the DES guidelines, these values are in the "good" to "exceptional" category, and considerably better than the NH Lake median value of 3.3 meters. However, lakes with similar mean depth and volume appear to have better transparency with a median Secchi depth reading of 5.8 meters. The 2005 Annual VLAP Report indicates that there is a statistically significant, declining trend in Secchi depth readings. This is especially true in the last 4 or 5 years which is not consistent with either the total phosphorus or chlorophyll *a* data. The worst year for transparency appears to be in 2004, with an average Secchi depth reading of 10 feet or 3.3 meters, which is the lowest in the 20 year history. This low transparency could be partially explained by chlorophyll *a* values for 2004, but total phosphorus data do not support either elevated levels of chlorophyll *a* or reduced Secchi depth. Conditions in 2005 appear to be slightly worse in terms of total phosphorus than in 2003 and yet there were no noticeable blooms of cyanobacteria in 2005. It is difficult to explain why cyanobacteria became so abundant in 2003 and 2004 but not in 2005. It is also unclear as to why transparency has diminished in recent years despite the improving or declining trend in phosphorus concentrations. If the reduction in transparency is due to increased turbidity from sediment erosion and related soil disturbances or storm events, then the summer of 2006 should have particularly poor transparency conditions given several extreme storm events that occurred in May and June.

Figure 3-4
Historical Average Secchi Depth Readings in Meters
(Water Transparency) for Webster Lake



Summary of VLAP Water Quality Data

The historical trend in the VLAP data suggests the total phosphorus and chlorophyll a concentrations are improving. However, even with these improvements, Webster Lake has experienced some recent occasional water quality problems with the nuisance algal blooms that occurred during the summer of 2003 and 2004. A notable algal bloom is usually linked to a recent influx of phosphorus in the water column either from "external" or "internal" sources. However, according to the VLAP data, the phosphorus concentrations during these two seasons were at historical low levels based on monthly sampling. Thus, it is unclear as to what caused these particular nuisance algal blooms. Phosphorus influxes could result from either "external" loading such as that from a major storm event, shoreline disturbances, construction activity, timber harvesting or a major septic system failure or from "internal" loading that could result from hypolimnetic or metalimnetic water being entrained in the upper surface waters.

With respect to possible "external" sources, if the possible cause for the previous blooms in 2003 and 2004 was related to major storm events and associated runoff, then similar blooms would have been expected in the summer of 2006 when several unusual intense storm events occurred in May and June of 2006. In May, the region had what was later determined to be a 100-year flood event with nearly 6.0 inches of rain in 24 hours and about 10.0 inches of rain over a 36–hour period. In June, there were at least two or three storms that had 2.5 to over 3.0 inches of rain in a matter of hours causing very high turbidity and sediment loads in the area streams. Based on the preliminary VLAP data collected in the summer of 2006, there were no unusually high phosphorus concentrations observed in the epilimnion and hypolimnion nor were there any unusual algal blooms reported. No other anecdotal evidence has been mentioned or discussed by local residents during the public hearings with respect to any unusual construction or other soil disturbance activities that may have occurred during the summers of 2003 and 2004.

With respect to possibility of internal loading from the hypolimnion, typically over the course of the summer, the epilimnion volume increases or deepens as a result of entrainment of metalimnetic water into the epilimnion and hypolimnetic water into the metalimnion. Entrainment accelerates during the late summer and early fall with cooling temperature until complete top-to-bottom mixing is achieved. The potential influence of hypolimnetic entrainment on the algae growth depends primarily on the magnitude of phosphorus concentrations in the hypolimnion and the relative difference in volumes between the epilimnion and hypolimnion. The potential change in the in-lake phosphorus concentration can be assessed by assuming complete mixing of the hypolimnion volume with the epilimnion volume with a predetermined phosphorus concentration, as discussed below.

The total volume of the lake it is estimated be approximately 452 million cubic feet. In review of Webster Lake's bathymetric data, about 80 % of this lake volume is contained in the upper 10 feet of water. Review of the historical dissolved oxygen/temperature profiles suggests that the hypolimnion during the summer stratification period consists of the volume of water below approximately 20 feet in depth. Although 20 feet is more than 50% of Webster Lake's maximum depth, this amount of water below 20 feet represents only 5% of the total Webster Lake volume (about 27 million cubic feet). Thus, if all the hypolimnetic water were to completely mix with the epilimnetic water and the typical phosphorus concentrations in the hypolimnion were 20 to 30 ppb, the resulting increase in the epiliminion would, at most, be only 1.0 to 1.5 ppb. Since this type of complete mixing only occurs during the early to mid-fall when water temperatures have cooled, the potential increase in the phosphorus concentration resulting from localized mixing or partial entrainment of the hypolimnion due to turbulence from boating activity or wind effects would likely be much less than 1.0 ppb. An increase of 0.5 to 1.0 ppb in the in-lake phosphorus concentration is not likely to cause a significant nuisance algal bloom similar to that observed in 2003 and 2004.

Existing Phosphorus Loading ("Budget") Analysis

Phosphorus concentrations in lakes are primarily a function of the phosphorus inputs or loading from the watershed over time and the hydraulic characteristics of the lake. Depending on the size of the lake and its flushing rate, the phosphorus concentrations observed in a lake are generally reflective of the amount of phosphorus contributed during the course of a year. Limnologists typically express the estimated phosphorus contributions or loads from each of the known sources in the watershed in terms of an "Annual Loading Budget". There are three basic approaches to developing a phosphorus budget including a measured mass balance approach, a land use export modeling approach or the use of model equations to back calculate the watershed load based on the observed in-lake concentration.

The measured mass balance approach involves frequent measurements of the stream flow rates and in-stream concentrations on a subwatershed basis. Depending on the sampling period and frequency of sampling this approach is generally considered the most accurate but also the most time-consuming and is relatively expensive. This approach may underestimate potential loads if storm event sampling was insufficient to capture peak concentrations and flow rates. The land use export model approach relies on assumed loading rates for various types of land uses based on rates expressed in the literature. This method is generally less accurate and difficult to validate to site-specific conditions but can be useful to evaluate the potential effects of various management alternatives. Various models (equations) have been established using statistical analysis of empirical data to express the relationship between phosphorus loading and in-lake concentrations while accounting for the lake's mean depth and flushing rate. The Vollenweider equation (1976) is one of the more widely used procedures for this analysis that has been considered to be reasonably accurate for calculating the likely in-lake concentration for a given annual phosphorus load and vice-versa. Internal loading from bottom sediments, however, is generally not factored into the equation and the equation assumes the lake is in a steady-state, well mixed condition and, in other words, not thermally stratified into eplimnion and hypolimnion.

The Dufresne-Henry (DH) Study (1981) developed a detailed phosphorus loading analysis using a modified mass balanced approach by collecting phosphorus concentration data from the lake's tributaries, and then estimating the hydrologic inputs based on extrapolated data recorded from the nearby USGS gauging station on the Swift River in Bristol, NH. The results provided reasonably accurate estimates of annual phosphorus inputs from the tributaries to Webster Lake. During the Diagnostic-Feasibility (D-F) study conducted by DES in the late 1980's, additional phosphorus concentration and flow data were collected within various sub-watersheds within the overall Sucker Brook watershed, which helped to identify where the highest increases in phosphorus loading were occurring in the Sucker Brook watershed. The phosphorus inputs from rainfall were also based on measured data.

Table 3.5 presents the estimated annual phosphorus inputs for four main sources during a normal or average precipitation year. The assumptions and methods used in developing these estimates are discussed in detail in the sections below:

Table 3.5
Phosphorus Loading Estimate Based on Dufresne-Henry Study (Normal Year)

Major Source Area	Amount (Kg/yr)	% of Total
Tributaries	458.7 Kg	74.1 %
Rainfall	68.1 Kg	11.0 %
Dry fall	20.4 Kg	3.3 %
Septic Systems	71.3 Kg	11.5 %
	618.5 Kg	100 %

The D/F study results indicated that Sucker Brook, which is the primary tributary to the

Lake, contributes about 63% (or 391.4 Kg) of the total annual phosphorus load to Webster Lake while the remaining tributaries account for about 11% of the total annual load. The Sucker Brook load estimate was based on an average in-stream phosphorus concentration of 0.019 mg/l based on biweekly grab sampling results collected over the course of a year and the average annual total hydrologic inflow. The Sucker Brook watershed, which includes Highland Lake accounts for about 80% of the total watershed area draining to Webster Lake. Individually, each of the other tributaries accounted for less than 2.5% of the annual phosphorus total. The estimated average in-stream phosphorus concentrations in the other tributaries ranged from 0.005 to 0.043 mg/l.

Use of Vollenweider Equation to Calculate In-Lake Phosphorus Concentrations

The Vollenweider equation describes the relationship between annual phosphorus loading and in-lake concentrations as influenced by the primary lake response characteristics including mean depth and hydraulic residence time. The equation was derived as a result of a five year study involving over 200 water bodies in 22 different countries (DES 1990: EPA 2005). The equation is widely used to predict the average in-lake phosphorus concentration based on an estimated average annual phosphorus load. The equation can also be used to estimate an acceptable or permissible load to maintain a certain in-lake phosphorus concentration. The components of the equation are described below:

Vollenweider Equation

$P = (Lp/qs) \times (1/(1 + \sqrt{z/qs}))$;

Where;

P = mean in-lake phosphorus concentration (mg/l);

Lp = annual phosphorus load / lake area, (grams/m^2/year);

z = mean depth (meters)

T= hydraulic residence time = lake volume/annual outflow volume.

qs = areal watershed = z/T

Assuming:

Estimated P Load is 618, 543 grams /year and

Lake area is 2,477,573 m^2, then 618,543 gms/2,477,573 m^2 = 0.250 gm/ m^2/yr.

z = 5.7 meters

T = Lake volume =1.4 x $10^7 m^3$ / outflow volume = 2.71 x $10^7 m^3$ (DES 1991)

= 1.4 x $10^7 m^3$ /2.71 x $10^7 m^3$ = 0.52 yr.

qs = mean depth / hydraulic residence time = z/T = 5.7m /0.52 yr = 10.96 m /yr

Thus,

In-Lake P conc. (mg/l) = (.250 /10.96) x (1/ 1 + ($\sqrt{5.7/10.96}$)) **= 0.013 mg/l**.

Based on the current estimated annual phosphorus load of 618.5 Kg per year for Webster Lake, the in-lake phosphorus concentration for Webster Lake, using the Vollenweider equation, is estimated to be 0.013 mg/l. This concentration compares very well to the average historical phosphorus concentration of 0.012 mg/l observed in the eplimnion as reported in the VLAP data. Since a major assumption in using the Vollenweider equation is that the lake is well mixed and there is no stratification, the equation may underestimate phosphorus concentrations in lakes that thermally stratify and have higher concentrations at depth such as in the case of Webster Lake. Thus, the actual historical in-lake concentration in Webster Lake would likely be slightly higher if the hypolimnion concentrations were included in the average. Recently, on April 3, 2006, a surface water sample was collected in Webster Lake, immediately after ice-out, when lakes are typically in a well-mixed condition. The phosphorus concentration was reported to be 0.015 mg/l or 15 ppb, which suggests that the average in-lake phosphorus concentration during well-mixed conditions for the entire lake volume may be slightly above the average summer eplimnetic concentration.

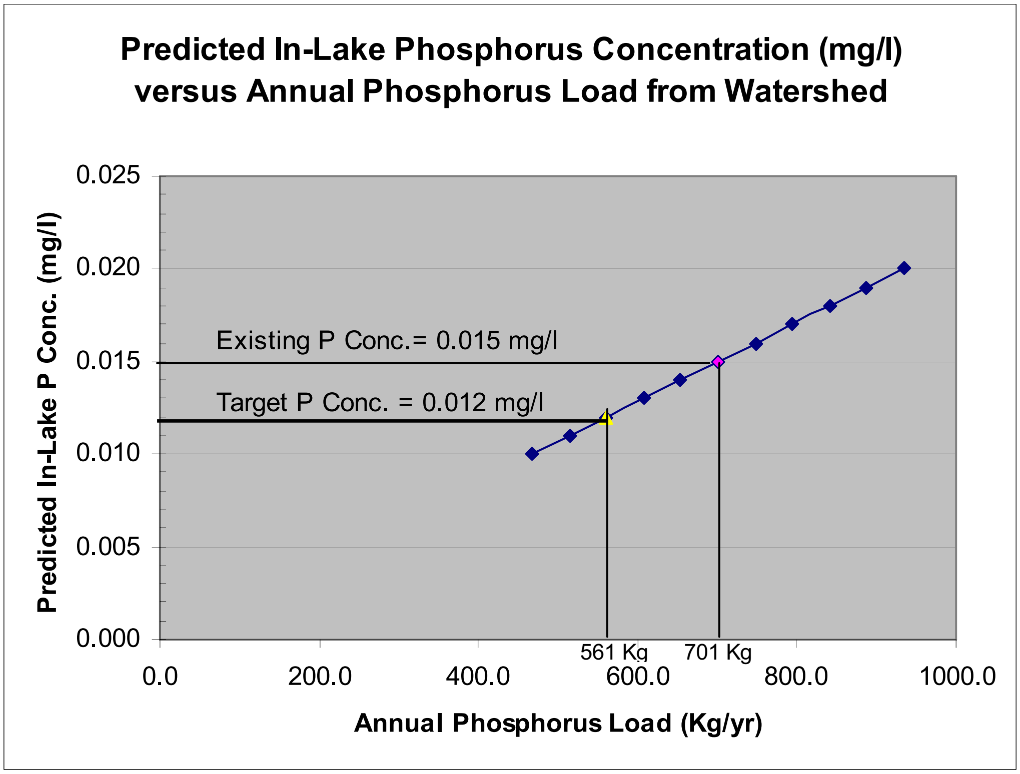
In addition, application of a widely used land use export model (discussed in Section 4.0) suggests that phosphorus loading to Webster Lake could be higher than indicated by the Dufresne-Henry study under well-mixed conditions. These modeling results combined with measured in-lake phosphorus levels at ice-out lead us to conclude that the "true" or "well-mixed" in-lake phosphorus concentration in Webster Lake is more likely 15 ppb instead the 12 ppb that is typically reported by VLAP for the epilimnion or 13 ppb reported in Dufresne-Henry study using the Vollenweider model.

Although the difference between 12 ppb and 15 ppb seems relatively small, it is important to recognize that an average in-lake phosphorus concentration of 0.015 mg/l would indicate that Webster Lake may be transitioning to more mesotrophic/eutrophic conditions rather than oligotrophic /mesotrophic conditions as previously indicated in the Dufresne-Henry study and the 1990 Diagnostic-Feasibility study. At a minimum, it will be important to prevent the in-lake phosphorus concentration from increasing above 15 ppb where one would anticipate algal blooms to become increasingly more common and perhaps for longer durations during the summer months.

Target Goal for In-lake Phosphorus Concentration

To improve existing water quality conditions, a reasonable goal would be to try to reduce the existing in–lake phosphorus concentration by 2 to 3 ppb to maintain an average in-lake phosphorus concentration closer to 11 or 12 ppb, rather than 13 to 15 ppb. This may seem like a minor difference in concentrations but lake water quality conditions, in terms of water clarity and algal productivity, can be substantially different with an average phosphorus concentration closer to 12 ppb as opposed to 15 ppb. This would provide a buffer against any short-term, episodic influxes similar to those that may have caused the algal blooms in 2003 and 2004. It also allows for some reasonable amount of residential growth that is likely to occur in the watershed in the future. This is consistent with the findings of the previous of the DES D/F study, which concluded that the Lake was essentially at capacity in terms of phosphorus loading and any future increases would likely result in a decline in water quality conditions.

Using the Vollenweider equation, it estimated that the existing phosphorus load would need to be reduced by about 94.0 Kg/yr to lower the in-lake concentration by 2 ppb and perhaps as much as 140 Kg /yr to lower the concentration by 3 ppb. These load reductions represent about 18 % and 26 %, respectively, of the existing estimated phosphorus load contributed from tributaries and septic systems (i.e. 530 Kg/yr). The next sections describe how this might be accomplished. To strive for even greater reductions may be cost-prohibitive.



4

Estimates of Annual Phosphorus Loads for the Various Sources

This section provides a general assessment of the phosphorus contributions from the various known sources within the watershed and around the shoreline of the Lake. In addition, the various opportunities, limitations and potential costs associated with implementing various control measures that are available to minimize inputs are also discussed. The assessment of the potential phosphorus contributions is based on a combination of previous sampling results, recent watershed modeling done as part of this study and the findings of other studies reported in the literature. In addition, local observations and information provided by members of the Partnership Group and the general public during the public "Listening Sessions" have also been included in this source identification and assessment. The sources are subdivided into two major categories including those in the watershed and those on or along the shoreline of the lake.

Watershed Sources:

Residential Development
Timber harvesting
Pastureland/Manure Spreading / Storage
Storm Runoff from Road Surfaces – Dirt and Paved Roadways

In-lake or Shoreline Sources:

Shoreline Septic Systems
Lawn Maintenance
Sediment Disturbances from Boating Activity
Ice fishing and "bob-house" launching and retrieval
Fire works
Pet Wastes

STEPL Model Analysis

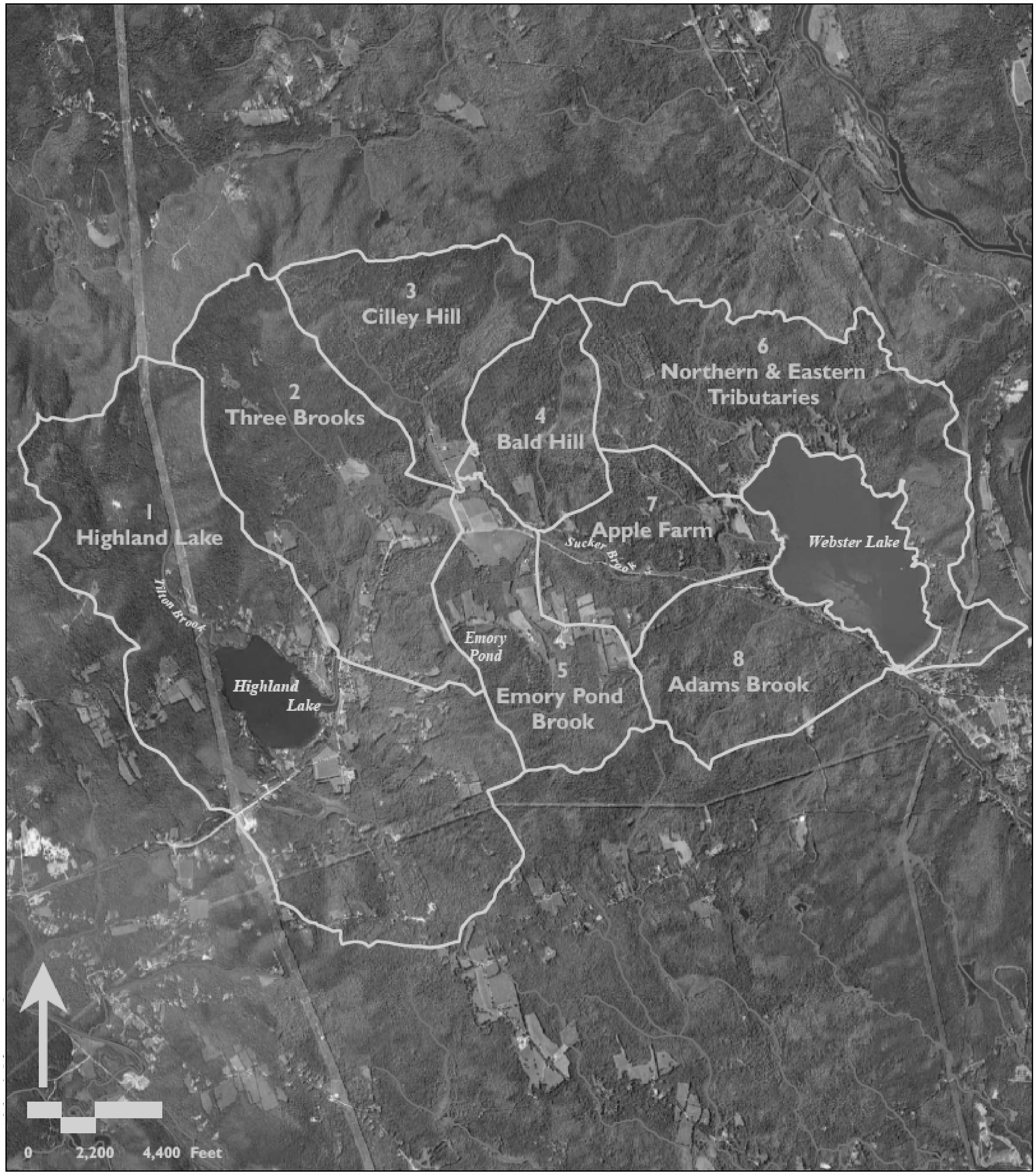
The Spreadsheet Tool for Estimating Pollutant Loading (STEPL) Model is designed to estimate annual nutrient and sediment loads conveyed by surface runoff on a watershed basis. The STEPL Model was developed for the EPA to specifically evaluate the effectiveness of various agricultural related management practices. Annual runoff is determined using the NRCS curve number method that is adjusted for land use conditions and the predominant soil type within the watershed. The relevant precipitation data were based on historical data recorded at the NWS station in Bristol, NH and includes average annual runoff total (inches), average storm rainfall amount and the average number of rainfall days per year. Sediment loads are computed based on the Universal Soils Loss Equation (USLE). The model contains default values for each of the USLE components including the rainfall erosiveness factor (R), soil erodibility factor (K), topographic factor (LS), crop or cover factor (C) and the land management practice factor (P). The estimated nutrient loading is based on the computed annual runoff volume combined with an estimated initial nutrient concentration in runoff adjusted for each land use. The initial concentration can be adjusted by the model user. The nutrient component associated with eroded sediment is also included in the total nutrient loss estimate for the watershed. An initial nutrient concentration in native soils is also included in the model. The model contains expected treatment efficiencies for numerous Best Management Practices (BMPs) that can be evaluated to estimate potential nutrient load reductions through BMP implementation.

The model was used to simulate phosphorus and sediment loads from each of the eight sub-watershed areas that were originally delineated as part of the phosphorus budget conducted back in 1991 DES Diagnostic/Feasibility study (See Figure 4-1). Table 4-1 provides a breakdown of the various land uses within each of the eight sub-watershed areas. The land use categories evaluated include residential development, forested areas, pasture land areas, roadway area.

Table 4-1
Summary of Land Use Areas within Each Subwatershed for Input in STEPL Model

	Area (acres)					
Watershed Area	Residential	Pastureland	Forest	Roadways	Feedlot	Total
W1- Highland Lake	168	180	2701	34	0	3083
W2- Three Brooks	23	102	1429	15	0	1569
W3- Cilley Hill	2	41	839	5	0	887
W4- Bald Hill Brook	2	40	529	2	0	573
W5- Emory Pond Brook	6	224	571	7	0	808
W6- North & East Tribs	104	1	1470	11	0	1586
W7- Apple Farm	23	113	556	13	0	705
W8- South West Tribs	43	6	725	6	0	780
Totals	371	707	8820	93	0	9991

Sources: Based on GIS land cover data contained in the NH GRANIT System and 2001 Lakes Region Planning Commission Land Use data with minor adjustments based on a 2003 Digital Ortho-photo.



Legend

Stream (USGS)

Webster Lake Sub-Watersheds

Figure 4-1

Webster Lake Sub-Watersheds

Franklin & Andover, New Hampshire

Source: Digital Orthophoto captured in 2003 by NAIP and distributed by NH GRANIT.

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The overall objective was to try to replicate the previous load estimates for each of the sub-watersheds that were delineated and sampled as part of the 1990 D/F study as well as in the earlier 1981 D-H study. The previous sampling data were collected during dry and wet-weather events for the major tributaries and provides a load estimate on a sub-watershed basis but not on a land use specific or individual source basis. The STEPL model does not compute the nutrient contributions from groundwater or base flow. Soils data for the USLE were based on the default values provided by the model and adjusted to representatives general soil types of the Merrimack County. It was assumed that Hydrologic Soil Group C soils were the predominant soil type throughout the watershed area with respect to runoff and infiltration calculations. Sub-watershed areas were determined using Arc Info Vers.9.0 software and NH GRANIT data layers containing USGS topographic and elevation data.

The following presents the selected phosphorus concentrations in runoff used to represent the various land uses based on the literature values presented in Table 4-2.

Table 4-2
Initial Phosphorus Concentrations in Runoff for Each Land Use

	Phosphorus Conc. (mg/l)
Forest	0.015
Pasture	0.30
Residential	0.50 (single family)
Roadways	0.50

Initial Soil P Conc. = 0.031 mg/kg

Table 4-3
Literature Values for Total Phosphorus Concentrations (mg/L)
in Runoff for Various Land Uses

Literature Source	Residential	Pastureland	Forest	Roadways
Default Values for STEPL Model [1]	0.04	0.04	0.015	0.05
National EMC Values[2]	0.40	1.04	0.13	0.35
Schueler[3]	0.46		0.15	
Default Values for Watershed Mgt Model (WMM)[4]	0.52	0.37	0.11	0.43
DES Guidance for Pollutant Loading Estimates[4]	0.40	na	na	0.55
Rhode Island DEM[5]	0.62	na	0.061	0.49

Sources: [1]STEPL User's Guide Manual
[2]CDM, 2004. Merrimack River Watershed Assessment Study;
[3]Schueler, T. 1987. Controlling Urban Runoff; a Practical Manual for Planning and Designing Urban BMPs. Metropolitan Washington Council of Governments. Washington, D.C.
[4]NH DES. 2005. Interim Guidance for Estimating Pre and Post Development Pollutant Loads, October 17, 2005.
[5]Rhode Island Department of Environmental Management: State of Rhode Island Storm Water Design and Installation Standards Manual. September 1993.

Septic system contributions were also estimated using the model based on the following input data. The estimated number of septic systems was based on various sources including the information in the D-H study septic survey for sub-watersheds W6, W7 and W8 around Webster Lake, aerial photos for sub-watersheds W2 through W5 and an estimate provided by the Town of Andover, Planning Board Chairman for the Highland Lake sub-watershed. The potential failure rates represent general estimates of the amount of area with shallow seasonal high water tables (i.e., < 18 cm) particularly around the Webster lake shoreline (See Figure 4-2). Approximately 12.5% of the area, within 300 feet of the lake, have extremely shallow seasonal high water tables that are less than 18.0 cm (~7.0 inches) below the ground surface, based on the Merrimack soil county data. Another 26% of the shoreline area has seasonal high water tables that are less than 24 cm (~10-inches) below the ground surface during wet years. Thus, it was generally assumed that 10% of the septic systems are located within these soil types and could be potentially failing or poorly functioning. This is reasonably consistent with the D-H study, which estimated that nearly 17% of the septic systems were failing due to shallow seasonal high water tables. It was assumed that some of the shoreline homeowners in these areas had upgraded their systems since the early 1980's. Around Highland lake, only 5% of shoreline was estimated to have a shallow seasonal high water table. The model default value failure rate of 2% was used in the other watersheds.

Table 4-4
Septic System Input Values Used
in the STEPL Model for the Various Sub-watersheds

Watershed	No. of Septic Systems	Population per Septic System	Septic Failure Rate, %
W1- Highland Lake	80	2.43	5
W2- Three Brooks	30	2.43	2
W3- Cilley Hill	2	2.43	2
W4- Bald Hill Brook	2	2.43	2
W5- Emory Pond Brook	7	2.43	2
W6- North & East Tribs	126	2.43	10
W7- Apple Farm	25	2.43	10
W8- South West Tribs	25	2.43	2
Total	297		

Model Results

Table 4-5 presents the results of the STEPL modeling analysis, which indicates a total annual phosphorus loading of 642 Kg from the watershed. This load estimate is about 4 % higher than the previous estimate of 618 Kg presented in the DES D/F study, which includes the direct precipitation and dustfall contributions. The tributary and septic system portions of the D/F estimate were 459 and 71.3 Kg per year, respectively. The tributary and septic system portions of this STEPL Model estimate were 539 and 103 Kg/yr, respectively, or roughly17 and 30% higher than the previous estimate. These higher estimates may reflect more conservative assumptions in included the STEPL Model and may also be more representative of storm runoff related inputs that may or may not have been fully captured in the sampling data.

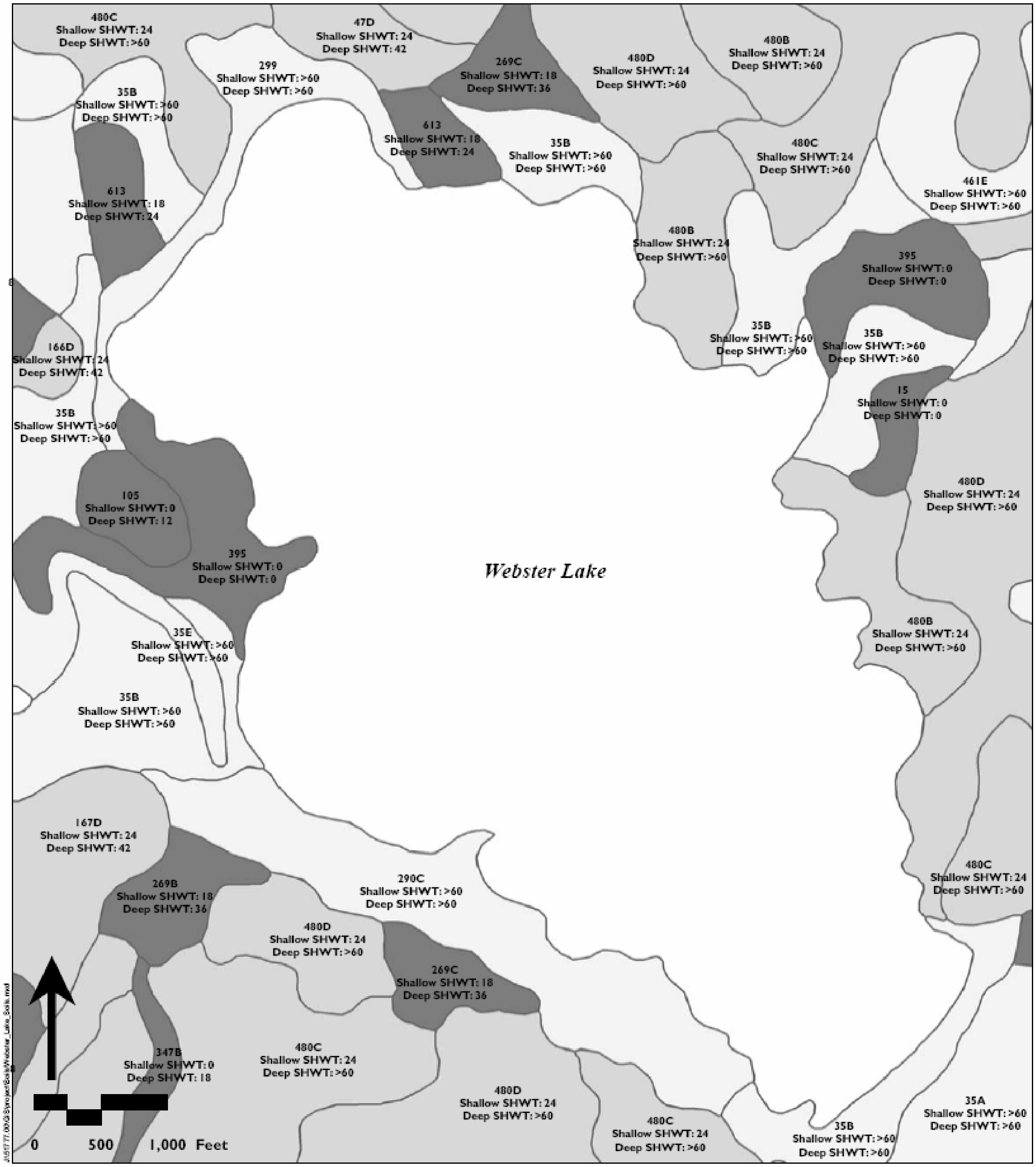
These model results suggest that runoff from pasture land may account for nearly 34% of phosphorus load from the watershed. This is somewhat consistent with sampling results observed in the D/F study, which showed that pasture area was one of the leading sources of phosphorus, especially during certain months of the year when manure spreading takes place. Residential areas accounted for another 26% of the estimated existing load, followed by forested areas at roughly 20% of the total load even though the initial phosphorus concentration in runoff is relatively low. Septic systems and roadways account for 16% and less than 10%, respectively, of the total load. The septic system contribution as a percentage of the total is consistent with the previous D/F study estimate. Although roadway area was suspected to be major source contribution, the results of this modeling suggests it is a relatively small contributor even with a relatively high concentration used in the analysis.

Table 4-5
Estimated Phosphorus Load by Land Use Using the STEPL Model

	Phosphorus Loading By Land Use (Kg/yr)					
Watershed Area	**Residential**	**Pastureland**	**Forest**	**Roadways**	**Septic**	**Total**
W1- Highland Lake *	42.0	32.7	23.3	13.6	12.2	124
W2- Three Brooks	10.5	34.9	23.7	11.1	3.3	84
W3- Cilley Hill	0.9	14.5	14.7	3.8	0.2	34
W4- Bald Hill Brk	0.9	14.5	9.6	1.5	0.2	27
W5- Emory Pond Brook	2.7	79.7	10.1	5.3	0.8	99
W6- North & East Tribs	47.3	0.3	24.4	7.9	69.5	149
W7- Apple Farm	10.5	40.5	9.9	9.7	13.8	84
W8- South West Tribs	19.5	2.2	12.8	4.1	2.8	41
Totals	**169**	**219**	**128**	**57**	**103**	**642**

Notes: * The Highland Lake load was reduced by 45 % to reflect the likely amount of estimated phosphorus load that is retained within the Lake.

For purposes of comparison on a sub-watershed basis, the phosphorus load estimates from previous DES D-F study for the Highland Lake outlet, Bald Hill Brook and Emory Pond Brook sub-watershed were 81.0, 13.8 and 69.5 kg/yr, which are roughly 30 to 50% lower. Although these recent estimates generated by the STEPL model are higher, they are considered to be reasonably valid for use in evaluating the effects of various alternatives. The following sections provide a more detailed discussion of the estimated phosphorus contributions from each of various land uses as well as other sources, based on the existing data available, as well as an assessment of the potential load reductions that could be achieved through various treatment measures.



Legend

Seasonal High Water Table (SHWT) Depth

- Shallow (0-18 cm)
- Moderate (>18-60 cm)
- Deep (>60 cm)

Figure 4-2

Webster Lake: Soils with Seasonal High Water Tables

Franklin
New Hampshire

Source: Soil data is from NRCS, Distributed by NH GRANIT.

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Watershed Sources

■ Residential Development

Studies have shown that the nutrient export from residential development can be more than 10 times greater than that from forested lands on a per acre basis (MeDEP 1992: DES 1996). The principal causes are three-fold: 1) as impervious areas increase due to roadways, driveways and rooftops so does the volume of runoff carrying various pollutants which ends up in the stream rather infiltrating back in the ground; 2) the increased volumes tend to wash off more sediments and cause erosion in channels and 3) new sources of nutrients introduced as they relate to lawn and garden fertilizers, grass clippings pet wastes and septic systems. Other studies have found that as the percent imperviousness rises above 10% in a watershed, downstream stream channels become more vulnerable to channel scour and stream bank erosion due to the increased peak flow rates (Schuler 1997).

Existing residential area accounts for less than 3% or about 371 acres of the overall Webster Lake watershed.

With respect to Webster Lake, the problem is not so much the existing residential development but the potential for future development in the watershed as development pressures continue to spread further out from the existing developing communities. Existing residential area accounts for less than 3% or about 371 acres of the overall Webster lake watershed, according to land use data generated by the Lakes Region Planning Commission using 2001 statewide aerial photography. This is a relatively small percentage in comparison to other lake watersheds in New Hampshire, particularly in the southern half of the state. The existing residential area is, however, highly concentrated with nearly 75 % of the existing residential area along the shorelines of both Highland and Webster Lake. The residential area in the Highland Lake sub-watershed accounts for about 5% of the watershed area, while in Webster Lake the percentage of residential area is roughly 6.5 % within the immediate drainage area (i.e.. excluding Sucker Brook watershed) around the lake.

At some point in the future, the City of Franklin and the Town of Andover could experience a major increase in development growth given their relative central location within the state. The development pressure will progress northward as the southern portions of the state reach their limits of development capacity in the coming years. The Lakes Region Planning Commission is currently conducting a build-out analysis for the Andover Planning Board. The results are still in the early stages of development and are not available at this time. The results of this effort, however, will be highly useful in gauging the potential for development growth in both the Highland Lake and Webster Lake watersheds and will form the basis for establishing goals in the next Andover Master Plan Update.

The City of Franklin has taken steps to limit development growth in its portion of the watershed with the adoption of a Webster Lake Overlay District (initially referred to as the Lake Protection District back in 1990) that was recently amended in 2004. The ordinance specifies a minimum lot size of 108,900 square feet (approx. 2.5 ac) for any new lot within the District, regardless of whether or not it is served by City sewer (up from 40,000 sq. ft.) and minimum road frontage of 200 feet. The following summarizes other major requirements included in the ordinance:

- A 50-foot setback from any surface water or wetland for all new structures and driveways.
- Impervious area is limited to no more than 30% of the lot area;
- A 100-foot setback from any surface water or wetland for any septic system associated with new construction.
- Any expansion or seasonal use change of an existing structure must comply with RSA 485A:38 and seek local building permit approval.
- Application of fertilizers and pesticides is not allowed within 200 feet of any surface water or wetland.
- All runoff from livestock feeding areas shall be directed away form surface water or wetland area.
- No stockpiling or spreading of animal manure on fields or pasture within 200 feet of any surface water or wetland.
- For forestry practices, a minimum of 75-foot vegetated buffer of natural vegetation shall be maintained adjacent to all surface water or wetland areas.

Both Communities have been active over the years in working with land preservation organizations to secure conservation easements and open space acquisitions. According to the July 2006 version of *The Andover Beacon*, the Ausbon Sargent Land Preservation Trust (ASPLT) is currently working on securing a conservation easement for the 267–acre Hersey Farm in East Andover with the help of a $173,000 grant received from the Farm and Ranchland Protection Program (FRPP) as part of the US Department of Agriculture Natural Resources Conservation Service. The article states that another $31,000 has been pledged by various individuals and another $71,000 would be needed to complete the project. The easement would preserve the land in an open space and would allow farming to continue in perpetuity but would prohibit any future development of the land. This easement acquisition would represent major step in limiting future residential development in area for land that has some of the highest development potential in the watershed.

The Town of Andover has had a Temporary Residential Growth Limitation Ordinance that limits the number of building permits that can be issued for new dwelling units each year. This has been in effect since March 2002, following adoption by voters at the Town meeting but will expire on March 31, 2007, unless otherwise extended by a town vote prior to that date. The results of the Build-Out Analysis currently underway will provide critical information as to whether this ordinance should be extended and/or other modifications to current zoning and site plan regulations should be considered. In general, the Town of Andover requires a minimum lot size of 2.0 acres and minimum road frontage of 250 feet for all new lots. New waterfront lots must have minimum 200 feet of waterfront frontage. As part of any new update, the Town of Andover may want consider the establishment of a Lake Water Quality Protection District that could include additional provisions and performance standards for specific sources or uses such as septic system maintenance, forestry practices and construction activities. Additional standards for forestry practices may include greater setbacks from streams and rivers, a timber management and erosion control plan with third party review.

Storm Water Runoff From Roads and Other Impervious Surfaces

Runoff from roadways and especially dirt roadways was raised by several members of the Partnership Group as being a suspected major source of phosphorus and sediment in the watershed. There are a number of roadways, particularly gravel and/or dirt roadways with relatively steep slopes that drain to and cross over tributaries of Webster Lake, particularly Sucker Brook. Based on a GIS analysis, there is approximately 93 acres of roadway area in the entire watershed area, which represents slightly less than 1.0% of the overall watershed area. About a third or 34 acres of this roadway area is located in the Highland Lake sub-watershed area. Using the STEPL model and a conservative assumption that the average phosphorus concentration in roadway runoff is about 0.5 mg/l, it was estimated that roadways would contribute 57.0 kg (~125 lbs) of phosphorus per year, which is less than 10% of the estimated total annual phosphorus load to the Lake. On an aerial basis, this translates into about 1.8 kg/ha/yr (1.6 lbs/ac/yr) for roadway surfaces, which was the highest loading rate on per acre basis relative to the other land use categories. This is fairly consistent with the findings of a previous study conducted by MeDEP, which showed that an average phosphorus loading rate of 1.8 lbs/ac/yr from paved rural roadways (Dudley et. al., 1997).

Currently, much of the road runoff around the lake travels primarily though roadside swales that provide some limited water quality treatment benefits. Roadside swales along Route 11 have recently been upgraded and lined with rip-rap stone to reduce flow velocities as part of the recent road improvements. The difficulty with treating roadway runoff in rural areas, where runoff generally flows as sheet flow to adjacent wetland and low-lying areas, is that only relatively short sections of roadway (i.e., 300 to 500 feet) can be treated or directed to a treatment device. In order to treat 1.0 acre of roadway, nearly 2000 feet of roadway would need to be directed to one location for storm water treatment, assuming an average roadway width of 24 feet. Thus, multiple storm water treatment devices would be required at various locations in order to achieve any significant phosphorus reductions from roadway runoff. Where many of the treatment of devices designed for roadway runoff generally cost upwards to $20,000 per device, these can become exceedingly costly on a per area basis of treatment.

Possible Treatment Measures

Smiling Hill Road and Lake Avenue are perhaps two roads within the immediate vicinity of Webster Lake that have the greatest potential for treatment because they are oriented perpendicular to the lake such that a relatively large section of the roadway drains to the lake or an adjacent stream that enter into the lake. Approximately 500 feet of Smiling Hill Road drains through roadside swales that empty into the lake near the Griffen Beach parking lot. At a minimum, the swale should be stabilized with rip-rap stone and enhanced with stone check dams to reduce flow velocity and reduce the potential sediment erosion. To achieve a treatment efficiency, perhaps a small bio-retention area or manufactured-type device could be created or installed at the lower end of the swale to provide added filtering or trapping of sediments before flow reaches the lake. . Assuming an annual loading rate of roughly 2.0 lbs/ac/year for roadway area, the maximum benefit or load reduction that might be achieved by installing a pre-cast, manufactured BMP treatment device at this location would be somewhere around a 0.5 to 1.0 lbs of phosphorus per year, which is < 0.1% of the total estimated phosphorus load from the watershed.

There are a number of measures that are on the market designed specifically to treat road runoff. The least expensive devices generally range from about $2,500 to $5,000a nd typically consist of screening type devices designed to be inserted into catch basins to capture the larger sediment particles and other debris. These devices require frequent maintenance (i.e., minimum quarterly) to prevent clogging and generally have sediment removal efficiencies of 10 to 20% and even less for phosphorus. The larger vault or over-sized catch basin type devices range in cost of $10,000 to $20,000 and typically have sediment removal efficiencies of 25 to 40% and perhaps as much as 10 to 20% for phosphorus. More detailed information on these types of devices can be found at a UMASS webs site www.mastep.org. Additional cost and treatment efficiency information is presented in Chapter 7.0 – Implementation Plan.

Due top the relatively high cost per area treated or cost per kg of phosphorus potentially removed with the manufactured devices, it is recommended that the Partnership focus on roadside swale stabilization measures as a more cost-effective means of limiting phosphorus contributions to Webster Lake. The other major drawback to the manufactured devices is that many recent studies have found that they are minimally effective if not frequently maintained. This added maintenance is often a deterrent for most municipalities.

For roadside swale stabilization, the lower portions of Sam Hill Road, Emory Pond Road and Hoyt Road in the Town of Andover are key locations in the watershed where improvements to roadside swales could result in water quality benefits. The primary recommendation would be to re-grade and perhaps widen the existing ditches as well as install adequately sized rip-rap stone to stabilize the swale during peak flow events. See Appendix E for details.

■ Livestock, Manure Spreading and Pasture Land

It is widely recognized that manure is often used as an effective fertilizer on agricultural land because of its nutrient richness. However, if not properly stored or if applied to land areas that are directly adjacent to a stream or another water body, especially during winter months and on frozen ground, manure can be a significant source of phosphorus. Similarly, in pasture areas or other pens, corrals or paddocks where livestock and domestic pets might defecate directly within or immediately adjacent to streams and drainage ways, this can also be a significant source of phosphorus. Additionally, fecal matter from all warm-blooded animals can be a major source of bacteria, particularly *E. coli* bacteria.

Based on GIS data, approximately 720 acres of pasture land exists in the Webster lake watershed representing about 7.2% of the total land area. This includes the larger field areas visible from aerial photography but may not include smaller horse paddock or livestock pens consisting of one or two acres in size. About 200 acres of this pasture area is in the Highland Lake watershed. Below Highland Lake, the majority of the pasture land exists in the Emory Pond Brook drainage area, which is a principal tributary to a Sucker Brook. The Emory Brook drainage area contains about 240 acres of pasture area that supports two moderate-sized dairy farms, known as the Shaw Farm and Hersey Farm, which have operated for many years and have about 40 to 60 cows each. As shown in Table 4.5, the STEPL Model results indicates that the pasture area in the Emory Pond Brook watershed accounts for a large portion of the phosphorus load from pasture area or roughly 80 kg (36%) of the total load for the entire watershed. This is consistent with the findings of the 1991 D-F Study, where Emory Pond Brook drainage area accounted for about 26% of the annual phosphorus load (71 kg) in the Sucker Brook watershed.

The majority of the loading may be related to the manure application practices that occur in this watershed. Although both farms have made considerable improvements to their manure storage practices in the last 15 to 20 years, manure spreading s still a typically applied on the nearby hay fields at least a couple times a year. For practical reasons, these applications are generally done in early spring before the growing season and perhaps later in the season as well. The sampling data contained in the D-F Study showed that the greatest increases in phosphorus loading occurred between the Three Brooks station and the Dyers Crossing station, which were only about 0.5 mile apart. The estimated total annual load increased from 88.0 to 185.0 kg between these two stations, representing a 110% increase. Nearly 71% of this annual loading increase occurred in February, April and July. In February alone, there was nearly a seven-fold increase in the measured monthly loading going from 4.2 to 28.9 kg between the two stations. This increase may be due to manure applications on frozen ground and when soils are saturated.

The other potential contribution of phosphorus in pasture areas is when cows or other livestock have direct access to stream and drainage ways where their wastes may enter directly or be washed away into the stream. Up until the fall of 2005, the cows on Hersey Farm have been able to directly access Emory Brook for drinking water purposes in the lower reaches of the Brook near Route 11 and Dyers Crossing Road. In working with the NRCS and DES, the farm owner has installed a new well to provide an alternative drinking water source for the dairy cows and a fence has been installed to keep the cows at least 75 feet from the stream. The new well and fencing should result in a significant decrease in the amount of phosphorus and bacteria that was being conveyed directly to the stream.

The Hersey Farm also utilizes pasture area on the north side of Route 11, along side of Sam Hill Road as the land slopes down to Sucker Brook. The pasture area sits on a moderate slope with till soils that have limited infiltration capacity. There is fence along the lower base of the pasture area that abuts the abandoned railroad bed that is about 75 to 100 feet from Sucker Brook. However, higher up in the pasture area, runoff flows through numerous drainage ditches that flow toward and eventually into Sucker Brook (see adjacent photo). These drainage ways are traversed by the cows and potentially convey nutrients

during major runoff events. The flow from these ditches drains across the railroad bed and into a channel that leads to Sucker Brook (see photo below).

Therefore, even though there is a substantial natural buffer between the pasture area and Sucker Brook, there is still channelized flow form the fields through this buffer into Sucker Brook. Some of this flow originates from Sam Hill Road and is diverted into the fields to minimize the erosive forces that are scouring the roadside ditches. This is generally a good drainage practice as long as nutrients from manure deposits are not also be conveyed to Sucker Brook by these ditches. To divert back into the roadside ditches would require substantial reinforcement with rip-rap stone and widening of the roadside ditches to handle the increased flow. This could be a relatively costly effort perhaps costing as much in $15,000 to $20,000, much of it in rip-rap material. Adding more drainage area and flow to these road side swales is not recommended.

Possible Treatment Measures

One of the possible treatment measures would be to install fencing along the major drainage ditches within pasture fields to keep cows out of drainage ditches. The fencing would parallel these drainage paths leaving a narrow buffer of perhaps of 10 to 15 feet on either side. This would obviously remove a good portion of the pasture area, maybe as much 20 to 30% of the lower field area. Perhaps a portion of the drainage way can be culverted to allow cows to cross over into other parts of the field. The additional fencing is likely to cost in the order of $2,500 to $5,000.

Another major issue that could reap substantial benefits would be to change the timing of manure applications to early part of growing season when grass is initially growing and avoid applying manure during on frozen ground and when soils are wet from seasonal high water table**.** Perhaps there are other application methods that incorporate manure into the soil and make it less vulnerable to wash-off and exposure with runoff. The capital costs associated with new technologies or adding more storage facilities are not readily available and would involve further consultation with experts at NRCS.

Timber Harvesting

Timber harvesting is suspected to be a significant source of phosphorus on a periodic, short-term basis, if the activity causes uncontrolled sediment erosion that allows sediments to be discharged to a lake or a tributary stream. There is very little sampling data directly related to this activity to develop loading estimates. The greatest threat relates to the phosphorus attached to eroded sediments and other organic debris. Loggers are required to employ proper erosion controls and other BMPs to prevent sediments from entering adjacent streams during and even after the timber harvesting activity have been completed.

Approximately 82 % or over 8,800 acres of the Webster Lake watershed consists of forested area. Based on a review of Intent to Cut Notices filed at the local assessor's offices, timber harvesting is carried out on hundreds of acres each year in the Webster Lake watershed. The majority of this activity typically occurs in the Andover portion of the watershed and particularly, in areas associated with Tucker Mountain and Cilley Hill. The extent to which timber harvesting contributes to phosphorus loading is difficult to assess since so much depends on many site-specific factors including the location, duration, size of the cut, time of year, weather conditions, slopes, number of stream crossings, and the types of erosion control measures utilized, to name a few.

Most recently, in May and June of 2006, a major timber harvest operation that extended over 300 acres off of Maple Street and in the Tilton Brook sub-watershed resulted in discharges of highly turbid waters into Highland Lake on several occasions. According to observations by adjacent landowners, the turbidity levels in Tilton Brook as it entered Highland Lake were exceedingly elevated during rain events. Several samples collected by DES personnel showed turbidity readings well above state water quality standards. Elevated turbidity levels are typically associated with total phosphorus concentrations that are an order of magnitude above background conditions, as demonstrated by previous phosphorus sampling by DES in Sucker Brook.

Following an investigation, DES issued a major fine of nearly $40,000 to the logging company for violating to a number of state regulations including not installing proper erosion control measures and other timber harvesting BMPs that would have helped to minimize or prevent the high turbidity discharges into Tilton Brook and eventually Highland Lake. The severity of this fine will certainly send a message to other loggers that proper erosion control and water diversion measures are necessary during timber harvesting activities. Appendix E provides examples of various BMP details that could be included local zoning ordinances forestry practices and based on excerpts from the state of Virginia Forestry BMP Manual.

Even for relatively short duration events (i.e., 24 to 48 hours), elevated levels of phosphorus can represent significant increases in phosphorus loading to the lake. The extent to which the phosphorus becomes available to the water column as the eroded material settles to the lake bottom or is flushed out of the lake is difficult to determine. The lake water quality conditions generally tend to respond to continuous discharges as opposed to periodic short-term discharges. The related organic debris that is discharged to the lake could have secondary adverse effect in increasing the biological oxygen demand during through decomposition process and potentially releasing additional phosphorus form the bottom sediments.

Possible Management Options:

It would appear that the effects of timber harvesting are perhaps limited to periodic and isolated incidences where a less than responsible forester may perform a cut in the watershed or a harvest occurs on particularly difficult land or under usual weather conditions. The primary solution to this problem would to have greater oversight and enforcement capabilities to review, monitor and regulate the timber harvesting activity. This responsibility is currently under the jurisdiction of the NH Department of Resources and Economic Development (DRED), Division of Forestry and Lands. In the discussions and comments received during the various listening sessions held as part of this project, local officials and landowners expressed serious concerns about the lack of sufficient number of foresters in the DRED Division of Forestry and Lands to adequately monitor the number and extent of timber harvesting activity that occurs in this State. Despite the need and expressed desire to have DRED hire more foresters, this situation is not likely to change in the near future. The additional review and site inspections needed will likely fall on the local communities to fulfill, despite even more limited funds and perhaps lack of technical expertise of staff to provide this role.

In addition to site inspections, adding more performance standards for forestry practices in local ordinances, as the City of Franklin has recently completed, will be necessary. The Town of Andover and the City of Franklin should consider pursuing an arrangement where they could hire and share a forester either on a contractual or part-time basis to perform the needed monitoring of the harvesting activity in their area. Perhaps other towns in the area would be interested in pooling resources for this effort. The potential costs associated with this concept will be discussed late in the final draft of this document. Some of the suggested standards that could be included in a Watershed Protection Ordinance include:

- imposing greater restrictions as to when, where and the amount of timber harvesting that can occur within the watershed as well as additional setbacks or no cut zones along stream corridors through local ordinance regulations;
- encourage updating or improving the BMP design guidance for stream crossings, landing areas, etc,
- increasing the extent of temporary and permanent soil stabilization measures;
- impose an additional fee as part of the intent-to-cut application process to fund greater professional oversight of timber harvesting activities through coordination with state agencies, third-party contractual arrangement or local code enforcement personnel.

Shoreline and On-Lake Sources of Phosphorus to Webster Lake

Shoreline Septic Systems

Shoreline septic systems that may be poorly functioning, improperly installed or inadequately sized can be significant sources of phosphorus. Information pertaining to shoreline septic systems around Webster Lake was obtained from previous studies and recent sampling activities. As part of the 1981 Water Quality Investigation for Webster Lake, prepared by Dufresne-Henry, Inc., a survey of shoreline septic systems around Webster Lake was conducted. The general findings of this survey are presented below:

1 There were 147 first-tier systems around Webster lake (lots having direct access to the lake),
2 65% or a total of 77 of the first tier homes were seasonal;
3 Nearly 17% or 29 of the first-tier systems were considered potentially failing because the separation distance from bottom of leach field to seasonal high water table < 2 feet.
4 47 systems were less than 50 feet from the lake and at least 15 systems were within 25 feet of the lake.
5 Approximately 42 systems were located less than 4 feet above the seasonal high water table.

The Dufresne-Henry study estimated that about **71.3 Kg (157 lbs) or roughly 12 % of the total** annual phosphorus **load 618 Kg (1,346 lbs) to Webster Lake was** contributed from shoreline septic systems**.** This load estimate was based on the following assumptions:

- Failing systems pass through 80% of the phosphorus contained in septic effluent (year-round homes had an effluent P conc. of 17 mg/l and seasonal homes had an effluent P conc. of 11 mg/l; the P conc. was lowered to reflect no washing machines).

- Non-failing or properly functioning septic systems pass through only 5% of the phosphorus (i.e., 95% retention of phosphorus in soils) in septic leachate and have an effluent P conc. of 0.11 mg/l, based on the results of soil column testing study conducted by the University of Massachusetts using secondary treated wastewater effluent.

In the end, 85% of the total estimated phosphorus load from septic systems was attributed to 29 homes that were considered to have potentially failing systems. These systems were considered failing because they had less than a 2–foot separation distance from the seasonal high water table based on existing soil mapping. Although this presumption was not verified through any field sampling or lab testing, it is reasonable to expect a less phosphorus retention in soils under these systems given the shorter path and the propensity for soil conditions to be anaerobic near the water table. Eighteen of the 29 homes were considered to be seasonal and the other eleven homes were assumed to be year-round. Eleven (11) year-round homes attributed for the bulk of the phosphorus load or 53.7 kg/yr. Also, distance from to shore was not factored into the loading estimate and could be a significant factor.

NOTE: Current DES subsurface disposal design standards require a separation distance of 4 feet from the bottom of leach field to the seasonal high water table and a horizontal distance of 75 feet from any water body.

Potential Additional Phosphorus Inputs from Seasonal to Year-Round Home Conversions

The septic system survey conducted in the early 1980s as part of the Dufresne-Henry study indicated that, at the time, 64% of the 147 first-tier homes or roughly 94 homes around the lake were used for seasonal purposes only. The other 53 of the 147 first-tier homes were considered year-round. The field survey information also indicated that 70% of the first-tier homes were within 75 feet of the Lake and thus, may have limited ability to meet the more recent DES septic systems design setback of 75 feet if the systems were to be upgraded for year-round use.

Recently, members of the Partnership Group have suggested that there are now many more homes being used for year-round use compared to the 1980s. The difference in phosphorus loading from year-round use as compared to seasonal use can be substantial, especially if the septic system does not meet current design standards. In calculating the phosphorus load from septic systems, the D-H study assumed that water usage increased from 45 to 75 gallons per capita per day (gpcd) going from a seasonal home to a year-round home primarily because washing machines were assumed to be more likely to be available in year-round homes. More importantly, is that there is a considerable difference in the volume of discharge from septic systems used over 365 days versus possibly only 90 days. Using the same assumption (i.e., that nearly 17% of all systems were failing and only 20% of the phosphorus was retained in soils beneath these systems), the D-H study

The D-H study estimated that the annual phosphorus load from septic systems would increase about 170% from 71.3 kg/yr to 192.1 kg/yr, if 54 more homes that are within 75 feet of the lake were converted to year-round use. This added load was estimated to increase the in-lake phosphorus concentration by as much as 4.0 ppb. The load estimate was based on a worst-case analysis by assuming all of these year-round conversions would have potentially failing systems (i.e., only 20% phosphorus retention) because of the limited distance of 75 feet to the lake and, as a result, may or may not be upgraded nor adequately sized to meet current DES standards. Using a more realistic assumption that perhaps 17% of these new 54 year-round systems might fail or not adequately function because of shallow depth to seasonal high water table (similar to the original estimate), then the annual phosphorus load from shoreline septic systems is estimated to increase by about 45 kg/yr for a total load of about 116 kg/yr. This increased phosphorus load could raise the in-lake phosphorus concentration by 1.5 to 2.0 ppb. Ascertaining the number of lake-front homes that are now used for year-round use would be extremely useful in updating the phosphorus load estimate from septic systems. In summary, if the average in-lake phosphorus concentration was estimated to be 0.013 mg/l back in the early 1980s, then it would be appear that the conversion of seasonal homes to year-round use, may have increased in-lake phosphorus concentration to 14.5 to 17.0 mg/l, depending on the number of homes that have been converted, the number of homes that have upgraded their systems, soil conditions and whether or not the loading to these systems have increased.

Based on a review of DES Subsurface System application/approval records over the last 18 years, approximately 60 homeowners along Webster Ave and Lake Shore Ave have applied for DES approval to install a new or upgrade their septic system. The tax map parcels that have received DES approval are shown on Figure 4-3. This data base should be used to continually update the status of various systems around the lake.

Possible Management Options

Some of the possible measures that could be considered:

- Update the previous shoreline septic system survey using GIS data to identify and record changes in usage, system upgrades, distances to the lake.
- Septic System locations should be recorded using GPS positioning equipment.
- The Webster–Highland Lakes Partnership Group should coordinate with DES Subsurface Bureau to host a local workshop to get an update on phosphorus reduction options using the latest septic system technologies.

Potential Phosphorus Reductions from Possible Sewer Extensions

The Dufresne-Henry study provided an assessment of potential phosphorus load reductions if sewer mains were extended around portions of the Webster Lake shoreline. Based on the loading estimate generated in the 1980s, if all the wastewater from the 147 first-tier homes were directed into the Franklin City sewers system this would reduce the phosphorus load by 71.5 kg or 12% of the load. The D-H Study assumed that nearly 17% of the systems were failing because of shallow seasonal high water tables. The STPEL Model produced a load estimate of 91 Kg/yr, with an assumed failure rate of 10% of the systems.

Cost estimates for sewer extensions developed in a recent engineering study (Levy Engineering, Inc, May 2004), indicated that to extend sewer down both sides of the lake (Webster Ave and Lake Ave) would cost about $5,625,000 and would require at least seven (7) pump stations. Assuming 20% of the cost was paid by a DES Grant and a 20-year bond was used to fund the remainder at a 5% interest rate, the annual payment was estimated to be roughly $361,000 to fund this project. Construction costs have increased considerably over the last few years, and, it may be reasonable to add 20 to 30% to this cost estimate that is now two years old. If the amount of phosphorus reduced by extending sewer and eliminating the use of septic systems around the Webster Lake shoreline ranges from the high estimate of 91 Kg/year, the resulting cost per kilogram of phosphorus eliminated could be as much as $75,000, assuming the 2004 estimated project cost has increased by 25% and would now cost about $7,500,000. It is difficult to estimate how many of the existing homes would connect to the sewer even if the upfront connection costs were paid by the City. In addition, extending sewer into new areas can also stimulate new residential growth in the watershed even with the new zoning regulations in place.

Other Phosphorus Sources:

There are number of other human activities that can contribute to phosphorus loading even though on an individual basis these may be generally minor in nature but on an aggregate basis, depending site-specific conditions can have an affect on water quality conditions. Many of these activities fall under the category of providing good stewardship of the lake and the adjacent shoreline property. These activities include the use of lawn fertilizers, management of pet wastes, maintaining vegetation for shoreline stabilization, use of boats at speeds that disturb bottom sediments or create waves that cause shoreline erosion and even the discharge of fireworks and flares, which contain varying levels of phosphorus. These smaller source contributions are not only increasingly important as in-lake phosphorus concentrations approach borderline conditions between oligotrophic and mesotrophic conditions, they are generally the least costly to remediate or eliminate because there is typically no major structural measures or capital costs involved. Although there is very little data available, either site-specific or in the literature, to generate any reasonably accurate phosphorus load estimates for these activities, it is possible that as much as 10 to 20 kg/yr of the existing phosphorus load to the lake could be eliminated through a coordinated, long-term plan of education and outreach program designed to educate and change in human behavior. The education and outreach plan is discussed in greater detail in Chapter 6.0 of this document.

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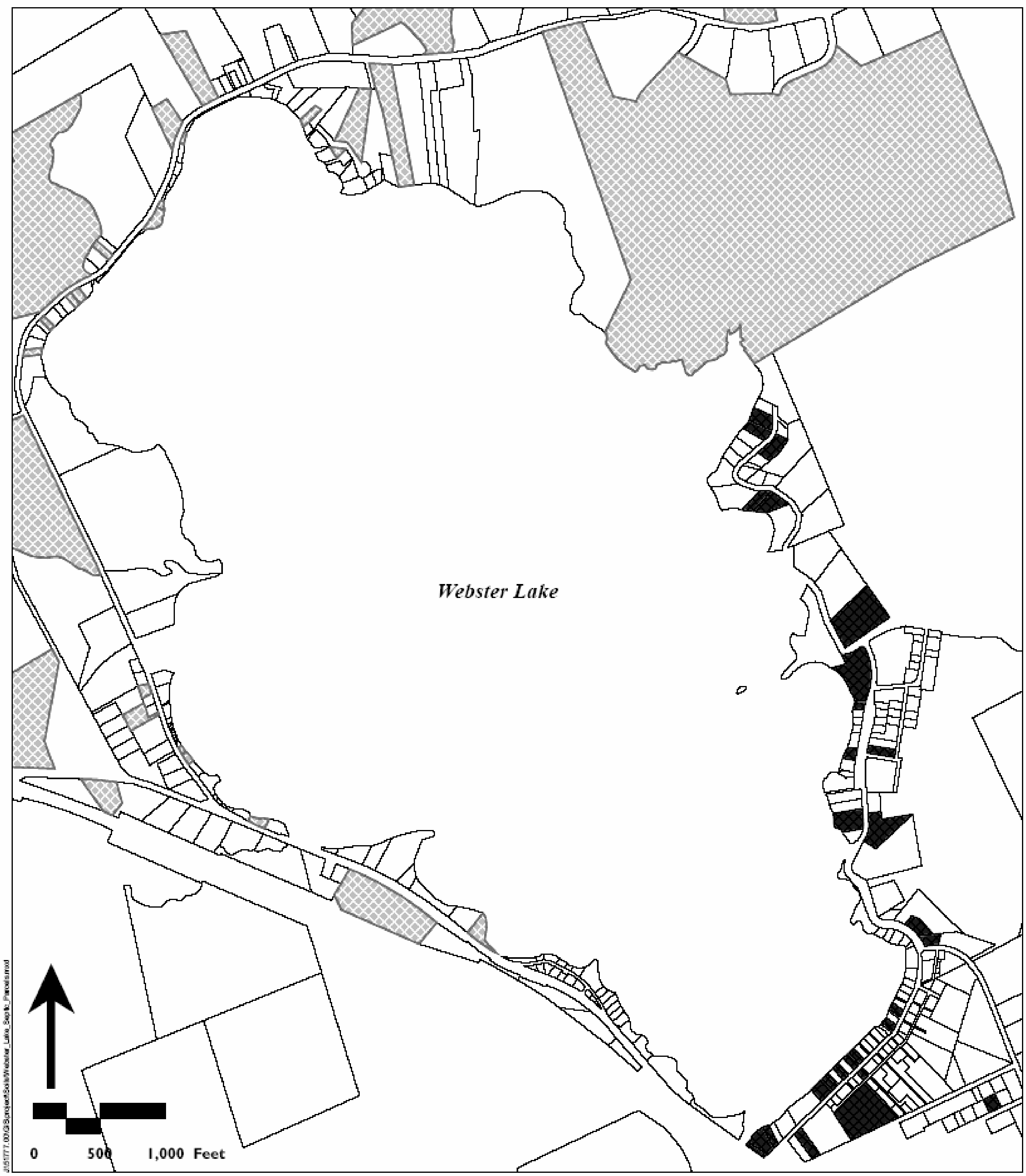

Legend

Parcels Listed in the NHDES Subsurface Septic Records since 1988

- Lakeshore Drive (30)
- Webster Ave (30)

Figure -4-3

DES Subsurface Septic Record Parcels

Franklin
New Hampshire

Vanasse Hangen Brustlin, Inc.

Source: Data from NHDES and the Town of Franklin

5

Summary of Management Objectives and Possible Action Steps

The following section summarizes various management objectives and possible action steps or activities that could be employed to reduce phosphorus loading and improve water quality   These activities are summarized in Table 5.1 for the various source categories and are discussed in detail below.

Watershed Activities and Sources

Residential Growth

Objective: **Limit Future Development Growth to account for no more than 10% of the Watershed Area.**

Action Steps:

1. The Town of Andover should initiate update to their zoning ordinances for the March 2007 Town Meeting while incorporating the findings of the recent Build-Out Analysis completed by the Lakes Region Planning Commission.

2. The Town of Andover should consider incorporating similar standards of the Lake Protection Zoning District Ordinance adopted by the City of Franklin. The Franklin ordinance establishes various performance standards and buffer setbacks for land use activities and minimum lot size and dimensions for residential development. The designated land area would include the Highland Lake watershed and perhaps 3,000 feet of either side of Sucker Brook from Highland Lake to the City of Franklin.

3. Site Plan and Subdivision Regulations should be review and updated as necessary in both communities to insure future development activities include proper Best Management Practices to treat storm water runoff and for erosion control purposes. Third-party engineering review and water quality impact assessments should be required for all projects within the designated lake protection district.

4. The City of Franklin and Town of Andover should collaborate with non-profit land trust organizations and pursue other funding sources to acquire conservation easements or fee-simple land purchases for the remaining large undeveloped parcels around the lakes.

Table 5-1. Summary of Various Management Measures, Potential Removal Efficiencies and Associated Implementation Cost Estimates

Estimated Source Contributions				Implementation						
		Est. Annual P. Load (Kg)				Est. Load Reduction (Kg)				
Source	Location	Low	High	Treatment Measure	Removal Efficiency	Low	High	Cost	Cost Per Kg reduced	Priority
Septic Systems	Webster Lake shoreline	71.5	91	Sewer Extension	50 -100%	36	91	$7,500,000	$ 75 -100 k	Low
		71.5	91	Inspections	variable	na	na	unk	unk	Mod.
		71.5	91	Encourage System Upgrade	variable	To Be Discussed		unk	unk	Mod.
		71.5	91	GPS Survey/GIS Data base	variable	na	na	unk	unk	Mod.
		71.5	91	Educ & Outreach Maintenance	variable	To Be Discussed		unk	unk	Mod.
Road Runoff	Webster Ave	2	5	StormTreat CB Inserts	5-10%	<0.2	0.5	$3,000	$ 5-15 k	Low
	Lake Ave	2	5	Grass Swale	25-40 %	0.5	1.6	$5 -10k	$ 6 -20 k	Low
	Smiling Hill Rd	2	5	Manufactured CB BMP Ex. "StormCeptor™"	25-40 %	0.5	1.6	$10 - 15 k	$ 6 -30 k	Low
	Sam Hill Rd	2	5	Stone Swale Rehabilitation	10-25 %	0.3	1.0	$1.5 -3 k	$1.5 -3 k	Mod
Timber Harvesting	Varies	TBD		Update Local Ordin. to Require BMP Standards and Indepen. Inspections by Forestor	To Be Discussed					
Pasture -Manure Mgt	Emory Pond / Dyers Crossing	65	80	Fencing out drainage ways	10-25 %	6.5	20	$10K	$500-$1,500	High
		65	80	change manure application timing	20 - 40 %	13	32	$ 75 K	$ 2,340 - $ 5,700	High
In-lake Sediment	Webster lake	TBD			To Be Discussed					

The cost estimates represent order of magnitude costs for the device or equipment being proposed and are for planning and discussion purposes only.
* The low P Load estimate generally represent values derived from the empirical data include in the DES D/F Study
# The high estimate was derived from the STEPL model using conservative assumption of a 10% failure rate for septic systems.
**The potential effectiveness of sewer extension depends on whether every homeowner would connect to the sewer if it was available.
The pasture –manure mgt focuses primarily on the Emory Pond Area. The removal estimates are based on limited to no data and could be higher or lower.

Pasture and Manure Management

Objective: **Minimize Phosphorus Loading from Livestock Feeding Areas and Manure Storage Facilities and Manure Fertilized Fields.**

Action Steps:

1. Continue to work with the NRCS and the Hersey Farm and Shaw Farm owners to install additional fencing along drainage ditches within pasture areas and, at a minimum, along the lower 500 feet of any swale or channel that drains to Sucker Brook or its tributaries. Specific locations would include the lower fields on the east side of Sam Hill Road and the lower portions of the pasture areas on the south side of Route 11 and west of Emory Pond Brook.

2. Incorporate buffer setbacks in local ordinances for manure applications.

3. Coordinate with farm owners to work with NRCS to develop a manure management plan that encourages use of the latest manure applications technologies and schedule applications during the growing season when vegetation is well established. The Management Plan will coordinate storage needs with application timing, rates and rotation of appropriate spreading areas.

4. Identify and work with other property owners that have small livestock pens and horse stables to insure proper management of wastes and use of vegetative buffers to reduce the potential wash off, conveyance and discharge of manure wastes into nearby streams and drainage channels.

5. Encourage possible composting of manure through mixing yard waste and/or other organic material to assist in moisture control and vector management.

Timber Harvesting

Objective: **Limit The Amount Of Potential Phosphorus And Sediment Contributions From Timber Harvesting Activities That Occurs Within the Watershed.**

Action Steps:

1. Increase the Amount of Oversight and Inspection Frequency for Timber harvest activities through greater coordination with NH DRED Division of Forests and Lands Personnel.

2. Coordinate and discuss with other community officials the possibility of sharing independent Forester to provide the added inspection and enforcement of performance standards and the use of BMPs to control erosion and nutrient loss.

3. The Town of Andover should consider adopting a Watershed Protection Ordinance to establish various performance standards for forestry practices and other activities that would increase setback requirements, riparian corridors, BMP Implementation, and require timber management plans for major harvests that would include incremental phasing, review and inspection reporting and contingency planning for unusual weather events.

4. Consult and coordinate with the DRED Division of Forestry and Lands and DES representatives to discuss the need for a regional or statewide workshop to update foresters and local officials on proper BMPs, new technologies and the need for requiring licensed foresters for all harvesting of a certain size or within a sensitive resource area.

Road Runoff

Objective:

Identify and Implement Appropriate Measures to Treat Roadway Runoff in Several Key Locations to Reduce Phosphorus and Sediment Loading from Roadway Surfaces

Action Steps:

1. Coordinate with the VLAP program to collect samples as part of the tributary monitoring from the culvert across Webster Ave near Griffen Beach and former public boat launch to acquire phosphorus concentration data for this discharge.

2. Stabilize roadside swale along Smiling Hill Road near Griffen Beach using rip-rap stone and install stone check dams to reduce flow velocity. Rip-lap lining would be similar to that installed in roadside swales along Route 11. Rip-rap should be placed all the way down the lake in main channel with some vegetation shrub-type plantings along lake shoreline and swale banks.

3. Seek additional funding through 319 Grant Program to fund installation pervious pavers within the lower Griffen Beach parking area near the lake.

4. Investigate the possibility of creating a grass swale along Lake Ave within power line easement to treat roadway runoff. May need to conduct topographic survey to along Lake Ave to determine the drainage area and appropriate outlet location of the swale

5. Coordinate with the Town of Andover to investigate possible cost-sharing and/or providing in-kind services to stabilize and reinforce side-slopes in roadside swales along base of Sam Hill Road and Hoyt Road to reduce sediment erosion during large storm events.

Shoreline Activities and On-Lake Activities

Shoreline Septic Systems

Objective: **Develop a Septic System Management Plan that Would Maintain an Up to Date Inventory of all Shoreline Septic Systems and Identifies Problem Areas, Outline Maintenance Schedules and Replacement/ Upgrade Approvals.**

Action Steps:

1. Recreate a homeowner survey to update the inventory of exiting septic system survey information to improve data base that tracks DES approval dates, construction dates, types of systems, soils data, seasonal vs. year round usage, etc.

2. Using GPS equipment, locate each septic system and adjacent resource area. Survey data would then be linked to GIS Tax Map parcel layer to display relevant information.

3. Coordinate with DES and perhaps various septic system vendors to host a technology demonstration workshop at the lake.

4. Consult with DES and septic system vendors to initiate a demonstration project to compare phosphorus removal efficiencies through actual sampling of installed systems using advance treatment versus conventional systems.

5. Update Watershed Protection Ordinance to require an onsite inspection by a licensed septic designer for all new additions requiring a building permit or for any real estate transaction.

6. The Lake Association and City personnel should establish incentives to conduct regular tank pump-outs through either reimbursements or volume discounts with septic tank contractors. This not only encourages the practice but may enable tracking as to how often it is being done.

Education and Outreach

Objective: **Provide A Long-Term Education And Outreach Plan That Continues To Educate And Update Shoreline Homeowners, Lake Users And Other Stake Holders About The Benefits Of Good Stewardship On The Lake And Surrounding Lands.**

Action Steps:

1. Develop and constantly update website to enable homeowners to educate themselves through posted material and links to other relevant websites.

2. The Lake Association and City personnel should coordinate and host annual workshops to invite key professionals and/or vendors to update shoreline home owners on the latest technologies for various issues.

3. Collaborate with DES and local schools and universities to promote and encourage students to conduct special environmental investigations regarding various aspects of the lake.

4. The Lake Association should coordinate to develop appropriate signage to promote headway speeds along shoreline areas and discourage the discharge of any material from boats:

5. The Lake Association and City personnel should post signs to encourage cleanup of pet wastes and discourage feeding of waterfowl.

6. The Lake Association and City personnel should adopt the Education and Outreach Plan contained in Section 6.0 and secure additional funds to retain the services of an Education and Outreach coordinator on a contractual basis.

6

Education and Outreach Plan

"How lovely to think that no one need wait a moment. We can start now, start slowly changing the world."
—Anne Frank

Introduction, Purpose, and Approach

The Partnership has identified several activities that may be harmful to the water quality in the watershed. The Partners have an opportunity to work together to implement at the local level recommendations and activities that will improve water quality.
The Associations' website as well as that of the Partnership, http://www.webster-highlandlakespartnership.org, are tools to disseminate information and resources. However, the Partnership should consider employing other and more direct strategies such as community based social marketing (CBSM) principles to foster sustainable behavior.

Community based social marketing relies on the principle that behavior change is best sustained when stakeholders are contacted directly to learn about their feelings and values. The resulting insight is used to determine where barriers to behaviors exist and to work with individuals and groups to remove the impediments and add incentives. Removing as many barriers or impediments as possible and providing incentives is more effective than passively offering information. For example, despite years of physicians and public health officials consistently and pervasively disseminating the message that smoking causes cancer, emphysema, and other illnesses, people still begin smoking, continue to smoke, or fail to quit. Disseminating information has not changed these individuals' behaviors. However, some studies have shown that when tobacco prices or taxes increase, some smokers will quit.

Steps to applying community based social marketing principles include conducting a search for and review of existing literature, qualitative research, observational studies, focus groups, and surveys (both pre- and post-campaign). An excellent resource for this approach is the book *Fostering Sustainable Behavior* by Doug McKenzie-Mohr and William Smith (cbsm.com). ToolsofChange.org offers additional resources.

The purpose of this plan is to introduce active vs. passive outreach strategies that include direct contact with watershed residents and stakeholders and incorporate community based social marketing principles:

Residential Land Use and Management

- The Webster Lake Association and the Highland Lake Association should provide information to their respective memberships. The Partnership website could be a repository for information and materials that are transferable throughout the watershed with each Lake Association website linking to it.
- Outreach activities
- Create demonstration site with a green lawn and adequate buffer that allows for a view while providing privacy, shade, and a lovely framed perspective of the lake or stream.
- Work with local suppliers to stock soil testing kits and lower-impact fertilizers and provide coupons and directories for "where to buy."
- Invite a nursery or landscaping firm conversant in and supportive of native plantings and vegetated buffers to make a presentation.
- Invite stakeholders to a picnic at a demonstration site.
- Have neighborhood district or area representatives visit landowners (who participated or didn't participate in the demonstration picnic) with where to buy directories and coupons as a follow-up and to assure that everyone receives the information and incentives.
- Follow-up with landowners to find out if they implemented buffer plantings and if not, why.

Other Land Use and Management

- Logging and farming are land uses that can promote open space, minimize impervious surfaces, and provide a cultural and element that is essential to rural life. Those operations that area challenged by hydrology, ledge, and steep slopes can contribute to nutrient loading and the introduction into the watershed of other substances harmful to water quality.
- Outreach activity
- Provide loggers with NH Department of Resources and Economic Development Best Management Practice manuals when applying for intents to cut. Post and publicize these resources on the Partnership, Lake Associations, and City and Town websites.
- Identify foresters and loggers who would act as harvesting neighborhood district or area representatives. These representatives would receive notice from the City and Town when an intent to cut is filed and would make a field visit to the harvest site to share BMP manuals, fact sheets, and offer assistance and resources. A similar approach should be applied to agricultural operations. Because permits are not required for ongoing agrarian activities, the visits should be made on an ad-hoc basis.
- The Partnership and its member's lake associations and city and town should consider recognizing exemplary operations as demonstration sites and bestow an annual award that is well publicized through out the region. The Partnership could invite State Senators and House Representatives along with municipal officials.

Shoreline Septic Systems

Properly designed and maintained septic systems can help preserve water quality. Most homeowners are not aware of their own septic system's age, condition, or maintenance record. For many homeowners, their first knowledge of their own systems is when there is a failure. Some "work around" failures causing harm to their own health and that of others.

Outreach Activities

- The Partnership should review the Granite State Designers and Installers Association *Septic System Recordkeeping File and Owner's Guide*. This tabbed file folder contains information about system maintenance as well as a form to document septic design, location, and maintenance records. Because this folder was produced with public funds, it may be duplicated without copyright infringement.
- The Partnership may wish to revise and customize the produce a bulk quantity. The Partnership could solicit and negotiate from haulers and maintenance firms incentive coupons that could be included with the folder. Those firms providing coupons could be listed on a directory handout also included in the file.
- Direct distribution is important. Partnership representatives should include the folder in "Welcome Wagon" packages and at City and Town offices where permit applications are distributed.
- The Partnership's City and Town and Lake Association staff and volunteers should consider delineating areas in the watershed where someone is a local neighborhood district or area contact. Not only would this representative be available for questions and to provide referrals to resources but also he/she would commit to visiting each house in that districts or area, introducing his/herself, and providing the septic folder and resources.

Recreation

Fast-moving boat traffic may contribute to phosphorus and other nutrients being introduced in the water column where they can facilitate algal blooms. Because it isn't likely that the current NH Department of Safety (NHDOS) process for applying no-wake zones and speed limits will consider most environmental issues, the Partnership may wish to focus its efforts on gaining compliance for the current no-wake within 150 feet of shore regulation

Outreach Activities

- The Partnership should contact NHDOS Marine Patrol to determine if additional personnel can be present on the lakes.
- The Partnership may be able to work with NHDOS Marine Patrol on recruiting additional Auxiliary personnel.
- Volunteers can work with residents and visitors (at the access points) to provide information and speak with them about their lake use and habits. If possible, contact information can be gathered for future surveys and focus groups.

Fireworks

Some studies have shown that the materials contained in the wrapper material around fireworks can contribute to nutrients in lakes and streams. Others suspect that there may be trace levels of heavy metals in the fireworks that can be released into water bodies when they are detonated over them. These materials can introduce nutrients and/or other materials harmful to water quality and human and wildlife life. The noise, odors, and light can be disruptive to wildlife.

Outreach Activities

- Designate one evening for Independence Day fireworks and encourage through publicity everyone's participation on that one date.
- Investigate finding receptacles that can effectively circumvent the debris going into the lake. If possible, customize the receptacle with a message and distribute using the neighborhood district or area strategy.
- Use this neighborly one-on-one opportunity to learn about fireworks detonation habits and explore with the individuals their willingness to contribute to a single and central display where pollutants can be controlled and minimized.

The Partnership as a Clearinghouse

Although the Partnership should strive for behavior change, providing information, resources, and referrals are still important first steps toward awareness and then change. The Partnership should provide on its Webster-HighlandLakesPartnership.org website a page where resources and documents can be posted or links to them can be posted. This includes links to other organizations that have good resources on their websites including state and federal agencies; state-level associations; local lake and watershed associations; and private industry such as nurseries, landscaping, and septic maintenance and hauler firms.

7

Summary of Recommended Measures to Improve Water Quality

Table 7-1 provides a listing of the various recommended measures to reduce the pollutant contributions from identified sources.. In addition, a general assessment of the priority is also provided based primarily on the relative source contribution and cost–effectiveness of the treatment measure.

These measures were selected based on their estimated cost-effectiveness, their estimated relative contribution to the decline in lake water quality, the availability of resources and the general assessment of the difficulty in implementation. The associated cost estimates are very preliminary and would require further investigations to develop more accurate estimates.

Table 7.1 - Summary of Recommended Measures		
Description of Measure	**Targeted Implementation**	**Estimated Cost***
1.0 Develop a Septic System Management Plan -On ground Property Owner Survey -GPS system locations -Develop GIS data base w/system data, location, soils data, maintenance schedule -Contact local septic haulers to develop pump-out discounts	June- Nov 2007	**$5,000**
2.0 Investigate possible cost-sharing with Andover and other towns to fund the services of an on-call Forester to monitor and inspect timber harvesting operations in the area	Immediate	TBD
3.0 Fund/Contract a Part-Time Watershed Coordinator provide Laison b/wn Andover and Franklin - Coordinate zoning updates, build-out analyses, etc. - Coordinate/update education and outreach efforts for shoreline - Provide consultation to interested property owners for suggestions on drainage and landscaping measures (i.e. rain gardens for roof drains, driveway runoff, etc). owners and other stakeholders	May 2007– Sept 2008	**$12,500**
4.0 Stabilize/Improve Roadside Swales Along Smiling Hill Rd	July–Aug. 2007	**$3,000**
5.0 Seek Section 319 funds to Improve/Stabilize Swales along Sam Hill Road and Hoyt Road in Andover Install pervious pavers for Griffen Beach Parking Lot	Sept. 2007	TBD
6.0 Coordinate with NRCS to assess need for additional fencing or culverts to isolate drainage ways from pasture areas and manure spreading areas	Spring 2007	TBD
7.0 Provide/Subsidize Use of Rain Barrels to reduce roof runoff for Shoreline Property Owners	Spring 2007	$2,500
* Cost estimates are preliminary rough estimates		

8

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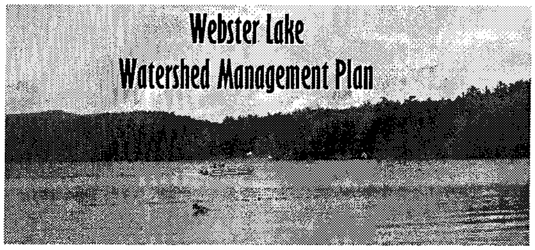
Appendix A
Public Meeting
Slide Presentations



June 27, 2006

Vanasse Hangen Brustlin, Inc.
Hutchins Consulting Services
Naturesource Communications

Study Objectives

- Identify Causes for Lake Water Quality Decline.
- Identify Feasible Measures to Improve and/or Prevent Further Degradation in Lake Water Quality.
- Increase Awareness and Educate Stakeholders on How Human Activities Can Affect Lake Water Quality.

Step-Wise Approach

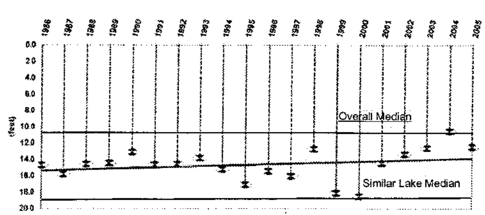
- Encourage and Listen to Public Input
- Identify Primary Water Quality Concerns
- Develop Specific Goals for Improvement
- Identify Possible Measures and Assess Potential Improvement
- Develop an Implementation Plan for Most Cost-Effective Solutions
- Outline a Monitoring to Measure Effectiveness

Signs of Water Quality Decline

- Lower Transparency (trending from 12 to 14 feet to 10 to 12 feet).
- Increased Abundance of Blue-Green Algae
- Increased Turbidity and Bacteria Readings in certain tributaries.
- Prevailing Low Dissolved Oxygen Levels at Depth.

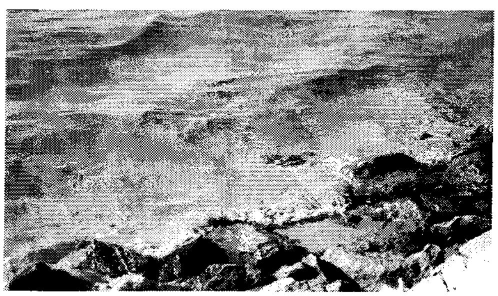
Historical Webster Lake Transparency Data

(Secchi Disk Depth in Feet)

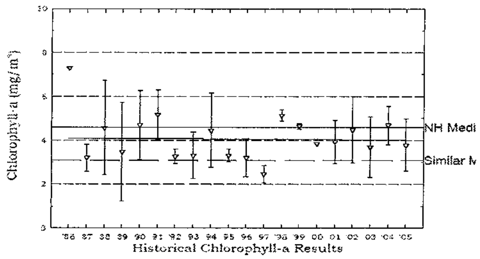


Source: 2005 VLAP Annual Rpt

Cyanobacteria

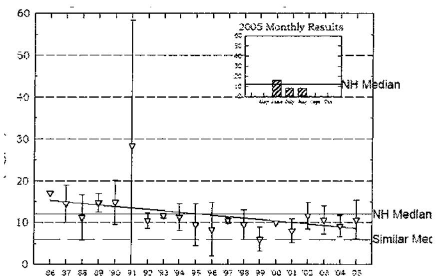


Historical Chlorophyll-a Concentration Data



Historical Phosphorus Data

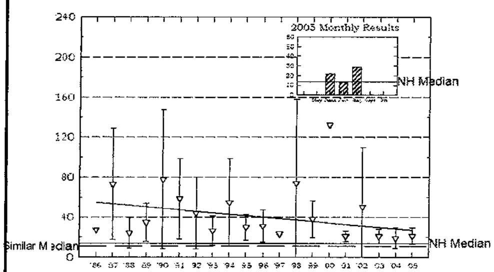
Epilimnion



Source: 2005 VLAP Annual Rpt

Historical Phosphorus Data

Hypolimnion

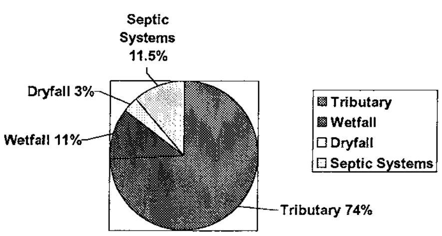


Source: 2005 VLAP Annual Rpt

Keys to a Successful Watershed Management Plan ?

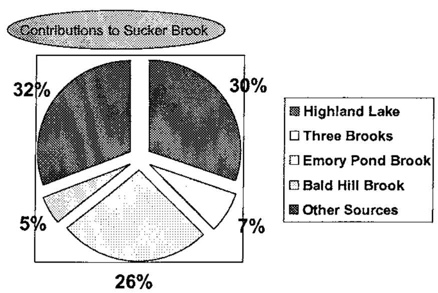
- Local **Stakeholder Involvement** and Support
- **Scientific Understanding** of the Lake Responses to Watershed Inputs and In-Lake Activities
- **Feasible Recommendations** Based on Existing Lake Data and Engineering Expertise

Approx. 74% of Annual Phosphorus Load to Lake is from Tributary Inflow



Source: 1990 DES Diagnostic Study

Approx. 81% of Annual Phosphorus Load From Tributaries is from Sucker Brook



Source: 1990 DES Diagnostic Study

Additional Sampling Activities in 2006

- Stormwater Sampling in Sucker Brook at Key Locations
- Additional Phosphorus Sampling at Lower Depths
- Shoreline Conductivity Survey
- More Frequent Monitoring of Algal Blooms
- In-lake Monitoring During Weekend Activity

Possible Areas of Focus

- Stormwater BMPs
  - Gravel Roads (ID key locations for grassed swales, level spreaders, diversion berms, etc).
- Review/Update Land Use Zoning and Site Plan Requirements
  - Riparian Corridors
  - Erosion Control Plans/Review
- Education & Outreach –
  - Benefits of Septic System Maintenance
  - Pet Waste Disposal

Roadside Ditches

Lake Ave Drainage

Flow Diverted Across Webster Ave

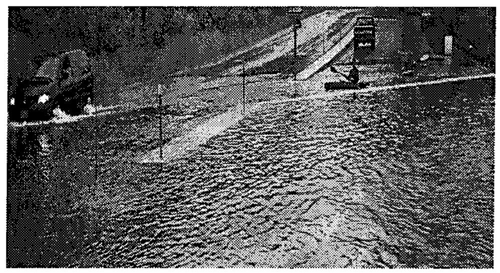
Lake Shore Rd Bridge

Riparian Buffers

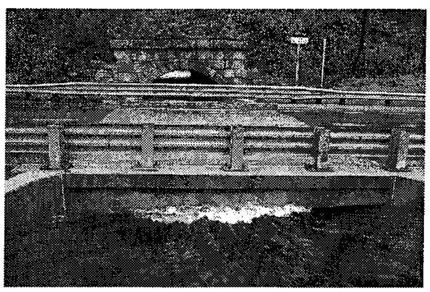
May Flood –Sucker Brook

May Floods

Where the Kayaks Meet the Road



Lake outlet



Webster - Highland Lake Watershed Management Plan

July 18, 2006

Vanasse Hangen Brustlin, Inc.
Hutchins Consulting Services
naturesource communications

Study Objectives

- Identify causes for lake water quality decline
- Identify feasible measures to improve and/or prevent further degradation in lake water quality
- Increase awareness and inform stakeholders on how human activities can affect lake water quality

Step-Wise Approach

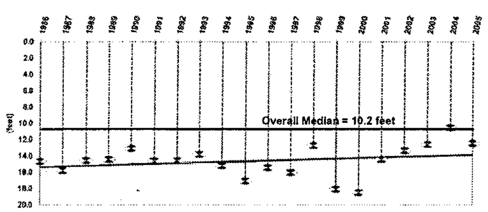
- Encourage and listen to public input
- Identify water quality primary concerns
- Develop specific goals for improvement
- Identify possible measures and assess potential improvement
- Develop an implementation plan for most cost-effective solutions
- Draft and implement an outreach strategy for sustainable results
- Outline a monitoring plan to measure effectiveness

Signs of Water Quality Decline in Webster Lake

- Lower transparency (trending from 12 to 14 feet to 10 to 12 feet).
- Increased abundance of blue-green algae
- Increased turbidity and bacteria readings in certain tributaries.
- Prevailing low dissolved oxygen levels at depth.

Historical Webster Lake Transparency Data

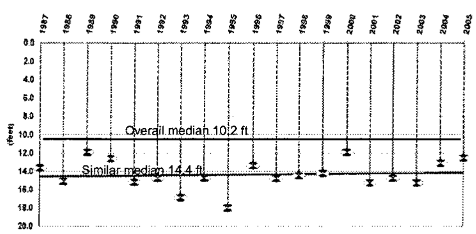
(Secchi Disk Depth in Feet)



Source: 2005 VLAP Annual Rpt

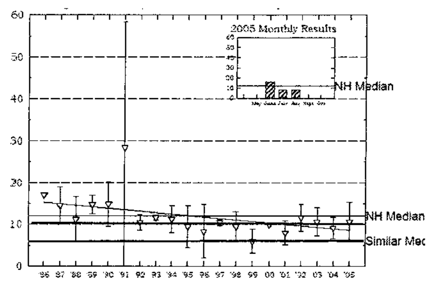
Historical Highland Lake Transparency Data

(Secchi Disk Depth in Feet)



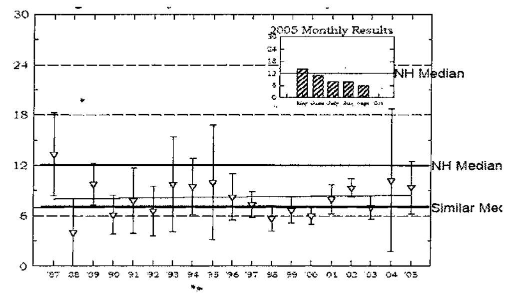
Source: 2005 VLAP Annual Rpt

Webster Lake Phosphorus Data
Epilimnion



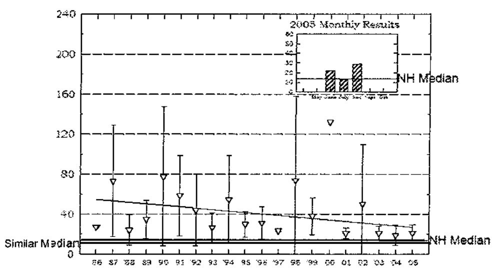
Source: 2005 VLAP Annual Report

Highland Lake Phosphorus Data
Epilimnion



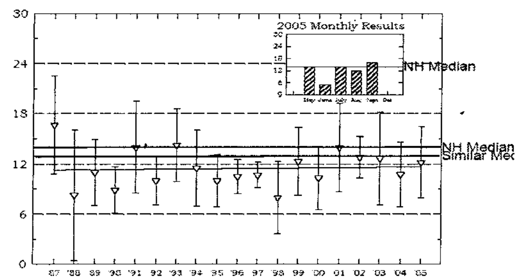
Source: 2005 VLAP Annual Report

Webster Lake Phosphorus Data
Hypolimnion



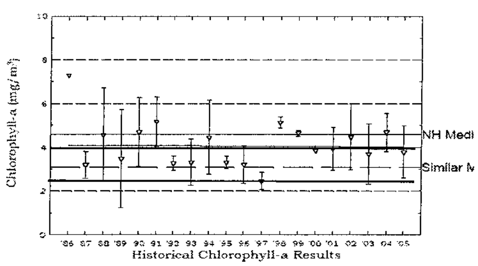
Source: 2005 VLAP Annual Report

Highland Lake Phosphorus Data
Hypolimnion

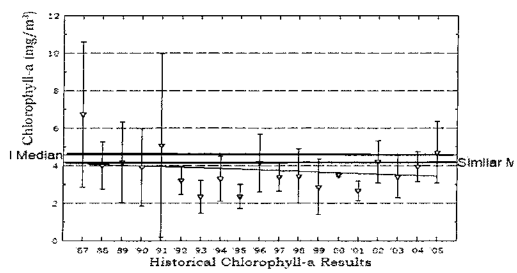


Source: 2005 VLAP Annual Report

Webster Lake Chlorophyll-a Concentration Data



Highland Lake Chlorophyll *a* Data

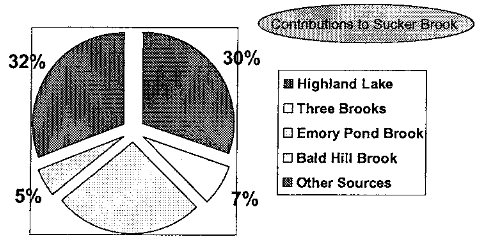


Source: 2005 VLAP Annual Report

Keys to a Successful Watershed Management Plan

- Local **Stakeholder Involvement** and support
- **Scientific Understanding** of the lake responses to watershed inputs and in-lake activities
- **Feasible Recommendations** based on existing lake data and engineering expertise

Approx. 81% of Annual Phosphorus Load From Tributaries is from Sucker Brook

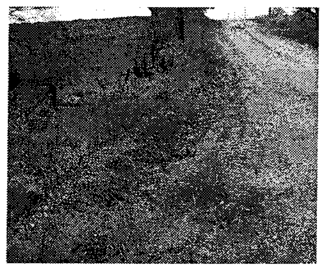


Source: 1990 DES Diagnostic Study

Possible Areas of Focus

- Stormwater BMPs
  - Gravel roads (ID key locations for grassed swales, level spreaders, diversion berms, etc).
- Review/update land use zoning and site plan requirements
  - Riparian corridors
  - Erosion control plans
- Education and outreach
  - Benefits of septic system maintenance and
  - Pet waste proper disposal

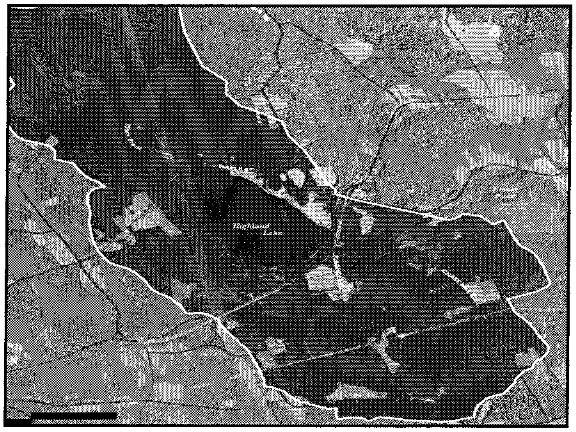
Roadside Ditches



Riparian Buffers

Timber Harvesting – turbidity

Floatable Debris and Turbidity



Your listening session

- Please share
  - Your thoughts on the proposed Plan
  - Your local observations
  - What you would like the Plan to address

Visit

webster-highlandlakespartnership.org

Appendix B Interim Interpretative Data Summary Report

Report 1: Water Quality Management Investigation; "Dufresne-Henry Report." 1981.

General Description: First major study of Webster Lake (precursor to the 1990 Diagnostic/ Feasibility Study; Tasks performed include; monthly and weekly water quality sampling in tributaries; flow measurements; lake sampling; lake bathymetry measurements; subwatershed delineation, land use inventory, sanitary survey of shoreline septic systems; determination of phosphorus budget; estimates of potential phosphorus reductions for several management alternatives (See Below).

Management Alternatives Evaluated

1. Sewering shoreline homes along Webster Ave and Lake Shore Ave,
2. Diverting 30 and 60 % of spring time flow from Sucker Brook to below lake outlet.
3. Use of sedimentation basins to reduce phosphorus concentrations in Sucker Brook during spring time flow (Mar-May).

DATA COLLECTED

Sampling Data

- Ave. P conc. in tribs. ranged from 0.005 to 0.043 mg/l; highest in Sucker Brk;
- Sucker Brook had an ave P conc. of 0.019 mg/l; peak conc. of 0.061 mg/l,
- Ave P conc. in precipitation was 0.026 mg/l; median of 0.015 mg/l based on 33 samples collected from 1973 to 1980,
- In-lake surface P conc. averaged 0.011 mg/l; with an ave of 0.016 mg/l over entire water column and a high of 0.142 mg/l in hypolimnion (12 meters).

Septic System Data

- In 1980, 96 of the 147 first-tier homes (lake frontage) and 30 of the 2nd tier homes were surveyed,
- 50% of surveyed systems were 10 to 20 yrs old,
- Nearly 50% of the 96 1st tier systems were w/in 50 feet of lake,
- Approx. 57 of the 1st tier homes were seasonal; 31 were year-round,
- Two systems had actual breakout observed and were failing,
- Sixteen systems were < 2 ft above water table.
- !5 systems along Webster Ave were < 25 ft from lake; 26 were < 50 ft from lake,
- 12 systems along Webster Ave were < 2 ft above water table,
- 3 systems consisted of cesspools.

Estimated Phosphorus Impact From Future Year –Round Conversions

- The P load was estimated to increase by 192.1 Kg or roughly 31 % if the 54 seasonal homes within 75 ft of lake were converted to year-round use.

- Septic system P load from the then 176 1st tier homes was 71.3 Kg based on an assumed Phosphorus concentration of 0.011 mg/l/person for seasonal and 0.017 mg/l/person for year-round (diff being washing machines in yr homes).

RELEVANT RESULTS

Phosphorus Budget

- Existing Annual Phosphorus Load to lake = 618.5 Kg (normal precipitation year);, Annual load of 618.5 Kg translates to ave. in-lake P conc of 0.013 mg/l.; based on Vollenweider Equation
- Breakdown of Ave. Annual Phosphorus Sources
    - 74 % comes from watershed (tribs. & unsampled sources)
    - Sucker Brook; 52 % of total; 63% of watershed portion,
    - Shoreline septic systems; 12% of total,
    - atmospheric deposition (wet and dry); 14 % of total

Findings of Alternatives Evaluation

- Analysis concludes that sewering all 147 1st tier homes would reduce P load to lake by 71.3 Kg (12% total) and reduce in-lake P conc. by 1 to 2 ppb to 12 ug/l or 0.012 mg/l. (could be more if > 64% homes are now YR use).
- Sewering 43 homes along Webster Ave from Rte 11 to Griffin Beach would reduce P Load by 20.8 Kg and would produce in-lake P conc. of 0.013 mg/l (no measurable effect and also depends on # of homes & 64% YR homes).
- Sewering 37 homes along Lake Shore Drive and North Shore Rd could reduce P load by 17.9 Kg and produce an in-lake P conc. of 0.013 mg/l (same assumptions and limitations as above).
- Diversion of 30 and 60 % of Sucker Brook flow during March, April, and May could reduce P Load by 96.1 and 192.0 Kg, respectively, and would result in estimated in-lake P conc. of 0.013 and 0.012 mg/l, respectively. (P conc. did not drop as much because retention time is also changed)
- Treating 30 and 60 % of Sucker Brk flow with sedimentation basins was estimated to reduce P load by 56.9 and 113.8 Kg (assume 40% removal) and would drop estimated in-lake P conc. to 0.012 and 0.011 mg/l, respectively. (assumes an average P conc of 0.027 mg/l in Sucker Brk during spring months). (not a feasible option – sediment basins would have to be > 5 acres).
- Study also predicted a possible major increase in phosphorus loading (192 Kg or roughly 31% increase), if the 54 remaining seasonal homes within 75 feet of the lake are converted to YR use without upgrading septic system.

Items that need further Review:

- Assumed P concentration of 17 mg/l per person in septic effluent
- Number and percentage of 1st tier homes that are seasonal vs year-round use – number of upgrades
- Whether there are homes still using cesspools
- Review and ID areas where homes/septic are w/in 2 ft of groundwater table.
- Obtain in-lake P sampling data described on page 37.
- Review future population estimates, land-use breakdown and rough build-out analysis on pages 3 to 17 and especially Table 7 on page 17.

Interpretation of Findings: Developed an average annual phosphorus loading estimate of 618 Kg per year based on tributary sampling data, which translates into average annual in-lake phosphorus concentration of 0.013 mg/l, which compares favorably with the observed average phosphorus concentration of 0.014 mg/l in the epilimnion, based on sampling data from 1986 to

1988. Study suggests 74% of the phosphorus was due to tributary inputs, 14% due to atmospheric or "Bulk" precipitation and 12% due to septic systems. Several management alternatives were evaluated including extending sewer to shoreline homes, diversion of Sucker Brook flow to the lake outlet during spring months and treatment of Sucker Brook via settling ponds during spring runoff. Diverting or treating 60% of the Sucker Brook flow through sedimentation basins during March to May was the alternative that showed the greatest potential reduction in the in-lake phosphorus concentration by roughly 0.002 mg/l. This study authors suggested that the amount of phosphorus contributed from bottom sediments was considered relatively minor because the anoxic portion of the hypolimnion was estimated to be about 2 % of the total lake volume.

The study authors conclude "that the most reasonable long-term goal, in terms of lake and watershed management, is to try to slow the trend toward eutrophication. It is questionable whether any restoration actions to improve in-lake water quality (such as dredging, nutrient inactivation, etc.) would be cost- effective. Preservation of the existing lake conditions via implementation of comprehensive phosphorus control measures in the watershed and near shore area would be a more realistic goal."

Report 2) Webster Lake Diagnostic / Feasibility Study, NH Department of Environmental Services, prepared in 1990.

General Description: As the study title indicates, there were two distinct portions of this study: one providing a diagnostic assessment of the lake water quality and watershed conditions and the other involves a feasibility assessment of various restoration/management alternatives. The diagnostic study focused on improving the phosphorus budget analyses, particularly for the Sucker Brook watershed, initially developed as part of the 1981 Dufresne-Henry study. The study confirmed that Sucker Brook watershed was a major source of phosphorus contributing about 63% (391 Kg) of the estimated 618 Kg of phosphorus entering Webster Lake on annual basis. Other lake tributaries accounted for another 11 %, septic systems contributed 12 % and atmospheric deposition accounted for another 14% of the total load. Additional details concerning Sucker Brook phosphorus sources are discussed below:

Management Alternatives Evaluated
This study evaluated the feasibility of several in-lake management / restoration alternatives. These included in-lake algal treatments as well as artificial circulation, hypolimnetic aeration, sediment removal and alum treatments.

Sucker Brook Phosphorus Sources
To gain a better understanding of the sources of phosphorus in Sucker Brook watershed, bi-weekly water quality sampling and stream flow measurements were conducted at 12 locations including 5 stations within Sucker Brook, four tributaries to Sucker Brook and three seasonal or intermittent streams. The following table summarizes the results of the phosphorus sampling;

Table 1.0 –Summary of Tributary Loads to Sucker Brook

Source	Annual Load (Kg)	Percent of total	April Load (Kg)	Percent of Annual
Highland Lk outlet**	81.0	31.0	19.0	23.0
Cilley Hill Brook	5.1	2.0	1.5	29.0
Emory Pnd Brk	69.5	26.0	30.5	44.0
Bald Hill Brk	13.8	5.2	2.7	19.5
Apple Farm Brk	2.9	1.1	1.1	38.0
Sucker Brook outlet**	265.0	100.0	124.5	47.0

The summary of phosphorus sources in the Sucker Brook watershed shows that the Highland lake outlet and the Emory Pond Brook watershed account for 31.0 and 26 % of the total phosphorus load from Sucker Brook, respectively, and represent two of the largest contributors. Unmonitored sources or direct runoff to the brook represented another major source accounting for another 28 % (74 Kg) of the total phosphorus from Sucker Brook. The unmonitored sources were determined based on the difference between the amount measured at the Sucker Brook outlet and that measured from all other sources. The other three streams accounted for less than 10 % total annual contributions from Sucker Brook.

Nearly half or roughly 47 % of the total phosphorus contribution from Sucker Brook occurred during the month of April. More than 90 percent of the unmonitored source contribution occurred during the month of April. The percentage contributed during April was much smaller in the more forested or less developed watersheds of Cilley Hill Brook and Bald Hill Brook. This would suggest that amount of disturbed soil and/or increased runoff due to impervious surfaces are important factors in contributing to phosphorus load during the Spring season.

The other significant finding of DES' Sucker Brook watershed investigation is that the largest observed increase in phosphorus loads occurred between the Three Brooks station and the Dyers Crossing station where the annual phosphorus load jumped from 88.0 to 185.0 Kg. About 80 % of this increase occurred during the months of February, April, May and July with the largest monthly increase occurring during the month of February. These major increases could be related to large runoff or snowmelt events or could be due to certain land use activities or disturbances that occurred during these months such as manure spreading on agricultural fields, timber harvesting or both.

In addition, a limited predictive modeling procedure was conducted to assess the lake's capacity to accept additional phosphorus from future development. The results indicated that the average chlorophyll *a* concentration would likely increase from 5.0 mg/m^3 to 6.0 mg/m^3 if 67 additional homes were built in the watershed. A 1.0 mg/m^3 increase in chlorophyll *a* increase can reduce water clarity or transparency by 1.5 feet.

Study 3: Recent NHDES Sucker Brook Sampling for *E. coli* bacteria 2004-2005

General Description: NHDES conducted a nine sampling events during the course of 2004 and 2005 to try identify bacteria sources (*E. coli*) within the Sucker Brook watershed. There is no report associated with this investigation, the following is an interpretative summary of the salient findings gleaned from the sampling results provided in an Excel spreadsheet and a map of the sampling stations, provided by Andy Chapman of the NHDES Watershed Management Bureau.

Sampling Approach;
In 2004, 7 events were conducted on May 13, June 25, 29 and 30, July 27 & Nov 4
In 2005, 3 sampling events were conducted June 28, July 18 and Oct 25;

During 2004, generally 11 to 12 locations located throughout Sucker Brook were sampled during each event. In 2005, the sampling was more focused on Bald Hill Brook along Philbrick Road and the lower part of Sucker Brook.

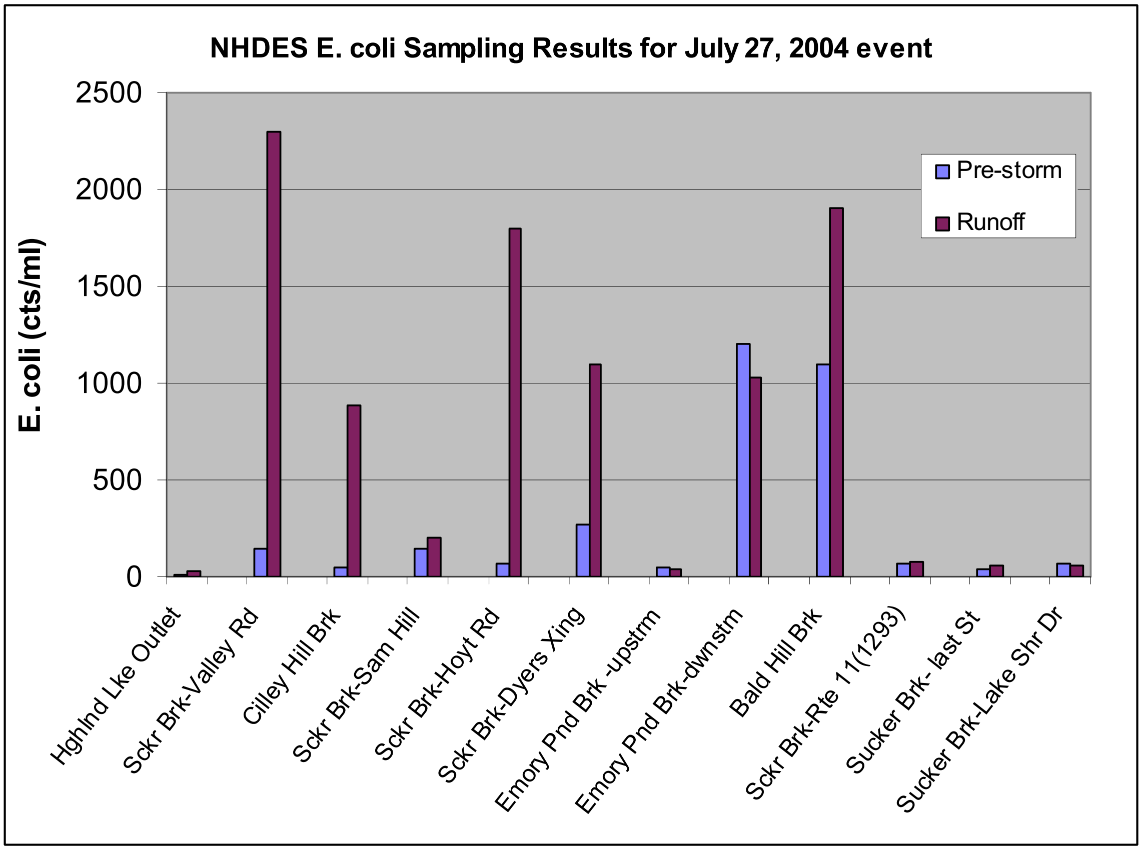
On June 29, 2004, total phosphorus was also sampled in the Sucker Brook at the Lake Shore Drive crossing and upstream at the Hoyt Road crossing. The sample results are shown below:

Location	Total Phosphorus
Sucker Brook at Lake Shore Dr.	0.048 mg/l
Sucker Brook at Hoyt Road	0.012 mg/l

Review of Bacteria Sampling Results
Results from six events showed relatively low bacteria (E. coli) levels (i.e., generally 10 to 80 cts/100 ml, except for a few higher readings of 140 and 210 cts/ml in Sucker Brook at the Valley Road crossing on June 25 and 29, 2004, respectively. During the June 25, 2004 event, Emory Pond Brook had an E. coli reading of 280 cts/ml.

The highest readings were observed on July 18, 2005 when Sucker Brook at Lake Shore Drive had an E. coli reading of 13,600 cts/ml. This magnitude of this level suggests a significant source in the watershed and perhaps one that is close by in the lower reaches of Sucker Brook. Further upstream, at Dyers Crossing, the E. coli reading was 4,700 cts/ml in a sample that was taken about an hour later. The lower level upstream could indicate that the source(s) of bacteria is located in between these two stations, or it could be just a function of the upstream sample being taken an hour later in the storm after the "first-flush" of runoff had already passed through this station. The other samples collected during this event were from Bald Hill Brook along Philbrick Road, which also had elevated readings of 2,500 to 3,300 cts/ml, but were lower than the readings recorded in Sucker Brook either upstream at Dyers Crossing or downstream at Lake Shore Drive.

The results from the July 27, 2004, are perhaps the most revealing in terms of where the highest increases in E. coli levels occur during a storm event. During this event, a pre-storm sampling round was first collected followed by a second sampling round an hour or later once rainfall and runoff began. The results are shown below in order of flow path from Highland Lake to Lake Shore Drive just before Sucker Brook enters Webster Lake.



These results clearly show major increases in bacteria following the initial first flush of runoff at certain locations, specifically at the Valley Road Crossing, Hoyt Road crossing and Dyers Crossing. Substantial increases were also observed in Cilley Brook and in Emory Pond Brook based on the difference in upstream and downstream samples in Emory Pond Brook. Interesting enough, the pre-storm samples in Emory Pond Brook and Bald Hill Brook had E. coli levels above 1,000 cts/ml where everywhere else E. coli levels in pre-storm samples were generally below 100 cts/ml. These elevated levels in pre-storm samples indicate that the source is essentially in the stream and not necessarily transported by runoff. This could be due to natural wildlife contributions but is more likely due to livestock entering in the stream. The major increases observed between pre-storm and runoff samples are also likely due to animal wastes in adjacent pasture areas and perhaps manure fertilized cropland adjacent to Sucker Brook or Cilley Brook. The greatest spike was observed in Sucker Brook at the Valley Road crossing, which warrants further investigation. This location had elevated bacteria levels during other sampling events as well. Surprisingly, the bacteria levels were observed to be relatively low at the lower end of Sucker Brook at the Lake Shore Drive crossing when most recently in 2005, especially on July 18, 2005, this location had an extremely high level of 13,600 cts/ml.

Variable results were observed in the other two 2005 events conducted on June 28 and October 25. During the June event, five stations were sampled including Lake Shore Drive and Dyers Crossing and 3 stations on the Bald Hill tributary. An upstream station on the Bald Hill tributary had a minor spike of 130 cts/ml but the downstream station had a reading of 20 cts/ml. The Dyers Crossing and Lake Shore Drive stations had readings of 40 and 30 cts/ml, respectively. The same stations were sampled on October25th plus an additional upstream station on the Bald Hill tributary. The Lake Shore Drive and Dyers Crossing stations had the highest readings of 1,370 and 890 cts/ml, respectively, while the Bald Hill tributary had readings ranging from 100 to 230 cts/ml with higher readings observed higher up in the watershed.

The variability in the bacteria sampling results is perhaps due in large part to the varying intensity of rainfall and runoff during each rain event as well as being due to differences in sample timing within the rain event. The results of at least two sampling events indicate that there may be a fairly significant source of bacteria near Lake Shore Drive since lower levels were observed further upstream during the same events. The extremely high level of 13,600 cts/ml observed on July 18, 2005 certainly warrants further investigation.

In addition, the findings of the July 27, 2004 event clearly indicate that there are locations within the watershed where there are other major sources of bacteria that, at a minimum, cause localized spikes in of E. coli within Sucker Brook above the state water quality standards during storm events. The evidence is not clear as to whether these sources continually affect bacteria levels in Webster Lake but it is quite likely these same sources are also sources of nutrients and particularly phosphorus, which would affect water quality in Webster Lake.

Study 4: Septic System Survey Data; Prepared by Jeanne Galloway of the Caring Community Network of Twin Rivers, dated August 12, 2004.

General Description: This report provides a review of the City's property files for lots within the Lake Protection Zone. Each file was reviewed seeking information regarding the age, location, type and permit status of the sewage disposal system. Eighty-five (85) lots have permitted sewage disposal systems while another 44 lots generally had older system with some notes regarding the location of their system.

Description of Findings: Of the 44 lots that have no permit according to the DES Subsurface records, there are currently 25 lots that have systems that are 25 years or older, if there have been no updates since this report has been prepared. Fourteen (14) of these systems are now 30 years or older, again, if not updates have taken place. Twenty (20) years is generally considered to be maximum age of an effective septic system in well drained soils. A follow-up survey should be conducted to see if any these systems have been updated. Many of these homes with little or no data are located in the Tier 1 zone along Webster Ave and Lake Shore Drive. This is a major data gap that should be reviewed to gain some certainty about possible septic system loading.

Seven of the more recent permitted systems are restricted for SEASONAL USE ONLY and another 4 systems are required to use holding tanks. These restrictions are indicative of the small areas and/or poor soil restrictions for septic design. Twenty-nine (29) are pumped systems and twenty–two are using advanced technology with 10 Eljien systems and another 12 Environseptic systems.

Report 5 - Webster Lake – Summary of Available In-Lake Water Quality Data from VLAP and other Reports

Water quality data have been collected from Webster Lake for more than 25 years. The first comprehensive effort of data collection was undertaken by Dufresne-Henry (Water Quality Management Investigation Webster Lake Franklin, NH 1981), with the actual sampling being done from fall 1979 to late summer 1980. A second comprehensive effort was undertaken by NHDES (Webster Lake Diagnostic Feasibility Study, 1990), with the actual in-lake sampling being conducted from fall 1987 to early winter 1988. In addition, Webster Lake volunteers have participated in the NHDES Volunteer Lake Assessment Program (VLAP) since 1986, taking Secchi depth measurements and gathering water samples for analysis for total phosphorus and chlorophyll *a* several times each year during the summer period. These data collectively form the basis of this summary of existing water quality.

The data from all sources cited above clearly establish that Webster Lake is a mesotrophic body of water. Various trophic state indices developed by NHDES and others also support a mesotrophic classification. Summer epilimnetic total phosphorus concentrations have averaged perhaps 8-12 parts per billion (ppb) for the last 10 years or more and maximum concentrations during that same time period have not exceeded ~15 ppb. According to NHDES guidelines for lake monitoring parameters, these concentrations place Webster Lake in the "average" category, and somewhat less than the median value of 12 ppb for all NH lakes. Furthermore, evaluation of nearly 20 years of VLAP data shows a statistically significant declining trend in epilimnetic total phosphorus levels which suggests that nutrient loading from all sources may be gradually declining.

Review of chlorophyll *a* data leads to similar conclusions. Chlorophyll *a* has historical averaged between 3 and 5 ppb for the summer, with recent maximum values almost always less 6 ppb. NHDES guidelines indicate that the average levels would result in a "good" classification, somewhat better than the NH median of 4.6 ppb. Even so, some of the maximum values exceed the "good" category, and while not at "nuisance" levels, they would place occasional Webster Lake chlorophyll *a* values at "more than desired" levels. There is no statistically significant trend in the long-term chlorophyll *a* data which suggests that concentrations are neither increasing nor decreasing. Given the natural variability of phytoplankton activity, this is not unexpected.

Secchi depth measurements also support a mesotrophic classification. Historic summer averages range from 4 to 5.5 meters, with the minimum value always above 2 meters. NHDES guidelines would place these values in the "good" to "exceptional" category, considerably greater than the State median value of 3.2 meters. Nevertheless, there is a statistically significant, declining trend in Secchi depth that is not explained by either the total phosphorus or chlorophyll *a* data. This trend his been particularly noticeable in the most recent 5-7 years, with minimum values declining steadily from approximately 5 meters in 1999 to ~2.2 meters in 2005.

Furthermore, other water quality indicators suggest that the mesotrophic classification may be somewhat misleading. Hypolimnetic total phosphorus levels have been elevated substantially above State median levels for the entire period of record. Even though there has been a statistically significant declining trend in these phosphorus concentrations, elevated levels could be playing a continuing role in contributing to occasional water quality problems. In addition, various species of blue-green algae, cyanobacteria - the so-called nuisance phytoplankton, have become more dominant components of the total phytoplankton assemblage in recent years, especially latter in the summer.

In addition, the State has attempted in this year's Biennual VLAP Report to compare lakes to "similar" lakes rather than to NH lakes as whole as has been done in the past. Although Webster Lake compares very favorably to the median conditions of all NH lakes, it compares far less favorably to the median conditions for similar NH lakes. In fact, Webster Lake chlorophyll *a* concentrations are ~1 ppb higher, epilimnetic total phosphorus concentrations at least 4 ppb higher and Secchi depths nearly 2 meters lower than median values for lakes that the State has determined to be similar.

We conclude that while all traditional measures of trophic state strongly suggest a mesotrophic state for Webster Lake, other occasional water quality measurements provide contrary signals and suggest that traditional measures may not be telling the whole story. Declining trends in transparency and increasing dominance by blue-green algae with occasional noticeable bloom conditions are of considerable concern, but available data do not clearly identify a cause. We will continue exploring potential causes in the evaluation and modeling stage of this project.

Appendix C

DES Shoreline Conductivity Survey Results

Webster Lake Conductivity Survey
By Josh Spaulding

Date of Survey: June 30, 2006
Field Staff: Josh Spaulding and Matt Richards

On Friday June 30th of 2006 we completed an experimental conductivity survey of Webster Lake in Franklin NH. The purpose of the survey was to experiment with using conductivity readings to identify and locate failed septic systems which could potentially be causing serious problems polluting the lake. Conductivity values, measured in micro Siemens per centimeter (µS/cm), were taken around the perimeter of the lake and at the center deep spot for calibration. The values were measured approximately 2 feet deep from a boat as a team went around the lake, attempting to keep as close to shore as safe navigation would allow.

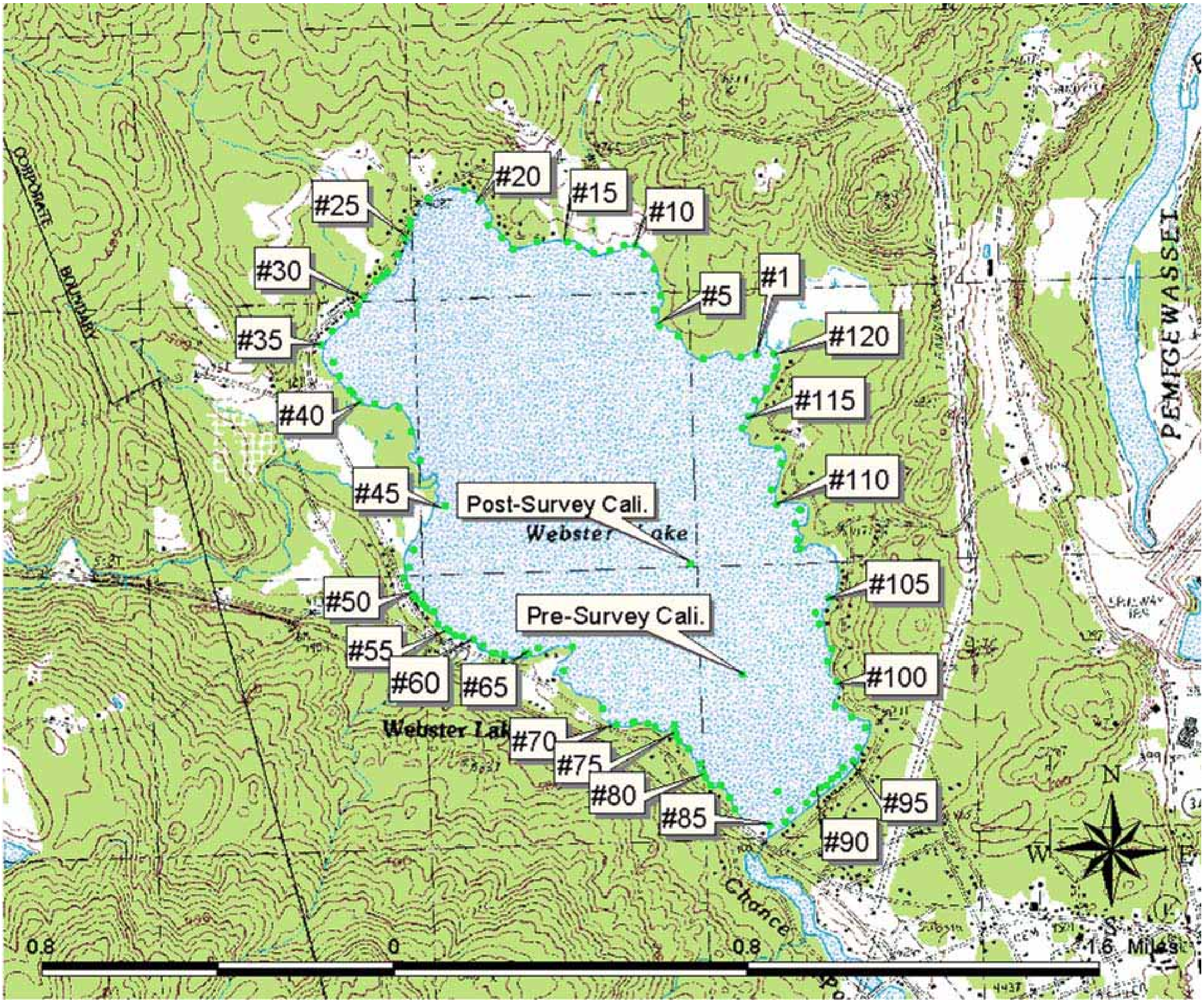
Electrical Conductivity is the measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions or sodium, magnesium, calcium, iron, and aluminum cations. Organic compounds like oil, phenol, alcohol, and sugar do not conduct electrical current very well and therefore have a low conductivity when in water. Conductivity is also affected by temperature: the warmer the water, the higher the conductivity. For this reason, conductivity measurements are reported as conductivity at 25^{o} C.

An electrical conductivity sensor consists of two electrodes exactly one centimeter apart. A constant voltage is applied across the electrodes and an electrical current runs through the water. The current measured is proportional to the concentration of dissolved ions in the water. The measured current (measured in µS/cm) holds a direct relation to the measure of Total Dissolved Solids (TDS) (measured in mg/l).
2 µS/cm = 1 mg/l. The TDS measurement is preferred for final data because it gives a more tangible measurement.

In our survey we measured the conductivity in over 120 locations around the lake; we then took that data and looked for any spikes or anomalies present. The EPA currently has no specific standards for electrical conductivity or TDS. It does however have Secondary Maximum Contamination Levels (MCL's), which are loose tolerances. These simply state that a water body or source should not have TDS levels greater then 500mg/l. Water levels equal to that or greater would show signs of hardness, colored water, staining, and salty taste.

Knowing of course we wouldn't find levels that high in New Hampshire our goal was slightly different. Because contaminates enter the lake from different distances and through different soils, their concentration upon reaching the lake cannot be expected to be a standard indicating value. We set out searching for a spike in the average levels someplace around the lake's perimeter which would indicate higher conductivity levels entering the lake through the groundwater. This spike would hopefully lead us in a direction of search for lake pollutants.

Analysis of our data showed several things. The lake had an average of
40.84 µS/cm. We found one solid spike and four other anomalies indicating higher conductivity levels. We were hoping to find more dramatic spikes in the data but those we found ranged 4 to 6 µS/cm higher then the average. With the data completed we face the question of how to bracket levels of conductivity, and determine what levels of increase are worth investigating.



#1
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#45
#50
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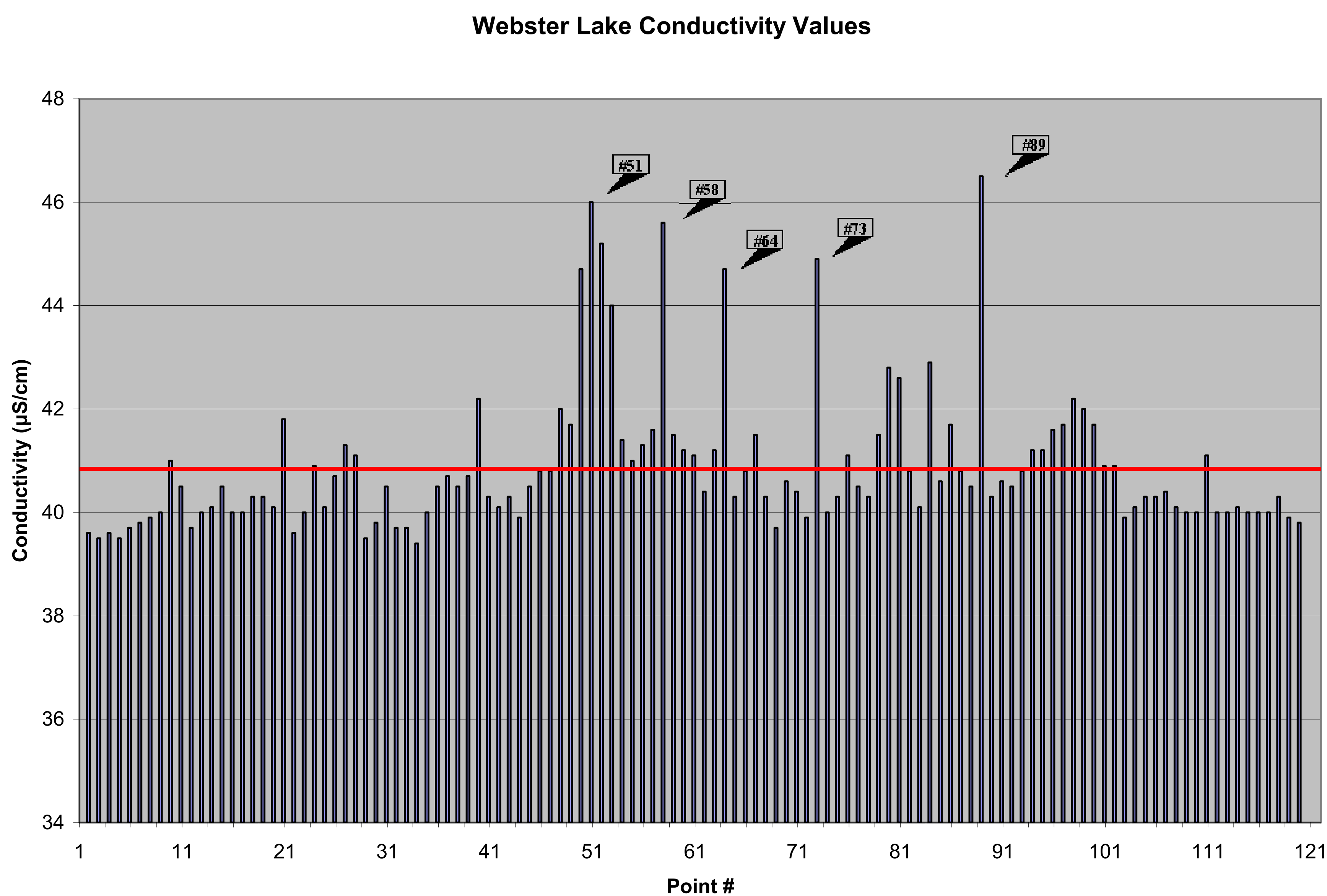
#75
#80
#85
#90
#95
#100
#105
#110
#115
#120
Post-Survey Cali.
Pre-Survey Cali.
Webster Lake
Webster Lak
PEMIGEWASSET
CORPORATE BOUNDARY
Chance
N
S
W
E
0.8
0
0.8
1.6 Miles

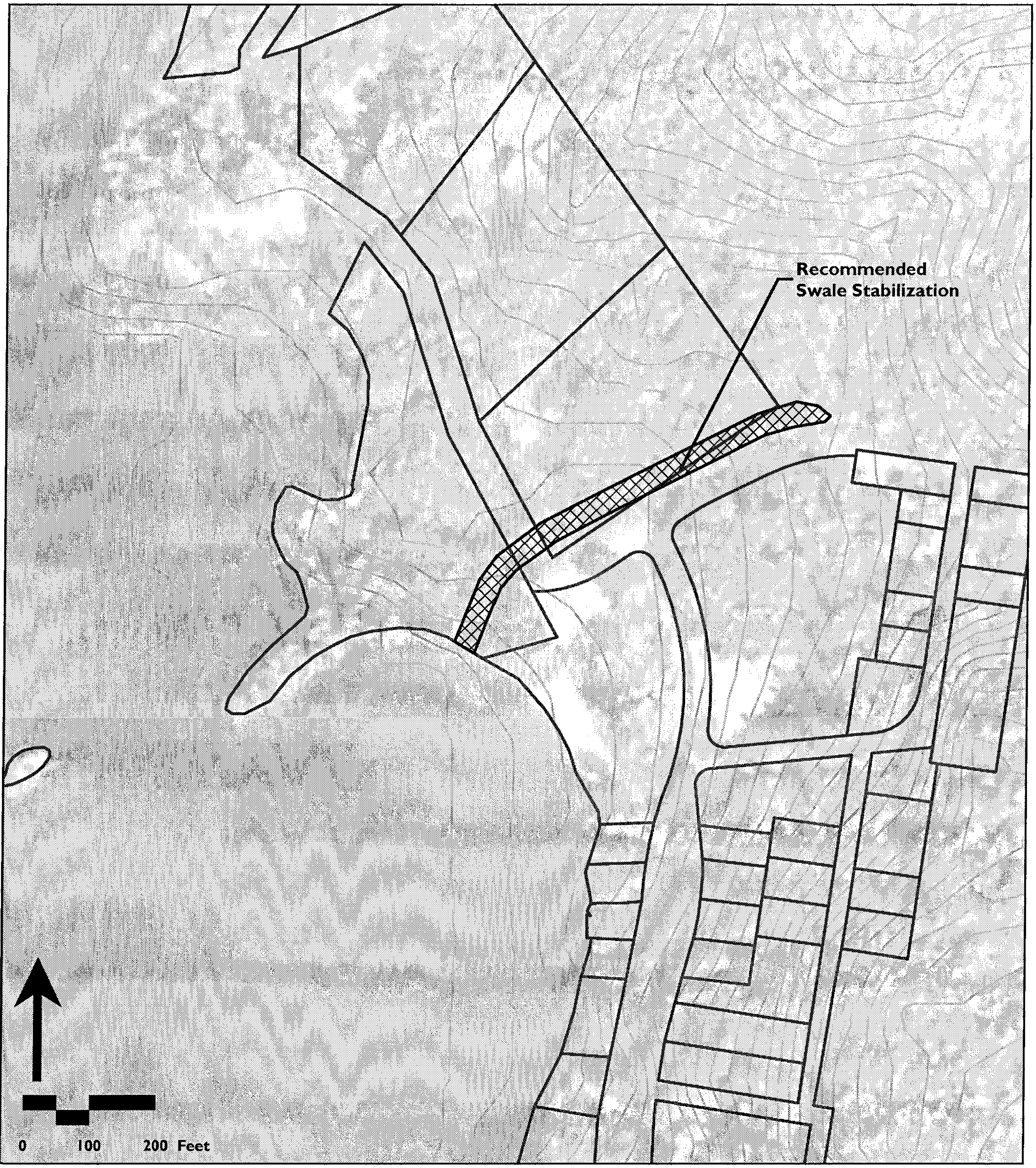
VHB

Point #	Conductivity (µS/cm)	Temp (°C)	Point #	Conductivity (µS/cm)	Temp (°C)	Point #	Conductivity (µS/cm)	Temp (°C)
1	39.7	23.4	43	40.3	24.4	85	40.6	23.9
2	39.6	23.4	44	39.9	24.2	86	41.7	24
3	39.5	23.4	45	40.5	23.2	87	40.8	23.9
4	39.6	23.5	46	40.8	23.4	88	40.5	23.6
5	39.5	23.5	47	40.8	23.5	89	46.5	23.7
6	39.7	23.7	48	42	24.5	90	40.3	23.9
7	39.8	23.7	49	41.7	23.6	91	40.6	23.9
8	39.9	23.8	50	44.7	23.7	92	40.5	23.9
9	40	23.9	51	46	23.6	93	40.8	23.9
10	41	24	52	45.2	24.1	94	41.2	23.9
11	40.5	24	53	44	24.3	95	41.2	23.9
12	39.7	23.5	54	41.4	24.2	96	41.6	23.9
13	40	23.9	55	41	24.2	97	41.7	23.9
14	40.1	24	56	41.3	24.1	98	42.2	23.8
15	40.5	24	57	41.6	24.2	99	42	23.9
16	40	23.5	58	45.6	24.2	100	41.7	24
17	40	23.8	59	41.5	24.2	101	40.9	24
18	40.3	23.9	60	41.2	24.1	102	40.9	24.1
19	40.3	24	61	41.1	23.9	103	39.9	23.8
20	40.1	24.1	62	40.4	23.9	104	40.1	23.9
21	41.8	23.7	63	41.2	23.9	105	40.3	24
22	39.6	23.7	64	44.7	24	106	40.3	24.1
23	40	23.7	65	40.3	23.9	107	40.4	24
24	40.9	23.6	66	40.8	23.8	108	40.1	23.9
25	40.1	23.6	67	41.5	23.7	109	40	23.8
26	40.7	23.6	68	40.3	23.8	110	40	23.8
27	41.3	23.5	69	39.7	23.4	111	41.1	24.2
28	41.1	23.5	70	40.6	23.2	112	40	24
29	39.5	23.5	71	40.4	24	113	40	24
30	39.8	23.6	72	39.9	23.9	114	40.1	24
31	40.5	24.2	73	44.9	23.6	115	40	23.9
32	39.7	23.7	74	40	23.7	116	40	24
33	39.7	23.9	75	40.3	23.7	117	40	24
34	39.4	23.7	76	41.1	23.5	118	40.3	24.4
35	40	23.5	77	40.5	23.6	119	39.9	24
36	40.5	24.2	78	40.3	23.7	120	39.8	23.9
37	40.7	24.2	79	41.5	23.6			
38	40.5	24.2	80	42.8	23.7			
39	40.7	24.3	81	42.6	23.7			
40	42.2	24.3	82	40.8	23.7			
41	40.3	24.4	83	40.1	23.8			
42	40.1	24.3	84	42.9	24.1			



Webster Lake Conductivity Values
Conductivity (µS/cm)
48
46
44
42
40
38
36
34
#51
#58
#64
#73
#89
1
11
21
31
41
51
61
71
81
91
101
111
121
Point #

Appendix D
Roadside Swale Stabilization Areas



Legend

5-Foot Contour

Parcels

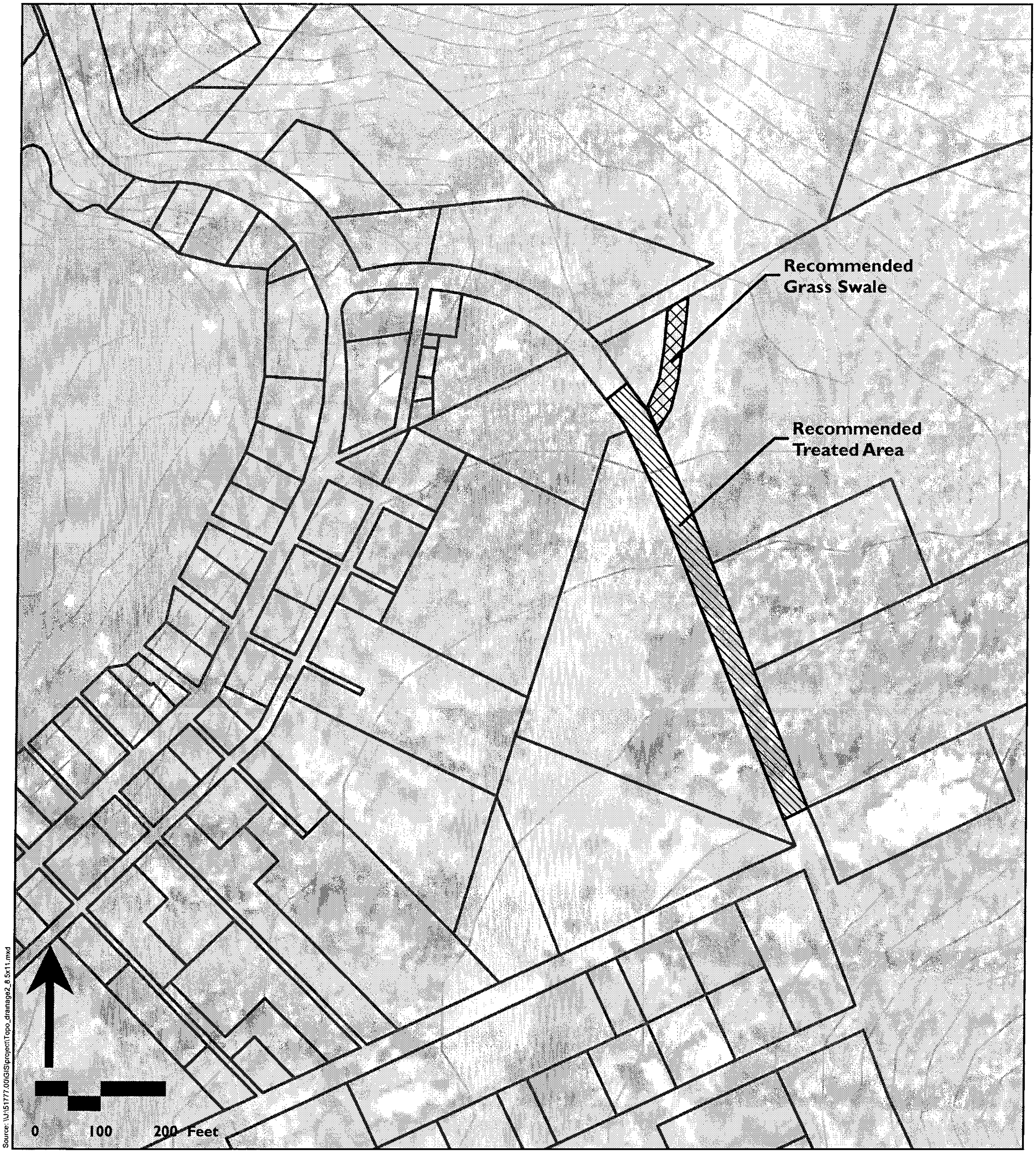
Figure 1

Existing Drainage Conditions - Area 1

Franklin & Andover, New Hampshire

Source: Digital Orthophoto captured in 2003 by NAIP and distributed by NH GRANIT. Contour data are from USGS, distributed by NH GRANIT.

Vanasse Hangen Brustlin, Inc. VHB



Legend

5-Foot Contour

Parcels

Figure 2

Existing Drainage Conditions - Area 2

Franklin & Andover, New Hampshire

Source: Digital Orthophoto captured in 2003 by NAIP and distributed by NH GRANIT. Contour data are from USGS, distributed by NH GRANIT.

Vanasse Hangen Brustlin, Inc. VHB

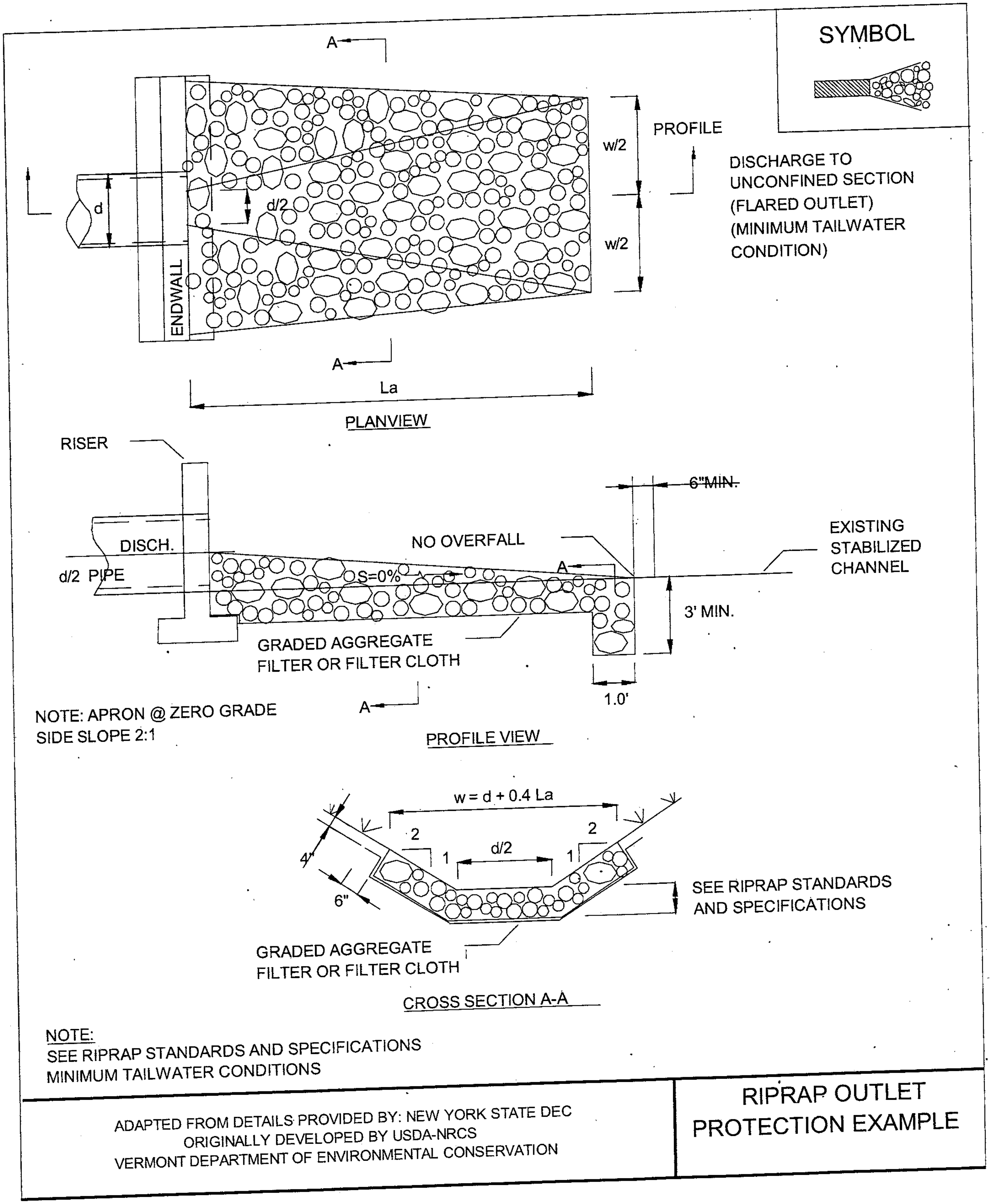


Figure 4.26a Riprap Outlet Protection Detail (1)

Appendix E
NH Forestry Practice BMP Manual