April 2016

PHOSPHORUS LOADING IN QUABOAG POND

Christopher B. Dobens
Worcester Polytechnic Institute

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PHOSPHORUS LOADING IN QUABOAG POND

A Major Qualifying Project
Submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
In partial fulfillment of the requirements for the
Degree of Bachelor of Science

By

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Date: March 1, 2007

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Professor Jeanine D. Plummer, Major Advisor

1. TMDL
2. Best Management Practices
3. Quaboag Pond
Abstract

Quaboag Pond, located in East Brookfield and Brookfield, MA, is degraded due to excessive phosphorus inputs. Phosphorus leads to increased plant growth and reduced dissolved oxygen levels. The goal of this project was to reduce non-point sources of phosphorus entering Quaboag Pond. Pollution sources were identified along the Sevenmile River in Spencer, the main inlet to Quaboag Pond. Based on test results, buffer strips, diversions and educational programs were recommended to reduce storm flows and pollutant loads.
Acknowledgements

The members of this project group would like to thank the Massachusetts Department of Environmental Protection, the town of Spencer officials, Carter Terenzini, Margaret Bacon, and Virginia Scarlet, and Professor Jeanine Plummer for the assistance and guidance throughout the project.
Capstone Design Statement

The purpose of this project was to provide recommendations to reduce the flow of pollutants, especially phosphorus, into Quaboag Pond which is located in Brookfield and East Brookfield, MA. The high nutrient loading in the pond was leading to eutrophication. The main inlet to the pond is the East Brookfield River, which is fed by the Sevenmile River in Spencer, MA. The town of Spencer received a National Pollutant Discharge Elimination System (NPDES) Phase II Stormwater Permit from the US Environmental Protection Agency (EPA), which includes a requirement that the town keep up with “good housekeeping” practices. Spencer was not within the regulations of the permit, therefore Best Management Practices (BMPs) were designed to reduce the pollutant load so that the town would be within the regulations.

This project tested water quality in ten locations along the Sevenmile River in Spencer. The land uses along this portion of the river included commercial development, residential development, and undeveloped forested and swamp areas. The water quality at each location was analyzed and BMPs were designed to reduce pollutant inflows in problem areas. This project meets capstone design requirements of analysis, synthesis, and design as follows:

Analysis of water quality.
Water samples were tested at ten locations in the watershed along the Sevenmile River. The samples were tested for suspended solids concentration, dissolved oxygen, biochemical oxygen demand, phosphorus concentration, nitrogen concentration, and pH. Samples were collected during the fall and winter, in dry and wet conditions. The land uses surrounding each sampling site were assessed via GIS maps of Spencer.

Synthesis of water quality data.
The data that were collected were synthesized to identify areas of concern. Two locations in the center of downtown Spencer showed higher concentrations of phosphorus and nitrogen than the other sites. The land use associated with these areas is commercial development. The data collected were compared to Massachusetts standards for Class B water bodies.

Evaluation of alternatives and Design of best management practices.
After the primary source of pollution was identified, best management practices were evaluated by the group for remediation of the problem. Alternatives were evaluated by comparing applicability to the site, cost, and effectiveness to remove the pollutants of concern. Several BMPs were selected for more in depth evaluation, including community involvement and education, vegetative buffer strips, bioretention systems, surface sand filters, stormwater wetlands, green parking and roofs, narrower residential streets, and eliminating curbs. Final recommendations were to implement the BMPs and conduct more tests during the summer months.
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1 Introduction

Surface waters, such as rivers, lakes, and reservoirs, are vulnerable to contaminant inputs from human activities as well as pollutants of natural origins. With regard to human-derived pollution, there are two primary classifications: point and non-point source pollution. Some examples of point sources are municipal wastewater effluents, industrial wastes, cooling waters from power plants, and intermittent discharges, such as over-flows from stabilization ponds. Point sources are the discharge of waste from identifiable locations, such as sewers or drainage channels. Non-point source pollution is conveyed overland by rain water or snowmelt. In developed areas, runoff creates pollution as a result of chemical use on lawns, gardens, and golf courses, improper use of fertilizers and pesticides, and inadequate removal of pet refuse (Cech, 2005).

Among the pollutants which enter surface waters, excessive nutrient inputs are of particular concern for standing waters such as lakes and ponds. Nutrients can accelerate the eutrophication process, stimulating plant growth and overall productivity. This causes a reduction of dissolved oxygen (DO) in the water when the plants die and are decomposed by bacteria. Reduced DO levels can negatively affect fish and other aquatic species (USGS, 2006). The main nutrients known to expedite the eutrophication of fresh waters are phosphorous and nitrogen. Because nitrogen is commonly found in the atmosphere, it is not considered a limiting nutrient. Therefore, phosphorus is what has to be reduced to decelerate the eutrophication process.

In the United States, pollutant inputs into water bodies are regulated by the National Pollutant Discharge Elimination System (NPDES) permitting program and Total Maximum Daily Loads (TMDLs). NPDES permits regulate point sources. Permits must be obtained by industrial, municipal, and other facilities that discharge waste streams into surface waters. NPDES permits specify both the volume of waste that may be discharged and the concentration limit of particular pollutants in the waste. TMDLs regulate both non-point sources and point sources. A TMDL is the maximum amount of a pollutant that a water body can receive while still meeting water quality standards, which are set by each state. TMDLs are used for impaired waters in which the NPDES permits alone are not sufficient to maintain the desired water quality standard. The TMDL value includes
all the allowable loads of a single pollutant from all contributing non-point and point sources. The loading also contains a margin of safety and accounts for variations in water quality throughout the different seasons (EPA, 2006b).

In central Massachusetts, two natural bodies of water affected by nutrients are Quaboag Pond and Quacumquat Pond. The ponds are located within the towns of Brookfield, East Brookfield, and Sturbridge. Quaboag Pond is 536 acres (0.84 square miles) and has a 76.7 square mile watershed. Quacumquat Pond is smaller, covering 225 acres (0.35 square miles) and having a 1.8 square mile watershed. These water bodies are listed on the “Massachusetts Year 2002 Integrated List of Waters,” a list created by the Massachusetts Department of Environmental Protection’s Division of Watershed Management which identifies all of the impaired water bodies in Massachusetts. Quacumquat Pond has a watershed that is less impaired than the Quaboag Pond watershed. The primary source of nutrients flowing into the Quacumquat Pond is the connection to Quaboag Pond (DEP, 2005). Therefore, the Quaboag Pond watershed is the major concern in the Brookfield area.

Phosphorus is the primary nutrient that is negatively impacting Quaboag Pond. A total phosphorus TMDL has been set by Massachusetts Department of Environmental Protection and the Massachusetts Surface Water Quality Standards of 2822 kg/yr; however, the load in 2003 was 3107 kg/yr (DEP, 2005). Therefore, the goals of this project were to identify point and non-point sources of phosphorous, and to provide recommendations for reducing phosphorus inputs into Quaboag Pond. This project was completed in collaboration with the Town of Spencer, which is located in the Quaboag Pond watershed along the Sevenmile River. The Town of Spencer has been an issued a NPDES Phase II Stormwater Permit. This permit regulates the amount of runoff from impervious surfaces and the concentration of pollutants in the runoff that may enter surface waters in the Spencer area. While the Town of Spencer is not the only town in the Quaboag Pond watershed, the town is currently not in compliance with the NPDES permit and therefore may be contributing excessive non-point source pollutants to Quaboag Pond, including phosphorus.

The following chapter provides background information on point and non-point source pollution, the NPDES permit program, and stormwater best management practices. Chapter 3 describes the methods in which pollutant inputs to Quaboag Pond were
determined and how remediation methods were developed. Next, the results chapter provides an analysis of the water test results and recommendations for preventing nutrients and other pollutants from entering the surface waters in Spencer. The final chapter provides conclusions and recommendations for the town of Spencer for future action.
2 Background

Nutrient loading is a common problem for many lakes across the country. This project focused on the Quaboag and Quacumquasit Ponds in central Massachusetts. This chapter provides background information on the ponds and watershed characteristics, the impact of nutrients on water quality, and the current issues in managing non-point source pollution in the town of Spencer.

2.1 Nutrient Inputs to Ponds

Although nutrients are necessary for life in ponds and other water bodies, too much can lead to a decrease in the water quality of the pond itself. The kinds of life that are affected by an increase in nutrient levels are fish, aerobic microorganisms, and animals that feed off of these microorganisms. Two of the main nutrients which are essential to life in these water bodies are nitrogen and phosphorus. Along with nitrogen and phosphorous, oxygen, hydrogen, carbon, and sulfur are a big part of the life systems in fresh water bodies. Small insects feed the fish which create waste for the plant life to live off of, and bacteria keep the levels of nutrients in balance.

Nitrogen is found abundantly in the atmosphere, and is also introduced into water bodies from point sources such as wastewater treatment plants and industrial activity, and from non-point sources such as manure and fertilizer on farms and urban run-off. In fresh water lakes and rivers, often the limiting nutrient in plant growth is phosphorous, which can come from many of the same sources as nitrogen. As large amounts of phosphorous flow into water bodies, excessive aquatic plant growth becomes a problem. When algae eventually die off, bacteria in the water decompose them using up a great deal of the dissolved oxygen in the water.

2.2 Impact of Nutrients on Dissolved Oxygen

Dissolved oxygen (DO) is the amount of oxygen dissolved in a unit volume of water. To keep water at a safe and clean level for life in the water and for recreation, the amount of dissolved oxygen must be higher than 6 parts per million. If the dissolved oxygen level drops below 4 ppm, the water begins to be harmful for fish such as bass,
trout, perch, and other cold water fish. Younger fish are even more sensitive to reduced DO levels. When the dissolved oxygen drops this low, the fish suffocate and harmful bacteria start to grow making it unsafe for swimming and for life in the water.

There are many factors which effect dissolved oxygen in water bodies. Temperature and climate are a major factor in DO levels. Colder water allows for more oxygen to be dissolved into it since colder water can hold more gas due to the relationship between cold temperatures and gas saturation. During the summer months, higher temperatures cause concern for fish and aerobic plants and animals in the water, since the warmer water cannot hold as much oxygen and fish. Sunlight is another factor in the dissolved oxygen level, as photoplankton in the water use the sunlight for photosynthesis which releases oxygen into the water on days where there is substantial sunlight. During the night or on cloudy days, oxygen is removed from the water when the plants are in their respiration process. Velocity of the water is another factor of DO in the water. Water moving swiftly over rocks allows oxygen to enter the water at all levels not just the surface, as in stagnant bodies of water. Extremely high levels of oxygen can also be harmful to life in ponds and lakes. Fish in water with high DO levels can experience a condition where the oxygen bubbles block the flow of blood to the brain.

2.3 How Nutrients are Managed and Regulated

As stated in section 2.1, phosphorous is typically the limiting nutrient in fresh water ecosystems. Therefore, control of this nutrient requires information on the phosphorous levels in the surrounding watershed. Two different ways phosphorous can enter surface waters are through point sources, such as wastewater treatment effluents, or non-point sources, such as rain water runoff from residential lawns and urban areas.

Point sources are traceable inputs of pollutants which are regulated through the National Pollution Discharge Elimination System. These point sources are usually regulated by the state or federal environmental agencies based upon how the surrounding area can handle the specific pollutants being released. Total Maximum Daily Loads (TMDLs) are one way the EPA and state Departments of Environmental Protection (DEPs) find how much of a particular pollutant can be released into the environment without having a significant impact (see section 2.1 and 2.4). The exact definition of the TMDL is the sum of the individual waste load allocations that may enter a water body.
while the water body still meets quality goals. Waste loads that are considered in TMDLs include point sources such as effluent of a wastewater plant and non-point sources such as sediment resuspension. TMDLs also include factor of safety for non-point source pollutants which may enter the watershed.

The TMDL for a certain lake or pond is based upon the volume of water and how the plant and animal life can handle the particular pollutant. In Massachusetts, the Department of Environmental Protection requires a TMDL which allows for 4 feet of visibility in the water and maintains a dissolved oxygen level of 6 ppm during the summer in the lower 1/3 of the water body. The state has a comprehensive list of pollutants, bacteria and other problematic materials, and the TMDL’s for each item and for particular watersheds. These lists also account for seasonal conditions such as excessive rainfall, heat, cold, and UV levels (DEP).

Point sources of pollution levels are regulated by the National Pollutant Discharge Elimination System (NPDES) permitting program. The NPDES permits started as a part of the Clean Water Act (CWA) of 1972. Originally called the Federal Water Pollution Control Act Amendments, as amended in 1977 it became know as the Clean Water Act. The CWA gave the EPA the authority to implement pollution control programs, such as setting regulations for effluent of wastewater treatment plants. The main goals of this act were to make all water bodies fishable and swimable, and maintain this cleanliness. Although this act has not been realized to completion, it still set a large body of legislation for states to clean their surface waters. Part of this legislation is for setting permits and water quality standards and other parts helping the cost sharing with companies causing pollution to help improve water quality. Many polluted waters have been slowly cleaned through the efforts of EPA permits in conjunction with more public education on the issues of water pollution.

The NPDES is a small part of the CWA which covers specific permits to point sources as opposed to regulating the quality of water in the surface waters. Industrial, municipal and other facilities must obtain NPDES permits if they have a waste to be released into waters in the United States. These permits include regulations and necessary permits for construction site dewatering, water treatment plants, reverse osmosis reject water, and non-contact cooling water. Permits can also be given for storm water quality and maintenance. Nutrients such as nitrogen and phosphorous are limited
to the amount that can be released from discharge points through the NPDES permits at a level of 10 ppm in the winter and 8 ppm in the summer on average for the state of Massachusetts.

### 2.4 Quaboag and Quacumquisit Ponds

Quaboag and Quacumquisit Ponds are located in South Central Massachusetts, and are the focus of this project.

#### 2.4.1 Quaboag Pond

Quaboag Pond (see Figure 1) is a natural water body located in Brookfield and East Brookfield, Massachusetts. It is a large pond, compared to other ponds in the region. It has an area of 540 acres and a maximum depth of 15 feet. The average depth of the pond is only six and a half feet. The average annual retention time of water in the pond is 12 days, and the summer retention time is 19 to 43 days. The retention time is the amount of time that the water stays in the pond. It is higher in the summer because of less rainfall, which results in a reduced flow. The major inlet to the pond is the East Brookfield River, which flows from Lake Lashaway in North Brookfield and East Brookfield. The major outlet of the pond is the Quaboag River, which flows through Brookfield, West Brookfield, and past the Warren Wastewater Treatment Plant in Warren. The water then joins with the Ware River, forming the headwaters of the Chicopee River in Palmer (EPA, 2002). The east and north shorelines of Quaboag Pond are developed with low density housing and there is a campground located on the Northwest shore. The West shore is undeveloped.
Figure 1- Quaboag Pond
2.4.2 Quaboag Pond Watershed

The watershed of Quaboag Pond is part of the Chicopee Basin Watershed, a large watershed covering 723 square miles and including 39 towns (DEP, 1998). The part of the watershed that contributes to Quaboag Pond is much smaller, with an area of 76.7 square miles. The land in the watershed has many uses, and is summarized in the Table 1. Within the watershed, there are the Green Hollow, Southwest, and Pine Grove cemeteries, several campgrounds, the Moose Hill Wildlife Management Area, Spencer State Forest, and a number of sand and gravel pits (DEP, 2005). A map of Quaboag and Quacomquasit Ponds and their watersheds is shown in Figure 2.

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Percentage of Watershed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forested</td>
<td>60</td>
</tr>
<tr>
<td>Agriculture</td>
<td>14</td>
</tr>
<tr>
<td>Low Density Residential Housing</td>
<td>7</td>
</tr>
<tr>
<td>High Density Residential Housing</td>
<td>4</td>
</tr>
<tr>
<td>Commercial-Industrial Land</td>
<td>2 ½</td>
</tr>
<tr>
<td>Open Land</td>
<td>3 ½</td>
</tr>
<tr>
<td>Other</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 1- Chicopee Basin Watershed Land Uses
2.4.3 Quacumquasit Pond

Quacumquasit Pond, like Quaboag Pond, is a large, natural pond (see Figure 3). Unlike Quaboag Pond however, Quacumquasit Pond is a deep, cold water pond, with a maximum depth of 74 feet and an average depth of about 30 feet. It is located in Brookfield, East Brookfield, and Sturbridge, and is known locally as South Pond because it is located directly south of Quaboag Pond. The area of this pond is 218 acres, less than
half the size of Quaboag Pond. There is no permanent inlet to Quacumquisit Pond, and the only major outlet is the inter basin connector that connects it to Quaboag Pond. This connector is located at the north end of the pond and is partly regulated by a man-made back flood control gate. The gate was installed to control the flood waters that flowed from Quacumquisit Pond to Quaboag Pond during high intensity rainfall events (BEC, 1986). This connector was deepened and widened after the mid-1800s and then again after the mid-1960s. The widening and deepening of the connector took place so that boats could easily pass from one pond to the other.

Figure 3- Quacumquisit Pond
2.4.4 Quacumquasit Pond Watershed

The watershed that contributes to Quacumquasit Pond is much smaller than the Chicopee Basin Watershed, with an area of only 1.8 square miles. The land use for this watershed is summarized in Table 2. Within the watershed, there are numerous gravel pits and Camp Day, a day camp for children (DEP, 2005).

Table 2- Land Use for Quacumquasit Pond Watershed

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Percentage of Watershed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forested</td>
<td>55</td>
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<tr>
<td>Water and wetlands</td>
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<tr>
<td>Low Density Residential Housing</td>
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<tr>
<td>High Density Residential Housing</td>
<td>8</td>
</tr>
<tr>
<td>Open Land</td>
<td>3</td>
</tr>
<tr>
<td>Commercial- Industrial Land</td>
<td>1</td>
</tr>
<tr>
<td>Agriculture</td>
<td>1</td>
</tr>
</tbody>
</table>

2.5 Pollutant Issues

In the Quaboag and Quacumquasit Ponds, there is an increasing problem with excessive amounts of phosphorous entering into the water bodies. As of 2002, both ponds were placed on the Massachusetts list of integrated waters. Bodies of water are placed on the list because of a potential threat to their survival as ponds. The list also includes the specific pollutants which are causing the water to be degraded. In 2004, the Massachusetts DEP wrote a draft report concerning the total maximum daily load of phosphorus in the ponds. The report also provided speculations of where in the watershed the majority of the phosphorus is coming from (DEP). The difficulty with controlling phosphorus loads in a watershed is that there are numerous sources, whether natural or introduced, that can contribute to nutrient loading. The DEP estimated that the load of phosphorus for both ponds in 2003 was 3107 kg/yr, when the target load was 2822 kg/yr. This is a difference of about 300 kilograms per year, which is a substantial.
The DEP made several recommendations for reducing phosphorus inflows into Quaboag Pond. The first method to help lower this load is by upgrading the wastewater treatment plant to a lower level of biological wastes to be released in the effluent thereby lowering nutrient levels. The second is controlling non-point sources in towns such as Spencer, MA with a storm water permit, as well as protecting the watershed from road runoff by having catch basin inspections and cleanings. The third part of the implementation is to raise the flood gate between the Quaboag and Quaqcumquasit ponds. The last part of the plan is to make modifications to the macrophyte management plan to specific recreational areas (DEP, 2005).

2.6 Town of Spencer Project

The town of Spencer is located northeast of the Quaboag and Quacumquasit Ponds. The Sevenmile River runs directly through the town of Spencer and leads to the Brookfield River, which inflows into Quaboag Pond. There is a high concentration of residential housing and commercial buildings surrounding the town center, but the majority of the town is forested land and low density residential housing. The town has a wastewater treatment plant that discharges effluent into the watershed. The treatment plant is a minor source of phosphorous in the watershed. The town of Spencer is developing much like the rest of the state and there are many new homes and construction within the town.

2.6.1 NPDES Phase II Storm water permit

The Massachusetts Department of Environmental Protection has issued the town of Spencer a National Pollutant Discharge Elimination System Phase II Storm Water Permit under the guidelines and restrictions of the Environmental Protection Agency. The permit addresses several pollution problems including the increased volume and rate of runoff from impervious surfaces and the concentration of pollutants in the runoff. Both components are directly related to development in urban and urbanizing areas, similar to the town of Spencer. Together, these components cause changes in hydrology and water quality that result in a variety of problems, including habitat modification and loss, increased flooding, decreased aquatic biological diversity, and increased sedimentation and erosion (U.S. EPA, 2006).
The Stormwater Phase II Final Rule expands the Phase I program, which dealt with medium and large municipal sources of storm water runoff, to include smaller urbanized areas. Phase II is intended to further reduce adverse impacts to water quality and aquatic habitat by instituting the use of controls on the unregulated sources of stormwater discharges that have the greatest likelihood of causing continued environmental degradation (U.S. EPA, 2006). The permit mostly covers small municipal separate storm sewer systems (MS4s) and construction activity for an area between one and five acres.

The Phase II permit encompasses six different aspects of stormwater runoff pollution: Public education and outreach, public participation and involvement, illicit discharge detection and elimination, construction site runoff, post-construction site runoff, and pollution prevention or “good housekeeping” control measures. Each one of these aspects must include an implementation and maintenance plan, the proper training and certification of employees, and the use of appropriate best management practices (BMPs).

2.6.2 Best Management Practices

Best management practices help prevent pollution by reducing the amount of nutrients introduced to water sources and minimizing risks to the environment without requiring high initial and maintenance costs (Hilliard & Reedyk, 2000). There are two main categories of best management practices: structural and non-structural. A structural BMP is a physical barrier or detention basin that has to be built. The structures can range from barriers and trenches that redirect flow to detention ponds that slow and filter the storm water. Non-structural best management practices can be planting grass, using different kinds of fertilizer, or teaching the public techniques for preventing runoff before it enters a water system.

Structural best management practices are often used by towns and cities that have the budget and means to implement them. A few examples of structural BMPs include controlling runoff from construction sites and municipal activities. Uncontrolled stormwater runoff from construction sites can significantly impact rivers, lakes and estuaries. Sediment in waterbodies from construction sites can reduce the amount of sunlight reaching aquatic plants, clog fish gills, smother aquatic habitat and spawning...
areas, and impede navigation. Best management practices that are effective against construction site runoff include mulching, silt fencing, land grading, seeding, slope diversions, vegetative buffers, and storm drain inlet protection. The City of Charlotte and the County of Mecklenburg in North Carolina collaborated to develop an effective erosion and sediment control enforcement program that employs frequent inspections, Notices of Violation, and fines as well as an appeal process to effectively and fairly require compliance (Stormwater Case Studies, 2006). Municipal activities, such as winter road maintenance and sanding, landscaping, and building maintenance can prevent pollution and sediments from entering the stormwater management systems. This causes the runoff to enter a water source more directly. BMPs for preventing municipal pollution additions consist of municipal landscaping, parking lot and street cleaning, road salt application and storage, and storm drain cleaning.

Non-structural are designed for stormwater runoff that is generated from dispersed land surfaces such as pavements, yards, driveways, and roofs. Efforts to control stormwater pollution must consider individual, household, and public behaviors and activities that can generate pollution from these surfaces. These common individual behaviors have the potential to generate stormwater pollution, such as disposing of pet-waste, applying lawn-chemicals, washing cars, changing motor-oil on impervious driveways, and disposing of leftover paint and household chemicals. It takes individuals to change and proper practices to control such pollution. Therefore it is important to make the public sufficiently aware and concerned about the significance of their behavior for stormwater pollution. Education programs can be used to encourage people to change their behaviors. Making sure people know about household best management practices is a key factor in reducing non-point source pollution on a larger scale.

An example of a non-structural BMP is that the state of Maine has 28 communities that worked with the Maine DEP and other agencies to launch the state’s first public outreach effort based exclusively on social marketing principles. Its aim was twofold – improve awareness of stormwater pollution sources and educate the public on how pollution gets into local waters. This is an example of public involvement that has been effective in reducing stormwater pollution (Stormwater Case Studies, 2006). Another example of non-structural BMPs is working with committee and groups in a town to collaborate in their efforts. The most effective public involvement BMPs
include Adopt-A-Stream programs, reforestation programs, storm drain marking, stream cleanup and monitoring, volunteer monitoring, and wetland plantings. Georgia implemented a non-structural BMP by introducing the Clean Water Campaign which offers a series of workshops. These workshops were instrumental in educating members of the public and encouraging them to reduce stormwater pollution. In addition, the Clean Water Campaign's comprehensive Web site, in English and Spanish, gave details how to reduce stormwater pollution around the home and on the job (Stormwater Case Studies, 2006).
3 Methods

The goal of this project was to provide recommendations for reducing phosphorus inputs into Quaboag Pond. The Quaboag Pond watershed is located in Spencer, MA, meaning that this is where most of the pollution originates. The first task completed was conducting interviews with several town officials in Spencer to determine concerns the town had with regard to non-point source pollution and any constraints that the town had in implementing remediation strategies. The second task was to determine current inputs of phosphorus into Quaboag Pond. This was achieved by testing water samples from the Sevenmile River, the major inlet to Quaboag Pond. Third, the water quality was compared to the standards of Class B waters to determine if there was a problem with the water quality. Lastly, Best Management Practices were researched for implementation in the Town of Spencer.

3.1 Interviews

The Town of Spencer recently acquired a NPDES Phase II Stormwater Permit. As discussed in Chapter 2, the town is not currently within the permit regulations. Specifically, phosphorus loading is over the target load, and the town is not in compliance with “good housekeeping” practices. Therefore, a series of interviews was conducted with town officials in Spencer, to determine what obstacles the town faces in meeting the permit requirements. Interviews were also aimed at determining what resources and constraints the town has in implementing plans to control non-point source pollution. Table 3 lists the persons who were interviewed. All interviews were conducted at the Spencer Town Hall on November 29, 2006 from 2:00 – 3:00PM. The interview questions and notes are provided in Appendix A.
Table 3 - Interview with Town Officials

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Contact Information</th>
</tr>
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<tbody>
<tr>
<td>Margaret Bacon</td>
<td>Facilities and Utilities Superintendent</td>
<td>(508) 885-7525 <a href="mailto:mbacon@spencerma.gov">mbacon@spencerma.gov</a> 3 Old Meadow Road Spencer, MA 01562</td>
</tr>
<tr>
<td>Virginia Scarlet</td>
<td>Wetlands/Soil Specialist</td>
<td>(508)885-1500x123 <a href="mailto:vscarlet@spencerma.gov">vscarlet@spencerma.gov</a> 157 Main Street Spencer, MA 01562</td>
</tr>
<tr>
<td>Carter Terenzini</td>
<td>Town Administrator</td>
<td>(508) 885-7500x155 157 Main Street Spencer, MA 01562</td>
</tr>
</tbody>
</table>

3.2 Geographical Information System Mapping

Geographical information systems (GIS) are computer-based systems used to store, retrieve, map and analyze geographic or spatial information. Spatial information links real-world location data, such as latitude and longitude coordinate pairs, with descriptive attribute data (Cech, 2005). With such spatial information at its core, GIS is a much more powerful tool than a traditional map. Within a GIS, information such as topography, land use, river and pond locations, watershed delineation and roads can all be combined to allow for simultaneous evaluation of information.

GIS was used in this project to determine the land uses along the Sevenmile River in the Quaboag Pond watershed in Spencer, MA. Knowing the land use in this area allowed for determination of the most appropriate sites for water quality sampling, which is described in Section 4.1.2. By placing sampling sites upstream and downstream of potential pollutant sources (such as the Spencer Wastewater Treatment Plant or the outflow of a wetlands area), particular inputs were isolated as much as possible.

3.3 Field Research

Field research was conducted to determine the major sources of phosphorus and other pollutants in the Town of Spencer. This research included collecting water samples along the Sevenmile River, testing the water quality, and evaluating pollutant problems.
3.3.1 Non Point Source Sampling

The Sevenmile River in Spencer flows into the East Brookfield River, which is the main inlet to Quaboag Pond. Therefore, water samples were collected at ten locations along the Sevenmile River in Spencer, and tested for water quality. Sample collection sites are identified on Figure 4 and listed in Table 5 in Section 4.1.2. The samples were collected from the Sevenmile River because it was estimated that 39% of the phosphorus load going into Quaboag Pond comes from the Sevenmile River watershed (DEP, 2005). To collect a sample, a one liter plastic Nalgene bottle was submerged in the water, filled and then capped. The samples were collected starting at Site A and then in order through Site H. The bottles were transported to the Environmental Engineering laboratory at WPI in Worcester, MA in a Styrofoam cooler with ice packs.

3.3.2 Field Measurements

While collecting water samples from each of the sites along the Sevenmile River, the dissolved oxygen concentration was measured in the field. This was accomplished with a YSI Model 85 Handheld Oxygen, Conductivity, Salinity, and Temperature System (YSI Inc., Yellow Springs, OH). First, the meter was turned on and allowed to warm up for 15 minutes. Then, the desired measurement mode (DO in mg/L) was selected by pressing and releasing the Mode button. After 15 minutes, the meter was calibrated by pressing the “up” and “down” buttons until it was in calibration mode. Then the altitude was set to 500 feet. If the reading was between 97 and 100%, the calibration was correct. Lastly, the probe was inserted into the stream to determine the DO concentration. The probe was swirled in the water at a rate of 1 foot per second until a steady reading appeared on the display in units of mg/L.

3.3.3 Laboratory Measurements

After collecting the water samples, they were brought to the WPI Environmental Engineering Laboratory for analysis. Each sample was tested for the parameters shown in
Table 4. The samples were tested for the various parameters because they all affect water quality. Both nitrogen and phosphorus can lead to eutrophication in ponds if the concentrations are too high. Dissolved oxygen (DO) and pH can both affect the organisms that live in the water. The pH level should remain neutral and the DO should not be less than a certain amount for the organisms to survive. Suspended solids in the water can lead to the water looking murky and causes concern for recreation and aesthetic value of the water. The biochemical oxygen demand (BOD) is an indication of the concentration of degradable organic matter, and can affect DO levels.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Method of Measurement</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus</td>
<td>Photometric</td>
<td>Causes eutrophication in ponds</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>Photometric</td>
<td>Causes eutrophication in ponds</td>
</tr>
<tr>
<td>pH</td>
<td>pH meter and probe</td>
<td>Can affect organisms in water, can be an indicator of pollution</td>
</tr>
<tr>
<td>Suspended Solids</td>
<td>Gravimetric analysis</td>
<td>Can impair aesthetic value and inhibit light penetration</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>Field meter</td>
<td>Needed for the survival of fish and other aquatic species</td>
</tr>
<tr>
<td>Biochemical Oxygen Demand</td>
<td>Field meter of DO before and after incubation</td>
<td>Decay of organic matter reduces DO</td>
</tr>
</tbody>
</table>

Nitrogen Concentration

The nitrogen concentration was measured using Nitrate 2 Vacu-vials with a Chemetric V2000 Photometer (CHEMetrics Inc., Calverton, VA). First, a sample cup was filled with 15 mL of the water sample. Then, a cadmium foil pack supplied by the manufacturer was emptied into the cup and the cup was capped and shaken vigorously for 3 minutes. After the cup sat for 30 seconds, a Vacu-vial ampoule was placed into the sample cup and the tip was broken off by pressing it into the side of the cup. The sample in the cup was transferred to the ampoule by the vacuum of the Vacu-vial. The contents of the ampoule were mixed by inverting it several times. The ampoule was placed in the photometer and 10 minutes was allowed for color development. Lastly, the result from
the photometer was read, which provided the concentration in mg/L. This process was repeated for each water sample.

**Phosphorus Concentration**

Phosphorus, like nitrogen, was measured using the Chemetrics V2000 Photometer. For phosphorus, Phosphate 2 Vacu-vials were used to measure the total phosphorus concentration. First, a sample cup was filled with 25 mL of the water sample. Then 2 drops of A-8500 Activator Solution was added to the sample. The cup was then capped and shaken to mix the contents well. The Vacu-vial ampoule was then placed in the sample cup and the tip was broken off by pressing it against the side of the cup. When the tip is broken off, the Vacu-vial vacuums the sample from the cup into the ampoule. After that, the contents of the ampoule were mixed by inverting the ampoule several times. The ampoule was then placed in the photometer and 3 minutes was allowed for color development. The result from the photometer was read, which provided the phosphorus concentration in mg/L. This process was repeated for each water sample.

**Suspended Solids Measurement**

Suspended solids were measured by passing each sample through a filter and quantifying the weight of solids retained on the filter after drying. To measure the suspended solids, first a Whatman 47 mm diameter Glass Microfibre Filter (#934-AH) was pre-washed with E-pure water. To do this, the filter was placed in a filter tower mounted on a manifold and connected to a KNF Neuberger vacuum pump (KNF Neuberger Inc., Trenton, NJ). Then, 50 mL of E-Pure water was added to the filter tower and filtered through the filter using vacuum suction. The filter was then removed from the tower and placed in a porcelain dish. The dish and filter were then put into the Lindberg/Blue oven overnight at 105° C. They were then transferred to a Nalgene desiccator for 30 minutes to let cool. After cooling, the porcelain dish and filter were weighed in a Mettler Toledo AB104-S scale to obtain the weight in grams. This process was repeated to prepare a filter for each of the sampling sites. All of the prepared filters and dishes were stored in a desiccator until use.

After collecting water samples, each porcelain dish and filter was taken out of the desiccator. Then, the filter from the porcelain dish was placed on a filter tower and the
same process that was used to filter the E-pure water was used for each water sample, using 300 mL of each sample. When all of the samples were filtered, the dishes and filters were put into the oven at 105°C for at least two hours. Then the dishes were removed from the oven and put into a desiccator to let the samples cool for 30 minutes. Each dish and filter was then re-weighed. The suspended solids in mg/L was calculated according to the equation:

\[
SS \text{ (mg/L)} = \left\{\frac{(A - B) \text{g}}{300 \text{ mL}}\right\} \times (1000 \text{ mL/L}) \times (1000 \text{ mg/g})
\]

Where

\(A\) = weight of dish + filter + retained solids (g)

\(B\) = weight of dish + filter (g)

**pH Measurement**

The pH was measured using an Orion pH meter model 420A (Thermo Fisher Scientific, Saugus, MA). First, the meter was powered on, then the probe was submerged into the sample until a steady reading was obtained. The probe was then rinsed with Epure water and the process was repeated for each sample.

**Five Day Biochemical Oxygen Demand Measurement**

To measure the five day biochemical oxygen demand (BOD\(_5\)), 300 mL BOD bottles were filled with the water samples to the top. Then a glass stopper was placed in each bottle so that some of the water overflowed, creating a water seal. A plastic cover was then placed on the bottle over the glass stopper. The BOD bottles were placed in an incubator at 20°C Celsius for five days. After five days passed, the samples were removed from the incubator. The YSI Model 85 Handheld Oxygen, Conductivity, Salinity, and Temperature System was calibrated the same way as for the DO measurements. Then the DO of each BOD sample was measured by swirling the probe in the water sample at a rate of 1 foot per second until there was a stable reading. The process was repeated for each water sample. The BOD\(_5\) was measured by subtracting the final DO from the initial DO, which was measured earlier in the field.
3.4 Comparison of Water Quality to Massachusetts Standards

The Sevenmile River is considered a Class B waterbody. This means that it is designated as a habitat for fish and other aquatic life, and is also designated for primary and secondary contact recreation. The water should be suitable for irrigation and other agricultural uses, as well as for industrial cooling and process uses. A good aesthetic value should also be maintained.

There are standards set by the state for dissolved oxygen, pH, and suspended solids. However, there are no standards set for biochemical oxygen demand, phosphorus concentration, or nitrogen concentration. These standards are shown in the 314 CMR 4.00: Massachusetts Surface Water Quality Standards (DEP).

3.5 Best Management Practices

Best Management Practices (BMPs) are techniques used to control storm water runoff, sediment, and soil stabilization, as well as management decisions to prevent or reduce non-point source pollution. The goal of these various techniques is to manage the quantity and improve the quality of storm water runoff in the most cost-effective manner. There are numerous different BMPs that can be utilized by the town of Spencer, with certain types of BMPs applicable to certain types of non-point source pollution.

3.5.1 Best Management Practices Research

There are numerous best management practices that aid in reducing nutrient and sediment inputs into a water system. A list of best management practices for non-point pollution control was compiled. This list was compiled from state and government agencies, such as the Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Protection. The EPA publishes information on NPDES stormwater case studies in towns and cities across the United States that have already implemented BMPs, including Monroe County, New York: Chittenden County, Vermont: and the State of Maine. Based on this research, a list including structural best management practices and nonstructural best management practices was established.

The BMPs were evaluated for use in the town of Spencer. The evaluation included assessment of the applicability of each BMP for the identified pollutant issues,
and a cost-benefit analysis for implementation of each BMP. The applicability was determined based on the criteria shown in Table 5.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Importance of Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate</td>
<td>Certain BMPs are only effective in warm weather climates. In the winter months, the BMP could freeze and become ineffective at removing nutrients and sediments from stormwater.</td>
</tr>
<tr>
<td>Space Required</td>
<td>The cost of land in Spencer is high and can prohibit a BMP from being implemented in the town. The more space that is needed for a BMP to properly remove pollutants from stormwater, the less applicable it becomes for the town of Spencer, MA.</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>How effective each of the BMPs are at removing various stormwater pollutants, specifically nitrogen and phosphorus. If a BMP has a high removal of a specific pollutant, such as suspended solids, but is not effective at removing phosphorus from stormwater, then it is not viable for Spencer, because the target pollutants are nitrogen and phosphorus.</td>
</tr>
<tr>
<td>Cost</td>
<td>Cost is a major factor for the town of Spencer. With no additional funding provided by the State or Federal governments, the town has to provide funding for any best management practice they implement. The lower the cost to the town, the more viable the BMP is for Spencer.</td>
</tr>
</tbody>
</table>

The best management practices were categorized based on the type of pollution each one is intended to manage and how effectively each practice removes those pollutants from stormwater runoff. The main focus for the town of Spencer is phosphorus loading that enters the Sevenmile River. A BMP such as catch basin inserts are highly effective at removing suspended solids from stormwater, but do not remove nitrogen or phosphorus (EPAh, 2007). Therefore they are not viable for Spencer, MA.

The effectiveness of each management practice could vary with different climates and locations, and therefore the New England weather was considered for the viability of each practice. Sand Filters are not effective in cold weather climates because the water within the filter freezes and does not remove any sediments or nutrients from the stormwater (EPAa, 2007).

Another limiting factor in our research is the space needed to implement the BMP properly. Because the town has limited space to implement storm water management.
practices such as detention ponds and settling tanks, relatively small BMPs that are applicable to such small spaces have to be used.

To complete the analysis, we considered costs for each method in other towns with a Phase II storm water permit, such as Burlington, VT, and estimated the actual costs for Spencer. This was done by taking the costs from other towns and taking into consideration the size and extent of the project, the current Massachusetts government inflation rate, and other additional costs the town may have to deal with during the implementation of the project. The information on other towns with a Storm Water Permit was available through the EPA case studies. The use of best management practices and storm water management strategies, in most cases, have little or no monetary value, and therefore the benefits are determined by how much pollution is prevented from entering the water system and eventually entering Quaboag Pond. The amount of pollution being prevented was assessed based on the effectiveness of other towns with similar best management practices.
4 Results and Analysis

The goal of this project was to provide recommendations to reduce inputs of phosphorus and other pollutants into Quaboag Pond. First, interviews with town officials in Spencer were used to determine the needs and resources of the town. Second, point and non-point sources of pollution in the Sevenmile River watershed in Spencer were determined through water quality testing. After determining pollutant issues, recommendations for reducing contaminant inputs using best management practices were developed.

4.1 Pollutant Issues

There were several different pollutants flowing into the Sevenmile River that were of concern to the environment. The most important one for this project, however, was phosphorus. The relative importance of various pollutants was determined by interviews and water quality testing.

4.1.1 Interviews

Interviews were conducted with Carter Terenzini, Virginia Scarlet, and Margaret Bacon on November 29th, 2006. Interview questions and transcriptions are located in Appendix A. The goal of the interviews was to determine what current actions are being taken by the town to comply with the stormwater permit, and determine any constraints the town had for the project.

Virginia Scarlet, Wetlands/ Soil Specialist, stated that the area with the highest concentration of pollutants is the residential and commercial areas surrounding Muzzy Pond. Lake Whittemore is also in the Sevenmile River watershed and may be a source of some of the nutrients. Therefore, Ms. Scarlet suggested that water quality test sites around Muzzy Pond may provide information on the sources of nutrient loadings into Quaboag Pond.

Carter Terenzini, Town Administrator, stated that the town of Spencer has an average annual increase in budget of two to two and a half percent. Due to inflation, the
necessary costs of the town increase by four to four and a half percent every year. Therefore, the town actually has a decrease of funds each year by about two percent, and any available funds are allocated to necessary town expenses. The town has made the stormwater permit an extremely low priority because there is no funding for any best management practices or remediation systems.

The interviews provided the conclusion that there is a very limited budget for any best management practices, so remediation plans had to be very cost effective.

4.1.2 Laboratory Results

Water samples were collected at 10 locations along the Sevenmile River in Spencer. The Sevenmile River flows into the East Brookfield River, which is the main inlet to Quaboag Pond. The sites are noted on Figure 4. Samples were collected on November 15, November 29, and December 29 of 2006, and January 18 of 2007. The samples were tested for phosphorus, nitrogen, pH, suspended solids, dissolved, and BODs.

The sample sites were selected by isolating the land uses along the Sevenmile River, as discussed in Table 6. Site A was selected because it is in the middle of downtown Spencer, with dense commercial development. Site B is located at the end of a residential area and at the beginning of a marsh. This site was selected so that the pollutants at the beginning of the marsh could be compared to the pollutants at the end of the marsh, which was Site C. Site D was selected because it is surrounded by a rural area. Site E is at the beginning of a marsh and is located in a low density residential area, and directly upstream are the Spencer Fairgrounds. Site F is at the end of the marsh of Site E, and is located in a commercial area. Site G was selected because it is part of Cranberry Brook, a confluence of the Sevenmile River. Site H was chosen because it is right before the wastewater treatment plant. Site I was chosen because it is part of the wastewater treatment plant, right after the effluent mixes with the stream, and site J was selected because it was right after the wastewater treatment plant. Additional site descriptions and photographs of the sites are provided in Appendix B.
Figure 4 - Sampling Points along Sevenmile River in Spencer
Table 6 - Water Sampling Sites along Sevenmile River in Spencer

<table>
<thead>
<tr>
<th>Site ID</th>
<th>Location</th>
<th>Sampling Point</th>
<th>Site Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Elm Street &amp; Valley Street</td>
<td>Collected on North side of Elm St.</td>
<td>Fenced in, small stream of water, commercial area</td>
</tr>
<tr>
<td>B</td>
<td>End of Valley Street at Ogara Park</td>
<td>Collected on South side of Valley St., at beginning of park</td>
<td>Outlet to a marsh, located near old parking lot, residential area</td>
</tr>
<tr>
<td>C</td>
<td>Main Street &amp; West Main Street</td>
<td>Collected on West side of Main St.</td>
<td>Road underpass, outflow from marsh, commercial area</td>
</tr>
<tr>
<td>D</td>
<td>Meadow St. at end of West Main St.</td>
<td>Collected on East side of Meadow St.</td>
<td>Near parking lot, road underpass, rural area</td>
</tr>
<tr>
<td>E</td>
<td>Meadow St. &amp; Smithville Rd.</td>
<td>Collected on North side of Smithville Rd.</td>
<td>Near fairgrounds, flows into marsh, residential area</td>
</tr>
<tr>
<td>F</td>
<td>South Spencer Rd. at R.E. Leveille Shop</td>
<td>Collected on North side of South Spencer Rd.</td>
<td>Road underpass, near parking lot, residential area</td>
</tr>
<tr>
<td>G</td>
<td>Main St. behind Ernie’s Car Wash</td>
<td>Collected on West side of Main St.</td>
<td>Surrounded by trees, outflow of marsh, commercial area</td>
</tr>
<tr>
<td>H</td>
<td>Main St. at Sunoco Gas Station</td>
<td>Collected on east side of Main St.</td>
<td>Bridge underpass, right on Main St., commercial area</td>
</tr>
<tr>
<td>I</td>
<td>Spencer Wastewater Treatment Plant</td>
<td>Collected on South side of South Spencer Rd.</td>
<td>Surrounded by trees, residential area</td>
</tr>
<tr>
<td>J</td>
<td>Route 49 Bridge</td>
<td>Collected on South side of Rt. 49</td>
<td>Bridge underpass, down hill to water, undeveloped area</td>
</tr>
</tbody>
</table>

The results of the tests are listed in Tables 7 – 10. For the phosphorus and nitrogen tests, there are limits to what concentrations can be detected. The phosphorus limits are between 0.75 and 8.00 ppm and the nitrogen limits are between 0.2 and 3.00 ppm. When the phosphorus concentrations were being measured, however, some readings were below 0.75 ppm.
Table 7 - Water Sample Test Results (November 15, 2006)

<table>
<thead>
<tr>
<th>Sample Site</th>
<th>DO (mg/L)</th>
<th>Phosphorus (ppm)</th>
<th>Nitrogen (ppm)</th>
<th>pH</th>
<th>BOD₅ (mg/L)</th>
<th>SS (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10.50</td>
<td>0.03</td>
<td>0.25</td>
<td>6.59</td>
<td>2.52</td>
<td>7.2</td>
</tr>
<tr>
<td>B</td>
<td>9.11</td>
<td>0.02</td>
<td>0.33</td>
<td>6.46</td>
<td>0.52</td>
<td>2.8</td>
</tr>
<tr>
<td>C</td>
<td>9.21</td>
<td>0.26</td>
<td>0.14</td>
<td>6.47</td>
<td>0.31</td>
<td>16.4</td>
</tr>
<tr>
<td>D</td>
<td>10.40</td>
<td>0.02</td>
<td>0.32</td>
<td>6.44</td>
<td>0.60</td>
<td>11.6</td>
</tr>
<tr>
<td>E</td>
<td>9.90</td>
<td>0.04</td>
<td>0.00</td>
<td>6.59</td>
<td>0.50</td>
<td>3.2</td>
</tr>
<tr>
<td>F</td>
<td>9.00</td>
<td>0.00</td>
<td>0.05</td>
<td>6.60</td>
<td>0.31</td>
<td>1.2</td>
</tr>
<tr>
<td>G</td>
<td>8.45</td>
<td>0.01</td>
<td>0.00</td>
<td>6.62</td>
<td>0.07</td>
<td>8.4</td>
</tr>
<tr>
<td>H</td>
<td>8.65</td>
<td>0.06</td>
<td>0.00</td>
<td>6.58</td>
<td>0.25</td>
<td>6.8</td>
</tr>
<tr>
<td>I</td>
<td>8.10</td>
<td>0.47</td>
<td>&gt; 3.0</td>
<td>6.32</td>
<td>0.03</td>
<td>4.8</td>
</tr>
<tr>
<td>J</td>
<td>8.90</td>
<td>0.00</td>
<td>0.19</td>
<td>6.81</td>
<td>0.07</td>
<td>6.0</td>
</tr>
</tbody>
</table>

Table 8 - Water Sample Test Results (November 29, 2006)

<table>
<thead>
<tr>
<th>Sample Site</th>
<th>DO (mg/L)</th>
<th>Phosphorus (ppm)</th>
<th>Nitrogen (ppm)</th>
<th>pH</th>
<th>SS (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>11.02</td>
<td>0.00</td>
<td>0.17</td>
<td>6.20</td>
<td>2.8</td>
</tr>
<tr>
<td>B</td>
<td>11.68</td>
<td>0.00</td>
<td>0.29</td>
<td>6.15</td>
<td>2.8</td>
</tr>
<tr>
<td>C</td>
<td>11.50</td>
<td>0.00</td>
<td>0.41</td>
<td>6.23</td>
<td>2.8</td>
</tr>
<tr>
<td>D</td>
<td>11.50</td>
<td>0.00</td>
<td>0.30</td>
<td>6.07</td>
<td>4.0</td>
</tr>
<tr>
<td>E</td>
<td>11.33</td>
<td>0.00</td>
<td>0.13</td>
<td>6.40</td>
<td>1.8</td>
</tr>
<tr>
<td>F</td>
<td>10.53</td>
<td>0.00</td>
<td>0.22</td>
<td>5.04</td>
<td>0.2</td>
</tr>
<tr>
<td>G</td>
<td>11.11</td>
<td>0.00</td>
<td>0.14</td>
<td>5.89</td>
<td>1.2</td>
</tr>
<tr>
<td>H</td>
<td>10.64</td>
<td>0.00</td>
<td>0.14</td>
<td>5.52</td>
<td>1.0</td>
</tr>
<tr>
<td>J</td>
<td>10.59</td>
<td>0.00</td>
<td>0.10</td>
<td>6.34</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Table 9 - Water Sample Test Results (January 18, 2007)

<table>
<thead>
<tr>
<th>Sample Site</th>
<th>DO (mg/L)</th>
<th>pH</th>
<th>BOD₅ (mg/L)</th>
<th>SS (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>11.24</td>
<td>6.66</td>
<td>2.94</td>
<td>1.2</td>
</tr>
<tr>
<td>B</td>
<td>12.62</td>
<td>6.60</td>
<td>4.11</td>
<td>0.4</td>
</tr>
<tr>
<td>C</td>
<td>12.77</td>
<td>6.23</td>
<td>3.80</td>
<td>2.3</td>
</tr>
<tr>
<td>D</td>
<td>12.97</td>
<td>6.17</td>
<td>3.90</td>
<td>2.8</td>
</tr>
<tr>
<td>E</td>
<td>10.42</td>
<td>6.52</td>
<td>1.58</td>
<td>79.5</td>
</tr>
<tr>
<td>F</td>
<td>12.36</td>
<td>5.26</td>
<td>3.79</td>
<td>86.1</td>
</tr>
<tr>
<td>G</td>
<td>12.13</td>
<td>6.02</td>
<td>3.51</td>
<td>1.8</td>
</tr>
<tr>
<td>H</td>
<td>12.47</td>
<td>5.47</td>
<td>2.85</td>
<td>2.0</td>
</tr>
<tr>
<td>I</td>
<td>9.54</td>
<td>6.58</td>
<td>1.81</td>
<td>1.1</td>
</tr>
<tr>
<td>J</td>
<td>12.01</td>
<td>6.37</td>
<td>3.45</td>
<td>1.8</td>
</tr>
</tbody>
</table>
Table 10 - Water Sample Test Results (December 29, 2006)

<table>
<thead>
<tr>
<th>Sample Site</th>
<th>DO (mg/L)</th>
<th>Phosphorus (ppm)</th>
<th>Nitrogen (ppm)</th>
<th>pH</th>
<th>BOD (mg/L)</th>
<th>SS (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10.92</td>
<td>0.96</td>
<td>&lt;0.2</td>
<td>7.76</td>
<td>1.49</td>
<td>0.1</td>
</tr>
<tr>
<td>B</td>
<td>10.82</td>
<td>0.03</td>
<td>&lt;0.2</td>
<td>8.01</td>
<td>1.65</td>
<td>0.5</td>
</tr>
<tr>
<td>C</td>
<td>12.41</td>
<td>0.13</td>
<td>&lt;0.2</td>
<td>7.72</td>
<td>3.40</td>
<td>63.0</td>
</tr>
<tr>
<td>D</td>
<td>10.46</td>
<td>0.03</td>
<td>&lt;0.2</td>
<td>7.50</td>
<td>0.88</td>
<td>37.0</td>
</tr>
<tr>
<td>E</td>
<td>12.91</td>
<td>0.04</td>
<td>0.19</td>
<td>8.31</td>
<td>3.79</td>
<td>2.4</td>
</tr>
<tr>
<td>F</td>
<td>8.85</td>
<td>0.01</td>
<td>0.15</td>
<td>8.35</td>
<td>0.25</td>
<td>20.0</td>
</tr>
<tr>
<td>G</td>
<td>10.03</td>
<td>0.00</td>
<td>0.31</td>
<td>7.96</td>
<td>1.25</td>
<td>1.5</td>
</tr>
<tr>
<td>H</td>
<td>11.92</td>
<td>0.07</td>
<td>0.17</td>
<td>8.00</td>
<td>3.47</td>
<td>3.3</td>
</tr>
<tr>
<td>I</td>
<td>9.31</td>
<td>0.46</td>
<td>&gt;8.0</td>
<td>6.90</td>
<td>1.63</td>
<td>0.2</td>
</tr>
<tr>
<td>J</td>
<td>11.33</td>
<td>0.01</td>
<td>0.33</td>
<td>8.08</td>
<td>2.58</td>
<td>1.1</td>
</tr>
</tbody>
</table>

4.2 Analysis of Laboratory Results

The Sevenmile River is classified as a Class B water body by the Mass DEP. A Class B waterbody is designated as a habitat for fish and other aquatic animals and also for primary and secondary contact recreation. The standards for this class of water include dissolved oxygen, pH, and suspended solids. The minimum value of DO in the water is 5.0 mg/L in order to sustain the life of fish. All of the water samples that were taken showed a value of 8.10 mg/L or higher, which is much higher than the limit. This means that DO is not an issue for the Sevenmile River. However, as DO is typically more critical in the summer, Do should be evaluated during this time to ensure the level is sufficient year round.

The pH level should be between 6.5 and 8.3 for a Class B water. Two samples exceed 8.3: Site E and Site F on December 29. However, the values were only 8.31 and 8.35, and therefore do not constitute a significant concern. The lowest pH measurement was 5.04 at sample site F. The pH measurement at site F was lower than 6.5 on 2 of the 4 sampling events. Low pH values were also observed at other sites as all sites except E were below the minimum value on November 29.

There is no quantifiable standard limit to the amount of allowable suspended solids in a class B water body. The only limits are that the water not be too impaired to
cause an aesthetic concern or to impair the use. By visual inspection of the sampling sites, the amount of suspended solids was not an issue.

There are not currently any water quality standards regarding nutrient loadings or BOD$_5$ in rivers. However, the limit of phosphorus concentration in the effluent of the Spencer Wastewater Treatment Plant is 0.2 mg/L. The highest single concentration of phosphorus was located at sample site A, with a value of 0.96 parts per million (or mg/L) on December 29. Other sites with high phosphorus concentrations are sample site C and sample site I on November 29, with concentrations of 0.26 and 0.47 parts per million, respectively. All of these measurements are over the limit for the treatment plant, therefore they should be considered too high. Sample sites A and C are both located in downtown Spencer, and site I is located in the wastewater treatment plant. The highest nitrogen concentrations were located at sample site I. The concentration was so high for the December 29 testing that it was above the range of the test, which is 8.0 parts per million. The other high concentrations were located at sample sites B and C, with values of 0.33 and 0.41 parts per million, respectively. There are no limits for the nitrogen concentration because nitrogen is readily found in the atmosphere, and it is not a limiting nutrient.

4.3 Analysis of Best Management Practices

A variety of stormwater best management practices were researched to cover the different aspects of the NPDES Phase II Stormwater Permit. These best management practices were compiled and compared based on criteria including cost, space needed, limitations on the BMP, and effectiveness for reduction of specific pollutants in receiving water bodies. The list and criteria for each practice is listed in Appendix D.

Many of stormwater best management practices provided in Appendix D were eliminated based on the constraints of the town of Spencer. The major constraint in implementing stormwater BMPs is available funding. There is currently no money to subsidize costly best management practices. Another limitation is the amount of space available to implement stormwater practices. The cost of land in Spencer is approximately $22,500 an acre, which makes acquiring land to construct best management practices impractical for the town. Therefore, the list of available best management practices was greatly reduced based on space and cost associated with each.
For example, stormwater wetlands require an average of 25 acres to be effective in reducing nutrient inputs into surface waters, and have an average cost of $350,000 (Brown, 1997). Stormwater wetlands are not practical for Spencer and therefore were not considered for the town.

After the initial screening, nine different best management practices were analyzed to determine which were best suited for the town of Spencer. These nine best management practices are described in Table 11.

<table>
<thead>
<tr>
<th>Best Management Practice</th>
<th>Cost</th>
<th>Limitations</th>
<th>Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-lot Infiltration</td>
<td>$100 per rain barrel</td>
<td>Maintenance of the barrels and excess water on private properties</td>
<td>Relatively low impact on watershed</td>
</tr>
<tr>
<td>Sand Filters</td>
<td>$2.50-7.50 ft²</td>
<td>Not effective during winter months, require cleaning and maintenance</td>
<td>Highly effective at removing suspended solids and phosphorous</td>
</tr>
<tr>
<td>Vegetated Filter Strip</td>
<td>$.70 per ft²</td>
<td>Limited pollution removal and cost of land in Spencer can be prohibitive</td>
<td>Remove 40% of phosphorous and 20% of nitrogen</td>
</tr>
<tr>
<td>Public Education</td>
<td>Cost of education materials</td>
<td>Only reach as many people as they are distributed to, and the residents of Spencer may not choose to follow pollutants prevention suggestions</td>
<td>Only as effective as how many people decide to participate in the remediation and prevention suggestions</td>
</tr>
<tr>
<td>Public Involvement</td>
<td>Cost includes providing proper instructions and materials to complete a project</td>
<td>Depends of the scale of the project, how many volunteers are involved and what remediation program is being undertaken</td>
<td>Only as effective as how many people decide to participate in the remediation and prevention suggestions</td>
</tr>
<tr>
<td>Construction Sites</td>
<td>Costs incorporated into new construction budgets, not the town’s</td>
<td>There are guidelines set by the state that regulate how much runoff is acceptable for a construction site, there is no profit in providing additional protection</td>
<td>Highly varied depending on the extent of the project</td>
</tr>
<tr>
<td>Alternative Pavers</td>
<td>Usually less than normal asphalt</td>
<td>Porous pavers and other alternatives are not suitable for high traffic areas like the problems sites in Spencer</td>
<td>Can reduced the amount of road runoff and the velocity of the runoff to provide percolation</td>
</tr>
<tr>
<td>Alternative Turnarounds</td>
<td>For new turnarounds it costs $6.40 per ft²</td>
<td>The local regulations may prohibit smaller turnarounds in high residential areas because emergency vehicles may need more room</td>
<td>Can reduce impervious surfaces in the turnaround up to 80%</td>
</tr>
<tr>
<td>Elimination Curbs and Gutters</td>
<td>Grassed swales instead of curbing is significantly cheaper for new roads</td>
<td>The removal of existing curbs and gutters can be costly, so this method can be cost-effective on new roads</td>
<td>Using grassed swales instead of curbs can greatly reduce peak flow discharges</td>
</tr>
</tbody>
</table>

On-lot infiltration refers to a range of practices designed to treat runoff from individual residential lots. The primary purpose of most on-lot practices is to manage runoff from rooftops and, to a lesser extent, driveways and sidewalks. Managing runoff from rooftops effectively disconnects these impervious surfaces, reducing a watershed's overall imperviousness, and therefore reducing stormwater runoff (EPAa, 2007). The
simplest and least costly on-lot infiltration system is a rain barrel. A rain barrel is connected to a building’s gutter system and collects the rainwater, preventing it from discharging to impervious surfaces. This limits the amount of water that can transport pollutants to surface waters. The barrels can then be discharged to lawns or gardens at the owner’s discretion. Rain barrels only cost about $100 and, if they are used to water lawns and gardens, can save on water costs. This BMP does not directly reduce phosphorus inputs into surface waters (EPAa, 2007).

Sand filters are usually designed as two-chambered stormwater practices. The first chamber is a settling chamber, and the second is a filter bed filled with sand or another filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as stormwater flows through the filtering medium (Brown, 1997). Sand filters are designed for relatively small watersheds (an average of two acres) and remove 40 to 85 percent of the total phosphorus in the stormwater (Brown, 1997). However, sand filters are not viable for Spencer because they are not effective in cold weather climates. The sand filters would freeze during the winter months in Spencer and will not remove any nutrients or sediments from stormwater during this season.

Vegetated filter strips are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils. With proper design and maintenance, filter strips can provide relatively high phosphorus removal (40 percent). Vegetated filter strips are also effective at reducing other pollutants, such as total suspended solids, nitrogen, lead and zinc (Yu, 1993).

Because stormwater runoff is generated from dispersed land surfaces (pavements, yards, driveways, and roofs), efforts to control stormwater pollution must consider individual, household, and public behaviors and activities that can generate pollution from these surfaces. Common individual behaviors like disposing of pet waste, applying lawn chemicals and fertilizers, and washing cars, have the potential to generate stormwater pollution. It takes individual behavior change and proper practices to control such pollution. Therefore it is important to make the public sufficiently aware and concerned about the significance of their behavior with regards to stormwater pollution. Information and education can be used to encourage residents to change improper
behaviors. The public can be educated through low cost measures such as classroom education, using educational pamphlets, and using the media to promote proper stormwater pollution prevention techniques (EPAb, 2007).

Public involvement in activities such as Adopt-A-Stream programs, reforestation programs, storm drain marking, and volunteer monitoring reduces costs to the town by replacing paid officials with volunteers. The only limitation to public involvement programs is providing a workshop or “how to” packet on the various stormwater activities (EPAc, 2007).

Construction sites are required to provide their own pollution prevention plans as part of the construction budget. This relieves some of the cost burden for the town and still helps prevent stormwater pollution runoff. Some examples of construction best management practices that are commonly used are silt fencing to prevent fine particles and nutrients from leaving the construction site, mulching and seeding to prevent erosion of disturbed soils, and sodding to provide immediate erosion prevention. Another BMP is the use of rip rap, which is a layer of large stones used to protect soil from erosion in areas of concentrated runoff. Check dams can also be used at construction sites as a temporary structure to slow the velocity of concentrated water flows in channels or swales. These can be used in conjunction with grass-lined channels that direct stormwater runoff through a channel to promote infiltration (EPAd, 2007).

Alternative pavers are permeable surfaces that replace asphalt and concrete in driveways, parking lots and walkways. Alternative pavers can also include porous pavement that allows water to permeate through the pavement and into the subsoil. This reduces the amount of stormwater transporting pollutants to surface waters. Porous pavement can be used in any medium to light traffic area and is comparable in cost to asphalt. However, porous pavement can allow road salts and chlorides to migrate through the pavement and enter ground water systems. According to Gburek and Urban (1980), porous pavement can reduce phosphorus inputs into surface waters up to 65 percent. Alternative pavers can also reduce suspended solids up to 82 percent, nitrogen up to 80 percent and heavy metals up to 98 percent.

Alternative turnarounds are another best management practices for urban areas. Alternative turnarounds are end-of-street vehicle turnarounds that reduce impervious cover in neighborhoods by replacing cul-de-sacs. Cul-de-sacs are local access streets.
with closed circular ends that allow for vehicle turnarounds. Reducing the size of cul-de-
sacs, either though the use of alternative turnarounds or by eliminating them altogether
can reduce the amount of impervious cover created at the site. If alternative turnarounds
are implemented during road construction, they can reduce costs up to $6.40 per cubic
foot (Schueler, 1995). However, Spencer’s cul-de-sacs are already in place and would
have to modified or removed, which presents a significant cost increase.

Eliminating curbs and gutters along roadways is an excellent method for promoting
natural stormwater permeation. Instead of the traditional curb, a grassed swale is
constructed along residential streets. Curbs are designed to quickly convey runoff from
the street to a stormdrain, and consequently provide little or no removal of stormwater
pollutants. The costs associated with eliminating curbs are relatively low. Curbs cost
more than grasses swales, but the removal of existing curbs adds cost (EPAe, 2007).

4.4 Recommended Best Management Practices

Two best management practices were recommended for the Town of Spencer,
including one for the short term and one for the long term. The short term BMP was
recommended because of the low cost to the Town of Spencer. During the interviews that
were previously conducted, it was made clear that the town had a very little, if any,
budget to work with. The long term BMP was recommended because the town might
come into some money at a later time and be able to implement more effective BMPs for
reducing phosphorus inputs to the Sevenmile Rive, and thus Quaboag Pond.

4.4.1 Recommended Short – Term Best Management Practice

As it was revealed in the meeting with the Spencer town officials, the town has a
very small budget to work with regarding stormwater permit compliance. The Best
Management Practice that was recommended for the short term was developed in
consideration of the limited funding. It was recommended that the town of Spencer use
filter strips, also known as vegetative buffer strips, to reduce the impact of stormwater
runoff going into the Sevenmile River and flowing into Quaboag Pond.

Filter strips are vegetated areas that are meant to reduce the flow velocity of water
coming from impervious areas. They also trap sediments and pollutants, and provide
some infiltration. The filter strips consist of grass and then some shrubs to advance the
process of infiltration and filtration. This BMP was selected because the cost is relatively low and the community can also get involved. There are two major areas that would benefit from filter strips in the town of Spencer. The first area that would benefit is the area between Adams Street and Clark Street and Muzzy Pond. Test sites A, B, and C are directly downstream of Muzzy Pond and all the effluents of the pond, such as sediments and nutrients, flow into those sample sites. The area between the road and the pond is currently undeveloped and pollutant runoff from the road directly enters Muzzy Pond. This area is high in road salts and runoff pollution. The rest of the pond perimeter is privately owned or developed and the majority is not owned by the Town of Spencer. This strip of land along Muzzy Pond is approximately 48,500 ft², as seen in Figure 5.

![Figure 5 - Muzzy Pond Filter Strips](image-url)

The area was determined using the Massachusetts Department of Environmental Protection Geographical Information System called Oliver. The layers regarding streams, water bodies, topographical contours, and physical streets were downloaded from Oliver.
and loaded into ArcGIS software. Then the area for the recommended best management practices was estimated in square feet using the area tool.

With an area of 48,500 ft², the cost of implementing filter strips is between $14,500 for dense grass seed planting and $34,000 for high density shrub plantings. These estimates are based on the rough cost estimates by the EPA (EPAg, 2007) of approximately 30¢ per ft² for seed or 70¢ per ft² for sod. There is currently little to no barrier between the road and Muzzy Pond that eventually drains to the Sevenmile River.

An additional area surrounding the stream connecting Muzzy Pond and the Sevenmile River is also a prime area for filter strips. This area surrounding the stream encompasses sample sites A, B, and C. This area is slightly larger than the area around Muzzy Pond with approximately 431,500 ft² of filter strips. This is approximately 10 feet of filter strips surrounding the entire stream bank, as shown in Figure 6. The cost of the filter strips ranges from $129,500 with dense grass planting to $302,000 with dense root shrub plantings (Yu, 1993).

![Figure 6 - Stream Bank Filter Strips](image)

To aide the town with the implementation of the filter strips, flyers were created to inform the residents of Spencer about non-point source pollution. The flyers were
made to send out to the town with the semiannual Spencer Town News letter. Sample flyers are located in Appendix E. In the flyers, the residents are notified of the pollution problem that the town is facing, including what the pollutants are. Also, the flyers inform the town residents of what they are doing that can contribute to pollutant problems, such as using too much fertilizer and pesticides, and not cleaning up after their pets. The flyers also explained what filter strips are and how they can help to reduce the flow of pollutants into the Sevenmile River. It is recommended that a certain day be dedicated to the planting of the new filter strips, where the town residents will be asked to volunteer and assist in the planting process.

4.4.2 Recommended Long – Term Best Management Practices

In the event that the Town of Spencer is able to find funding for the NPDES Phase II Stormwater Permit program, several best management practices that would help reduce phosphorous and nitrogen inputs into the Quaboag Pond watershed were developed. Sand filters in key locations around the town would greatly reduce nutrient loadings to the town’s stormwater. Sand filters are usually designed as two-chambered stormwater practices; the first is a settling chamber, and the second is a filter bed filled with sand or another filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as stormwater flows through the filtering medium.

The sand filters can be placed in stormwater hot spots in the downtown, Main Street area. Stormwater hot spots are areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater. These areas include commercial nurseries, auto recycle facilities, commercial parking lots, fueling stations, storage areas, industrial rooftops, marinas, outdoor container storage of liquids, outdoor loading/unloading facilities, public works storage areas, hazardous materials generators (if containers are exposed to rainfall), vehicle service and maintenance areas, and vehicle and equipment washing/steam cleaning facilities. Sand filters are an excellent option to treat runoff from stormwater hot spots because stormwater treated by sand filters has no interaction with, and thus no potential to contaminate, the groundwater (Brown, 1997).
Sand filters would have to be maintained regularly to prevent clogging and erosion. Required maintenance includes checking to see that the filter bed is clean of sediments, and the sediment chamber is no more than one-half full of sediment. Removal of sediments may be necessary periodically. Also, the filters need to be inspected to ensure that there is no evidence of deterioration or cracking of concrete of the filter beds, and there are no signs of erosion (Brown, 1997).

Another best management practice that Spencer can use in the event that funding is available is eliminating curbs and gutters. This practice promotes grass swales as an alternative to curbs and gutters along residential streets. Curbs and gutters are designed to quickly convey runoff from the street to the storm drain and, ultimately, to a local receiving water. Consequently, they provide little or no removal of stormwater pollutants. These practices can be used in low to medium residential areas and will allow the stormwater to naturally percolate through grassy swales instead of being directed to stormwater basins. Curbs and gutters and the associated underground storm sewers have been documented to cost as much as $36 per foot, which is roughly twice the cost of a grass swale (Schueler, 1995). It is much more cost effective to install grassed swales instead of installing curbs and gutters on new roads to begin with.

Porous pavement is another option for the Town of Spencer in the future. Porous pavement is a permeable pavement surface, often built with an underlying stone reservoir that temporarily stores surface runoff before it infiltrates into the subsoil. Porous pavement replaces traditional pavement, allowing parking lot stormwater to infiltrate directly and receive water quality treatment. There are various types of porous surfaces, including porous asphalt, pervious concrete, and even grass or permeable pavers. From the surface, porous asphalt and pervious concrete appear to be the same as traditional pavement. However, unlike traditional pavement, porous pavement contains little or no "fine" materials. Instead, it contains voids that encourage infiltration. Porous asphalt pavement consists of an open-graded coarse aggregate, bonded together by asphalt cement, with sufficient interconnected voids to make it highly permeable to water (Gburek and Urban, 1980).

Porous pavement can be used to provide ground water recharge and to reduce pollutants in stormwater runoff. Some data suggest that as much as 70 to 80 percent of annual rainfall will go toward ground water recharge (Gburek and Urban, 1980). Porous
pavement is more expensive than traditional asphalt. While traditional asphalt and concrete costs between $0.50 and $3.00 per ft$^2$ (EPAf, 2007), porous pavement can range from $2 to $8 per ft$^2$ (EPAf, 2007), depending on the design.

4.5 Summary

Water quality testing along the Sevenmile River showed that sampling sites A, B, and C had the most significant density of phosphorus of the ten sample sites we tested. Reduction of non-point source pollution entering the Sevenmile River would improve water in Quaboag Pond, which is downstream of the river. At the present time, the town of Spencer has limited funding and can therefore implement pollution prevention measures such as public education through pamphlets and handouts to the residents of the town. If in the future the town receives funding for additional stormwater pollution control measures, other remediation methods can be used such as vegetated filter strips, sand filters, porous pavement and eliminating curbs and gutters from roadways.
5 Conclusions and Recommendations

The goal of this project was to reduce the inflow of pollutants, especially phosphorus, into Quaboag Pond. The main inlet to Quaboag Pond is the Sevenmile River in Spencer, MA. At the beginning of this project, it was determined that the Town of Spencer was granted a NPDES Phase II Stormwater Permit; however, the town was not in compliance with the requirements. The stormwater permit was meant to reduce the flow of pollutants in surface water and was mandated by the state. If the town is not in compliance, the state and EPA have the right to pursue civil and criminal actions.

5.1 Conclusions

Several methods were completed to assess point and non-point source pollution in the Quaboag Pond watershed. Then, this information was used to design best management practices to reduce pollution inputs and improve water quality in the pond. The findings of this project are as follows:

1. Interviews were conducted with town officials in Spencer to determine the status of the NPDES Stormwater Permit and the resources the town has to manage non-point source pollution. It was found that water quality and pollution were important issues in the town; however the town did not have any funds for pollution management. In the short term, only remediation plans requiring minimal investment could be considered.

2. Water samples were collected at 10 locations along the Sevenmile River in Spencer, and tested for nitrogen concentration, phosphorus concentration, suspended solids concentration, dissolved oxygen, biochemical oxygen demand, and pH. The measurements were then compared to the Massachusetts standards for Class B water bodies. It was found that the phosphorus and nitrogen concentrations were highest at in the center of downtown Spencer, directly off of Main Street.

3. Best management practices were designed for the town of Spencer to reduce the inflow of phosphorus and nitrogen into the Sevenmile River and Quaboag Pond. The BMPs considered both effectiveness for reducing
pollutants and cost. The first BMP is vegetated buffer strips installed along the sides of portions of the river to slow down the flow of stormwater into the river. The second BMP is educational pamphlets to inform the town residents of non-point source pollution issues and how they can reduce pollution. The pamphlets will be mailed to the residents of Spencer along with the town newsletter that is mailed semi-annually.

5.2 Recommendations

There were several limitations that were faced during this project. The sampling was only done during the months of November, December, and January. This makes the results different than what they would have been if samples were taken during other seasons. Several recommendations are as follows:

1. It is recommended that the town of Spencer collect water samples in the spring and summer months to obtain year round water quality data.

2. It is also recommended that the town implement the short term BMPs as soon as possible. This will help to reduce the stormwater flow into Quaboag Pond. After the BMPs have been put into effect, more water samples should be taken and tested to determine if they are working and reducing the pollutants in the Sevenmile River and also Quaboag Pond.
References


http://www.bmpdatabase.org/

(http://www.mass.gov/dep/water/laws/regulati.htm#gwp)


Appendix A – Interviews With Town Officials

Interviews Notes:

Carter Terenzini
Town Administrator
Memorial Town Hall
157 Main Street
Spencer, MA 01562
cterenzini@spencerma.gov
508-885-7500 x155

What limitations does the town of Spencer have on its stormwater?

The town of Spencer has two sets of limitations on their stormwater. One regulation is the NPDES Phase II Stormwater Permit which applies to all of Spencer. The other is the regulations for the Seven Mile river watershed in the town. These regulations are stricter than the stormwater permit because the Seven Mile River eventually flows to the Quaboag Pond and Quacumquasit Pond. Each set of regulations are fairly costly to properly implement, but there is no funding provided by the state or federal government.

Is there currently a budget existing concerning the stormwater permit? If not, is there any funding to provide a budget?

The town has an average annual increase in budget of 2 to 2 ½ percent. Due to inflation, the necessary costs of the town increase by 4 to 4 ½ percent every year. Therefore the town has made the stormwater permit an extremely low priority because the available funds are being allocated to necessary town expenses.

The town has the ability to provide low cost pamphlets or handouts to the public that are printed in-house at the town hall. This is done by inserting the pamphlet into the various mailings sent to the citizens of Spencer.

Has the town looked into any federal or state grants to fund stormwater practices?

The town has applied for a 319 grant several times, but do not currently qualify for one. This grant would allow the town to fund and implement basic stormwater management practices. Perhaps with a better stormwater management plan, the town can receive a 319 grant and implement some best management practices.

Is there currently any public education or outreach concerning the town’s waterways?

There is currently no public or community outreach happening in Spencer. However, a potential future outreach program could be to find educational videos that provide information on the issues that stormwater runoff presents. These videos could then be shown on the local cable network station for little cost and it would reach a lot of people.
Another public outreach idea could be having students from WPI come into the town meetings and present to the various boards on the standings of the stormwater permits and what can be done about them. The town meetings are videotaped and rebroadcast 3 times for people that miss the meetings. This would allow the town to educate the public about the problems associated with stormwater runoff and what can be done about these problems.

Are there any surrounding towns that you do, or could, collaborate with concerning the stormwater permit and water quality?

There are a lot of other towns that have NPDES permits that Spencer could collaborate with, but most of them blame Spencer for any problems in the watershed. They believe that the Spencer Wastewater Treatment Plant is the only source of pollution in the area and therefore blame “everything” on Spencer. The surrounding towns collaborate in “hating Spencer.”

What do you consider the most important aspect or goal that our project can complete?

The most important aspect of our project that would help the town the most would be a map of the town with watersheds and drainage areas. This would provide a starting place for additional research and planning.

Virginia Scarlet
Wetland Soil Specialist
Memorial Town Hall
157 Main Street
Spencer, MA 01562
vscarlet@spencerma.gov
508-885-7500 X180

Ms. Scarlet was the former head of the Mass DEP NPDES stormwater permit division. She was also a laboratory technician and has an extensive background in water testing.

Are there any specific water tests or test sites that you think we should pursue?

With regards to sampling protocol, doubles of each sample should be taken and tested to assure that accurate results are obtained for each sample time and place. In addition, she noted that blanks should be run for each of the tests to assure that the results and equipment are working properly.

With regards to sampling sites, the most concentrated area(s) that flow toward the Seven Mile River are the residential and commercial areas directly surrounding Muzzy Pond. Lake Whitemore also may provide some of the nutrients flowing to the Seven Mile River. Therefore, additional test sites around Muzzy Pond may provide more accurate and complete results.
Also, it would be interesting to see what affect a snow melt or thaw has on the water quality and an additional test should be done later in the winter after a snow melt.

Is there a lake association for Lake Whittemore or Muzzy Pond that could provide information or even funding for stormwater management practices?

There are many lake associations in the town and a list of the contacts for each of them will be supplied to us. These groups are run by private donations and may be able to donate money or time for stormwater best management practices. Some of these lakes have their own taxes to maintain the water quality. It may be possible to have a tax base on shorefront property around Lake Whitemore, which could provide some income for best management practices in the future. Also, there are private road taxes in some places around lakes surrounding Spencer which could be allocated to preventing the runoff created by the private dirt roads.

In your opinion, what is the most important aspect of our project?

The most important aspect of this project is finding any major sources of pollution and identifying them so the town can take action on reducing and preventing problems.

Margaret Bacon
Utilities and Facilities Manager
3 Old Meadow Road
Spencer, MA 01562
mbacon@spencerma.gov
(508) 885-7525

What information or resources are available concerning water quality and permit compliance in Spencer?

There are limited water quality tests done by the town in the major inflows of the Seven Mile River. The Spencer Wastewater Treatment Plant also does frequent water quality testing for the discharge to make sure they are in compliance with regulations.

Who is responsible for implementation of the stormwater permit?

The town administration is in charge of implementing stormwater practices, including the town administrator Charter Terenzini.

What is the priority of the stormwater permit and water quality compared to other town issues?

Currently the NPDES Stormwater Permit is extremely low in the importance to the town. There is no funding provided by the state or federal governments and the town does not have the funds to implement them on their own.
Are there reports submitted regarding the stormwater permit? If so, who writes them and how often are they completed?

There are required yearly reports that must be submitted to the Massachusetts Department of Environmental Protection regarding the measures being taken by the town to comply with the NPDES Phase II stormwater permit. These reports are now the responsibility of Margret Bacon, however she has just assumed this position and has not completed one herself.
Appendix B – Sample Site Descriptions

Site A:

Site A is located at the intersection of Elm Street and Valley Street. The site is opposite the energy delivery station on the opposite side of the green wire fence. The samples were taken from the trench before it crosses Elm Street.
Site B:

Site B is located at the end of Valley Street in the parking area of the playing fields. The site is to the right of the entrance of the parking lot down the embankment.
Site C:

Site C is located at the corner of Main Street and West Main Street. The site is near the Spencer Furniture sign.
Site D:

Site D is located on Meadow Street to the left of the parking lot of the Knights of Columbus. This site is right before the stream meets the Seven Mile River.
Site E:

Site E is located near the corner of Meadow Street and Smithville Street. The Site is at the bridge on the Spencer Fair Grounds side of the road.
Site F:

Site F is located on South Spencer Road at the woodworking shop.
Site G:

Site G is located off West Main Street behind the car wash. The site is on the Seven Mile River approximately 100 yards away from the rear of the car wash.
Site H:

Site H is located on Main Street at the near the Sunoco station. The site is where Main Street crosses the Seven Mile River.
Site I:

Site I is located at the discharge site of the Spencer Wastewater Treatment Plant. There are no pictures of the discharge site.

Site J:

Site J is located along Route 20 at the bridge crossing the Seven Mile River.
### Appendix C – Best Management Practices

<table>
<thead>
<tr>
<th>Best Management Practices</th>
<th>Description</th>
<th>Cost (Approximate)</th>
<th>Space Needed</th>
<th>Limitations</th>
<th>Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infiltration Systems</td>
<td></td>
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</tr>
<tr>
<td>On-lot infiltration</td>
<td>1) practices that infiltrate rooftop runoff; 2) practices that divert runoff to a pervious area; 3) practices that store runoff for later use.</td>
<td>$100 for Rain Barrel</td>
<td>relatively small</td>
<td>Maintenance Excess water</td>
<td>low impact on watershed</td>
</tr>
<tr>
<td>Infiltration basins</td>
<td>An infiltration trench is a rock-filled trench with no outlet that receives stormwater runoff. Stormwater runoff passes through some combination of pretreatment measures, such as a swale and detention basin, and into the trench. There, runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. The primary pollutant removal mechanism of this practice is filtering through the soil.</td>
<td>$2 per cubic foot</td>
<td>less than 10 acres</td>
<td>Not Aesthetic Clogs High Failure Rate Mosquitoes</td>
<td>TSS 75% Phosphorous 60-70% Nitrogen 55-60%</td>
</tr>
</tbody>
</table>
| Bioretention systems | Bioretention areas are landscaping features adapted to provide on-site treatment of stormwater runoff. They are commonly located in parking lot islands or within small pockets of residential land uses. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff ponds above the mulch and soil in the system. Runoff from larger storms is generally diverted past the facility to the storm drain system. The remaining runoff filters through the mulch and prepared soil mix. The filtered runoff can be collected in a perforated underdrain and returned to the storm drain system. | \[ C = 7.30 V^{0.99} \]
\[ C = \text{cost of design and construction} \]
\[ V = \text{volume of water being treated} \] | 5 acres or less | Not useful in large watersheds Maintenance needed | TP 65-87% TN 15-16% |
| Surface sand filters | Sand filters are usually designed as two-chambered stormwater practices; the first is a settling chamber, and the | $2.50-7.50 \text{ per cubic foot}$ | 2 Acres | Frequent Maintenance Not good for floods | TSS 65-90% TP 40-85% TN 44-47% |
second is a filter bed filled with sand or another filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as stormwater flows through the filtering medium.

**Filter strips**

- Vegetated filter strips (grassed filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils.
- Cost: $0.70 per square foot
- Width: 2-5 foot wide strips
- Limited pollutant removal require relatively large space
- Pollutant removal:
  - TP: 40%
  - TN: 20%

**Constructed Wetlands**

**Stormwater Wetlands**

- Stormwater wetlands are structural practices similar to wet ponds that incorporate wetland plants into the design. As stormwater runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake within the practice.
- Cost:
  \[ C = 30.6V^{0.705} \]
  - \( C \) = Cost of design
  - \( V \) = Volume of water from 10 year storm
- Area: 25 acres
- Large space mosquitoes may release nutrients
- Pollutant removal:
  - TP: 64%
  - TN: 19%
<table>
<thead>
<tr>
<th>Systems</th>
<th>Wet ponds</th>
<th>C = 24.5V^{0.705}</th>
<th>25 acres</th>
<th>safety hazard</th>
<th>Very large</th>
<th>Not effective in cold water streams</th>
<th>TP 48%TN 31%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet ponds</td>
<td>Wet ponds are constructed basins that have a permanent pool of water throughout the year. Ponds treat incoming stormwater runoff by allowing particles to settle and algae to take up nutrients. The primary removal mechanism is settling as stormwater runoff resides in this pool, and pollutant uptake, particularly of nutrients, also occurs through biological activity in the pond.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25 acres</td>
</tr>
</tbody>
</table>

### Public Education

#### Promoting the Stormwater Message

<table>
<thead>
<tr>
<th>Classroom Education on Stormwater</th>
<th>Providing stormwater education through schools conveys the message not only to students but to their parents. Many municipal stormwater programs partner with educators and experts to develop storm water-related programs for the classroom.</th>
<th>$100-200</th>
<th>None</th>
<th>Fitting storm water into curricula</th>
<th>Varies</th>
</tr>
</thead>
</table>

### Stormwater Outreach for Commercial Businesses

<table>
<thead>
<tr>
<th>Stormwater Outreach for Commercial Businesses</th>
<th>A successful outreach campaign must tailor its message to a targeted audience. The target audience</th>
<th>Informational packet production and delivery</th>
<th>None</th>
<th>Must convince owners to change practices</th>
<th>Varies</th>
</tr>
</thead>
</table>
may be industry or business groups whose activities influence the health of watersheds. It is important to address commercial activities specifically in an outreach strategy and recognize that in most cases incentives must be provided to encourage businesses to change their behavior.

<table>
<thead>
<tr>
<th>Using the Media</th>
<th>The media can greatly enhance a stormwater pollution prevention campaign. Through the media, a campaign can educate a targeted or mass audience about the problems of and solutions to stormwater pollution.</th>
<th>Usually Free</th>
<th>None</th>
<th>Needs to catch attention of audience</th>
<th>Varies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stormwater Outreach Materials</td>
<td></td>
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</tr>
<tr>
<td>Educational Displays, Pamphlets, Booklets, and Bill Inserts</td>
<td>Printed materials are commonly used to inform the public about stormwater pollution.</td>
<td>based on cost of alternatives</td>
<td>None</td>
<td>Cost of displays</td>
<td>Varies</td>
</tr>
<tr>
<td>Education for Homeowners</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternatives to Toxic Substances</td>
<td>Using alternative products instead of toxic substances drastically reduces the presence of toxics in stormwater and receiving waters.</td>
<td>based on cost of alternatives</td>
<td>None</td>
<td>Cost of displays Cost of alternatives</td>
<td>Varies</td>
</tr>
<tr>
<td>Chlorinated Water Discharge Options</td>
<td>Chlorinated water discharged to surface waters has an adverse effect on local water quality. Swimming pools are a major source of chlorinated water discharged into sanitary and storm sewer systems.</td>
<td>Proper design costs</td>
<td>None</td>
<td>Enforceme</td>
<td>Varies</td>
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<tr>
<td>Landscaping and Lawn Care</td>
<td>This management measure uses education and outreach to control the effects of landscaping and lawn care practices on stormwater.</td>
<td>Cost of alternatives Cost of production</td>
<td>None</td>
<td>Convincing residents</td>
<td>Varies</td>
</tr>
<tr>
<td>Pest Control</td>
<td>This management measure involves limiting the impact of pesticides on water quality by educating residents and businesses on alternatives to pesticide use, and on proper pesticide storage and application techniques.</td>
<td>Cost of education</td>
<td>None</td>
<td>No effective alternative</td>
<td>Varies</td>
</tr>
<tr>
<td>Pet Waste Management</td>
<td>When pet waste is improperly disposed of, it can be picked up by stormwater runoff and washed into stormdrains or nearby water bodies. Since stormdrains do not always connect to treatment facilities, untreated animal feces often end up in lakes and streams, causing significant water pollution.</td>
<td>Depends on extent of education</td>
<td>None</td>
<td>Dependent on pet owners</td>
<td>Varies</td>
</tr>
<tr>
<td>Proper Disposal of Household Hazardous Wastes</td>
<td>Many products found in homes contain chemicals potentially harmful to both people and the environment. Chemical products such as oven cleaners, paint removers, bug killers, solvents, and drain cleaners are just a few common hazardous products in the home.</td>
<td>Can cost $100,000 for collection of wastes</td>
<td>None</td>
<td>Need sanitary services for waste</td>
<td>Varies</td>
</tr>
<tr>
<td>Residential Car Washing</td>
<td>This management measure involves educating the general public, businesses, and municipal fleets (public works, school buses, fire, police, and parks) on the water quality impacts of the outdoor washing of automobiles and how to avoid allowing polluted runoff to enter the storm drain system.</td>
<td>Cost of commercial car wash</td>
<td>None</td>
<td>Lack of knowledge</td>
<td>Varies</td>
</tr>
<tr>
<td>Water Conservation Practices for Homeowners</td>
<td>Widespread reductions in water consumption could reduce the need for new or expanded water and sewage treatment plants.</td>
<td>Saves money for public</td>
<td>None</td>
<td>Change of habits</td>
<td>Varies</td>
</tr>
<tr>
<td>Education for Businesses</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Automobile Maintenance</td>
<td>This pollution prevention measure targets automobile maintenance businesses and other groups running fleets of</td>
<td>$300 initial, $150 each year</td>
<td>None</td>
<td>Space and time constraints for facilities</td>
<td>Eliminates 78% of direct discharge</td>
</tr>
<tr>
<td>Program Type</td>
<td>Description</td>
<td>Cost</td>
<td>Who Must Convince Business to Front Initial Costs</td>
<td>Reduction of Water Usage</td>
<td></td>
</tr>
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<tr>
<td>Pollution Prevention for Businesses</td>
<td>Activities that reduce or eliminate chemical contaminants at their source are called pollution prevention, or P2. Such activities include the efficient use of raw materials, water, and energy, the substitution of less harmful substances for more harmful ones, and the elimination of toxic substances from the production process.</td>
<td>Up to $300,000</td>
<td>None</td>
<td>Up to 90%</td>
<td></td>
</tr>
<tr>
<td>Public Involvement</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Adopt-A-Stream Programs</td>
<td>Volunteer programs in which participants &quot;adopt&quot; a stream, creek, or river to study, clean up, monitor, protect, and restore.</td>
<td>Production of &quot;how to&quot; packets</td>
<td>None</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>Reforestation Programs</td>
<td>Reforestation programs attempt to preserve and restore forested buffers and natural forests.</td>
<td>Varies depending on community donations</td>
<td>Sites being restored</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>Storm Drain Marking</td>
<td>Storm drain marking involves labeling storm drain inlets with plaques, tiles, painted or pre-cast messages warning citizens not to</td>
<td>Cost of marking materials</td>
<td>None</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>Activity</td>
<td>Description</td>
<td>Funding</td>
<td>Cost of Developing Plan</td>
<td>Certification Costs</td>
<td>Maintenance</td>
</tr>
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<tr>
<td>Volunteer Monitoring</td>
<td>Citizen monitoring can provide important data and information during the development of a stormwater program.</td>
<td>Can be funded through EPA or parks</td>
<td>None</td>
<td>Volunteer commitment Quality</td>
<td>Varies</td>
</tr>
<tr>
<td>Wetland Plantings</td>
<td>Wetlands, unique ecosystems home to a great diversity of terrestrial and aquatic plants and animals, are beneficial in many ways.</td>
<td>Varies on plant types and size of project</td>
<td>Size of wetland</td>
<td>Weather Insect damage Maintenance</td>
<td>Low at first</td>
</tr>
<tr>
<td>Construction Site Stormwater runoff and control</td>
<td>The purpose of construction site runoff control is to reduce pollutants in stormwater runoff from construction activities. The Phase II Final Rule requires the operator of a regulated municipality to &quot;have procedures for site plan review of construction plans that consider potential water quality impacts.&quot;</td>
<td>Cost of developing plan</td>
<td>None</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Municipal Program Oversight</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Contractor Training and Certification</td>
<td>One of the most important factors determining whether erosion and sediment control BMPs are properly installed</td>
<td>Cost to hire or train and certification</td>
<td>N/A</td>
<td>Certification costs</td>
<td>Varies</td>
</tr>
</tbody>
</table>
and maintained is the knowledge and experience of the on-site contractor who is implementing and inspecting the BMPs.

<table>
<thead>
<tr>
<th>Local Ordinances for Construction Site Runoff Control</th>
<th>Phase I and Phase II municipalities must implement a stormwater management program that includes a component for controlling erosion and sediment on construction sites disturbing at least one acre.</th>
<th>N/A</th>
<th>N/A</th>
<th>N/A</th>
<th>Only effective to the point at which they are implemented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal Construction Inspection Program</td>
<td>To reduce the water quality impacts of active construction sites, NPDES regulations require that many construction projects install and maintain appropriate erosion and sediment control, stormwater management, and housekeeping BMPs.</td>
<td>Cost of training and employing inspection officials</td>
<td>N/A</td>
<td>Lack of staff to inspect</td>
<td>Varies</td>
</tr>
<tr>
<td>Construction Site Planning and Management</td>
<td>Construction sequencing is a specified work schedule that coordinates the timing of land-disturbing activities and the installation of erosion and sediment control measures.</td>
<td>Cost of writing plan</td>
<td>N/A</td>
<td>Weather</td>
<td>~42% reduction in sediments</td>
</tr>
<tr>
<td>Construction Site Operator BMP Inspection and Maintenance</td>
<td>Stormwater control BMPs need regular inspections to ensure their effectiveness, and many permitting authorities require self-inspection for construction projects. Three types of BMP inspections are performed: routine inspections, inspections performed before rain events, and inspections performed after rain events.</td>
<td>Time for BMP inspection and management</td>
<td>N/A</td>
<td>Time to maintain BMPs</td>
<td>Varies</td>
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<tr>
<td>Land Grading</td>
<td>Land grading involves reshaping the ground surface to planned grades as determined by an engineering survey, evaluation, and layout.</td>
<td>$2 per square yard</td>
<td>Depends on size of construction and slope</td>
<td>Need other buffers</td>
<td>Highly effective for sediment reduction</td>
</tr>
<tr>
<td>Preserving Natural Vegetation</td>
<td>The principal advantage of preserving natural vegetation is protecting desirable trees, vines, bushes, and grasses from damage during project development.</td>
<td>Additional labor to maneuver around vegetation</td>
<td>Dependent on extent of existing vegetation at the site</td>
<td>Dependent on extent vegetation at the site</td>
<td>Varies</td>
</tr>
<tr>
<td>Erosion Control</td>
<td></td>
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</tr>
<tr>
<td>Chemical Stabilization</td>
<td>Chemical stabilizers, also known as soil binders or soil palliatives, provide temporary soil stabilization. Vinyl, asphalt, or rubber are sprayed onto the surface of exposed soils to</td>
<td>$4 to $35 a pound</td>
<td>N/A</td>
<td>Must be properly applied</td>
<td>70-90%</td>
</tr>
<tr>
<td>Method</td>
<td>Description</td>
<td>Cost</td>
<td>Slope Ratio</td>
<td>Sediment Control</td>
<td>Other Notes</td>
</tr>
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<tr>
<td>Compost Blankets</td>
<td>A compost blanket is a layer of loosely applied compost or composted material that is placed on the soil in disturbed areas to control erosion and retain sediment resulting from sheet-flow runoff.</td>
<td>$0.83 to $4.32 per cubic foot</td>
<td>4:1 to 1:1 slopes</td>
<td>Not usually used for slopes &gt;2:1</td>
<td>80-90% sediment control</td>
</tr>
<tr>
<td>Dust Control</td>
<td>Dust control BMPs reduce surface activities and air movement that causes dust to be generated from disturbed soil surfaces.</td>
<td>Vary depending on materials</td>
<td>Size of dry area</td>
<td>Need mineral soils Time intensive</td>
<td>Mulch - up to 80%</td>
</tr>
<tr>
<td>Geotextiles</td>
<td>Geotextiles are porous fabrics also known as filter fabrics, road rugs, synthetic fabrics, construction fabrics, or simply fabrics.</td>
<td>$0.50 to $10.00 per square yard</td>
<td>Size of area</td>
<td>Disintegrates in light</td>
<td>Varies depending on material</td>
</tr>
<tr>
<td>Gradient Terraces</td>
<td>Gradient terraces are earthen embankments or ridge and channel systems that reduce erosion by slowing, collecting and redistributing surface runoff to stable outlets that increase the distance of overland runoff flow. Terraces hold moisture and help trap sediments, minimizing sediment-laden runoff.</td>
<td>Size of area</td>
<td>Can't use on sandy or shallow soils or steep slopes</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>Method</td>
<td>Description</td>
<td>Cost Range</td>
<td>Size of Area</td>
<td>Benefits</td>
<td>Erosion Reduction</td>
</tr>
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<tr>
<td>Mulching</td>
<td>Mulching is an erosion control practice that uses materials such as grass, hay, wood chips, wood fibers, straw, or gravel to stabilize exposed or recently planted soil surfaces.</td>
<td>$800 to $3,500 per acre</td>
<td>Size of area</td>
<td>Can delay seed germination</td>
<td>53-99.5% at reducing soil loss</td>
</tr>
<tr>
<td>Riprap</td>
<td>Riprap is a layer of large stones used to protect soil from erosion in areas of concentrated runoff. Riprap can also be used on slopes that are unstable because of seepage problems.</td>
<td>$35 to $50 per square yard</td>
<td>Size of area</td>
<td>Steep slopes hard to manage</td>
<td>Can fully prevent erosion</td>
</tr>
<tr>
<td>Seeding</td>
<td>Seeding is used to control runoff and erosion on disturbed areas by establishing perennial vegetative cover from seed. It reduces erosion and sediment loss and provides permanent stabilization.</td>
<td>$200 to $1000 per acre</td>
<td>Size of area</td>
<td>Need temporary erosion control</td>
<td>TSS 50-100%</td>
</tr>
<tr>
<td>Sodding</td>
<td>Sodding is a permanent erosion control practice and involves laying a continuous cover of grass sod on exposed soils. Sodding can stabilize disturbed areas and reduce the velocity of stormwater runoff.</td>
<td>$0.20 per square foot</td>
<td>Size of area</td>
<td>Costly Needs a lot of water</td>
<td>TSS up to 90%</td>
</tr>
<tr>
<td>Soil Retention</td>
<td>Soil retention measures are structures or practices that hold soil in place or keep it contained within a site</td>
<td>Minimal additional costs to project</td>
<td>Size of area</td>
<td>Must account for all heavy rains</td>
<td>Varies</td>
</tr>
</tbody>
</table>
boundary. They include grading or reshaping the ground to lessen steep slopes or shoring excavated areas with wood, concrete, or steel structures.

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
<th>Cost of heavy equipment and minimal materials</th>
<th>Size of area</th>
<th>Not good for rocky slopes or heavy storm areas</th>
<th>moderate erosion protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Roughening</td>
<td>Soil roughening is a temporary erosion control practice often used in conjunction with grading. Soil roughening involves increasing the relief of a bare soil surface with horizontal grooves by either stair-stepping (running parallel to the contour of the land) or using construction equipment to track the surface.</td>
<td>Cost of heavy equipment and minimal materials</td>
<td>Size of area</td>
<td>Not good for rocky slopes or heavy storm areas</td>
<td>moderate erosion protection</td>
</tr>
<tr>
<td>Temporary Slope Drain</td>
<td>A temporary slope drain is a flexible conduit for stormwater that extends the length of a disturbed slope to divert the flow and serve as a temporary outlet. Temporary slope drains, also called pipe slope drains, convey runoff without causing erosion on or at the bottom of the slope.</td>
<td>Drainage watershed up to 10 acres</td>
<td>Should not exceed drainage area of 5 acres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temporary Stream Crossings</td>
<td>A temporary stream crossing is used to provide a safe, stable way for construction vehicle traffic to cross a</td>
<td>Depends on size needed</td>
<td>Any width stream</td>
<td>Can cause erosion</td>
<td>Varies</td>
</tr>
<tr>
<td>Watercourse</td>
<td>Wind Fences and Sand Fences</td>
<td>Runoff Control</td>
<td></td>
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<tr>
<td></td>
<td>Sand fences are barriers made of small, evenly spaced wooden slats or fabric. They are erected to reduce wind velocity and to trap blowing sand.</td>
<td>Check Dams</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>low cost wood slats and wire</td>
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<td>effective for dune formations</td>
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<td>Low cost wood slats and wire</td>
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<td>$100 per dam</td>
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<td>No more than 3 feet high</td>
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<td>cannot be used on live flowing streams</td>
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<td>more effective than silt fencing</td>
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<td>$202 to $625 per 100 feet of channel</td>
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<td>Any size</td>
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<td>Can change natural flow of streams</td>
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<td>Effective for transporting water from site</td>
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<td>$20 to $50 per foot water elevation of at least 4 feet</td>
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<td>Needs to be seeded and mulched</td>
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<td></td>
<td>Varies</td>
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Grass-Lined Channels:
A grass-lined channel conveys stormwater runoff through a stable conduit. Vegetation lining the channel slows down concentrated runoff.

Permanent Slope Diversions:
Permanent slope diversions are designed to transport runoff down a slope in a manner that minimizes the potential for erosion. Diversions can be constructed by creating channels laterally across slopes to intercept the downslope flow of runoff.
<table>
<thead>
<tr>
<th>Temporary Diversion Dikes</th>
<th>An earthen perimeter control usually consists of a dike or a combination dike and channel constructed along the perimeter of and within the disturbed part of a site.</th>
<th>$46.33 to $124.81 for a 100-foot dike</th>
<th>Smaller than 5 acres</th>
<th>Increased erosion potential in the diversion</th>
<th>Effective for transporting stormwater around disturbed area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sediment Control</td>
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<tr>
<td>Brush Barrier</td>
<td>Brush barriers are perimeter sediment control structures constructed of material such as small tree branches, root mats, stone, or other debris left over from site clearing and grubbing.</td>
<td>$390 to $620</td>
<td>no longer than 100 ft</td>
<td>Bad for high-velocity areas</td>
<td>Effective for reducing of site transportatio n of sediments</td>
</tr>
<tr>
<td>Compost Filter Berms</td>
<td>A compost filter berm is a dike of compost or a compost product that is placed perpendicular to sheet flow runoff to control erosion in disturbed areas and retain sediment.</td>
<td>$1.90 to $3.00 per foot</td>
<td>Small drainage areas</td>
<td>Need to cut out heavy vegetation</td>
<td>TSS 90%</td>
</tr>
<tr>
<td>Compost Filter Socks</td>
<td>A compost filter sock is a type of contained compost filter berm. It is a mesh tube filled with composted material that is placed perpendicular to sheet-flow runoff to control erosion and retain sediment in disturbed areas.</td>
<td>$1.40 to $1.75 per ft</td>
<td>Small drainage areas</td>
<td>Need to cut out heavy vegetation</td>
<td>100% removal of motor oil</td>
</tr>
<tr>
<td>Construction Entrances</td>
<td>The purpose of stabilizing entrances to a</td>
<td>$1,000 to $4,000</td>
<td>Size of largest vehicle</td>
<td>May transport soil on</td>
<td>TSS only if maintained</td>
</tr>
<tr>
<td>Method</td>
<td>Description</td>
<td>Cost</td>
<td>Size</td>
<td>Limitations</td>
<td>Removal Efficiency</td>
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<tr>
<td>Fiber Rolls</td>
<td>Fiber rolls (also called fiber logs or straw wattles) are tube-shaped erosion-control devices filled with straw, flax, rice, coconut fiber material, or composted material.</td>
<td>$20 to $30 per 25-foot roll</td>
<td>Any size</td>
<td>Limited capture zone Need trenches</td>
<td>TSS only if maintained</td>
</tr>
<tr>
<td>Filter Berms</td>
<td>A gravel or stone filter berm is a temporary ridge made up of loose gravel, stone, or crushed rock. It slows and filters flow and diverts it from an open traffic area.</td>
<td>Low cost wood slats and wire</td>
<td>Any size</td>
<td>Only gentle slopes</td>
<td>Sediment up to 90%</td>
</tr>
<tr>
<td>Sediment Basins and Rock Dams</td>
<td>Sediment basins and rock dams can be used to capture sediment from stormwater runoff before it leaves a construction site.</td>
<td>$0.20 to $1.30 per cubic foot</td>
<td>5 to 100 acres</td>
<td>Cannot be used with continually flowing water</td>
<td>Varies</td>
</tr>
<tr>
<td>Sediment Filters and Sediment Chambers</td>
<td>Sediment filters are sediment-trapping devices typically used to remove pollutants (mainly particulates) from stormwater runoff. Sediment filters have four components: (1) inflow regulation, (2) pretreatment, (3) filter bed, and (4) outflow mechanism.</td>
<td>$3.00 to $10.00 per cubic foot of runoff treated</td>
<td>Varies</td>
<td>Only remove sediments from stormwater</td>
<td>TP 30-75% TN 30-60%</td>
</tr>
<tr>
<td>Sediment Traps</td>
<td>Sediment traps are small impoundments that allow sediment to settle out of construction runoff. They are usually installed in a drainage way or other point of discharge from a disturbed area.</td>
<td>$0.20 to $2.00 per cubic foot of storage</td>
<td>Drainage areas less than 5 acres</td>
<td>Need drainage areas less than 5 acres</td>
<td>TSS 60%</td>
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<tr>
<td>Silt Fences</td>
<td>Silt fences are used as temporary perimeter controls around sites where construction activities will disturb the soil. A silt fence consists of a length of filter fabric stretched between anchoring posts spaced at regular intervals along the site at low/downslope areas.</td>
<td>$6.00 per linear foot</td>
<td>Drainage areas less than 0.25 acre per 100-foot fence length</td>
<td>Need to be able to trench the fence and posts</td>
<td>TSS 70%</td>
</tr>
<tr>
<td>Storm Drain Inlet Protection</td>
<td>Storm drain inlet protection measures prevent soil and debris from entering storm drain drop inlets. These measures are usually temporary and are implemented before a site is disturbed.</td>
<td>$50 to $150 per inlet</td>
<td>N/A</td>
<td>Small drainage areas</td>
<td>Increases effectiveness of other measures</td>
</tr>
<tr>
<td>Straw or Hay Bales</td>
<td>Straw or hay bales have historically been used on construction sites for erosion and sediment control as check dams, inlet protection, outlet protection, and perimeter control.</td>
<td>$5 to $7 each</td>
<td>N/A</td>
<td>Cannot be used in drainage channel</td>
<td>Not effective if improperly used</td>
</tr>
<tr>
<td>Vegetated Buffers</td>
<td>Vegetated buffers are areas of natural or established vegetation maintained to protect the water quality of neighboring areas. Buffer zones slow stormwater runoff, provide an area where runoff can permeate the soil, contribute to ground water recharge, and filter sediment.</td>
<td>Depends on vegetation used and installation costs</td>
<td>5-10 feet around rivers and streams</td>
<td>Need adequate buffer areas, not cost effective in high land-cost areas</td>
<td>TP 60% TN 90%</td>
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<tr>
<td>Innovate BMPs for Site Plans</td>
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<tr>
<td>Alternative Pavers</td>
<td>Alternative pavers are permeable surfaces that can replace asphalt and concrete and can be used for driveways, parking lots, and walkways.</td>
<td>Highly variable depending on materials used</td>
<td>N/A</td>
<td>Not for high traffic areas</td>
<td>Highly variable depending on materials used</td>
</tr>
<tr>
<td>Alternative Turnarounds</td>
<td>Alternative turnarounds are end-of-street vehicle turnarounds that reduce impervious cover in neighborhoods by replacing cul-de-sacs.</td>
<td>$6.40 per cubic foot</td>
<td>Less than normal turn-around</td>
<td>Local regulations vary</td>
<td>Can reduce impervious surface up to 80%</td>
</tr>
<tr>
<td>Eliminating Curbs and Gutters</td>
<td>This practice promotes grass swales as an alternative to curbs and gutters along residential streets. Curbs and gutters are designed to quickly convey runoff from the street to the stormdrain and, ultimately, to a local receiving</td>
<td>Less than cost of curbing</td>
<td>N/A</td>
<td>Snowplowing more difficult Shoulder maintenanc e needed more often</td>
<td>Greatly reduced peak flow discharges</td>
</tr>
</tbody>
</table>
Consequently, they provide little or no removal of stormwater pollutants.

Green Parking techniques include: setting maximums for the number of parking lots created; minimizing the dimensions of parking lot spaces; utilizing alternative pavers in overflow parking areas; using bioretention areas to treat stormwater; encouraging shared parking; and providing economic incentives for structured parking.

Green Roofs absorb, store, and later evapotranspire initial precipitation, thereby acting as a stormwater management system and reducing overall peak flow discharge to a storm sewer system.

Infrastructure planning involves changes in the regional growth planning process to contain 'sprawl' development. Sprawl

| Green Parking | Can save on construction costs | N/A | applicability, cost, and maintenance | Can reduce impervious surface up to 80% |
| Green Roofs | $5 to $20 per square foot | N/A | Need drought resistance vegetation | Greatly reduced peak flow discharges |
| Infrastructure Planning | Varies depending on size and state | N/A | Can cause more stormwater problems | Unknown |
development is the expansion of low-density development into previously undeveloped land.

<table>
<thead>
<tr>
<th>Narrower Residential Streets</th>
<th>This better site design practice promotes the narrowing of streets to reduce the amount of impervious cover created by new residential development. By doing so, stormwater runoff and associated pollutant loads may also be reduced.</th>
<th>can save around $35,000 per mile of residential street</th>
<th>3 to 5 feet less for streets</th>
<th>Developments up to 50 families</th>
<th>5 - 20% impervious surface reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Space Design</td>
<td>Open space design, also known as conservation development or cluster development, is a better site design technique that concentrates dwelling units in a compact area in one portion of the development site in exchange for providing open space and natural areas elsewhere on the site.</td>
<td>save $800 per home</td>
<td>N/A</td>
<td>Developers decide what is more &quot;desirable&quot;</td>
<td>Nutrient export 45-60%</td>
</tr>
<tr>
<td>Protection of Natural Features</td>
<td>Undeveloped sites can have numerous natural features that provide environmental, aesthetic, and recreational benefits if preserved and protected from the impacts of construction and</td>
<td>can save homeowner up to $1000 a year</td>
<td>N/A</td>
<td>Can save up to 68% of the site</td>
<td></td>
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<tr>
<td>Redevelopment</td>
<td>Redevelopment is typically defined as development that occurs on previously developed land.</td>
<td>Variable depending on scale</td>
<td>Requires regional cooperation</td>
<td>Varies</td>
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<tr>
<td>Riparian/Forested Buffer</td>
<td>A riparian or forested buffer is an area along a shoreline, wetland, or stream where development is restricted or prohibited</td>
<td>Depends on vegetation used and installation costs</td>
<td>100 ft or less</td>
<td>3 zone buffer is most effective</td>
<td>TP 57-74% TN 50-67%</td>
</tr>
</tbody>
</table>
Appendix D – Example Best Management Practice Brochures

**ACTIONS**

In addition to structural BMPs, non-structural BMPs are everyday actions or behaviors that can help improve water quality.

- Never put anything into a storm drain, drainage ditch, or creek.
- Always clean up after your pet.
- Use fertilizers and pesticides only when needed and apply the correct amounts. (Get a soil test from your local greenhouse)
- Dispose of leaves, grass clippings, and other yard waste properly.
- Throw litter in the trash. Reduce, reuse, and recycle.
- Recycle motor oil, antifreeze, and other auto fluids at an auto parts store or the County landfill.
- Dispose of paints, pesticides, and other household hazardous chemicals properly.
- Wash your vehicle on the grass or take it to a commercial car wash.
- Check your vehicle for leaks and repair them.
- Tell a friend or neighbor how they can help protect our waterways too!

**FOR MORE INFORMATION ON BEST MANAGEMENT PRACTICES (BMPs)**

Visit the Environmental Protection Agency website on stormwater best management practices.

http://www.epa.gov/npdes/stormwatermenus.htm

**Best Management Practices:**

**TURN YOUR YARD INTO PART OF THE SOLUTION**

In Spencer, most storm water runoff does not go to a treatment plant. Instead, runoff and the pollution in it, flows into our creeks and streams, then eventually into the Seven-Mile River and Quaboag Pond.

Best Management Practices (BMPs) are actions, behaviors, or on-the-ground landscaping practices that reduce pollution and/or the amount of runoff flowing into waterways. BMPs can be structural, such as a rain garden, or non-structural, such as picking up pet waste. This brochure focuses on structural BMPs that can be used in your yard.

City of Spencer
Spencer Water Department
Spencer, MA 01562
(508) 885-7572

YOU are the solution to storm water pollution!
STORM WATER BEST MANAGEMENT PRACTICES (BMPs)

Rain Barrels are designed to capture and store storm water runoff from rooftops, which can then be used to water the landscape (with a regular or soaker hose) or indoor houseplants. Several rain barrels can be connected to store additional water. A rain barrel with a tight lid or screen will prevent mosquitoes.

Benefits: Reduce storm water runoff, leaving your property, water your landscape for free, conserve water, and save money on water utility bills.

Permeable Materials, also known as porous or permeable materials, allow runoff to soak into the ground instead of running off. Permeable materials such as gravel, concrete and gravel, can be used for driveways, walkways, and low flow parking areas.

Benefits: Reduce storm water runoff, increase infiltration, filter pollutants in runoff, and recharge groundwater.

Native Plants are indigenous to a particular region and are adapted to the local climate and soil conditions. Native plants provide habitat, food, and beneficial ecosystem values as well.

Benefits: Eliminate/reduce the use of fertilizers, pesticides and irrigation. Decrease yard work, create a healthy and diverse native ecosystem.

Swales are long, shallow, gravel depressions designed to hold and convey large amounts of runoff. They are much wider than they are deep. Swales are found alongside highways, streets, sidewalks, and parking lots.

Benefits: Collect runoff and reduce flooding, slow down and filter runoff, prevent erosion, and easy to maintain.

Baffles are areas of vegetation located next to a water body. Baffles are a barrier between storm water runoff and a receiving body of water such as a stream, lake, etc.

Benefits: Stabilize banks and decrease erosion, control flooding, provide habitat for wildlife, act as a pollution barrier between water and developed land, provide privacy, and increase property values.

Habitat Gardens are planted with vegetation known for attracting birds, butterflies, beneficial insects, and small wildlife. Place these anywhere with good sunlight, soil, and water.

Benefits: Provide habitat for wildlife in urban areas, improve water quality, remove pollutants by attracting their predators, and enhance the beauty of your yard.

Retention Ponds, also called wet ponds, maintain a permanent pool of water by adding to temporarily storing storm water runoff flowing from roads, parking lots, and other impervious (hard) surfaces.

Benefits: Remove pollutants from storm water runoff including sediment, nutrients, toxicants, and heavy metals. If planted and maintained properly, retention ponds can provide aesthetic and recreational value.

Stream Bank Restoration is the process of rebuilding or stabilizing the banks of streams, creeks, or rivers. When stream banks erode, they carry soil and other debris into the water. A stream may fill in and become so shallow that it reduces flow and no longer provides habitat for fish and wildlife that depend on it for survival. Stream bank erosion also causes flooding, property loss, and poor water quality.

Benefits: Prevent erosion, restore habitat, and reduce the new vegetation filters polluted storm water runoff.

Backyard Wetlands can temporarily store, filter, and clean runoff from your lawn, rooftop, or driveway. Sediment, nutrients, heavy metals, and bacteria are able to settle out, be taken up by wetland plants, or be "digested" by naturally occurring microorganisms. Wetlands should be planted in naturally occurring wet areas on your property.

Benefits: Absorb and filter runoff, reduce flooding, prevent erosion, recharge groundwater, provide wildlife habitat, and enhance the beauty of your yard.

Rain Gardens and Bioswales Areas are placed between sources of runoff (roofs, driveways, parking lots) and rainwater destinations (storm drains, streets, ditches). Rain gardens are shallow depressions in the center designed to capture runoff and allow it to soak back into the ground. They are planted with trees, shrubs, and perennials that are suitable for both wet and dry conditions.

Benefits: Reduce runoff leaving your property, reduce flooding, recharge groundwater, provide habitat, and enhance the beauty of your yard.

Shade Trees act as the environment's natural solution to air and water pollution by converting carbon dioxide to oxygen and absorbing polluted runoff. In developed areas, shade trees reduce the temperature of runoff flowing from pavement or concrete, improving waterways.

Benefits: Anchor soil in place, prevent erosion, reduce heating and cooling costs at home, absorb and filter polluted runoff, improve air quality, and increase property values.

LOCAL RESOURCES
- Spencer Greenery 665-7142
- Bemis Farm Nursery 805-4247
- Klamath Irrigation District 665-2709
- Canby Hill Greenhouse 503-80-5300
Have you ever seen an oily sheen on pavement after a rain? Mounds of foam in a creek?

It is a known fact that cars cause air pollution. But you may be unaware that cars also cause water pollution. While driving, our automobiles leave bits of tires, brakes, and rusty metal on the street. When parked, our vehicles leave stains of oil, grease, and transmission fluid on driveways and parking lots. When we wash our cars on pavement, soap and dirt washes into streets and storm drains.

What happens to all this auto pollution when it rains? Rainwater washes these pollutants into storm drains and drainage ditches. This water, called storm water runoff, does not go to a treatment plant. In Spencer, storm water runoff empties directly into the Seven Mile River and then to the Quaboag Pond.

Fortunately, by following the simple steps listed inside, you can help reduce pollution that comes from our cars, streets, driveways and parking lots.

**TIPS FOR CLEAN CARS & CLEAN WATER**

Did you know that your car could be a source of water pollution?

**City of Spencer**
**Sponsor-Water Department**
Spencer, MA 01562
(508) 888-7572

You are the solution to stormwater pollution!
Car Washing
Phosphates in car washing soap contribute to algae blooms in water which in turn can kill fish and other aquatic life. If you wash your car at home, wash it on the grass and let the dirt and soapy water soak into the soil instead of washing into a storm drain. The soil will filter out most of the pollutants and the soapy water will not harm your lawn. Taking your car to a commercial car wash is also a good alternative to protecting water quality in Spencер. Dirty water from a commercial car wash goes to a wastewater treatment plant where pollutants are removed.

Keep Your Car Tuned-Up
Cars that run smoothly burn less fuel and cause less pollution. A tuned-up car saves you money by using up to 20% less gasoline. Regular tune-ups also reduce the amount of pollutants that come out of your car’s exhaust pipe. This helps keep pollutants out of our waterways.

Repair Leaks
Spots on your driveway mean the engine, transmission, or radiator in your car is leaking. Have the leak repaired right away!

Spills
Clean up vehicle leaks and fluid spills by using kitty litter to soak up the spill. Sweep up the kitty litter, put it in a bag, seal it, & place in the trash. Do not scrub the spot or sweep the kitty litter into the street.

Check Tire Pressure
One of the simplest and cheapest ways to prevent pollution is to keep your tires inflated. For every pound that your tires are under-inflated, your car loses 1% in gas mileage. Under-inflated tires also wear out sooner. Check your tire pressure frequently, especially as temperature changes in the fall and spring. Properly inflated tires reduce the amount of gasoline your car burns and therefore reduce the amount of polluted exhaust your car makes.

Recycle Used Motor Oil
Recycling is the only safe way to dispose of used motor oil. Put oil in a container with a tight lid and take it to a local auto parts store or a local landfill. Don’t pour anything else in with the oil because contaminated oil cannot be recycled. Oil poured down storm drains ends up in our waterways.

Recycle Antifreeze
Antifreeze is poisonous to people and animals. Because of its sweet taste and smell, antifreeze may attract children, pets and other animals. Drinking only 3 ounces will kill an adult and even less will kill children and pets. In Spencer, antifreeze can be recycled at a local landfill during regular business hours.

Return Used Batteries
Batteries contain hazardous chemicals that can leach through soil and contaminate water. Return used car batteries to an auto parts store. Do not throw old batteries in the trash or bury them—you’ll be breaking the law.

Drive Less
Driving less is the best way to prevent pollution. Water quality research shows that most polluted runoff comes from heavily traveled streets and highways. This runoff often contains enough zinc, copper and lead to kill fish and other aquatic life.
IRRIGATION

Over-watering or irrigating improperly can wash fertilizers, pesticides, motor oil, and other pollutants directly into our waterways.

Proper irrigation practices can save you time and money, as well as protect our waterways.

- Irrigate when the soil is nearly dry.
- Water the lawn, not the sidewalk, street, or driveway. Adjust sprinklers if necessary.
- Water in the early morning to discourage lawn disease and reduce evaporation.
- Irrigate slowly so that water doesn’t run off or compact the soil.
- Use a rain gauge or tuna can to measure the amount of water you’re putting on your lawn; 1/2 to 1” is plenty of water for most lawns.
- Plant drought-tolerant native plants to reduce irrigation needs.
- Use a rain barrel to collect rainwater, irrigate your landscape and save $$$.

EROSION

Sediment impacts aquatic life, habitat, and water quality, and can lead to property flooding.

- Re-seed bare lawn areas.
- Mulch exposed soil in gardens and flower beds.
- Plant vegetation (groundcover, trees, shrubs) to anchor soil in place, reduce erosion, and filter pollutants from runoff.
- Keep sediment off sidewalks, driveways, and other hard surfaces.
- Follow all construction site runoff laws and practices.

*Please share these tips with your landscaping company and neighbors!

Make the Connection between Lawn Care & Water Pollution

Did you know that YOU can prevent water pollution from lawn care and gardening activities?

What you do to your lawn or property can impact our waterways, even if you don’t live near water. Stormwater runoff and improper irrigation methods can wash fertilizers, pesticides, sediment, yard debris, and other pollutants directly into our waterways. Poor lawn care practices can impact waterways by causing:

- fish kills
- algae blooms and aquatic weeds
- low dissolved oxygen
- impaired aquatic habitat and wildlife
- recreational water closures
- disturbed esthetic views.

*Please use the following lawn care tips to improve and protect our waterways.

You are the solution to stormwater pollution!
FERTILIZER

Fertilizing properly can save you time and money and prevent water pollution. Over-fertilizing your lawn may seem insignificant, but careless application on hundreds of lawns can add up to major problems for our waterways, including high nutrient levels, algal blooms, and low dissolved oxygen levels.

- **GET A SOIL TEST:** It’s cheap, it will save you time and money, and provides specific nutrient needs and application rates for your lawn.
- **Grasscycling:** Leave grass clippings on the lawn; they are a cheap, safe, and effective natural fertilizer and soil conditioner.

Avoid fertilizing before it rains.
- Keep fertilizer off paved surfaces like sidewalks, streets, and driveways.

If fertilizer is applied too heavily or unevenly, it may burn the grass or result in a patchy lawn. To avoid this, use the following method:

- **Estimate your lawn area in square feet:** Pace off the length and width of your yard (1 large pace equals 2 ft.). Multiply length x width to get total square feet.
- **Example:** If your yard is 10 paces wide, that would equal 20 ft., and 12 paces long, would equal 24 ft. Then multiply 20 ft. X 24 ft., for a total of 480 square feet of lawn area. Calculate and measure the correct amount of fertilizer for the total square feet per application rates on the bag of fertilizer.

Be sure to calibrate your (fertilizer) spreader so that you are applying the correct amount of fertilizer. Drop spreaders do the best job of keeping fertilizer on the lawn, so it doesn’t get on the sidewalk, street, or driveway.

---

PESTICIDES & HERBICIDES

Most insects found on a lawn are beneficial.
- **Grasscycling leaves grass clippings on the lawn to decompose and provide up to 25% of your lawn’s total fertilizer needs, naturally. Grass clippings contain about 4% nitrogen, 2% potassium, and 1% phosphorus. Clippings break down fast and serve as a food source for bacteria in the soil, which are doing many beneficial things, such as decomposing thatch.

**Grasscycling saves you time and money, and will eventually help improve Spencer’s waterways**

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MOWING

Proper mowing techniques prevent water loss, reduce weeds, and keep your lawn healthy and growing.
- Mow only when the grass is dry.
- Alternate mowing patterns.
- Don’t cut grass too short, lack of shade can dry out the soil and cause weed and insect problems.
- Mower blades should be kept sharp.

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YARD WASTE

Yard waste, such as leaves and grass clippings, that end up in streets, storm drains or ditches, can cause algal blooms, oxygen depletion and fish kills in waterways. Clogged drains and ditches can also cause street and property flooding.
- **Grasscycling:** Leave grass clippings on the lawn as a natural fertilizer/silica conditioner.
- **Leaves and yard clippings can be composted and used as a mulch**
- **Bag or containerize waste for collection day or take to a disposal facility**
- **Do not blow, sweep, or rake leaves and other debris into a street, storm drain, ditch, or waterway.**

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LANDSCAPING WITH NATIVE PLANTS

Native plants require less water and virtually no fertilizer and pesticides. They are adapted to the region and are drought, disease, and pest resistant. Native plants help create a healthy, diverse ecosystem, and require a lot less maintenance than a traditional lawn. Landscaping with native plants can also save you time and money spent on fertilizers, pesticides, and irrigating.
Did you know there are approximately 26,000 dogs in Worcester County?

Consider this: A dog drops on average 3/4 pounds of waste daily. That means approximately 19,500 pounds or 10 tons of dog waste is generated in Worcester County each day!

When it rains, bacteria from pet waste can wash directly into storm drains and drainage ditches and eventually into our waterways — untreated!

PET WASTE, WATER QUALITY AND YOUR HEALTH

Pet waste is a health hazard and a water pollutant.

Protect your health and our waterways... clean up after your pet!

PROTECT WATER QUALITY AND YOUR HEALTH - CLEAN UP AFTER YOUR PET!
ARE YOU POLLUTING OUR WATERWAYS?

Pet waste is a health hazard and a storm water pollutant. Storm water runoff can wash bacteria from pet waste directly into local creeks and waterways. Bacteria, parasites and viruses contained in pet waste are a health risk to other animals and people, especially children. In particular, fecal coliform bacteria, found in the feces of warm-blooded animals, is a common pollutant in Spencer creeks and waterways. High levels of this bacteria indicate that water may be unsafe for human contact.

In addition to health risks, poor water quality caused by pet waste can also lead to shellfish bed closures and impaired water quality of recreational waters. Excreta in pet waste also encourage weed and algae growth. This nutrient-rich water is cloudy, green, unattractive and unhealthy for swimming, boating, fishing or drinking. Finally, when pet waste decays, it uses up oxygen and releases ammonia which can lead to fish kills.

ARE YOU RISKING YOUR HEALTH?

When pet waste is left on the ground or disposed of improperly, water quality in our creeks and waterways suffers and your health may be at risk too. Pets, children who play outside, and adults who garden, are among the highest risks of infection from pathogens found in pet waste. Fleas also spread diseases found in pet waste.

Diseases that can be transmitted from pet waste to humans include:

- **Camping bacteria** — a bacterial infection carried by dogs and cats that frequently causes diarrhea in humans. 
- **Salmonella** — the most common bacterial infection transmitted to humans by other animals. Symptoms include fever, muscle aches, headache, vomiting, and diarrhea.
- **Toxoplasmosis** — a protozoan parasite carried by cats that can cause birth defects such as mental retardation and blindness if a woman becomes infected during pregnancy; also, a problem for people with suppressed immune systems.
- **Fecal Coliform Bacteria**

A bacteria present in the feces of warm-blooded animals and a common pollutant in Spencer waterways. High levels of fecal coliform bacteria in waterways indicate that:

- Other harmful microorganisms may be present in the water as well.
- A potential health risk exists for individuals exposed to the water.

**CLEANING UP PET WASTE**

There are many factors contributing to water pollution, but pet waste is one you can easily prevent. Listed below are several simple ways to properly dispose of pet waste:

- Always clean up after your pet.
- Use a scoop, bag or shovel to pick up pet waste. Remember to put waste in a bag and seal it before placing in the trash. It's best to double-bag the waste!
- Utilize free pet waste stations and supplies in City and County Parks.
- Bury waste in a hole that is at least 5" deep and away from gardens, ditches, storm drains and waterways.
- Install a pet waste digester on your property.
- Waste from cats should also be contained. Provide covered litter boxes for outdoor cats. Dispose of the kitty litter properly.

**DO NOT**

- Flush pet waste down the toilet, compost it, or dump it into storm drains or ditches.
- DO NOT leave pet waste on streets, sidewalks or other impervious (hard) surfaces where it can wash into storm drains, ditches or waterways.