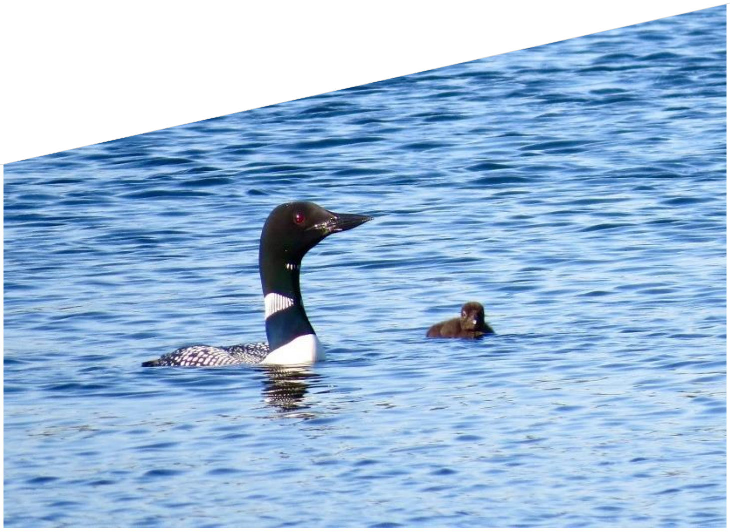
GEORGES POND WATERSHED-BASED MANAGEMENT PLAN (2020-2029)



Georges Pond Association

Preserve • Protect • Promote

JANUARY 2020

GEORGES POND
WATERSHED-BASED MANAGEMENT PLAN

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COMMONLY USED ACRONYMS

The following are used throughout this document:

BMP	Best Management Practice
Chl-a	Chlorophyll-a
DO	Dissolved Oxygen
GPA	Georges Pond Association
LLRM	Lake Loading Response Model
Maine DEP	Maine Department of Environmental Protection
NPS	Nonpoint Source (pollution)
NRCS	Natural Resources Conservation Service
ppb	Parts Per Billion
ppm	Parts Per Million
SDT	Secchi Disk Transparency
TAC	Technical Advisory Committee
TP / P	Total Phosphorus / Phosphorus
US EPA	United States Environmental Protection Agency
UMaine	University of Maine
WBMP	Watershed-Based Management Plan

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GEORGES POND WATERSHED-BASED MANAGEMENT PLAN (2020-2029)

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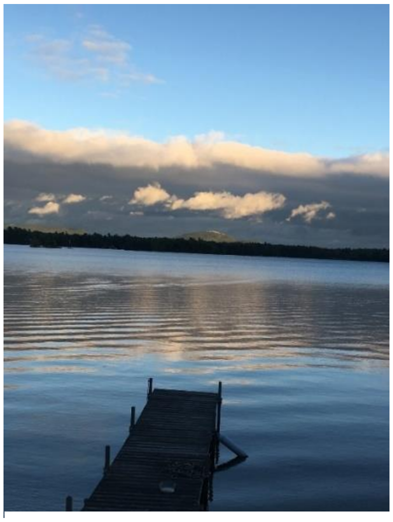
PURPOSE

The Georges Pond Watershed-Based Management Plan (WBMP) describes the water quality conditions, watershed characteristics, and steps that can be taken to restore the lake's water quality. The plan provides revised strategies and an updated schedule for the next 10-year planning period (2020 - 2029), establishes water quality goals and objectives, and outlines the actions needed to reach them. This plan outlines strategies to:

1. Address the internal phosphorus load;
2. Ramp up water quality protection efforts throughout the watershed to mitigate nonpoint source (NPS) pollution; and
3. Monitor improvements in Georges Pond's water quality.

THE LAKE & WATERSHED

Georges Pond (MIDAS 4406)[1] is a 358-acre Great Pond (Class GPA)[2] located in Franklin, Maine. Georges Pond is on the Maine DEP's Nonpoint Priority Watersheds List (because it is on the ME DEP "watch list") due to changes in the water quality in the past decade – and specifically because of nuisance algal blooms which began in 2012.



Southern view on Georges Pond. Source: GPA

Water enters Georges Pond from multiple intermittent flowages and a small unnamed brook, and drains to the lake's only outlet, Georges Brook, that flows north into Webb Pond located in the Town of Eastbrook. Georges Pond has a relatively low flushing rate (0.45 flushes/year), and it is relatively shallow (max depth of 45 ft, mean depth of 14 ft).

The watershed of Georges Pond includes one square mile of mixed forestland, wetlands, agriculture, gravel mining, and residential development- especially along the shoreline. A popular public beach and boat ramp are located at the northern end of the lake. The majority of the non-lake watershed is forested (53%), consisting mostly of mixed forest, followed by wetlands (19%),[3] developed land (15%), open green spaces and meadows (7%), and agriculture (6%). Logging and forestry accounts for approximately 8% of the forested area. Residential development accounts for the largest percentage

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[1] The unique 4-digit code assigned to a lake.

[2] Defined by MRSA Title 38 §465-A, Standards for Classification of Lakes and Ponds. Class GPA is the sole classification of great ponds (>10 acres) and natural lakes and ponds <10 acres in size. Class GPA waters must have a stable or decreasing trophic state, subject only to natural fluctuations, and must be free of culturally induced algal blooms that impair their use and enjoyment.

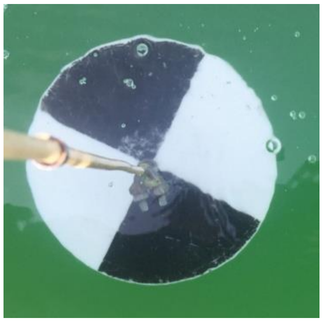
[3] The total wetland area does not include the area of Georges Pond.

of the developed urban land cover category at 10%, with gravel operations and roads together making up 5%.

The soils within the Georges Pond watershed are a concern for phosphorus loading into the lake. Approximately 40% of the watershed land area is Hermon and Colton soil series, which consists of very deep, excessively-drained gravelly and sandy loam soils with rapid permeability- making them poorly suited for septic system leach fields due to potential for groundwater contamination. Pockets of fine sandy and silt loam soils (Brayton and Dixfield soil series) are intermixed with gravelly and sandy loams throughout the watershed. Brayton and Dixfield soil series make up 14% and 13% of the watershed, respectively and exhibit seasonally high-water tables (1 – 1.5 ft below the surface), also presenting severe limitations for uses like wastewater system leach fields.

THE PROBLEM

Georges Pond's water quality is considered below average, and the potential for nuisance algal blooms is high as a result of low levels of dissolved oxygen in deep areas of the lake, and internal recycling of phosphorus. Water quality data have been collected by Maine DEP and volunteer lake monitors intermittently since 1977 at the deep hole monitoring station. This includes 18 years of data collection over the 41-year monitoring period. Monitoring has become more frequent and consistent since the cyanobacteria bloom in 2012.



Georges Pond has bloomed 4 of the last 8 years resulting in low transparency readings that do not meet State water quality standards. (Photo: mtlakebook.org)

Data have been collected every year for the past nine years (2011-2019), whereas only nine years of data exist between 1977 and 2004. In 2018 Georges Pond was considered for the 303(d) list by the Maine Department of Environmental Protection (Maine DEP) for failure to meet State water quality standards as a result of low Secchi disk transparency (SDT) readings and presence of nuisance blue-green algal blooms (a.k.a. cyanobacteria). However, the lake was not included on the 2018 303(d) list because it has not met the minimum criteria for the number of years with documented algal blooms.[4] Georges Pond has experienced recurring algal blooms since 2012, blooming four of the last eight years resulting in SDT readings well below the state minimum standard of 2 m.

Maine statutory water quality goal: All Maine lakes are free of nuisance algal blooms and have stable or improving water and habitat quality.

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[4] Georges Pond only has 8 years of bloom data (2012 - 2019) blooming 4 years in the last 8 years. To be listed by Maine DEP for algal blooms, the pond must bloom 6 of the last 10 years (Correspondence with Linda Bacon, Maine DEP).

Average annual SDT prior to 2012 ranged from 3.7 m to 5.5 m, with an average of 4.6 m. More recent SDT data between 2012 and 2019 ranged from 1.4 m to 4.6 m with an average annual mean of 3.1 m; a decrease in clarity of 1.5 m compared with the pre-2012 average.

Annual average epilimnetic TP concentrations from data collected across five years between 1979 and 2004 (1979, 1982, 1983, 1999, and 2004) ranged from 8 ppb to 15 ppb with an annual average of 12 ppb. TP data collected in 2012, 2013, 2014, 2015, 2017 and 2018 show epilimnetic TP concentrations between 15 ppb and 36 ppb with an annual average concentration of 22 ppb – almost two times the pre-2012 annual average.

Blue-green algal bloom – Blue-green algae are actually a type of photosynthetic bacteria known as Cyanobacteria. The term 'bloom' is used to describe an accumulation of algal cells to a point where they discolor the water, form scums, produce unpleasant tastes and odors, effect fish populations, and reduce water quality. Decomposing algae can also cause depletion of oxygen and induce fish kills.

Chl-a has been variable with a direct correlation to algae production, remaining low until 2012, with three samples > 40 ppb that year. Chl-a was lower again in subsequent years, but there has been enough of an uptick in recent years from the historic values to cause a statistically significant upward trend in Chl-a concentrations in Georges Pond corresponding with the decrease in water clarity, increase in total phosphorus, and documented cyanobacteria blooms.

Phosphorus inputs from the internal load vary depending on where the theromocline sets up and how much of the lake is exposed to anoxia and for how long. Thermal stratification in Georges Pond is typically between 6 and 8 m, with anoxia occuring in even shallower water if mixing is not sufficient, as occurred in 2012 with anoxia as shallow as 4 m. The shallower the depth of anoxia, the greater the area of sediment available to release iron-bound phosphorus. It is likely that expanded exposure of sediment rich in iron-bound phoshorus to anoxia has led to an increased internal load that has promoted observed cyanobacteria blooms that varies by year depending on weather conditions. Monitoring data shows that Georges Pond experiences nuisance algal blooms that begin between August and September each year as a result of this internal load, which ranges from 36 – 105 kg P/yr depending on the depth of anoxia.[5] The conservative estimate of 105 kg was used to set water quality targets and be most protective of water quality, representing approximately 56% of the total phosphorus load.

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[5] The internal load is expected to range from as low as 10 kg P/yr to 126 kg P/yr based on calculations by WRS, Inc in 2019. For this plan, the range of 36 – 105 kg P/yr was used to represent the most frequently observed depth of anoxia that occurs in Georges Pond (>5 m - >7 m).

The external phosphorus load represents the difference between the total load and the internal load, or 84 kg/yr (44% of the total load). External sources of phosphorus include runoff from the watershed (32 kg/yr), septic systems (20 kg/yr), atmospheric deposition (22 kg/yr), and wildlife (10 kg/yr). Medium-density residential development on the shoreline makes up the greatest percent of developed land in the watershed.

Developed land makes up 22% of the land area in the watershed, but accounts for more than half of the total phosphorus load from the watershed. The density of development, and proximity of the development to the lake are significant factors in the amount of phosphorus being exported to the lake on an annual basis.

THE GOAL

A team of scientists and local stakeholders worked collaboratively over a one-year period to set a realistic water quality goal that would prevent the future occurrence of nuisance algal blooms in Georges Pond. An average phosphorus concentration of 10 ppb is a desirable target to improve the water quality in Georges Pond. This equates to a loading goal of 90 kg/yr. Reducing this load even further would provide a margin of safety for years of extreme heat or high precipitation, and be more protective of future development. Because there is little that can be done about atmospheric or wildlife inputs, the three other primary sources (internal load, septic systems and watershed runoff) must be addressed to achieve the loading reductions needed to make necessary improvements in water quality.

To meet the goal, the amount of phosphorus entering the lake will need to be reduced by 52% (98 kg P/yr). This represents 90% of the internal load and 10% of the external load from watershed runoff, over the next 10 years. A 90% reduction in internal loading is possible, and seen as the option with the greatest potential for success, but will not be enough to reach the target of 10 ppb without addressing the load from the watershed. Even with treatment of the internal load, it will build again over time in the absence of managing external sources.

GOAL

Georges Pond is free of Nuisance Algal Blooms

In-Lake P = 10 ppb
Annual P Load ~ 90 kg/yr

INTERNAL LOAD

Current: 105 kg/yr
Goal: 10.5 kg/yr
Reduction: 90% (95 kg/yr)
Project: Alum Treatment
Timeframe: 2020 - 2021

EXTERNAL LOAD

(Watershed Drainage)

Current: 32 kg/yr
Goal: 29 kg/yr
Reduction:10% (3 kg/yr)
Projects: 319, LakeSmart, Septics
Timeframe: 2020 - 2029

ACTIONS NEEDED TO ACHIEVE THE GOAL

The Georges Pond WBMP provides strategies for achieving the water quality goal. The loading analysis for Georges Pond weighed the pros and cons of different management options for treating the internal load (e.g. algaecides, dredging, oxygenation, and phopshorus inactivation). These recommendations are outlined in detail in the report and were presented to the Technical Advisory Committee (TAC) for review and feedback. The action plan was developed over a year-long planning period with input from both the TAC and the steering committee. The action plan represents solutions for improving water quality in Georges Pond based on the best available science.

The action plan is divided into six major objectives, along with the following load reductions and costs:

Planning Objective	Planning Action (2020-2029)	P Load Reduction Target	Cost
1	**Address the Internal P Load** (Alum Treatment)	95 kg/yr	$276,465
2	**Address the External P Load** (NPS Sites, Septics, LakeSmart, Education & Outreach)	3 kg/yr	$297,500
3	**Education, Outreach & communications** (public meetings, educational material distribution, websites and social media, & alum treatment community PR)	n/a	$4,000
4	**Prevent New Sources of NPS Pollution** (Land Conservation, Ordinances, Enforcement)	TBD	$3,500 - TBD
5	**Build Local Capacity** (Funding Plan, Steering Committee, Grant Writing)	n/a	$18,000
6	**Long-Term Monitoring & Assessment** (Baseline Monitoring, algal bloom tracking, etc.)	n/a	$126,500
	TOTAL	**98 kg/yr**	**$725,965**

Actions to address both the internal and external phosphorus load were designed to improve the water quality in Georges Pond, while simultaneously promoting communication between residents, the Town of Franklin, and watershed groups. The action plan outlines pollution reduction targets, responsible parties, potential funding sources, approximate costs, and an implementation schedule for each task within each of the five categories.

A diverse source of funding and a sustainable funding strategy is needed to fully fund planned implementation activities. A large portion of the estimated cost of implementing this plan will be needed in the first 1-2 years for the alum treatment. State and federal grants, towns, private landowners, and lake association members can all be called upon to address the external watershed load, and to support watershed implementation projects (319 grants), LakeSmart, and long-term monitoring. The funding strategy should be incorporated into this plan within the first year and be revisited on an annual basis.

MEASURING SUCCESS

Environmental, social and programmatic milestones were developed to reflect how well implementation activities are working and provides a means by which to track progress toward the established goals (Section 7). The steering committee will review the milestones on an annual basis to determine if progress is being made, and then determine if the watershed plan needs to be revised if the targets are not being met.

ADMINISTERING THE PLAN

The Georges Pond WBMP provides a framework for restoring the water quality in Georges Pond so that the lake no longer supports nuisance algal blooms. The plan will be led by the Georges Pond Association (GPA) with guidance and support from a watershed steering committee including the Maine DEP, Town of Franklin, Hancock County Soil & Water Conservation District, agricultural producers, and individual landowners. The formation of subcommittees that focus on the five main watershed action categories will result in more efficient implementation of the plan. The steering committee will need to communicate regularly, especially during the first 1-2 years to closely plan for and monitor the alum treatment.

INCORPORATING US EPA'S 9 ELEMENTS

The Georges Pond WBMP includes nine key planning elements to restore waters impaired by nonpoint source (NPS) pollution. These guidelines, set forth by the U.S. Environmental Protection Agency (US EPA), highlight important steps in protecting water quality for waterbodies impacted by NPS pollution, including specific recommendations for guiding future development, and strategies for reducing the cumulative impacts of NPS pollution on lake water quality. The nine required elements can be found in the following locations in this plan:

> **A. Identify Causes and Sources: Sections 1, 3, 4 and 5 and Appendix A** highlight current programs and research that have helped frame the internal loading problem (Section 1), water quality analyses that describe changes in the water quality and the effects of internal loading (Section 3), watershed loading (Section 4), and a summary known sources of NPS sites in the Georges Pond watershed (Section 5 and Appendix A). Both internal and external sources of pollution must be controlled to achieve load reductions estimated in this plan, as discussed in item (B) below.

B. Estimated Phosphorus Load Reductions Expected from Planned Management Measures described under (C) below: **Section 5 and 8** provide an overview of target water quality and phosphorus reduction targets to reduce annual phosphorus loading to Georges Pond from both internal and external sources over the next ten years, and describes the methods used to estimate phosphorus reductions. These reductions apply to both in-lake phosphorus inactivation (alum treatment), and watershed loading- including applying best management practices (BMPs) to documented NPS sites in the watershed (e.g. installing vegetated buffers, improving and maintaining roads, and upgrading septic systems). These actions will be supported by public education, planning and zoning activities, land conservation, and other activities that will prevent additional inputs from future development.

C. Description of Management Measures: Sections 6, 8, and Appendix A identify ways to achieve the estimated phosphorus load reduction and reach water quality targets described in (B) above. The action plan focuses on five major topic areas that address NPS pollution, including: addressing the internal load, addressing the external load, preventing new sources of phosphorus, building local capacity, and conducting long-term monitoring and assessment.

D. Estimate of Technical and Financial Assistance: Sections 6, 8 and Table 10 includes a description of the associated costs, sources of funding, and primary authorities responsible for implementation. The estimated cost to address NPS pollution and reduce phosphorus loading to Georges Pond is estimated at $725,965 over the next ten years. A diverse source of funding, a sustainable funding strategy, and collaborative partnerships (state, town, lake association, soil & water districts, private landowners, road associations, agricultural producers, and local businesses) will be needed to fully fund planned implementation activities.

E. Information & Education & Outreach: Section 1 and Table 10 describe how the Education and Outreach component of the plan should be implemented to enhance public understanding of the project. This includes leadership from the Georges Pond Association to promote lake/watershed stewardship. Public meetings to discuss the alum treatment, press releases and mailings, as well as targeted septic education are among a few of the proposed actions within the plan.

F. Schedule for Addressing the NPS Management Measures: Section 7 and Table 10 provide a list of strategies and a set schedule that defines the timeline for that action. The schedule should be adjusted by the steering committee on an annual basis.

G. Description of Interim Measurable Milestones: Section 7 includes the milestones that measure implementation success that should be tracked annually. Using milestones and benchmarks to measure progress makes the plan relevant and helps sustain the action items. The milestones are broken down into three different categories: programmatic, environmental, and social milestones. Environmental milestones are a direct measure of environmental conditions, such as reduced in-lake phosphorus concentration and decreased prevalence of algal blooms. Programmatic milestones are indirect measures of restoration activities in the watershed, such as how much funding has been secured or how many BMPs have been installed. Social milestones measure change in social behavior over time, such as the number of steering committee meetings or the number of properties participating in LakeSmart.

H. Set of criteria: Section 7 provides a list of criteria and benchmarks for determining whether loading reductions are being achieved over time, and if substantial progress is being made towards water quality objectives. These benchmarks will help determine whether this plan needs to be revised.

I. Monitoring component: Section 6 provides a description of planned monitoring activities for Georges Pond, the results of which can be used to evaluate the effectiveness of implementation efforts over time as measured against the criteria in (H) above. The ultimate objective of this plan is to prevent the occurrence of nuisance algal blooms in Georges Pond. This requires taking immediate action to reduce the amount of phosphorus in the lake as a result of both internal and external loading. The success of this plan cannot be evaluated without ongoing monitoring and assessment and careful tracking of load reductions following successful implementation projects.

1. BACKGROUND


Algal bloom in Georges Pond in 2018. (Photo: GPA)

There has been concern over deteriorating water quality in Georges Pond since 2012 when the lake experienced its first significant cyanobacteria bloom. The blooms appear during the summer or fall and have been severe since 2012, but not consistently across all years. In 2018, Georges Pond was considered for placement on the 303(d) list of impaired waters by Maine Department of Environmental Protection (Maine DEP) for failure to meet State water quality standards as a result of low Secchi disk transparency (SDT) readings and presence of nuisance blue-green algal blooms. However, the lake was not included on the 2018 303(d) list because it did not meet the minimum criteria for the number of years with documented algal blooms,[6] but did exhibit bloom conditions in four of the last eight years with resulting SDT readings well below the state minimum standard of >2 m.

The complex dynamics that fuels these blooms has now been brought to light- excess phosphorus, thermal stratification, anoxia (low oxygen), and sediment chemistry results in a release of phosphorus from the sediments (internal loading) which fuels algal growth and leads to persistent, recurring nuisance algal blooms in Georges Pond. It is likely that expanded exposure of sediment rich in iron-bound phosphorus to anoxia has led to an increased internal load that has promoted observed cyanobacteria blooms that varies by year depending on weather conditions.

Development of this WBMP included a water quality analysis, an internal loading analysis, sediment analysis, watershed modeling, an alum treatment and diagnostic feasibility study, and development of watershed maps. Since phosphorus is the nutrient driving algal blooms in Georges Pond, it was used as the primary parameter for setting the water quality goal for the next 10-year planning period.

PURPOSE

The purpose of this Watershed-Based Management Plan, herein referred to as the "Plan" or "WBMP", is to guide the implementation efforts needed over the next 10 years (2020-2029) to restore Georges Pond such that it no longer supports algal blooms.

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[6] Georges Pond only has 8 years of bloom data (2012 - 2018) in the last 10-year assessment period blooming 4 years in the last 10 years. To be listed by Maine DEP for algal blooms, the pond must bloom 6 of the last 10 years (Correspondence with Linda Bacon, Maine DEP).

This plan outlines strategies to:

1. Address the internal phosphorus load;
2. Ramp up water quality protection efforts throughout the watershed to mitigate nonpoint source (NPS) pollution; and
3. Monitor water quality improvements in Georges Pond.

This WBMP was developed to satisfy national watershed planning guidelines provided by the United States Environmental Protection Agency (US EPA). An approved nine-element plan is a prerequisite for future federally funded work in impaired watersheds. Georges Pond meets these eligibility criteria because this Plan was developed to include these required planning elements.

STATEMENT OF GOAL

The goal of this plan is to restore the water quality of Georges Pond so that it meets state water quality standards and no longer supports reoccurring nuisance algal blooms. Planning recommendations include a 90% decrease in the internal load (95 kg/yr), and a 10% decrease in the watershed load (3 kg/yr). Combined, these reductions will result in an overall decrease in the phosphorus load in Georges Pond by 52% or 98 kg/year[7]- thereby reducing the average annual in-lake phosphorus concentration from 22 ppb to approximately 10 ppb, and reducing the probability of summer time algal blooms from approximately 30% to <1%.[8]

Water Quality Goal

(2020-2029)

Restore the water quality of Georges Pond so that it no longer supports nuisance algal blooms.

PLAN DEVELOPMENT AND COMMUNITY PARTICIPATION PROCESS

This plan was developed with input from a diverse group of local stakeholders and scientists. The final product is a result of monthly project subcommittee meetings and conference calls between professional consultants, the Georges Pond Association (GPA), Maine DEP, and other project partners over a year-long planning period.

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[7] Loading estimates and estimated phosphorus reductions are LLRM estimates with anoxia at depths >5m and phosphorus inactivation for all depths greater than 5 m. This represents a conservative approach to treatment as it addresses the highest expected loading.

[8] <1% is based on predictions from the LLRM based on predicted chlorophyll-a concentrations of approximately 10 ppb at the water quality goal.

Georges Pond Association Board of Directors Meetings

GPA Board of Directors meetings take place on the second Wednesday of every month. The project consultants attended eight board meetings in 2018/2019 to discuss specific project tasks and to present project deliverables. In addition to formal board meetings, the project team held several additional conference calls and virtual meetings during the planning and development process in 2019 to focus on fundraising, prioritizing identified watershed survey sites, and strategizing on how to address the potential impacts from septic systems.

Technical Advisory Committee (TAC) Meetings

The purpose of the Technical Advisory Committee (TAC) was to provide input on the technical aspects of the watershed planning process. This includes review and feedback on key project materials such as the water quality analysis and watershed modeling, as well as the recommendations for reducing the internal and external phosphorus load in Georges Pond. The TAC also reviewed and provided feedback on the draft of this watershed plan.

> TAC Meeting #1 was held on June 10, 2019 at the Maine DEP offices in Bangor and Augusta. Eleven people attended the meeting, representing GPA, Ecological Instincts, Water Resource Services (WRS), Maine DEP, Maine Department of Agriculture, Conservation and Forestry (Maine DACF), University of Maine (UMaine), and Hancock County Soil & Water Conservation District (HCSWCD). The focus of the meeting was to review the historical water quality analysis, preliminary watershed modeling, sediment sampling results, muck mapping assessment, and 2019 water quality monitoring. The proposed alum treatment and permitting requirements were also discussed.
>
> TAC Meeting #2 was held on November 20, 2019 at the Maine DEP offices in Bangor and Augusta. Fourteen people attended the meeting from GPA, Ecological Instincts, WRS, Maine DEP, Maine DACF, UMaine, and HCSWCD. The meeting included review of the future monitoring plan, action plan, fundraising update, phosphorus loading reduction estimates, sediment assay results, alum treatment recommendations, permitting, and public messaging.

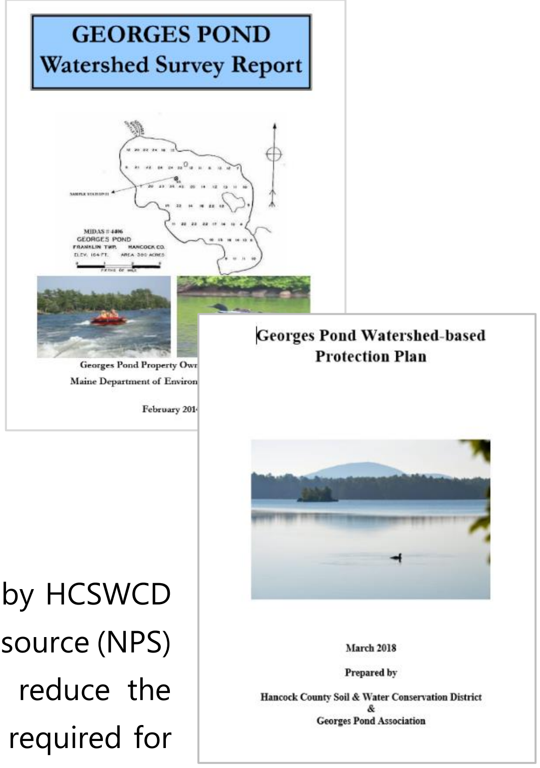
Public Presentation

Consultants from Ecological Instincts and WRS presented information on the watershed plan update at the July 7, 2019 GPA annual meeting at the Franklin Community Center in Franklin, Maine. The presentation included an overview of the water quality and preliminary watershed loading analyses, and a schedule for completing the work. Time was set aside for questions from attendees following the presentations. Seventy-four people attended the meeting, representing 41 properties on the lake.

WATERSHED PROJECTS, PROGRAMS & RESEARCH

Watershed partners have been effectively working together to understand why Georges Pond's water quality is declining, taking actions to address the water quality threats, and conducting ongoing monitoring and research to help make the best possible management decisions. The list of projects below represents watershed activities that have taken place in recent years. Development of a comprehensive list of projects and a reliable and accessible database is needed to track activities conducted by the numerous project partners that work in the watershed over time.

2013 Watershed Survey



GEORGES POND
Watershed Survey Report

Georges Pond Property Own
Maine Department of Environ

February 201

Georges Pond Watershed-based
Protection Plan

March 2018

Prepared by

Hancock County Soil & Water Conservation District
&
Georges Pond Association

Volunteers and technical staff identified 53 sites in the Georges Pond Watershed that are impacting or have the potential to impact water quality. The majority of identified sites were found on residential areas. Typically, residential sites have less severe erosion than commercial or public sites and can usually be fixed easily and at low cost. A very small portion of the erosion sites were associated with dirt roads or public areas; However, these sites involve higher levels of erosion and higher remediation costs.

2018 Watershed-Based Protection Plan

A Watershed-Based Protection Plan (WBPP) was developed by HCSWCD and GPA in 2018 to begin the process of addressing nonpoint source (NPS) pollution identified in the 2013 watershed survey and to reduce the potential for recurring blooms in Georges Pond. WBPPs are required for threatened lakes on the Maine DEP NPS Priority Watersheds list in order to receive state and federal 319 grant funding.

2018 and 2019 Shoreline, Culvert, & Road Surveys

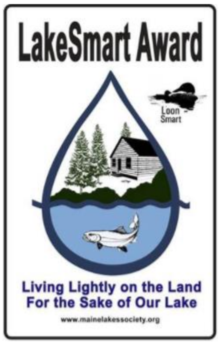
GPA conducted a survey of the culverts on roads and the shoreline of Georges Pond. The survey identified an additional 11 NPS sites that were added to the list of the 2013 watershed survey sites. In April 2019, Josh Platt (Maine Environmental Solutions), Zack Steele (HCSWCD) and Chuck Dawes (GPA) met to re-survey 15 high-priority road, culvert, and shoreline sites identified in the 2013 watershed survey and 2018 follow-up survey work. The purpose of this assessment was to develop a list of high-priority candidate sites for the Phase I 319 grant.

Washout on Cousins Road in 2019. (Photo: GPA)

2018 Septic System Survey

A septic survey form was mailed to 145 shoreline residents with homes on the shoreline to gain a better understanding of the state of wastewater systems in the watershed. The total response rate for the septic survey was 23%. The information from the survey was used to develop a septic system database and to inform the watershed loading model. Follow-up work was conducted by GPA to incorporate available town/state septic records and to identify areas of the watershed most prone to septic system failure as a result of the coarse soils in the watershed.

LakeSmart



In just the first year of GPA's LakeSmart program (2018), 20 LakeSmart evaluations were completed, resulted in nine (9) LakeSmart awards and 11 commendations. More than 40 new requests for property evaluations were received in 2019.

Public Outreach

GPA is the primary entity conducting public outreach in the watershed. The association holds an annual public meeting for all interested watershed residents, provides watershed updates on its website, and distributes a bi-annual newsletter. HCSWCD provides technical assistance to the association and the Town of Franklin to protect and preserve the natural resources within the watershed. GPA also coordinates LakeSmart programming in the watershed.

Water Quality Monitoring

Georges Pond has been monitored by ME DEP since the 1970's (baseline surveys), and more recently by GPA through Lake Stewards of Maine (formerly Volunteer Lake Monitoring Program). In 2018 – 2019 GPA's Water Quality Monitoring Team stepped up monitoring efforts to better understand the role of internal phosphorus loading and nutrient dynamics in the lake. Measurements collected include dissolved oxygen, temperature, SDT, and phosphorus profile samples collected at multiple depths every two weeks from late April through mid-October. Winter sampling in March of 2019 provided information about anoxia at the sediment interface and phytoplankton at the ice interface prior to spring mixing. Water quality will be discussed in Section 3.

GPA volunteers collecting monitoring data. (Photo: GPA)

Bathymetric Map, Sediment Geochemistry, and Submerged Sediments

A bathymetric map was created for Georges Pond with help from Lakes Environmental Association (LEA) in 2018. Lake sediments were also collected by Maine DEP in 2018 from the bottom of Georges Pond at three locations to determine the total iron and aluminum concentrations and available phosphorus in the sediment. Extracted iron, aluminum, and phosphorus were compared in units of μmol element/g sediment. The purpose of the analysis was to attain Al: Fe and Al:P ratios in the sediments to determine the capacity of sediments to hold onto phosphorus under anoxic (low oxygen) conditions at the sediment/water interface. These results indicated favorable conditions for release of phosphorus into the water column under anoxic conditions (internal loading), suggesting that increasing the concentration of aluminum in the bottom sediments will help bind excess phosphorus that has been deposited at the bottom of the lake over decades, and prevent its release into the water column.

In June 2019, an assessment of bottom sediments was completed by Hillary Snook, US EPA, with assistance from GPA to create a "muck map". The process took seven hours to complete and resulted in a lake-wide map of bottom sediments to determine the extent of alum application in Georges Pond. The results documented soft sediment at 2 m water depth, with organic "muck" beginning between 4 and 6 m. Because phosphorus in benthic lake sediments declines as sediments become coarser, an alum treatment on Georges Pond should focus on areas where both anoxic conditions and soft, organic sediments occur together.

Watershed Model, Nutrient Loading Analysis & Alum Treatment

The Lake Loading Response Model (LLRM) was used to generate phosphorus loading estimates and loading reduction estimates for the Georges Pond watershed. A Nutrient Loading Analysis and Management Review was completed in 2019 to examine the best possible options for managing algae in Georges Pond (WRS, 2019). The analysis looked at numerous management strategies including a) watershed controls, b) in-lake chemical controls, and c) in-lake physical controls (see Appendix B for the full list). This analysis determined that Georges Pond is clearly suffering from excessive internal loading and has enough ongoing watershed loading to warrant both in-lake and watershed remediation efforts. Given a primary goal of eliminating cyanobacteria blooms, a combination of in-lake treatment and watershed runoff controls will be needed. Treatment of one or the other alone will not improve water quality to the degree needed to reach the water quality target, and the internal load will begin to build again without the management of external sources. However, treatment with aluminum to inactivate phosphorus release from surficial sediments represents the greatest potential for success in terms of rapid achievement toward the water quality target.

2. LAKE & WATERSHED CHARACTERISTICS

Georges Pond is a 358-acre[9] Great Pond (Class GPA) located in the Town of Franklin, in Hancock County, Maine. The lake has a max depth of 45 ft (14 m) and a mean depth of 14 ft (4.3 m) and a flushing rate of 0.45 flushes/yr (~2-year residence time). Water enters Georges Pond from several intermittent drainages, multiple springs, and a small unnamed brook. The lake's outlet, Georges Brook, flows north into Webb Pond, located in the Town of Eastbrook.

Figure 1*. Georges Pond Base Map.*

The watershed of Georges Pond includes one square mile of mixed forestland, wetlands, agriculture (blueberries), gravel mining, and residential development- including dense residential development on the shoreline. The lake is surrounded by a network of town and private gravel roads, including Georges Pond Road (paved) that runs along the east, north, and northwest shore of Georges Pond (Figure 1). Many unimproved private gravel roads lead down to the lake off Georges Pond Road. Cousins Road and South Shore Colony Road are the largest private gravel roads that provide access to the residential homes along the western and southern shorelines.

Georges Pond is an attractive destination for various kinds of recreation throughout the year. Residents and non-residents alike enjoy swimming, boating, bird watching, cross country skiing, fishing, and snowmobiling on the lake. A popular public beach and boat ramp are located at the north end of the lake off Georges Pond Road.

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[9] Lake surface area was calculated using GIS based on the most recent National Hydrography Dataset downloaded April 2019 from USGS.

POPULATION, GROWTH TRENDS & LAND USE

Population

Sailing on Georges Pond. (Photo: GPA)

Georges Pond is located just north of the coastal U.S. Route 1 corridor on Taunton Bay and Hog Bay in Franklin, Maine, and just a few miles inland from Frenchman's Bay and one of Maine's most traveled tourist destinations – Acadia National Park. The watershed boasts picturesque views of blueberry barrens, scenic ledges overlooking the lake, and distant views of mountains. The population in the Georges Pond watershed increases substantially during the summer months due to a high percentage of seasonal lakeshore residents. The percentage of year-round residents is estimated at just 14-22% of development on the shoreline.[10]

As of 2016, Hancock County's population was 54,398; an increase of 2,607 people, or 5% since 2000. However, from 2000 to 2016, the population growth rate for the Town of Franklin was 10%; double the increase for Hancock County and the 4.4% increase for Maine as a whole (Maine State Economist, 2018) (Table 1). According to the Town of Franklin, there are over 75 businesses within the town, many of which are home-based and include photographers, potters, sculptors, jewelers, woodcutters, tile makers, and electricians.[11] Like most rural New England communities, Franklin draws its existence from its people and its natural resources.

The historic town consists of economically diverse residential and waterfront development, working blueberry farms, natural habitats, rural landscapes, and commercial gravel operations. However, the growing population, and accompanying development in Franklin may have an important influence on the character and environment of the community. Franklin's growth rate, being higher than both the county and state averages, suggests that development pressure may be steadily increasing within the town.

Table 1. *Population demographics for Town of Franklin, Hancock County, and the State of Maine.*

	Total Population 2000	**Total Population 2006**	**Total Population 2011**	**Total Population 2016**	**Projected Population 2031**	**% Change 2000-2016**	**% Change 2016-2031**
Franklin, ME	1,370	1,457	1,483	1,507	1,561	10%	3.6%
Hancock Co.	51,791	53,570	54,523	54,398	54,522	5%	0.2%
State of ME	1,274,923	1,323,593	1,327,968	1,330,232	1,341,046	4.4%	0.8%

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[10] Estimated based on the GPA septic database.

[11] Town of Franklin website homepage https://www.franklinmaine.com/site/

Growth Trends & Future Development

The desirability of Georges Pond to attract new seasonal and year-round residents will likely be directly related to lake water quality. Should management recommendations achieve desired results of preventing recurrent summertime nuisance algal blooms, Georges Pond may become an even more popular recreational destination. Landowners, businesses and the Town will likely see a monetary benefit from improved water quality. Factors such as increased property values will also improve the town's tax base. A 2002 study on 36 Maine lakes found that lakes with one meter greater clarities have higher property values on the order of 2.6% - 6.5%. Similarly, lakes with a one meter decrease in minimum transparencies cause property values to decrease anywhere from 3.1% to 8.5% (Boyle and Bouchard, 2003). On a relatively shallow lake like Georges Pond, a one meter improvement in water clarity will be noticeable and highly desirable.

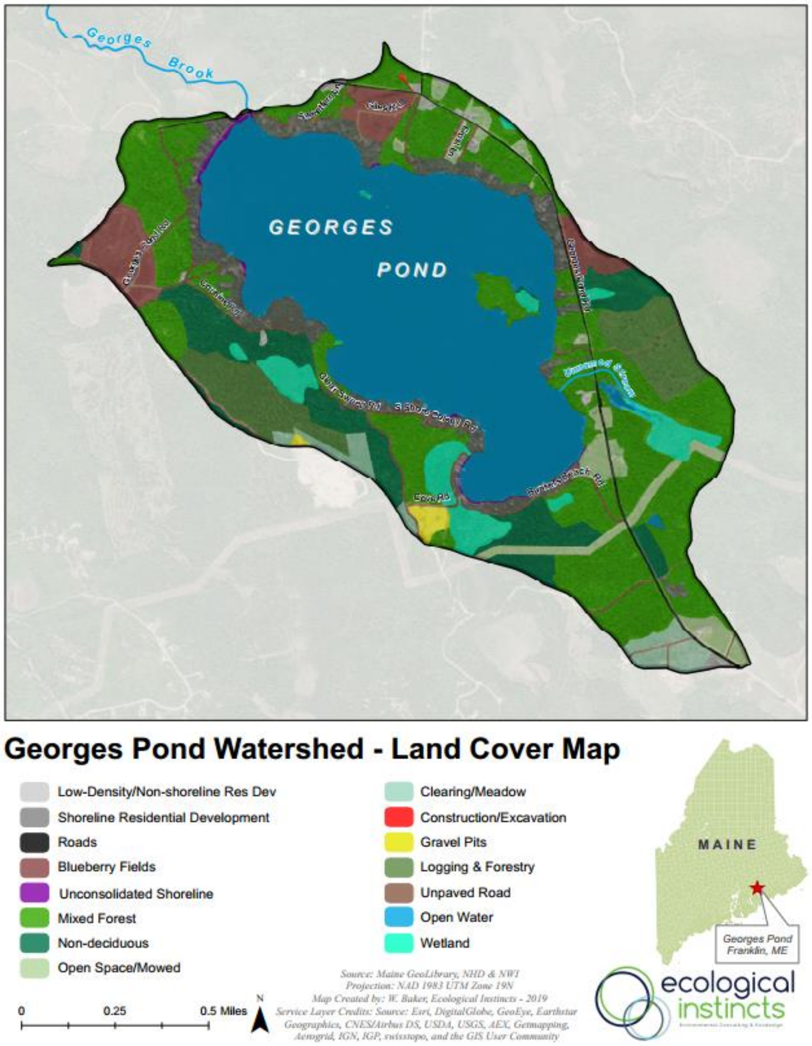
Factoring in water quality improvements, the growth rates described above, and the high cost of proposed water quality improvement initiatives, the Town of Franklin should carefully consider the effects of existing municipal land-use regulations in order to protect water quality in Georges Pond from degradation as a result of new development. As the watershed is developed, erosion from disturbed areas will deliver new, and previously unaccounted for phosphorus into Georges Pond, thereby affecting the success of planned management strategies to improve water quality. Long-term strategies such as permanent protection of sensitive riparian zones along the lake and tributaries and undeveloped forests, as well as other conservation strategies including low-impact development for new construction, and enforcement of existing ordinances in the shoreland zone are all important municipal management considerations.

Climate change adaptation planning, such as upgrading infrastructure on roads, is one way to counteract the effects of the potential increase in watershed runoff in the future. Watershed modeling estimates an additional 14 kg/yr of phosphorus will be delivered to Georges Pond with an increase in precipitation of 25%.

Land Cover

Conducting a land-cover assessment is an important component of determining how much phosophorus is contributing to the external watershed load as a result of stormwater runoff. The assessment provides a birds-eye view of the watershed at a much larger spatial scale than a watershed survey. As part of the watershed planning process, digital land cover data for the Georges Pond watershed was updated by Ecological Instincts. This included carefully reviewing the assigned land cover types and making changes based on local knowledge or field observations.[12]

Developed areas within the watershed are characterized by impervious areas such as roads, driveways, rooftops, and patios. Unlike naturally vegetated areas such as forests, impervious cover does not allow water to infiltrate into the ground, and therefore results in stormwater runoff that can carry pollutants such as sediment, nutrients, pathogens, and pesticides directly to the lake.



Source: Maine GeoLibrary, NHD & NWI
Projection: NAD 1983 UTM Zone 19N
Map Created by: W. Baker, Ecological Instincts - 2019
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

***Figure 2**. Georges Pond Land Cover Map.*

An analysis of land cover in the watershed indicates that the majority of the non-lake watershed is forested (53%), consisting mostly of mixed forest, followed by wetlands (19%),[13] developed land (15%), open green spaces and meadows (7%), and agriculture (6%) (Figure 2). Logging and forestry accounts for approximately 8% of the forested area. Residential development accounts for the largest percentage of the developed urban land cover category at 10%, with gravel operations and roads making up 5%.

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[12] 2010 (0.3 m resolution) or 2015 (1.0 m resolution) ESRI (Environmental Systems Research Institute) World Imagery aerials were uploaded and compared to 4/23/2016 Google Earth satellite images for major land cover changes. If discrepancies between the aerials and the MELCD (ME Land Cover Dataset) land cover file were found, changes were made using editing tools. Each new polygon was relabeled in the attribute table with the appropriate LLRM land cover category.

[13] The total wetland area does not include the area of Georges Pond.

Soils

Sediment entering Georges Pond via stormwater runoff from a gravel road. (Photo: GPA)

Soils in the Georges Pond watershed are a mix of deep, well-drained gravelly sandy loams with very low runoff potential (Colton and Hermon soils- hydrologic group A), and fine sandy loams, silt loams, and hydric soils with high water tables and high runoff potential (Brayton, Peru, Colonel, Lamoine, and Scantic soils- hydrologic group D and C/D). Wetlands bordering the lake are classified as muck (Wonsqueak and Bucksport) which are considered to have moderately low runoff potential if dry or drained (hydrologic group B), and high runoff potential when thoroughly wet (hydrologic group D) (Table 2).

Table 2. *Soil descriptions, area, and hydrologic soil group for the Georges Pond watershed.*

MAP UNIT SYMBOL	MAP UNIT NAME	ACRES	% OF WATERSHED	HYDROLOGIC SOIL UNIT
COB	Colton gravelly sandy loam, 0 to 8 percent slopes	83.7	13.1%	A
BSB	Brayton-Colonel association, 0 to 8 percent slopes, very stony	55	8.6%	D
HVC	Hermon-Monadnock-Peru complex, 8 to 15 percent slopes, very stony	53.1	8.3%	A
WS	Wonsqueak and Bucksport mucks, 0 to 2 percent slopes	47.5	7.5%	B/D
HTB	Hermon and Monadnock soils, 0 to 8 percent slopes, very stony	45.5	7.1%	A
DTB	Peru-Colonel complex, 3 to 8 percent slopes, very stony	42.4	6.7%	D
SA	Scantic silt loam, 0 to 3 percent slopes	40.3	6.3%	D
DSB	Peru-Colonel complex, 3 to 8 percent slopes	37.9	5.9%	C/D
BGB	Brayton fine sandy loam, 0 to 8 percent slopes, very stony	36.8	5.8%	D
COC	Colton gravelly sandy loam, 8 to 15 percent slopes	36.7	5.8%	A
SOB	Sheepscot sandy loam, 3 to 8 percent slopes, very stony	24.5	3.8%	B
LAB	Lamoine silt loam, 3 to 8 percent slopes	24.1	3.8%	C/D
NCB	Nicholville very fine sandy loam, 3 to 8 percent slopes	23.1	3.6%	C
MHC	Monadnock-Hermon complex, 3 to 15 percent slopes, extremely bouldery	20	3.1%	B
HTC	Hermon and Monadnock soils, 8 to 15 percent slopes, very stony	16.1	2.5%	A
HMC	Hermon and Monadnock soils, 8 to 15 percent slopes	15.7	2.5%	A
SMB	Sheepscot sandy loam, 0 to 8 percent slopes	9.2	1.4%	B
ADB	Adams loamy sand, 0 to 8 percent slopes, wooded	6.3	1.0%	A
MBC	Marlow fine sandy loam, 8 to 15 percent slopes, very stony	5.9	0.9%	C
WO	Wonsqueak muck, 0 to 2 percent slopes, frequently flooded	5.5	0.9%	B/D
DAB	Peru fine sandy loam, 3 to 8 percent slopes	4.3	0.7%	C/D
MDC	Marlow-Peru association, 3 to 15 percent slopes, very stony	2.3	0.4%	C
SDB	Scantic-Lamoine complex, 0 to 8 percent slopes, very stony	0.6	0.1%	D

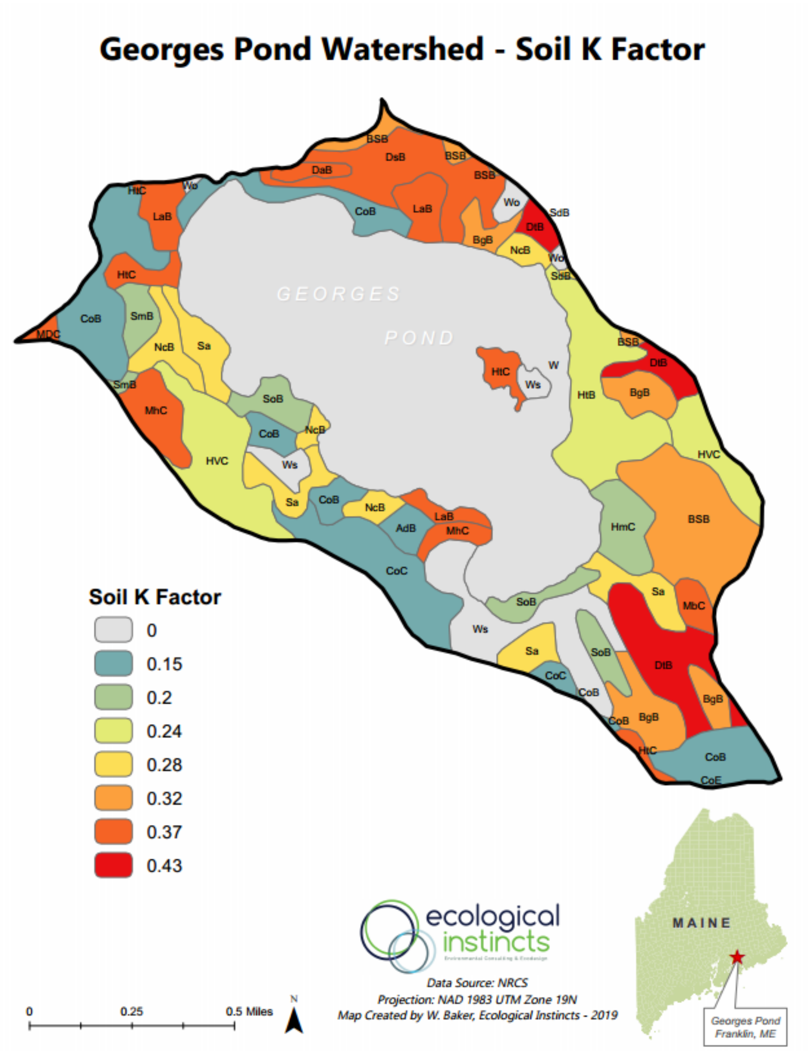

Figure 3. *NRCS Soil K Factor values for Georges Pond soils.*

An assessment of the erodibility of soils around the lake was completed to determine how susceptible the watershed is to sheet and rill erosion by water. A ‘K Factor’ value is assigned to each soil unit, which is one of six factors used by NRCS (Natural Resources Conservation Service) in the Universal Soil Loss Equation (USLE) to predict average annual rates of soil loss by sheet and rill erosion. These estimates are based on the percentage of silt, sand, and organic matter, soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69 (the higher the value, the more susceptible the soil is to sheet and rill erosion by water).[14] K Factor values in the Georges Pond watershed range from 0.15 – 0.43 (Figure 3). Soils with clay content tend to have low K values (0.5-0.15) because they resist detachment more than coarse textured soils, such as sandy soils that also have moderately low K values (0.05-0.2) because of low runoff potential even though sandy soils can easily detach. Medium textured soils (silty loams) have moderate K values (0.25-0.4) because they are susceptible to detachment and can produce moderate runoff. Silty soils have the highest K values (0.4+) and are the most erodible because they are easily detached and produce large amounts of runoff.

However, a description of highly erodible soils is not characterized in this plan because the degree of soil erodibility depends on the types of activities that occur on a particular soil and the slope on which that the soil is located. Therefore, <u>every soil in the watershed should be taken into consideration</u>. For example, Hermon soil is a sandy loam, but the top 4” could wash away if located on a slope;

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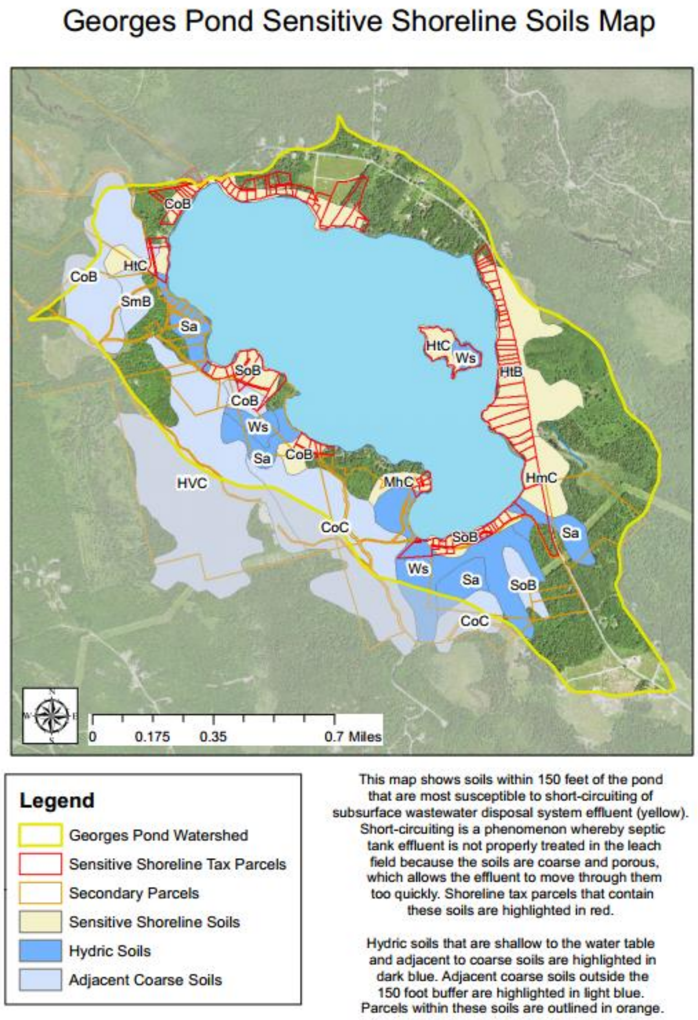
[14] NRCS Web Soil Survey, Georges Pond Watershed AOI. Soil and Erosion Factors, K Factor (Whole Soil). https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx.

A forested Lamoine would have much less runoff than a deforested Lamoine that was converted to a field for agriculture; Scantic soils on a flat slope would not be considered a problem but on a slope they might be at risk of erosion; Hermon soil on a slope that is plowed and compacted has a much higher potential for erosion.[15]

Subsurface Wastewater Systems and Sensitive Soils

Soils can act as an efficient filter of phosphorus and bacteria, especially in properly designed and installed subsurface wastewater systems. However, the rapid permeability in the substratum of the soils surrounding Georges Pond may be causing pollution of the groundwater because the filtration rate is too fast for normal treatment of septic effluent and proper formation of the biological mat or "biomat" (a.k.a., a short-circuiting leach field). The soils in this region lack the finer silts and clay that provide for the attenuation of phosphorus in leach field soils. Finely-textured soils provide the best filtration and retention of microbes and phosphorus because aerobic and anaerobic digestion within and surrounding the biomat, and filtration in the surrounding soils removes pollutants from the effluent before reaching groundwater. Coarse soils, like those dominant in this watershed, are not as effective. It is likely that it is not just old systems that are contributing to phosphorus inputs to the lake from septic systems. Even properly designed systems installed between 1974 (subsurface wastewater rules enacted) and 1995 (rules amended) didn't properly address this issue of rapid percolation in coarse and gravelly soils.



This map shows soils within 150 feet of the pond that are most susceptible to short-circuiting of subsurface wastewater disposal system effluent (yellow). Short-circuiting is a phenomenon whereby septic tank effluent is not properly treated in the leach field because the soils are coarse and porous, which allows the effluent to move through them too quickly. Shoreline tax parcels that contain these soils are highlighted in red.

Hydric soils that are shallow to the water table and adjacent to coarse soils are highlighted in dark blue. Adjacent coarse soils outside the 150 foot buffer are highlighted in light blue. Parcels within these soils are outlined in orange.

Figure 4*. Georges Pond sensitive soils and associated parcels (Maine DEP).*

Coarse and gravelly soils along the shoreline of Georges Pond should be considered sensitive or at risk because rapid permeability of these soils may result in a "short-circuit" to groundwater. Short-

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[15] Personal communications, David Rocque, State Soil Scientist, MDACF, December 2019.

circuiting occurs when septic tank effluent is not properly treated in the leach field because the soils are coarse and porous, which allows the effluent to move through them too quickly. Additionally, coarse or gravelly soils that are set back from the shore, but adjacent to hydric soils with shallow water tables that abut and are hydrologically connected to the lake are also at risk.

Soils within 150 feet of Georges Pond most susceptible to short-circuiting are presented in yellow in Figure 4 (right). Properties considered at risk are highlighted in red, while hydric soils shallow to the water table and abutting Georges Pond are highlighted in dark blue. Coarse soils outside the 150-foot buffer and adjacent to hydric shoreline soils are highlighted in light blue and named "secondary parcels". These soils are outlined in orange. The highlighted 'sensitive shoreline tax parcels' (102 properties) and 'secondary parcels' (40 properties) are the highest priority for future subsurface wastewater investigations.

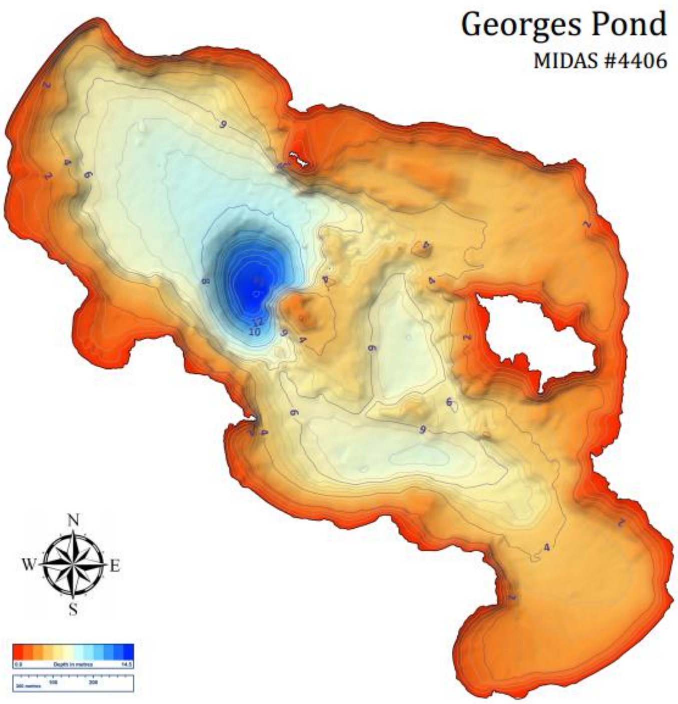
Submerged Sediments

Bathymetry

A bathymetric map was developed for Georges Pond with the assistance of the Lakes Environmental Association (LEA) in 2018 (Figure 5). The map clearly shows that only a small area of the lake is associated with the deepest water (dark blue). This also translates into a very small volume of lake water below depths of about 8 m.

It is estimated that roughly 4% of the lake area and only 2% of the lake volume is in water deeper than 8 m compared to 26% of the lake area and 9% of the lake volume in water deeper than 6 m. This is important to understanding the internal load, because in recent years, monitoring data has indicated that anoxia occurs in Georges Pond in late summer at depths between 6 and 8 m (with anoxia occurring as shallow as 4 m). This is a relatively large range of area exposed to anoxia contributing to internal load (WRS, 2019).

Georges Pond Bathymetry



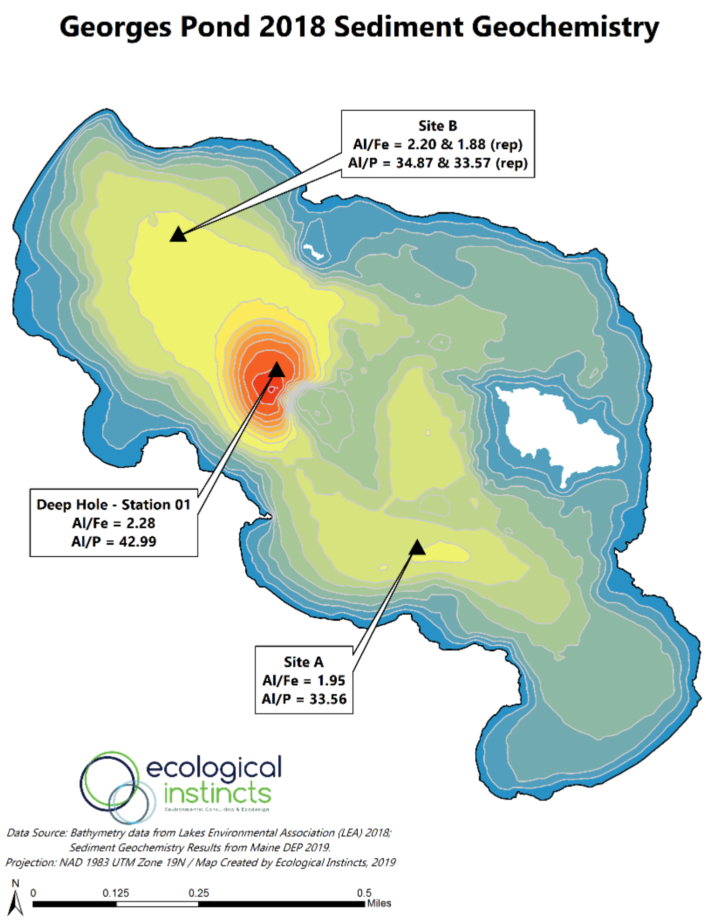
***Map Notes**: Produced at Lakes Environmental Association using ReefMaster 2.0 software. Field data collected November 7-8, 2018 by Charles Dawes using a Humminbird HELIX 5 CHIRP G2.*

***Disclaimer**: This map is not intended to be used as a primary navigational aid.*

***Figure 5**. Georges Pond bathymetric (LEA, 2018)*

Submerged Sediments

Lake sediments were collected by Maine DEP in the fall of 2018 and winter of 2019 at three locations in Georges Pond (Figure 6). The purpose of the study was to determine Al: Fe and Al:P ratios to gain a better understanding of the capacity of the sediments to hold onto phosphorus under anoxic conditions. The Al:Fe ratio can tell us about the potential for *internal recycling* in Georges Pond; the Al:P ratio is an indicator of how *overwhelmed* the system is.[16]


Georges Pond 2018 Sediment Geochemistry

Data Source: Bathymetry data from Lakes Environmental Association (LEA) 2018; Sediment Geochemistry Results from Maine DEP 2019. Projection: NAD 1983 UTM Zone 19N / Map Created by Ecological Instincts, 2019

***Figure 6**. 2018 sediment sample locations and results.*

The 2018 samples were analyzed at UMaine to determine the total iron (Fe), aluminum (Al), and phosphorus (P) concentrations in the top 5 cm of sediment. Extracted Fe, Al, and P were compared in units of µmol element/g sediment. 2018 sediment testing results indicated favorable conditions for internal loading, with Al:Fe ratios <3 at all three locations (range of 1.88 to 2.28), suggesting that increasing the concentration of aluminum in the bottom sediments will help bind phosphorus at the bottom of the lake and prevent release of phosphorus into the water column. The highest Al:Fe ratio (2.28) was collected at Station #1 (deep hole). Al:P ratios were >25 at all three sampling locations (range 33.56 to 42.99) indicating that the system is not yet totally overwhelmed with Phosphorus, but is approaching the threshold. Over time, if sediment phosphorus increases such that the ratio is driven below 25, internal recycling under anoxia will become chronic. The 2018 Al:Fe and Al:P ratios demonstrate a lake 'on-the-edge.'[17]

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[16] Al:Fe ratios <3 create conditions where reductive dissolution of Fe(III) can release significant amounts of Fe-bound phosphorus into the bottom water of the lake, resulting in internal phosphorus loading that causes algal blooms. Similarly, Al:P ratios <25 are favorable for the release of phosphorus under anoxic conditions.

[17] Personal Correspondence, Linda Bacon (Maine DEP), December 19, 2019.

Sediments and lake water collected in 2019 were delivered to UMaine to conduct sediment assays. The assays were designed to determine the necessary dose of aluminum needed to achieve inactivation of phosphorus in Georges Pond. Aluminum was added to the three samples at specific concentrations (between 10 and 100 g/m^2). Results of the laboratory assays (Figure 7) suggest consistent reductions in phosphorus with aluminum addition across the three locations. Although the three samples had different P concentrations, they merge between 35 and 45 g/m^2. Available P is exhausted at a dose of about 60 g/m^2 (WRS, 2019).

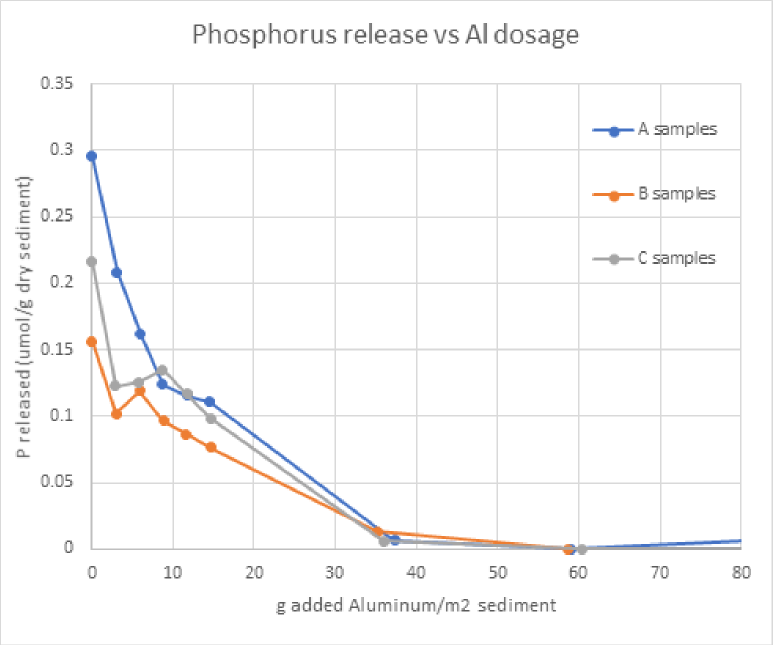
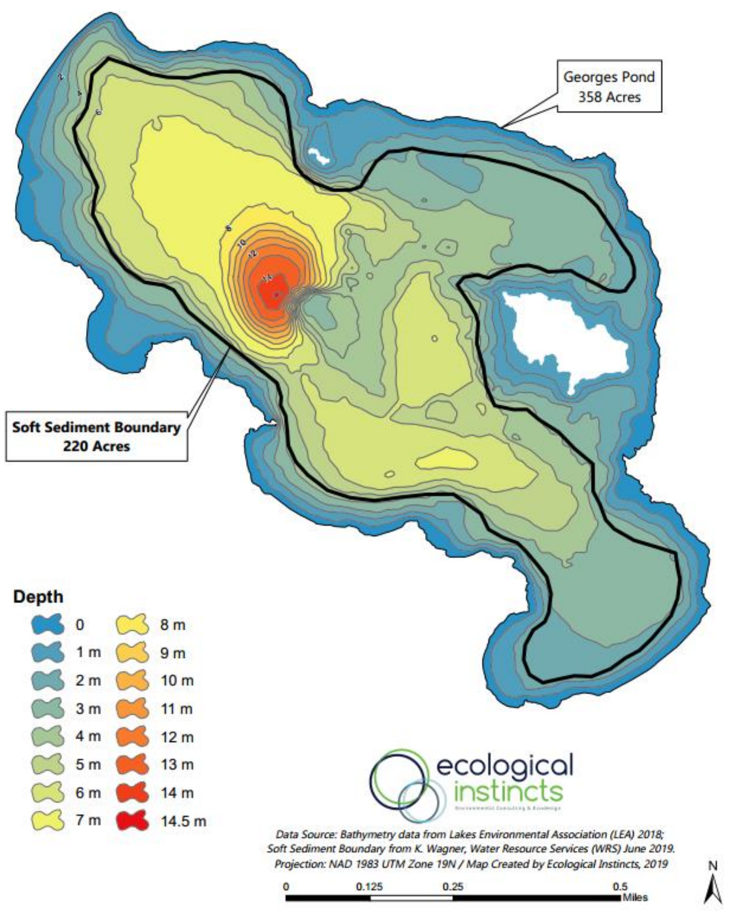


Figure 7. *Reduction in available sediment P with increasing aluminum addition (WRS, 2019).*

Substrate Composition

An assessment of the bottom sediments in Georges Pond was completed by Hillary Snook (US EPA) with assistance from Brian Friedmann (GPA) in June 2019. The overall goal of this effort was to understand where soft organic sediments, that exert substantial oxygen demand, and are also high in available P, are dominant in the lake. A series of transects with a sonar transducer were completed to determine the composition of bottom sediments and organic muck. Grab samples were also collected from the lake bottom using a Petite Ponar dredge.

Hilary Snook (US EPA) setting up a sonar transducer and recording computer to assess dominant bottom substrates in Georges Pond on June 5, 2018. (Photo: Brian Friedmann, GPA)



Georges Pond 2019 Soft Sediment Boundary

Data Source: Bathymetry data from Lakes Environmental Association (LEA) 2018; Soft Sediment Boundary from K. Wagner, Water Resource Services (WRS) June 2019. Projection: NAD 1983 UTM Zone 19N / Map Created by Ecological Instincts, 2019

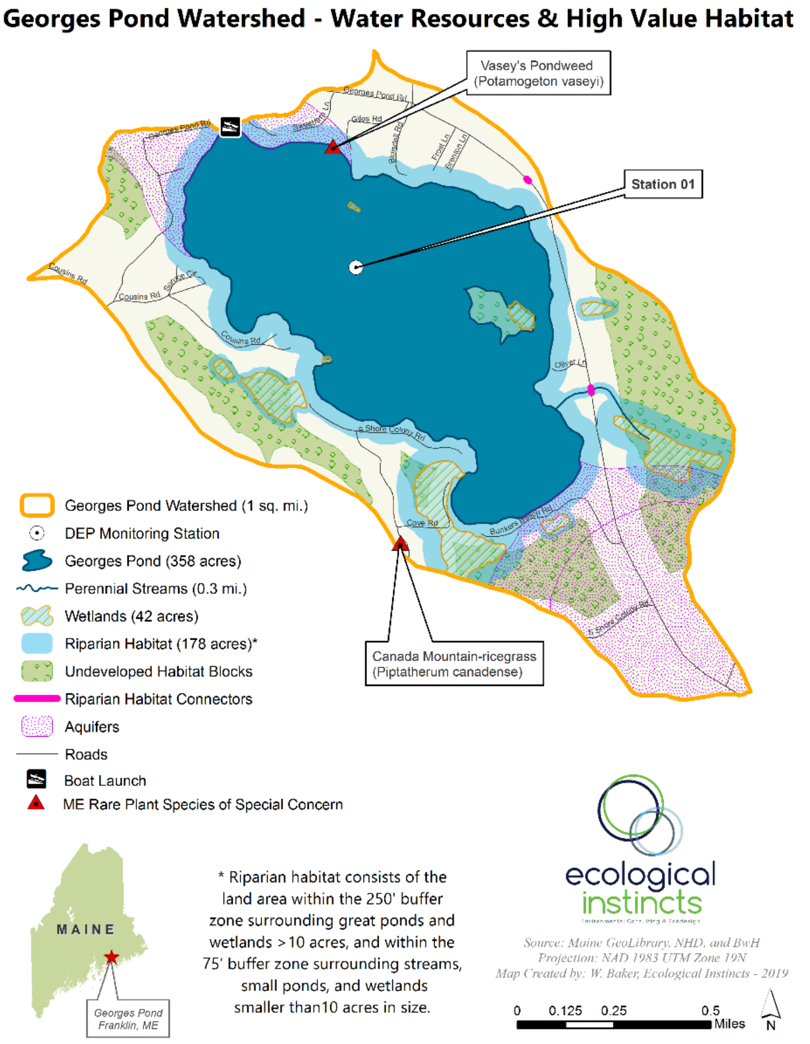
Figure 8*. Soft sediment boundary in Georges Pond based on US EPA sonar data collected by Hillary Snook in 2019.*

Highly organic soft sediment occurring in the deep water, where seasonal anoxia occurs in the hypolimnion (DO <2 mg/L), is the area of most concern as this indicates the imbalance between oxygen demand and oxygen resupply at the bottom of the lake. Additionally, available phosphorus in lake sediment declines as sediments become coarser. Therefore, phosphorus inactivation in the sediment should target areas where anoxic conditions and soft, organic sediments occur together.

Figure 8 (left) displays the general boundary where soft, organic sediments become the dominate substrate in Georges Pond. Overall, results indicate soft sediment occurring in water as shallow as 2.5 m, becoming dominant in water deeper than 4 m, with organic muck beginning between 4 - 6 m.

Water Resources and High Value Habitat

Wildlife habitat is not limited to Georges Pond and its shoreline. Fish and wildlife require healthy habitat beyond the lakeshore, with healthy riparian buffers, wetlands, and large undeveloped habitat blocks strategically linked to provide movement of wildlife. Beginning with Habitat (BwH) states that 80-95% of all Maine's terrestrial vertebrate species would likely be present today if riparian habitats, high value animal habitats, and large habitat blocks were strategically protected.[18] A recent habitat assessment using BwH data highlights the undeveloped habitat blocks (194 acres), wetlands (42 acres), and riparian habitat (178 acres) present within the Georges Pond watershed (Figure 9).



* Riparian habitat consists of the land area within the 250' buffer zone surrounding great ponds and wetlands >10 acres, and within the 75' buffer zone surrounding streams, small ponds, and wetlands smaller than10 acres in size.

Source: Maine GeoLibrary, NHD, and BwH
Projection: NAD 1983 UTM Zone 19N
Map Created by: W. Baker, Ecological Instincts - 2019

***Figure 9**. Water Resources and Wildlife Habitat in the Georges Pond Watershed.*

Riparian habitat is the transitional area between aquatic habitats and dry, upland areas. Healthy riparian zones are not only important for water quality but are essential for more than 60 species of Maine wildlife- as more animals live in riparian zones than in any other habitat type in Maine with hundreds of species depending on riparian zones for survival.[19] In the Georges Pond watershed, much of the riparian area is developed with camps and roads. As development of the Georges Pond shoreline continues, this valuable habitat will diminish - underlining the need for strong protection of the shoreland zone and conservation of undeveloped land within watershed.

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[18] Beginning with Habitat webpage https://beginningwithhabitat.org/about_bwh/index.html

[19] Maine Audubon, 2006. Conserving Wildlife in Maine's Shoreland Habitats. https://beginningwithhabitat.org/pdf/MA.ShorelandHabitats-5405-FINALcolor_000.pdf

The watershed also provides habitat for two rare plant species of special concern in Maine - Canada Mountain-ricegrass (*Piptatherum canadense*) and Vasey's Pondweed (*Potamogeton vaseyi*). Other locally important wildlife species include the American eel (*Anguilla rostrata*), and the common loon (*Gavia immer*). A symbol of summertime on Maine lakes, the loon is not uncommon on Georges Pond despite the recent algal blooms, with four adult loons and one chick counted on the lake in 2018.[20]

Georges Pond is also home to 10 fish species, including six indigenous native species, and four introduced non-native species (Table 3).[21, 22]

Table 3. *Native and non-native fish species in Georges Pond.*

Fish Species	Scientific Name	Fish Species	Scientific Name
Native		*Non-Native/Introduced*	
Yellow perch	*Perca flavescens*	White perch	*Morone americana*
Golden Shiner	*Notemigonus crysoleucas*	Black crappie	*Pomoxis nigromaculatus*
American eel	*Anguilla rostrata*	Smallmouth bass	*Micropterus dolomieu*
White sucker	*Catostomus commersoni*	Largemouth bass	*Micropterus salmoides*
Chain pickerel	*Esox niger*		
Brown bullhead	*Icalurus nebulosus*		

Protecting the land and water in the Georges Pond watershed is important for maintaining the high value wildlife habitat existing today. While the shoreline of the lake has little land left for development, the habitat map shows forestland that currently serves as wildlife connectors and large undeveloped habitat blocks. A build-out analysis for the watershed will help determine the best location for future watershed development that is most protective of these valuable resources.

Phytoplankton and Cyanobacteria

Cyanobacteria are present in lakes all around the world. Their presence, species composition and abundance can be used as an indicator of water quality. Blue-green algae is a term used to describe cyanobacteria, which are not true planktonic algae, but photosynthetic bacteria that can form dense growths (blooms) in lakes when nutrients are plentiful, water

Cyanobacteria collected from Georges Pond in 2019 under a microscope. (Photo: Brian Friedmann, GPA)

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[20] Lake Stewards of Maine, Conservation & Biodiversity: Loons. Accessed online: https://www.lakesofmaine.org/loons.html?m=4406&grouped=false&singleton

[21] Maine Inland Fisheries & Wildlife, 2000. Georges Pond Lake Survey and Map. https://www.maine.gov/ifw/docs/lake-survey-maps/penobscot/george_pond.pdf

[22] Georges Pond is currently managed as a warm water fishery that also includes largemouth bass. Personal communication, John Perry, Maine Dept. of Inland Fisheries & Wildlife, January 13, 2020.

temperature is warm, and sunlight is abundant. These blooms are an indication that the ecology of the lake is out of balance.

Georges Pond has experienced more frequent and severe algal blooms since 2012 when the first bloom occured. So far, watershed management efforts have focused on treating phosphorus loading from external (watershed) sources. It is entirely plausible that the cyanobacteria blooms over the last few years are a function of anoxia occurring at a shallower depth, having been at 8+ m historically and rising to as shallow as 4 m in recent years. The depth of anoxia will be related to weather and may vary among years, leading to less predictable conditions.

Cyanobacteria bloom in Georges Pond in 2018. (Photo: GPA)

Data from recent years suggests that oxygen <1 ppm has occurred at depths of between 6 and 8 m by late summer; this represents a potentially large swing in the amount of phosphorus contributed from sediment exposed to anoxia. When the anoxic interface occurs at shallower depths, not only is there more phosphorus being released, but there may be enough light reaching the bottom to support algae growth at the sediment-water interface that will later rise to form blooms. A seemingly minor shift in the depth of anoxia can result in a major change in phosphorus availability to algae (WRS, 2019).

Many cyanobacteria initiate growth on the bottom, then form gas pockets in their cells and rise to the surface almost synchronously. Those cells tend to carry excess phosphorus, and once in the upper waters, the algae can grow with adequate light. When cells die, some portion of the phosphorus is released into the upper waters and can support other algae growth. Blooms that start on the bottom and move to the surface are therefore not just symptoms of increasing fertility, but vectors of it.

The effects of toxins produced by cyanobacteria (cyanotoxins) to humans, domestic animals and wildlife, is closely associated with the occurrence of Harmful Algal Blooms (HABs) (US EPA, 2016). The effects are well documented, and can affect kidney, brain and liver function. However, not all blue-green algae blooms are toxic. Microcystis is the most common bloom-forming genus, and is almost always toxic (US EPA, 2017a). Both the Maine DEP and the US EPA are keeping an eye on HABs in Maine. Data collected on 24 Maine lakes between 2008-2009 documented HAB toxins in 50% of all samples, but only three exceeded drinking water guidelines, and

Maine DEP is currently working on a statewide advisory for harmful algal blooms. Signage can be used to warn the public about HABs.

all the samples were below the World Health Organization (WHO) guideline for recreational exposure (Maine DEP, 2017a).

Microcystin testing for Georges Pond was conducted by ME DEP at multiple locations on four dates in 2017 and 2018. Preliminary results indicate that only one sample exceeded US EPA's drinking water standard (0.3 for babies and toddlers, 1.6 ug/L for kids and adults) from a scum sample collected along the shore on 6/27/18. All other samples were below the US EPA recreational standard (4 ug/L).

While many states have implemented HAB response guidelines in the event of a significant bloom in recreational waterways (e.g. analyzing water, posting public advisories, beach closures, etc.), these criteria have not yet been finalized in Maine. Maine DEP is working closely with the US EPA and a regional cyanobacteria working group to define these standards. A statewide advisory is expected to be released in the future similar to what was issued for the State's mercury standard.[23] Draft guidelines are currently available from US EPA. Guidelines are based on the relative probability of acute health effects, where microcystin levels <10 ug/L are considered "low", and 10-20 µg/L "high". These guidelines are very similar to the Chlorophyll-*a* guidelines (<10 µg/L = "low"; 10-50 µg/L = moderate probability of acute health effects) (US EPA, 2017b). For more information on cyanobacteria and cyanotoxins and how to avoid exposure, visit Maine DEP's website at https://www.maine.gov/dep/water/lakes/cyanobacteria.html.

Research at the University of New Hampshire has shown that reducing total phosphorus levels in lakes can significantly reduce the risks associated with cyanobacteria blooms. A survey of cyanotoxins in New Hampshire lakes has shown that in-lake phosphorus concentrations above 9-10 ppb result in a dramatic increase in the toxicity of phytoplankton.[24]

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[23] Personal communication (email), Linda Bacon, Maine DEP Biologist. August 8, 2017.

[24] Personal Communication, Dr. Jim Haney, University of New Hampshire.

3. WATER QUALITY ASSESSMENT

Georges Pond's water quality is considered below average, and the potential for nuisance algal blooms is high as a result of low levels of dissolved oxygen in deep areas of the lake and internal recycling of phosphorus.

Water quality data have been collected by Maine DEP and volunteer lake monitors intermittently since 1977 at the deep hole (Station 1, Figure 10). This includes 18 years of data collection over the 41-year monitoring period. Monitoring has become more frequent and consistent since the cyanobacteria bloom in 2012. Data have been collected every year for the past nine years (2011-2019), whereas only nine years of data exist between 1977 and 2004.

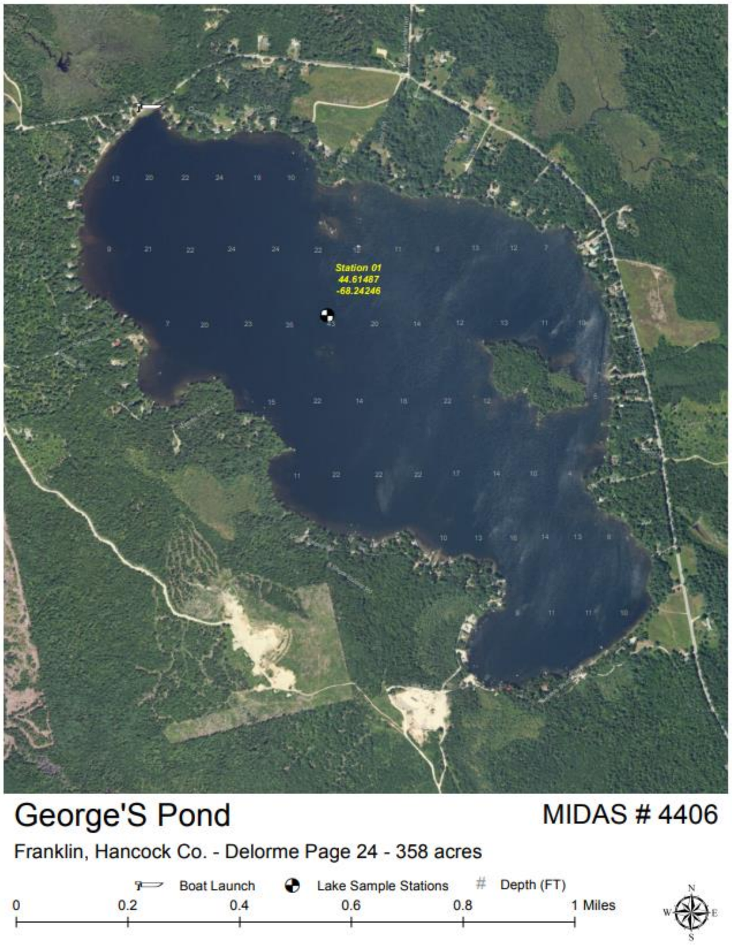

***Figure 10**. Water quality monitoring stations in Georges Pond (LakesofMaine.org).*

Trophic State Indicators

Trophic state indicators are key parameters for measuring how productive a lake is and can be used to calculate a Trophic State Index (TSI) which can be compared to other lakes across the state. In Maine lakes, TSI ranges from 8-136 with a mean of 45. A TSI has not been calculated for Georges Pond. However, more consistent collection of water quality data on an annual basis will allow for a more recent TSI Index value to be used as a baseline in the future. Less productive lakes are typically clearer, colder, and have fewer algae than productive lakes. The primary trophic state indicators are Secchi disk transparency, total phosphorus and chlorophyll-a. Monitoring results from these key parameters are described below.

Water Clarity

Measuring water clarity (a.k.a. transparency) is one of the most useful ways to determine whether a lake is changing from year to year. Changes in transparency may be due to increased or decreased algal growth, or the amount of dissolved or particulate materials in a lake, resulting from human disturbance or other impacts to the lake watershed area. Factors that affect transparency include algae, water color, and sediment. Since algal density is usually the most common factor affecting transparency in Maine lakes, transparency is an indirect measure of algae abundance. Water clarity is measured using a Secchi disk, obtained by lowering a black and white disk into the water until it is no longer visible.

Secchi Disk Transparency (SDT):
A vertical measure of water transparency (ability of light to penetrate water) obtained by lowering a black and white disk into the water until it is no longer visible. Measuring SDT is one of the most useful ways to show whether a lake is changing from year to year. Changes in transparency may be due to increased or decreased algal growth, or the amount of dissolved or particulate materials in a lake, resulting from human disturbance or other impacts to the lake watershed area. Factors that affect transparency include algae, water color, and sediment. Since algal density is usually the most common factor affecting transparency in Maine lakes, transparency is an indirect measure of algae abundance.

Secchi disk transparency (SDT) measurements in Georges Pond have been collected over a period of 17 years between 1977 and 2019. SDT readings collected during this historic sampling period range from a low of 0.7 m (June 2018) to a high of 6.2 m (August 2004 and July 2011). Average annual SDT in Georges Pond ranges from 1.4 m (2012) to 5.5 m (2011). The 2011 average is consistent with data collected in 1977 (5.4 m) and 1979 (5.0 m). SDT readings were consistently at or below 2 m from July - October 2012, July 2015, October 2017, and May - October 2018. Readings below 2 m typically signal that an algal bloom is in progress, and is the standard used by Maine DEP to signal a water quality impairment. Most recent SDT data collected in 2019 ranges from 2.5 m to 5.4 m with an average of 3.6 m.

Figure 11 provides a visual representation of the average water clarity readings in Georges Pond. No data were collected between 1983 and 1999. 2012 is the first year in which SDT readings were recorded below the DEP limit of 2 m as a result of the severe cyanobacteria bloom beginning in July, and continuing into fall; the November SDT was the lowest measurement that year at 0.98 m.

Average annual SDT prior to 2012 ranged from 3.7 m to 5.5 m, with an average of 4.6 m. More recent SDT data between 2012 and 2019 ranged from 1.4 m to 4.6 m with an average annual mean of 3.1 m; more than 1.5 m less than the pre-2012 average.

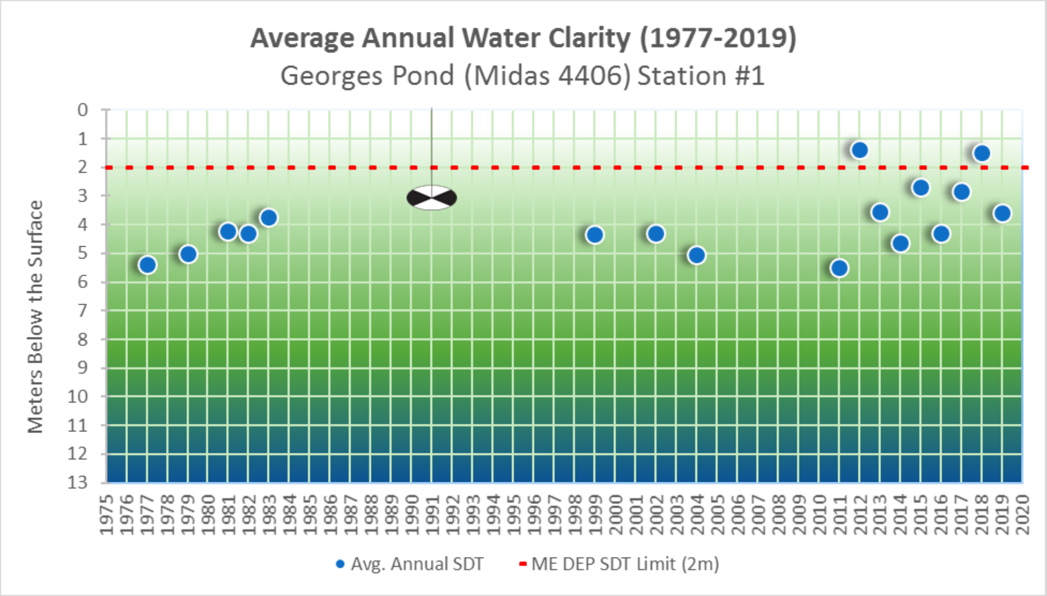

***Figure 11**. Average annual Secchi disk transparency (water clarity) for Georges Pond.*

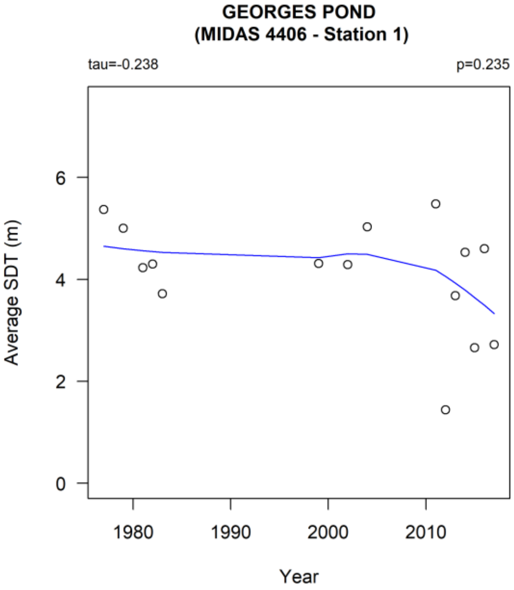

***Figure 12**. Trend plot of long-term SDT for Georges Pond, Station 1, with results of Mann-Kendall Trend test (Source: Maine DEP).*

A statistical analysis was conducted by Maine DEP to determine whether the water clarity in Georges Pond has changed over time. Long-term (1977-2018) trends were examined for SDT. Results of the Mann-Kendall trend test indicate no significant trend in average SDT (lower water clarity over time) (Figure 12). The blue line is a lowess (locally weighted scatter plot smoothing) curve. Significance of the SDT results may be influenced by a higher number of lower readings in recent years, timing of sampling, and density of samples in a given year. SDT data becomes more variable over time. Though the trend is not significant, it is evident that data collected in recent years has resulted in some of the lowest annual means on record.

Total Phosphorus

Epilimnion – the top-most layer of a thermally stratified lake. The epilimnion is typically warmer and higher in oxygen as a result of the sun penetrating the waters surface and mixing from wind.

Total phosphorus (TP) is the concentration of phosphorus found in the water, including organic and inorganic forms. It is one of the major nutrients needed for plant growth, and generally present in small amounts, which limits plant growth in freshwater ecosystems. As phosphorus increases, the amount of algae generally increases. Humans can add phosphorus to a lake through stormwater runoff, lawn or garden fertilizers, agricultural runoff and leaky or poorly maintained septic systems. Phosphorus can also be released from the lake's bottom sediments through a chemical release when there is no oxygen at the sediment water interface (internal loading).

A combination of watershed loading, and internal loading can result in an overabundance of phosphorus that throws the lake ecosystem out of equilibrium, resulting in nuisance algal blooms similar to blooms documented at Georges Pond since 2012. Total phosphorus is most often measured by collecting an "integrated core sample" from the epilimnion of the lake (representing the water column from the surface of the lake to the bottom of the epilimnion) and is reported in parts per billion (ppb). Other methods for measuring TP include collection of water from the surface (surface grab), approximately 1m off the bottom of the lake (bottom grab), and at selected depths through the water profile (profile grabs).

TP concentrations in the epilimnion range from 8 ppb (February 1983) to 36 ppb (September 2012) with a mean of 20 ppb over the historical sampling period (1979 - 2018). TP surface grab samples collected at the lake's surface were collected between 2012 and 2019. Results are in alignment with epilimnion concentrations with an annual average of 19 ppb. Annual average epilimnetic TP concentrations from data collected across five years between 1979 and 2004 (1979, 1982, 1983, 1999, and 2004) ranged from 8 ppb to 15 ppb with an annual average of 12 ppb. TP data collected in 2012, 2013, 2014, 2015, 2017 and 2018 show

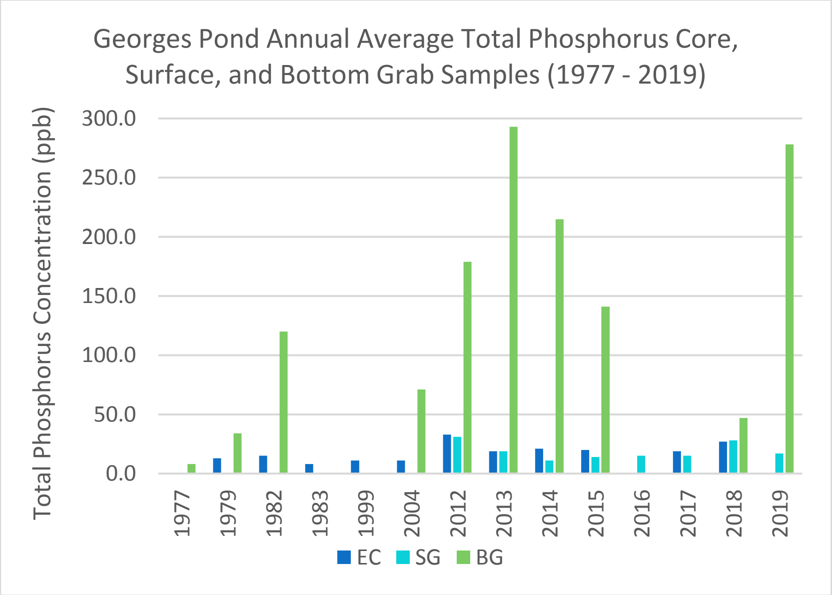

Figure 13*. Average annual total phosphorus concentrations for composite core samples, surface grab samples, and bottom grab samples collected in Georges Pond from 1977 - 2019.*

epilimnetic TP concentrations between 15 ppb and 36 ppb with an annual average concentration of 22 ppb – almost two times the pre-2012 annual average.

TP concentrations at the bottom of Georges Pond were measured over 10 years between 1977 and 2019. TP concentrations from bottom grab samples range from 8 ppb (May 1977) to 980 ppb (October 2019), with an annual mean concentration of 138 ppb (Figure 13). Elevated levels of TP at the bottom of Georges Pond (compared with surface or epilimnetic samples) point to an internal source of phosphorus loading. This is most indicative when comparing these results to the dissolved oxygen profiles.

Monitoring data for Georges Pond show a substantial increase in TP starting in 2012 both at the surface and at depth. A statistical analysis was conducted by Maine DEP for samples collected between 1979 and 2018. The trend is not significant due to large variability in available data but does show a significant increase in recent years (Figure 14).

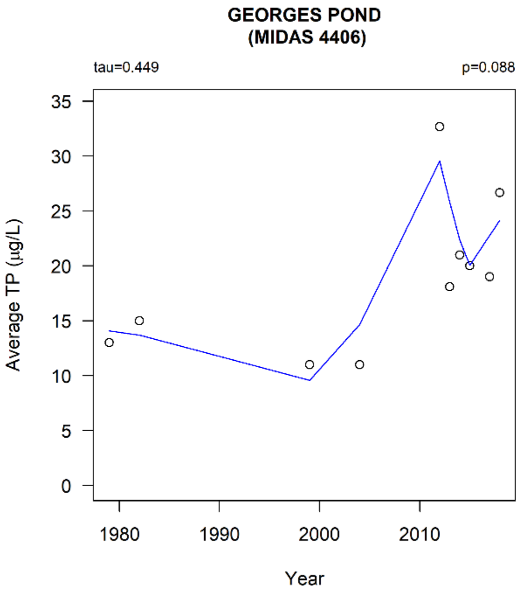

***Figure 14**. Trend plot of long-term TP for Georges Pond, Station 1, with results of Mann-Kendall Trend test (Source: Maine DEP).*

Chlorophyll-a

Chlorophyll-a (Chl-a) is the third trophic state indicator, measuring the green pigment found in all plants, including microscopic plants such as algae. Chl-a is used as an estimate of algal biomass; higher Chl-a equates to greater amounts of algae in the lake. Monitoring data for Georges Pond show a substantial increase in Chl-a concentrations beginning in 2012. Like TP, Chl-a is typically collected as an integrated core from the epilimnion as this is typically the depth to which light penetrates, and plants, including algae, grow.

Chl-a was measured in 12 years between 1979 and 2019 (1979, 1982, 1989, 1999, 2004, 2012-2015, 2017-2019). Prior to 2012, Chl-a ranged from 2.9 ppb to 4.6 ppb with an annual average concentration over that time period of 3.9 ppb. After 2012, Chl-a ranged from 3.5 (June 2013) to 76 ppb (July 2012) with an annual average Chl-a over the most recent time period of 21.3 ppb; a substantial increase over the previous sampling period.

Chl-a has been variable with a direct correlation to algae production, remaining low until 2012, with three samples > 40 ppb that year. Chl-a was lower again in subsequent years, but there has been enough of an uptick in recent years from the historic values to cause a statistically significant upward trend in Chl-a concentrations in Georges Pond. Results of the Mann-Kendall trend test by Maine DEP indicate a statistically significant increase in Chl-a (increasing algal density) over the historical sampling period (Figure 15), corresponding with the decrease in water clarity, increase in total phosphorus, and documented blue-green algae blooms (Figure 16).

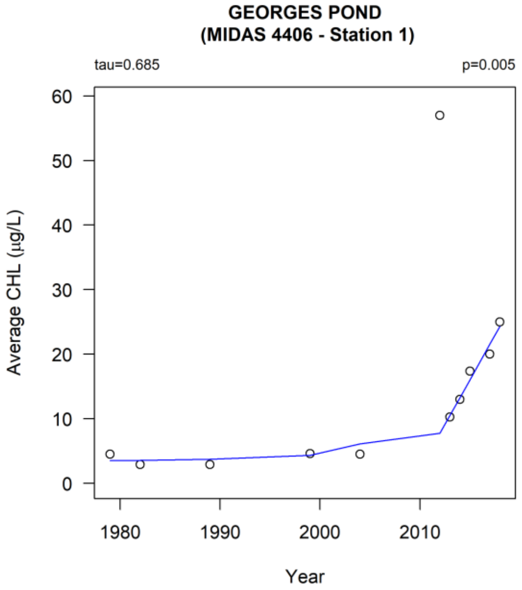

Figure 15. Trend plot of long-term Chl-a for Georges Pond, Station 1, with results of Mann-Kendall Trend test (Source: Maine DEP).

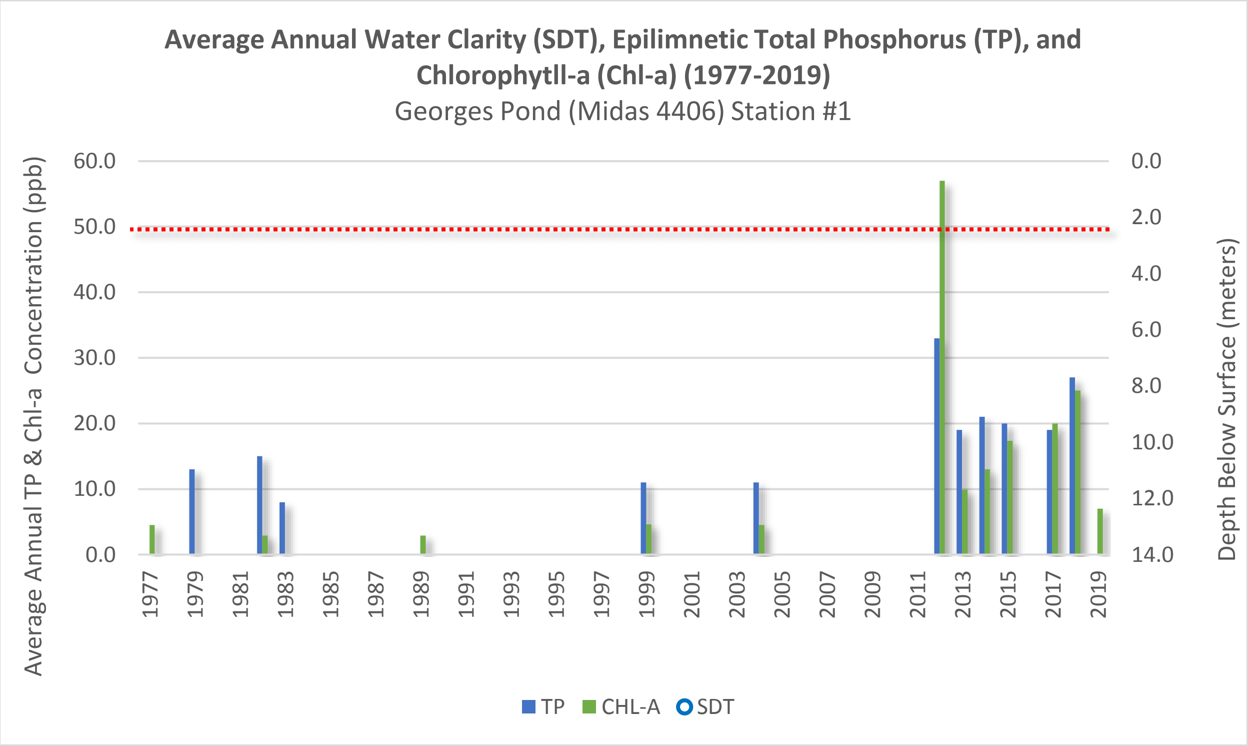

***Figure 16**. Annual average SDT, TP, and Chl-a in Georges Pond 1977 - 2019.*

Dissolved Oxygen & Temperature

Dissolved oxygen (DO) is the concentration of oxygen dissolved in the water, and is vital to fish, algae, macrophytes, and chemical reactions that support lake functioning. DO levels below 5 ppm can stress some species of cold-water fish, and over time reduce habitat for sensitive cold-water species. DO levels in lake water are influenced by several factors, including water temperature, concentration of algae and other plants in the water, and the amount of nutrients and organic matter flowing into the lake as runoff from the watershed. DO is measured using a dissolved oxygen meter that is lowered through the water column at one-meter increments and reported in parts per million (ppm).

DO concentrations can change dramatically with lake depth, as oxygen is produced in the top portion of the lake (where sunlight drives photosynthesis), and oxygen is consumed near the bottom of the lake (where organic matter accumulates and decomposes). In stratified lakes, such as Georges Pond, the difference in DO concentrations from top to bottom can be very different, with high levels of oxygen near the surface and little to no oxygen near the bottom, especially during the summer and fall when water temperature and decomposition are at their highest. Stratification prevents atmospheric O_2 (wind, wave mixing) from reaching the deep areas, cutting off the supply. In addition, microbial respiration (microbes breaking down decaying plant and animal matter) at the bottom of the lake consumes oxygen, the combination of which results in loss of DO in deep areas of the lake (anoxia). A combination of excess phosphorus in the bottom sediments, thermal stratification, anoxia, sediment chemistry, and mixing of the water column results in a release of phosphorus from the sediments (internal loading) which fuels algal growth, which can lead to persistent, recurring nuisance algal blooms such as those documented in Georges Pond.

Hypolimnion **–** the bottom-most layer of a thermally stratified lake. The hypolimnion is typically cooler and lower in oxygen than the warmer, oxygenated epilimnion above.

DO and temperature data in Georges Pond were collected over a period of 12 years between 1979 and 2019. This includes 48 DO and temperature profiles. Every profile recorded to-date (collected between June and September) shows DO at <5 ppm in the hypolimnion, and anoxic conditions (DO <1 ppm) at the greatest depths. DO data collected pre-2012 show anoxia occurring in a narrow band between 8 and 12 m below the surface (Figure 17). An increase in the area of anoxia is most evident in readings after 2012, with anoxia occurring between 4 m to 12 m below the surface (Figure 18). DO was <5 ppm at a shallow depth of just 4 m in 2012, 2015, and 2018, respectively. Algal blooms were also confirmed during these years with SDT recorded at <2 m below the lake surface. A DO profile collected in August 2018 shows DO at <5 ppm at 4 m below the surface, with anoxia occurring at just 5 m and below – conditions not recorded since the summer of 2012. Temperature changes are also occurring within the lake, increasing over time with higher temperatures at lower depths, and higher surface temperatures in recent years.

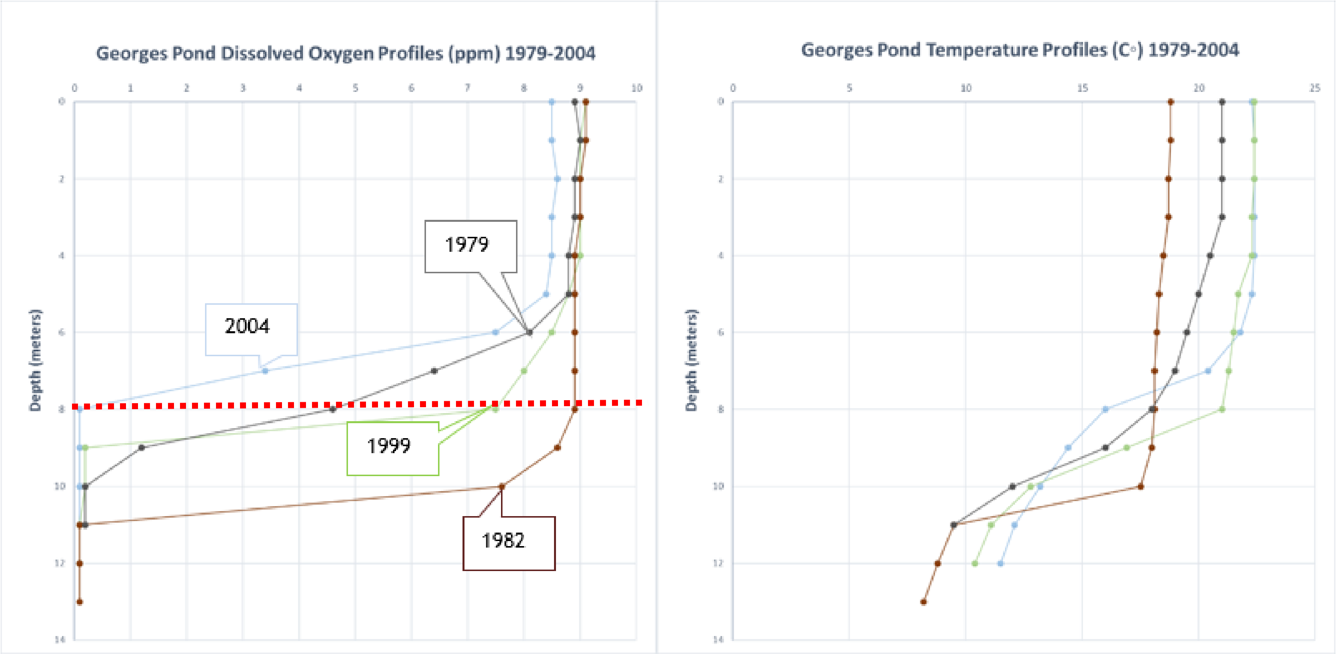

***Figure 17**. Dissolved oxygen (DO) and temperature profiles collected in Georges Pond 1979 - 2004. The red line indicates the lowest depth (8 m) that anoxia (DO <1pm) was documented during this time period.*

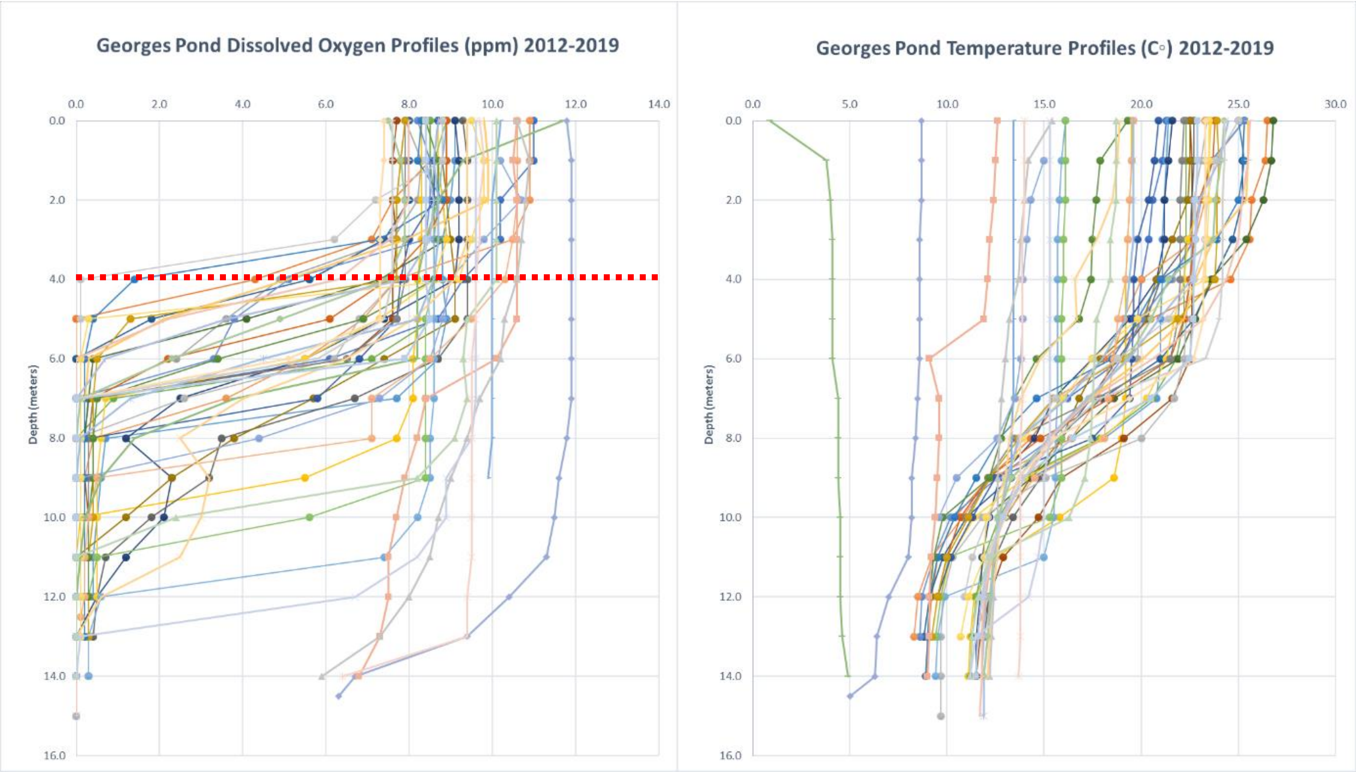

***Figure 18**. Dissolved oxygen (DO) and temperature profiles collected in Georges Pond 2012 - 2019. The red line represents the lowest depth of anoxia (4 m) documented during this time period.*

SUMMARY

Georges Pond has experienced a significant shift in water quality since sampling began in 1977. Most notably, since 2012, the lake has experienced a significant decrease in water clarity (to <2 m in some years), a significant increase in chlorophyll-a (at concentrations 5 to 10+ times greater than historic levels), an increase in the area of anoxia at the bottom of the lake (from below 8 m to 4 m), and reoccurring nuisance algal blooms (in four of the past eight years).

Understanding the increase in anoxia in recent years is especially important considering the relationship between depth and area or volume in Georges Pond. The bathymetry indicates a fairly uniform decline in area with declining water level to a depth of 7 m, then a steep reduction in the amount of area with each increment of water depth greater than 8 m. This is important because only a small area of the lake (4%) is associated with the deepest water, meaning that there is a very small volume of water (2%) below a depth of about 8 m, compared to 26% of the area and 9% of the volume greater than 6 m. Anoxia has commonly occurred at depths between 6 and 8 m (and as shallow as 4m in 2012) in recent years, representing a relatively large range of area and possible internal loading contribution in Georges Pond.

Like many other freshwater lakes in Maine and elsewhere, rainfall, or lack thereof, can have a significant effect on water quality, where wet years result in shallow SDT readings and high phosphorus concentrations, and dry years result in deep SDT readings and low phosphorus concentrations. This annual variation indicates that addressing phosphorus and sediment loading from the watershed is necessary for addressing the phosphorus load in Georges Pond. Table 4 (next page), provides an overview of water quality indicators for the past ten sampling years highlighting conditions during late summer and fall.

Table 4. *Ten-year summary of water quality in Georges Pond (2002-2019).*

Year	Avg. SDT (m)	SDT Range (m)	**Total Phosphorus (ppb)	Chl-*a* (ppb)	*Date of first bloom (SDT < 2m)
2002	4.3	3.9 - 4.7	--	--	----
2004	5.0	3.8 - 6.2	11	4.5	----
2011	5.5	4.7 - 6.2	--	--	----
2012	1.4	0.97 - 2.3	33	57.0	July 10
2013	3.5	2.3 - 5.6	19	9.9	----
2014	4.6	3.3 - 5.9	21	13.0	----
2015	2.7	1.5 - 4.0	20	17.4	July 8
2016	4.3	2.7 - 5.6	--	--	----
2017	2.8	1.8 - 4.7	19	20.0	October 14
2018	1.5	0.7 - 2.3	27	25.0	May 30
2019	3.6	2.5 - 5.9	--	7.0	----

*Date of first bloom based on SDT < 2m. SDT readings were not consistently collected in Georges Pond with some years having more data than others. Blooms that occurred during times with no SDT readings may not be represented in the table.

**TP values presented are annual averages of epilimnetic core samples. Only surface grab samples were collected in 2016, and only profile grabs were collected in 2019.

Condition Analysis

Maine DEP recently conducted a classification and condition analysis for Maine lakes (Maine DEP, 2017b). Based on this analysis, Georges Pond is classified as a "coastal pond", and its watershed is in the "altered" category due to the level of human activity it contains. Table 5 (below) presents the ranges of water quality parameters observed in coastal ponds for each condition class.

Table 5. *Coastal Pond Lake Type: Water Quality Parameter Ranges (Maine DEP).*

	Condition Classes			Georges Pond
Parameter	Reference	Average	Altered	
Secchi Disk Transparency (m)	≥ 4.5	4.5 - 4.8	< 4.8	**3.9**
Total Phosphorus - Epilimnion Core (ppb)	< 10.0	10.0 - 14.2	≥ 14.2	**18**
Chlorophyll-*a* (ppb)	< 4.6	4.6 - 5.7	≥ 5.7	**14**
Specific Conductivity (μS/cm)	< 23.9	23.9 - 49.6	≥ 49.6	**34**

According to this analysis, Georges Pond is classified as 'altered' in all but one parameter. Specific conductivity is average for the lake type, but lower than in other coastal ponds with 'altered' watersheds. This parameter is directly related to the level of dissolved ions in the water. Higher levels of conductivity can indicate a greater concentration of contaminants such as road salt that indicate human activity in the watershed.

4. WATERSHED MODELING

Understanding the contribution of pollutants from both external and internal sources in the Georges Pond watershed is an important component of watershed management, helping focus planning efforts where they are most needed.

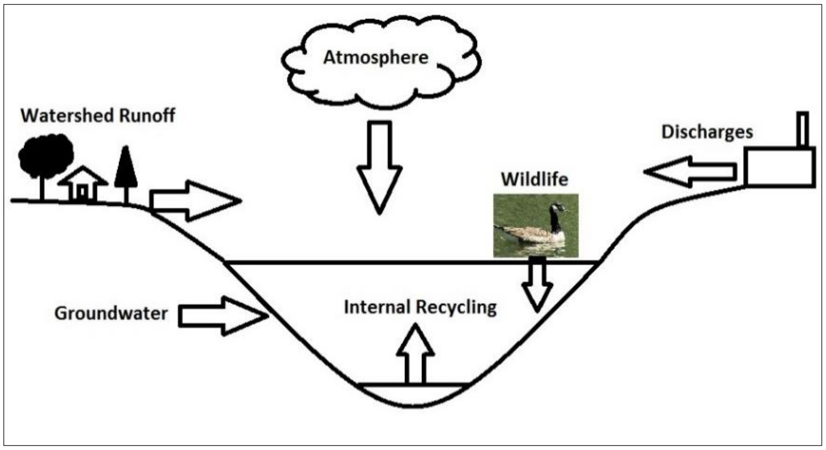

Figure 19*. Diagram of potential pollutant loading sources. (Source: WRS, 2019)*

Watershed modeling for Georges Pond was completed by Water Resource Services using the Lake Loading Response Model (LLRM) (WRS, 2019). Water and phosphorus loads (in the form of mass and concentration) are traced from various sources in the watershed to the lake. The model requires using the best available data about the waterbody, including the type and area of land cover, water quality measurements, lake volume, septic systems and internal loading estimates, among other criteria. The model includes six primary categories (Figure 19) including atmospheric deposition, direct groundwater seepage, overland (surface) flow, direct discharges, wildlife (mainly waterfowl) and internal loading. A summary of each category as it relates to Georges Pond is provided below:

<u>Atmospheric Deposition</u>- Includes pollutants landing on the lake surface either with precipitation or dryfall. This form of deposition may result in a large source only when the lake area is large relative to the watershed area, as is the case for Georges Pond. On average, 1.14 m of precipitation lands directly on Georges Pond and the surrounding land every year, providing approximately 1.7 million m^3/yr of water (WRS, 2019). Using average phosphorus concentrations in precipitation from the northeast, the model estimates a range from 6 to 56 kg/yr with an average of 20 kg/yr from atmospheric sources.

<u>Direct Groundwater Seepage</u>- Includes pollutants entering with groundwater that directly enters the lake and can be a major factor when the soils are sandy or rocky- such as in the Georges Pond watershed. No data currently exists for phosphorus levels entering Georges Pond. A mean seepage value of just over 1 million m^3/yr was used in the model along with a value of 25 ppb to calculate a groundwater seepage load of 27 kg/yr. The load is expected to be largely from onsite wastewater disposal systems on residential properties (~ 20 kg/yr). However, the load from wastewater is likely to be a small portion of the overall annual phosphorus load to Georges Pond, since most phosphorus

***Phosphorus* –** The main limiting nutrient needed for plant growth naturally present in small amounts in freshwater ecosystems. As phosphorus increases, the amount of algae generally increases. Humans can add phosphorous to a lake through stormwater runoff, lawn or garden fertilizers, and leaky or poorly maintained septic tanks.

coming from wastewater is likely to be precipitated with iron in the pond- making it a long-term threat as part of the internal load, but not a likely immediate source of phosphorus for algae or a direct driver of cyanobacteria blooms (WRS, 2019). An assessment of inflow and groundwater inseepage may be useful in the watershed to determine the quality and quantity of phosphorus from onsite wastewater disposal systems if septic systems are deemed a concern.

Overland Flow- Includes pollutants entering the lake via surface flow, including direct runoff from the watershed, streams, and upstream lakes. Georges Pond receives flow from many small drainage channels and intermittent streams (often dry in summer and fall) that can transport runoff from storms into the lake quickly with little detention. No existing stream data exists for Georges Pond, so surface water loading was estimated at 64 kg/yr in the LLRM using existing land cover data for the watershed. The effective load is assumed to be approximately half of the total load, or 32 kg/yr phosphorus entering Georges Pond from its watershed. These estimates could be improved using passive stormwater samplers to collect total and dissolved phosphorus from the "first flush" of runoff during storms and with pre- and post-storm sampling of incoming streams.

Discharges- Includes pollutants entering in any release that is not a natural flow channel such as directed flows from industry (wastewater treatment facility, cooling water, etc.). There are no known discharges in the Georges Pond watershed.

Wildlife- Includes pollutants released directly to the lake by birds, beavers, muskrats and other wildlife using the lake based on the estimated number of animal units present. These inputs are often much higher for small ponds in urban settings with lots of birds. In the absence of documented bird counts for Georges Pond, literature-based values of 100 waterfowl present for half the year and an average of 0.2 kg/bird-year results in an estimate of 10 kg/yr. While a small portion of the total load, it may contribute to the internal load over time. Management of wildlife would be a challenging pursuit without much benefit to reducing the phosphorus load in Georges Pond.

Internal Loading- Includes pollutants entering the lake from all the above sources being retained by the lake, usually by incorporation into the sediment, and recycling back into the water column. Plants pull nutrients from the sediment and may either leak some of those nutrients into the water column or release them upon typical fall senescence. Bottom feeding fish or wind and boats in shallow areas can resuspend sediment and processes in the water column may make some of the associated nutrients available. Decay of organic matter in shallow water releases phosphorus into the water column, and this can be a significant source where highly organic

Internal Loading – Pollutants enter the lake from multiple sources and are retained by the lake, usually by incorporation into the sediment, but are recycled back into the water column. This can include release from the sediment, release from plants after uptake from sediment as "leakage", or from stirring up of the bottom by wind or foraging fish. Internal loading can be a major portion of the phosphorus load in lakes with long detention times. The potential for this source to be influential in recurrent summer algal blooms on Georges Pond is high.

sediments are found in shallow water. Most often substantial internal loading is a function of release of phosphorus from iron complexes under anoxic conditions near the sediment-water interface. This tends to happen in deeper water, below the thermocline, but can occur anywhere that the surficial sediment goes anoxic. Anoxia arises when oxygen consumption exceeds the rate of resupply. Even with adequate oxygen in the overlying water column, sediments can experience anoxia and release phosphorus from iron compounds.

Anoxia **–** when oxygen consumption exceeds the rate of resupply. Anoxia at the lake bottom can lead to internal loading as iron-bound phosphorus is released into the water column at the sediment-water interface.

Release of phosphorus from iron-bound forms in surficial sediments is a function of the concentration of iron-bound phosphorus and the extent and duration of anoxia. Once stratification begins, replenishment of deep water oxygen is strongly curtailed, while decomposition accelerates as temperatures rise. Oxygen near the bottom is used up first, with the anoxic interface rising from the bottom as oxygen is consumed and not replaced. As that anoxic interface rises, more sediment area is exposed to anoxia and iron-bound phosphorus may be released. The actual release process is a function of redox potential, the intensity of electron stripping from available compounds, preferentially oxygen, but later nitrate and eventually sulfate. While oxygen can only decline to a concentration of zero, redox potential can continue to decline, going negative, increasing the rate of phosphorus release even after oxygen is depleted.

Once phosphorus has been released from the sediment into the overlying water, it will tend to accumulate in the hypolimnion and lead to elevated concentrations such as those observed in recent years in Georges Pond. Thermal stratification in Georges Pond is typically between 6 and 8 m, with anoxia occuring in even shallower water if mixing is not sufficient, as occurred in 2012 with anoxia as shallow as 4 m. The shallower the depth of anoxia, the greater the area of sediment available to release iron-bound phosphorus.

Thermocline **–** the thin layer in a stratified lake where water temperature changes rapidly separating the warm, well-mixed epilimnion (surface layer) from the colder, heavier hypolimnion (bottom layer). The thermocline is characterized by a temperature gradient (change of at least 1 degree Celsius per 1 meter in depth) because it separates the warmer top layer from the cooler bottom layer.

Phosphorus inputs from the internal load vary depending on where the theromocline sets up and how much of the pond is exposed to anoxia and for how long (WRS, 2019). It is likely that expanded exposure of sediment rich in iron-bound phoshorus to anoxia has led to an increased internal load that has promoted observed cyanobacteria blooms that varies by year depending on weather conditions.

Water quality data collected by the GPA in 2019 and sediment data analyzed by the Univeristy of Maine helped assess the extent of the internal load in the lake, including the mass of phosphorus and the phosphorus release rate from the sediment. Figure 20 (below) represents the increase in phosphorus in the deepest area of the lake during the summer under anoxic conditions.

The internal load in Georges Pond is estimated to range from 36 - 105 kg/yr.[25] Frequency and duration of algal blooms is highly weather dependant. Inceasing frequency of elevated internal loading can be expected in Georges Pond in the future without some form of in-lake treatment (WRS, 2019).

Nitrogen, while not typically considered a limiting nutrient in freshwater lakes, may become limiting to algae during the summer in Georges Pond as phosphorus concentrations rise in response to internal loading, thereby favoring cyanobacteria that utilize dissolved nitrogen. Sampling in 2019 indicates that ammonium is only elevated in deep areas with low oxygen (WRS, 2019).

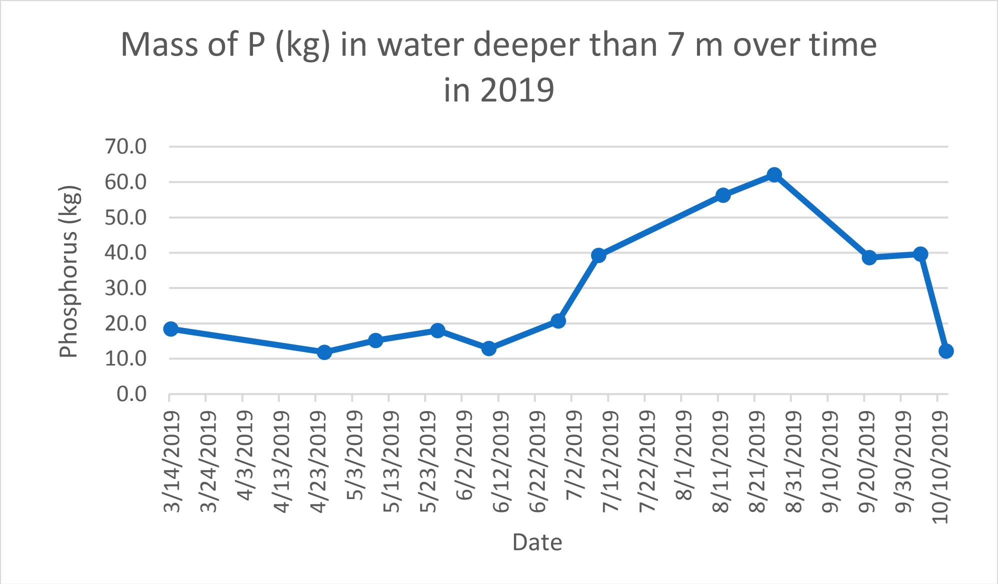

Figure 20*. Phosphorus mass in the Georges Pond hypolimnion over time in 2019 (WRS, 2019).*

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[25] The internal load is expected to range from as low as 10 kg P/yr to 126 kg P/yr based on calculations by WRS, Inc in 2019. For the purpose of this plan, the range of 36 – 105 kg P/yr was used to represent the most frequently observed depth of anoxia that occurs in Georges Pond (>5 m - >7 m).

Loading Summary

The LLRM generates load estimates for water, phopshorus and nitrogen to come up with a single estimate of "steady state" loading (average annual input of water and phosphorus over a period of years) using varying assumptions with regard to export coefficients, attenuation, and details of loading such as number of people per household for wastewater loading.

The in-lake phosphorus range in Georges Pond is between 15 – 25 ppb, varying by year, and driven largely by the weather. The LLRM predicted an in-lake phosphorus concentration of 20 ppb, well within the range of measured values. Predicted and actual values for 2019 are generally very close and suggest that this simple modeling approach is reliable enough for management planning.

Georges Pond outlet during a bloom in 2018. (Photo: GPA.)

Modeling results are presented as several different scenerios based on varying degrees of anoxia at different depths in the water column, and with increased levels of precipitation (25% increase). A background condition is presented for comparison based on a pre-development, forested watershed (Scenario A) (Table 6).

Table 6. *Phosphorus loading summary for various scenarios in Georges Pond.*

Scenario		**A**	**B**	**C**	**D**	**E**	**F**	**G**
	Average	Background (forested, no anoxia)	Low O2 at >7m	Low O2 at >6 m	Low O2 at >5m	Low O2 at >7m, 25% more precipitation	Low O2 at >6m, 25% more precipitation	Conditions associated with TP=10 ug/L
Source	Water (m3/yr)	Phosphorus (kg/yr)	Phosphorus (kg/yr)	Phosphorus (kg/yr)	Phosphorus (kg/yr)	Phosphorus (kg/yr)	Phosphorus (kg/yr)	Phosphorus (kg/yr)
Atmosphere	1668960	22.0	22.0	22.0	22.0	27.5	27.5	
Internal	0	4.8	36.1	77.0	105.3	36.1	77.0	
Wildlife	0	10.0	10.0	10.0	10.0	10.0	10.0	
Onsite wastewater	14854	0.0	20.1	20.1	20.1	20.1	20.1	
Watershed drainage	1238937	15.9	32.1	32.1	32.1	40.6	40.6	
Total P Load	2922751	52.7	120.3	161.2	189.5	134.2	175.1	90
Prediction								
Mean TP (ug/L)		6	13	19	23	15	21	10
Mean Secchi (m)		5.9	3.1	2.4	2.1	2.9	2.3	4.0
Peak Secchi (m)		6.5	4.7	4.3	4.1	4.6	4.2	5.2
Mean Chl-a (ug/L)		1.4	4.4	6.9	8.8	5.2	7.8	2.8
Peak Chl-a (ug/L)		5.5	15.8	23.9	30.0	18.5	26.9	10.5
% of time Chl-a >10 ug/L		0.0	3.0	16.1	30.5	6.1	22.9	0.3

Background modeling results indicate that direct precipitation is the greatest single input to the average water load (57%), followed by watershed surface flows (42%). Scenarios B, C and D represent potential current watershed and in-lake conditions across a range of depths at which low oxygen is encountered. The shallower the depth of anoxia in the water column (5 m, 6 m, 7 m), the greater the internal load, and the greater the overall phosphorus load. Scenario D is most representative of 2012 conditions when low oxygen extended to as shallow as 4 m for a few weeks but was as low as 5 m for much of the summer, and the lake was green. In this scenario, the predicted phosphorus concentration is 23 ppb and an algal bloom would be expected 30% of the time between June and October (WRS, 2019). Column G in Table 6 provides an estimate of the phosphorus load representing a 10 ppb in-lake concentration, expected to result in an average water clarity of 4 m and minimal probability of algal blooms.

Target Load Reduction & Management Scenarios

An average phosphorus concentration of 10 ppb is a desirable target to improve the water quality in Georges Pond. This equates to a loading goal of 90 kg/yr. Reducing this load even further would provide a margin of safety for years of extreme heat or high precipitation, and be more protective of future development. Because there is little that can be done about atmospheric or wildlife inputs, the three other primary sources (internal load, septic systems and watershed runoff) must be addressed to achieve the loading reductions needed to make necessary improvements in water quality.

Internal Load is estimated to range from 36 – 105 ppb (Scenerios B, C & D), and is the largest single source of phosphorus in Georges Pond, and one that favors cycanobacteria. A 90% reduction in internal loading is possible, and seen as the option with the greatest potential for success, but will not be enough to reach the target of 10 ppb without addressing the load from the watershed. Additionally, even with treatment of the internal load, it will build again over time in the absence of managing external sources.

The loading analysis for Georges Pond weighed the pros and cons of different management options for treating the internal load (e.g. algaecides, dredging, oxygenation, and phopshorus inactivation). These recommendations are outlined in detail in the report and were presented to the Technical Advisory Committee (TAC) for review and feedback.

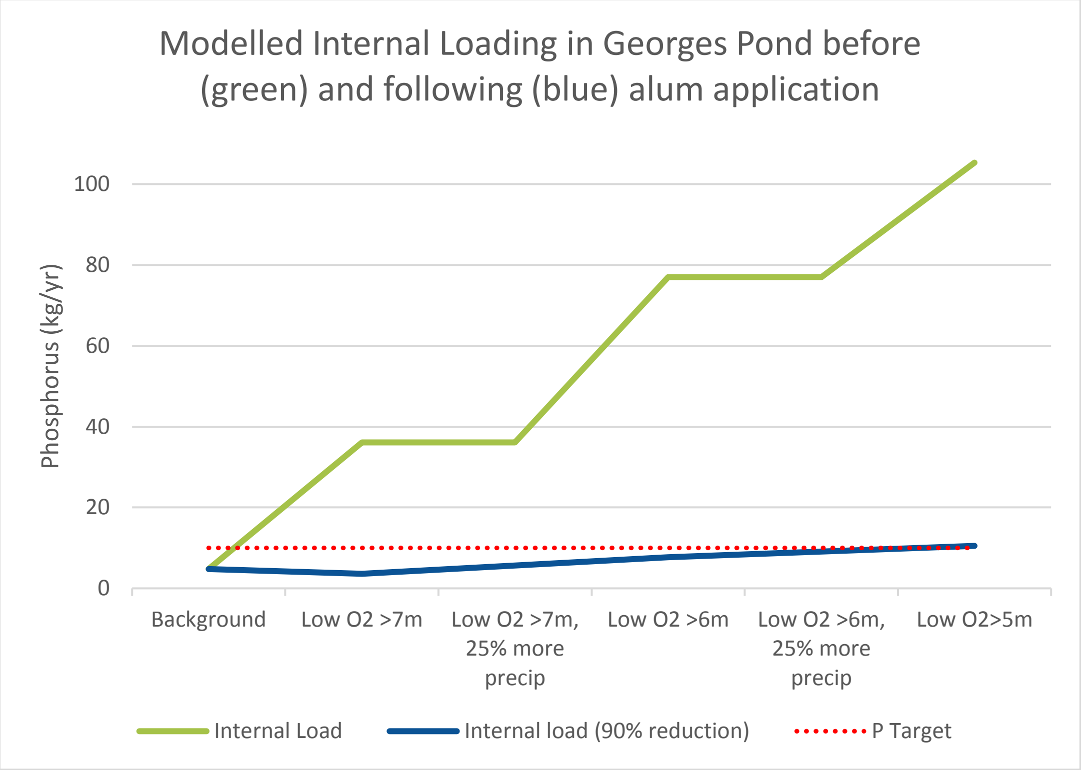

Figure 21*. Internal loading in Georges Pond under various anoxia scenarios based on depth of anoxia and weather conditions.*

<u>Watershed Drainage (External Load)</u> is estimated at 32 kg/yr (17-27% of the total load). Medium-density residential development on the shoreline makes up the greatest percent of developed land in the watershed (Table 7). Numerous scientific studies have shown that the more developed a watershed is, the more impact there is on the water quality of lakes and streams due to pollutants delivered by stormwater runoff. In fact, what may seemingly be a small amount of development can result in a large pollutant load.

Developed land makes up 22% of the land area in the watershed, but accounts for more than half of the total phosphorus (TP) load from the watershed (Figure 22). The density of development, and proximity of the development to the lake are significant factors in the amount of phosphorus being exported to the lake on an annual basis.

A 10% reduction in phosphorus from stormwater runoff will be needed through application of Best Management Practices (BMPs) such as erosion control, detention/infiltration of stormwater, and agricultural improvements. Improving the external load alone would be insufficient to achieve target reductions, yet is essential for reaching the water quality goal, and will ultimately help protect any investments made to address the internal load.

Table 7. *Land cover phosphorus export coefficients and land cover areas for Georges Pond.*

LAND COVER TYPE	Runoff P export coefficient	Baseflow P export coefficient	Area (hectares)	% of Total Area
Urban 1 (LDR/Non-shoreline)	0.50	0.010	2.9	1.1%
Urban 2 (MDR/Shoreline)	0.60	0.010	26.4	10.3%
Urban 3 (Paved Road)	0.40	0.010	3.5	1.4%
Urban 4 (Unpaved Road/Unconsolidated Shoreline)	0.50	0.010	8.8	3.4%
Urban 5 (Park/Recreational Open Space)	0.50	0.010	13.5	5.2%
Agric 1 (Blueberry Fields)	0.40	0.010	16.4	6.4%
Forest 1 (Upland)	0.10	0.005	135.1	52.6%
Open 1 (Wetland)	0.10	0.005	16.4	6.4%
Open 2 (Meadow/Clearing)	0.15	0.005	7.9	3.1%
Open 3 (Excavation)	0.50	0.005	2.2	0.9%
Forest 3 (Logging)	0.20	0.050	23.5	9.2%
		TOTAL	**256.5**	**100%**

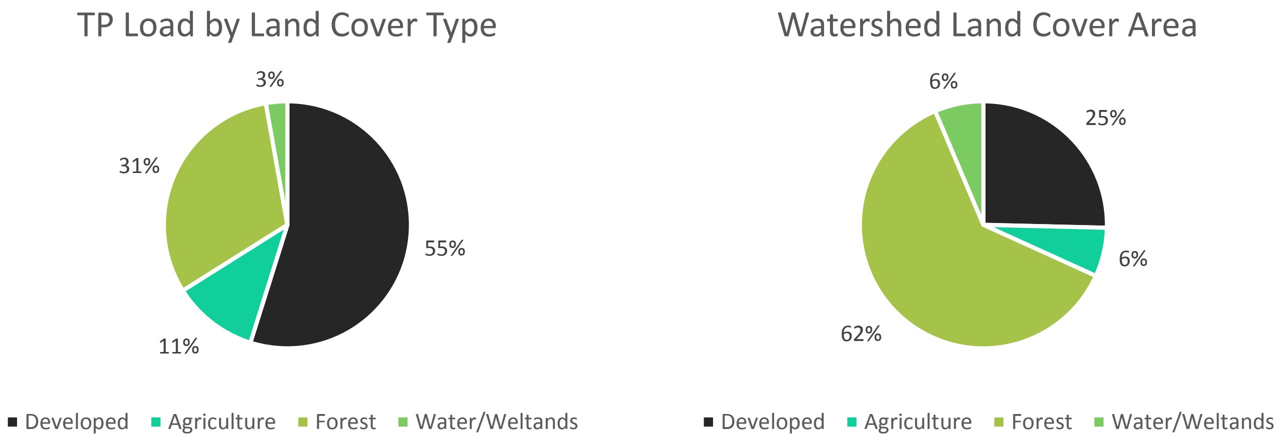

Figure 22. *Watershed land cover area by general category (developed, agriculture, forest, and water/wetlands) and total phosphorus (TP) load by general land cover type.*

The best phosphorus loading estimate for septic systems in the watershed is 20 kg/yr (11-17% of the total load) based partly on data from a limited septic survey conducted by GPA in 2018 and available state records. The coarse soils, shallow depth to groundwater, proximity to the lake (<100 ft), and aging systems are all valid concerns raised by stakeholders for the potential for direct connectivity of wastewater to the lake, and a probable source for the internal load. Sewering the watershed would eliminate the wastewater load, but is not deemed a feasible option due to the expense and ongoing cost for treatment and disposal. However, taking better care of existing systems, using contained systems, pumping annually, and a more complete septic survey are more acheivable recommendations.

5. ESTABLISHMENT OF WATER QUALITY GOALS

Results of the watershed loading model indicate that addressing the internal load should be given high priority for this watershed management plan. However, addressing the watershed load (atmospheric deposition and natural inputs from waterfowl are difficult to manage and not a high priority), is no less important, and will support management strategies to address the internal load by reducing the current load to reach water quality targets, and preventing new sources of phosphorus from entering the lake.

The Georges Pond Technical Advisory Committee reviewed and discussed the results of relevant documents developed over the one-year planning period in order to develop a water quality goal. Specifically, the committee reviewed the results of water quality sampling by the Georges Pond Association and Maine DEP, water quality analyses conducted by Ecological Instincts, watershed modeling and internal loading analysis conducted by WRS, and the sediment analysis conducted by the University of Maine. Previous watershed assessment work, including a watershed survey and follow-up assessment work in 2019 was also considered to increase the probability that water quality goals could be met based on estimated load reductions.

Reducing the internal load by 90% (32 -95 kg/yr), and the watershed load by 10% (3.2 kg/yr) will result in a reduction of the total phosphorus load to Georges Pond by 35 - 43% or approximately 35 - 98 kg/yr (Table 8). These reductions are expected to result in a reduction of the in-lake total

GOAL

Georges Pond is free of
Nuisance Algal Blooms

In-Lake P = 10 ppb
Annual P Load ~ 90 kg/yr

INTERNAL LOAD

Current: 105 kg/yr
Goal: 10.5 kg/yr
Reduction: 90% (95 kg/yr)
Project: Alum Treatment
Timeframe: 2020 - 2021

EXTERNAL LOAD
(Watershed Drainage)
Current: 32 kg/yr
Goal: 29 kg/yr
Reduction:10% (3 kg/yr)
Projects: 319, LakeSmart, Septics
Timeframe: 2020 - 2029

phosphorus concentration to 10 ppb, increase summer water clarity readings to between 3.9 m – 4.3 m (12.8 ft- 14.1 ft), and result in a minimum probability of algal blooms (.1 - .3%).[26]

***Table 8**. Predicted results from LLRM runs with various assumptions relating to management of Georges Pond and its watershed (Source: WRS, 2019).*

Scenario	**A**	**B-IL**	**C-IL**	**D-IL**	**B-IL/WS**	**C-IL/WS**	**D-IL/WS**	**G**
	Background (forested, no anoxia)	Low O2 at >7m, 90% reduction in internal load	Low O2 at >6 m, 90% reduction in internal load	Low O2 at >5m, 90% reduction in internal load	Low O2 at >7m, 90% reduction in internal load, 10% reduction in surface load	Low O2 at >6 m, 90% reduction in internal load, 10% reduction in surface load	Low O2 at >5m, 90% reduction in internal load, 10% reduction in surface load	Conditions associated with TP=10 ug/L
Source	Phosphorus (kg/yr)	Phosphorus (kg/yr)	Phosphorus (kg/yr)	Phosphorus (kg/yr)	Phosphorus (kg/yr)	Phosphorus (kg/yr)	Phosphorus (kg/yr)	Phosphorus (kg/yr)
Atmosphere	22.0	22.0	22.0	22.0	22.0	22.0	22.0	
Internal	4.8	3.6	7.7	10.5	3.6	7.7	10.5	
Wildlife	10.0	10.0	10.0	10.0	10.0	10.0	10.0	
Onsite wastewater	0.0	20.1	20.1	20.1	20.1	20.1	20.1	
Watershed drainage	15.9	32.1	32.1	32.1	29.2	29.2	29.2	
Total P Load	52.7	87.8	91.9	94.7	84.9	89.0	91.8	90
Prediction								
Mean TP (ug/L)	6	9	10	10	9	9	10	10
Mean Secchi (m)	5.9	4.2	4.0	3.9	4.3	4.1	4.0	4.0
Peak Secchi (m)	6.5	5.2	5.2	5.1	5.3	5.2	5.2	5.2
Mean Chl-a (ug/L)	2.7	2.9	3.0	2.5	2.7	2.9	8.8	2.8
Peak Chl-a (ug/L)	5.5	10.0	10.7	11.2	9.5	10.2	10.7	10.5
% of time Chl-a >10 ug/L	0.0	0.2	0.3	0.4	0.1	0.2	0.3	0.3

ADDRESSING THE INTERNAL LOAD

The internal loading analysis and feasibility study conducted by WRS provided recommendations for inactivating phosphorus in Georges Pond's sediments by treatment with alum. The rationale for this treatment is that watershed runoff controls alone cannot improve water quality to the degree needed to prevent nuisance algal blooms. Georges Pond has experienced frequent cyanobacteria blooms since 2012, which are only expected to increase with warmer predicted temperatures and an increase in the zone of anoxia in the lake over time.

Algal blooms both promote and are encouraged by low oxygen at the bottom of the lake, creating a cyclical process resulting in excessive algae growth and low oxygen supporting each other. Aluminum has been the phosphorus binder of choice in New England for the past 30 years, including successful applications in several Maine lakes that have resulted in improved water quality that extended two to three decades (Table 9).

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[26] Defined here as Chl-a concentrations >10 ppb.

The goal of the Georges Pond alum treatment is to modify the lake's natural chemical balance by increasing the amount of available aluminum in the sediments in order to bind the available phosphorus. The alum treatment is designed to address 90% of the internal phosphorus load in the lake by inactivating phosphorus in the deepest areas of the lake where anoxia is occurring (>5m) equating to a reduction of 94.5 kg P/yr, reducing the internal load from 105 kg/yr to 10.5 kg/yr.

Table 9*. List of Maine lakes successfully treated with alum, including lake surface area and longevity of treatment.*

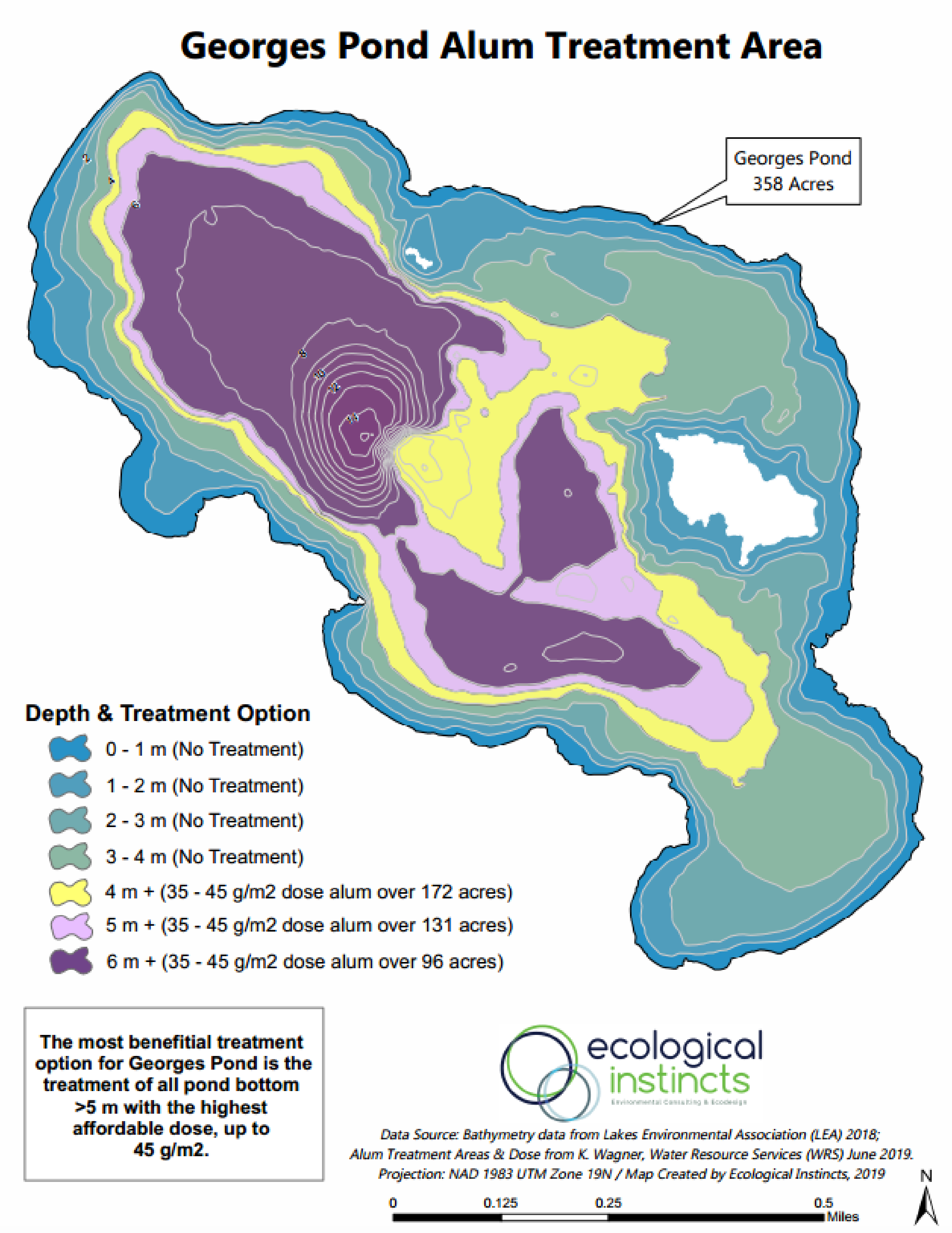
Lake	Acres	Longevity
Annabessacook *Monmouth, ME*	1,415	30 years
Cochnewagon *Monmouth, ME*	394	20 years
Chickawaukie *Rockland, ME*	354	25 years
East Pond *Oakland, ME*	1,717	Treated 2018
Lake Auburn *Auburn, ME*	1,168	Treated 2019
Cochnewagon *Monmouth, ME*	225	Treated 2019

The area of the lake to be treated and the treatment dose are subject to consensus by GPA and is heavily influenced by availability of funding. Current management recommendations include treating all areas in Georges deeper than 5 m with a dose of aluminum between 35 and 45 g/m2. This represents an area of approximately 131 acres (Figure 23) and is estimated to cost around $206,000 and $265,000 for a one-time treatment, though final costs won't be determined until a contractor has been selected.

Superior benefits and maximum longevity (10 - 20 years or more) would be expected from application at the highest dose (WRS, 2019). Separating the treatment into two treatments over a span of several years is also considered a feasible option which may reap additional water quality benefits (e.g. stripping phosphorus out of the water column twice rather than once) but will increase the overall cost of the treatment.

Monitoring will be conducted before, during and after the alum treatment. Post-alum treatment monitoring will help determine if additional alum is needed to treat other areas of the lake (e.g. 4-5m).

Public outreach is planned for early 2020, followed by the alum treatment in the spring of 2020 (see Action Plan). Effects of the alum treatment should be apparent during the first year, with more noticeable effects the following year.



Georges Pond Alum Treatment Area

The most benefitial treatment option for Georges Pond is the treatment of all pond bottom >5 m with the highest affordable dose, up to 45 g/m2.

ecological instincts
Environmental Consulting & Ecodesign

Data Source: Bathymetry data from Lakes Environmental Association (LEA) 2018;
Alum Treatment Areas & Dose from K. Wagner, Water Resource Services (WRS) June 2019.
Projection: NAD 1983 UTM Zone 19N / Map Created by Ecological Instincts, 2019

Figure 23. *Proposed alum treatment area and dosage for Georges Pond.*

ADDRESSING THE EXTERNAL LOAD

Addressing the internal load is just one part of a multi-step process to improve the water quality in Georges Pond. While an alum treatment is planned for the first year, addressing the external load will require ongoing work annually over the ten-year planning period and beyond. Cooperation from private landowners will be needed to successfully reduce watershed phosphorus load by 3.2 kg/yr. Preliminary estimates indicate that this goal can be met by addressing the high and medium priority sites identified through recent watershed assessments including steep slopes, shoreline residential properties, and gravel roads. Additional loading reductions can be achieved by reducing the phosphorus load from septic systems.

Watershed NPS Sites

The 2013 Watershed Survey identified 53 sites in the Georges Pond watershed that are impacting or have the potential to impact water quality. In 2018, GPA conducted a follow-up to the original 2013 survey identifying an additional 11 NPS sites, and in April 2019, technical staff met to re-survey 15 high-priority road, culvert, and shoreline sites for the purpose of developing a list of high-priority candidate sites for the Phase I 319 grant project. An NPS Site Tracker spreadsheet was developed in 2019 and includes a total of 74 individual NPS sites within the Georges Pond Watershed.

The majority of NPS sites are located on private residential property (48 sites) and rank low (22 sites) or medium impact (22 sites). A smaller portion of the sites ranked as high impact (14 sites) and are largely located on town and private roads (Figure 24 and Appendix A). Though fewer in number, road sites commonly contribute higher loads of pollutants to lakes and have a much higher impact to water quality. These findings suggest the need for a commitment from residential property owners and road associations to do their part to improve water quality and to protect the planned ~$265,000 investment in treating the internal load. The watershed action plan (Table 10) outlines the strategies and cost for reducing the watershed load from NPS sites in the watershed:

- Apply for Section 319 funding to address high priority private gravel road NPS sites;
- Utilize Section 319 grant funding to address three high priority culverts on town roads;
- Utilize Section 319 grant funding to address 28 high & medium priority sites (19 residential, and 9 steep slope sites);
- Target shorefront property owners to become LakeSmart- goal 50% of shoreline properties are participating in LakeSmart by 2029;
- Utilize LakeSmart to address 20 low impact residential NPS sites.

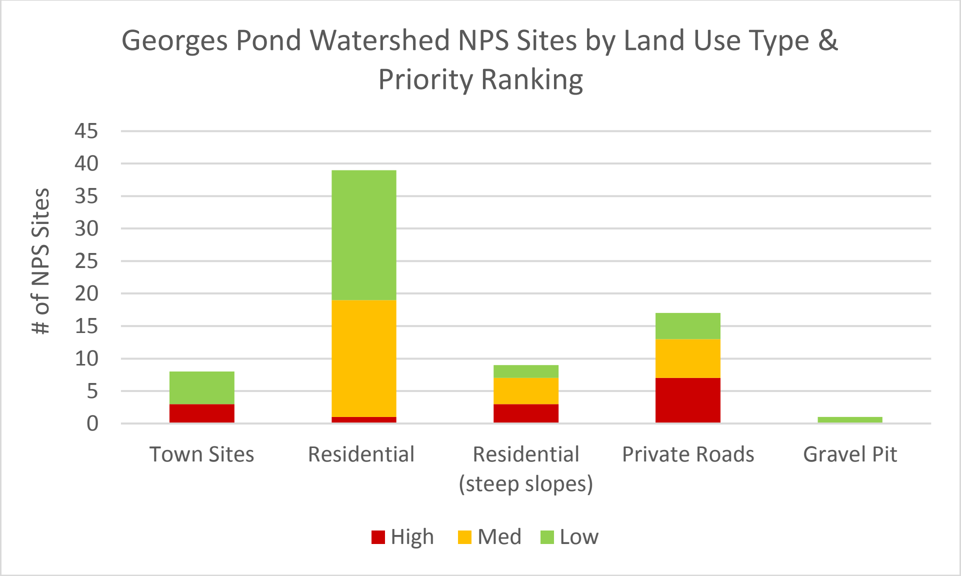


Figure 24. *Number of NPS sites in the Georges Pond Watershed by land-use type (Updated Oct. 2019).*

Septic Systems

While phosphorus loading from septic systems appears to have a small impact on the water quality of Georges Pond based on the watershed modeling (6%), just one or two failing septic systems leaching nutrient rich wastewater into the lake could contribute to the current water quality problem. This plan proposes the following strategies for better understanding the effect of septic systems on Georges Pond. Current loading reduction estimates do not include phosphorus reductions from mitigating impacts from septic systems. Any improvements to septic systems will decrease phosphorus loading from the watershed and help extend the longevity of inactivating phosphorus in bottom sediments.

- Identify parcels located on sensitive soils and prioritize based on potential impact to water quality;
- Continue outreach to landowners to acquire septic system information to update septic system database;
- Update septic system database following annual requests to the Town of Franklin for septic system upgrade information;
- Offer landowners free septic evaluations & septic designs for high priority systems with a goal of 20 free evaluations and 10 system designs;
- Provide cost-share grants to assist landowners with replacing problem septic systems Goal: 5 systems (targeted outreach to landowners with systems >20 years old and/or failing or malfunctioning systems).

New Sources of NPS Pollution

The prevention of new sources of phosphorus from the watershed will be key to the success of the management strategies described above. As the water quality in the lake improves, Georges Pond will become an even more desirable place to live and to visit, resulting in new development in the watershed. Prevention strategies will include ongoing public education, municipal planning, and land conservation. Project partners will need to:

- Attend regular planning board meetings to update town officials about watershed activities;
- Work with town officials to strengthen town ordinances, ensure timely enforcement of current rules that protect water quality, and upgrade infrastructure to adapt to changes in precipitation;
- Conduct a build-out analysis to determine the most suitable areas in the watershed for future development and areas best reserved for land conservation;
- Meet annually to review and discuss progress on the plan and update planning goals;
- Create a sustainable funding plan to cover the cost of watershed restoration projects, long-term monitoring and future alum treatments.

Table 10. *Georges Pond Watershed Action Plan & Management Measures.*

Action Plan & Management Measures	Schedule	Who	Potential Funding Sources	Estimated Cost
Address the Internal Phosphorus Load in Georges Pond (Load Reduction 95 kg/yr)				
Conduct Alum Treatment(s)				
Complete required permitting for alum treatment(s)	Year 1	GPA, consultant, contractor	GPA, US EPA (319), Maine DEP	$6,500 (plus $793 annual permit fee)
Develop Request for Proposals (RFP) and select contractor for alum application(s)	Year 1	GPA	Landowners, GPA, US EPA (319), Maine DEP	$1,000
Conduct alum treatment(s)	Years 1 & 2	GPA, contractor	US EPA (319), Towns, Private Donors, Landowners	$250,000
Implement alum treatment monitoring plan before and during treatment(s)	Years 1 & 2	GPA, consultants	GPA, Private donors	$15,000
Address the External Phosphorus Load in Georges Pond (Load Reduction 3 kg/yr)				
Address High Priority Sites within Watershed				
Address gravel roads identified in the Watershed and Road Surveys ***Goal: Roads for Cousins Road and South Shore Colony Road; implementation of Road Management Plans***	Years 1-6	GPA, HCSWCD, Landowners/Road Associations	US EPA (319), Maine DEP, GPA, Landowners/Road Associations	$110,000
Address high priority sites on town roads and public properties ***Goal: 3 high priority culverts (C1, C3 & C4), and continue to work with the Town to address erosion at the Town beach/boat launch***	Years 1-6	GPA, Town of Franklin, HCSWCD	US EPA (319), Maine DEP, Town of Franklin	30,000
Address high priority (high & medium impact, steep slope) sites on residential properties ***Goal: 28 residential sites (19 high & medium impact, 9 steep slopes)***	Years 1-4	GPA, HCSWCD, Landowners	US EPA (319), Maine DEP, Landowners	$50,000
Address Low Impact NPS Sites				
Utilize LakeSmart to Address Low Impact Sites ***Goal: 20 properties with identified low impact sites***	Years 1-10	LakeSmart, Landowners	Landowners, Towns, US EPA (319), Maine DEP	$25,000
Target shorefront properties to become LakeSmart **Goal:** 50% of shorefront property owners participating by 2029	Years 1-10	GPA	GPA, landowners, US EPA (319), Maine DEP	$10,000
Reduce NPS from Septic Systems (not included in external load reduction estimate above)				
Identify parcels located on sensitive soils and prioritize based on potential impact to water quality	Year 1-2	GPA, HCSWCD, Maine State Soil Scientist	Grants, GPA	$2,500
Continue outreach to landowners to acquire septic system information to update septic system database	Ongoing	GPA, HCSWCD	Grants, GPA	$2,500
Update septic system database following annual requests to the Town of Franklin for septic system upgrade information	Ongoing	GPA, Town of Franklin, HCSWCD	GPA, Town, Grants	$2,500

Action Plan & Management Measures	Schedule	Who	Potential Funding Sources	Estimated Cost
Offer landowners free septic evaluations & septic designs for high priority systems ***Goal: 20 free evaluations, 10 system designs***	Years 3-4	GPA, HCSWCD, Site Evaluators	Grants	$15,000
Provide cost-share grants to assist landowners with replacing problem septic systems **Goal: 5 systems (targeted outreach to landowners with systems >20 years old and/or failing or malfunctioning systems)**	Years 4-10	GPA, HCSWCD, DHHS, Town	Grants	$50,000
Education, Outreach & Communications				
Conduct community meetings to inform residents about the alum treatment **Goal: 2 meetings**	Year 1-2	GPA, Consultants, Contractor	GPA, Grants	$1,500
Prepare and distribute educational materials about the alum treatment	Year 1-2	GPA, Town	GPA	$1,000
Prepare and distribute press releases about the alum treatment and send to local papers (pre & post-treatment); Conduct interviews with local news media	Year 1-2	GPA, Consultants	GPA	$500
Keep websites updated regarding alum treatment, on-going monitoring efforts, and NPS pollution projects.	Ongoing Years 1-10	GPA, Town	Operating funds	$1,000
Prevent New Sources of NPS Pollution				
Attend regular select board meetings to update Town on watershed activities and needs ***Goal: Minimum 2 meetings/year***	Ongoing Years 1-10	GPA	n/a	n/a
Work with town officials to promote cleaning up winter sand and ongoing road maintenance	Ongoing Years 1-10	GPA	n/a	n/a
Work with landowners/road associations to conduct annual road maintenance on gravel roads	Ongoing Year 1-10	GPA	GPA, HCSWCD	n/a
Work with town boards to strengthen town ordinances and ensure timely enforcement of current rules that protect water quality	Ongoing Years 1-10	GPA	n/a	n/a
Conduct a build-out analysis to determine suitable areas for future development and areas for conservation	Year 5-6	GPA, HCPC, Consultant	GPA, grant	$3,500
Coordinate with local land trusts to acquire land to protect lakefront & riparian areas, and open/green spaces throughout the watershed.	Ongoing Years 1-10	GPA	n/a	n/a
Build Local Capacity				
Steering committee to meet at least once/year to discuss action items and goals	Annually Years 1-10	GPA, Steering Committee	n/a	n/a
Create a sustainable funding plan to pay for the cost of watershed restoration projects, long-term monitoring and future alum treatment ***Goal: $726,000 raised by 2029***	Year 1-2	GPA	GPA, private donors	$5,000

Action Plan & Management Measures	Schedule	Who	Potential Funding Sources	Estimated Cost
Apply for US EPA Clean Water Act Section 319 watershed implementation grants to address NPS sites ***Goal: 3 phases of 319 implementation projects***	Years 1, 3, & 5	GPA, HCSWCD, Consultants	GPA	$7,500
Apply for other state, federal or private foundation grants that support planning recommendations	Ongoing Years 1-10	GPA	GPA	n/a
Hold educational workshop to inform gravel road landowners on how to form road association	Year 2	GPA	GPA, US EPA (319)	$500
Formation of formal Road Associations on private roads. ***Goal: formed Road Associations on all major private roads***	Years 3-10	Road Associations	Road Associations	$2,500/Association
Continue working with the Town of Franklin to strengthen stakeholder relationships and bolster community support for restoration efforts	Ongoing Years 1-10	GPA	n/a	n/a
Conduct Long-Term Monitoring & Assessment				
Continue collecting intensive baseline water quality data (including post-alum treatment monitoring in years 1-5)	Ongoing Years 1-10	Maine DEP, Volunteers, Consultants	Private donors, grants	$10,000/year
Track and document the presence, toxicity, and duration of algal blooms	Annually Years 1-10	GPA, Maine DEP, volunteers	GPA	$300/yr
Set up NPS Site Tracker & update annually	Ongoing Years 1-10	GPA	US EPA (319)	$500/yr
Install “peepers” on developed properties with sensitive soils for septic systems	Years 1-2	GPA	Grants	$2,500
Conduct DO monitoring at each contour interval from deep to shallow across the lake during summer when lake is fully stratified, and anoxia is present	Year 1	GPA	n/a	n/a
Develop a stream monitoring plan to include use of game cameras and collection of samples from intermittent streams during storm events to determine P loading from tributaries	Years 2-6 (3-year baseline)	GPA, Volunteer Monitors, Consultants	Grants	$6,000
Walk blueberry barrens with Maine State Soil Scientist to identify at risk soils and discuss options for reducing P inputs from agricultural practices	Years 1-2	GPA, Maine DFAC, Farmers	n/a	n/a
Assess groundwater P inputs from agricultural fields in the watershed via ground water monitoring	Year 3	GPA, Maine DEP	TBD	TBD
Investigate potential sources of phosphorus in runoff from adjacent gravel operations and work with landowners to remedy the problem	Years 1-2	GPA, Landowners	n/a	n/a
Resurvey the watershed for new NPS sites 10 years after initial survey	Year 4	GPA, volunteers, DEP, HCSWCD	GPA, grants	$5,000
Join Maine’s Courtesy Boat Inspection (CBI) Program to provide inspections at the public boat launch, and conduct invasive plant surveys	Ongoing Years 1-10	GPA, volunteers	n/a	n/a

6. MONITORING ACTIVITY, FREQUENCY AND PARAMETERS

Maine water quality criteria requires Georges Pond to have a stable or improving trophic state and be free of culturally induced algal blooms. Measuring changes in water quality of the lake is a necessary component of successful watershed planning because it informs the planning process. If improvements in water clarity, dissolved oxygen, and phosphorus are evident, then planning objectives are being met. Whereas, if water quality stays the same or gets worse, then additional management strategies may be needed.

Future Baseline Monitoring

An assessment of existing water quality monitoring in Georges Pond was completed as part of the water quality analysis (1977 - 2018). Additional data was collected as part of a more robust monitoring program in 2019 to inform alum treatment recommendations. In 2019, bi-weekly Secchi transparency, dissolved oxygen/temperature and total phosphorus samples were collected at Sample Station 1 from ice-out in April through October.

The Technical Advisory Committee determined that ongoing baseline monitoring should continue on Georges Pond over the next 10 years in order to assess the effects of the alum treatment, as well as the work to reduce the watershed load from the NPS sites in the watershed. Future baseline monitoring conducted at Station # 1 (deep hole) will include:

Volunteer monitors collecting baseline data on Georges Pond. (Photo: GPA)

- **Water Clarity, Temperature, Dissolved Oxygen, Chlorophyll-*a*, and pH** collected bi-weekly.
- **Nutrients** collected monthly at 1m, 3m, 5m, 7m, 9m, 11m, and 13m where the deepest sample is approximately 1m from the bottom (dependent on lake volume), using a Van Dorn sampler.
- **Phytoplankton** collected monthly from an epilimnetic core and analyzed by qualified taxonomist. If blooms occur following alum treatment, weekly phytoplankton samples will be collected through the bloom period and at least one sample will be tested for microcystins.
- **Duplicate Samples** collected from the same horizontal grab sample collected for nutrient analysis above. Duplicates will be collected for 10% of samples, or 1 sample for every 10 collected.

The Georges Pond Association will continue to work with project partners including Lake Stewards of Maine (LSM) volunteer water quality monitors, Maine DEP, and consultants to conduct long-term water quality monitoring at Georges Pond, and to analyze the results of this data to inform future watershed management planning and assessment.

Stream Monitoring

Georges Pond receives flows from several intermittent streams that deliver stormwater runoff from developed and agricultural areas throughout the watershed. These drainages have been mapped by the Georges Pond Association, many of which are associated with culverts (i.e., Georges Pond Rd. and South Shore Colony Rd.). Currently, there is no monitoring data available for these tributaries. Therefore, a significant degree of uncertainty exists regarding phosphorus loading in these areas. Stream monitoring is recommended and should occur over a time frame of at least three years to develop a baseline phosphorus concentration for each tributary. Tributary samples should be obtained under a range of flow conditions each year, with strong emphasis on high flow conditions in order improve the accuracy of phosphorus loading estimates for Georges Pond. Future stream monitoring samples should be collected at accessible locations as near as possible to the outlet of the tributary during at least three (3) storm events per year, and will be analyzed for **Total Phosphorus, Total Suspended Solids (TSS), and E. coli**. Due to the intermittent nature of these streams, automated samplers may be deployed to collect flow during storm events, or a watershed volunteer should be available to monitor flow during storms to determine if a sample can be collected. Employing game cameras and a stream gauge may be useful for documenting high flows at each stream simultaneously with limited volunteer resources.

Understanding in-stream phosphorus concentrations in the Georges Pond watershed will help inform future watershed planning in these drainages by determining to what extent runoff from streams plays in the phosphorus equation. Observed data can be compared with modelled predictions to better inform current watershed modeling.

Ground Water Monitoring

Understanding Subsurface Wastewater System Inputs to Groundwater

Soils can act as an efficient filter of phosphorus and bacteria in subsurface wastewater systems; however, the rapid permeability in the substratum of the soils surrounding Georges Pond may be causing pollution of the ground water because the filtration rate is too fast for normal treatment of septic effluent and proper formation of the biological mat or “biomat”. Specifically, the soils in this region lack the finer silts and clay that provide for the attenuation of phosphorus in leach field soils. Finely textured soils provide the best filtration and retention of microbes and phosphorus as aerobic and anaerobic digestion within and surrounding the biomat and filtration in the surrounding soils removes pollutants from the effluent before exiting to groundwater. Coarse soils, like those present in this watershed, are not as effective.

It is recommended that watershed stakeholders investigate subsurface wastewater systems of varying ages along the shoreline of Georges Pond, as it is likely that not only the old systems are contributing to the problem. Even properly designed and installed systems between 1974 (subsurface wastewater rules enacted) and 1995 (rules amended) didn't properly address this issue of rapid percolation in coarse and gravelly soils.

Leach field investigations will determine the presence and health of the system's "biomat". Porewater diffusion samplers (a.k.a. peepers) may also be installed between the leach field and the lake within the groundwater/surface water interface to better understand phosphorus loading from groundwater sources. Project partners should coordinate with the State Soil Scientist and local certified site evaluators to determine the presence and health of the "biomat" through in-field visual examination of sediment samples collected with a soil auger, and for proper placement of the peeper samplers. Peepers remain in-field for two weeks, and collected water samples will be analyzed for **ammonia, nitrate/nitrite, and total dissolved phosphorus**. The data from these investigations will be entered into the watershed septic system database, used to estimate phosphorus loading from septic systems in the watershed, and possibly identify systems that may not be functioning properly.

Understanding Groundwater Phosphorus Loading from Agricultural Areas

The Technical Advisory Committee determined that watershed stakeholders should determine the feasibility of groundwater monitoring to better understand subsurface phosphorus loading from blueberry fields within the watershed. The Georges Pond Association will continue to work with project partners including Maine DEP and consultants to determine if groundwater sampling is feasible in the Georges Pond watershed with the goal of understanding groundwater phosphorus inputs from agriculture, and to analyze the results of this data to inform future watershed management planning and assessment. Areas with shallow groundwater connections to the lake should be considered for testing.

Alum Treatment Monitoring Plan

Baseline monitoring, detailed above, will provide an accurate assessment of the pre-treatment conditions in Georges Pond and measure changes in the long-term water quality trends. Additional monitoring performed during and after the alum treatment(s) will ensure water quality criteria are met for the protection of fish and aquatic life from aluminum toxicity and will allow for evaluation of short and long-term effects of the treatment(s). Short-term objectives include maintaining appropriate pH, alkalinity, and aluminum levels during the alum treatment, and long-term objectives include reduced in-lake TP concentrations and the elimination of harmful algal blooms in Georges Pond.

Pre and Post Alum Treatment Monitoring

The following parameters will be monitored in Georges Pond before and after the proposed alum treatment(s) collected from Station 1. Sampling will be conducted as part of the proposed Baseline Monitoring (above) within a week prior to treatment, within a week after treatment completion, and monthly thereafter:

- **Water Clarity** will be measured using a Secchi disk.
- **Temperature, Dissolved Oxygen, Conductivity/pH (profiles)** will be collected at 1-meter intervals from the surface to the bottom of the lake.
- **Chlorophyll-a and Alkalinity** samples will be collected from the epilimnion (epilimnetic core) as determined by the dissolved oxygen and temperature profile. Additionally, a bottom grab sample will be collected for alkalinity.
- **Aluminum**[27] samples (total and dissolved) will be collected monthly from an epilimnetic core and bottom grab for three years following an alum treatment or until concentrations return to pre-treatment levels.
- **Total Phosphorus** profile grab samples will be collected at 1m, 3m, 5m, 7m, 9m, 11m, and 13m with the deepest sample approximately 1m from the bottom (dependent on lake volume), using a grab sampling device.
- **Plankton –** Phytoplankton will be collected from the epilimnetic core sample and analyzed by a qualified taxonomist. If blooms occur following alum treatment, weekly phytoplankton samples will be collected through the bloom period and at least one sample will be tested for microcystins. Zooplankton will be collected using a Wisconsin Net (80-micron mesh size recommended by Maine DEP) and analyzed by a qualified taxonomist.
- **Sediment** samples (composited) will be collected and analyzed using a modified Psenner Al/Fe/P speciation technique, within one week after the end of treatment, one year after treatment, and at 5-year intervals thereafter.
- **Fish and aquatic life surveys** will be ongoing during and after the alum treatment (see below).

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[27] Collection of monthly aluminum samples may be discontinued once background levels are achieved following treatment.

Monitoring During Alum Treatment(s)

Monitoring needs during the alum treatment will take place throughout the day at specific monitoring locations:

- **Treatment area monitoring (each morning, before the treatment barge begins)** – Both the proposed treatment area and the location treated the previous day will be sampled. Parameters collected include: Secchi disk transparency, dissolved oxygen, temperature, conductivity/pH, and aluminum (total and dissolved).
- **Control monitoring (morning and late afternoon)** will take place at the same location each day, at a location that will be treated the very last day of the application. Monitoring will occur in the morning before the barge begins, and again at the same location following treatment that day. Parameters collected include: Secchi disk transparency, dissolved oxygen, temperature, and conductivity/pH.
- **In-plume monitoring and floc evaluation** will occur continuously during treatment and conducted within the alum plume (between 50’ and 200’ from the barge). Conductivity, pH, and alkalinity data will be collected. Evaluation of floc will be completed via an underwater camera.
- **Fish and aquatic life surveys** on the shoreline of Georges Pond will occur daily during the alum treatment and monthly thereafter. Surveyors will observe shoreline areas for fish, shellfish, snail, amphibian, and bird fatalities, insect hatches and other signs of potential aluminum or pH toxicity.

Table 11 (next page) summarizes the monitoring schedule, frequency and parameters before, during, and after the proposed alum treatment(s).

Table 11*. Georges Pond Monitoring Plan: before, during and after proposed 2020 alum treatment.*

Georges Pond Alum Treatment Monitoring Plan

When?	**BEFORE/AFTER TREATMENT**	**DURING TREATMENT**					
	Within a week before treatment starts, within a week of completion, monthly thereafter	***Morning before barge starts treatment***			***During treatment***	***Following treatment - late afternoon***	***Evening (or early the next morning)***
Where?	*Station 1*	*Proposed treatment location*	*Control - treated on final day*	*Location treated previous day*	*In plume***	*Same control location as morning*	*Shoreline (especially downwind shore)*
Secchi Transparency	●	●	●	●		●	
Profile: Temp/ DO	●	●	●	●		●	
Profile: Conductivity/ pH	●	●	●	●	●	●	
Alkalinity (core & bottom grab)	●	●	●	●	●	●	
Phytoplankton (core)	●						
Zooplankton (min. 5 tows)	●						
Total Phosphorus grabs (1, 3, 4, 5, 7, 9, 10, 11, 13)	●						
Total and dissolved Al (core & bottom grab)	●	●*		●*			
Chl-a (core)	●						
Sediment (3, composited)	●						
Fish & Aquatic Life	●	●	●	●	●	●	●
Floc evaluation with camera	(test camera day before treatment begins)				●		

* Aluminum sampling will occur within one treatment block per week. Sampling will happen before treatment and during treatment (day 1), then again 1, 2 & 3 days following treatment.

** Continuously during the first days, less frequently thereafter.

This monitoring plan was developed using the "Lake Auburn Alum Treatment Monitoring Plan" by Linda Bacon, ME DEP, 2019

7. MEASURABLE MILESTONES, INDICATORS & BENCHMARKS

The following section provides a list of interim, measurable milestones to measure progress in implementing management strategies outlined in the action plan (Table 10). These milestones are designed to help keep project partners on schedule. Additional criteria are outlined to measure the effectiveness of the plan by documenting loading reductions and changes in water quality over time and providing the means by which the steering committee can reflect on how well implementation efforts are working to reach established goals.


Collecting baseline data. (Photo: Brian Friedmann, GPA)

Environmental, social, and programmatic indicators and proposed benchmarks represent short-term (1-2 years), mid-term (2-5 years), and long-term (5-10 years) targets for improving the water quality in Georges Pond. The steering committee will review the criteria for each milestone annually to determine if progress is being made, and then determine if the watershed plan needs to be revised if water quality and loading reduction targets are not being met. This may include updating proposed management practices and the loading analysis, and/or reassessing the time it takes for phosphorus concentrations to respond to watershed planning actions.

Environmental Milestones are a direct measure of environmental conditions. They are measurable quantities used to evaluate the relationship between pollutant sources and environmental conditions. Table 12 (below) outlines the water quality benchmarks, and interim targets for improving water quality of Georges Pond over the next 10 years.

Table 12*. Water quality benchmarks and interim targets.*

Environmental Milestones			
Water Quality Benchmarks	***Interim Targets****		
	Years 1-2	*Years 3-5*	*Years 6-10*
a) Increase in average late summer epilimnetic water clarity (SDT) **Current:** 3.1 m **Goal:** 4.1 m	3.9 m *(▲0.8 m)*	4.0 m *(▲0.1 m)*	4.1 m *(▲0.1 m)*
b) Phosphorus loading reductions from both internal and external phosphorus sources **Current:** 120 – 190 kg/yr **Goal:** 90 kg P/yr (reduce by 100 kg P/yr	95 kg/yr *(▼ 95 kg/yr)*	92 kg/yr *(▼ 98 kg/yr)*	90 kg/yr *(▼ 100 kg/yr)*
c) Decrease in average in-lake total phosphorus concentration **Current:** 22 ppb **Goal:** 10 ppb	12 ppb *(▼ 10 ppb)*	11 ppb *(▼ 11 ppb)*	10 ppb *(▼ 12 ppb)*

** Benchmarks are cumulative unless otherwise noted. Years 1-2 (2020-2021); Years 3-5 (2022-2024); Years 6-10 (2025-2029)*

Social Milestones measure changes in social or cultural practices and behavior that lead to implementation of management measures and water quality improvements. Table 13 (below) outlines the social indicators, benchmarks and interim targets for the Georges Pond WBMP.

Table 13*. Social indicators, benchmarks, and interim targets.*

Social Milestones			
Indicators	***Benchmarks & Interim Targets****		
	Years 1-2	*Years 3-5*	*Years 6-10*
a) Number of NPS sites addressed by private landowners or cost-sharing grants **Goal:** 50 Sites	20 *(20 sites total)*	*15 sites* *(35 sites total)*	*15 sites* *(50 sites total)*
b) Number of LakeSmart site visits and new landowners participating (cumulative) **Goal:** 50% of landowners participating	15% of all shoreline properties	25% of all shoreline properties	50% of all shoreline properties
c) Pollutant load reductions as a result of watershed projects (external load) **Goal:** 3 kg P/yr	1 kg P/yr	1kg P/yr *(2 kg P total)*	1 kg P/yr *(3 kg P total)*

Social Milestones			
Indicators	***Benchmarks & Interim Targets****		
	Years 1-2	*Years 3-5*	*Years 6-10*
d) Number of property owners participating in the septic survey **Goal:** 50% of property owners	n/a	50%	n/a
e) Number of landowners upgrading their septic systems as a result of free septic evaluations and septic matching grants programs **Goal:** 30 evaluations and 10 septic upgrades	n/a	8 new upgrades *(8 total)*	2 new upgrades *(10 total)*
f) Number of planning board/selectman meetings attended to strengthen town ordinances and relationships with town officials **Goal:** 2 meetings/yr	4 meetings *(4 total)*	6 meetings *(10 total)*	10 meetings *(20 total)*
g) Increase in residential lakeshore property values as a result of improved water quality **Goal:** 10%	0%	5%	10%

** Benchmarks are cumulative unless otherwise noted. Years 1-2 (2020-2021); Years 3-5 (2022-2024); Years 6-10 (2025-2029)*

Programmatic Milestones are indirect measures of watershed protection and restoration activities. Rather than indicating that water quality reductions are being met, these programmatic measurements list actions intended to meet the water quality goal. Table 14 (below) outlines the programmatic indicators, benchmarks and interim targets for the Georges Pond WBMP.

***Table 14**. Programmatic indicators, benchmarks, and interim targets.*

Programmatic Milestones			
Indicators	***Benchmarks & Interim Targets****		
	(Years 1-2)	*(Years 3-5)*	*(Years 6-10)*
a) Number of acres treated with alum	131 acres	TBD	n/a
b) Number of NPS sites addressed **Goal:** 33 high priority sites	15 sites *(15 total)*	10 sites *(25 total)*	8 sites *(33 total)*
c) Number of Steering Committee Meetings **Goal:** 1 meeting/year	2 meetings (2 total)	3 meetings *(5 total)*	5 meetings *(10 total)*
d) Amount of funding raised for water quality projects **Goal:** $725,965	$400,000	$200,000 *($600,000 total)*	$125,965 *($725,965 total)*
e) Number of 319 projects to address high & medium impact sites **Goal:** 2 gravel road plans implemented, 3 town culvert projects completed, & 28 high priority residential residential sites addressed.	Phase I	Phase II	Phase III

** Benchmarks are cumulative unless otherwise noted. Years 1-2 (2020-2021); Years 3-5 (2022-2024); Years 6-10 (2025-2029)*

8. POLLUTANT LOAD REDUCTIONS & COST ESTIMATES

The following pollutant load reductions and costs were estimated for the next 10-year planning cycle based on six primary planning objectives outlined in the Action Plan:

Table 15. *Georges Pond planning objectives, P load reduction targets & cost.*

Planning Objective	Planning Action	P Load Reduction Target	Cost
1	**Address the Internal P Load** (Alum Treatment)	95 kg/yr	$276,465
2	**Address the External P Load** (NPS Sites, Septic Systems, LakeSmart, Education & Outreach)	3 kg/yr	$297,500
3	**Education, Outreach & communications** (public meetings, educational material distribution, websites and social media, & alum treatment community PR)	n/a	$4,000
4	**Prevent New Sources of NPS Pollution** (Land Conservation, Ordinances, Enforcement)	TBD	$3,500 - TBD
5	**Build Local Capacity** (Funding Plan, Steering Committee, Grant Writing)	n/a	$18,000
6	**Long-Term Monitoring & Assessment** (Baseline Monitoring, Stream Monitoring, Groundwater Monitoring, etc.)	n/a	$126,500
	TOTAL	**98 kg/yr**	**$725,965**

Actual pollutant load reductions will be documented as work is completed as outlined in this plan. This includes reductions for completed NPS sites to help demonstrate phosphorus and sediment load reductions as the result of BMP implementation. Pollutant loading reductions will be calculated using methods approved and recommended by Maine DEP and the US EPA and reported to Maine DEP for any work funded by 319 grants using an NPS site tracker.

9. PLAN OVERSIGHT AND PARTNER ROLES

Implementation of a ten-year watershed plan cannot be accomplished without the help of a central organization to oversee the plan, and a diverse and dedicated group of project partners and the public to support the various aspects of the plan. The following organizations will be critical to the plan's success and are ideal candidates for the watershed steering committee. The committee will need to meet annually to update the action plan, to evaluate the plan's success, and to determine if the water quality goal is being met.

Georges Pond Association (GPA) will serve as the designated entity for overseeing plan implementation and plan updates. GPA will provide project match as available, and work with a fundraising committee to raise funds from outside sources to support the plan.

Hancock County Soil & Water Conservation District (HCSWCD) may provide technical assistance, including engineering assistance for road projects, pollutant load reduction calculations, and sponsorship for grant funding.

Landowners & Road Associations will address NPS issues on their properties and provide a private source of matching funds by contributing to fundraising efforts and participating in watershed projects and LakeSmart.

Maine Department of Environmental Protection (Maine DEP) will provide watershed partners with ongoing guidance, technical assistance and resources, and the opportunity for financial assistance through the NPS grants program including the US EPA’s 319 grant program. Maine DEP will also serve on the steering committee.

Maine Lakes Society may provide support to the Georges Pond Association's LakeSmart Program Manager to evaluate and certify properties and provide LakeSmart signs for landowners meeting certification requirements.

Town of Franklin will serve on the watershed steering committee, and may provide funding for water quality monitoring, match for watershed restoration projects, and support for the CBI program. The town will also play a key role in addressing any documented NPS sites on town roads and municipal/public property and providing training and education for municipal employees.

US Environmental Protection Agency (US EPA) may provide Clean Water Act Section 319 funds and guidance.

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APPENDIX A. Georges Pond NPS Sites (Updated October 2019).

GEORGES POND NPS SITES (Updated October 2019)

Impact of NPS Sites: The impact rating is an indicator of how much soil and phosphorus erodes into the lake from a given site. Factors such as slope, soil type, amount and severity of eroding soil, and buffer size are considered. Generally, low impact sites are those with limited transport of soil off-site, medium impact sites exhibit sediment transportation off-site, but the erosion does not reach high magnitude, and high impact sites are those with large areas of significant erosion and direct flow to water.

Unique Site ID	LOCATION	LAND USE	Impact/ Priority	ISSUE	RECOMMENDATION
1	#128 Cousins Rd	Residential	High	Surface erosion, inadequate shoreline vegetation	Install runoff diverters and a rubber razor in driveway, define footpath to pond and add to buffer..
2	13 Spruce Circle	Residential (Steep Slope)	High		
3	184/186 GPR, M/L: 17-64,65 & 9-008. Bunker, Herklotz & Noyes	TOWN ROAD	High	Runoff from Noyes Wetland & Stream and town road flow directly through culvert, onto and across Herklotz & Bunker land, directly into pond. 15" metal bottom gone, too short, hanging.	New 36" x 38' culvert replacement w/ bottom buried
4	206/208GPR, M/L: 18-01,02 & 9-008. Stormwater: Shaw & Noyes (BBFld)	TOWN ROAD	High	Runoff from Noyes BBFld and town road flow directly through culvert, onto and across Shaw land, directly into pond. Possible erosion at outlet of the owners' culvert under his garage.	Improve ditching to inlet of C4
5	Bunker Field	TOWN ROAD	High	36" x 48 ' metal culvert failed, bottom plate gone, too short	42" w/ buried bottom, x 60'. Need to cut pavement.
6	Cousins Road - M/L 18-63,64,74 Stormwater: Erikson, Gray, Cousins et al.	PRIVATE ROAD	High	Private unimproved 600"+ woods road (Cousins) feeds significant stormwater onto and across Erikson land directly into pond.	

Unique Site ID	**LOCATION**	**LAND USE**	**Impact/ Priority**	**ISSUE**	**RECOMMENDATION**
7	Cousins Road, (off Rt. 200 Eastbrook Rd) in the blueberry fields at the intersection of 67 Cousins Rd (Dugas gravel road), Cousins Road to camps, and Georges Pond Rd (to Public Beach).	PRIVATE ROAD	High	Winter residents described a severe washout on 1/24/2019 below the blueberry fields at the intersection of Cousins Rd, Georges Pond Rd, and the road to the Dugas gravel pit from heavy rains and melting snow causing dramatic run-off. Water flowed off the blueberry fields on both sides of Cousins Rd. There was flow on the left side (as you head towards the Pond) above the rock pit at the intersection, as well as large pool of water that accumulated from the fields on the right side on the Dugas branch of the road. This pool eventually gave way and joining the other flow to create a 12"+ gulley coursing down Cousins Rd, and finding its way into the Pond (road gravel deposited onto the ice) at about lot 18-074 Winer, 116 Cousins Rd (or 18-074-01, Green, 108 Cousins Rd) TBConfirmed.	To make the road passable in the immediate near term, 3 loads of coarse stone were used to fill the deep ruts; the road was restored to grade, but not pitched (pitched road may have caused the washout). Will need to wait until the spring thaw to continue with further repair. Year-round residents say this washout is NOT a new occurrence, but it is the worst to-date.
8	Georges Pond Road (wooded section)	PRIVATE ROAD	High	Bad mud, erosion, road is ditch 1000' section. Barely passable during spring.	Option 1: cap road with 2" minus and leave it rough. Option 2: Gate end with EMS key and improve with base and surface gravel.
9	The Cousins Zone includes: A.) the upper section, running through four quadrants of blueberry fields.	PRIVATE ROAD	High	Complicated issue of whether "road stays as the acting ditch" or gets properly built. Need to examine drainage, add culverts and decide on surface material.	Rebuild Road with proper ditches, turnouts, and better surface material (phase I: Ditching and turnouts / Phase II: Road base, surface material, culverts)
10	B.) the lower section, running through the woods down as far as the low point at Pond	PRIVATE ROAD	High	Poor materials, turnouts full of sand – needs work determined by full plan.	Rebuild Road with proper ditches, turnouts, and better surface material (phase I: Ditching and turnouts / Phase II: Road base, surface material, culverts)
11	67 Cousins Rd (from shooting range downhill beyond intersection to ponded area on right	PRIVATE ROAD	High	Ponded water from fields near intersection, water not getting away from shoulders and ponding. Overtopping road in places during spring and big storms.	Ditch toward the back of the field to low spot allowing for water to move away from road. Add 6" pipe under road so ponded water moves toward new ditching. Install shoulder turnout across from shooting range road to get water away from shoulders.
12	2 Needle Point Road	Residential (Steep Slope)	High		
13	#358 GPR Rd	Residential (Steep Slope)	High	Surface, ditch, and roof runoff erosion	Install infiltration trench, establish buffer and re-seed bare areas

Unique Site ID	**LOCATION**	**LAND USE**	**Impact/ Priority**	**ISSUE**	**RECOMMENDATION**
14	Georges Pond Road (Erikson/Gray/Beyer Stretch)	PRIVATE ROAD	Medium/High	Road saturation is possible with standing water in new ditch at bottom of hill. Observe performance during 2019.	Possible 12" x 25' x-culvert with PP on lake side in new ditch. 50+' swale through woods between camps or 2nd 12" under driveway. Road saturation possible with standing water in new ditch at bottom of hill.
15	Fork from SSCR, and portion of road through pit within watershed.	PRIVATE ROAD	Medium/High	Will require a Road Plan and a revisit to fully assess	Potential road work, possible major rebuilds, BMP work with pit & camps. Include in SSCR Road Mgmt. Plan.
16	SSCR beyond Bert's Dirt pit	PRIVATE ROAD	Medium/High	Will require a Road Plan and a revisit to fully assess	Turnouts, Culverts, Shaping, Surface Gravel
17	Between 153-154 South Shore Colony Rd. (Bellai / Feezel)	PRIVATE ROAD	Medium	Slight surface erosion, clogged, undersized, unstable culvert	Replace culvert with longer and larger diameter pipe and armor ends with riprap, also resurface road with gravel
18	#136 South Shore Colony Rd.	Residential (Driveway)	Medium	Clogged, undersized culvert under driveway, moderate ditch erosion	Lengthen culvert and stabilize ends with riprap, remove sediment from ditch and install sediment pools.
19	near 136 South Shore Colony Rd.	PRIVATE ROAD	Medium	Clogged, undersized culvert under driveway, moderate ditch erosion	Lengthen culvert and stabilize ends with riprap, remove sediment from ditch and install sediment pools
20	near 136 South Shore Colony Rd.	PRIVATE ROAD	High	Private association road channels collective runoff to a culvert and across lot 17-015 into pond	
21	#21 Bunkers Beach Rd.	Residential	Medium	Bare soil and lack of shoreline vegetation	Vegetate bare fill next to marsh/stream and establish vegetated buffer
22	#18 Cove Rd	Residential	Medium	Slight surface erosion, undercut shoreline, inadequate shoreline vegetation	Stabilize or remove pile of soil and stabilize exposed soil with mulch, augment vegetated buffer and re-seed thin areas
23	#122 Cousins Rd	Residential	Medium	Inadequate shoreline vegetation	
24	#162 GPR Rd	Residential	Medium	Moderate surface erosion from bare soil and uncovered pile of soil	Install temporary erosion controls such as mulch and/or silt fence and maintain until site is permanently stabilized
25	#166 GPR Rd	Residential	Medium	Bare driveway	Install culvert on adjacent GPR, install turnouts and reshape (crown) driveway

Unique Site ID	**LOCATION**	**LAND USE**	**Impact/ Priority**	**ISSUE**	**RECOMMENDATION**
26	#190 GPR Rd	Residential	Medium	Bare soil, surface erosion	Install runoff diverter and stabilize bare soil with mulch, establish buffer
27	#198 GPR Rd	Residential	Medium	Bare soil, severe surface erosion	Reshape and crown dirt driveway, install runoff diverters
28	Sweet Fern Rd.	Residential	Medium	Exposed soil - surface erosion	Establish vegetated buffer
29	#322 GPR Rd	Residential	Medium	Inadequate shoreline vegetation	Stabilize bank and add to existing shoreline buffer
30	#324 GPR Rd	Residential	Medium	Sheet flow over open area to pond	Install runoff diverter and stabilize bare soil with mulch
31	#330 GPR Rd	Residential	Medium	Shoreline erosion, unstable access	Define and stabilize footpath to pond and establish shoreline buffer
32	#332 GPR Rd	Residential	Medium	Surface and shoreline erosion	Stabilize shoreline by establishing vegetated buffer
33	#370 GPR Rd	Residential	Medium	Dirt driveway shoulder erosion, undercut shoreline, unstable access	Minimize boat launch area, install broad based dip in dirt driveway
34	#372 GPR Rd	Residential	Medium	Surface erosion, undercut shoreline	re-seed bare areas, stabilize shoreline
35	#5 Fir Spur	Residential	Medium	Undercut shoreline and lack of shoreline vegetation	Define footpath, add to buffer
36	#3 Fir Spur	Residential	Medium	Undercut shoreline and lack of shoreline vegetation	Set mower cutting height higher, install waterbar in driveway, add to buffer
37	#116 Cousins Rd	Residential	Medium	Inadequate shoreline vegetation	Add to Buffer
38	#6 Clean Sweep Rd	Residential (Steep Slope)	Medium	Surface and shoreline erosion, undercut bank	Establish buffer, re-seed bare soil/thin areas, install waterbar and stabilize footpath
39	#337 GPR Rd	Residential (Steep Slope)	Medium	shoreline erosion with undercutting	Limit foot traffic and dock storage footprint to allow vegetation to regenerate. Use mulch and/or add to buffer to control erosion.
40	#54 Peters Rd. (350 GP Rd?)	Residential (Steep Slope)	Medium	Moderate surface and roof runoff erosion	Install drywell and gutter downspout to address roof runoff, add to buffer
41	#5 Peters Ln (352 GP Rd?)	Residential (Steep Slope)	Medium	Bare soil, moderate surface erosion	Add to buffer and re-seed bare & thin areas

Unique Site ID	LOCATION	LAND USE	Impact/ Priority	ISSUE	RECOMMENDATION
42	Extension of South Shore Colony Rd	PRIVATE ROAD	Medium	Will require a Road Plan and a revisit to fully assess	2 loads of surface gravel and 6” pipe 40’+ culvert
43	SSCR - Commercial Gravel Pit	Gravel Pit	Low	Externally drained gravel pit, runoff toward pond	redirect and/or contain runoff from pit
44	Clean Sweep Road	PRIVATE ROAD	Low	Moderate surface erosion from bare soil	Tilt road towards forested area, resurface road with gravel, install runoff diverters
45	Head of South Shore Colony Rd. ?"Berts Dirt" FORK? Stormwater	PRIVATE ROAD	Low	Slight surface erosion, unstable, undersized culvert(s), eroding ditch	Lengthen culvert and stabilize ends with riprap, install plunge poll, add gravel to road surface and reshape (crown)
46	8 Needle Point Lane	Residential	Low	Bare soil, roof runoff erosion, undercut shoreline (shared by two adjacent properties)	Install infiltration trench & roof dripline
47	9 Needle Point Ln	Residential	Low	Bare soil, roof runoff erosion, undercut shoreline (shared by two adjacent properties)	Install water bar diverter, install infiltration trench & roof dripline, and spread mulch/erosion control mix over bare areas
48	#132 South Shore Colony Rd.	Residential	Low	Lack of shoreline vegetation	Establish Buffer
49	#144 South Shore Colony Rd	Residential	Low	Inadequate shoreline vegetation	Establish buffer
50	#164 South Shore Colony Rd.	Residential	Low	Bare soil	Stabilize exposed soil with mulch/erosion control mix
51	#29 Cove Rd	Residential	Low	Lack of shoreline vegetation	Establish Buffer
52	#28 Cove Rd.	Residential	Low	Bare soil	Minimize parking area and establish buffer
53	#17 Cove Rd	Residential	Low	Inadequate shoreline vegetation	Establish Buffer
54	#17 Cove Rd	PRIVATE ROAD	Low	Unstable/undersized culvert	Lengthen Culvert and stabilize ends with riprap
55	#35 Bunkers Beach Rd	Residential	Low	Inadequate shoreline vegetation	Establish vegetated buffer

Unique Site ID	**LOCATION**	**LAND USE**	**Impact/ Priority**	**ISSUE**	**RECOMMENDATION**
56	#200 GPR Rd	Residential	Low	Slight surface erosion, inadequate shoreline vegetation	Establish vegetated buffer where none exists and augment existing buffer
57	#206 GPR Rd	Residential	Low	Undercut shoreline and lack of shoreline vegetation	Set mower cutting height higher, add to buffer
58	#208 GPR Rd	Residential	Low	Unstable pile of soil adjacent to pond	Relocate pile of soil to a better location and stabilize, re-vegetate disturbed area where pile currently is located
59	#11 Brenton Ln	Residential	Low	Unstable driveway	Vegetate bare soil
60	#15 Frost Ln	Residential	Low	Slight surface erosion from unstable soil	Establish vegetated buffer
61	#5 Outlet Rd	Residential	Low	Bare soil adjacent to pond	Install runoff diverter and stabilize bare soil with mulch
62	#326 GPR Rd	Residential	Low	Sheet flow over open area to pond	Install runoff diverter and stabilize bare soil with mulch
63	#328 GPR Rd	Residential	Low	Slight surface erosion	Define and stabilize footpath to pond and establish shoreline buffer
64	#364 GPR Rd	Residential	Low	Surface erosion, undercut shoreline	Address roof runoff by installing a rain barrel, clean gutters, stabilize shoreline
65	#108 Cousins Rd	Residential	Low	Undercut shoreline	Remove hanging trees (keep the root wads) and add to buffer
66	#18 Sweet Fern Rd.	Residential (Steep Slope)	Low	Lack of shoreline vegetation	Define and stabilize footpath to pond; Establish Buffer
67	#354 GPR Rd	Residential (Steep Slope)	Low	Moderate surface erosion	Add to buffer
68	#168 GPR Rd (next to) abutting Jordan, Joe & Diane	TOWN ROAD	Low	Winter sand	Install sediment pools in ditch, remove snowplow berms from road surface and build up road surface
69	GPR at outlet; Public Beach/Ramp, M/L: 18-051	TOWN: Public Beach/Boat Launch	Low	No defined boat launch, boats launched randomly on beach, disrupting area	Define and stabilize boat launching area to keep vehicles off beach

Unique Site ID	LOCATION	LAND USE	Impact/ Priority	ISSUE	RECOMMENDATION
70	Fur Spur or Spruce Circle? - entire "Length of road" (most likely in 18-062/18-063 area based on site/sector noted)	PRIVATE ROAD	n/a	Moderate road surface and road shoulder erosion	Reshape and crown road, install turnouts
71	120 Cousins Rd (BETWEEN 18-074/17-001)	Residential	n/a		
72	224/226 GPR, M/L 18-08,09 zone Function Unclear / high invert upland	TOWN ROAD	n/a	Hanging culvert, draining wetland away from GP watershed (Not 319 eligible). Not armored, incorrect pitch for draining as intended, too long.	Replace and reset culvert
73	242 GPR zone, M/L: 18-13,14 zone	TOWN ROAD	n/a	Draining wetland away from GP watershed (Not 319 eligible). 18" metal culvert, not armored, 1/2 full of sediment, bottom plate gone.	Clean out and add inlet/outlet protection (armoring) - Not 319 eligible
74	166/168 GPR: M/L: 17-55,56 & 9-008. Stormwater: Jordan&Bunker, & Noyes (BBFld)	TOWN/STREAM/ WETLAND	n/a	Wetland Stream flow Runoff from Beaver Wetland & Stream and town road flow directly through (stone) culvert, onto and across Bunker & Jordan land, directly into pond. 2019 Assessment: Granite Arch, w/ live bottom, good shape, no project needed.	None required in 2019 - recheck at later date

APPENDIX B. Options for Control of Algae and Floating Plants (Adapted from Wagner 2001).

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
WATERSHED CONTROLS			
1) Management for nutrient input reduction	♦ Includes wide range of watershed and lake edge activities intended to eliminate nutrient sources or reduce delivery to lake ♦ Essential component of algal control strategy where internal recycling is not the dominant nutrient source, and desired even where internal recycling is important	♦ Acts against the original source of algal nutrition ♦ Creates sustainable limitation on algal growth ♦ May control delivery of other unwanted pollutants to lake ♦ Facilitates ecosystem management approach which considers more than just algal control	♦ May involve considerable lag time before improvement observed ♦ May not be sufficient to achieve goals without some form of in-lake management ♦ Reduction of overall system fertility may impact fisheries ♦ May cause shift in nutrient ratios which favor less desirable algae
1a) Point source controls	♦ More stringent discharge requirements ♦ May involve diversion ♦ May involve technological or operational adjustments ♦ May involve pollution prevention plans	♦ Often provides major input reduction ♦ Highly efficient approach in most cases ♦ Success easily monitored	♦ May be very expensive in terms of capital and operational costs ♦ May transfer problems to another watershed ♦ Variability in results may be high in some cases
1b) Non-point source controls	♦ Reduction of sources of nutrients ♦ May involve elimination of land uses or activities that release nutrients ♦ May involve alternative product use, as with no phosphate fertilizer	♦ Removes source ♦ Limited ongoing costs	♦ May require purchase of land or activity ♦ May be viewed as limitation of “quality of life” ♦ Usually requires education and gradual implementation
1c) Non-point source pollutant trapping	♦ Capture of pollutants between source and lake ♦ May involve drainage system alteration ♦ Often involves wetland treatments (det./infiltration) ♦ May involve storm water collection and treatment as with point sources	♦ Minimizes interference with land uses and activities ♦ Allows diffuse and phased implementation throughout watershed ♦ Highly flexible approach ♦ Tends to address wide range of pollutant loads	♦ Does not address actual sources ♦ May be expensive on necessary scale ♦ May require substantial maintenance

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
IN-LAKE PHYSICAL CONTROLS			
2) Circulation and destratification	♦ Use of water or air to keep water in motion ♦ Intended to prevent or break stratification ♦ Generally driven by mechanical or pneumatic force	♦ Reduces surface build-up of algal scums ♦ May disrupt growth of blue-green algae ♦ Counteraction of anoxia improves habitat for fish/invertebrates ♦ Can eliminate localized problems without obvious impact on whole lake	♦ May spread localized impacts ♦ May lower oxygen levels in shallow water ♦ May promote downstream impacts
3) Dilution and flushing	♦ Addition of water of better quality can dilute nutrients ♦ Addition of water of similar or poorer quality flushes system to minimize algal build-up ♦ May have continuous or periodic additions	♦ Dilution reduces nutrient concentrations without altering load ♦ Flushing minimizes detention; response to pollutants may be reduced	♦ Diverts water from other uses ♦ Flushing may wash desirable zooplankton from lake ♦ Use of poorer quality water increases loads ♦ Possible downstream impacts
4) Drawdown	♦ Lowering of water over autumn period allows oxidation, desiccation and compaction of sediments ♦ Duration of exposure and degree of dewatering of exposed areas are important ♦ Algae are affected mainly by reduction in available nutrients.	♦ May reduce available nutrients or nutrient ratios, affecting algal biomass and composition ♦ Opportunity for shoreline clean-up/structure repair ♦ Flood control utility ♦ May provide rooted plant control as well	♦ Possible impacts on non-target resources ♦ Possible impairment of water supply ♦ Alteration of downstream flows and winter water level ♦ May result in greater nutrient availability if flushing inadequate
5) Dredging	♦ Sediment is physically removed by wet or dry excavation, with deposition in a containment area for dewatering ♦ Dredging can be applied on a limited basis, but is most often a major restructuring of a severely impacted system ♦ Nutrient reserves are removed, and algal	♦ Can control algae if internal recycling is main nutrient source ♦ Increases water depth ♦ Can reduce pollutant reserves ♦ Can reduce sediment oxygen demand ♦ Can improve spawning habitat for many fish species ♦ Allows complete renovation of aquatic ecosystem	♦ Temporarily removes benthic invertebrates ♦ May create turbidity ♦ May eliminate fish community (complete dry dredging only) ♦ Possible impacts from containment area discharge ♦ Possible impacts from dredged material disposal

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
	growth can be limited by nutrient availability		♦ Interference with recreation or other uses during dredging
5a) "Dry" excavation	♦ Lake drained or lowered to maximum extent practical ♦ Target material dried to maximum extent possible ♦ Conventional excavation equipment used to remove sediments	♦ Tends to facilitate a very thorough effort ♦ May allow drying of sediments prior to removal ♦ Allows use of less specialized equipment	♦ Eliminates most aquatic biota unless a portion left undrained ♦ Eliminates lake use during dredging
5b) "Wet" excavation	♦ Lake level may be lowered, but sediments not substantially exposed ♦ Draglines, bucket dredges, or long-reach backhoes used to remove sediment	♦ Requires least preparation time or effort, tends to be least cost dredging approach ♦ May allow use of easily acquired equipment ♦ May preserve aquatic biota	♦ Usually creates extreme turbidity ♦ Normally requires intermediate containment area to dry sediments prior to hauling ♦ May disrupt ecological function ♦ Use disruption
5c) Hydraulic removal	♦ Lake level not reduced ♦ Suction or cutterhead dredges create slurry which is hydraulically pumped to containment area ♦ Slurry is dewatered; sediment retained; water discharged	♦ Creates minimal turbidity and impact on biota ♦ Can allow some lake uses during dredging ♦ Allows removal with limited access or shoreline disturbance	♦ Often leaves some sediment behind ♦ Cannot handle coarse or debris-laden materials ♦ Requires sophisticated and more expensive containment area
6) Light-limiting dyes and surface covers	♦ Creates light limitation	♦ Creates light limit on algal growth without high turbidity or great depth ♦ May achieve some control of rooted plants as well	♦ May cause thermal stratification in shallow ponds ♦ May facilitate anoxia at sediment interface with water
6.a) Dyes	♦ Water-soluble dye is mixed with lake water, thereby limiting light penetration and inhibiting algal growth ♦ Dyes remain in solution until washed out of system.	♦ Produces appealing color ♦ Creates illusion of greater depth	♦ May not control surface bloom-forming species ♦ May not control growth of shallow water algal mats ♦ Altered thermal regime
6.b) Surface covers	♦ Opaque sheet material applied to water surface	♦ Minimizes atmospheric and wildlife pollutant inputs	♦ Minimizes atmospheric gas exchange ♦ Limits recreation

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
7) Mechanical removal	♦ Filtering of pumped water for water supply purposes ♦ Collection of floating scums or mats with booms, nets, or other devices ♦ Continuous or multiple applications per year usually needed	♦ Algae and associated nutrients can be removed from system ♦ Surface collection can be applied as needed ♦ May remove floating debris ♦ Collected algae dry to minimal volume	♦ Filtration requires high backwash and sludge handling capability ♦ Labor and/or capital intensive ♦ Variable collection efficiency ♦ Possible impacts on non-target aquatic life
8) Selective withdrawal	♦ Discharge of bottom water which may contain (or be susceptible to) low oxygen and higher nutrient levels ♦ May be pumped or utilize passive head differential	♦ Removes targeted water from lake efficiently ♦ May prevent anoxia and phosphorus build up in bottom water ♦ May remove initial phase of algal blooms which start in deep water ♦ May create coldwater conditions downstream	♦ Possible downstream impacts of poor water quality ♦ May promote mixing of remaining poor-quality bottom water with surface waters ♦ May cause unintended drawdown if inflows do not match withdrawal
9) Sonication	♦ Sound waves disrupt algal cells	♦ Supposedly affects only algae (new technique) ♦ Applicable in localized areas	♦ Unknown effects on non-target organisms ♦ May release cellular toxins or other undesirable contents into water column
10) Hypolimnetic aeration or oxygenation	♦ Addition of air or oxygen provides oxic conditions ♦ Maintains stratification ♦ Can also withdraw water, oxygenate, then replace	♦ Oxic conditions reduce P availability ♦ Oxygen improves habitat ♦ Oxygen reduces build-up of reduced cpds	♦ May disrupt thermal layers important to fish community ♦ Theoretically promotes supersaturation with gases harmful to fish
IN-LAKE CHEMICAL CONTROLS			
11) Algaecides	♦ Liquid or pelletized algaecides applied to target area ♦ Algae killed by direct toxicity or metabolic interference ♦ Typically requires application at least once/yr, often more frequently	♦ Rapid elimination of algae from water column, normally with increased water clarity ♦ May result in net movement of nutrients to bottom of lake	♦ Possible toxicity to non-target species ♦ Restrictions on water use for varying time after treatment ♦ Increased oxygen demand and possible toxicity ♦ Possible recycling of nutrients

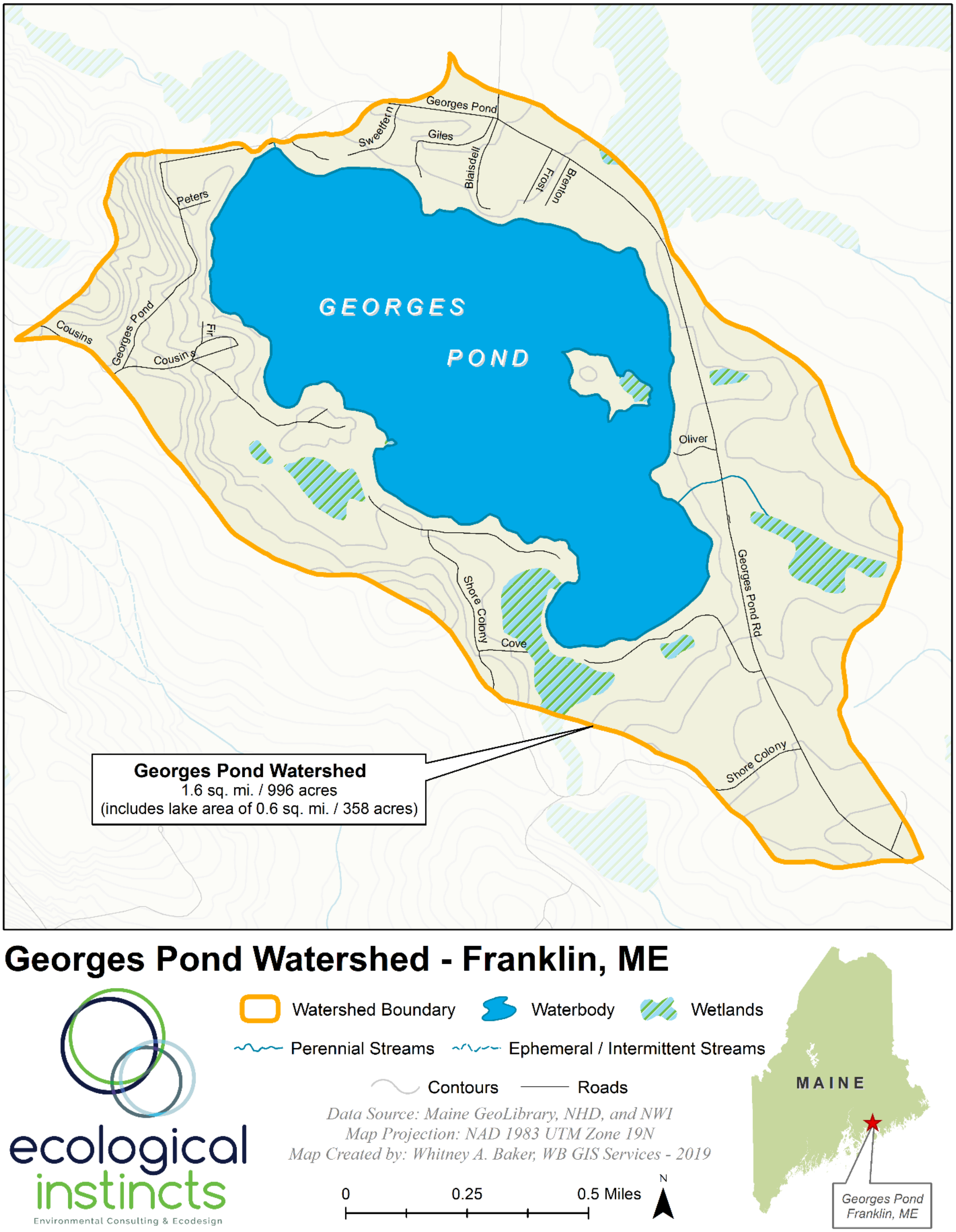
OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
11a) Forms of copper	♦ Cellular toxicant, disruption of membrane transport ♦ Applied as wide variety of liquid or granular formulations	♦ Effective and rapid control of many algae species ♦ Approved for use in most water supplies	♦ Possible toxicity to aquatic fauna ♦ Accumulation of copper in system ♦ Resistance by certain green and blue-green nuisance species ♦ Lysing of cells releases nutrients and toxins
11b) Peroxides	♦ Disrupts most cellular functions, tends to attack membranes ♦ Applied as a liquid or solid. ♦ Typically requires application at least once/yr, often more frequently	♦ Rapid action ♦ Oxidizes cell contents, may limit oxygen demand and toxicity	♦ Much more expensive than copper ♦ Limited track record ♦ Possible recycling of nutrients
11c) Synthetic organic algaecides	♦ Absorbed or membrane-active chemicals which disrupt metabolism ♦ Causes structural deterioration	♦ Used where copper is ineffective ♦ Limited toxicity to fish at recommended dosages ♦ Rapid action	♦ Non-selective in treated area ♦ Toxic to aquatic fauna (varying degrees by formulation) ♦ Time delays on water use
12) Phosphorus inactivation	♦ Typically salts of aluminum, iron or calcium are added to the lake, as liquid or powder ♦ Phosphorus in the treated water column is complexed and settled to the bottom of the lake ♦ Phosphorus in upper sediment layer is complexed, reducing release from sediment ♦ Permanence of binding varies by binder in relation to redox potential and pH	♦ Can provide rapid, major decrease in phosphorus concentration in water column ♦ Can minimize release of phosphorus from sediment ♦ May remove other nutrients and contaminants as well as phosphorus ♦ Flexible with regard to depth of application and speed of improvement	♦ Possible toxicity to fish and invertebrates, especially by aluminum at low pH ♦ Possible release of phosphorus under anoxia or extreme pH ♦ May cause fluctuations in water chemistry, especially pH, during treatment ♦ Possible resuspension of floc in shallow areas ♦ Adds to bottom sediment, but typically an insignificant amount

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
13) Sediment oxidation	♦ Addition of oxidants, binders and pH adjustors to oxidize sediment ♦ Binding of phosphorus is enhanced ♦ Denitrification is stimulated	♦ Can reduce phosphorus supply to algae ♦ Can alter N:P ratios in water column ♦ May decrease sediment oxygen demand	♦ Possible impacts on benthic biota ♦ Longevity of effects not well known ♦ Possible source of nitrogen for blue-green algae
14) Settling agents	♦ Closely aligned with phosphorus inactivation, but can be used to reduce algae directly too ♦ Lime, alum or polymers applied, usually as a liquid or slurry ♦ Creates a floc with algae and other suspended particles ♦ Floc settles to bottom of lake ♦ Re-application typically necessary at least once/yr	♦ Removes algae and increases water clarity without lysing most cells ♦ Reduces nutrient recycling if floc sufficient ♦ Removes non-algal particles as well as algae ♦ May reduce dissolved phosphorus levels at the same time	♦ Possible impacts on aquatic fauna ♦ Possible fluctuations in water chemistry during treatment ♦ Resuspension of floc possible in shallow, well-mixed waters ♦ Promotes increased sediment accumulation
15) Selective nutrient addition	♦ Ratio of nutrients changed by additions of selected nutrients ♦ Addition of non-limiting nutrients can change composition of algal community ♦ Processes such as settling, and grazing can then reduce algal biomass	♦ Can reduce algal levels where control of limiting nutrient not feasible ♦ Can promote non-nuisance forms of algae ♦ Can improve productivity of system without increased standing crop of algae	♦ May result in greater algal abundance through uncertain biological response ♦ May require frequent application to maintain desired ratios ♦ Possible downstream effects
IN-LAKE BIOLOGICAL CONTROLS			
16) Enhanced grazing	♦ Manipulation of biological components of system to achieve grazing control over algae ♦ Typically involves alteration of fish community to promote growth of grazing zooplankton	♦ May increase water clarity by changes in algal biomass or cell size without reduction of nutrient levels ♦ Can convert unwanted algae into fish ♦ Harnesses natural processes	♦ May involve introduction of exotic species ♦ Effects may not be controllable or lasting ♦ May foster shifts in algal composition to even fewer desirable forms
16.a) Herbivorous fish	♦ Stocking of fish that eat algae	♦ Converts algae directly into potentially harvestable fish	♦ Typically requires introduction of non-native species

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
		♦ Grazing pressure can be adjusted through stocking rate	♦ Difficult to control over long term ♦ Smaller algal forms may be benefited and bloom
16.b) Herbivorous zooplankton	♦ Reduction in planktivorous fish to promote grazing pressure by zooplankton ♦ May involve stocking piscivores or removing planktivores ♦ May also involve stocking zooplankton or establishing refugia	♦ Converts algae indirectly into harvestable fish ♦ Zooplankton response to increasing algae can be rapid ♦ May be accomplished without introduction of non-native species ♦ Generally compatible with most fishery management goals	♦ Highly variable response expected; temporal and spatial variability may be high ♦ Requires careful monitoring and management action on 1-5 yr basis ♦ Larger or toxic algal forms may be benefitted and bloom
17) Bottom-feeding fish removal	♦ Removes fish that browse among bottom deposits, releasing nutrients to the water column by physical agitation and excretion	♦ Reduces turbidity and nutrient additions from this source ♦ May restructure fish community in more desirable manner	♦ Targeted fish species are difficult to control ♦ Reduction in fish populations valued by some lake users (human/non-human)
18) Microbial competition	♦ Addition of microbes, often with oxygenation, can tie up nutrients and limit algal growth ♦ Tends to control N more than P	♦ Shifts nutrient use to organisms that do not form scums or impair uses to same extent as algae ♦ Harnesses natural processes ♦ May decrease sediment	♦ Minimal scientific evaluation ♦ N control may still favor cyanobacteria ♦ May need aeration system to get acceptable results
19) Pathogens	♦ Addition of inoculum to initiate attack on algal cells ♦ May involve fungi, bacteria or viruses	♦ May create lakewide "epidemic" and reduction of algal biomass ♦ May provide sustained control through cycles ♦ Can be highly specific to algal group or genera	♦ Largely experimental approach at this time ♦ May promote resistant nuisance forms ♦ May cause high oxygen demand or release of toxins by lysed algal cells ♦ Effects on non-target organisms uncertain
20) Competition and allelopathy by plants	♦ Plants may tie up sufficient nutrients to limit algal growth ♦ Plants may create a light limitation on algal growth	♦ Harnesses power of natural biological interactions ♦ May provide responsive and prolonged control	♦ Some algal forms appear resistant ♦ Use of plants may lead to problems with vascular plants ♦ Use of plant material may cause

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
	♦ Chemical inhibition of algae may occur through substances released by other organisms		depression of oxygen levels
20a) Plantings for nutrient control	♦ Plant growths of sufficient density may limit algal access to nutrients ♦ Plants can exude allelopathic substances which inhibit algal growth ♦ Portable plant “pods”, floating islands, or other structures can be installed	♦ Productivity and associated habitat value can remain high without algal blooms ♦ Can be managed to limit interference with recreation and provide habitat ♦ Wetland cells in or adjacent to the lake can minimize nutrient inputs	♦ Vascular plants may achieve nuisance densities ♦ Vascular plant senescence may release nutrients and cause algal blooms ♦ The switch from algae to vascular plant domination of a lake may cause unexpected or undesirable changes
20b) Plantings for light control	♦ Plant species with floating leaves can shade out many algal growths at elevated densities	♦ Vascular plants can be more easily harvested than most algae ♦ Many floating species provide waterfowl food	♦ Floating plants can be a recreational nuisance ♦ Low surface mixing and atmospheric contact promote anoxia
20c) Addition of barley straw	♦ Input of barley straw can set off a series of chemical reactions which limit algal growth ♦ Release of allelopathic chemicals can kill algae ♦ Release of humic substances can bind phosphorus	♦ Materials and application are relatively inexpensive ♦ Decline in algal abundance is more gradual than with algaecides, limiting oxygen demand and the release of cell contents	♦ Success appears linked to uncertain and potentially uncontrollable water chemistry factors ♦ Depression of oxygen levels may result ♦ Water chemistry may be altered in other ways unsuitable for non-target organisms

APPENDIX C. WATERSHED MAPS



Georges Pond Watershed - Franklin, ME

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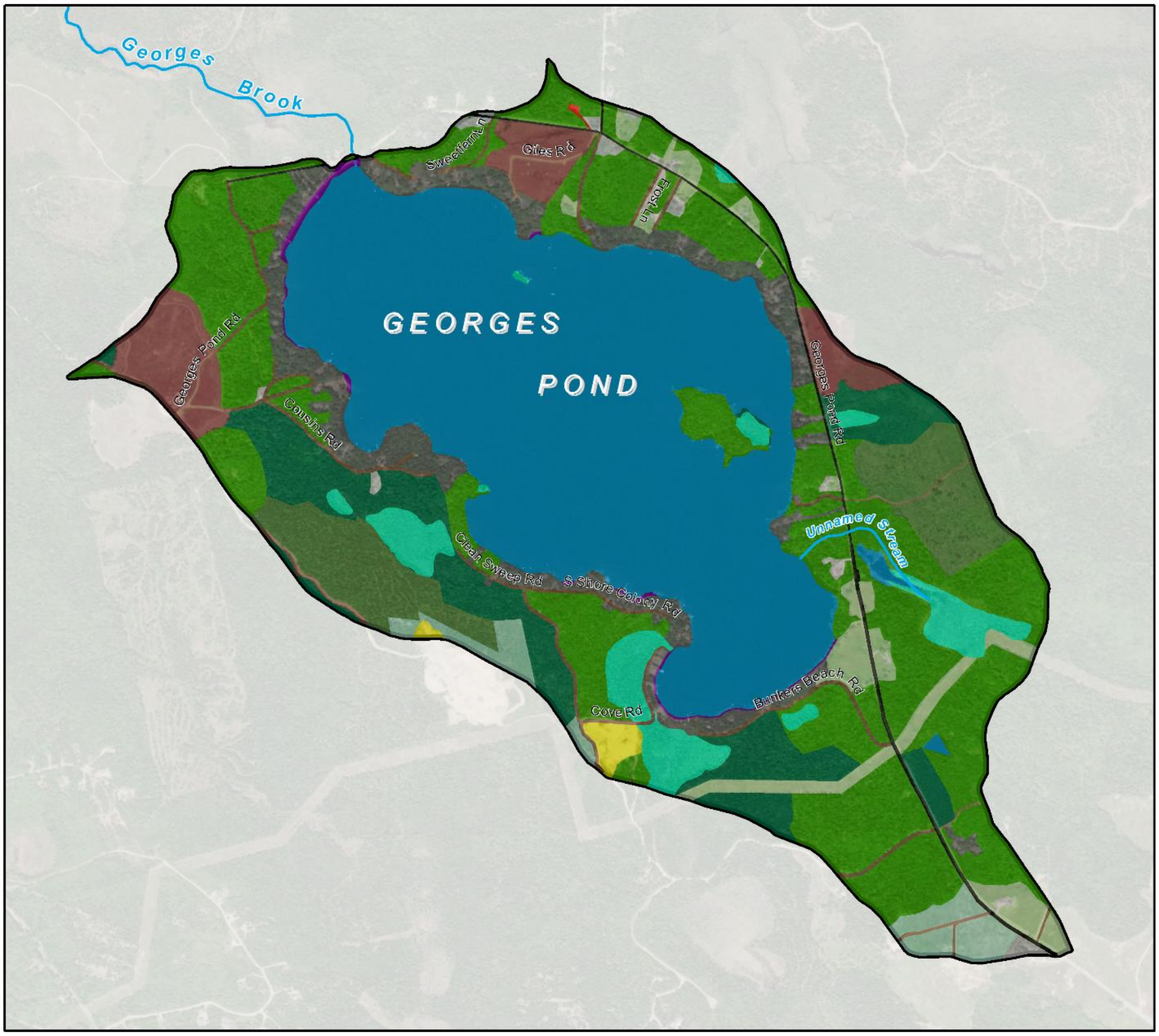
Data Source: Maine GeoLibrary, NHD, and NWI
Map Projection: NAD 1983 UTM Zone 19N
Map Created by: Whitney A. Baker, WB GIS Services - 2019



Georges Pond Watershed - Land Cover Map

⬜ Low-Density/Non-shoreline Res Dev	🟦 Clearing/Meadow
⬜ Shoreline Residential Development	🟥 Construction/Excavation
⬛ Roads	🟨 Gravel Pits
🟫 Blueberry Fields	🟩 Logging & Forestry
🟪 Unconsolidated Shoreline	🟫 Unpaved Road
🟩 Mixed Forest	🟦 Open Water
🟩 Non-deciduous	🟦 Wetland
🟩 Open Space/Mowed	

0 0.25 0.5 Miles N

Source: Maine GeoLibrary, NHD & NWI
Projection: NAD 1983 UTM Zone 19N
Map Created by: W. Baker, Ecological Instincts - 2019
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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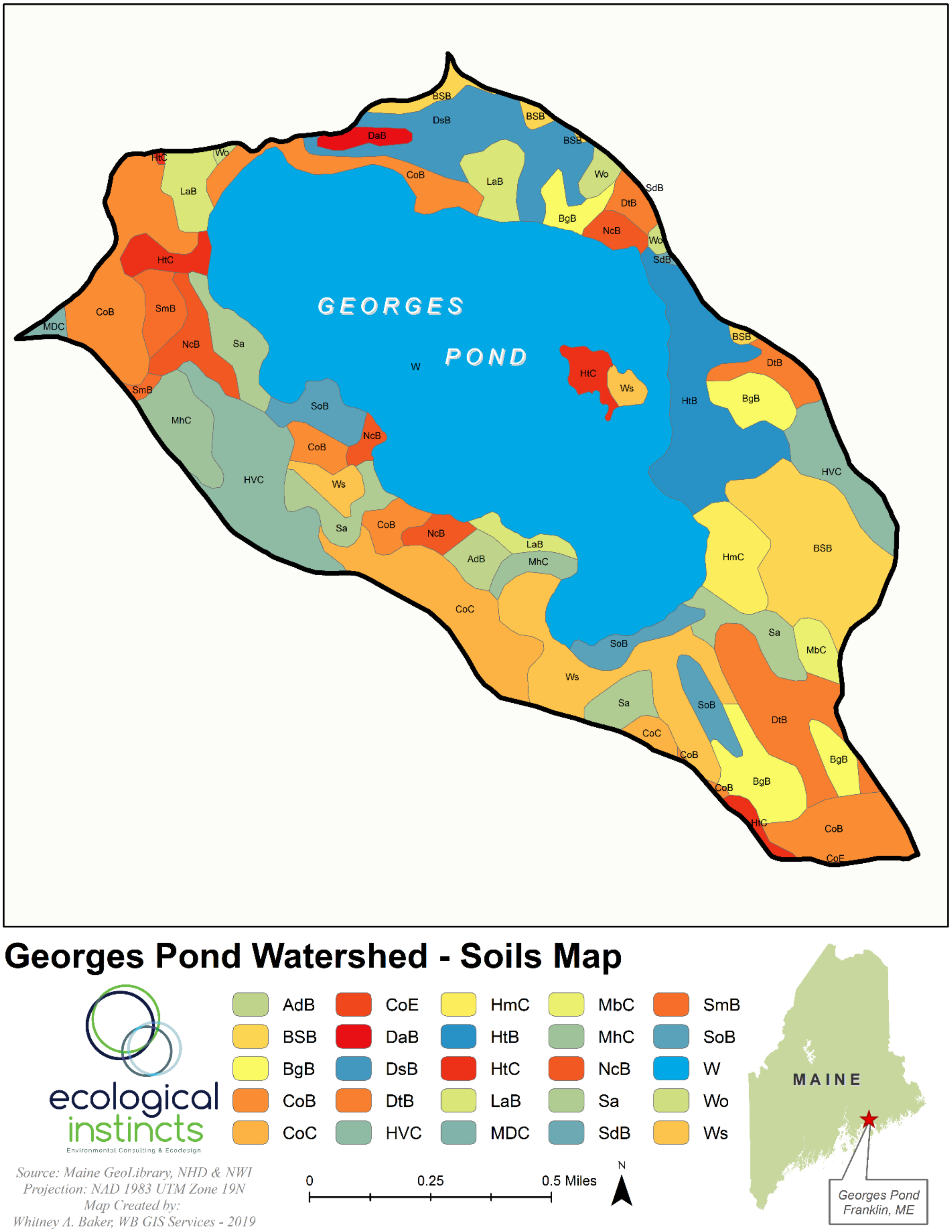
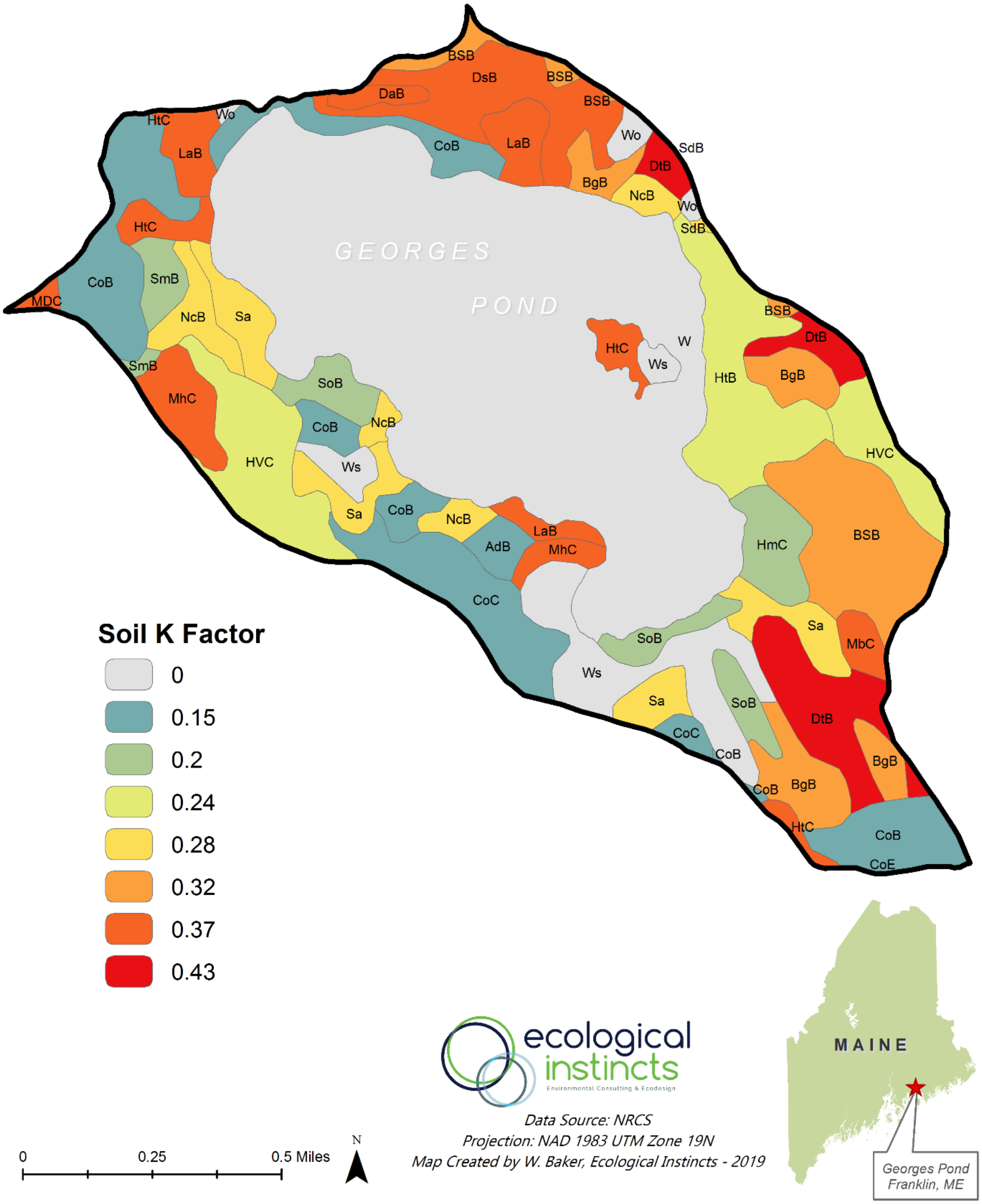


Georges Pond Watershed - Soils Map

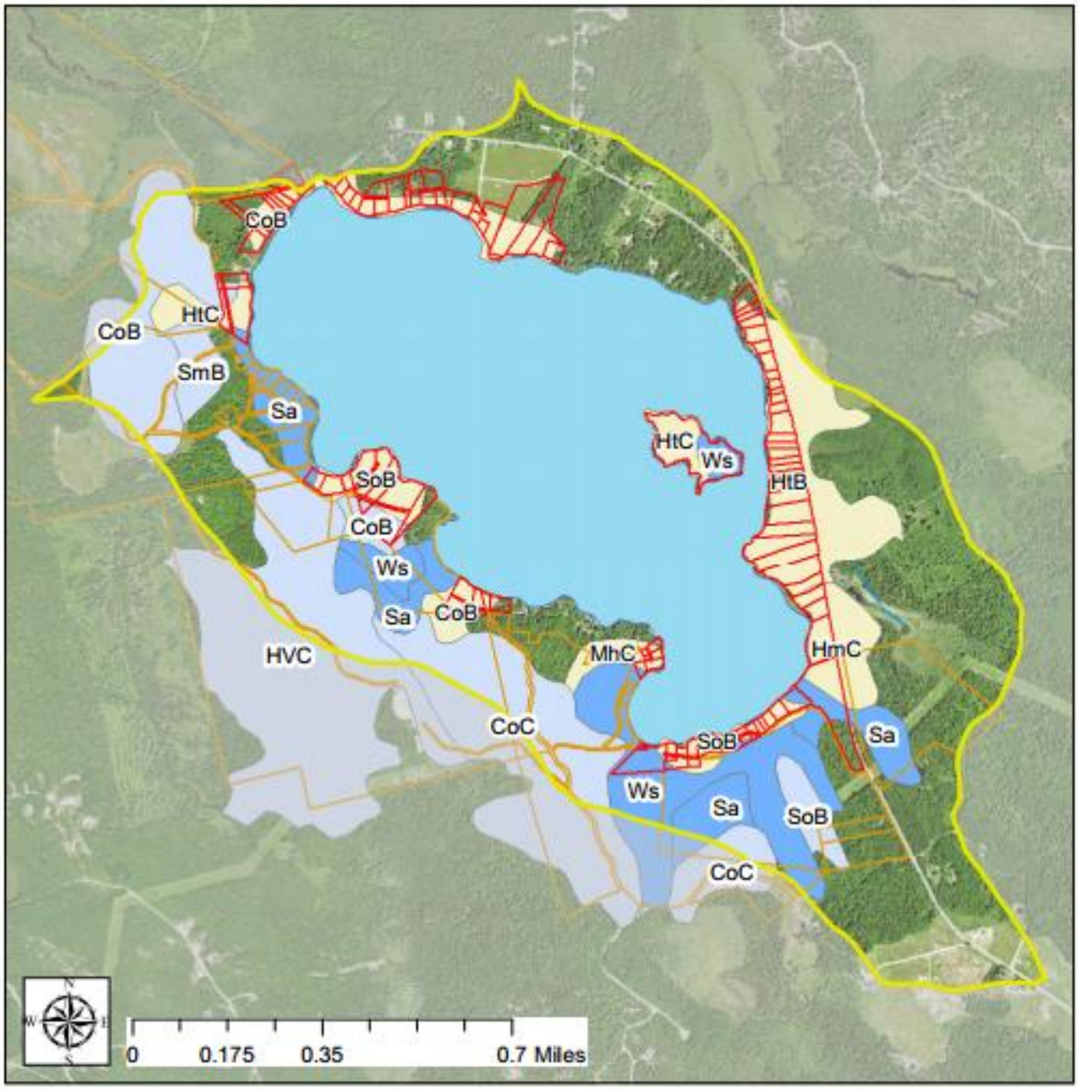
Source: Maine GeoLibrary, NHD & NWI
Projection: NAD 1983 UTM Zone 19N
Map Created by:
Whitney A. Baker, WB GIS Services - 2019

Georges Pond Watershed - Soil K Factor



Data Source: NRCS
Projection: NAD 1983 UTM Zone 19N
Map Created by W. Baker, Ecological Instincts - 2019

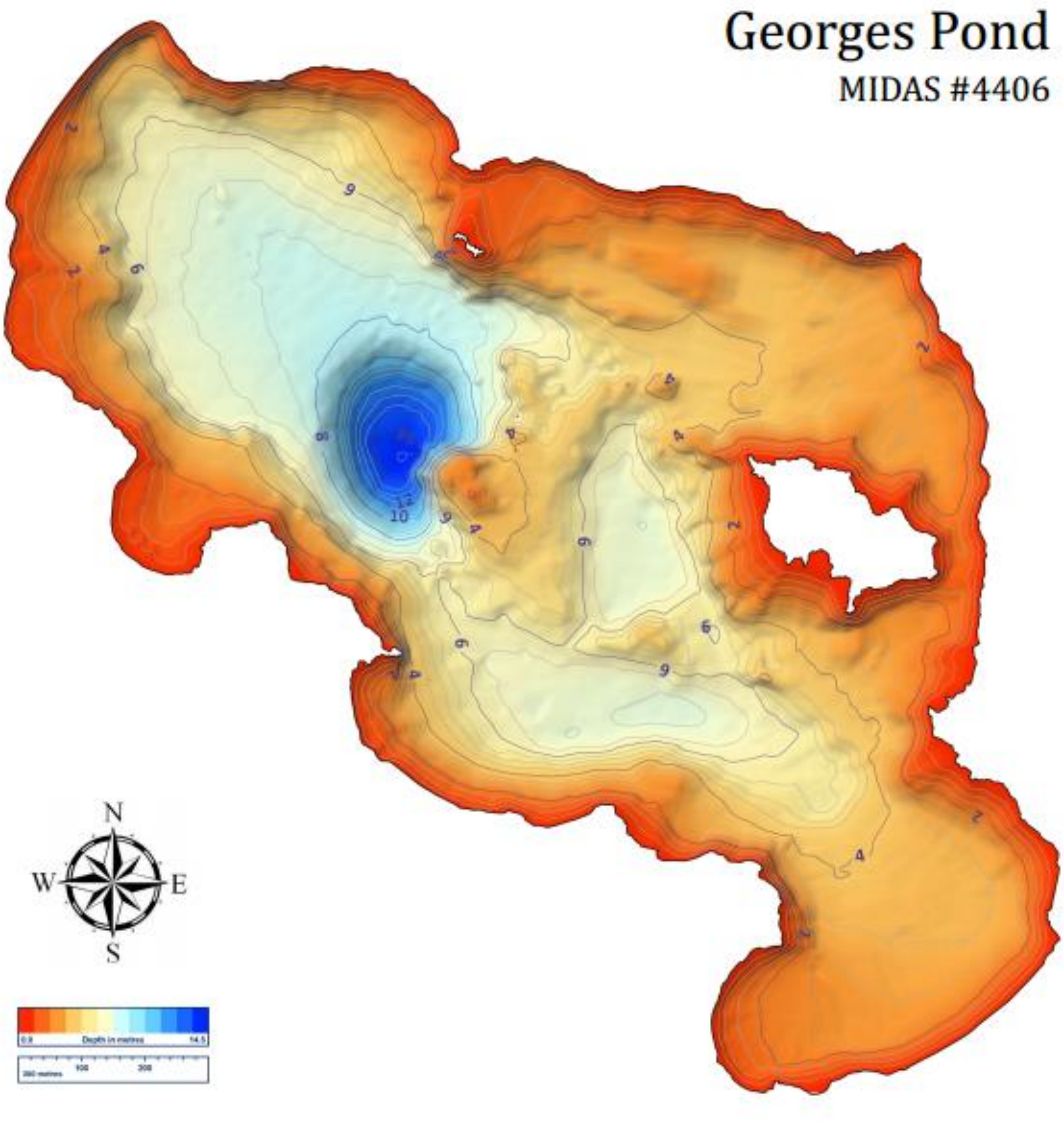
Georges Pond Sensitive Shoreline Soils Map



This map shows soils within 150 feet of the pond that are most susceptible to short-circuiting of subsurface wastewater disposal system effluent (yellow). Short-circuiting is a phenomenon whereby septic tank effluent is not properly treated in the leach field because the soils are coarse and porous, which allows the effluent to move through them too quickly. Shoreline tax parcels that contain these soils are highlighted in red.

Hydric soils that are shallow to the water table and adjacent to coarse soils are highlighted in dark blue. Adjacent coarse soils outside the 150 foot buffer are highlighted in light blue. Parcels within these soils are outlined in orange.

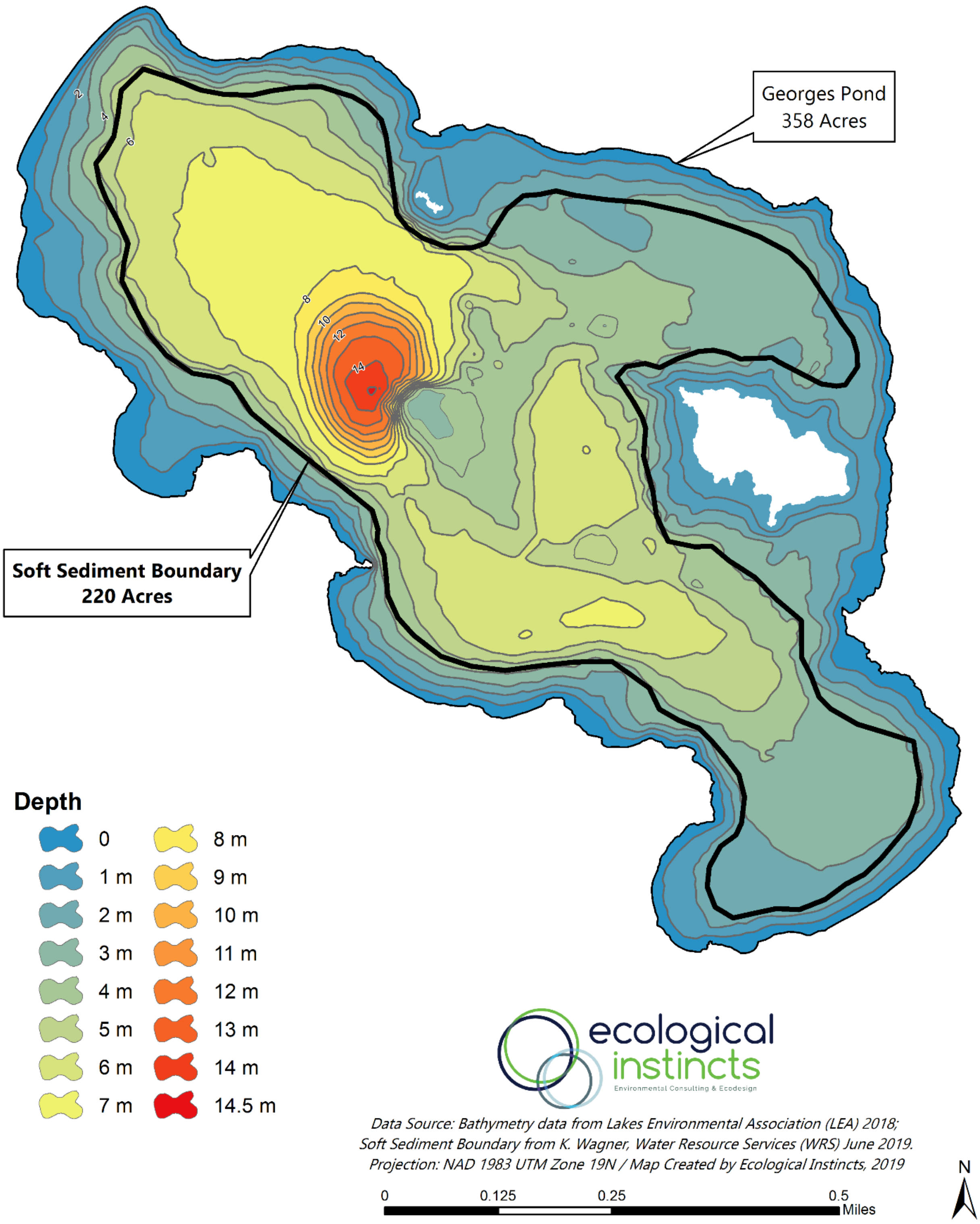
Georges Pond Bathymetry Map



Map Notes: ***Produced at Lakes Environmental Association using ReefMaster 2.0 software. Field data collected November 7-8, 2018 by Charles Dawes using a Humminbird HELIX 5 CHIRP G2.***

Disclaimer: ***This map is not intended to be used as a primary navigational aid.***

Georges Pond 2019 Soft Sediment Boundary



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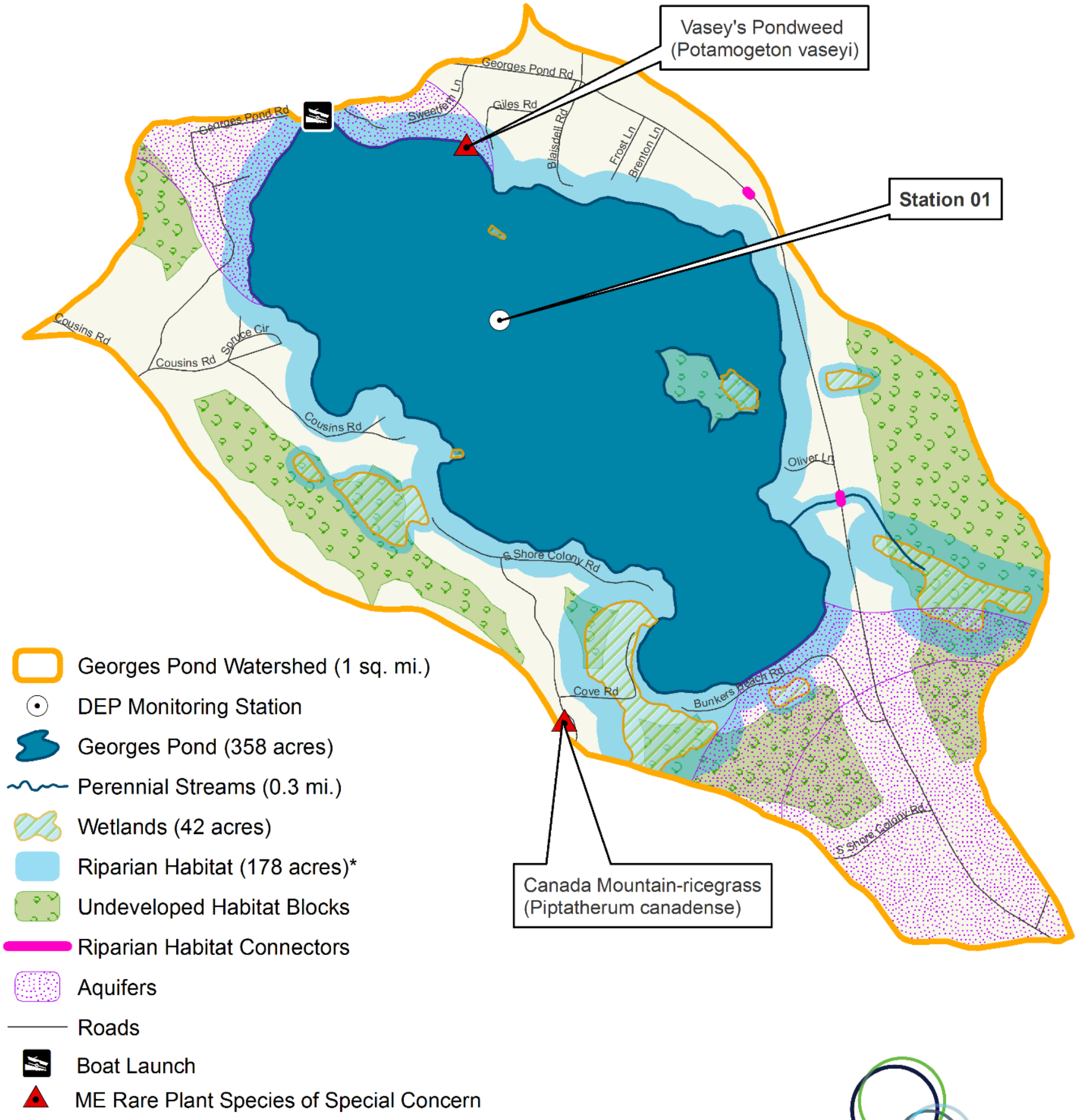
Data Source: Bathymetry data from Lakes Environmental Association (LEA) 2018;
Soft Sediment Boundary from K. Wagner, Water Resource Services (WRS) June 2019.
Projection: NAD 1983 UTM Zone 19N / Map Created by Ecological Instincts, 2019

Georges Pond Watershed - Water Resources & High Value Habitat



* Riparian habitat consists of the land area within the 250' buffer zone surrounding great ponds and wetlands >10 acres, and within the 75' buffer zone surrounding streams, small ponds, and wetlands smaller than10 acres in size.

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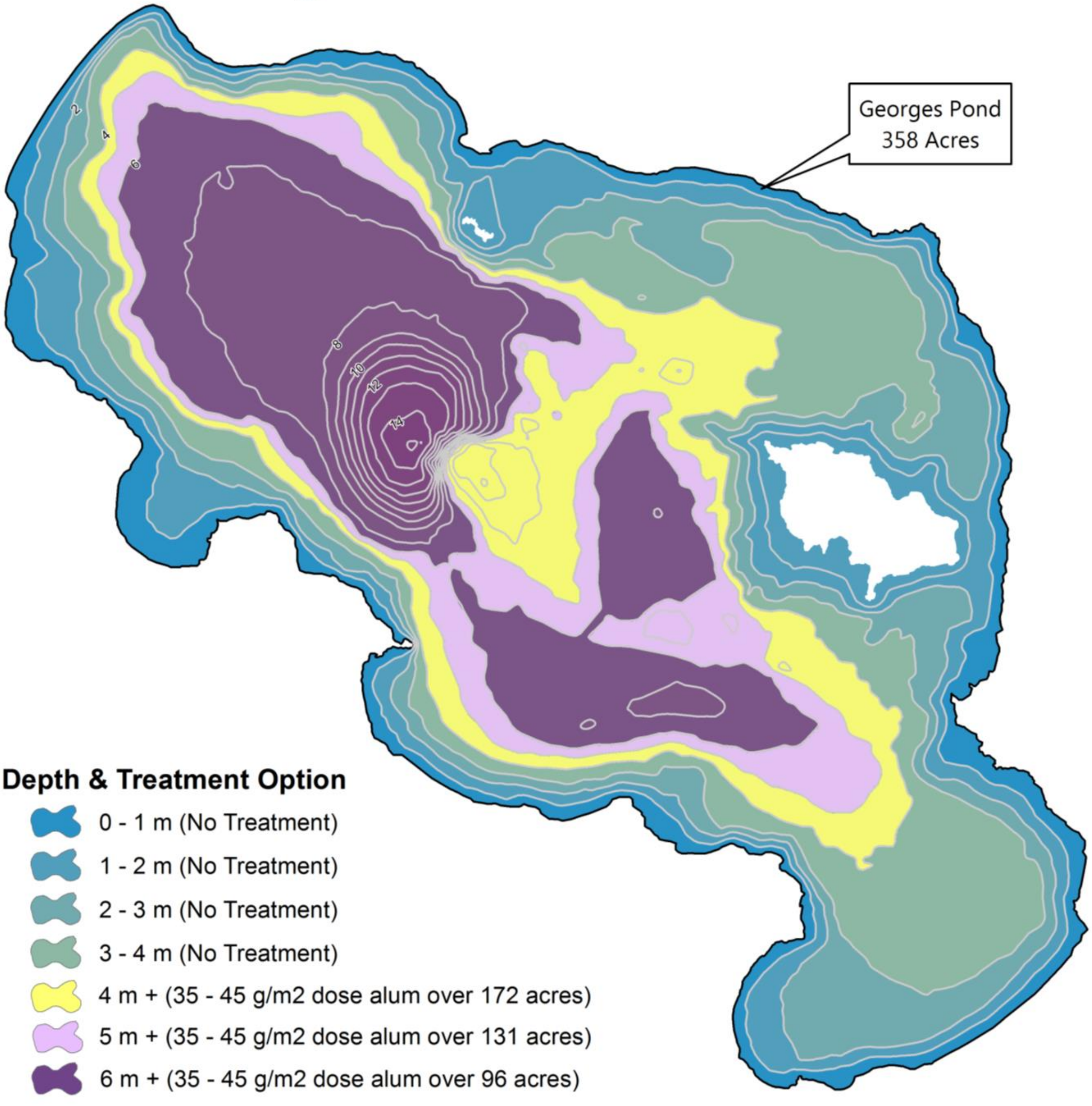
Source: Maine GeoLibrary, NHD, and BwH
Projection: NAD 1983 UTM Zone 19N
Map Created by: W. Baker, Ecological Instincts - 2019

Georges Pond Alum Treatment Area



The most benefitial treatment option for Georges Pond is the treatment of all pond bottom >5 m with the highest affordable dose, up to 45 g/m2.

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Data Source: Bathymetry data from Lakes Environmental Association (LEA) 2018;
Alum Treatment Areas & Dose from K. Wagner, Water Resource Services (WRS) June 2019.
Projection: NAD 1983 UTM Zone 19N / Map Created by Ecological Instincts, 2019