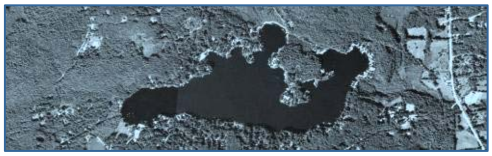
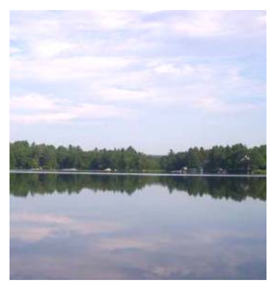


BABOOSIC LAKE
WATERSHED BASED PLAN

May 2008

Prepared For:

New Hampshire Department of Environmental Services
29 Hazen Drive
Concord, NH 03302-0095

Prepared By:

Geosyntec consultants
289 Great Road
Acton, MA
www.geosyntec.com

TABLE OF CONTENTS

TABLES

FIGURES

1. INTRODUCTION

Baboosic Lake

Geosyntec Consultants, Inc. (Geosyntec) was contracted by the New Hampshire Department of Environmental Services (NHDES) to develop a Watershed Based Plan (WBP) for Baboosic Lake (222 acres), located in the towns of Amherst and Merrimack in southern New Hampshire. The lake has a 1,909 acre watershed and an estimated 139 year-round and seasonal homes located around the lake's perimeter.

Baboosic Lake has experienced declines in water quality in recent years, and has been included on the *Draft 2008 List of Threatened or Impaired Waters That Require a TMDL* for nuisance blooms of Cyanobacteria (hepataoxic blue-green algae), elevated Chlorophyll-a concentrations, and elevated levels of the bacteria *Escherichia coli*.

Reducing Cyanobacteria blooms and Chlorophyll-a (a green pigment associated with cyanobacteria and other algae) concentrations in Baboosic Lake and will require reducing the amount of phosphorus entering the lake from sources such as septic systems and stormwater runoff. In freshwater lakes, phosphorus is usually the most important nutrient determining the growth of algae and aquatic plants. Because phosphorus is typically relatively less abundant than nitrogen, it is considered the "limiting nutrient" for biological productivity. As such, increases in phosphorus levels tend to be strongly correlated with decreased water clarity, increased algal abundance and other indicators of declining water quality. The primary purposes of this WBP are:

- to identify and quantify specific sources of phosphorus contributing to the lake's water quality impairments; and
- to develop a management plan to reduce phosphorus loading to the lake to a targeted level that would significantly improve in-lake conditions.

To achieve the goals listed above, this WBP includes the following elements, in conformance with the U.S. Environmental Protection Agency's guidance for watershed based plans:

a. Identify Pollutant Sources (Section 2)

b. Pollutant Load Reduction Estimates (Section 3)

c. Describe Nonpoint Source Pollution Management Measures (Section 4)

d. Estimate Technical and Financial Assistance (Section 5)

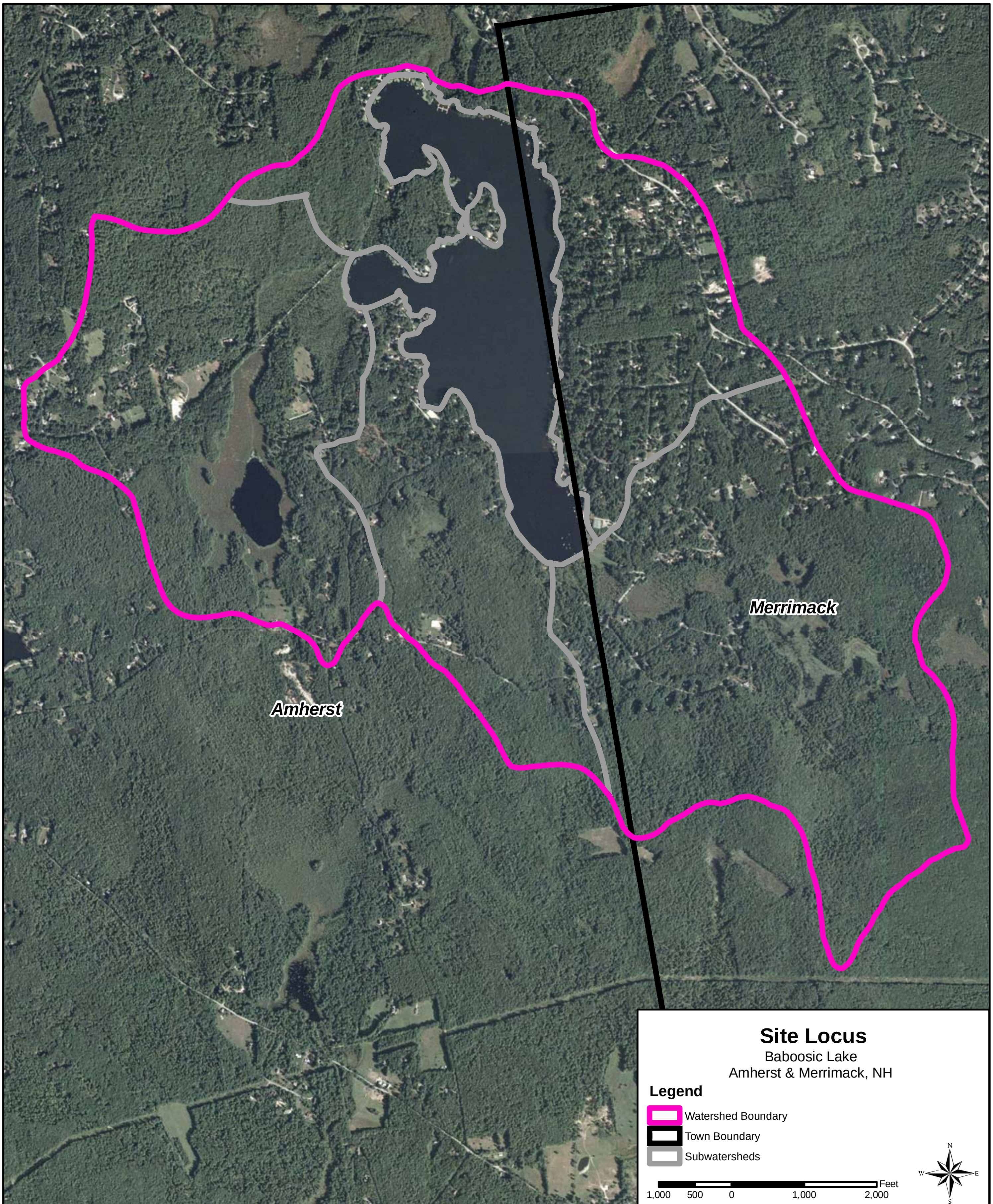
e. Public Information and Education (Section 6 and Appendix A)

f. Implementation Schedule (Section 7)

g. Interim Milestones (Section 7)

h. Evaluation Criteria (Section 8)

i. Monitoring (Section 8)



Site Locus

Baboosic Lake
Amherst & Merrimack, NH

Legend

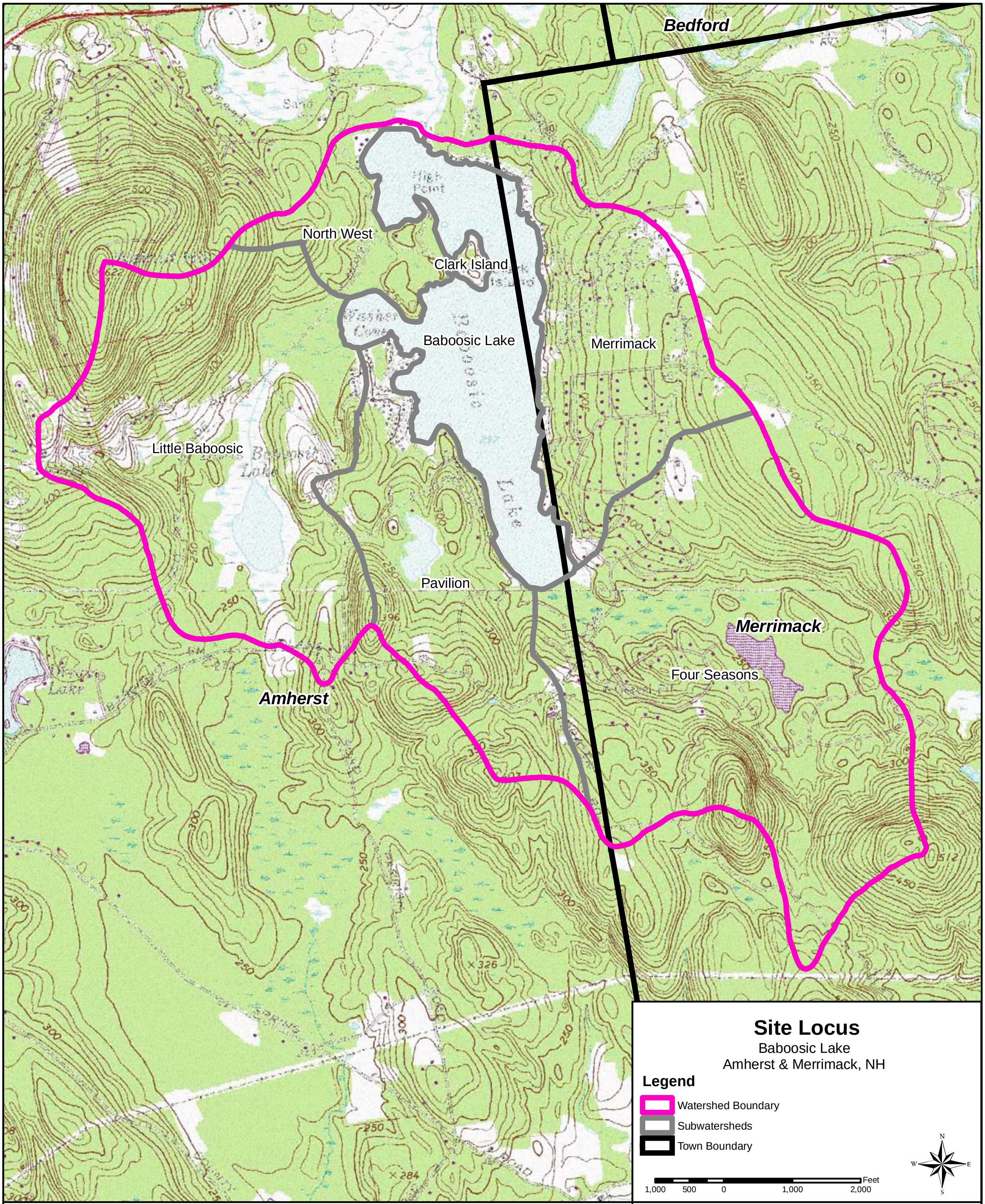
- Watershed Boundary
- Town Boundary
- Subwatersheds

Feet
1,000 500 0 1,000 2,000

Geosyntec consultants
ACTON, MASSACHUSETTS

FIGURE NO. 1	
PROJECT NO.	BW0086
DATE:	05/13/08
Baboosic_Aerial.mxd	

Q:\GISProjects\BW0086-Baboosic\Projects



Geosyntec consultants

ACTON, MASSACHUSETTS

FIGURE NO. 2

PROJECT NO. BW0086

DATE: 05/13/08

Baboosic_USGS.mxd

Q:\GISProjects\BW0086-Baboosic\Projects

2. SUMMARY OF EXISTING WATER QUALITY CONDITIONS

2.1 Summary of Existing Water Quality Reports

As of May 2008, NHDES was in the process of reviewing a draft diagnostic study for Baboosic Lake. A summary of lake trophic data made available to Geosyntec by NHDES from this draft report is provided below in Table 1. A summary of in-lake phosphorus concentrations is included in Section 2.1.1.

Table 1: Baboosic Lake Trophic Data

Lake Name	Baboosic Lake
Lake Area (ha)	89.84
Town	Amherst
County	Hillsborough
River Basin	Merrimack
Elevation (feet)	231
Shore Length (m)	6900
Maximum Depth (m)	7.9
Mean Depth (m)	3.0
Volume (m3)	2,737,500
Relative Depth (m)	0.7
Shore Configuration	2.05
Areal Water Load	3.28
Flushing Rate (yr-1)	1.10
P Retention Coefficient	0.73
Lake Type	Natural

2.1.1 Phosphorus Concentrations in Baboosic Lake

Eutrophication is the gradual process of nutrient enrichment in aquatic ecosystems such as lakes. Eutrophication occurs naturally as lakes become more biologically productive over geological time, but this process may be accelerated by human activities that occur in the watershed. Nutrients that contribute to eutrophication can come from many natural and anthropogenic sources, such as fertilizers applied to residential lawns and agricultural fields; septic systems; deposition of nitrogen from the atmosphere; erosion of soil containing nutrients; and sewage treatment plant discharges. Land development not only increases the sources of nutrients, but also decreases opportunities for natural attenuation (e.g. uptake by vegetation) of such nutrients before they can reach a water body.

Nutrients such as phosphorus and nitrogen can stimulate abundant growth of algae and rooted plants in water bodies. Over time, this enhanced plant growth leads to reduced dissolved oxygen in the water, as dead plant material decomposes and consumes oxygen. Phosphorus is typically the "limiting nutrient" for freshwater lakes, which means that plant productivity is most often controlled by the supply of this nutrient. As such, increases in phosphorus load in a lake watershed are closely correlated with increases in plant productivity and accelerated eutrophication.

Surface water bodies are typically categorized according to trophic state as follows:

Oligotrophic: Low biological productivity. Oligotrophic lakes are very low in nutrients and algae, and typically have high water clarity and a nutrient-poor inorganic substrate. Oligotrophic water bodies are capable of producing and supporting relatively small populations of living organisms (plants, fish, and wildlife). If the water body is stratified, hypolimnetic oxygen is usually abundant.

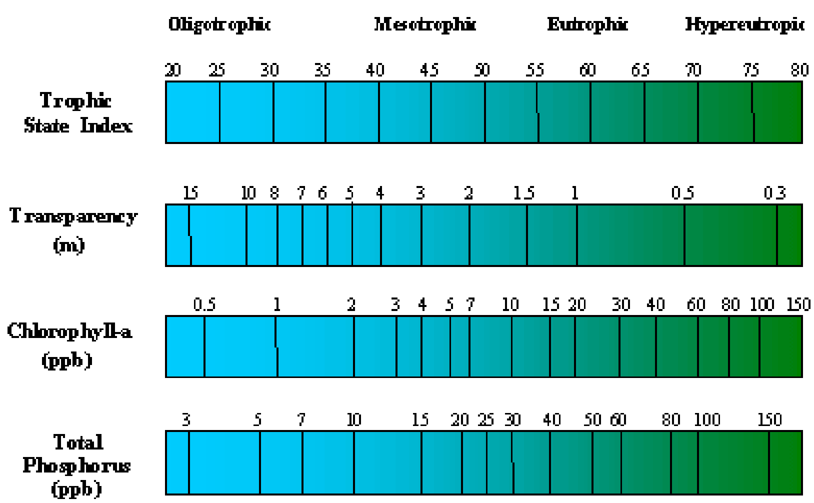
Mesotrophic: Moderate biological productivity and moderate water clarity. A mesotrophic water body is capable of producing and supporting moderate populations of living organisms (plant, fish, and wildlife).

Eutrophic: High biologically productivity due to relatively high rates of nutrient input and nutrient-rich organic sediments. Eutrophic lakes typically exhibit periods of oxygen deficiency and reduced water clarity. Nuisance levels of macrophytes and algae may result in recreational impairments.

Hypereutrophic: Dense growth of algae throughout the summer. Dense macrophyte beds, but extent of growth is light-limited due to dense algae and associated low water clarity. Summer fish kills are possible.

Figure 3: Carlson Trophic State Index

(Figure from 1988 Lake and Reservoir Restoration Guidance Manual. USEPA. EPA 440/5-88-002.)



The Carlson Trophic State Index (TSI) is one of the most commonly used means of characterizing a lake's trophic state. As illustrated in the Figure 3 below, the TSI assigns values based upon formulas which describe the relationship between three parameters (total phosphorus, chlorophyll-a, and Secchi disk (clarity) and the lake's overall biological productivity. As shown in the figure below, TSI scores below 40 are considered oligotrophic, scores between 40 and 50 are mesotrophic, scores between 50 and 70 are eutrophic, and scores from 70 to 100 are hypereutrophic.

The NH DES categorizes lakes into trophic state according to total phosphorus concentration, as follows:

Total Phosphorus Concentration (ug/L)	Trophic Status
<10	Oligotrophic
10-20	Mesotrophic
>20	Eutrophic

As summarized below, there have been three recent primary studies of total phosphorus concentrations in Baboosic Lake.

UNH Monitoring Data:

The University of New Hampshire (UNH) measures total phosphorus (primarily in the epilimnion) at least once per summer during 1983-84, 1987-88, 1993, 1995, and 1997-98. Total phosphorus was also measured in the metalimnion and hypolimnion in later years of the study. The average epilimnetic total phosphorus concentration for the data collected between 1983 and 1998 was 12.2 µg/L.

UNH conducted total phosphorus sampling approximately every two weeks in June, July, and August of 1998. The 1998 UNH study collected total phosphorus concentrations in the epilimnion, metalimnion, and hypolimnion. The 1998 UNH study found an average epilimnetic total phosphorus concentration of 17.7 µg/L with a standard deviation of 2.9 µg/L.

NHDES Monitoring Data:

NHDES measured total phosphorus at varying depths in July of 1998 and February of 1999. The NHDES study found an epilimnetic phosphorus concentration of 17 µg/L, very close to the average concentration found for the same period by the UNH study.

Using a combination of water quality monitoring data and other indicators of lake trophic status (e.g., dominant phytoplankton and zooplankton, vascular plant growth, chlorophyll), the NHDES has classified Baboosic Lake as eutrophic. Previous studies by NHDES in 1977 and 1993 classified Baboosic Lake as mesotrophic. The 1998 chlorophyll-a value was nearly four times the values found in previous studies. However, the report notes that more frequent monitoring is needed to determine if the elevated chlorophyll values are simply outliers or indicative of a trend.

3. ESTIMATES OF ANNUAL PHOSPHORUS LOADS TO BABOOSIC LAKE AND RECOMMENDED GOALS FOR IMPROVEMENT

3.1 Land-Use Based Pollutant Modeling

Geosyntec conducted land-use based modeling to estimate annual phosphorus export from six subwatersheds within the Baboosic Lake watershed. The National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP) land-use data was used to represent the current Watershed's land-use condition. C-CAP data was the most recently published land-use data available for public use. Land-use pollutant export coefficients (represented in lbs/acre-yr) were derived from New Hampshire GIS data (GRANIT) information.

Table 2: Phosphorus Export Coefficients by Land Use Category

C-CAP Land Use Code	C-CAP Land Use Category	Phosphorus Export Coefficient (lbs/ac-yr)
2	High-Intensity Developed	0.446
3	Low-Intensity Developed	0.446
4	Cultivated Land	0.535
5	Grassland	0.535
6	Deciduous Forest	0.178
7	Evergreen Forest	0.178
9	Scrub/Shrub	0.178
10	Palustrine Forested Wetland	0.045
11	Palustrine Scrub/Shrub Wetland	0.045
12	Palustrine Emergent Wetland	0.045
13	Estuarine Forested Wetland	0.045
14	Estuarine Scrub/Shrub Wetland	0.045
15	Estuarine Emergent Wetland	0.045
17	Bare Land	0.446
18	Water	0.000
19	Palustrine Aquatic Bed	0.000
20	Estuarine Aquatic Bed	0.000
21	Tundra	0.000

Land use based exports are an average measure of pollutant export and are typically reported for specific land use categories. These data were used in a land-use based pollutant model to predict annual phosphorus loading from the Watershed. The area of each land cover type is shown below in Table 3. A table summarizing the results of the land-use loading model is provided in Table 4.

Table 3: Subwatershed Land Cover Areas (all values in acres)

	Clark Island	Four Seasons	Little Baboosic	Merrimack	Northwest	Pavilion
Low-Intensity Developed	0.0	0.2	0.0	1.4	0.7	0.2
Cultivated Land	0.0	6.4	2.8	20.7	0.5	3.5
Grassland	0.0	13.7	6.7	79.7	0.1	21.4
Deciduous Forest	0.0	2.5	2.4	0.0	0.0	0.0
Evergreen Forest	0.0	6.7	30.7	0.0	1.4	0.1
Scrub/Shrub	3.9	110.9	133.5	26.3	19.7	75.5
Palustrine Forested Wetland	0.0	347.0	172.2	127.1	39.4	104.8
Palustrine Scrub/Shrub Wetland	0.0	55.0	13.7	6.0	2.5	8.8
Palustrine Emergent Wetland	0.0	7.9	5.7	1.0	0.0	0.7
Estuarine Forested Wetland	0.0	35.5	24.0	1.4	16.9	10.2
Estuarine Scrub/Shrub Wetland	0.0	12.6	56.7	0.2	2.0	1.1
Estuarine Emergent Wetland	0.0	16.1	2.5	9.6	3.3	10.3
Water	0.0	0.0	1.3	0.0	0.1	0.0
Palustrine Aquatic Bed	2.4	0.9	13.9	0.1	5.0	9.3

Table 4: Subwatershed Pollutant Loading Summary

Subwatershed	Area (acres)	Estimated Annual Phosphorus Load (lbs/yr)		Estimated Annual Phosphorus Load (kg/yr)	
		Total	Per Acre	Total	Per Hectare
Clark Island	6	<1	0.03	<1	0.03
Four Seasons	615	53	0.09	24	0.10
Little Baboosic	466	47	0.10	21	0.11
Merrimack	256	64	0.25	29	0.28
North West	87	7	0.08	3	0.09
Pavilion	244	33	0.13	15	0.15
Baboosic Lake Watershed (total)	1909	205	0.11	94	0.12

The land-use based pollutant loading model provides a tool for estimating and comparing (1) total annual pollutant loads (in pounds per year and kilograms per year) and (2) annual pollutant load rates normalized to the watershed area (in pounds per acre per year and kilograms per hectare per year) for each subwatershed within the Watershed. This type of land-use model cannot be used to accurately predict in-lake conditions (e.g., in-lake total phosphorus concentrations) because it does not reflect site-specific land management practices or other variables such as internal nutrient recycling, lake volume, etc. However, the land-use pollutant loading model estimates do provide a useful comparative measure of the relative impact that each subwatershed has on lake water quality, and therefore are a useful tool to prioritize sites for watershed improvements. A brief summary of the land-use pollutant loading model results for each of the subwatersheds is provided below:

Clark Island: Clark Island is located in the northwestern portion of Baboosic Lake and covers only 6.3 acres, making it the smallest subwatershed. The subwatershed is dominated by wetlands (62%) and palustrine aquatic bed (38%). Clark Island's phosphorus contribution is 0.03 kg P/ha/year, which accounts for less than 1% of the Lake's total predicted phosphorus load.

Four Seasons: Four Seasons is the largest subwatershed at 615 acres and is located to the southeast of Baboosic Lake. Land cover in the subwatershed consists primarily of wetlands (77%) and forest (20%). Cultivated land/grasslands and low intensity development comprise the remaining 3% of land cover in the subwatershed. The phosphorus loading rate from Four Seasons is 0.10 kg P/ha/year and accounts for 31% of the Lake's total predicted phosphorus load.

Little Baboosic: Little Baboosic subwatershed is located to the west of Baboosic Lake and contains the drainage area for Little Baboosic Lake. Land cover is dominated by wetlands (58%) and undeveloped scrub/shrub forest (35%). The subwatershed contains approximately 3% open water. The phosphorus loading rate from the Little Baboosic subwatershed is 0.11 kg P/ha/year, which represents 27% of the Lake's total predicted phosphorus load.

Merrimack: Merrimack is the most developed subwatershed and is located on the eastern side of Baboosic Lake. Despite being the most heavily developed, land cover in the Merrimack subwatershed is still dominated by wetlands (54%), cultivated land/grassland (37%), and forest (10%). This subwatershed has the highest predicted phosphorus loading 0.28 kg P/ha/year, which represents approximately 37% of the Lake's total predicted phosphorus loading.

Northwest: Land cover in the Northwest subwatershed is 70% wetlands, 23% forest, and 6% open water. The remaining 1% is composed of developed land and grassland/cultivated land. The phosphorus loading rate of the Northwest subwatershed is 0.09 kg P/ha/year, accounting for 4% of the Lake's total predicted phosphorus load.

Pavilion: The Pavilion subwatershed is located to the southwest of Baboosic Lake. Land cover in the subwatershed is composed of wetlands (55%), forest (31%), cultivated land/grassland (10%), water (4%), and low-intensity development (1%). The phosphorus loading rate for Pavilion 0.15 kg P/ha/year, which represents 19% of the Lake's total predicted phosphorus load.

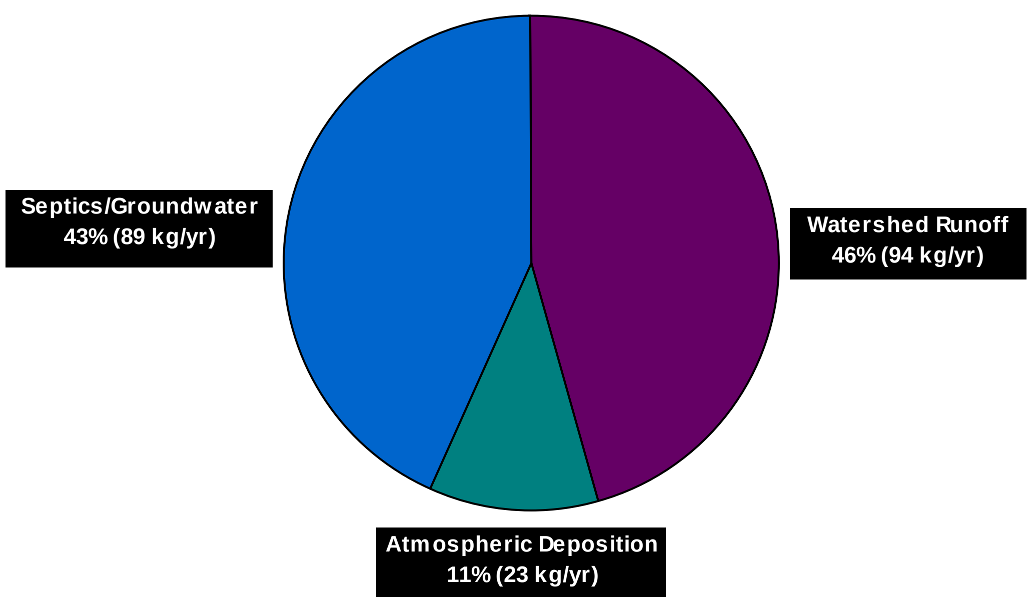
3.2 Estimated Annual Phosphorus Loading Budget

To estimate the Baboosic Lake's annual external phosphorus loading budget, Geosyntec has combined estimates for septic systems and atmospheric sources of phosphorus with the watershed loading estimates (including tributaries and direct runoff) derived from the land use pollutant loading model presented in Section 3.1 of this report.

The estimated annual external phosphorus budget of 206 kg/year is summarized below and presented in Figure 4.

- The combined phosphorus load from all 6 subwatersheds (including tributaries and direct runoff) draining to Baboosic Lake account for an estimated 46% (94 kg) of the annual external phosphorus load to the lake.
- Septic systems are estimated to account for approximately 43% (89 kg/year) of the lake's annual phosphorus load. Details regarding the phosphorus load from septic systems are discussed further in Section 4.2.1.
- Atmospheric deposition, including wet and dry deposition, is estimated to account for 11% of the annual external phosphorus load (23 kg/year). Atmospheric deposition of phosphorus was calculated by multiplying the annual rainfall by the surface area of the lake and an atmospheric deposition loading rate of 6.1x10-7 kg P/yr.

Figure 4: Estimated Annual External Phosphorus Loading to Baboosic Lake



3.3 Vollenweider Equation Estimates of In-Lake Phosphorus Concentrations

The Vollenweider model is commonly used to predict in-lake phosphorus concentrations as a function of annual phosphorus loading, mean lake depth and hydraulic residence time. The Vollenweider model is based on a five year study of about 200 waterbodies in Europe, North America, Japan and Australia. The Vollenweider Equation is provided below, with calculations for Baboosic Lake based on the phosphorus loads discussed in Section 3.2. For this calculation, Geosyntec's estimate of phosphorus loading from septic systems (89 kg/year) and atmospheric deposition (23 kg/year) have been added to the predicted watershed load (including tributaries and direct runoff) from the land use pollutant loading model (94 kg/year), resulting in a total predicted phosphorus load of 206 kg/year.

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 = mean depth /hydraulic residence time = z/T

Assuming:

Estimated P load is 206,000 grams/year and

Lake area is 898,400 $m^{2,}$ then 206,000 grams/898,400 m^2 = 0.229 grams/m^2/year;

z = 3.0 meters;

T = Lake volume= 2,737,500 m^3 /annual outflow volume = 3,704,100 m^3

= 2,737,500 m^3/3,011,250 m^3 = 0.91year;

qs = z/T = 3.0 m /0.91yr = 3.297 m/yr

Thus:

In-lake P concentration = $(0.229/3.297) \times (1/1+(\sqrt{3.0/3.297}))$ = 0.036 mg/L = **36 µg/L**

Based on the predicted average annual phosphorus load of 206 kg/year , the Vollenweider equation predicts an in-lake phosphorus concentration of 36 µg/L. This estimate is roughly twice the observed historic mean epilimnetic total phosphorus concentrations for Baboosic Lake (approximately 17 µg/L, as reported from NHDES and UNH data), and more than three times the New Hampshire median of 11.0 µg/L.

In assessing the result of the Vollenweider equation with regard to NHDES and UNH monitoring data, it is important to note that the Vollenweider equation assumes that phosphorus concentrations are uniform throughout the lake. In thermally stratified lakes such as Baboosic Lake, it is typical for summer phosphorus concentrations in the epilimnion to be lower than those found in the hypolimnion. The NHDES reports that the median summer total phosphorus concentration in the epilimnion of New Hampshire lakes and ponds is 11 µg/L, while the median hypolimnetic concentration is 14 µg/L. As such, the Vollenweider equation will typically predict a lakewide phosphorus concentration that is somewhat higher than the levels observed in the epilimnion of a stratified lake during summer.

However, this does not fully explain the difference between the predicted and measured phosphorus concentrations for the Baboosic Lake. It is likely that most of this difference is due to the general assumptions that were incorporated into the land use loading model and septic system loading calculations, which together account for 89% of the lake's estimated annual phosphorus load. Further field investigations beyond the scope of this project are required in order to develop a more refined and accurate understanding of the lake's phosphorus budget. Such field investigations may include:

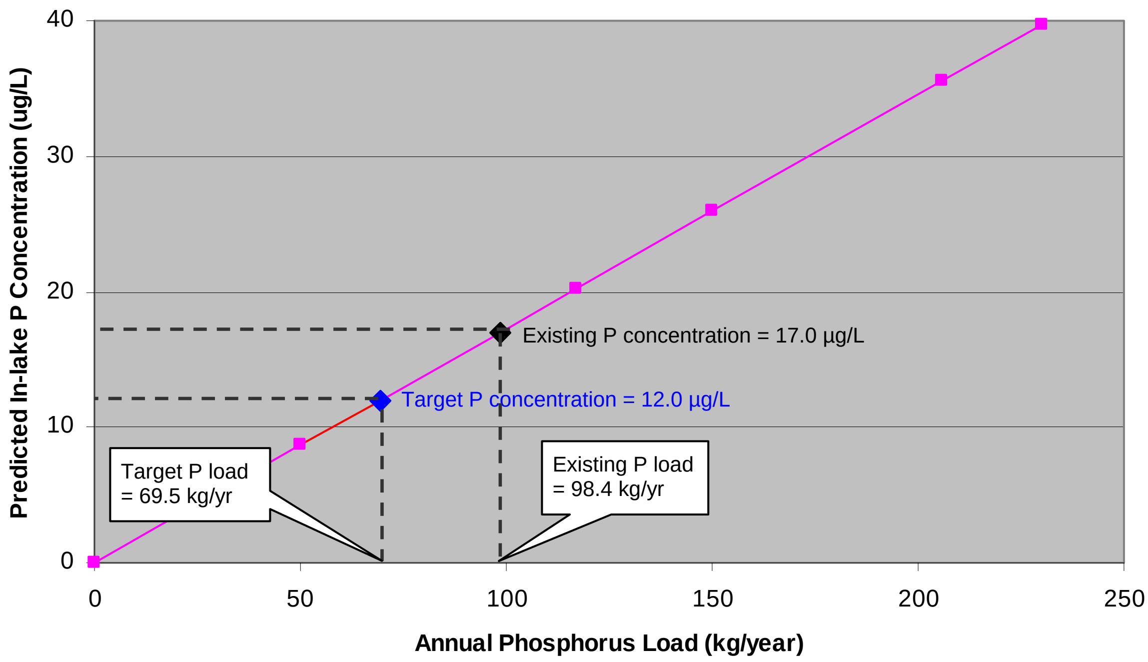
- Nutrient and flow monitoring at the lake's tributary inflow locations to allow for development of a precise hydrologic and nutrient budget for each tributary and associated subwatershed area; and
- Conduct a survey and GPS mapping to obtain updated in formation on the location, age, and type of septic systems around the perimeter of the Lake. This and other recommendations related to septic system management are discussed in Section 4.2. Many factors such as the age of the system, proximity to the lake, household occupancy, and soil permeability contribute to the phosphorus loading to the lake resulting from on-site sanitary systems. As a result of the high degree of variability of these factors, estimates of phosphorus loads from on-site sanitary systems can vary significantly and tend to have a relatively high degree of uncertainty.

3.4 Recommended Phosphorus Reduction Goal

To improve water quality conditions in Baboosic Lake and reduce the occurrence of nuisance algal blooms, Geosyntec recommends targeting an in-lake total phosphorus concentration reduction of 5 µg/L, which would reduce the in-lake concentration from 17 µg/L (based on NHDES measurements) to 12 µg/L. This reduction in in-lake phosphorus concentration would improve the lake to low mesotrophic status and could significantly improve in-lake conditions with regard to water quality indicators such as water clarity, algal abundance and chlorophyll-a concentrations.

As shown in Figure 5, the Vollenweider equation predicts that the lake's phosphorus load would need to be reduced by 28.9 kg/year in order to achieve the recommended in-lake phosphorus concentration reduction of 5 µg/L. It is important to note that the "existing" phosphorus load shown in Figure 5 has been estimated based on 1998 NHDES in-lake phosphorus measurements of 17 µg/L. As previously discussed in Section 3.2, additional field investigations are required in order to refine the external phosphorus loading estimates from watershed land uses and septic systems. Section 4 provides a discussion of how the recommended phosphorus load reduction may be achieved.

Figure 5: Predicted In-Lake Phosphorus Concentration (µg/L) vs. Annual Phosphorus Load from External Watershed



4. OPTIONS FOR REDUCING PHOSPHORUS LOADING TO BABOOSIC LAKE

This section presents a discussion of potential measures that could be implemented in the Baboosic Lake watershed to reduce phosphorus loading to the Lake. As presented in the phosphorus loading budget in Section 3.2, external sources of phosphorus loading to Baboosic Lake include flowing tributaries, direct runoff, groundwater sources (including septic systems), and atmospheric deposition (including wetfall and dryfall). This section provides a discussion of potential phosphorus reduction measures that relate to storm water management, septic systems, and watershed land uses. Table 7 (pp. 48-50) provides an overview and prioritization of all proposed measures to reduce phosphorus loading that are presented in Section 4.

4.1 Storm Water Management

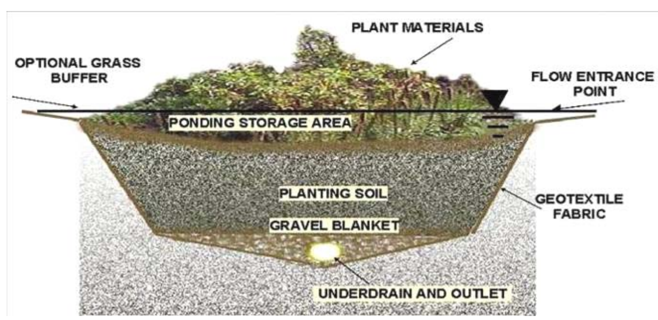
4.1.1 Description of Selected Storm Water Best Management Practices

Storm water best management practices (BMPs), including Low-Impact Development (LID) techniques, are management approaches that reduce storm water impacts through a variety of small-scale techniques that are distributed throughout a watershed. LID techniques aim to mimic pre-development hydrology by using small-scale practices that infiltrate, evaporate and transpire storm water. Examples of LID techniques include bioretention cells, rain gardens, and vegetated filter strips. These techniques can be incorporated directly into the design of new developments, or can be retrofit into existing developed areas, often replacing or enhancing direct pipe discharges to water bodies such as Baboosic Lake. Examples of other storm water management BMPs include unpaved road management and stabilization techniques.

The sections below provide a general description of storm water BMPs and LID improvements that are recommended for use at specific sites within the watershed as described in Section 4.1.2.

Bioretention Cells/Rain Gardens

Bioretention cells are shallow landscaped depressions that incorporate plantings and an engineered soil mixture with a high infiltration rate. Bioretention cells are used to: control storm water runoff volume by providing storage capacity; reduce peak discharge by increasing the travel time of storm water through a watershed; and remove pollutants through physical, chemical and biological processes that occur in the plants and soil media.



A cross-section of a typical bioretention cell.

Storm water that drains into a bioretention cell accumulates in a shallow depression and infiltrates the engineered soil mixture. Bioretention cells are typically designed to provide an infiltration rate approximately equal to the peak discharge rate associated with the 10-year, 24-hour storm event. Infiltration rates are enhanced during the growing season by uptake from vegetation (i.e., evapotranspiration) within the cell.

Installed costs for engineering, materials and construction of a typical bioretention cell are estimated between $3,000 (for a small individual shallow cell) up to $30,000 (for a large retrofit cell that involves significant earth work). The installed costs also depend on site-specific requirements. Pre-fabricated bioretention cells (e.g., Filterra™) can treat storm water runoff from an area up to 0.25-acres and cost approximately $7,000 each (installed cost). Rain gardens are small-scale bioretention cells.

A rain garden installed on a residential property.

Rain gardens are shallow vegetated depressions designed to capture and infiltrate storm water runoff. Rain gardens are often appropriate for residential developments, to treat storm water from impervious areas associated with individual lots. The total installed cost of a typical rain garden is approximately $1,500 to $4,000, depending on garden size, soil conditions, type of plantings used, and other site-specific requirements.

Unpaved Road Best Management Practices

Unpaved roads, if not properly managed, can be a significant contributor of non-point source pollution. Structural BMP techniques and preventative maintenance practices can reduce unpaved road erosion and improve downstream water quality while potentially reducing the cost of road maintenance. Storm water or surface water accumulated on or adjacent to unpaved roads can create an unstable road bed, resulting in rutting, potholes, shoulder erosion, washouts, and clogged culverts. Poor drainage can also result in sediment deposits at culverts and in ditches and cause flooding. In addition, erosion of unpaved roads can result in sediment loads to downstream receiving waters. Unpaved road BMPs and preventative maintenance practices include:

- **Surface Grading** is one of the most important aspects of maintaining a gravel road surface. Surface grading is conducted to preserve and maintain a proper road crown for good drainage. When grading, maintain a safe distance (minimum one foot) from the ditch so that vegetation or rock ditch stabilization is not disturbed.
- **Shoulder Maintenance** is an important unpaved road management practice to maintain proper drainage of storm water from the traveled portion of the road to the side slope and into ditches. The shoulder should help separate the traveled way from the side slopes and ditches. The shoulder should be kept clear of vegetation so that water can freely drain from traveled portions into adjacent ditches.
- **Storm Water Ditches** are used to convey storm water runoff from the shoulders to an outlet without causing erosion or sedimentation. Ditches should be properly lined (e.g., rock or vegetation) to prevent erosion. Regular maintenance should be performed to keep ditches clear and stable, and maintain the original capacity.
- **Culverts** are closed conduits (e.g., pipes) typically used to convey storm water across unpaved roads. Culverts are important in preserving the road base by draining water from road side ditches and thereby keeping the road sub-base dry. Culverts should be inspected on a regular basis. The inlets and outlets of culverts should be protected by marking their location, stabilizing, and maintaining ditch linings (both up gradient and down gradient of culverts) to prevent erosion and clogging.

- **Bank Stabilization** is the vegetative or structural means used to prevent erosion and failure of any side slope or bank. Unpaved road banks should be carefully evaluated before selecting stabilization techniques. Vegetation should be used whenever possible as a cost-effective way to stabilize banks. Additionally, recently stabilized banks should be regularly maintained and inspected to ensure that adequate stabilization is established.

Stone Infiltration Trenches

Infiltration trenches are typically deep stone filled trenches lined with a non-woven geotextile. The base of the trench can be stepped to maximize storage capacity and promote infiltration. Infiltration trenches are used to: control storm water runoff volume by providing storage capacity; promote infiltration; and remove sediment and associated pollutants through filtration. Storm water that drains to an infiltration trench either infiltrates the stone immediately or flows on the stone surface a short distance before infiltrating. Storm water then filters through the stone and percolates to the base. The storm water then infiltrates the existing subsurface and recharges the aquifer.

Infiltration trenches are typically designed to provide an infiltration rate approximately equal to the peak discharge rate associated with the 10-year, 24-hour design storm event. Infiltration trenches typically include a maintenance stone layer at the top of the trench that can be easily removed, cleaned and replaced.

The installed cost for engineering, materials and construction of a typical infiltration trench is estimated between $200 to $800 per linear foot of trench, depending on trench size, material and site-specific requirements.

A stone-filled infiltration trench constructed to intercept runoff from the adjacent unpaved road in the Silver Lake watershed (Harrisville, NH).

Vegetated Buffer Strip

Vegetated buffer strips are vegetated areas designed to treat overland flow from adjacent surfaces. Vegetated buffers are designed to: reduce flow velocities; trap sediment and other pollutants; and promote infiltration. If designed properly, vegetated buffers can provide relatively high pollutant removal while providing an aesthetic landscape feature. Storm water that drains through a vegetated buffer strip filters through the vegetation, which reduces the flow velocity. The runoff then either drains through the buffer strip or infiltrates the soil media and subsurface.

A newly planted shrub buffer installed adjacent to the Lake Wyola State Park beach in Shutesbury, MA.

Vegetated buffers are typically designed to treat runoff from areas less than 60 feet in width measured perpendicular to the buffer strip. Slopes along a vegetated buffer strip should not exceed 5%. Vegetated buffers should include a diverse selection of low growing, drought tolerant, native vegetation. The species should be selected so that the growing season corresponds to the wet season to optimize plant uptake (i.e., evapotranspiration).

Vegetated buffers can also act as a physical and visual barrier to deter geese and other waterfowl from using shorelines directly adjacent to a water body. Geese prefer a clear line of sight and unobstructed access between a food source and the adjacent water body. The buffer breaks the clear line of sight and therefore discourages geese from using the area as a food source. Vegetated buffers for goose control should include plants at least three feet tall.

Installed cost for engineering, materials, and construction of a typical vegetated buffer is estimated between $50 to $400 per linear foot of buffer, depending on buffer width, material and site-specific requirements.

Vegetated Swales

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and convey runoff to downstream discharge points. Vegetated swales are alternatives to conventional piped storm water conveyances and are used to: reduce runoff flow velocities, filter storm water runoff through vegetation and soil media, trap pollutants, and infiltrate storm water runoff.

Installation of turf reinforced mat (TRM) for a vegetated swale.

Vegetated swales are typically designed to convey storm water runoff from a 25-year, 24-hour design storm event in a non-erosive manner while maintaining a conservative freeboard (i.e., height between water surface and top of swale). The swale should have longitudinal slopes not exceeding 2.5%. The swale configuration should take into account maintenance requirements (e.g., mowing) and storm water treatment goals. Swales should be lined with a material that will inhibit erosion. These materials include turf reinforced mat (TRM), vegetation and rock. Vegetation in swales should include a diverse selection of native plant species that thrive under site-specific conditions.

Installed cost for engineering, materials and construction of a typical vegetated swale is estimated between $200 to $600 per linear foot of swale, depending on the depth and width of swale, material and site-specific requirements.

Rain Barrels and Rainwater Harvesting Systems

Rain barrels or cisterns are above-ground storage vessels with either a manually operated valve or a permanently open outlet. These devices are designed to capture and temporarily store roof runoff. The stored water is then released for irrigation or infiltration between storms. Rain barrels are used to capture and store runoff associated with the first flush of a storm event and reduce pollutant loads, including thermal pollution.

Installed costs for a rain barrel or cistern system is estimated between $50 and $250 depending on the size and intended uses of the stored storm water.

A typical rain barrel application.

Porous Pavement

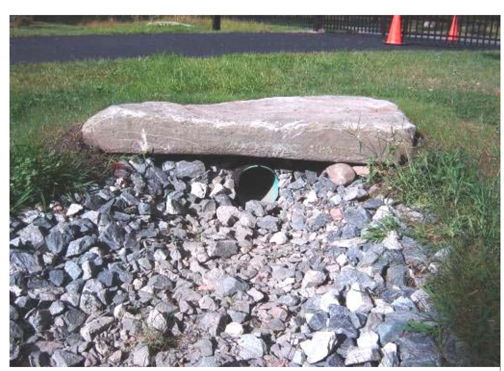
Porous pavement is an LID technique that uses pervious material to replace an impervious material, promoting infiltration and reducing storm water runoff volume. Porous pavement allows storm water to soak into the ground, reducing the discharge of pollutants while increasing groundwater recharge.

Porous pavers are designed with a stone infiltration bed installed below the pervious surface. The voids between the pavers are typically filled with small crushed stone that drain storm water to the stone infiltration bed. The porous asphalt functions in the same way, containing voids to allow water to percolate into the underlying infiltration bed.

Uni Eco-stone porous interlocking pavers

Rock Inlet Protection

Inlet protection devices are typically either manufactured devices made for temporary use at construction sites or permanent fixtures installed at inlet structures to provide long-term protection and storm water management. Permanent inlet protection consists of rock installed in a ring around the inlet structure. The rock device can be excavated deep into the sub grade to provide storm water storage capacity and promote infiltration. If an inlet is located in a swale or depression that receives high flow velocities, the rock device can be shaped as a "key-hole"



Rip-rap used to protect and stabilize a culvert inlet.

with rock extending up gradient of the inlet structure. This configuration reduces flow velocities prior to entering the inlet and provides filtration. These devices can be effective in unpaved road applications by providing filtration of sediment-laden storm water.

The installed cost for engineering, materials and construction of a permanent inlet protection device is estimated between $500 and $1,000 per device, depending on the depth of the device and site-specific requirements.

Bioengineering Techniques

Bioengineering is the practice of using living woody and herbaceous material with organic and inorganic materials to increase the strength and structure of the soil to reduce erosion. The above ground vegetation increases the resistance to flow and reduces flows velocities by dissipating energy. The biomass also acts as a buffer against the abrasive effect of transported materials and promotes sediment deposition. Bioengineering designs incorporate native plant material collected during the dormant season and a range of plant species and sizes depending on the site-specific requirements.

Live stakes of quick-rooting tree and shrub species can be used to stabilize and establish vegetation on eroding slopes.

Bioengineering techniques are typically labor-intensive relative to material and engineering cost. Materials can be obtained from the local landscape (if allowed) and standard bioengineering details can be used. Installed costs for biostabilization is estimated between $50 to $300 per square yard depending on site access, material availability and the site specific requirements.

Energy Dissipation and Level Spreader Devices

Outlet protection is a physical device composed of rock, rip-rap or recycled concrete rubble which is placed at the outlet of a pipe or channel to prevent scour of the down gradient soil caused by concentrated, high velocity flows. Level spreader devices are typically pre-cast concrete structures that are used to convert channelized flow into sheet or shallow concentrated flow. Level spreader devices are typically installed at culvert outfalls to reduce erosion of downstream channels or areas. Outlet protection designs vary and are based on the discharge rate and pipe diameter. Typical outlet protection and level spreader designs are based on the peak discharge resulting from a 25-year, 24-hour design storm event.

Installed cost for engineering, materials and construction of a typical outlet protection device is estimated to be $200 to $400 per device, depending on the site-specific requirements.

Drop Inlet Maintenance

Drop inlet structure maintenance includes trash removal if a screen or other debris capturing device is used, and removal of accumulated sediment and leaf debris from structure grates and sumps. Operators need to be properly trained in catch basin maintenance and should maintain a log of the amount of sediment collected, and the date of removal. Catch basins should be cleaned when accumulated sediment reaches no more than 60% of the sump capacity or at least twice per year. The cleared debris should be properly disposed of in accordance with local regulations.

Maintenance costs are a function of the number of structures, accessibility and method of cleaning (e.g., hand, vac-truck). Annualized maintenance costs based on one inlet device, excluding disposal costs, is estimated between $1,000 and 2,000 per year. Depending on the rules within a community, disposal costs of the sediment captured in catch basins may be significant.

Detention Basin

Storm water management systems often include storm water detention basins. Dry detention basins are basins whose outlets have been designed to detain the storm water runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow particles and associated pollutants to settle. Dry ponds function to: store storm water and reduce peak discharge rates; trap pollutants, and provide flood control. Dry detention basins are typically designed according to local storm water regulations and are typically configured with a length to width ratio of at least 1.5:1. The drawdown time (i.e., time to drain basin) is typically a minimum of 48-hours.

Installed cost for engineering, materials and construction of a typical detention basin is estimated between $10,000 for a small basin with little earthwork to $100,000 for a large basin with significant earthwork.

4.1.2 Field Watershed Investigation

Bob Hartzel (Senior Water Resources Scientist) and Daniel Bourdeau (Water Resource Engineer) of Geosyntec conducted a field investigation of the Watershed on 23 August 2006. Mr. Hartzel and Mr. Bourdeau are both Certified Professionals in Sediment and Erosion Control (CPESC). A CPESC is a recognized specialist in soil erosion and sediment control, with certification by the Soil and Water Conservation Society and the International Erosion Control Association. The field investigation was conducted following a rain event that occurred on 20 August 2006 that resulted in a 24-hour accumulation of 1.56 inches of rain. During the field investigation, Geosyntec identified several sites that were potential sources of pollutants and potential sites for implementing storm water best management practices (BMPs) and improvements. A description of the sites identified during the 23 August 2006 field investigation and recommended improvements are presented in the following pages. Generic descriptions of recommended BMP improvements that may be implemented at specific sites within the Watershed are provided in Section 4.0.

It is important to note that the sites discussed in this section are not intended to be a comprehensive listing of recommended stormwater improvements in the Baboosic Lake watershed. Rather, these sites are representative examples of potential stormwater improvements and retrofits that could be implemented at numerous sites throughout the watershed.

SITE #1: Four Seasons Community Private Park, Site A

Site Summary:

The Four Seasons Community owns a private park area on the southeast corner of the Lake. Storm water runoff from vegetated portions of the site discharges overland onto the park's beach area (Photo 1-1). A portion of this vegetated area, between the boat ramp and the stairs, is vegetated with grass and slopes toward the Lake (Photo 1-2). Canada geese and goose feces were observed in this area during the field investigation. Erosion was observed immediately down gradient of this sloped area (Photo 1-3). The private beach area is used for swimming and boating by residents of the Four Seasons development.

Photo # 1-1

Proposed Improvement:

Geosyntec recommends installation of a <u>vegetated buffer strip</u> along the slope, between the stairs and the boat ramp. The buffer strip would deter geese from accessing the area. The buffer would also filter storm water runoff from the upgradient areas prior to draining onto the beach and into the lake. The buffer strip would include:

- Soil amendments to ensure an adequate growth media for planted shrubs.
- A mixture of herbaceous and shrub plantings to create a visual and physical barrier to deter geese from accessing the grassed area. This would help reduce the amount of goose droppings and associated pollutants introduced to the beach area.
- In addition, improvements may include beach nourishment along the toe of the slope to reduce the erosion that has been caused by storm water runoff.

Photo # 1-2

Estimated Cost: $5,000 to $7,000

Estimated Pollutant Load Reduction: 0.1 lbs P/yr (0.05 kg P/yr)

Photo # 1-3

SITE #2: Four Seasons Community Private Park, Site B

Site Summary:

Storm water runoff from Four Seasons Lane in the area of the park entrance drains into a road side ditch that discharges through a culvert under Sheridan Way (Photo 2-1) The culvert discharges into an unnamed tributary located southwest of the intersection of Sheridan Way and Four Seasons Lane. Erosion and scour was observed at the culvert outfall (Photo 2-2). However, evidence of erosion and sedimentation was not observed in the stream channel down gradient of the outfall (Photo 2-3).


Photo # 2-1

Proposed Improvement:

Geosyntec recommends that energy dissipation and a level spreader device be installed at the culvert outfall. Recommended improvements include:

- Install energy dissipation consisting of a rip-rap lined plunge pool to reduce erosion and provide protection at the outfall.
- Install a level spreader device to reduce flow velocities discharging from the culvert. The level spreader would convert channelized flows to non-erosive shallow concentrated flows.


Photo # 2-2

Estimated Cost: $1,000 to $1,600

Estimated Pollutant Load Reduction: 0.2 lbs P/yr (0.1 kg P/yr)


Photo # 2-3

SITE #3: Amherst Town Beach, Bath House

Site Summary:

The Amherst town beach is located in the southwest portion of the lake. Storm water runoff from the gravel town beach parking area is collected in a drop inlet structure located at the southeast corner of the bath house (Photo 3-1). The drop inlet structure discharges via a 12-inch diameter culvert to a drainage ditch along the north side of Broadway. The ditch also collects storm water runoff from Broadway and conveys these flows to an outfall located to the west of the town beach area (Photo 3-2). The outfall did not appear to be stabilized and erosion was observed at this location.

Storm water runoff from the bath house roof discharges from the north side of the roof to the picnic area (Photo 3-3). Erosion was observed in the sand immediately down-gradient of the bath house.

Photo # 3-1


Photo # 3-2


Photo # 3-3

Proposed Improvements:

Recommended improvements include:

- Install a pre-fabricated bioretention cell (i.e., Filterra) at the drop inlet adjacent to the bath house. The cell would infiltrate storm water or discharge during large storms via the exiting culvert. An educational kiosk could be installed to provide an educational component.
- Install a gutter and rain barrel system at the northeast corner of the bath house. The barrel would capture storm water from the roof rather than allow the runoff to drain onto the picnic area. The barrel would provide storm water storage and can be used as a non-potable water source for garden irrigation.
- Install an energy dissipation device at the outfall of the drainage ditch. The device would reduce erosion at the outfall.
- Additional improvements include removing accumulated debris (i.e., sediment) from the drainage ditch and improving the channel lining (i.e., pavement) in portions that have been damaged.

Estimated Cost: $8,000 to $9,000

Estimated Pollutant Load Reduction: 0.1 lbs P/yr (0.05 kg P/yr)

SITE #4: Amherst Town Beach, Picnic Area

Site Summary:

Storm water runoff from portions of the gravel town beach parking area drain via overland flow toward the grassed picnic area located to the north of the parking area (Photo 4-1). These flows drain overland through the grassed picnic area and discharge onto the beach area before entering the Lake (Photo 4-2). Erosion was observed in the beach immediately down gradient of the grassed picnic area (Photo 4-3).

Photo # 4-1

Proposed Improvement:

Storm water improvements recommended at the town beach picnic area include:

- Install a gravel infiltration trench along the north side of the unpaved parking area. The trench would be comprised of gravel and would provide storm water storage capacity and promote infiltration.
- Install a bioretention cell immediately north of the parking area to capture storm water runoff from the parking and picnic area. The cell would filter storm water runoff and provide infiltration rather than discharging through the picnic area and onto the beach.
- Additional improvements include stabilizing the eroded and exposed portions of the picnic area with loam and vegetation.

Photo # 4-2

Estimated Cost: $9,000 to $11,000

Estimated Pollutant Load Reduction: 0.2 lbs P/yr (0.1 kg P/yr)

Photo # 4-3

SITE #5: Lakeside Drive and Greenwood Drive

Site Summary:

Storm water runoff from the paved portions of Lakeview Drive (near the intersection of Surrey Lane) drains onto unpaved portion of Lakeview Drive (Photo 5-1). The runoff is collected in several drop inlet structures located along the edge of the unpaved road (Photo 5-2). At least two of these structures, in the area of Surrey Lane, discharge to an unnamed tributary that drains south toward the Lake. Sediment was observed in the unnamed tributary (Photo 5-3). Several other inlet structures appeared to be blocked with leaf litter and accumulated sediment.

Photo # 5-1

Proposed Improvement:

Recommended storm water improvements storm in this area include:

- Install rock inlet protection devices at drop inlet structures. These devices would be "key-hole" shaped and comprised primarily of rock underlain with a geotextile. The device would filter storm water runoff prior to entering the drop inlets. Depending on sub-base material and water table, the protection devices could be excavated deep to provide maximum storm water storage and promote infiltration.

Photo # 5-2

- Restore and stabilize the unnamed tributary that receives storm water from the inlet structures. Biostabilization techniques are recommended to achieve stabilization goals and provide vegetative trapping and uptake of nutrients.
- Depending on the condition of each drop inlet structure (i.e., solid concrete bottom), increase the sump capacity of each structure. The increased sump would provide additional capacity to capture sediment.

Photo # 5-3

- Additional BMPs to improve storm water quality include a maintenance program to clear drop inlet grates and clean accumulated sediment from the structure sumps.

Estimated Cost: \$8,000 to \$10,000 (based on four drop inlet structures)

Estimated Pollutant Load Reduction: 0.1 lbs P/yr (0.05 kg P/yr)

SITE #6: #24 Lakeside Drive

Site Summary:

Storm water runoff from the forested area to the north of Lakeside Drive drains onto an existing paved parking area (Photo 6-1). These flows are primarily collected in a drop inlet structure located in the paved area (Photo 6-2). The structure apparently drains into a second drop inlet structure located on the north side of Lakeside Drive (Photo 6-3). This structure also receives storm water runoff from a portion of the unpaved Lakeside Drive. The structure discharges via a culvert directly to the lake.


Photo # 6-1


Photo # 6-2


Photo # 6-3

Proposed Improvement:

Recommended storm water controls and improvements include:

- Replace the existing impervious asphalt parking area with pervious porous-pavers. This would promote infiltration and reduce the volume of storm water runoff that is collected in the drop inlet structure and discharged to the lake.
- Install a pre-fabricated bioretention cell (i.e., Filterra) to replace the existing drop inlet structure on the north side of Lakeside Drive. The bioretention cell would overflow during large runoff events via the existing culvert that drains into the lake.

Estimated Cost: $11,000 to $12,000

Estimated Pollutant Load Reduction: 0.1 lbs P/yr (0.05 kg P/yr)

Site #7: Jebb Road

Site Summary:

Storm water runoff from Jebb Road in the area of house #17 drains via overland flow to a low-point in the road (Photo 7-1). The runoff then drains into a small depression located along the east side of Jebb Road (Photo 7-2). The small depression also receives flows from two culverts that apparently drain other portions of Jebb Road. The depression drains via a small diameter culvert to the west, directly to the lake (Photo 7-3).

Photo # 7-1

Proposed Improvement:

Recommended storm water improvements in the area of #17 Jebb Road include:

- Install a retrofit bioretention cell at the existing depression along the east side of Jebb Road. The depression could be expanded to the north and south to provide additional storage capacity.
- Install rock baffles in the bioretention cell to divert inflows in a flow pattern that would not cause hydraulic short-circuiting in the bioretention cell.
- Install energy dissipation at the exiting culvert outfall at the beach.

Photo # 7-2

Photo # 7-3

Estimated Cost: $6,000 to $8,000

Estimated Pollutant Load Reduction: 0.1 lbs P/yr (0.05 kg P/yr)

Site #8: #30 Lakeside Drive

Site Summary:

Storm water runoff from the northern end of Lakeside Drive (in the area of house #30) drains via overland flow to the north (Photo 8-1). The runoff is collected in a drop inlet structure located to the north of Lakeside Drive adjacent to the driveway to house #30 (Photo 8-2). The drop inlet appears to discharge via the Lakeside storm drain system directly to the lake (Photo 8-3).

Photo # 8-1

Proposed Improvement:

Recommended storm water improvements in the area of #30 Lakeside Drive include:

- Install a retrofit bioretention cell at the existing drop inlet device. The bioretention cell would infiltrate storm water runoff of overflow during large runoff events via the existing storm drain.
- Repair the existing energy dissipation at the outfall on the west side of Lakeside Drive.

Photo # 8-2

Estimated Cost: $7,000 to $9,000

Estimated Pollutant Load Reduction: 0.5 lbs P/yr (0.2 kg P/yr)

Photo # 8-3

SITE #9: Paul's Boat Ramp

Site Summary:

Paul's boat ramp is a private boat ramp located on along the east shore of the lake near 310 Baboosic Lake Road (Photo 9-1). Storm water runoff from the unpaved road leading to the boat ramp drains via overland flow toward the lake (Photo 9-2). Erosion was observed in the ramp area. Accumulated sediment from erosion of the up-gradient portions of the unpaved road was also observed (Photo 9-3).

Photo # 9-1

Proposed Improvement:

Storm water improvements at Paul's boat ramp include:

- Construct a stabilized boat ramp using porous pavers. The stabilized portion should extend at least one-third of the way up the unpaved road.
- Construct a defined grass-lined channel along the northern side of the unpaved road and proposed ramp to convey storm water runoff from upgradient portions of the road to the lake. Stone check dams should be installed to reduce flow velocities and capture sediment.

Photo # 9-2

Estimated Cost: $8,000 to $12,000

Estimated Pollutant Load Reduction: 0.1 lbs P/yr (0.05 kg P/yr)

Photo # 9-3

SITE #10: North Jebb Road

Site Summary:

Storm water runoff from portions of North Jebb Road near the intersection with Jebb Road is collected in drop inlet devices (Photo 10-1). The drop inlet device along the east side of North Jebb Road discharges via a culvert to a drop inlet along the west side of the road (Photo 10-2). This drop inlet discharges to the lake via the Jebb Road storm water system. The westernmost drop inlet structure was buried in accumulated sediment and leaf debris (Photo 10-3).

Photo # 10-1

Proposed Improvement:

Storm water improvements at the intersection of North Jebb Road and Jebb Road include:

- Install a pre-fabricated bioretention cell (i.e., Filterra) at the westernmost drop inlet structure. The structure is located adjacent to a large diameter deciduous tree and may require adjustment during construction depending on the root structure.
- Additional BMPs to improve storm water quality include a maintenance (i.e., cleaning) program to clear drop inlet grates and clean accumulated sediment from the structure sumps.

Photo # 10-2

Estimated Cost: $7,000 to $8,000

Estimated Pollutant Load Reduction: 0.2 lbs P/yr (0.1 kg P/yr)

Photo # 10-3

SITE #11: 24 Greenwood Drive

Site Summary:

Storm water runoff from portions of Greenwood Drive in the area of house #24 drains to a low-point in Greenwood Drive (Photo 11-1). The accumulated storm water drains via a small diameter pipe that appeared to be partially blocked with accumulated sediment (Photo 11-2). The pipe appears to discharge south toward the lake. Erosion was observed in the area of the pipe outfall (Photo 11-3).

Proposed Improvement:

Storm water improvements in the area of 24 Greenwood Drive are recommended to include:

- Re-grade the portion of Greenwood Drive in the area of house #24 so that storm water drains north into the wetland system adjacent to the road. The wetland system will provide storm water treatment, infiltration and provide storage capacity.
- Clear the pipe inlet of accumulated sediment and install rock protection at the inlet.
- Install energy dissipation at the pipe outfall.

Estimated Cost: $2,000 to $3,000

Estimated Pollutant Load Reduction: 0.1 lbs P/yr (0.05 kg P/yr)

Photo # 11-1

Photo # 11-2

Photo # 11-3

SITE #12: Lakeside Drive

Site Summary:

Storm water runoff from portions of Lakeside Drive in the area of house #12 drain overland and is collected in drop inlet structures located along the northern side of the road (Photo 12-1). At least one of these inlet devices was blocked with accumulated sediment and leaf debris (Photo 12-2). The drop inlets appear to discharge through a culvert to an unstabilized channel adjacent to the lake (Photo 12-3). Erosion was observed in the channel between the culvert outfall and the lake.

Photo # 12-1

Proposed Improvement:

Storm water improvements in the area of 12 Lakeview Drive include:

- Install rock inlet protection devices at drop inlet structures. These devices would be "key-hole" shaped and comprised primarily of rock underlain with a geotextile.
- Restore and stabilize the channel that receives storm water from the inlet structures. Biostabilization techniques are recommended to achieve stabilization goals as well as provide additional filtration.
- Install energy dissipation at the channel outfall at the lake. The energy dissipation would reduce erosion at the outfall.
- Additional BMPs to improve storm water quality include a maintenance program to clear drop inlet grates and clean accumulated sediment from the structure sumps.

Photo # 12-2

Estimated Cost: $6,000 to $8,000 (based on two drop inlet structures)

Estimated Pollutant Load Reduction: 0.2 lbs P/yr (0.1 kg P/yr)

Photo # 12-3

SITE #13: Autumn Lane

Site Summary:

Storm water management associated with Autumn Lane generally consists of a series of vegetated swales that drain to a culvert under Autumn Lane. The culvert discharges these flows into an undefined channel that drains into a wetland area prior to discharging to the lake (Photo 13-1). Severe erosion was observed in the unstabilized channel immediately down gradient of the culvert outfall (Photo 13-2). Sediment was observed in the lower reach of the channel in the location of the wetland (Photo 13-3). However, the wetland was densely vegetated and there did not appear to be evidence of erosion within the wetland area.

Photo # 13-1

Proposed Improvement:

In general, flows from the contributing watershed into the channel immediately down gradient of the Autumn Lane culvert can be characterized by high peak discharge rates. Storm water improvements made to the channel are end-of-pipe improvements that are not necessarily a long term solution. The long-term solution is to improve storm water management by increasing storm water storage volume within the watershed. The design should mimic pre-development flow conditions to reduce the peak discharge rates. These long term solutions may include LID techniques (as described in Section 2.0) distributed throughout the contributing watershed. However, immediate improvements are recommended to include:

Photo # 13-2

Photo # 13-3

- Install energy dissipation and a level spreader device at the culvert outfall to reduce flow velocities.
- Construct a stepped rock-lined down chute between the culvert outfall and the down stream wetland system. Install a level spreader device at the outfall of the down chute at the wetlands. The down chute should be constructed using existing boulders as well as imported rock to create cascading plunge pools.

Estimated Cost: $8,000 to $10,000
Estimated Pollutant Load Reduction: 0.6 lbs P/yr (0.3 kg P/yr)

SITE #14: Carter Road

Site Summary:

Storm water runoff from portions of Carter Road (in the area of the intersection with Arnold Road) drain via overland flow toward the lake (Photo 14-1). The runoff is either captured in drop inlet structures or continues to flow overland onto the unpaved extension of Carter Road (Photo 14-2). These flows ultimately drain or discharge via a culvert to a rock-lined area adjacent to the lake (Photo 14-3). Some of the rock had been eroded and rills were observed in portions of this area.

Photo # 14-1

Proposed Improvement:

Storm water improvements in the area of #14 Lakeview Drive include:

- Install a vegetated swale along the south side of Carter Road, similar to the recently constructed swale along the north side of the road.
- Construct a small storm water basin adjacent to the south side of Lakeview Drive in the area of the culvert outfall. The existing culvert may be shortened to increase the area for a basin. The basin would provide storm water storage capacity and capture sediment prior to draining toward the lake.
- Construct a stepped rock-lined drainage channel between the basin outfall and the lake. The channel would be stabilized with rock and include steps or terraces to reduce flow velocities and trap sediment while providing an aesthetic value.

Photo # 14-2

Photo # 14-3

Estimated Cost: $16,000 to $20,000

Estimated Pollutant Load Reduction: 0.1 lbs P/yr (0.05 kg P/yr)

SITE #15: Walnut Hill Road/Clark Island Road

Site Summary:

Storm water runoff from the paved portions of Clark Road drain overland into an unlined channel along the south side the road (Photo 15-1). The channel was not stabilized and erosion was observed in portions of the channel, especially at the lower end of the channel (Photo 15-2). The channel drains into a beaver impoundment located on the south side of Clark Island Road. Accumulated sediment was observed at the channel outlet (Photo 15-3).

Photo # 15-1

Proposed Improvement:

Recommended improvements to the Clark Island Road drainage channel include:

- Constructing a rock-lined storm water channel along the south side of Clark Island Road. The channel could be up to 3-feet wide and would consist of rock underlain by geotextile. The channel should be constructed with a proper outfall structure.
- Install energy dissipation at the channel outfall at the beaver impoundment.

Photo # 15-2

Estimated Cost: $6,000 to $8,000

Estimated Pollutant Load Reduction: 1.3 lbs P/yr (0.6 kg P/yr)

Photo # 15-3

SITE #16: 20 Shore Road

Site Summary:

A forested area located to the north of Shore Road drains west via an unstabilized intermittent channel (Photo 16-1). The channel discharges into a drainage ditch along the north side of Shore Road. The channel, which also receives road runoff, drains through a culvert to a drop inlet structure located in the southeast corner of house #20 (Photo 16-2). The drop inlet structure discharges via a culvert to an undefined drainage ditch along the paved driveway to house #20 (Photo 16-3).


Photo # 16-1

Proposed Improvement:

The area of 20 Shore Road does not appear to present significant storm water quality concerns. However, recommended storm water improvements in the area include:


Photo # 16-2

- Install a pre-fabricated <u>bioretention cell</u> (i.e., Filterra) at the existing drop inlet structure in the southeast corner of the 20 Shore Road property.
- <u>Stabilize</u> the bottom of the channel along the north side of Shore Road. Stabilization measures may include erosion control mats and vegetation. Small woody vegetation may be planted in the channel bottom to help reduce velocities and filter storm water runoff. These plants include wild raisin, bayberry, sweet pepperbush, and meadowsweet.
- Construct a defined <u>storm water channel</u> along the 20 Shore Road driveway to convey storm water from the drop inlet structure to the outfall. The channel should be lined with erosion control mat, vegetation, and have proper energy dissipation at the outfall.


Photo # 16-3

Estimated Cost: $8,000 to $12,000

Estimated Pollutant Load Reduction: 0.1 lbs P/yr (0.05 kg P/yr)

SITE #17: Hillside Road/Broad Street

Site Summary:

Storm water runoff from unpaved portions of Hillside Road drain east via overland flow toward the lake (Photo 17-1). The runoff drains over the paved portion of Broad Street at the intersection (Photo 17-2). These flows discharge over a stone wall and through a vegetated buffer prior to entering the lake (Photo 17-3). The stone wall had been washed-out and repaired prior to the field investigation. Accumulated sediment was observed on the paved portion of Broad Street.

Photo # 17-1

Proposed Improvement:

Recommended storm water improvements in the area of the intersection of unpaved Hillside Road and paved Broad street include:

- Construct a <u>vegetated swale</u> along either side of unpaved Broad Street.
- <u>Regrade</u> the unpaved road to drain toward the swale.
- Install a <u>drop inlet structure</u> and culvert to capture storm water in the swale and convey these flows across the paved portion of Broad Road.
- Install <u>energy dissipation</u> device at the culvert outfall to the lake.

Photo # 17-2

Estimated Cost: $14,000 to $18,000

Estimated Pollutant Load Reduction: 0.1 lbs P/yr (0.05 kg P/yr)

Photo # 17-3

4.1.3 Estimated Storm Water BMP Pollutant Load Reduction

Pollutant load reductions were estimated for each of the proposed improvements described above in Section 4.1.2. The phosphorus load reductions were estimated using published pollutant reduction rates for BMPs as follows: The predicted phosphorus load entering each BMP was estimated based on the land cover in the drainage area contributing flows through the BMP. Each BMP drainage area was delineated based on United States Geological Survey (USGS) topography maps. Next, land use categories were interpreted from aerial maps and assigned to the drainage area. An annual pollutant load was estimated for each catchment using the land-use based model as described in Section 3.1. This pre-BMP annual pollutant load represents the amount of pollutant expected to enter the Lake if the BMP was not in-place. Next, published BMP reduction values were used to estimate the total amount of phosphorus which is expected to be removed (provided that the improvement is properly installed and maintained). The post-BMP pollutant load represents the pollutant load predicted to enter the Lake if the BMP was installed. The results of the land-use loading model are provided in Table 5 on the following page.

The BMPs proposed for Sites 1-17 would reduce the annual phosphorus load to Baboosic Lake by an estimated 2.2 kg/year. This load reduction represents about 7.6% of the targeted phosphorus load reduction (28.9 kg/year) for Baboosic Lake as discussed in Section 3.4. However, as previously stated, Sites 1-17 are not intended to be a comprehensive listing of recommended stormwater improvements in the Baboosic Lake watershed. Rather, these sites are representative examples of potential stormwater improvements and retrofits that could be implemented at numerous sites throughout the watershed. Significantly greater phosphorus load reductions could be attained from a watershed-wide effort to improve stormwater management through LID practices (e.g. raingardens on residential lots) and improvements to existing storm water drainage features. As such, we estimate that a realistic range for phosphorus load reduction from a watershed-wide effort to install storm water BMPs is between 2.2 and 11 kg/year.

Table 5: Estimated Phosphorus Removal for Stormwater Improvement Sites

Site #	Site Description	Drainage Area (acres)	Annual Export (lbs/yr)	Annual Export (kg/yr)	BMP Type	BMP Reduction (% Capture)	Estimated Phosphorus Removal (lbs/yr)	Estimated Phosphorus Removal (kg/yr)
1	Four Seasons Park, Site A	0.6	0.3	0.1	Grassed Swale	20%	**0.1**	**0.05**
2	Four Seasons Park, Site B	5.2	1.3	0.6	Open Channel Vegetated	15%	**0.2**	**0.1**
3	Amherst Town Beach, Bath House	0.5	0.1	0.1	Filtration System	45%	**0.1**	**0.05**
4	Amherst Town Beach, Picnic Area	0.5	0.2	0.1	Vegetated Filter	75%	**0.2**	**0.1**
5	Lakeside Drive/Greenwood Drive	2.7	0.7	0.3	Open Channel Vegetated	15%	**0.1**	**0.05**
6	#24 Lakeside Drive	1.3	0.3	0.1	Filtration System	45%	**0.1**	**0.1**
7	Jebb Road	0.2	0.1	0.0	Vegetated Filter	75%	**0.1**	**0.05**
8	#30 Lakeside Drive	3.2	0.6	0.3	Vegetated Filter	75%	**0.5**	**0.2**
9	Paul's Boat Ramp	2.9	0.6	0.3	Grassed Swale	20%	**0.1**	**0.1**
10	North Jebb Road	2.9	0.5	0.2	Filtration System	45%	**0.2**	**0.1**
11	#24 Greenwood Drive	3.1	0.6	0.3	Open Channel Vegetated	15%	**0.1**	**0.05**
12	Lakeside Drive	3.0	0.6	0.3	Grassed Swale/ Infiltration	30%	**0.2**	**0.1**
13	Autumn Lane	17.6	3.9	1.8	Open Channel Vegetated	15%	**0.6**	**0.3**
14	Carter Road	1.7	0.4	0.2	Grassed Swale/ Infiltration	30%	**0.1**	**0.1**
15	Walnut Hill Road/ Clark Island Road	47.5	8.8	4.0	Open Channel Vegetated	15%	**1.3**	**0.6**
16	20 Shore Road	1.1	0.2	0.1	Filtration System	45%	**0.1**	**0.05**
17	Hillside Road/Broad Street	1.1	0.3	0.1	Open Channel Vegetated	15%	**0.1**	**0.05**
Total Estimated Phosphorus Removal:							**4.2**	**2.2**

4.2 Phosphorus Loading from On-Site Sanitary Systems

4.2.1 Estimated Total Phosphorus Load from On-Site Sanitary Systems

Geosyntec conducted an assessment to estimate phosphorus loads from on-site sanitary systems located in developed areas around Baboosic Lake. On-site sanitary systems considered in the analysis include septic tanks with leaching fields, septic tanks with chambers, cesspools, holding tanks, chemical toilets, dry-wells, and outhouses. Based on Geosyntec's analysis of high-resolution aerial images and information provided by Richard Sullivan of the Baboosic Lake Association, there are an estimated 142 homes around the immediate lake perimeter which are served by on-site septic systems. Based on information from the Baboosic Lake Association, occupancy of these homes can be categorized as follows:

- 80 year round homes;
- 38 homes used during the summer months (June 1 to September 30)
- 21 homes only used on the weekends during the summer months; and
- 3 vacant homes.

Many factors such as the age of the system, proximity to the lake, household occupancy, and soil permeability contribute to the phosphorus loading to the lake resulting from on-site sanitary systems. As a result of the inherent variability of these factors, estimates of phosphorus loads from on-site sanitary systems are subject to an inherent degree of uncertainty.

The estimated annual phosphorus load to Baboosic Lake from on-site sanitary systems is 89 kg P/yr, as calculated using the following equation:

$$M = (E_S)(\#\ \text{Capita Years})(1 - S_R)$$

Where:

M is the predicted phosphorus loading;

E_s is the phosphorus export coefficient of 0.82 kg P/capita-year (1.8 lbs P/capita-year). E_S was determined based on the "middle range" estimate per Reckhow et al., 1980.

 # Capita Years is the product of the number of parcels (142 parcels) multiplied by the average number of residents per parcel (2.3 residents/parcel) and the average occupancy;

S_R is the soil retention coefficient (0.5). S_R was determined based on typical values in southern New Hampshire and is the "low range" estimate per Reckhow et al., 1980.

<u>Calculations</u>

P load per home = 0.82 kg per capita/year x 2.3 people/home = 1.88 kg/home/yr.

80 homes x 1.88 kg/home/yr. = 150.4 kg/year x 0.5 (soil retention) =	75.2 kg/yr.
38 homes x 1.88 kg/home/yr. x 0.33 (four months per yr.) x 0.5 (soil retention) =	11.9 kg/yr.
21 homes x 1.88 kg/home/yr. x 0.095 (four months, weekends) x 0.5 (soil retention) =	1.9 kg/yr.
3 vacant homes =	0.0 kg/yr.
Total =	89.0 kg/yr.

4.2.2 Existing and Potential Community Septic System Locations

CLD Engineers has been contracted by the town of Amherst for design of a community wastewater system for a portion of the Baboosic Lake watershed. The area of the planned community septic system improvements is in the vicinity of Moonbeam Cove, primarily along the streets of Broadway, Clark Avenue and West Street. Construction of the system will be implemented in three phases. Phase 1 was recently completed, Phase 2 will be completed in spring of 2008, and Phase 3 is scheduled for completion by fall 2008. In total, 34 homes are planned for inclusion in the community wastewater treatment system. A map of the areas to be served by the system is included in Figure 6.

As described above in Section 4.2.1, Geosyntec has estimated an annual phosphorus load of 89 kg/year from on-site septic systems around the Baboosic Lake shoreline. This estimate does not reflect estimated load reductions from the Phase 1-3 community wastewater treatment system improvements described above. Assuming that there are 139 occupied homes (year-round and seasonal) and three vacant homes around the lake, the average annual phosphorus load per home is 0.64 kg/year. Assuming that the Phase 1-3 community septic system will result in a phosphorus loading reduction range of 75% for 34 homes, phosphorus loading will be reduced by an estimated 16.3 kg/year. The total cost the Phase 1-3 improvements are estimated at approximately $1 million dollars, or approximately $30,000 per household.

Geosyntec conducted a preliminary review of additional potential areas for community septic systems (Table 6). The review was based on (1) the density of existing homes in close proximity to the Lake and tributaries and (2) data on soil types and soil drainage classes in the areas surrounding the Lake. The majority of the soils surrounding the Lake are characterized as a Canton Stony Fine Sandy Loam or a Chatfield-Hollis Complex soils. Further studies including a detailed soils analysis, surveys of property owner buy-in, and existing site conditions must be done to determine the appropriateness of sites A though E for community septic improvements.

Table 6 on the following page includes details regarding the three existing and proposed sites from CLD and the five additional potential locations identified by Geosyntec.

Table 6: Existing and Proposed Community Septic System Locations

Area	Estimated # of Homes	Location
Phase I	11	Phase I of the Community Wastewater System is complete, though not all homes are connected (as of May 2008). Phase I of the community septic improvements is located west of Moonbeam Cove along West Street and Washer Cove Road.
Phase II	10	Phase II of the Community Wastewater System is expected to be completed in Spring of 2008. Phase II improvements will be located south of Moonbeam Cove along Broadway.
Phase III	13	Phase II of the Community Wastewater System is expected to be completed in Fall of 2008. Phase III will be located north of Moonbeam Cove along Clark Avenue and a Private Way north of Moonbeam Cove.
A	31	Area A includes the properties south of the proposed Phase II improvements located along Broadway and Milford Street.
B	42	Area B includes the properties along the eastern side of the lake located west of Shore Drive, north of Scenic Vista Way, and south of Miriam Way.
C	34	Area C is located on the western side of the lake and includes the homes along Lake Front Street.
D	30	Area D includes all lakefront properties in the northeastern portion of the lake including those accessed by Jebb Road, Northend Way, and Langer Way.
E	30	Area E is located immediately south of Area B and includes all lakefront properties along Lakeside Drive and Greenwood Drive.

The installed cost for a community septic system can vary widely depending on site-specific conditions such as soils, slopes, piping distances, etc. In general, the cost of a community system per household will decrease significantly as the number of homes sharing the system increases. Based on the estimated installed cost of Phases 1 through 3, the estimated cost per household for a community septic system is approximately $30,000 per household. The cost of building additional community septic systems and connecting the 167 additional homes identified in Areas A through E to the system would be approximately $5,010,000. Annual maintenance costs are estimated at $5,000 ($200 annually per home).

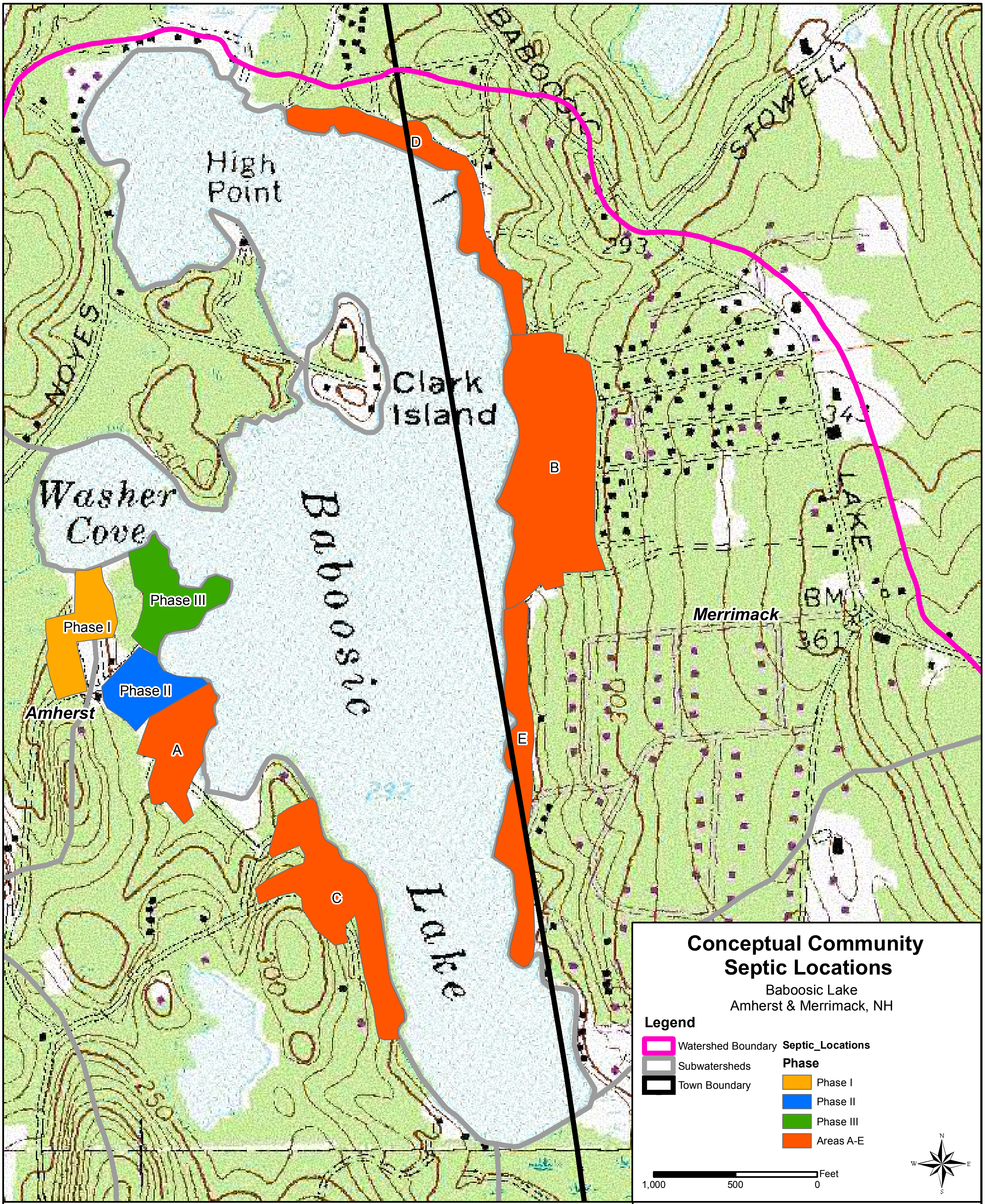
It is important to note that the phosphorus load reductions that may be achieved by installing community septic systems can vary widely depending on variables including: the proximity and condition of existing on-site septic systems; the location of the proposed community septic systems (e.g. distance from the lake); and treatment technology of the systems. The phosphorus loading estimates from septic systems presented in Section 4.2.1 include only the 139 occupied homes directly abutting Baboosic Lake. The proposed community septic locations also include homes which are close to, but do not directly abut the lake. For purposes of this report, we have conservatively estimated the phosphorus loading reductions from lakefront homes only. Assuming complete buy-in by lakefront property owners in Areas A through E, 105 lakefront homes would be served by community septic systems in these areas. Assuming a 75% reduction in phosphorus loading from these homes, the estimated total phosphorus load reduction would be 50.4 kg/year.

4.2.3 On-Site Wastewater Management Program

To help address issues related to proper ongoing maintenance and management of existing septic systems around Baboosic Lake, the Baboosic Lake Association (BLA) and the Towns of Amherst and Merrimack should consider establishment of an On-site Wastewater Management Program (OWMP). Program elements may include:

- Conduct a survey and GPS mapping of to obtain updated information on the location, age and type of septic systems around the perimeter of the Lake;
- Development of a municipal bylaw requiring regularly scheduled system inspections;
- Development of a bylaw requiring more stringent treatment standards in environmentally sensitive areas; and
- Development of homeowner education materials and related outreach efforts.

Initial costs that associated with development of an OWMP are estimated to be in the range of $5,000 to $7,500 including an estimated $3,000 to $4,500 for survey and GPS mapping efforts, and $2,000 to $3,000 for development, printing, and distribution of public education materials. These could be significantly lower with contributions of volunteer labor from the BLA and/or town committees. The cost estimate above does not include any cost sharing or rebates related to septic system pump-outs, although these types of incentives may be considered. No costs associated with development of bylaws or other regulatory activities are included in the above cost estimate. A phosphorus reduction efficiency of 5-10% is estimated for homes involved in an OWMP. Assuming that such a program would only apply to areas not included in the Phase 1-3 community septic system improvements; this would result in a phosphorus load reduction estimate of 3.3 to 6.7 kg/year for the remaining 105 lakefront homes.



Conceptual Community Septic Locations

Baboosic Lake
Amherst & Merrimack, NH

Geosyntec consultants

ACTON, MASSACHUSETTS

FIGURE NO. 6	
PROJECT NO.	BW0086
DATE:	05/13/08
Baboosic_Septic.mxd	

Q:\GISProjects\BW0086-Baboosic\Projects

4.3 Phosphorus Loading From Watershed Land Uses

4.3.1 Landscaping/Lawn Fertilizers

Landscaping fertilizers can be a significant source of phosphorus from areas of residential development and other areas where grass lawns are maintained (e.g. office parks, schools, sports fields, etc.). The Baboosic Lake Association and/or the Towns of Amherst and Merrimack could develop a program to reduce pollution from fertilizer applications within the watershed. Aspects of this program could be modeled after similar efforts that have been implemented successfully in other communities and include the following:

Landscaping fertilizers from grassed lawns, such as this property adjacent to Baboosic Lake, can be a significant source of phosphorus to water bodies.

- As an incentive to promote the use of phosphorus-free fertilizers, the Towns could offer this type of fertilizer to homeowners at a reduced price. Fertilizer providers (e.g. local hardware stores, etc.) would be selected to provide reduced-priced fertilizer for homeowners living in targeted watershed areas. The retailers would be subsidized by the Town for the balance of the fertilizer cost. Homeowners using the fertilizer would be provided signage (optional) to post in their yard, which would educate neighbors about the phosphorus-free fertilizer, and its role in protecting pond water quality. A follow up survey is recommended to evaluate the performance of the program. Printed public outreach materials (e.g., brochure, flyer) are also recommended to ensure that watershed residents are informed of the program, including a discussion of the benefits of and options for a "no-fertilizer" approach to landscaping.

- Develop landscaping fertilizer bylaws or ordinances to reduce the amount of phosphorus fertilizer that is applied to landscaped portions of each watershed. There have been numerous successful local ordinances regulating the use of phosphorus fertilizer on lawns. Some examples include the statewide programs in Maine and Minnesota, and portions of states including Dane County, Wisconsin, Muskegon County, Michigan, and Ottawa County, Michigan. A report was prepared for the Minnesota legislature on the law's effectiveness. That report and related information on the law is available at: www.mda.state.mn.us/phoslaw.

The phosphorus load reductions that can be achieved by a fertilizer reduction program are expected to vary widely depending on how the program is structured and implemented. For purposes of developing a load reduction estimate for this report, we have assumed that the program would be targeted to the estimated 139 residential homes around the perimeter of Baboosic Lake, and that one third of these homes fertilize a 2,000 square foot lawn area twice per growing season using 10-10-10 (N-P-K) formula fertilizer at a typical application rate of 3.5 lbs per 1000 square feet. If 25% to 50% of the homes using fertilizer are convinced to switch to phosphorus-free fertilizer, the amount of phosphorus applied to lawns around Baboosic Lake would be reduced by approximately 7.3 to 14.7

kg per year. If 10% of the applied fertilizer phosphorus washes into the lake via storm water runoff, then the estimated annual phosphorus load reduction would range from 0.73 to 1.47 kg/year.

Costs for a one-year fertilizer reduction program as described above are anticipated to be in the range of \$3,500 - \$5,000. These costs include printed outreach materials (brochure, signage, homeowner survey), and costs associated with providing a rebate or subsidy for purchase of phosphorus–free fertilizer. If 25 homes participated and purchased two bags of fertilizer, and assuming a rebate of \$15 per bag, the total cost of the rebate would be \$750.

4.3.2 Agricultural Best Management Practices (BMPs)

Agricultural activities compose a small fraction of the total land use within the Baboosic Lake watershed. In general, agricultural activities appeared to consist of small horse farms and other small scale agricultural activities. Nonetheless, Section 319 funds or additional funding from the USDA could potentially be used for the following tasks related to agricultural BMPs in the Baboosic Lake watershed:

Install additional fencing and buffer plantings at priority locations such as farms located on tributaries and wetlands draining to Baboosic Lake.

Farms, such as the Walnut Hill Road property shown above, may qualify for additional assistance for the installation of stormwater management features.

- Conduct a detailed nutrient management assessment related to all agricultural activities in the Baboosic Lake watershed. This assessment could involve a development of more accurate nutrient runoff estimates, based on field sampling and a site-by-site assessment of ongoing practices related to nutrient management, manure/fertilizer application, the number of livestock on site, etc.

The estimated cost for the tasks listed would be approximately \$10,000, with the biggest variable being the extent of additional BMP installation/construction (fencing, buffer plantings etc.). Based on limited existing information related to runoff conditions at agricultural sites in the watershed, it is difficult to project the net phosphorus reduction that could be achieved from the measures listed above.

Table 7: Baboosic Lake Water Quality Improvement / Implementation Plan

Source	Site	Proposed Improvements	Estimated Cost [1]	Estimated P Load Reduction (kg)	Cost per kg of P Reduced (x 1,000)	Priority
Road Runoff	Site #1: Four Seasons Park, Site A	Install a vegetated buffer strip along the slope located to the east of the beach.	$5-7K	0.05	$100-140	High
	Site #2: Four Seasons Park, Site B	Install energy dissipation and level spreader device at culvert outfall.	$1-1.6K	0.1	$10-16	Low
	Site #3: Amherst Town Beach, Bath House	Install a pre-fabricated bioretention cell at the drop inlet adjacent to the bath house. Install a gutter and rain barrel system at the northeast corner of the bath house. Install an energy dissipation device at the outfall of the drainage ditch.	$8-9K	0.05	$160-180	Medium
	Site #4: Amherst Town Beach, Picnic Area	Install a gravel infiltration trench along north side of parking area. Install bioretention cell immediately north of parking area to capture runoff from the parking and picnic area. Stabilize the eroded and exposed portions of the picnic area with loam and vegetation.	$9-11K	0.1	$90-110	Medium
	Site #5: Lakeside Drive /Greenwood Drive	Install rock inlet protection devices at drop inlet structures. Restore and stabilize unnamed tributary receiving storm water from the inlet.	$8-10K	0.05	$160-200	Medium
	Site #6: #24 Lakeside Drive	Replace impervious asphalt parking area with pervious porous-pavers. Install a pre-fabricated bioretention cell (i.e., Filterra) to replace existing drop inlet on the north side of Lakeside Drive.	$11-12K	0.1	$110-220	Medium
	Site #7: Jebb Road	Install a retrofit bioretention cell with rock baffles at the existing depression along the east side of Jebb Road. Install energy dissipation at the exiting culvert outfall at the beach.	$6-8K	0.05	$120-160	Low
	Site #8: #30 Lakeside Drive	Install a retrofit bioretention cell at the existing drop inlet device. Repair existing energy dissipation at outfall (west side of Lakeside Dr.)	$7-9K	0.2	$35-45	High
	Site #9: Paul's Boat Ramp	Construct a stabilized boat ramp using porous pavers. Construct a defined grass-lined channel along the northern side of the unpaved road and proposed ramp to convey storm water runoff from upgradient portions of the road to the lake.	$8-12K	0.1	$80-120	Low
	Site #10: North Jebb Road	Install pre-fabricated bioretention cell at the westernmost drop inlet structure. Develop a cleaning program to clear drop inlet grates and clean accumulated sediment from the structure sumps	$7-8K	0.1	$70-80	Low
	Site #11: #24 Greenwood Drive	Regrade the portion of Greenwood Drive in the area of house #24 so that storm water drains north into the wetland system adjacent to the road. Clean the pipe inlet of accumulated sediment and install rock protection at the inlet. Install energy dissipation at the pipe outfall.	$2-3K	0.05	$40-60	Low

Table 7: Baboosic Lake Water Quality Improvement / Implementation Plan (Continued)

Source	Site	Proposed Improvements	Estimated Cost [1]	Estimated P Load Reduction (kg)	Cost per kg of P Reduced (x 1,000)	Priority
Road Runoff (cont'd)	Site #12: Lakeside Drive	Install rock inlet protection devices at drop inlet structures. Restore and stabilize the channel that receives storm water from the inlet structures. Install energy dissipation at the channel outfall at the lake.	$6-8K	0.1	$60-80	Low
	Site #13: Autumn Lane	Install energy dissipation and a level spreader device at the culvert outfall to reduce flow velocities. Construct a stepped rock-lined down chute between the culvert outfall and the down stream wetland system. Install a level spreader device at the outfall of the down chute at the wetlands. The down chute should be constructed using existing boulders as well as imported rock to create cascading plunge pools.	$8-10K	0.3	$26-33	Low
	Site #14: Carter Road	Install a vegetated swale along the south side of Carter Road, similar to the recently constructed swale along the north side of the road. Construct a small storm water basin adjacent to the south side of Lakeview Drive in the area of the culvert outfall. Construct a stepped rock-lined drainage channel between the basin outfall and the lake.	$16-20K	0.1	$160-200	Medium
	Site #15: Walnut Hill Rd./ Clark Island Rd.	Constructing a rock-lined storm water channel along the south side of Clark Island Road. Install energy dissipation at the channel outfall at the beaver impoundment.	$6-8K	0.6	$10-13	Low
	Site #16: Shore Road	Install a pre-fabricated bioretention cell (i.e., Filterra) at the existing drop inlet structure in the southeast corner of the 20 Shore Road property. Stabilize the bottom of the channel along the north side of Shore Road. Construct a defined storm water channel along the 20 Shore Road driveway to convey storm water from the drop inlet structure to the outfall.	$8-12K	0.05	$160-240	Low
	Site #17: Hillside Road/ Broad Street	Construct a vegetated swale along either side of unpaved Broad Street. Regrade the unpaved road to drain toward the swale. Install a drop inlet structure and culvert to capture storm water in the swale and convey these flows across the paved portion of Broad Road. Install energy dissipation device at the culvert outfall to the lake.	$14-18K	0.05	$280-360	Medium

Table 7: Baboosic Lake Water Quality Improvement / Implementation Plan (Continued)

Source	Site	Proposed Improvements	Estimated Cost [1] (x 1,000)	Estimated P Load Reduction (kg)	Cost per kg of P Reduced (x 1,000)	Priority
Septic Systems	Phase 1	Community septic system - Phase 1 (11 homes)	$310K	5.3	$58.5	*installed*
	Phase 2	Community septic system - Phase 2 (10 homes)	$316K	4.8	$65.8	*Spring 2008*
	Phase 3	Community septic system - Phase 3 (13 homes)	$386K	6.2	$62.3	*Fall 2008*
	Area A	Community septic system (31 homes)	$922K	14.9	$61.9	Medium
	Area B	Community septic system (42 homes)	$1247K	20.2	$61.9	Medium
	Area C	Community septic system (34 homes)	$1009	16.3	$61.9	Medium
	Area D	Community septic system (30 homes)	$891K	14.4	$61.9	Medium
	Area E	Community septic system (30 homes)	$891k	14.4	$61.9	Medium
		On-site Wastewater Management Program.	$5 – 7.5K (1 year)	3.3 - 6.7	$0.7 - 2.3	High
Land Use Activities	Baboosic Lake watershed	Fertilizer reduction program	$3.5 - 5K (1 year)	0.7 - 1.5	$2.3 - 7.1	High
	Various Agricultural Sites	Agricultural BMPs	$10K	NA	NA	----
		TOTALS:	$6,120 – $6,160	102.7	$57.6 (low)	
				106.9	$59.6 (high)	

5. SUMMARY OF TECHNICAL AND FINANCIAL SUPPORT

5.1 Technical Support

Most of the phosphorus loading reduction measures described in Section 4.0 will require a moderate to high level of technical support. Moderate to high technical support may include a site topographic survey, preparation of existing conditions base plans, and preparing definitive site drawings by an Engineer that would be used for permitting and construction.

Storm water management improvements (described in Section 4.1) that require a moderate to high level of technical support include: Site 2 (Four Seasons Park, Site B), Site 3 (Baboosic Lake Town Beach, Bath House), Site 4 (Baboosic Lake Town Beach, Picnic Area), Site 5 (Lakeside Drive/Greenwood Drive), Site 6 (#24 Lakeside Drive), Site 7 (Jebb Road), Site 8 (#30 Lakeside Drive), Site 10 (North Jebb Road), Site 12 (Lakeside Drive), Site 13 (Autumn Lane), Site 14 (Carter Road), Site 16 (#20 Shore Road), and Site 17 (Hillside Road/Broad Street). The remaining sites require a low level of technical support and include Site 1 (Four Seasons Park, Site A), Site 9 (Paul's Boat Ramp), Site 11 (#24 Greenwood Drive) and Site 15 (Walnut Hill Road/Clark Island Road). A low level of technical support includes design-build construction using field manuals. In addition to the technical support described above, construction of some of the projects described in Section 3 may require a Minimum Impact Wetlands Application to the NH DES Wetlands Bureau. Wetlands were not delineated as part of this project. As such, technical support from a New Hampshire certified wetland scientist may be required for wetland delineation and permitting support.

Improvements related to wastewater management and the proposed community septic systems discussed in Section 4.2 will require a high degree of technical support from a wastewater engineering firm. Such support is expected to include a feasibility study with detailed investigations and recommendations on siting options and costing for the proposed community systems. Detailed engineering plans for the systems will then be required.

Other types of technical support that may be required for the required for the measures discussed in Section 4 include graphic design and printing support for public outreach and educational materials, septic system inspection services, and support with development of regulatory language for new municipal bylaws.

5.2 Financial Support

Improvements and management techniques described in Section 4 above will require funding to install and complete. Sources of funding to be considered shall include, but are not limited to, Section 319 funding, NH DES Small Outreach and Education Grants, NH DES Agricultural Nutrient Management Grant Program, USDA's Environmental Quality Incentives Program and USDA's Conservation Reserve Program. Alternative funding may be in the form of donated labor from the Nottingham Department of Public Works as well as local volunteer groups and contractors from communities around the lake. Brief descriptions of potential funding sources are provided below:

Section 319 Grant Funding: Funds for NH DES Watershed Assistance and Restoration Grants are appropriated through the U.S. Environmental Protection Agency under Section 319 of the Clean Water Act (CWA). Two thirds of the annual funds are available for restoration projects that address impaired waters and implement watershed based plans designed to achieve water quality standards. A project eligible for funds must plan or implement measures that prevent, control, or abate no-point source (NPS) pollution. These projects should: (1) restore or maintain the chemical, physical, and biological integrity of New Hampshire's waters; (2) be directed at encouraging, requiring, or achieving implementation of BMPs to address water quality impacts from land-use; (3) be feasible, practical and cost effective; and (4) provide an informational, educational, and/or technical transfer component. The project must include an appropriate method for verifying project success with respect to the project performance targets, with an emphasis on demonstrated environmental improvement.

Nonprofit organizations registered with the N.H. Secretary of State and governmental subdivisions including municipalities, regional planning commissions, non-profit organizations, county conservation districts, state agencies, watershed associations, and water suppliers are eligible to receive these grants. More information on the NH DES Watershed Assistance and Restoration Grants can be found at: http://www.des.state.nh.us/wmb/was/grants.htm.

Small Outreach and Education Grant: The NHDES provides funding to promote educational and outreach components of water quality improvement projects. This program provides small grants of $200 to $2,000 for outreach and education projects relating to NPS issues that target appropriate audiences with diverse NPS water quality related messages. These small grants are available year round on an ongoing basis, which allows applicants to move forward with outreach and education projects without having to wait for annual application deadlines. The NH DES Watershed Assistance Section administers the grant program using $20,000 each year from the U.S. EPA under Section 319 of the CWA. More information on the Small Outreach and Education Grant can be found at: http://www.des.state.nh.us/wmb/was/grants.htm.

Agricultural Nutrient Management Grant Program: This grant program seeks to provide financial, educational and technical assistance for livestock and agricultural land operations and related organizations with implementing BMPs and such other measures necessary to prevent or mitigate water pollution. Applicants may apply for cost assistance of up to $2,500 per year. There is no match required, however, in-kind services such as labor provided by the applicant will enhance the application. The majority of funding will be used for on-farm projects that address or prevent water pollution. Funding may also be utilized by organizations for educational projects. This grant program is administered through the N.H. Department of Agriculture, Markets and Food, Bureau of Markets with support from NH DES. Applications are due by June 1 and December 1 each year. More information on the Agricultural Nutrient Management Grant Program can be found at: http://www.des.state.nh.us/wmb/was/grants.htm.

USDA's Environmental Quality Incentives Program: The Environmental Quality Incentives Program (EQIP) was reauthorized in the Farm Security and Rural Investment Act of 2002 (Farm Bill) to provide a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible participants install or implement BMPs on eligible agricultural land.

EQIP offers contracts with a minimum term that ends one year after the implementation of the last scheduled practices and a maximum term of ten years. These contracts provide incentive payments and cost-shares to implement conservation practices. Persons who are engaged in livestock or agricultural production on eligible land may participate in the EQIP program. EQIP activities are carried out according to an environmental quality incentives program plan of operations developed in conjunction with the producer that identifies the appropriate conservation practice or practices to address the resource concerns. The practices are subject to NRCS technical standards adapted for local conditions. The local conservation district approves the plan.

EQIP may cost-share up to 75 percent of the costs of certain conservation practices. Incentive payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the incentive. However, limited resource producers and beginning farmers and ranchers may be eligible for cost-shares up to 90 percent. Farmers and ranchers may elect to use a certified third-party provider for technical assistance. An individual or entity may not receive, directly or indirectly, cost-share or incentive payments that, in the aggregate, exceed $450,000 for all EQIP contracts entered during the term of the Farm Bill. More information on the USDA EQIP can be found at: http://www.nrcs.usda.gov/Programs/eqip/.

USDA's Conservation Reserve Program: The Conservation Reserve Program (CRP) provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. The program provides assistance to farmers and ranchers in complying with Federal, State, and tribal environmental laws, and encourages environmental enhancement. The program is funded through the Commodity Credit Corporation (CCC). CRP is administered by the Farm Service Agency, with NRCS providing technical land eligibility determinations, conservation planning and practice implementation. The program encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as tame or native grasses, wildlife plantings, trees, filter strips, or riparian buffers. Farmers receive an annual rental payment for the term of the multi-year contract. Cost sharing is provided to establish the vegetative cover practices. More information on the USDA CRP can be found at:

http://www.nrcs.usda.gov/Programs/crp/.

6. PUBLIC INFORMATION AND EDUCATION

Public information and education will be used to enhance public understanding of the phosphorus loading reduction projects. Public awareness encourages the use of storm water improvements and other measures throughout a watershed. Public information and education about the BMPs implemented in the watershed are provided via a project website (listed below) and informational brochure. State grants are available, as described above, to assist with public information and education.

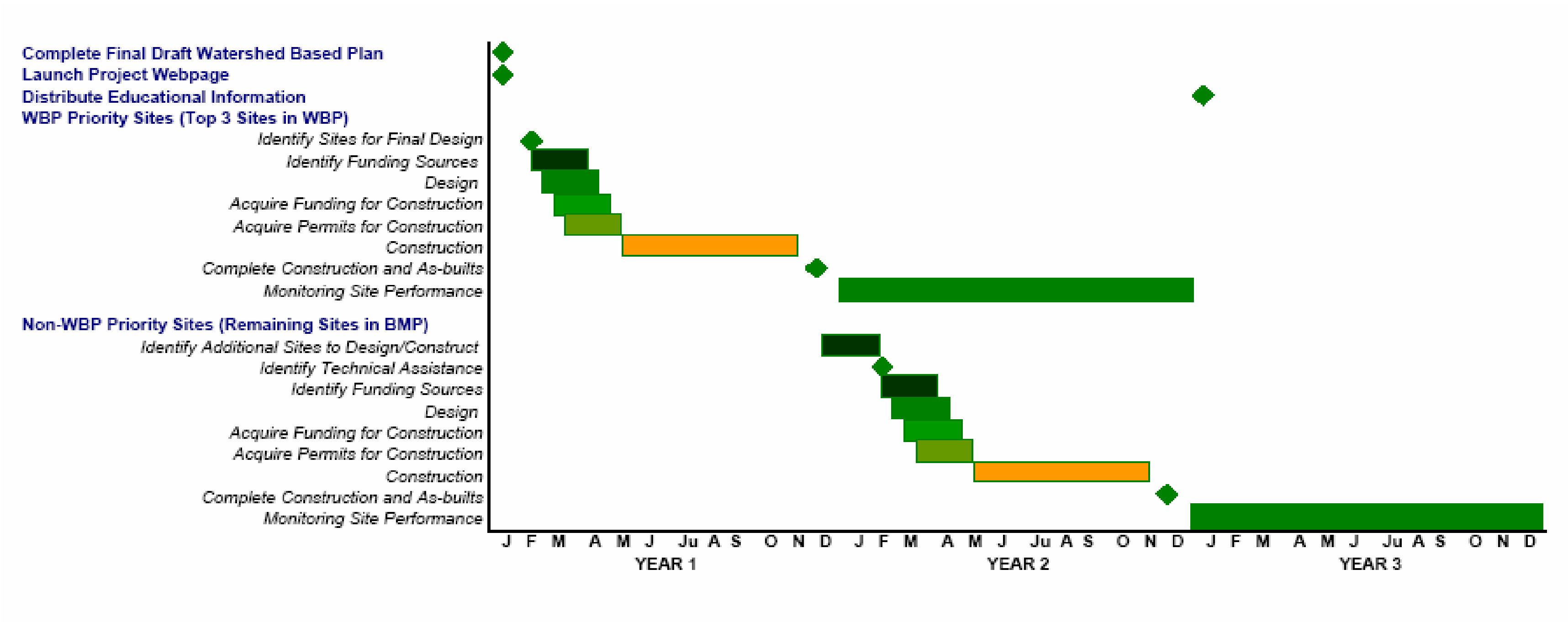
Project Website: A project web site is available to provide the public with access to all project-related documents and reports. The website is a convenient method for reviewing and commenting on this watershed management plan and other project deliverables. The project website can be accessed at: http://projects.geosyntec.com/BW0086/.

Brochure: In cooperation with the BLA, Geosyntec developed an educational brochure specific to the Baboosic Lake watershed and potential improvements and practices to reduce phosphorus loading to the lake. A copy of the brochure developed through this project is available from NHDES and the BLA.

7. SCHEDULE AND INTERIM MILESTONES

The improvements recommended for the Baboosic Lake watershed are ranked in order of priority as described in Section 4 of this report. A proposed schedule and associated interim milestones for these improvements are shown in Figure 9.

Figure 7: Planning and Interim Milestones Schedule



8. EVALUATION CRITERIA AND MONITORING

As discussed in Section 3.4, this watershed based plan recommends targeting an in-lake phosphorus concentration for Baboosic Lake of 12 μg/L. To achieve the recommended in-lake phosphorus concentration, the Vollenweider equation in Section 3.4 predicts that the annual phosphorus load to the lake must be reduced by an estimated 28.9 kg/year. Section 4 of this report describes management measures that may be implemented to achieve this targeted phosphorus load reduction. To determine the effectiveness of these proposed measures in reducing in-lake phosphorus concentrations and improving the water quality of Baboosic Lake, the following monitoring and evaluation criteria are recommended:

Phosphorus Monitoring: Continued monitoring of in-lake phosphorus concentrations should be conducted through the NH-VLAP program or NHDES programs. In-lake phosphorus measurements will provide the most direct means of evaluating the effects of measures which have been implemented specifically to reduce phosphorus loading to the lake. As discussed in Section 3.4, the in-lake phosphorus concentrations predicted by the Vollenweider equation are based on an assumption that the lake is uniformly mixed. As such, the results of epilimnetic phosphorus monitoring during the summer (when the lake is thermally stratified) are likely to understate the phosphorus levels that would be measured if the lake was uniformly mixed. However, regular monitoring of phosphorus levels from a depth profile (samples from the epilimnion, metalimnion and hypolimnion) will provide useful data on phosphorus concentration trends in response to implementation of the measures recommended in Section 4. Monitoring during the periods of fall and spring turnover will also provide useful data that will reflect in-lake nutrient concentrations when the lake is evenly mixed.

Nutrient and flow monitoring at the lake's tributary inflow locations to allow for development of a precise hydrologic and nutrient budget for each tributary and associated subwatershed area;

Algae Monitoring: In recent years, an increase in the reported incidence of nuisance cyanobacteria blooms has been one of the most notable and visible symptoms of nutrient enrichment and declining water quality in Baboosic Lake. Annual monitoring of the abundance and composition of the lake's algal community would provide a useful metric for understanding water quality trends in response to implementation of the measures recommended in Section 4.

Public Outreach, Education and Land Use Activities: In addition to the monitoring efforts described above, the effectiveness of recommended measures related to public outreach and land use activities can be evaluated with several simple metrics, including:

- Quantify the number of public education brochures that are printed and distributed to watershed residents;
- Quantify the number of homes involved in the proposed On-site Wastewater Management Program, including the number of septic system inspections and pump-outs conducted, the number of septic system locations mapped through the GPS survey effort, etc.; and
- Quantify the number of homes involved in the proposed fertilizer reduction program, including information on specific program elements such as the quantity of no-phosphorus fertilizer applied within the watershed.