WATER QUALITY IMPROVEMENT PLAN

For:

FREMONT POND

Located at:

Lakeview Avenue and Pokahoe Drive
Village of Sleepy Hollow, Westchester County, New York
Tax ID 01/110.15-1-71

Dated:

September 21, 2017
Revised: November 15, 2017

Prepared For:

Village of Sleepy Hollow

28 Beekman Avenue
Sleepy Hollow, NY 10591
(914) 366-5100

PREPARED BY:

Land Planning ~ Civil Engineering~ Environmental Services ~Surveying Services ~ Landscape architecture

85 Civic Center Plaza, Suite 103
Poughkeepsie, NY 12601
Phone 845-243-2880
Fax 845-265-8175

Table of Contents

1.0 EXECUTIVE SUMMARY
- 1.1 Background
- 1.2 Location

2.0 IMPROVEMENT PLAN

3.0 HOMEOWNER BEST MANAGEMENT PRACTICES (BMPs)
- 3.1 Lawn Maintenance
- 3.2 Fertilizers
- 3.3 Buffer Protection
- 3.4 Waste Management

4.0 POND IMPROVEMENTS
- 4.1 Aeration
- 4.2 Pond Draw Down
- 4.3 Bio-Swale and upstream Management

5.0 CLOSING STATEMENT

APPENDICIES

Appendix A: Final Water Quality Report, Fremont Pond
Appendix B: Mapping

1.0 EXECUTIVE SUMMARY

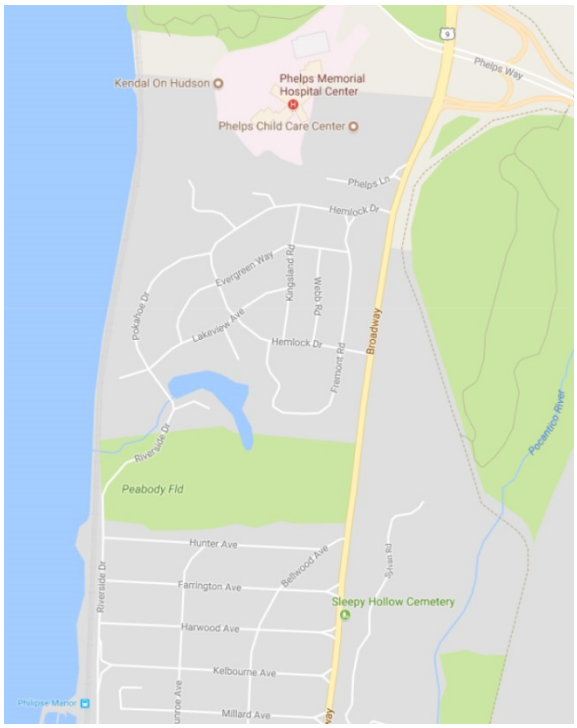
This water quality improvement plan serves as a resource for the Sleepy Hollow community to improve the water quality of Fremont Pond and its aesthetic, biological and recreational functions. The purpose of this report is to outline Best Management Practices (BMP's), which can improve water quality in Fremont Pont. This report focuses on the identification of practical and cost effective measures to reduce contaminates that enter Fremont Pond, in order to improve pond health without undertaking major pond or stream modifications.

1.1 Background

Fremont Pond is a small, approximately 5-acre pond, located in the Village of Sleepy Hollow, Westchester County, New York. The pond is located in an established residential area and is considered an aesthetic and recreational asset to the surrounding community. The primary recreational activities are fishing and small paddle craft boating. However, declining water quality and the prevalence of algae blooms have impacted the pond's appeal and functionality as identified within a water quality study that was conducted in 2016 by Life Inc. Their final report is included as **Appendix A**. This report identified a number of negative attributes which are nutrient sources for increased algae growth and contribute to negative water quality. Nitrate, phosphate, iron, and zinc levels exceed state water quality standards. The report also found that the pond has high levels of coliform bacteria, total suspended solids, and low levels of dissolved oxygen. This report will recommend practices to help reduce contaminate loading and mitigate their effect.

1.2 Location

The pond is located just east of the Hudson River and west of Route 9, and is bounded to the south in part by Peabody Field (soccer) and Peabody Preserve (Tarrytown Public Schools), and to the north by Sleepy Hollow Manor (a single family residential neighborhood). The pond property (except that part of the pond within the Peabody Preserve) is owned by the Village of Sleepy Hollow, identified as Tax ID 01/110.15-1-71, according to Westchester County GIS data. The pond is in the west central edge of a 275-acre watershed that extends east beyond NY Route 9, and stops short of the Hudson River to the west. Other significant land uses within the watershed include a portion of the Sleepy Hollow Cemetery (east of Route 9) and Phillips Manor, a single family neighborhood south of the Peabody Preserve. Detailed soil information, land use, and watershed characteristics can be found in the Water Quality Report in **Appendix A**.



Additionally, the pond has several direct inlets from the neighboring residential dwellings identified on the attached photo in blue. These direct discharge points are areas that contribute to the degradation of the pond from various pollutant pathways further described in the future sections. As indicated in the LIFE Inc. report there are two direct stream corridors from Route 9 that likely contribute to higher levels of metals and nutrients in the pond as well, shown in red.

2.0 IMPROVEMENT PLAN

This general implementation plan is included for use by local agencies, watershed managers, and citizens for decision-making and detailed planning purposes. The BMPs discussed in this document are presented as potential tools that will help achieve water quality improvements if appropriately utilized. Additionally, there may be other BMP's not discussed that should be considered. This water quality improvement plan should be used as a guide or foundation for detailed and comprehensive management of Fremont Pond and as an aid to the development of restoration plans by local stakeholders. It should be noted that these measures will help reduce the contaminate loading, but they will not solve all of the water quality issues as the BMP's presented here do not address in-pond sources of water quality issues.

Collaboration and action by residents, landowners, and local agencies will be critical to improving the water quality of Fremont Pond. History suggests that efforts at the local level prove to be the most successful in making real and significant water quality improvements. Improved water quality will benefit all of the people who live, work, and play in the watershed. Therefore, each citizen or interest group has a stake in promoting awareness and educating others about water quality, working together to adopt a comprehensive watershed improvement plan, and applying additional BMP's and land management changes (policy and regulatory) within the watershed.

3.0 HOME OWNER BEST MANAGEMENT PRACTICES (BMP's)

When lawn clippings, fertilizers, soil, leaves, or animal wastes, are picked up by storm water runoff, they are carried directly to our local streams and lakes. All of these materials contain phosphorus and other contaminants which are harmful to water quality. According to the U.S. EPA, phosphorus is one of the most troublesome pollutants in storm water runoff and it is considered the primary cause of water quality problems in our lakes, ponds, and streams. Reducing or eliminating these contaminants at the source is critical to improving water quality in the long run and it is the most cost-effective way to improve the quality of Fremont Pond. The following Best Management Practices (BMP's) can be achieved by local residents and the municipality through direct action, community outreach and education, and policy or regulatory actions.

3.1 Lawn Maintenance

Grass clippings and leaves contribute nutrients such as nitrogen and phosphorous, which cause unwanted and uncontrolled growth of algae in the waterways and pond. Increased algae growth is observed as green algae blooms or "scums". Too much algae is harmful to a lake system and greatly reduces aesthetics along with overall water quality. Algae blooms block sunlight and prevent other plants from growing. When it dies and decays, algae takes much needed oxygen away from fish. Limiting phosphorus levels will reduce algae blooms. According to the Northeast Wisconsin Stormwater Coalition, one bushel of fresh grass clippings can contain 0.1 pounds of phosphorus, which - if it ends up in lakes or ponds - is enough to produce 30 to 50 pounds of algae.

The following items are specific lawn maintenance practices that can and should be undertaken at both the homeowner and village level:

A. When mowing yards, do not blow grass clippings or leaves into the street or directly into the pond. When mowing, make the first few passes with the lawnmower blowing the grass clippings into the lawn area and not the street or pond. If there are grass clippings or leaves on the street or sidewalk, use a broom or leaf blower to blow them back into the lawn area. Do not blow or wash them into the street or storm drains.

B. "Runoff" includes excess water that washes the grass clippings, leaves, fertilizer and other "pollutants" from lawns, sidewalks and driveways, carrying them into our water system. To reduce the volume of runoff water contributing to the pond, direct downspouts onto your lawn, not onto hard surfaces and use rain barrels or cisterns to collect rain water which can be used at a later time for watering plants. Keeping your leaves and lawn clippings out of the streets and gutters will have significant benefits to Fremont Pond by reducing the amount of phosphorus being added to the pond chemistry.

C. The NYSDEC recommends letting grass grow to a three inch height, and then cutting off one inch. Slightly longer grass will stay greener, reducing the need for watering, and less watering means less runoff. Sharpen mower blades twice a year. Mulching your grass reduces the need for fertilizer - as the grass clippings break down, nutrients are released into your lawn. According to the U.S. EPA, leaving your grass clippings on the lawn does not cause thatch buildup. Grass clippings are about 90 percent water, so they decompose very quickly. Leaving your grass clippings on the lawn can reduce your lawn's annual fertilizer needs, reduce your fertilizer costs, and reduce water pollution. If you don't want to mulch, compost your grass clippings.

D. Blow-away leaves can be an even bigger problem than grass clippings. Mulch or compost the leaves in your yard as soon as they fall and as often as possible**.** This minimizes the chance that they will reach the pond waters. Also, regularly clean leaves from your gutters so they can't be washed away with the rain. Don't rake leaves into the street for the street sweeper pickup. Instead, mulching leaves, like grass, adds nutrients to your lawn, reducing the need for fertilizer**.** Do not stockpile leaves within the Fremont Pond watershed and remove any piles that may be leaching into the streams and drainage systems.

E. Control soil erosion around your house. Rain water hitting and flowing over bare soil will gather and carry soil particles with it. These soil particles have the potential to have phosphorus (P) and other contaminants attached to them that will contribute to the degradation of the pond. Some soils are naturally high in phosphorus and thus can be another source of phosphorus in storm water runoff.

3.2 Fertilizers

The overuse of chemical or inorganic fertilizers has serious consequences including the leaching of nitrates into the groundwater supply and the introduction of certain contaminants, including cadmium, into the soils. The following items are specific fertilization practices that can and should be under taken at both the homeowner and village level.

A. Apply only the amount of fertilizer a lawn needs. A soil test will tell how much fertilizer, if any, a lawn needs. While phosphorous is an important nutrient for grasses and other green plants, it is also an important nutrient for algae and weeds in pond or lake systems. Often times lawns do not need additional phosphorus and a soil test will inform you of the amount of phosphorus in the soil and the appropriate application rate. Excess fertilizer that cannot be taken up by grass may harm lawns or pollute surface water.

B. Do not apply fertilizers directly on hard surfaces. Fertilizer applied to even incidentally to surfaces such as driveways, streets or sidewalks will get into Fremont Pond. If any fertilizer spills onto walks or driveways, sweep it into the lawn and do not use a hose to wash it into the street or drainage systems.

C. Do not apply fertilizers within 20 feet of the pond or any contributing streams.

D. Whenever possible, use of organic fertilizers which release nutrients slowly into the ground, resulting in overall higher-quality soil composition and decreased runoff into local water systems. Non-organic fertilizers can have a quicker release of nutrients and are also more susceptible to runoff which would further impact the pond.

E. When fertilizing, using the correct amount of fertilizer can reduce the amount of pollutants reaching waterways, save water and money, and result in a healthier landscape. Over fertilizing can aggravate pest problems, stimulate excessive plant growth, and demand frequent irrigation.

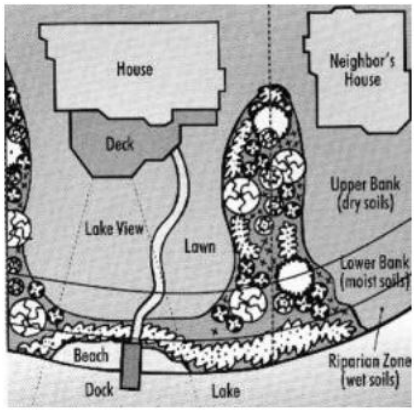
F. Avoid the unwise or excessive use of pesticides and herbicides, which can harm people, pets, beneficial organisms and the environment. Use nontoxic alternatives whenever possible, and pull weeds by hand. Also, avoid overuse of fertilizers, which can wash into ponds and water bodies and cause harmful algae blooms.

3.3 Buffer Protection

Off-site transport of Phosphorus (P) to surface waters tends to be associated with sediment erosion. Phosphorus readily bonds to very fine textured soils and organic matter particles. These very fine particles are easily eroded and carried off by runoff water and wind, thus potentially transporting the

Phosphorus bonded to them to streams and ponds. Living plants such as trees, shrubs, and tall grasses around lakes which form a riparian buffer can stabilize the soil against wind and water erosion; act as filters to help remove these fine soil particles from the air, thus trapping both the soil particles and any associated nutrients bonded onto them; and take up water borne nutrients and contaminants in surface water.

A. Reducing the amount of lawns directly adjacent to the pond and development of vegetated buffers can reduce airborne and waterborne movement of soil particles, encourage nutrient take by plants, and can reduce the chance of grass clippings being blown into the Fremont Pond.



B. Ideally vegetation should cover 50-75% of the property's lake frontage.

C. Minimize the size of the lawn as expansive grass lawns add to increased fertilizers and pesticide uses. A typical grass lawn will infiltrate significantly less stormwater runoff from rainfall than a natural landscaped area.

D. Shoreline buffer creation is one of the most effective ways to protect water quality.

3.4 Waste Management

Keeping pollutants and waste out of the watershed's drainage systems is an important step in keeping them out of Fremont Pond and will result in immediate and significant positive effect. Some of the typical pollutants that may be dumped into a storm drain and into waterways such as Fremont Pond include: antifreeze, motor oil, paint, trash and litter, pesticides, fertilizers, dirt, leaves, grass, and animal waste. Mechanisms and facilities for proper management of wastes already exist, so the increased use is largely a behavioral issue that can be supported by modest neighborhood improvements.

Specific actions to limit the contribution of waste related pollutants include:

A. Eliminate waste products going directly into the storm drain system. In some instances, residents have been known to scoop animal waste and other pollutants directly into street drains. Adding signs or stickers to the catch basins and drainage grates within the watershed can help to educate the local residents of the connection. The EPA and NYSDEC have effective programs for marking basins with the phrases "Keep it Clean, Drains to Stream" and/or "No Dumping Drains to Stream". Stenciling a storm drain is a small effort that brings a large result. Stenciling a message conveys to the public that everything that goes down a storm drain flows, untreated, into a nearby stream. Citizens can help educate others not to dump trash, yard clippings or other debris by stenciling storm drains.

B. Reduce contribution of waste from roadways. A significant source of pollution is sediment and waste from roads. Sweeping local streets and maintaining clean catch basin sumps can reduce pollutants. Roads should be routinely swept when surface litter accumulates. Streets should also be cleaned in the early spring to remove salts and sands used during the winter. Catch basin sumps can help prevent sediments from reaching the local water bodies. Sumps are most effective when they remain free of debris and the sump depths are maintained. All catch basins within the watershed should be inspected routinely and cleaned out when the sediment reaches half the depth of the sump.

C. Reduce the impact of animal wastes. The water quality report showed the presence of coliform bacteria in Fremont Pond. One source of bacteria is animal waste. Local residents should be advised to properly dispose of animal waste. It appears that many local residents use the trails in Peabody Field to walk their dogs. Adding dog waste bag dispensers and trash receptacles throughout the watershed can help to reduce animal waste. Such dispensers could include communication graphics about the direct benefit to Fremont Pond's water quality.

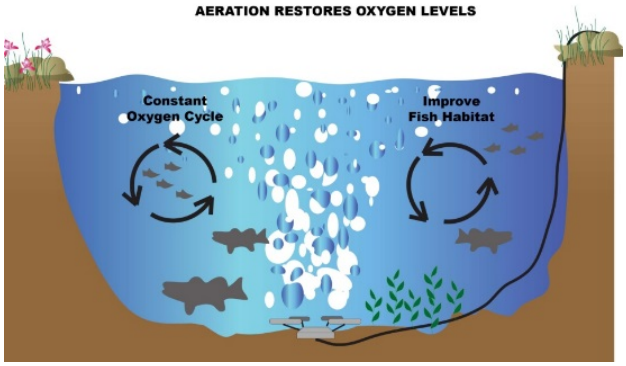
4.0 POND IMPROVEMENTS

4.1 Aeration

The water quality report by Life, Inc. showed that oxygen levels are very low in Fremont Pond. Eutrophication is a process whereby ponds and lakes accumulate excessive nutrients that stimulate excessive plant growth (algae and aquatic plants). Dissolved oxygen concentrations can severely decline when large amounts of algae and aquatic plants begin to decompose. In turn, very low dissolved oxygen concentrations can cause other aquatic organisms to die. Maintaining healthy oxygen levels can greatly increase water quality. Adding an aeration system to the pond can help by adding air to the water (oxygenation) and reducing stagnation.

Moving water bodies with steps, rocks or falls are naturally oxygenated by the action of the tumbling water. However, standing water requires a mechanical system to provide a similar action. In very simple terms, an aeration system for a standing body of water consists of an electrically powered pump which takes air from the atmosphere and forces it through a diffuser directly into the water body.

The benefits of an aeration system include:



A. Aeration cuts the nutrient load, like pond muck and other decomposing debris, in your pond. The increased oxygen and water movement provided by aeration helps to encourage the colonization of beneficial aerobic bacteria. These bacteria are responsible for digesting and preventing muck and nutrient accumulation.

B. Aeration also increases the amount of oxygen in the water. Beneath the water surface, diffuser plates release tiny bubbles of oxygen. They disperse and circulate throughout the water column, providing life-sustaining O2 to beneficial bacteria, fish and submerged plants.

C. Aeration circulates the water and eliminates thermocline, which is a stratified layer of water between the warmer, surface zone and the colder, deep-water zone. Bottom diffuser aeration churns and mixes those temperature layers. The cloud of tiny air bubbles force the cooler, oxygen-starved water to the pond's surface where it becomes infused up with O2. The warmer, oxygen-rich water then drops down, fueling the beneficial bacteria.

By reducing the pond muck, increasing oxygen and circulating the water column, your water quality will improve. You'll see reduced algae growth, clearer water, and happier, healthier fish.

4.2 Pond Draw Down

One item that should be considered for this upcoming winter cycle is to complete a winter drawdown. This may require some modification to the outlet structure under the road to maintain a lower pond level. It may also be achieved by pumping down the pond after large rainfall events in the winter. By draining down the pond you would expose submerged aquatic plans to freezing and drying cycle. This is typically achieved by having the pond 1/3 full from November through March to expose the plants to 20 degrees or colder for at least three months.

While the pond is down we would recommend exploring the outfall structure for more control over water volume within the lake. These controls would allow for the proper maintaining of the water table through dry periods and during high water periods.

4.3 Bio-Swale and Upstream Management.

One of the items that should be considered as part of the early phases of the project would be to restore and work to create a detailed management plan for the two streams that enter the head of the pond.

One stream comes directly from Route 9 through an un-vegetated swale into what appears to be a plunge pool or forebay. As noted in the LIFE Inc. report this practice alone without proper maintenance and plant species can add to nutrient loading observed within the pond. A detailed landscaping and erosion control plan should be looked at to determine the best plant types and routing of the stormwater to assist in reducing the nutrient loads.

The second stream comes from Route 9 as well but comes through the adjacent cemetery. As noted by LIFE Inc. the runoff from the cemetery should be investigated further to determine if the cemetery is contributing to the pond impacts. Additionally, it was observed that large amounts of wood chip mulch was located on pathways within the wetland area to the south. Further investigation should be made to determine if the use of wood chips along the pathways may have adverse impacts to the adjoining stream.

As noted previously this area should be studied in further detail to determine if and where applicable stormwater practices may be installed to reduce the overall impacts from the runoff of Route 9 and the cemetery.

It is noted that the area south of the pond at the head is located within a park that seems to have some maintenance and nature paths that are maintained by TeaTown.org. It looks like the Village could contact TeaTown.org and possibly jointly work together to reduce erosion and increase the biodiversity of the plant species within this corridor to further protect the Pond.

5.0 CLOSING STATEMENT

The first step to increasing the use and water quality of Fremont Pond is education. Educating the people who live and work in the area to know that their actions directly affect the health of Fremont Pond is key to a successful plan to revitalize the pond. Through that education we hope to bring awareness to the potential impacts that their everyday lives may have on the pond water quality. With that education we hope that more people will become aware of the problems and look to become part of the solutions on an individual basis.

While these above homeowner steps may not see an immediate impact to the restoration of the pond these are the biggest steps preserving its future. These steps will help bring balance to the ecology of the pond. Once a keen awareness and BMP's have been established the Village should look to proceed with the additional steps of determining upstream mitigation plans along the stream corridors from Route 9 to further maintain the health of the pond.

Appendix A:
Final Water Quality Report, Fremont Pond

FINAL WATER QUALITY REPORT

FREMONT POND

Prepared by:

John Brandt
LIFE INC

July 2016

TABLE OF CONTENTS

TABLE OF CONTENTS 2
LIST OF FIGURES 2
LIST OF TABLES 2
EXECUTIVE SUMMARY 3
INTRODUCTION AND BACKGROUND 4
STUDY OBJECTIVES 5
METHODS 5
Watershed Modelling 5
Field Sampling and Analysis 5
Water Quality Parameters Considered 5
RESULTS 8
Watershed Modelling 9
Field Sampling and Analysis 17
SUMMARY AND RECOMMENDATIONS 23
LITERATURE CITED 26

LIST OF FIGURES

Figure 1. Watershed 8
Figure 2. Land Use 11
Figure 3. Canopy Cover 12
Figure 4. Soil Type 13
Figure 5. Erosion 14
Figure 6. Tributaries 14
Figure 7. Flow Accumulation 15
Figure 8. Hazardous Waste 16
Figure 9. Sampling Locations 17
Figure 10. Phosphate Interpolation 19
Figure 11. Nitrate Interpolation 20
Figure 12. Turbidity Interpolation 20
Figure 13. Iron Interpolation 21
Figure 14. Coliform Bacteria 22
Figure 15. Gullying on Route 9 24

LIST OF TABLES

Table 1. Watershed Soil Type 10
Table 2. Nutrient Results 18
Table 3. D.O., pH, TSS Results 19

EXECUTIVE SUMMARY

Fremont pond is a significant recreational and aesthetic component to its surrounding Sleepy Hollow neighborhoods. However, it has been imperiled by algal blooms and nuisance vegetation which have burdened its recreational appeal and created unhealthy conditions for aquatic life. In order to create a framework upon which water quality can be improved in the future, the present study investigated the present water quality conditions of Fremont pond. The main findings are that nitrate and phosphate concentrations are more than an order of magnitude higher than state water quality standards, as are zinc and iron concentrations. The investigation concludes that the former are caused by residential runoff, erosion from the proximal cemetery, and improper storm water management on Route 9. The metal concentrations are likely so high because of automobile waste entering highway runoff from Route 9. Furthermore, the study found high levels of general coliform bacteria in samples within Fremont pond that had the highest phosphate concentrations, indicating that they came from similar sources. Finally, the study found low levels of dissolved oxygen and high levels of suspended solids in the water column.

External nutrient loading is the primary driving factor of algal blooms within Fremont pond given the heterogeneity of nutrient distribution and the correlation between nutrient concentrations and suspended solids. However, there is significant potential for internal nutrient cycling: even though nutrient concentrations decreased farther away from the inflows, they remained at extremely unhealthy levels throughout the entire pond. In order to restore the water quality of Fremont pond to healthy, aesthetically pleasing, and recreationally attractive conditions, nutrient and metal loading to the pond needs to be reduced. To do so, we recommend better storm water management along Route 9 to reduce gullying and erosion, runoff management within the cemetery, and legislation reducing fertilizer application during the winter months. If these measures are not effective in reducing algal blooms, the pond may need to be drawn down in the winter or dredged to remove the deposited nutrients. Reducing the input of nutrients may not change conditions if there are enough nutrients within the pond to support algal blooms for the foreseeable future; however, reducing the internal nutrient storage without reducing external nutrient loading will also not create visible differences in water quality. The best plan moving forward for Fremont pond would be to reduce nutrient loading from the watershed in tandem with removing nutrients already stored within the pond.

INTRODUCTION AND BACKGROUND

Ponds are complex ecosystems which comprise of the interactions between physical, biological, and chemical components such as animals, plants, nutrients, sediment, and light. While some of the regulators of ecosystem function originate within the pond, the watershed dictates a large portion of how ponds function, since they receive more than 75% of their nutrients and energy as subsidies from their watersheds (Richardson et al., 2010). Any changes in terrestrial inputs of energy or nutrients can drastically change freshwater productivity and character. Increases in nutrient subsidies from urbanization or agriculture can foster eutrophication and the over-abundance of algae which leads to a visually unappealing and ecologically unhealthy state. At the other end of the spectrum, decreases in terrestrial inputs can shift the ecosystem towards an oligotrophic state where fish are unable to find enough food.

The most pervasive human impact on ponds to this day is the cumulative degradation of water quality as a result of watershed development. As watersheds are urbanized, impervious surface cover increases and canopy cover decreases, resulting in increased erosion and sediment input into freshwater systems. Increased sediment load into ponds reduces water clarity and increases the magnitude of the watershed nutrient subsidy. Water clarity reduction reduces light penetration and can affect water temperature and carbon cycling. Increased nutrient loading via runoff and erosion, in combination with fertilizer usage in the watershed, can drastically change nutrient cycling and algal productivity. Both abnormal sediment loads and nutrient loads can kill aquatic insects, fish, and other pond inhabitants. While society values lakes with high water quality, urbanized watersheds constitute a double standard where the recreational benefits of being in close proximity to a pond often leads to anthropogenic reductions in water quality which diminishes the joy that one receives from recreation.

Fremont Pond is a small, 5-acre pond situated in Sleepy Hollow, NY which has been subjected to abnormal algal growth and cultural eutrophication. Fremont Pond is situated in a predominately urban 275-acre watershed with the exception of a park directly south of the pond. Route 9 bisects the watershed north-south, with the eastern portion of the watershed consisting of the Sleepy Hollow Cemetery and the western portion consisting of residential neighborhoods. Because of its urban watershed, the Pond is continuously inundated by human activity at the expense of water quality. Due to the prevalence of algal blooms and nuisance vegetation in Fremont Pond, stakeholders within the town of Sleepy Hollow have requested the consultation of LIFE Inc. in order to assess the water quality of the pond.

STUDY OBJECTIVES

1. **Assess water quality parameters in Fremont Pond**
2. **Determine if nutrient concentrations are stimulating algae and eutrophication**
3. **Assess the presence of watershed characteristics that may provide significant nutrient subsidies to the pond**
4. **Assess whether conditions are present for internal nutrient cycling within the pond**

METHODS

Watershed modelling

Watershed characteristics that influence water quality were mapped in QGIS and GRASS, including land use, canopy cover, impervious surfaces, hazardous waste sites, soil erodibility, hydrologic flow paths, septic systems, and storm water outflows.

Field sampling and analysis

In order to assess the water quality of Fremont Pond, 10 surface samples were taken randomly through the pond. The samples were stored at 4°C until analysis. Samples were analyzed for NO_2^-, NO_3^-, PO_4^-, and total iron spectrophotometrically with Hach reagents (Methods numbers EPA 353.2, DOC316.53.01066, DOC316.53.01119, DOC316.53.01053, respectively). Zinc was measured for a subset of two of the samples to determine concentration near the inflow versus the rest of the pond (Hach 8009, 40 CFR 136). NH_3 was measured of the same subset of samples as zinc (DOC316.53.01145). Samples were filtered through a 1 um membrane and analyzed for total suspended solids (TSS) by calculating the amount of material added to the filter paper per ml filtered. Water samples were also analyzed for general and fecal coliforms with Coliscan EasyGel. Finally, dissolved oxygen, turbidity, specific conductivity, and pH were taken at the same intervals as nutrient and TSS samples. All data were mapped in QGIS and GRASS and interpolated to estimate values at non-sampled locations within the pond.

Water quality parameters considered

Phosphorus: Phosphorus is a nutrient that is essential to plant growth, comprising a large portion of the backbone of DNA. It is often the most limiting nutrient which controls algae and macrophyte growth, and its surplus or lack thereof regulates plant abundance. Phosphorus is found in fertilizers and animal and human wastes. The River Quality Network suggests that phosphate concentrations remain below 0.05 mg/L and notes that concentrations above 0.1 mg/L will cause recurrent algal blooms (Behar, 1997). The NYSDEC maintains that total phosphorus (of which PO_4^{3-} is only one part) remain below 0.02 mg/L, concentrations above which are considered eutrophic and in need of remediation (NYSDEC Clean Lakes Assessment, n.d.).

Nitrogen: Nitrogen is another essential nutrient to plants which is also found in fertilizers and animal and human wastes. Nitrogen also exists in the atmosphere as nitrogen gas, where it can diffuse into water and be "fixed" by algae into ammonia for plant use. Nitrogen can also enter waterbodies through tributaries in inorganic forms. Nitrogen is commonly found as:

Nitrate (NO_3^-) – High nitrate concentrations can impair the immune system of aquatic animals and create dead zones. Nitrate enters water from sewage disposal systems, livestock, fertilizers, parks, lawns, and gardens. Nitrate is readily uptaken by algae and can cause algal blooms, which ultimately foster anoxia during decomposition. NO_3 concentrations can be reported as NO_3 or as NO_3-N, with the latter only considering the amount of nitrate that is nitrogen. Because of this, NO_3-N concentrations will be about one-fifth the concentration of a reported NO3 value. The New York State water quality standard for nitrate is 0.1 mg/L to protect aquatic life and 1 mg/L to protect human health (NYSDEC, n.d.).

Nitrite (NO_2) – Nitrite is converted to nitrate by nitrifying bacteria, which can then be uptaken by plants. Nitrite itself is not available to algae or plants, but is extremely reactive and dangerous. Nitrite is the product of the nitrification of ammonium, and its presence is a negative indicator of water quality. Any available nitrite should be immediately nitrified to the biologically available nitrate, and so the presence of nitrite indicates that there is an excess of ammonium because nitrite is a product of the breakdown of ammonium and is only present when ammonium has recently been present in high concentrations.

Ammonia (NH_3) – Ammonia is excreted by animals and released by dead plant biomass and can be converted into NO_2 and then NO_3 by bacteria and afterwards uptaken by plants and animals for use. Because bacteria convert it into bioavailable forms of nitrogen, it is relatively uncommon to see in healthy systems, and its presence indicates an over abundance of nitrogen to the point that nitrifying bacteria are saturated and cannot process the ammonia into nitrite fast enough. Ammonia is very toxic and can sterilize fish, cause them to die, and hinder their growth. As such, ammonia should not be present at concentrations greater than 0.025 mg/L NH_3-N.

Dissolved Oxygen (D.O.): D.O. is the dissolved form of oxygen in water, and is a necessity for the respiration of heterotrophs like fish and invertebrates. D.O. is generated by photosynthesis and by diffusion from the atmosphere. Excessive algae growth can over-saturate the water with D.O. However, decomposition of algae can remove the majority of D.O. from the water column. A minimum of 4-5 mg/L of D.O. is necessary for heterotrophs to survive.

pH: pH is a measure of the relative acidity or basicity of water. In other words, pH reflects the number of hydrogen (H^+) ions in solution, with samples containing more H+ ions having lower pH. The concentration of H^+ is important to water quality because H^+ is an electron acceptor and

can participate in certain reactions based upon its concentration. Healthy water systems typically have a pH between six and eight. Considering that pH is a logarithmic scale, this means that the H^+ concentration in healthy systems can range by a factor of 100.

Total Suspended Solids (TSS): TSS is a metric of how many grams of particulate matter are suspended in the water column of a sample. It is often employed as a measure of turbidity and water clarity; as clearer waters will have less suspended solids. The amount of TSS in a water sample also allows one to make inferences about nutrient loading from the watershed because TSS originates primarily from watershed inputs. For instance, a high concentration of nutrients in a sample with relatively low TSS is indicative of internal nutrient cycling as nutrients are present without other suspended solids from the watershed. However, samples with high nutrient concentrations and high TSS indicate that the nutrients likely came from the watershed at the same time that the TSS entered the water body.

Turbidity: Turbidity is another way of measuring water clarity, and is measured by the number of turbulating units (NTU). Values above 20 NTU are considered unclear water.

Specific Conductivity: This measures the concentration of positive and negative ions in the water, such as sodium, calcium, potassium, chloride, and carbonate. Every organism has a range of conductivity it can tolerate, and can vary from 100 to 2000 uS/cm although values around 1200 are considered optimal (State Water Resources Control Board, 2002).

General and Fecal Coliform: Fecal coliform including *E. coli* are toxic species of bacteria that are found in animal and human waste. Their presence is a serious issue because people can get very sick from ingesting or swimming in contaminated waters. General and fecal coliform results are displayed in terms of colony forming units (CFU) per 100 mL of water sampled. Any amount of fecal coliform is dangerous.

Zinc: Iron was included in the analysis because Fremont pond is in an urbanized watershed with a major highway. As car tires and brake pads wear, they leach zinc into the highway runoff which ultimately finds its way into rivers and ponds. The EPA recommends that zinc concentrations be below 0.12 mg/L in water and designates zinc as a 'priority pollutant' with extremely high ability to disrupt aquatic life (EPA, 2005).

Iron: Iron is the second major metal found in highway runoff, and enters runoff as a result of car chassis and engine rust. The New York water quality standard for iron is 0.3 mg/L, with higher concentrations not being immediately dangerous to human health but fostering oxygen deficit and in very high concentrations (>1 mg/L) contributing to fish kills and elevated concentrations of hazardous chemicals (NYSDEC, n.d.).

RESULTS

Figure 1. The watershed of Fremont pond is a mix of urban and forested land and is bisected by Route 9.

Watershed modelling

The land use of the Fremont watershed is displayed in Figure 2 below. The watershed consists predominately of developed land with some medium and high intensity urban neighborhoods. In terms of water quality, the high degree of development within the watershed highlights the importance of runoff and erosion to the nutrient subsidies of the pond, given that urban watersheds tend to have fertilized lawns and large amounts of impervious surfaces. The watershed has a high degree of canopy cover, with low canopy cover only in portions of roadways and neighborhoods. However, the lack of canopy cover near the Bellwood intersection is disconcerting because it receives runoff from route 9, the details of which are discussed with the text accompanying Figures 5 and 6.

Soil characteristics are incredibly important to water quality because erosion and runoff carry soil into ponds and lakes where nutrients and other chemicals can be released. As such, the propensity for soils in a watershed to foster or resist erosion is important in determining how the soil of given localities will affect water quality in ponds. There are a few metrics that are used to understand soil erodibility, including the K factor, particle size distribution, and the wind erodibility index. The K factor ranges from 0.02 to 0.69, with higher values representing more erodible soil. It is calculated based upon the soil type, depth to bedrock, soil drainage and permeability, and soil texture and is a vector to understand the susceptibility of soil to sheet and rill erosion. The particle size distribution is also a metric of soil erodibility because coarser sediments drain more water and thus erode more readily than do finer sediments. As such, soils with a higher sand content are likely to contribute more sediment and thus nutrients and pollutants to surrounding waterbodies. Finally, the wind erodibility index is used to calculate the total number of tons of soil per acre that will be mobilized due to wind erosion in a given year.

Soil characteristics of the watershed are displayed in Table 1 below, with symbol names matching those in Figure 4. The soil analyses demonstrate that a significant portion of the Fremont watershed has high sand content and is very susceptible to wind erosion. Additionally, the north-eastern portion of the riparian zone of Fremont Pond is Pompton silt loam, a soil type which is extremely prone to erosion. Ultimately, stormwater runoff management and erosion control need to be integral in the management of the Fremont watershed and specific attention should be given to mitigating the impacts of the neighborhoods proximal to the pond.

Table 1. Soil characteristics of the Fremont watershed that directly relate to water quality (Web Soil Survey, n.d.).

Symbol	Name	% Watershed	K Factor	% sand	Wind Erosion (tons/acre year)
ClF	Charlton loam	1.7	0.32	48.2	56
CrC	Charlton-Chatfield complex, rolling	15.2	0.32	48.2	56
CsD	Chatfield-Charlton complex, hilly	6.9	0.24	44.2	56
CtC	Chatfield-Hollis-Rock outcrop complex, rolling	1.5		68.1	
CuD	Chatfield-Hollis-Rock outcrop complex, hilly	6.4	0.17	68.1	
Ff	Fluvaquents-Udifluvents complex	0.6	0.32	30.4	48
Fr	fredon silt loam	0.1	0.28	34.3	56
HrF	Hollis-Rock utcrop complex	1.8	0.17	68.1	86
KnB	Knickerbocker fine sandy loam 2-8% slope	10	0.17	64.6	86
KnC	Knickerbocker fine sandy loam 8-15% slope	0.1		64.6	86
Pw	Pompton silt loam	7.5	0.37	30.7	56
RhB	Riverhead loam, 3-8% slope	6.2	0.28	52.7	56
RhE	Riverhead loam, 25-50% slope	3.5	0.28	52.7	56
Sh	Sun loam	2.2	0.32	45.3	56
SuB	Sutton loam	0.7	0.24	47.9	56
Ub	Udorthents, smoothed	0.5	0.2	43.6	48
Uc	Udorthents, wet substratum	2.9	0.17	43.6	48
UhC	Urban land-Charlton complex, 8-15% slope	6.4			
UlC	Urban land-Charlton-Chatfield Complex	4.7			
UrB	Urban land-Ridgebury complex	2.5			
UvB	Urban land-Riverhead complex	16.4			

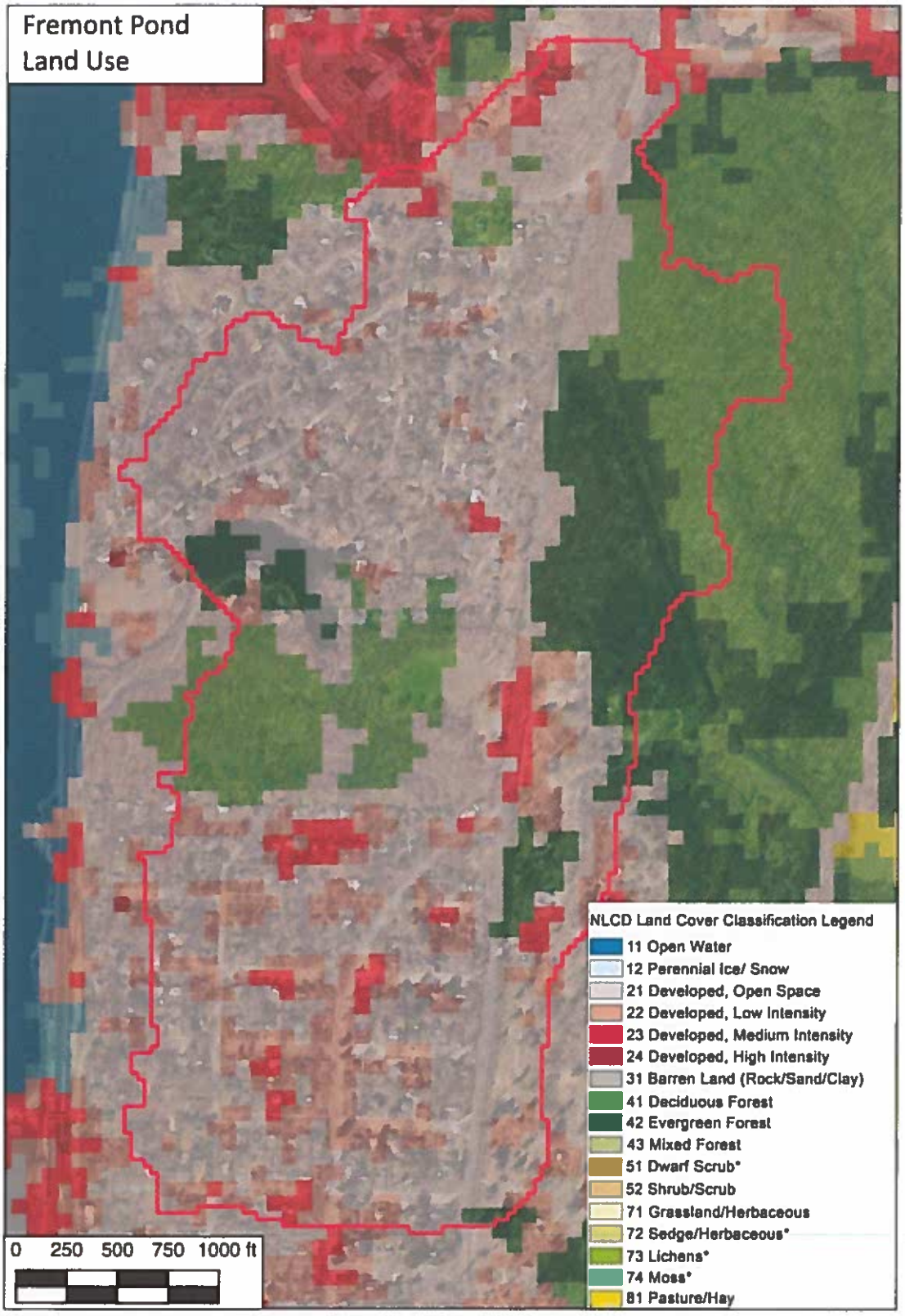


Figure 2. Land use of the Fremont watershed (NLCD, 2011).

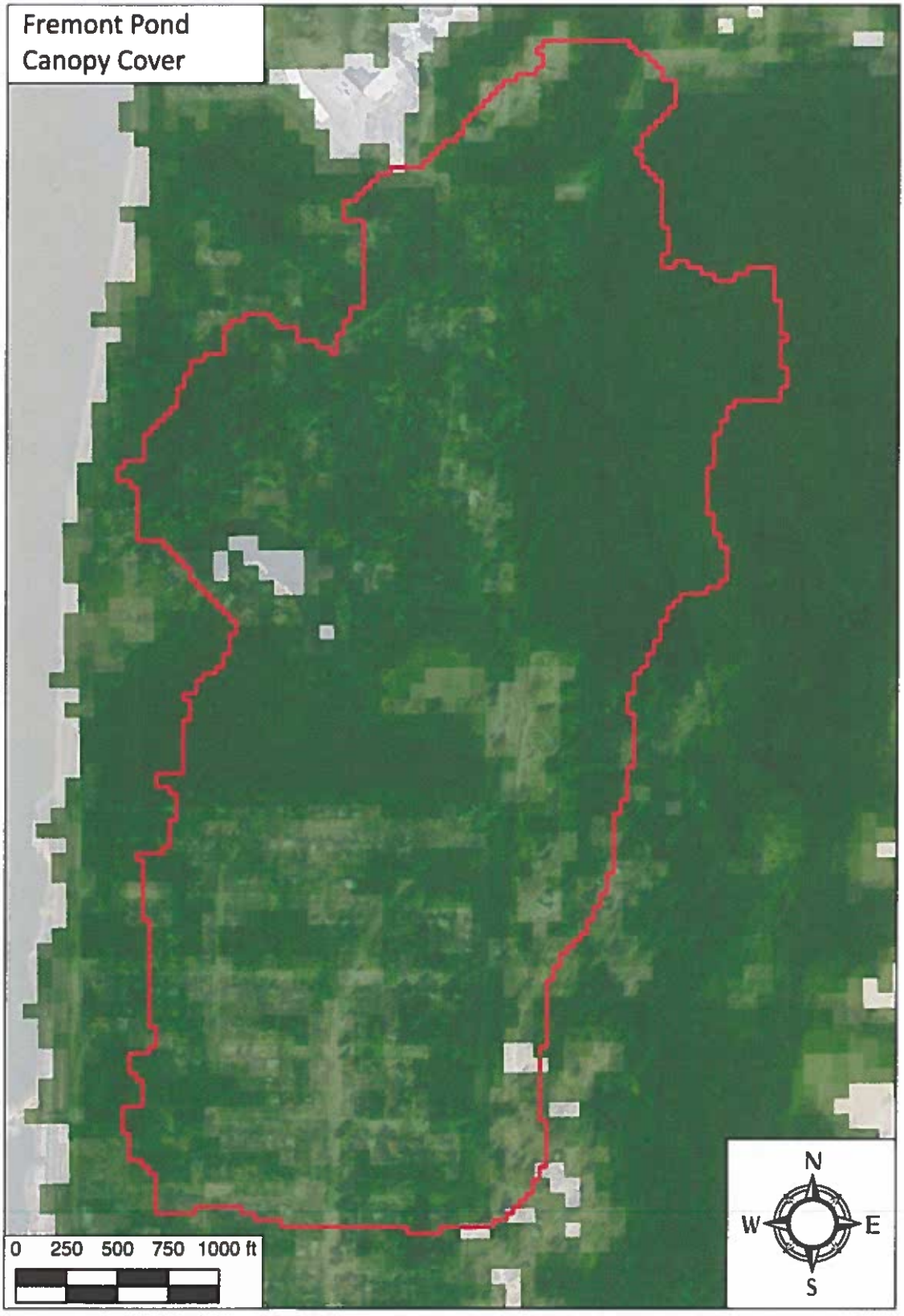


Figure 3. Canopy cover of the Fremont watershed, greener areas have more trees (NLCD, 2011).

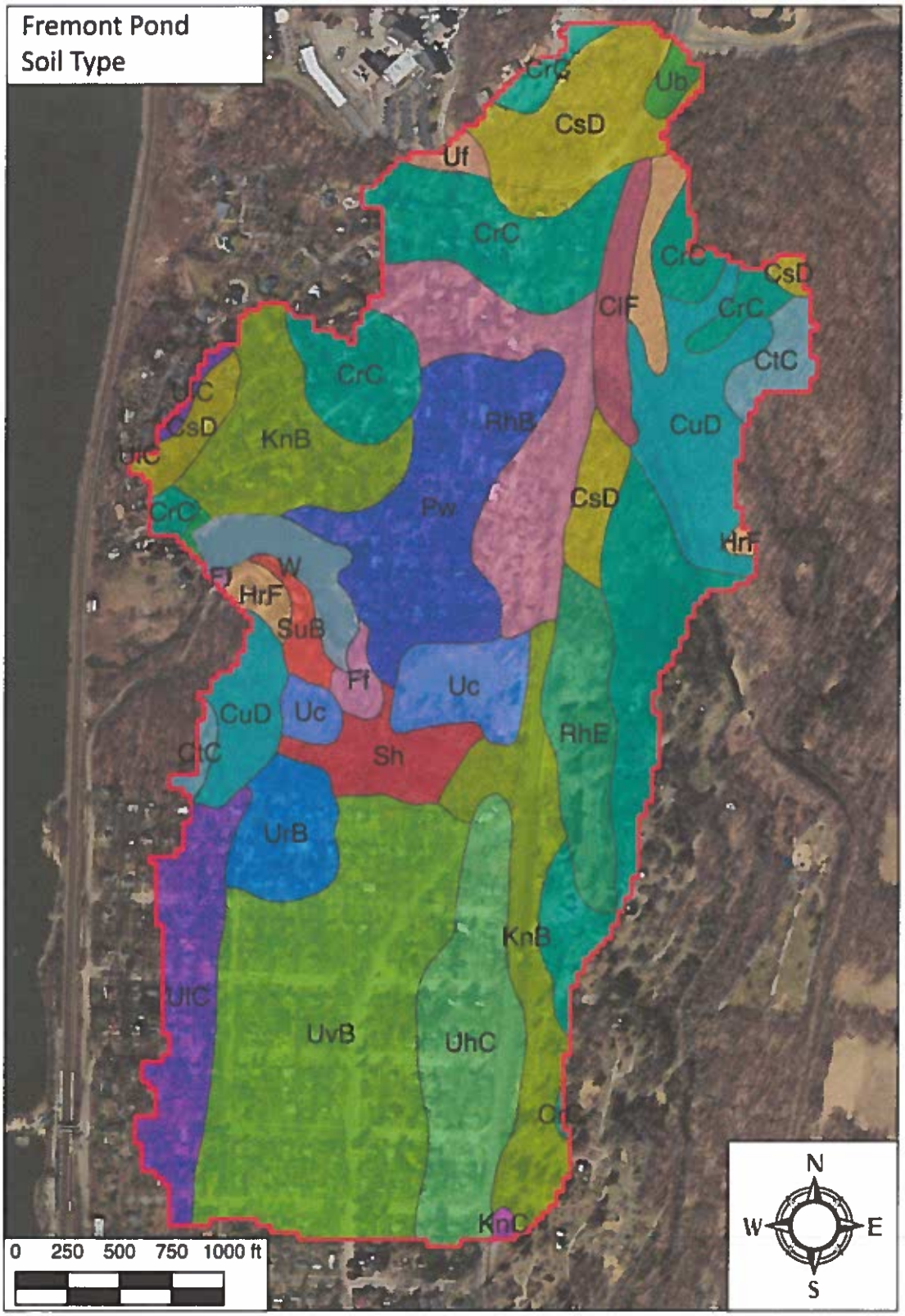


Figure 4. Soil map of the Fremont watershed, characteristics for the abbreviated soil types can be found in Table 1.

The map below displays the tributaries which bring water directly into Fremont pond, while Figure 7 shows accumulation pathways by which runoff within the Fremont watershed enters the pond. Fremont pond receives the bulk of its allocthonous nutrients from Route 9, especially since there is a seasonal stream that captures runoff from the highway (See Fig. 6). Figure 5 shows the side of the road near where the runoff becomes a gulley and shows high amounts of soil erosion. The pond also receives runoff from Route 9 via Hemlock Drive and Fremont Road which only further inundate the pond with storm water runoff. There is also a strong flow path directly across Route 9 from the cemetery which likely carries much of the runoff from the northern portions of the cemetery into the pond. The neighborhoods in the southern portion of the watershed are also likely to contribute nutrients because they are directly within flow accumulation pathways and have large, well maintained lawns.

Figure 5. Erosion on the side of Route 9.

Figure 6. Tributaries of Heatherdell pond, the eastern most one receives runoff from Route 9.

Figure 7. Flow accumulation of the Heatherdell watershed.

Figure 8. Hazardous waste and septic systems in the Heatherdell watershed.

Field sampling and analysis

Figure 9. Locations of water samples taken July 9th, 2016.

Fremont pond is inundated with nutrient loads that greatly exceed federal regulations and EPA standards. All results for nutrient and metal analysis are presented in Table 2 below. The average concentration of nitrate within the pond was 2.24 mg/L NO_3-N, well above the state water quality standard of 0.1 mg/L (NYSDEC, n.d.). Phosphate concentrations averaged 0.22 mg/L, well above the state standard of 0.02 mg/L (NYSDEC Clean Lakes Assessment, n.d.). The overabundance of both nitrate and phosphate suggest abnormal nutrient loading from the watershed.

We can conclude that external nutrient subsidies are the primary driving factor of the observed nutrient concentrations because the nitrate and phosphate concentrations are highly variable within the pond, increasing closer to the inflows (see Figures 10 and 11). However, nitrate and phosphate remained at close to an order of magnitude higher concentrations than the state water quality standards at all sampling locations within the pond, suggesting that while nutrient loading from the watershed is making matters worse, reductions in nutrient loading may not increase water quality because of internal nutrient cycling. As such, any remediation efforts need to consider both the reduction of nutrient loading and the reduction of the nutrients already present in the pond.

Nitrite was present but at small amounts, averaging 0.01 mg/L. Such a small amount of NO_2^- suggests that the water body does not have an excess of ammonia due to its location in the nitrogen cycle. Indeed, the ammonia concentration was 0.02 mg/L at both samples 2 and 8. While the NO_2^- and NH_3 concentrations suggest good water quality, it is the phosphate and nitrate concentrations that drive eutrophication in Fremont pond.

Iron concentrations were highest near the regions receiving runoff from Route 9 (samples 10 and 1), and lowest towards the western portion of the pond. Overall, iron concentrations averaged 0.38 mg/L, but ranged from 0.5 mg/L where highway runoff enters to 0.12 on the other end of the pond. Zinc was present at nearly an order of magnitude higher concentrations than the EPA water quality guidelines (0.12 mg/L) averaging 1.03 mg/L. In a similar manner to iron, zinc concentrations were higher in the portion of the pond receiving runoff from Route 9 (1.14 mg/L) than portions farther away (0.92 mg/L). From these observations it is clear that the pond is receiving metal pollution from automobile parts leaching into storm water runoff along Route 9.

Table 2. Results for nutrient and metal analysis of samples taken July 9th 2016.

Sample	NO_3-N mg/L	PO_4 mg/L	NO_2-N mg/L	Zinc mg/L	NH_3-N mg/L	Fe mg/L
1	2.5	0.31	0.014	1.14	0.02	0.49
2	2.8	0.25	0.015			0.47
3	2.6	0.19	0.010			0.40
4	2.6	0.29	0.006			0.45
5	2.5	0.31	0.009			0.40
6	1.9	0.18	0.010	0.92	0.02	0.38
7	2.1	0.13	0.007			0.34
8	1.7	0.20	0.008			0.12
9	1.8	0.19	0.007			0.28
10	1.9	0.18	0.007			0.50

The results for turbidity, pH, specific conductivity, DO and TSS are displayed in Table 3. Turbidity and TSS were much higher near samples 1 and 10, where runoff and overland flow enters the pond. Based upon TSS concentrations and the volume of the lake, there is an estimated 771,000 kg of sediment suspended in the pond. The relationship between TSS and nutrient levels is clear, with TSS being higher in samples that had more nutrients. This relationship corroborates the conclusion that external nutrient loading is driving the observed nutrient patterns. Specific conductivity averaged 601 uS/cm, which is considerably low for a freshwater pond. The pond exhibits healthy pH for a freshwater body, but has extremely low levels of dissolved oxygen with levels being lowest near where water enters the pond.

Table 3. Water quality results for non-chemical analyses.

Sample	Turbidity (NTU)	pH	SpCond (uS/cm)	DO (mg/L)	TSS (mg/L)
1	26.3	7.29	0.636	1	46.622
2	30.5	7.38	0.537	0.04	58.97
3	18.3	7.51	0.565	0.47	23.102
4	10.5	7.54	0.593	2.91	0.17
5	7.5	7.74	0.645	3	1.65
6	2.1	7.37	0.757	2.76	1.15
7	9.2	7.42	0.632	2.57	2.55
8	7.5	7.55	0.655	2	1.05
9	37.9	7.64	0.639	0.58	80.726
10	25.5	7.8	0.558	0.46	44.27

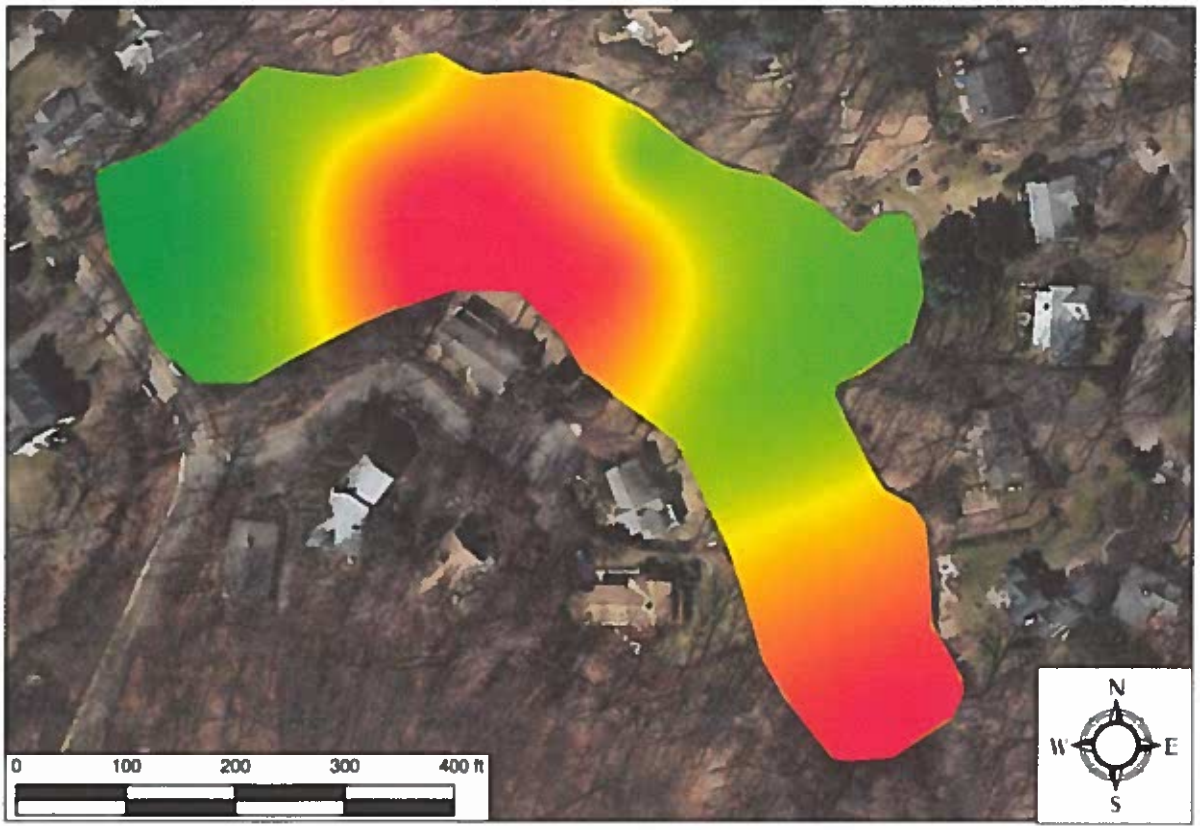


Figure 10. Spline interpolation of phosphate concentrations in Fremont Pond. Red indicates high concentrations of phosphate. Note that green areas are still beyond EPA guidelines, map is intended to show the influx of phosphate from the southern inflow.

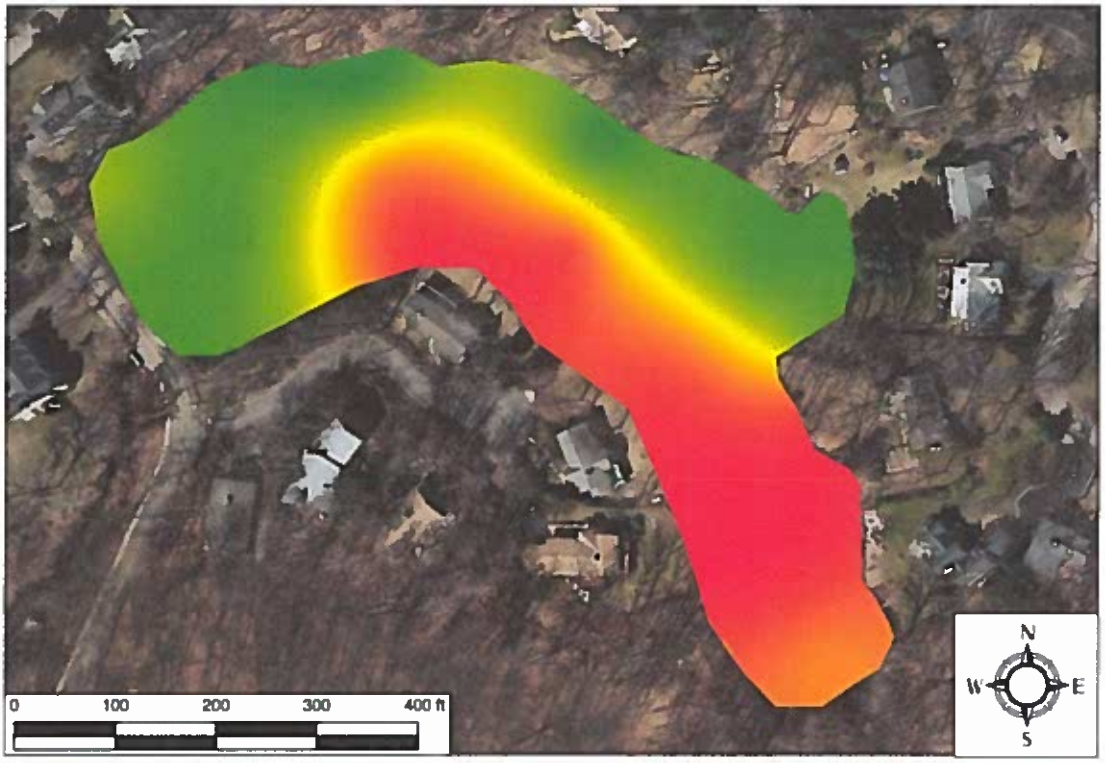


Figure 11. Spline interpolation of nitrate concentrations in Fremont Pond. Red indicates high concentrations. Note that the southern portions of the watershed contribute most of the NO_3.

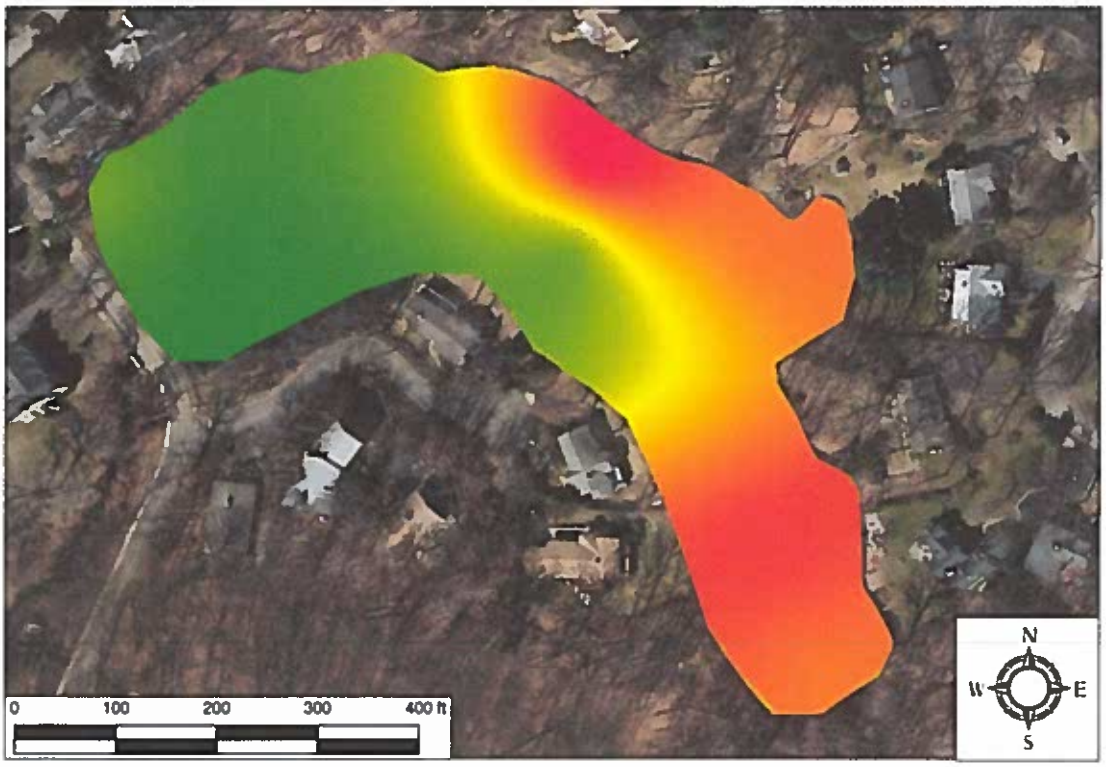


Figure 12. Spline interpolation of turbidity in Fremont Pond. Red indicates turbid water.

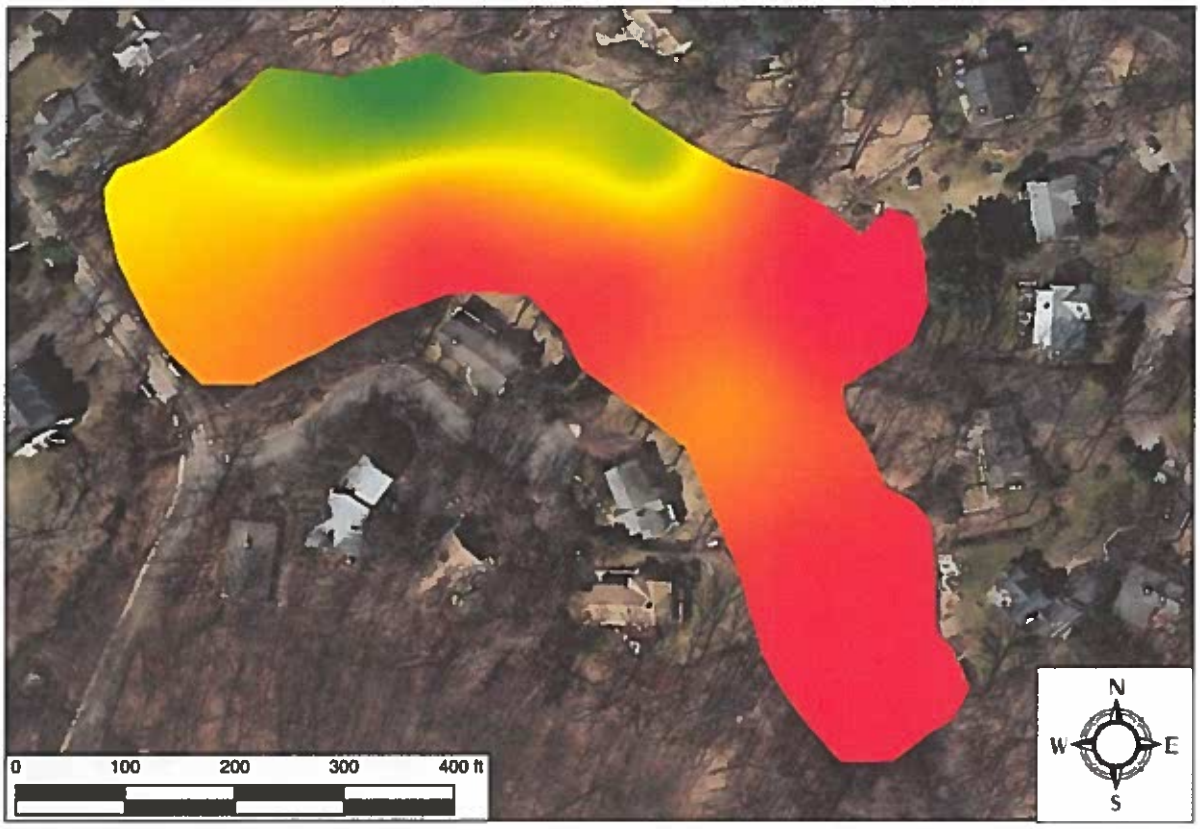


Figure 13. Spline interpolation of iron concentrations in Fremont Pond. Red indicates high concentrations of iron. Note that iron concentrations are highest near the areas that receive inflow from the watershed.

Bacterial concentrations in Fremont pond were found to be well beyond the EPA limit for safe contact, at 24,000 CFU/100 mL near the inflow and 2,800 CFU/100 mL at sample site 8 (EPA, 2005),. Samples with high general coliform bacteria concentrations were proximal to the portions of Fremont pond that receive runoff from the cemetery and Route 9. Regions of Fremont pond that had higher than average nutrient levels also had extremely high amounts of general coliform bacteria. This suggests that portions of the watershed which create high bacterial concentrations are also significant nutrient sources. The Sleepy Hollow cemetery is likely one such source given that cemeteries are often high in nutrients and coliform bacteria. For example, Fineza et al. (2014) sampled groundwater quality in cemeteries and found that they are significant exporters of general and fecal coliform bacteria and nutrients to the watershed. This makes sense given that 60% of human biomass is decomposed and released into groundwater once buried and that decomposing biomass is a host to many unhealthy bacteria.

While sampling bacteria at one point in time is not confirmative of larger trends, it is likely that Fremont pond is receiving a large bacterial and nutrient subsidy from the nearby cemetery. The lack of fecal coliform in the water and overabundance of general coliform indicates that the

general coliform is coming from non-septic sources. Runoff from Route 9 may also contribute coliform to the water, as general coliform tends to be higher in watersheds with higher stormwater runoff from highways (Gaffield et al., 2003). General coliform in itself is not harmful to the environment, however it is an indicator of water quality in that viruses and other harmful bacteria tend to also be present in samples containing high coliform. Therefore, it is likely that Fremont pond is receiving harmful bacteria from its watershed through the southern inflow near where sample one was taken (see Figure 9).

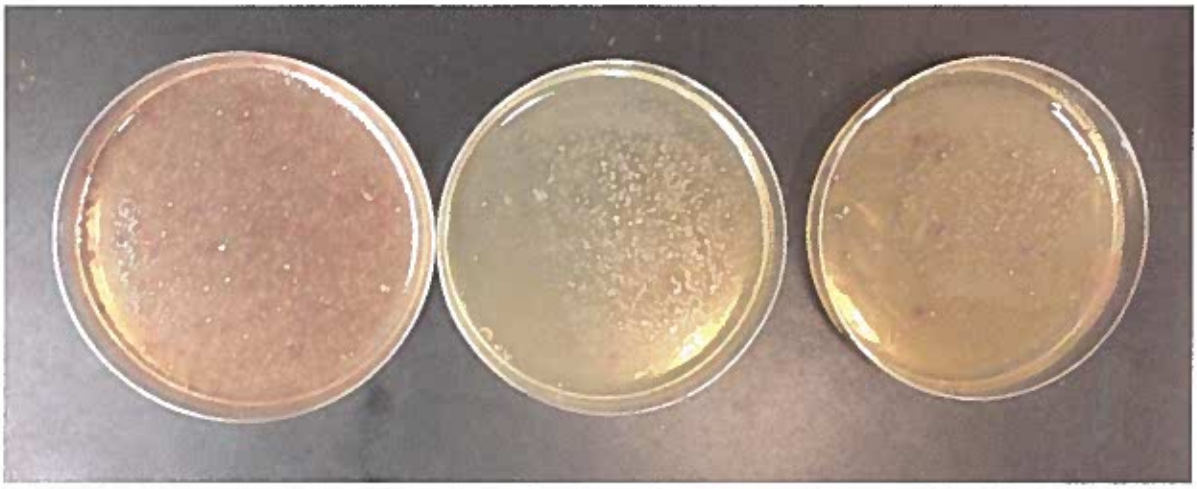


Figure 14. General coliform count for a 2 ml sample of water from sites 2 (left), 4 (middle), and 8 (right). Each pink dot represents a colony forming unit (CFU) of general coliform. Note the vast differences in abundance of coliform between samples close to the inflow receiving runoff from the cemetery (left) and samples farther away from the inflow.

SUMMARY AND RECOMMENDATIONS

The persistent algal blooms in Fremont pond are driven by the excess of nitrogen and phosphorus in the water column, both of which are present at more than an order of magnitude higher concentrations than the state water quality standards. External nutrient loading is likely more of a contributor to algal blooms than is internal nutrient cycling in Fremont pond due to the spatial heterogeneity of nutrients and bacteria within the pond. However, the existence of abnormally high nutrient levels in all portions of the pond highlight a significant degree of internal nutrient cycling which must be addressed in tandem with watershed-level reductions in nutrient loading. The study has identified significant sources of external nutrient loading including Route 9, residential lawns, and the proximal cemetery. This study also concluded that Fremont pond receives harmful levels of iron and zinc from the watershed, has high amounts of general coliform and very turbid waters near both inflows. Furthermore, at the sampling time the dissolved oxygen levels were insufficient to support aquatic life. After analysis of the water quality data gathered, LIFE Inc. makes the following recommendations to improve the water quality of Fremont pond.

Manage storm water runoff from Route 9

Fremont pond receives a large amount of metals and nutrients in storm water runoff from Route 9. Presently, the roadside is designed to encourage stormwater runoff into the flow paths which enter Fremont pond, with no curb, little vegetation in the portions where runoff leaves the road, and a moderate slope towards the pond. These conditions foster erosion along the sides of the highway, which not only brings pollutants from automobiles into the pond but also mobilizes soil along the sides of the road and transports it as well. LIFE Inc. recommends the construction of a bioswale along the side of Route 9. Even though there is a storm water retention pond proximal to Fremont Pond, when retention ponds are used as the sole buffer against storm water runoff they can often be a net source of nutrients and metals to ponds during rain events (Booth et al., 2002). The sampled water quality data indicate that the retention pond is not adequately mitigating the loading of nutrients and metals into the pond. It is likely that during intense storm events the retention pond is unable to deal with all of the runoff from Route 9 and overflows, exporting some of its sediment (filled with metals from previous storms) into the pond. Furthermore, the retention pond seems to be a single-stage pond, which are known to vary in their ability to reduce nutrient loadings in rainfall after extended dry periods (Emerson et al., 2005).

Figure 15. Gullying of the runoff from Route 9 forms the major tributary of Fremont pond. The severe gullying is likely a tremendous source of sediment and nutrients to Fremont pond. Source: Google Maps

The construction of a bioswale along the primary flow path and seasonal tributary of Fremont pond directly adjacent to Route 9 would, in combination with the current retention pond, better mitigate storm water by treating it closer to its source than its outlet. This would help reduce the gullying that increases sediment load into the current retention pond. This location is prime for a bioswale because it currently is an unattractive site seen while driving through Sleepy Hollow on Route 9. The construction of a green, environmentally friendly bioswale here would increase storm water awareness of commuters as well as increase the image of Sleepy Hollow as an ecofriendly city. Alternatively, the construction of a forebay prior to the existing storm water retention pond could increase its effectiveness by reducing the impact of large rain events after dry periods.

Enact regulations on lawn watering and fertilizer application

Due to the strong flow accumulation pathways (Figure 7) and seasonal tributaries (Figure 6) within the southern residential portions of the watershed that bring water into Heatherdell pond, as well as the high degree of erodibility (Figure 4) in the northern neighborhoods, the pond likely receives an abnormal amount of household runoff. Furthermore, the interpolations (e.g. Figure 8) demonstrate that nitrate is entering the watershed from the neighborhoods in the southern portions of the watershed, where much of the water in Fremont pond originates (See Figure 3). While there is little way to concretely determine the effects of lawn watering and fertilizer applications specific to Heatherdell pond in the framework of a water quality study, previous research has demonstrated their significant deleterious impacts on water quality. For instance, the USGS found that fertilized lakeshore lawns contributed 30% more ammonia and 48% more phosphate to lakes than do unfertilized lawns, strongly increasing the nutrient load into lakes and exacerbating eutrophication (USGS Water Resources Investigations, 2002). These findings are consistent with our visual observations of fertilized lawns within significant areas of runoff and erosion along with the high degree of eutrophication seen in Fremont pond.

Other counties in the state have passed legislation which reduce fertilizer applications on lawns in order to mitigate their negative effects on water quality. For instance, Suffolk County (41-2007) law prohibits the application of fertilizers between November 1 and April 1, during which nitrate leaching is the highest (Bellone and Minieri, 2012). Suffolk County imposes a $1,000 dollar fine on households that use fertilizers during the prohibited time, and have developed brochures, signs, best management practices, and presentations about how fertilizers and lawn watering can harm water quality. Similar practices within the Heatherdell pond watershed could reduce the annual nutrient loading into the pond and over the long term reduce algal blooms and nutrient concentrations.

Investigate and reduce nutrient loading from the cemetery

We suggest that the City of Sleepy Hollow investigate runoff originating in the cemetery due to the proximity of Fremont pond to the Sleepy Hollow Cemetery and the lack of barriers between the cemetery and Route 9. To do so, we suggest that fecal coliform, *E. coli*, and phosphate concentrations in runoff from the cemetery be monitored to determine whether the cemetery is harming water quality. At present conditions, the cemetery is very visible from the highway because it is popular destination. While this is beneficial to the cemetery, the planting of trees or even a rain garden could reduce the amount of runoff that Fremont pond receives from the cemetery by creating a physical barrier between the cemetery and the flow paths entering Fremont pond.

Consider means to reduce internal nutrient cycling

If external nutrient loading is reduced via fertilizer legislation, storm water management, or investigations into runoff from the cemetery and water quality does not positively respond, it may be necessary to also reduce internal nutrient cycling within the pond. This can be done either via dredging or winter drawdown. The benefit of the former is that it will remove all of the nutrients that have deposited in the lake bed and essentially reset the nutrient conditions of the lake. However, it is often cost-prohibitive for smaller lakes, and one has to find a location to put the hazardous sediment once it is removed. A winter drawdown is more cost efficient but may be less effective overall at reducing nutrient levels. Drawdowns work by removing all the water from the lake, in doing so all dissolved nutrients and metals are removed. When new water is added, some of the nutrients and metals in the sediment will be put back into the water column, and the total amount of nutrients and metals in the system will decrease. However, dredging or winter drawdowns will not be effective if nutrient loading from the watershed is not addressed first.

REFERENCES

Behar, S. Testing the Waters: Chemical and Physical Vital Signs of a River. Montpelier, VT: River Watch Network, 1997. ISBN-0-782-3492-3

Bellone, S. And Minieri, J., 2012. Local Law No. 41-2007 to Reduce Nitrogen Pollution by Reducing Use of Fertilizer in Suffolk County. Available online at http://www.suffolkcountyny.gov/Portals/0/environmentandenergy/Annual%20Report%202011-2012.pdf

Booth, D.B., D. Hartley, and R. Jackson, 2002. Forest Cover, Impervious-Surface Area, and the Mitigation of Stormwater Impacts. Journal of the American Water Resources Association 38:835-846.

Fineza, A.G., Marques, E.G., Bastos, R., and L.S. Betim, 2014. Impacts on Groundwater Quality Within a Cemetery Area in Southest Brazil. Soils and Rocks 37(2):161.

Garn, H. S., & Geological Survey (U.S.). 2002. Effects of lawn fertilizer on nutrient concentration in runoff from lakeshore lawns, Lauderdale Lakes, Wisconsin.

Emerson, C.H., C. Welty, and R.G. Traver, 2005. Watershed-Scale Evaluation of a System of Storm Water Detention Basins. Journal of Hydrologic Engineering 10:237-242.

New York State Department of Environmental Conservation, n.d. Nitrate Fact Sheet. Retrieved from http://www.dec.ny.gov/docs/water_pdf/cslaplkpara.pdf

New York State Department of Environmental Conservation, n.d. Iron Fact Sheet. Retrieved from http://www.dec.ny.gov/docs/water_pdf/cslaplkpara.pdf

New York State Department of Environmental Conservation, n.d. Phosphorus Fact Sheet. Retrieved from http://www.dec.ny.gov/docs/water_pdf/cslaplkpara.pdf

New York State Department of Environmental Conservation, n.d. New York State Clean Lakes Assessment. Retrieved from http://www.dec.ny.gov/docs/water_pdf/305blakes10.pdf

Richardson, J. S., Y. Zhang, and L. B. Marczak. 2010. Resource subsidies across the land freshwater interface and responses in recipient communities. River Research and Applications 26:55–66.

Schwede, D.B. and G.G. Lear, 2014. A novel hybrid approach for estimating total deposition in the United States, Atmospheric Environment, 92, 207-220.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/.

The Clean Water Team Guidance Compendium for Watershed Monitoring and Assessment State Water Resources Control Board FS-3.1.3.0(EC)V2e 4/27/2004

United States Environmental Protection Agency, 1988. Water Quality Standards Criteria Summaries: A Compilation of State/Federal Criteria.

USEPA National Recommended Water Quality Criteria for Freshwater and Human Consumption of Water: 2002, 2005. The Environmental Science of Drinking Water, 237-239. doi:10.1016/b978-075067876-6/50011-7

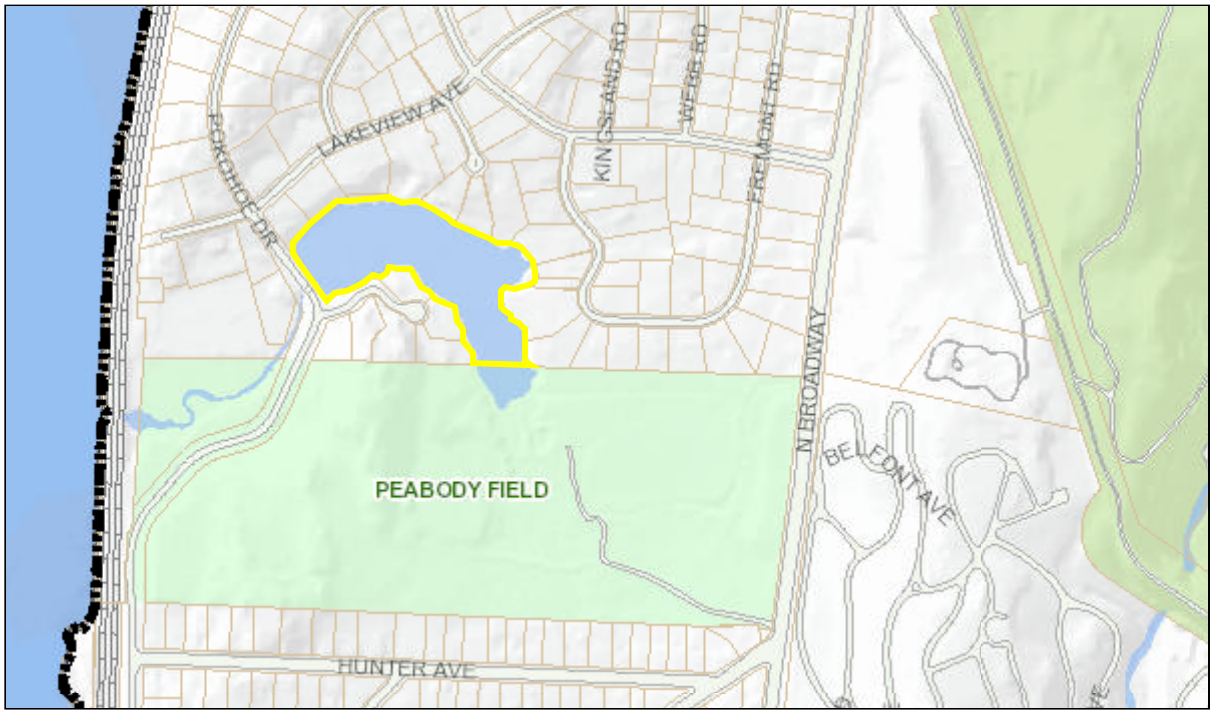
USEPA National Recommended Water Quality Criteria: 2004, 2005. Available online at https://www.epa.gov/sites/production/files/2015-06/documents/nrwqc-2004.pdf

Appendix B:
Mapping

Tax Parcel Maps

Address: POKAHOE DR

Print Key: 01/110.15-1-71 **SBL:** 110015000107100000000



Disclaimer:
This tax parcel map is provided as a public service to Westchester County residents for general information and planning purposes only, and should not be relied upon as a sole informational source. The County of Westchester hereby disclaims any liability from the use of this GIS mapping system by any person or entity. Tax parcel boundaries represent approximate property line location and should NOT be interpreted as or used in lieu of a survey or property boundary description. Property descriptions must be obtained from surveys or deeds. For more information please contact the assessor's office of the municipality.


Sleepy Hollow
HEMLOCK DR
Owned by Village of Sleepy Hollow
Tax ID 01/110.15-1-71
ROKAHOE DR
LAKE SHORE CLOS
Private Property Owner
RIVERSIDE DR
Owned by the Town of Mount Pleasant
Tax ID 01/110.15-1-79
Owned by UFSD of the Tarrytowns - Board of Education
Tax ID 01/110.15-1-78
BELFONT AVE
HUNTER AVE
BELLWOOD AVE