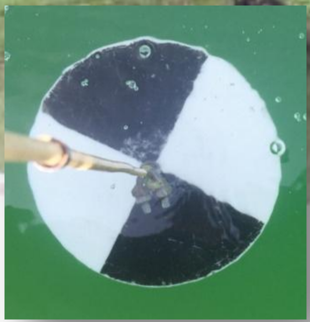
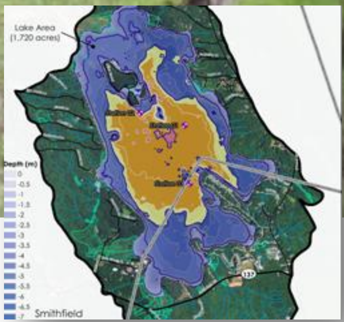
EAST POND WATERSHED-BASED MANAGEMENT PLAN (2018-2027)





FEBRUARY 2018

EAST POND

WATERSHED-BASED MANAGEMENT PLAN

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Cover photos: *Whitefish Lake Institute, Logan Parker, FB Environmental, East Pond Association*

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East Pond WBMP Steering Committee

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Mel Croft	East Pond Association/BRCA
Mary Ellen Dennis	Maine DEP
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COMMONLY USED ACRONYMS

The following acronyms are used throughout this document:

BMP	Best Management Practice
BRCA	Belgrade Regional Conservation Alliance
Chl-a	Chlorophyll-a
MAINE DEP	Maine Department of Environmental Protection
NPS	Nonpoint Source (pollution)
ppb	Parts Per Billion
ppm	Parts Per Million
SDT	Secchi Disk Transparency
TP	Total Phosphorus
US EPA	United States Environmental Protection Agency
WBMP	Watershed-Based Management Plan
YCC	Youth Conservation Corps

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EXECUTIVE SUMMARY

PURPOSE

The East 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 (2018 - 2027), 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 East Pond's water quality.

THE LAKE & WATERSHED

East Pond is a Great Pond Class GPA (MIDAS 5349), and is the headwater lake in the seven-lake chain known as the Belgrade Lakes Watershed, a subwatershed of Messalonskee Stream within the larger Kennebec River watershed. The watershed is located in the towns of Smithfield (60%), Oakland (40%), and Belgrade (<1%), in Kennebec County, Maine. The lake has a surface area of 1,720 acres (2.7 sq mi), and is spring fed with no major inlets. The lake's outlet is at the north end of the lake via the Serpentine Stream, which flows through a large freshwater wetland complex known as the Serpentine Marsh. The Serpentine Stream flows over a low-head dam (owned and controlled by the East Pond Association) into downstream North Pond.

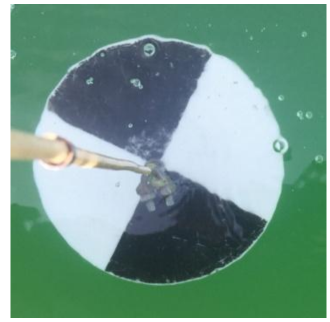
Shoreline development on East Pond. (Photo: Colby College)

East Pond is relatively shallow, with a mean depth of 16 feet (4.9 m) and maximum depth of 27 feet (8.2 m) (Maine DEP, 2017a). The lake has a slow turnover rate at 0.37 flushes/year, or about once every 2.5 years,[1] and is classified as a fairly shallow and weakly stratified, wind-disturbed aquatic system (Halliwell and Evers, 2008). The watershed is characterized by a relatively small direct drainage area (2,832 acres), approximately 1.6 times larger than the lake.

[1] East Pond's flushing rate was recalculated in 2017 as part of the watershed plan update.

THE PROBLEM

East Pond was placed on 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. East Pond has experienced recurring algal blooms since the early 1990's, resulting in SDT readings well below the state minimum (2 meters).



East Pond does not meet State water quality standards due to low transparency readings and presence of nuisance blue-green algal blooms. (Photo: mtlakebook.org)

Within the past three years, the complex dynamics that fuels these blooms has been brought to light- excess phosphorus, 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, and leads to persistent, recurring nuisance algal blooms in late summer and early fall. Monitoring data shows that East Pond experiences predictable nuisance algal blooms that begin between July and September each year as a result of this internal load, which makes up close to half of the available phosphorus in East Pond (400 kg P/yr, or 49% of the total phosphorus load).

External sources of phosphorus contribute the other half of the phosphorus in East Pond (408 kg P/yr, or 51% of the total phosphorus load). External sources include runoff from the watershed (25%), atmospheric deposition (17%), septic systems (6%), and waterfowl (3%).

THE GOAL

A team of scientists and local stakeholders worked collaboratively over a two-year period to set a realistic water quality goal that would prevent the future occurrence of nuisance algal blooms on East Pond. To meet the goal, the amount of phosphorus entering the lake will need to be reduced by 43-51% (350 -410 kg P/yr). This represents 80-90% of the internal load and 15-25% of the external load combined, over the next 10 years.

This goal can only be achieved through a combination of management strategies that address both the internal load and external load.

GOAL

East Pond Meets State Water Quality Standards & is free of Nuisance Algal Blooms

In-Lake P = 11 ppb
Annual P Load ~ 398 kg/yr

INTERNAL LOAD

Reduction: 80-90% (320-360 kg/yr)
Project: Alum Treatment
Timeframe: 2018 - 2019

EXTERNAL LOAD

Reduction: 15-25% (30-50 kg/yr)
Projects: 319, YCC, LakeSmart, Septics
Timeframe: 2018 - 2027

ACTIONS NEEDED TO ACHIEVE THE GOAL

The East Pond Watershed-Based Management Plan provides revised strategies for achieving the water quality goal. The action plan was developed over the course of two years and with significant stakeholder input. Steering Committee members reviewed recent research and planning documents, including a water quality analyses, backflushing study, sediment analysis, and an alum treatment and diagnostic feasibility study, and then developed solutions based on best available science to address the water quality problem.

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

Planning Objective	Planning Action (2018-2027)	P Load Reduction Target	Cost
1	**Address the Internal P Load** (Alum Treatment)	320 - 360 kg/yr	$800,000 - $950,000
2	**Address the External P Load** (NPS Sites, Septic Systems, YCC, LakeSmart, Education & Outreach)	30 - 50 kg/yr	$200,000 - $250,000
3	**Prevent New Sources of NPS Pollution** (Build-out, Land Conservation, Ordinances, Enforcement)	TBD	$10,000 - $15,000
4	**Build Local Capacity** (Funding Plan, Steering Committee, Grant Writing)	n/a	$5,000 - $6,500
5	**Long-Term Monitoring & Assessment** (Baseline Monitoring, algal bloom tracking, etc.)	n/a	$300,000 - $355,000
	TOTAL	**350 - 410 kg/yr**	**$1.3 - $1.6 million**

Actions to address both the internal and external phosphorus load were designed to improve the water quality in East Pond, while simultaneously promoting communication between residents, towns, 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, road associations and commercial camp owners all be called upon to address the external watershed load, and to support watershed projects such as the Youth Conservation Corps (YCC), 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 East Pond WBMP provides a framework for restoring the water quality in East Pond so that the lake no longer supports nuisance algal blooms. The plan will be led by the East Pond Association with guidance and support from a watershed steering committee including the Maine DEP, towns of Smithfield and Oakland, BRCA, Colby College, road associations, local businesses (including the large summer camps) 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 East Pond Watershed-Based Management Plan 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 nonpoint source pollution, including specific recommendations for guiding future development, and strategies for reducing the cumulative impacts of nonpoint source (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 2), watershed loading (Section 4), and a summary known sources of NPS sites in the East 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. Estimate 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 East 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 12 include 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 East Pond is estimated at $1.3 - $1.6 million over the next ten years. A diverse source of funding, a sustainable funding strategy, and collaborative partnerships (states towns, lake and watershed associations, Colby College, private landowners, road associations and commercial camps) will be needed to fully fund planned implementation activities.

E. Information & Education & Outreach: Section 1 and Table 12 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 East Pond Association and BRCA 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 12 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 Measureable 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 new certified LakeSmart properties.

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 East 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 on East 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

East Pond was placed on the 303(d) list by the Maine Department of Environmental Protection (Maine DEP) for failure to meet State water quality standards. Maine DEP requires Secchi disk transparency (SDT) readings of 2 meters or more, and absence of nuisance blue-green algal blooms. East Pond has experienced recurring algal blooms since 1993 that lower SDT readings to well below the state minimum of 2 meters for a significant period of the summer and fall.

East Pond does not meet State water quality standards due to low transparency readings and presence of nuisance blue-green algal blooms. (Photo: Logan Parker)

Within the past three years, the complex dynamics that fuels these blooms has been brought to light- excess phosphorus, 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, and leads to persistent, recurring nuisance algal blooms in late summer and early fall.

Development of this WBMP included a water quality analysis, a study to examine the effects of backflushing from the Serpentine wetland, 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 East 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 (2018-2027) to restore East Pond such that it meets state water quality standards.

This updated 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 East Pond's water quality.

This Plan 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. East 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 East Pond so that it meets state water quality standards. Planning recommendations include an 80-90% decrease in the internal load (320-360 kg/yr), and a 15 - 25% decrease in the external load (30 to 50 kg/yr). Combined, these reductions will result in an overall decrease in the phosphorus load in East Pond by 43 - 51% or 350 - 410 kg/year- thereby reducing the average annual in-lake phosphorus concentration from 19 ppb to between 11-12 ppb, and reducing the probability of summer time algal blooms from approximately 75% to 5%.[2]

Goal for East Pond

(2018-2027)

Restore the water quality of East Pond so that it meets state water quality standards.

PLAN DEVELOPMENT AND COMMUNITY PARTICIPATION PROCESS

This updated plan was developed with input from a diverse group of local stakeholders including the East Pond Association, Belgrade Regional Conservation Alliance (BRCA), Colby College, the towns of Smithfield and Oakland, commercial camp owners, community members, and the Maine DEP. The final product is a result of this input and numerous project management team meetings and conference calls between professional consultants, BRCA, East Pond Association, Maine DEP, and Colby College (see Acknowledgments). A description of these meetings is provided below.[3]

Steering Committee members prepare for meeting # 2 at the Smithfield Town office in June 2017. (Source: Ecological Instincts)

- Steering Committee # 1 was held at the Maine DEP offices on September 2, 2016. Twelve people attended this kick-off meeting. The meeting focused on improving current monitoring efforts for 2016/17 to ensure data would be collected to inform the management decisions in the 2017 WBMP.
- Water Quality Technical Review Committee #1 was held at the Maine DEP offices in Augusta. Twelve people attended the meeting. The focus of the meeting was to review Colby's 2015-2016 monitoring results, the WRS phosphorus loading and alum treatment recommendations, and to discuss available backflushing data.

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[2] 75% is based on feedback from the steering committee indicating that East Pond blooms in at least 3 out of every 4 years. 5% is based on predictions from the LLRM based on chlorophyll-a >10 ppb.
[3] Copies of all meeting notes are available electronically through BRCA.

- Steering Committee # 2 was held at the Smithfield Town office on June 26, 2017. Seventeen people attended the meeting. The meeting included a summary of background information about the project for new committee members, a presentation of Colby monitoring results including results of the sediment analysis, a description of possible treatment options to address the internal load, and an open question and answer period for the science advisors. Communications and Fundraising subcommittees were also organized.
- A public presentation was made at the East Pond Association's annual meeting on July 19, 2017 at Brickett Point in Oakland. Speakers included Ecological Instincts, BRCA and East Pond Association (LakeSmart). An educational flyer was developed about the alum treatment and distributed at the meeting.
- Water Quality Technical Review Committee # 2 was held at the Maine Lakes Resource Center on October 25, 2017. Thirteen people attended the meeting. The purpose of the meeting was to review Colby's water and sediment chemistry data as well as the results of the 2017 backflushing study on the Serpentine, to discuss planning for the alum treatment (i.e., jar testing, treatment area, contractor selection, permitting, fundraising, etc.), and to finalize a schedule for review of the WBMP.
- Steering Committee # 3 was held at the RSU 18 Superintendent's office in Oakland on December 4, 2017. Thirteen people attended the meeting. The meeting included a review of the watershed action plan and watershed maps, water quality goals, an update on the proposed alum treatment, fundraising and communications. This was the final planned steering committee for the plan development project.

WATERSHED PROJECTS, PROGRAMS & RESEARCH

Watershed partners have been effectively working together to understand why East Pond's water quality is impaired, 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 current selective watershed activities that have taken place since the last WBMP was developed in 2007. Therefore, it is not an exhaustive list of projects that have been completed in the watershed. 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.

2014 Watershed Survey

A dirt driveway carries water directly to East Pond. (Source: East Pond Association)

The East Pond Association conducted nonpoint source pollution (NPS) survey of the East Pond watershed and a portion of the Serpentine watershed in October 2014 in order to document current sources of NPS pollution on developed land in the watershed. The survey identified 124 NPS sites containing soil erosion and/or polluted runoff that have a direct impact on the water quality of the lake. These sites were revisited by staff from BRCA and Maine DEP in October 2017 to help track which sites had been addressed and which still needed attention. Currently 81 sites are still considered a problem that needs addressing. The remaining sites were ranked High (4), Medium (19), and Low impact (58). A summary of these results is presented in Section 5 and Appendix A. The final NPS site count does not include sites documented in the Serpentine Stream watershed. These sites are the focus of efforts being completed by the North Pond Association.

Youth Conservation Corps

Example of infiltration steps installed by the BRCA YCC. (Source: BRCA)

The BRCA formed a Youth Conservation Corps YCC) in 1996 in response to the need for addressing erosion control projects on residential properties throughout the Belgrade Lakes Watershed. The YCC is a summer program that utilizes the assistance of local high school and college students to protect improve water quality. To date, the YCC has installed 1,401 BMPs on all seven Belgrade Lakes in the watershed, including 139 in the East Pond watershed.

319 Projects

East Pond has been the recipient of three past 319 implementation projects between 1999 and 2012 that addressed 64 NPS sites, and resulted in a reduction of the external phosphorus load to East Pond on the order of 31 pounds of phosphorus annually.[4] The BRCA is in the process of planning for a Phase IV implementation project following announcement of a conditional grant award from the US EPA to conduct an alum treatment on East Pond. The project is expected to begin in the spring of 2018.

[4] Personal communication, Charlie Baeder, BRCA. January 9, 2015 via email. Loading reductions were not calculated for Phase I.

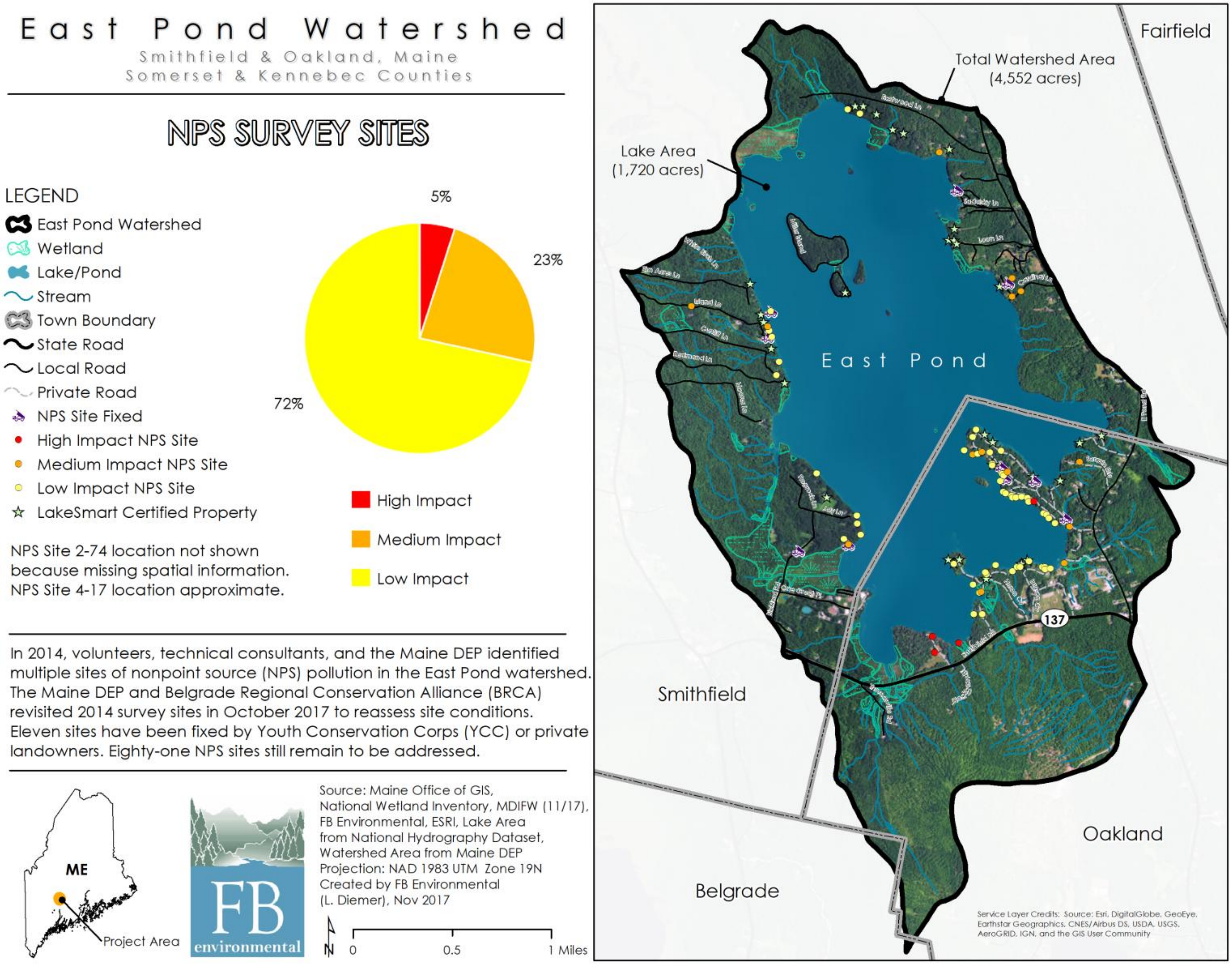


Figure 1. Location of documented watershed survey sites, completed YCC projects, and certified LakeSmart properties in the East Pond Watershed.

LakeSmart

The East Pond Association has had an active LakeSmart program since 2009. LakeSmart is a state-wide education and reward program headed by the Maine Lake's Society designed to assist lakefront property owners with improving and maintaining their property using lake-friendly landscaping practices that help protect water quality. Since its inception, the East Pond Association has completed 49 LakeSmart evaluations on East Pond resulting in 32 LakeSmart awards. This means that 10% of the shoreline properties on East Pond are currently LakeSmart. The LakeSmart program and the YCC dovetail nicely, as LakeSmart evaluations lead to free technical assistance from BRCA to complete the LakeSmart recommendations.

Public Outreach

The East Pond Association and BRCA are the primary entities conducting public outreach in the watershed. The association holds a public meeting each July for all interested watershed residents, provides watershed updates on its website, and distributes an annual newsletter each summer. BRCA provides technical assistance to the association and the watershed towns to protect and preserve the natural resources within the watershed. BRCA adminsters the YCC, the Courtesy Boat Inspection (CBI) program, and provides public lectures, and guided nature walks.

Water Quality Monitoring

East Pond has been monitored by volunteers as part of the Volunteer Lake Monitoring Program (VLMP) since the 1970's, by Maine DEP (baseline surveys), and more recently by the Colby College Water Research Team (2015-2017) to better understand the role of internal phosphorus loading and nutrient dynamics in the lake. Measurements include dissolved oxygen, temperature, pH and conductivity at 10 second intervals through the water column, and water samples were collected at 2, 4, 6, 6.5 and 7m every two weeks from late April through mid-November. Monthly phytoplankton samples were also collected between May and August 2017 to determine phytoplankton species and concentrations throughout the summer months. Winter sampling in February of 2015 and 2016 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.

The Colby College Water Quality Research Team has been collecting weekly water quality data on East Pond. (Photo: Kennebec Journal)

Biomanipulation Study

The East Pond biomanipulation study spanned 2004-2015. (Photo: Dave Halliwell, Maine DEP)

A long-term biomanipulation study on East Pond (& North Pond) was initiated in 2004 by Maine DEP and the University of Maine with Clean Water Act Section 319 funds from the US EPA. Over a 6-year period (2007-2012) a grand total of 46.5 tons of fish were removed, 92% of which was comprised of White Perch (42.6 tons), 5% Yellow Perch (2.4 tons) and 3% Black Crappie (1.5 tons). Water quality, in terms of the prevalence, intensity and duration of summertime nuisance blue-green algal blooms, appeared to gradually improve, coincident with fish removal (Halliwell, 2017a). Following this biomanipulation project (2004-2015) the water quality of East Pond returned to a state of nuisance algal blooms during the summer months (2016-2017). So, the goal of this biomanipulation project to possibly reset the trophic state of the pond in favor of the ability of large-bodied zooplankton to possibly harvest the phytoplankton (blue-green algae) was not met.

Backflushing Study

Location of pressure transducers installed in the Serpentine Marsh 2016-2017. (Source: Whitney King, Colby College)

A study of the potential effects of backflushing from the Serpentine into East Pond was investigated by Colby College in 2016-2017 using a series of three pressure transducers. Results of this research indicate that when the East Pond level increases relative to the North end of the Serpentine, the depth differences become less negative (increasing values indicate rising lake levels). The water level gradient between the lake and the north end of the Serpentine changes very little (at most 3 cm); except during late October storm events. Spikes in lake level correlate with rain and wind, where rain tends to raise the north end of the serpentine level relative to the East Pond, and wind to the north raises lake levels. Therefore, water is flowing both south and north into the middle of the Serpentine Bog; the bog is a hydraulic sponge. These results suggest that rapid flow into or out of the Serpentine is minimal and of short duration. Preserving the tortuous flow path in the Serpentine would be a good strategy for minimizing large Serpentine flows by maximizing hydraulic storage in the middle of the Serpentine bog (King, 2017a).

Members of the East Pond Steering Committee have suggested that dam management, and possibly dam modification, may be used to increase East Pond flushing rates to reduce phosphorus concentrations in the lake.

Dam Management

Dam management is already being conducted at the outlet dam by the East Pond Association, the owners of the dam. The association opens up the dam in anticipation of major precipitation events, unless the weather has been very dry and the lake level is already low. The ability to regulate the dam is limited by the flashboards at the dam spillway which allow the dam height to be modified by only one foot. This has led to some discussion of whether dam modification, to lower the dam height, might be a useful strategy to increase flushing rates. Based on the backflushing studies conducted by Colby, the consensus of the Science Committee is that modification will be insufficient to improve water quality to meet the water quality goals identified in this management plan.

The Science Committee recommends that current dam management practices continue, that dam management activities be carefully documented, and that lake levels continue to be monitored with pressure sensors to confirm the impact of dam height on the water levels in the Serpentine. A dam modification feasibility study may be considered based on the dam management and sensor data collected over the next several years.

Sediment Analysis

A 2017 analysis of East Pond's sediments examined the unique geochemistry to determine the total iron and aluminum concentrations and available phosphorus in the sediment. The analysis required collecting numerous sediment samples (1 cm and 10 cm core samples) at 23 locations between 2015-2017. Extracted iron, aluminum, and phosphorus were compared in units of μmol element/g sediment. The purpose of the study was to determine Al:Fe ratios to inform scientists about the level of dosing needed for a successful alum treatment. Al:Fe ratios below five create conditions where reductive dissolution of Fe(III) can release significant amounts of Fe-bound phosphorus to the bottom water of the lake, resulting in internal phosphorus loading that results in algal blooms. Results of this analysis show that significant areas of East Pond, especially in the deepest areas of the lake, have Al:Fe ratios below this threshold (King, 2017b). Increasing the concentration of aluminum in the bottom sediments will bind phosphorus at the bottom of the lake and prevent its release into the water column.

Alum Treatment & Diagnostic Feasibility Analysis

A feasibility analysis was conducted by WRS in 2016 to examine the best possible options for managing algae in East Pond (WRS, 2016). The analysis looked at numerous management strategies including: a) watershed controls, b) in-lake biological controls, c) in-lake chemical controls, and d) in-lake physical controls (see Appendix B for the full list).

Techniques that represent scientifically sound approaches consistent with all known goals for management of East Pond include nonpoint source watershed controls, artificial circulation, dredging, phosphorus inactivation and enhanced grazing. The analysis determined that watershed management in the form of site-specific runoff controls, and phosphorus inactivation within the pond, appear to have the greatest potential for achieving the targeted load reduction in East Pond at an affordable cost (e.g., dredging is highly effective but cost-prohibitive). Since a primary goal for East Pond is improved water clarity, a combination of watershed management and in-lake actions will be needed, but a single treatment with aluminum to inactivate surficial sediment phosphorus is expected to provide immediate and substantial benefit that will last anywhere from 10-20 years. From the available data, an aluminum treatment at a dose of 25 to 28 g/m2 over an area of at least 400 acres could reduce internal loading by about 360 kg/yr, lowering the average total phosphorus load and increasing summer clarity to 3.6 m (11.9 ft) with <1% probability of algae blooms (>10 µg/L as chlorophyll-a). This improvement should last at least a decade, and might provide effective for 20 years.


A barge applying aluminum on a lake. (Photo: WRS, Inc.)

Shoreline Photos

The entire shoreline of East Pond was photographed by Colby College in 2011 using digital cameras with built in GPS units[5]. The photos provide information on changes in shoreland conditions over time. In 2017, Colby began retaking these photos using drone technology[6].

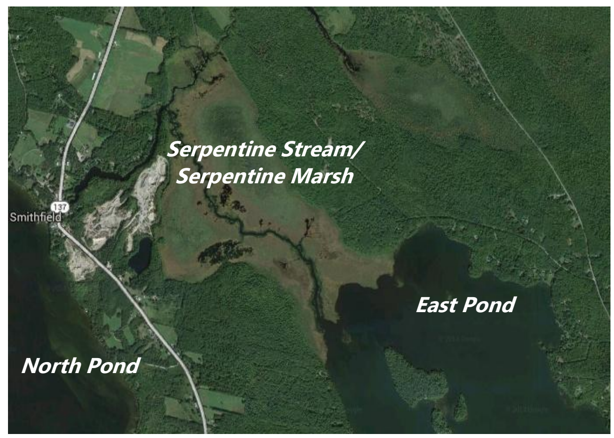
[5] Photos can be viewed from the following website: http://web.colby.edu/epscor/east-pond/

[6] Brenda Fekete, Maine Lakes Resource Center, Personal Communication, November 2017.

2. LAKE & WATERSHED CHARACTERISTICS

East Pond is a Great Pond Class GPA (MIDAS 5349), and is the headwater lake in the seven-lake chain known as the Belgrade Lakes Watershed, a subwatershed of Messalonskee Stream within the larger Kennebec River watershed. The watershed is located in the towns of Smithfield (60%), Oakland (40%), and Belgrade (<1%), in Kennebec County, Maine (Figure 2). The lake has a surface area of 1,720 acres (2.7 sq mi), and is spring fed with no major inlets. The lake's outlet is at the north end of the lake via the Serpentine Stream, which flows through a large freshwater wetland complex known as the Serpentine Marsh. The Serpentine Stream flows over a low-head dam (owned and controlled by the East Pond Association) into downstream North Pond. The area that drains the Serpentine Stream is considered part of the North Pond watershed.

East Pond is relatively shallow, with a mean depth of 16 feet (4.8 m) and maximum depth of 27 feet (8.2 m) (Maine DEP, 2017a). The lake has a slow turnover rate at 0.37 flushes/year, or about once every 2.5 years,[7] and is classified as a fairly shallow and weakly stratified, wind-disturbed aquatic system (Halliwell and Evers, 2008). The watershed is characterized by a relatively small direct drainage area (2,832 acres), approximately 1.6 times larger than the lake.



The Serpentine Stream and marsh are located between East Pond and North Pond. The watershed area draining to the marsh is considered part of the North Pond watershed. (Source: Google Maps)

East 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. The shoreline contains numerous residential homes and camps with private beaches (including dense residential development at Brickett Point), three summer youth camps, two commercial camps with rental cabins, and one public boat launch.

The lake is surrounded by a network of state, town, and private roads, including State Route 137 and Route 8 that run along the south and east side of the watershed. Many long unimproved private roads lead down to the lake on the west shore from Route 8. These roads provide access to the residential homes along the shoreline, as well as homes, farms and businesses elsewhere in the watershed.

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[7] East Pond's flushing rate was recalculated in 2017 as part of the watershed plan update.

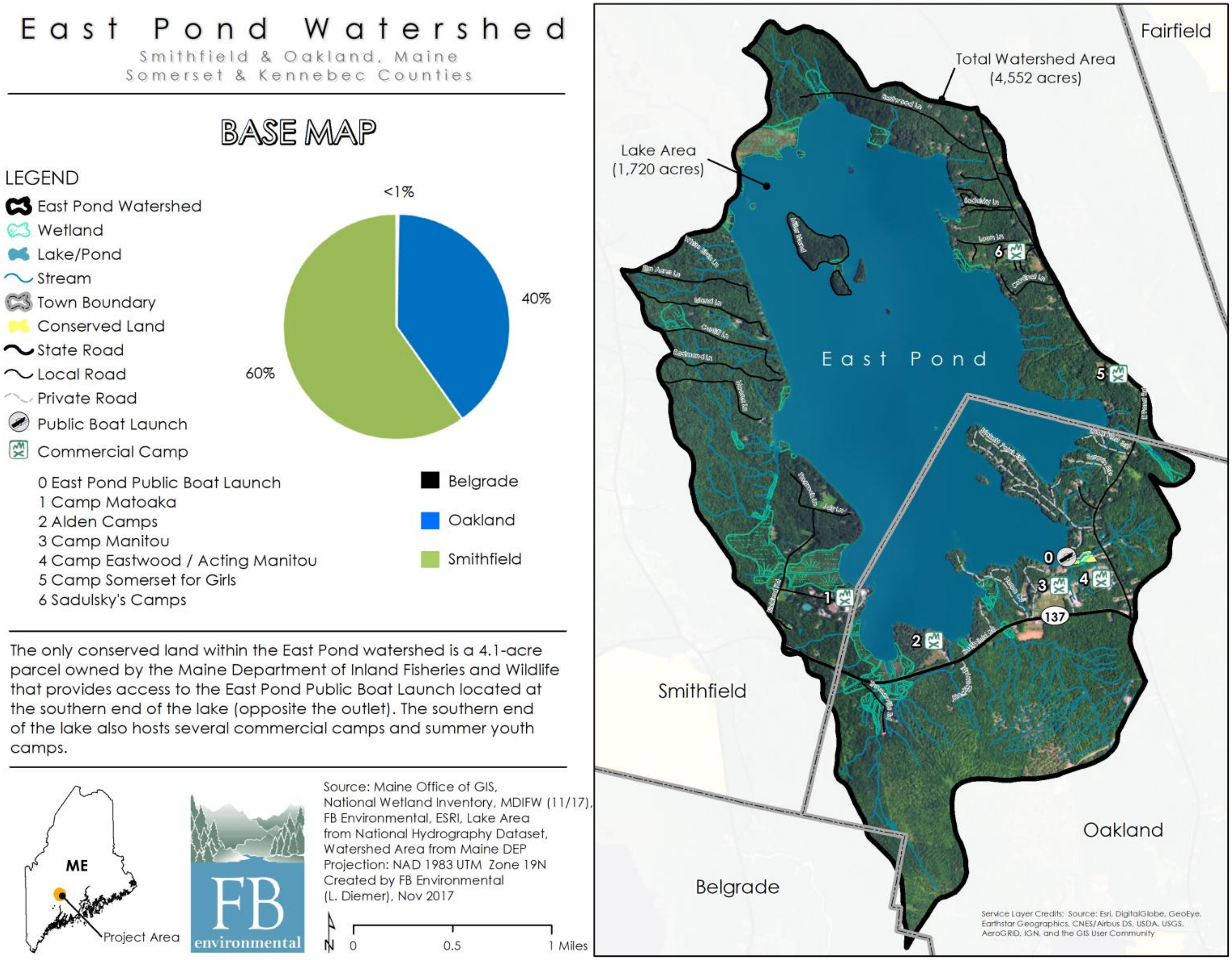


Figure 2. East Pond Base Map.

POPULATION, GROWTH TRENDS & LAND USE

Population

The population of the East Pond Watershed increases substantially during the summer months due to a high percentage of seasonal lakeshore residents, and an increase of 1,000 or more people that visit the five large summer camps over the course of the summer.

Colby College looked at the demographics of the Belgrade Lakes region as a whole and found:

- While the population of the larger Belgrade Lakes Watershed declined by 5.3% between 2000-2010, the population in each of the watershed towns increased by 4.7% - 11.1% (Table 1).
- The change in total housing units is similar to the change in total housing units over this same time period for the watershed towns, with an increase of 19.6% in Smithfield (608 to 727 housing units), and 6.2% for Oakland (2,847 to 3,024 housing units).
- The number of seasonal homes as a percent of the Belgrade Lakes Watershed's total housing stock increased during this period, and census block data show a decline in population among lake front properties compared to homes located away from the lakes. This information suggests that lake-front property is being purchased by people whose primary residence lies outside the Belgrade Lakes Watershed. This is further backed by census data showing an increase in seasonal homes in the watershed towns of 11.5% and 8.2% for Smithfield and Oakland, respectively (Chen et al., 2014).

Table 1. Population demographics for towns in the East Pond watershed.

Town	% of East Pond Watershed	Total Population 2000	Total Population 2010	% Change Watershed Towns	% Change Belgrade Lakes Watershed
Oakland, ME		5,959	6,240	4.7%	-5.3%
Smithfield, ME		930	1,033	11.1%	

(Adapted from: Chen, et al., 2014)

Growth Trends

Water quality improvements on East Pond will be noticeable and may make the watershed more attractive for development. (Photo: Colby College)

The desirability of East 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, East Pond may become an even more popular recreational destination. Landowners, businesses and towns 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 shallow lake like East Pond, a one meter improvement in water clarity will be noticeable and highly desirable.

Factoring in water quality improvements, the historical growth rates shown above, and the high cost of proposed water quality improvement initiatives, watershed communities should carefully consider the effects of existing municipal land-use regulations in order to protect East Pond from future 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 East Pond, thereby affecting the success of strategies to address improve the water quality.

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 East Pond watershed was updated. This included carefully reviewing the assigned land cover types, and making changes where necessary based on local knowledge or field observations.[8]

[8] 2010 (0.3 m resolution) or 2015 (1.0 m resolution) ESRI World Imagery aerials were uploaded and compared to 4/23/2016 Google Earth satellite images for major land cover changes in each quad. If discrepancies between the aerials and the MELCD land cover file were found, changes were made using the Topology tool for editing polygon vertices or the Editor tool for splitting polygons. Each new polygon was relabeled in the attribute table with the appropriate LLRM land cover category.

Developed areas within the East Pond 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.

An analysis of land cover in the watershed indicates that the majority of the non-lake watershed is forested (79%), consisting mostly of mixed forest, followed by developed land (15%), wetlands (6%)[9], and agriculture (<1%) (Figure 3). Logging accounts for approximately 18% of the forested area, equivalent to 487 acres. Low density residential development accounts for the largest percentage of the developed urban land cover category at 7.6%.

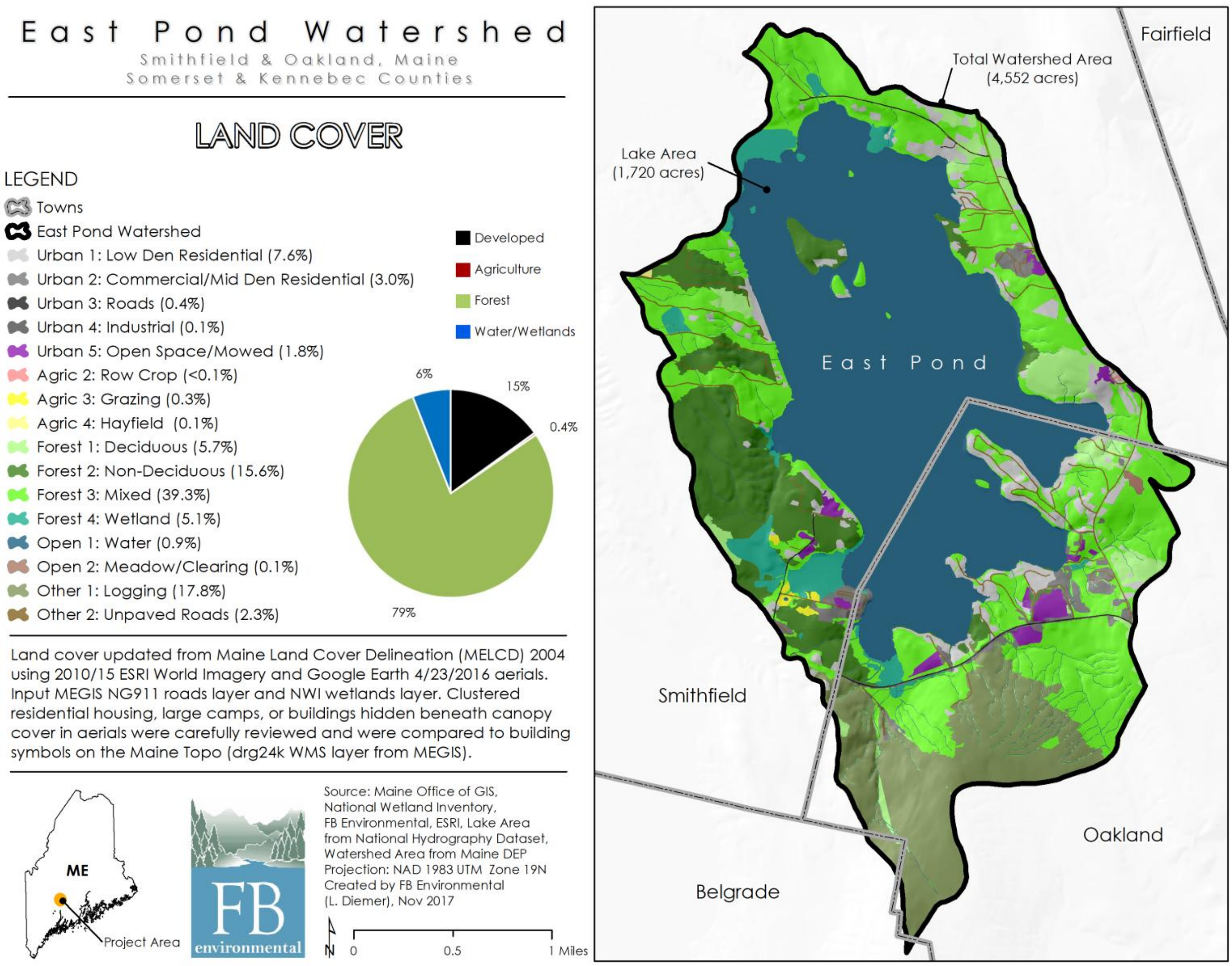


Figure 3. East Pond Land Cover Map.

[9] The total wetlands area does not include the area of East Pond.

Soils

Soils in the East Pond watershed are dominated by fine sandy loams and sandy loams with moderately low runoff potential (Berkshire soils -hydrologic group B) (Table 2, Figure 4). Pockets of silt loam soils are intermixed with sandy loams throughout the watershed (Buxton, Lamoine and Scantic soils). These soils have moderate to high runoff potential (hydrologic groups C/D). Wetlands bordering the lake are classified as muck and peat (Biddeford, Rifle) which are considered to have low runoff potential when dry (hydrologic group A, and high runoff potential when thoroughly wet (hydrologic group D)(USDA NRCS, 2007).

Table 2. Soil descriptions, area, and hydrologic soil group for the East Pond Watershed.

Map Unit Symbol	Map Unit Name	Acres	% of Watershed Area	Hydrologic Soil Group
BkC	Berkshire fine sandy loam, 8 to 15 percent slopes, very stony	791.5	28.7%	B
BkB	Berkshire fine sandy loam, 0 to 8 percent slopes, very stony	588.2	21.3%	B
PkB	Peru fine sandy loam, 0 to 8 percent slopes, very stony	313.7	11.4%	C/D
BhB	Berkshire fine sandy loam, 3 to 8 percent slopes	183.1	6.6%	B
PdB	Peru fine sandy loam, 0 to 8 percent slopes, very stony	175.3	6.4%	C/D
Lc	Leicester very stony loam	97.3	3.5%	A/D
Bo	Biddeford mucky peat, 0 to 3 percent slopes	74.6	2.7%	D
BuB	Lamoine-Buxton complex, 0 to 8 percent slopes	74.3	2.7%	C/D
Sc	Scantic silt loam, 0 to 3 percent slopes	73.5	2.7%	D
Pa	Peat and Muck	69	2.5%	A/D
SkC2	Scio very fine sandy loam, 8 to 15 percent slopes, eroded	61.1	2.2%	C
BkD	Berkshire fine sandy loam, 15 to 35 percent slopes, very stony	45.4	1.6%	B
SkB	Scio very fine sandy loam, 3 to 8 percent slopes	38.1	1.4%	C
RdA	Ridgebury very stony fine sandy loam	34.2	1.2%	C/D
ScA	Scantic silt loam, 0 to 3 percent slopes	28.2	1.0%	D
PfB	Peru fine sandy loam, 3 to 8 percent slopes	23.7	0.9%	C/D
Rf	Rifle mucky peat	20	0.7%	A/D
Wa	Walpole fine sandy loam	17.8	0.6%	A/D
BuB2	Lamoine silt loam, 3 to 8 percent slopes	13.2	0.5%	C/D
BuC2	Buxton silt loam, 8 to 15 percent slopes	12	0.4%	C/D
StB	Stetson fine sandy loam, 0 to 8 percent slopes	9.9	0.4%	A
CnC	Colton gravelly sandy loam, dark materials, 8 to 15 percent slopes	6.1	0.2%	A
BhC	Berkshire fine sandy loam, 8 to 15 percent slopes	4.7	0.2%	B
PcB	Peru fine sandy loam, 3 to 8 percent slopes	2.1	0.1%	C/D
W	Water	1,247	28.0%	n/a
W	Water bodies	452	10.1%	n/a

A previous assessment of East Pond soils looked at the potential erodibility of soils in the watershed, and found that soils in the immediate shoreline area (~150 ft) are, for the most part, highly erodible (Table 3A); whereas soils in the uplands are mostly not highly erodible (Table 3B). Areas of potentially highly erodible soils should be further assessed prior to development based on slope and the proposed development to ensure development is compatible with the proposed use.

Table 3A. Soils of the East Pond Shoreline.[10]

Soil Series & Sub-Series	Erodibility	Prevalence
BuB2, SkC2	Highly Erodible	13 acres (2%)
RdA, Sc, ScA, RF, Pa, Lc, Bo, Wa	Potentially Highly Erodible	167 acres (21%)
BkB, BkC, PkB, SkB, PdB, BhB, BuB, BhB, BuC2	Not Highly Erodible	617 acres (77%)

Table 3B. Soils of the East Pond Uplands.[11]

Soil Series & Sub-Series	Erodibility	Prevalence
BuB2	Highly Erodible	1.0 acres (<1%)
RdA, ScA, RF, Pa, Sc, Lc, Bo	Potentially Highly Erodible	153.5 acres (74%)
BkB, BkC, PkB, SkB, PdB, BhB, BuB, BhB, BuC2	Not Highly Erodible	53.5 acres (26%)

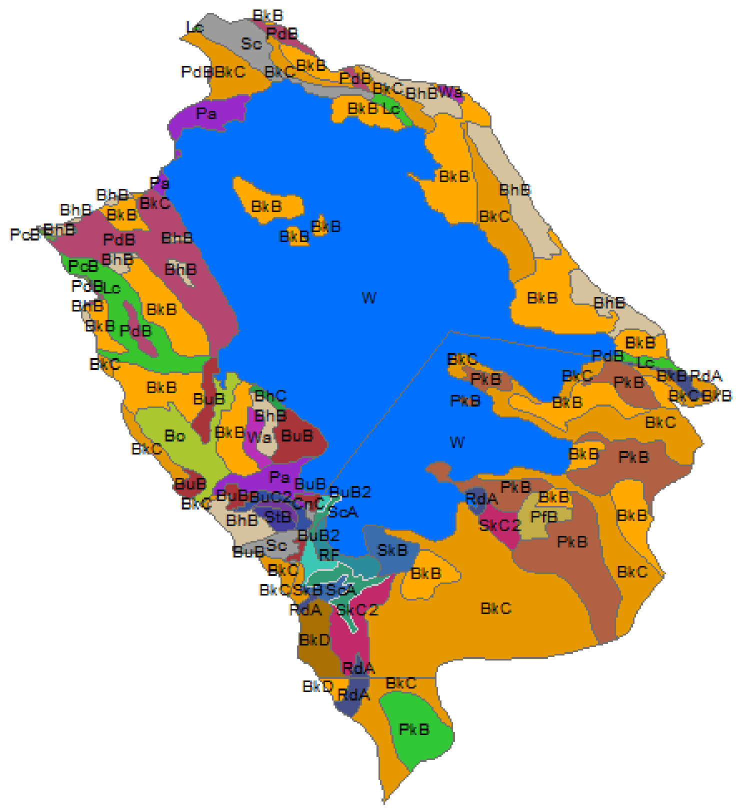


Figure 4. East Pond Soils Map.

[10] Defined as water's edge to ~ 150 ft. upland, a perimeter of ~ 200 acres (excluding submerged lands). Source: USDA digitized Soil Surveys, Kennebec & Somerset Counties. In: 2007 East Pond WBMP.

[11] Defined as ~150 - 1,000' upland, a perimeter of ~ 780 acres (excluding submerged lands). Source: USDA digitized Soil Surveys, Kennebec & Somerset Counties. In: 2007 East Pond WBMP.

Submerged Sediments

Bottom sediments in East Pond have been characterized as an organic rich, moderately well-sorted silt. This is consistent with the lake's glacial formation and subsequent Holocene history. Both the grain sizes present and their distribution are to be expected in a hydrodynamically low energy system (Nesbeda, 2004). It is suspected that a miniscule clay fraction may exist in East Pond sediments.

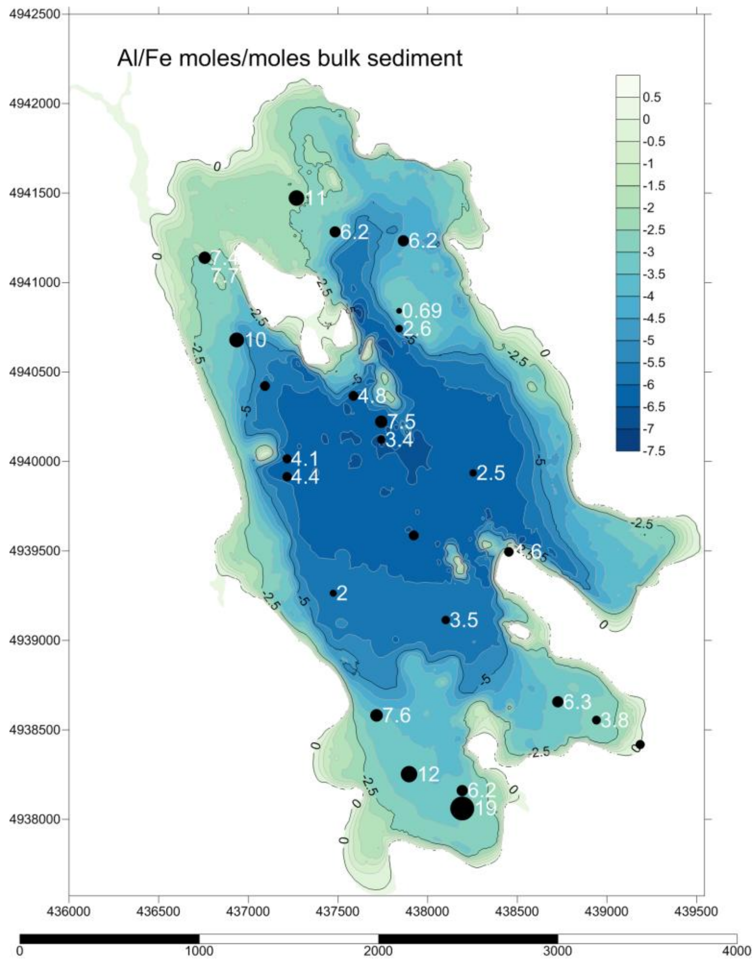


Figure 5. Al:Fe ratios in East Pond bottom sediments. *Source: Colby College.*

A 2017 analysis of East Pond's sediments examined the geochemistry to determine the total iron and aluminum concentrations and available phosphorus in the sediment. The analysis required collecting numerous sediment samples (1 cm and 10 core samples) at 23 locations between 2015-2017. Extracted iron, aluminum, and phosphorus were compared in units of μmol element/g sediment. The purpose of the study was to determine Al:Fe ratios to inform scientists about the dosing needed for a successful alum treatment. Al:Fe ratios below five create conditions where reductive dissolution of Fe(III) can release significant amounts of Fe-bound phosphorus to the bottom water of the lake, resulting in internal phosphorus loading that results in algal blooms. Results of this analysis show that significant areas of East Pond, especially in the deepest areas of the lake, have Al:Fe ratios below this threshold (Figure 5) (King, 2017b). Increasing the concentration of aluminum in the bottom sediments will help bind phosphorus at the bottom of the lake and prevent its release into the water column.

Habitat

East Pond is considered to have moderate to high value habitat compared to other lakes and ponds in Maine, as it serves as valuable habitat for fish, birds and other wildlife. This habitat is not limited to the lake or the shoreline. In fact, a recent habitat assessment using Beginning with Habitat data highlights the large area of undeveloped land blocks in the watershed (Figure 6) as well as U.S. Fish & Wildlife Service high value grassland habitat (23 acres), upland forest habitat (49 acres), wild brook trout habitat, inland waterfowl/wading bird habitat, and deer wintering areas.

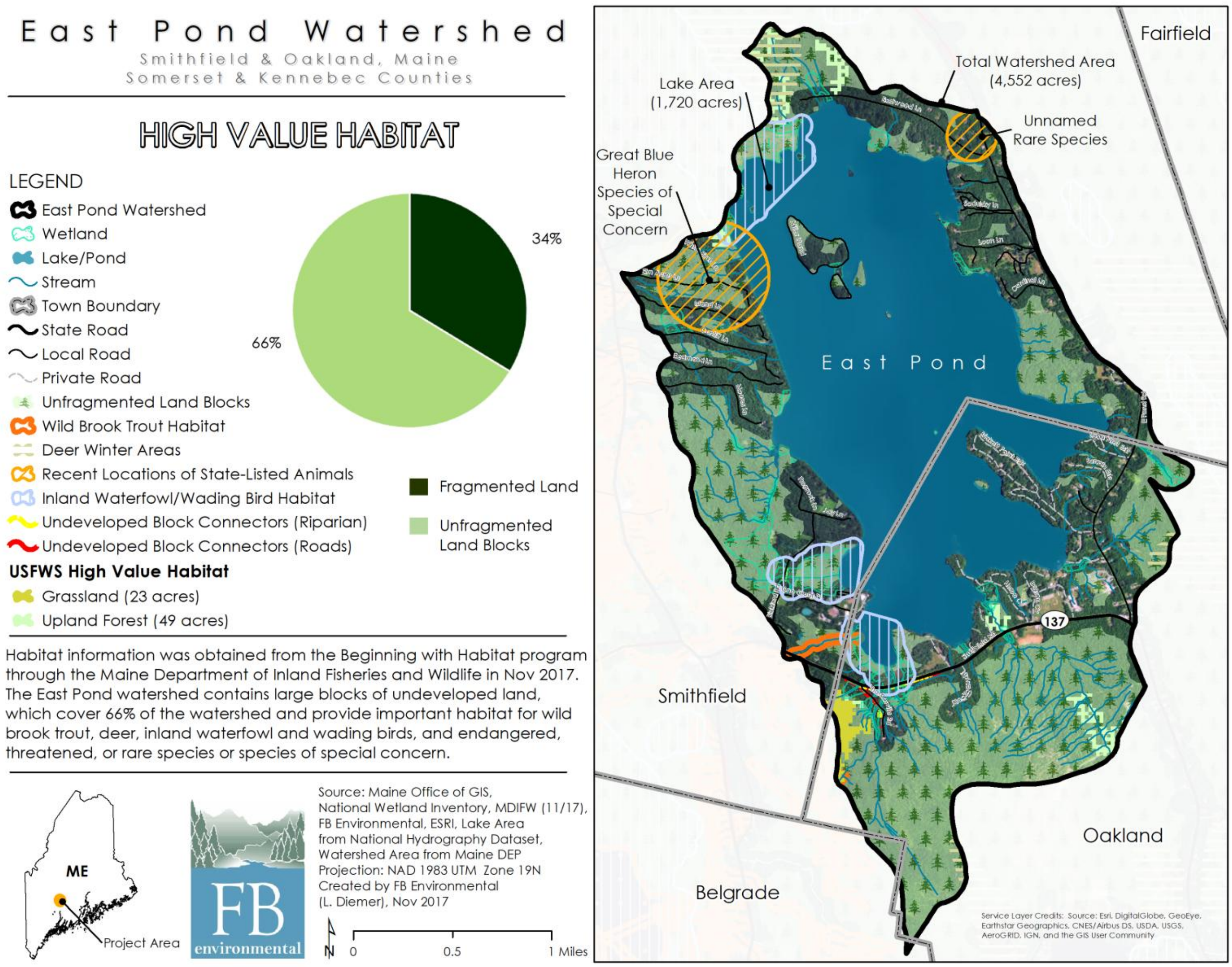


Figure 6. High Value Habitat in the East Pond Watershed.

The watershed also provides habitat for the State-endangered sedge wren (*Cistotharus platensis*) and special concern wildlife species including the Great Blue Heron (*Ardea herodias*). Other locally important wildlife species include the American eel (*Anguilla rostrata*) and nesting pairs of Bald Eagles (*Haliaeetus leucocephalus*). Under the Maine Endangered Species Act, all eagle nests are protected as Essential Habitat. The Common Loon (*Gavia immer*), a symbol of summertime on Maine Lakes, is not uncommon on East Pond despite annual blooms, with eight adult loons counted the lake in 2016.[12] Further, the Serpentine marsh, which begins on the north end of East Pond, is believed to be the original state-wide location of the first nesting pair of Sand Hill Cranes (*Grus canadensis*), with fourteen birds counted in 2013.[13] In addition, the Serpentine Marsh is classified by the Maine Department of Inland Fisheries and Wildlife as Inland Wading Bird and Waterfowl Habitat and a Wetland of Special Significance.

The East Pond biomanipulation study examined the Fish assemblages in East Pond. The lake is comprised of 19 fish species, including eleven indigenous native species, and eight introduced non-native species (Table 4). [14]

Table 4. Native and non-native fish species in East Pond.

Fish Species *Native*	**Scientific Name**	**Fish Species** *Non-Native/Introduced*	**Scientific Name**
Yellow perch	*Perca flavescens*	White perch	*Morone americana*
Pumpkinseed	*Lepomis gibbosus*	Black crappie	*Pomoxis nigromaculatus*
Redbreast sunfish	*Lepomis auratus*	Landlocked alewife	*Alosa pseudoharengus*
Golden Shiner	*Notemigonus crysoleucas*	Smallmouth bass	*Micropterus dolomieu*
American eel	*Anguilla rostrata*	Largemouth bass	*Micropterus salmoides*
White sucker	*Catostomus commersoni*	Northern pike	*Esox lucius*
Brown bullhead	*Icalurus nebulosus*	Brown trout (stocked)	*Salmo trutta*
Chain pickerel	*Esox niger*	Brook trout (stocked)	*Salvelinus fontinalis*
Banded killlifish	*Fundulus diaphanus*		
Fallfish	*Semotilus corporalis*		
Brook stickleback	*Eucalia inconstans*		

Conserved land in the watershed is limited to a 4.1 acre of land owned by the Maine Department of Inland Fisheries and Wildlife that provides access to the East Pond public boat launch on the south east end of the lake. Protecting the land and water in the East Pond watershed is important for maintaining the high value wildlife habitat. While the shoreline of East Pond has very little land left

[12] Maine Audubon, Maine Loon Lakes. Accessed online: http://audubon.maps.arcgis.com/apps/OnePane/basicviewer/index.html?appid=0a8791ab1734466da4c46064c88e7be9

[13] Personal communication, Christine Keller, East Pond Association, via email January 6, 2015, and Kennebec Journal: http://www.centralmaine.com/2013/06/22/cranes-protectors-fighting-against-speeding-boats-on-north-east-ponds/

[14] Table adapted from Halliwell and Evers, 2008.

for development[15], the habitat maps shows large areas of forestland that currently serve 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.

Invasive Plants

The large area of shallow, littoral habitat in East Pond provides perfect conditions for growth of aquatic plants. If an aquatic invasive plant were to be introduced to East Pond, it will be very difficult to manage. Fortunately, East Pond has been surveyed for invasive aquatic plants[16], and found to be free of these nuisance species. The BRCA Milfoil Committee was formed in 2002 to coordinate invasive plant prevention efforts throughout the Belgrade Lakes Watershed. The East Pond Association is one of five lake associations working collaboratively to place Courtesy Boat Inspectors (CBIs) at all public boat launches, including the launch on East Pond. The East Pond CBIs are paid employees that check all incoming vehicles, boat and trailers during the busy summer season. BRCA milfoil also provides trainings for volunteers interested in conducting in-lake surveys or becoming a CBI at no cost. Continued monitoring and assessment is needed to protect East Pond from the threat of invasive species.

Invasive variable-leaf milfoil has been found in several downstream waterbodies. (Photo: BLA)

Phytoplankton and Cyanobacteria

Both phytoplankton and 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 truly algae, but photosynthetic bacteria that can form dense growths (blooms) in lakes when nutrients are plentiful, water temperature is warm, and sunlight is abundant. These blooms are an indication that the ecology of the lake is out of balance.

An algal bloom on East Pond during the watershed survey in September 2014. (Photo: East Pond Association)

[15] Personal communication, Rob Jones, President, East Pond Association. December 2017.

[16] According to LakesofMaine.org, the last Level 3 survey was conducted by Maine DEP in 2014, followed by a Level 1 survey by volunteers in 2015, and a limited survey by volunteers in 2016.

East Pond has experienced more frequent and severe algal blooms over the past 20 years. During that time, watershed management efforts have focused on treating phosphorus loading from both external (watershed) and internal sources (biomanipulation) Yet, blooms have not slowed down in frequency or severity. The variability in weather, specifically temperature, may track bloom frequency in East Pond, and internal loading is indicated as a major influence.

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 cyanobacteria blooms in East Pond undoubtedly get their start this way, but the elevated phosphorus levels in the water column may support those blooms for longer than is sometimes observed in other lakes where deep water phosphorus is elevated, but surface water levels are low (WRS, 2016).

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). Phytoplankton monitoring by Colby College reported that spring blooms are generally tied to green algae species, while summer and fall blooms are composed of Cyanobacteria, specifically *Anabaena, sp.* (Fekete, 2017). *Anabaena* is known for producing several different toxins including anatoxin and microcystin, especially during die off. The best thing to do is avoid coming in contact with water near an algal bloom or algal scum on the shore.

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 HABs in 50% of all samples, but only three exceeded drinking water guidelines, and all of the samples were below the World Health Organization (WHO) guideline for recreational exposure (Maine DEP, 2017b). Follow-up monitoring in 2014-2015 by Maine DEP documented the occurrence of mycrocystin in East Pond, with the highest concentrations at the deep hole (12.37 μg/L) and in the downwind surface scum (9.67 μg/L) in early September. All other results from other areas of the lake and during other times of the year (August-October) were less than 1.05 μg/L (Bacon, 2016).

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

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.[17] 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).

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 have shown that in-lake phosphorus concentrations above 9-10 ppb result in a dramatic increase in the toxicity of phytoplankton.[18]

3. WATER QUALITY ASSESSMENT

In Maine, Great Ponds Class A (GPA) waters are required to have a stable or decreasing trophic state (based on appropriate measures, e.g., total phosphorus, chlorophyll-*a*, Secchi disk transparency) that is subject only to natural fluctuations, and free of culturally induced algal blooms that would impair their potential use and enjoyment (Maine DEP, 2017b). Maine DEP's functional definition of nuisance algal blooms include episodic occurrence of Secchi disk transparencies (SDTs) < 2 meters for lakes with low levels of apparent color (<30 SPU), and for higher color lakes where low SDT readings are accompanied by elevated chlorophyll-a levels (>8 ppb).

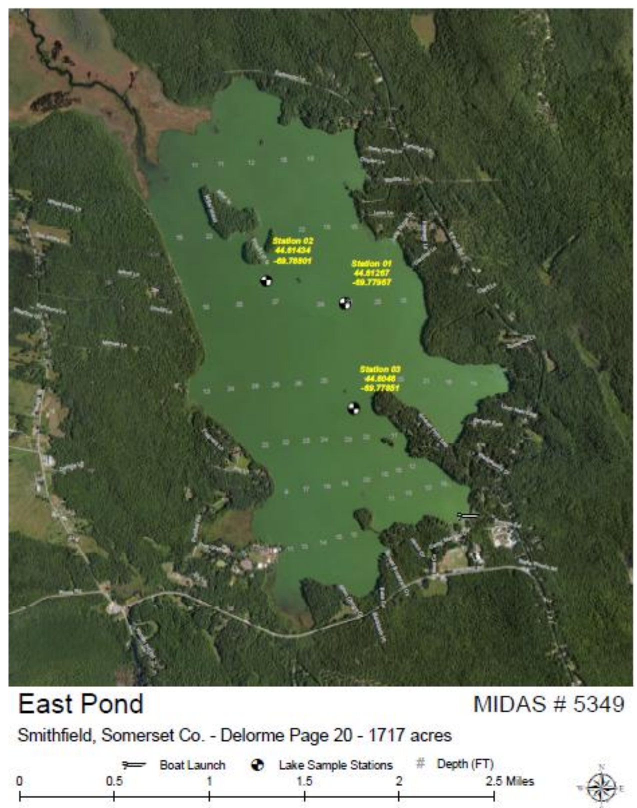


Figure 7. Water quality monitoring stations in East Pond (LakesofMaine.org).

In addition, Maine's Antidegradation Provision states that no change of land use in the watershed of a Class GPA waterbody may, by itself or in

[17] Personal communication (email), Linda Bacon, Maine DEP Biologist. August 8, 2017.
[18] Personal Communication, Dr. Jim Haney, University of New Hampshire.

combination with other activities, cause water quality degradation that would impair designated uses of downstream GPA waters or cause an increase in their trophic state. Maine's anti-degradation policy requires that "existing in-stream water uses and the level of water quality necessary to sustain those uses, must be maintained and protected."

Maine DEP conducts trophic surveys on lakes to determine trophic status. The trophic surveys evaluate physical lake features and chemical and biological indicators. Trophic state includes: oligotrophic, mesotrophic and eutrophic. These are broad categories used to describe how productive a lake is. Generally, less productive lakes have higher water quality (oligotrophic), while very productive lakes (eutrophic) exhibit frequent algal blooms. East Pond is considered a mesotrophic lake (between oligotrophic and eutrophic).

Several physical characteristics of East Pond make it vulnerable to algal blooms. The lake is spring fed with no permanent flowing inlet, and only one outlet (Serpentine Stream). The lake has a very low flushing rate (0.37 flushes/year)[19], is relatively shallow (max depth of 27 ft., mean depth of 16 ft.), and is funnel shaped, which has a significant effect on water chemistry.

Water quality data has been collected in East Pond every year since 1975 at Station 1, 14 years (1980 - 2016) at Stations 2, and nine years (2004-2012) at Station 3 (Figure 7). Data is collected by Maine DEP, the Colby College Water Quality Research Team, and volunteer water quality monitors. East Pond received a higher degree of monitoring by Maine DEP and the University of Maine between 2004-2015 as a result of a six-year targeted fish removal project aimed at reducing nuisance blue-green algae (Halliwell, 2017a). Additionally, intensive weekly sampling was conducted over the past three years (2015-2017) by the Colby College Water Quality Research Team to gain a better understanding of sediment/nutrient dynamics and internal loading in the lake

Monitoring data shows that East Pond experiences predictable nuisance algal blooms that begin between July and September each year. These blooms result in diminished water clarity (SDT <2m) and loss of recreational opportunities. This annual pattern was confirmed by the recent data collected by Colby College which shows that changes in water quality are triggered by short-lived periods of stratification followed by anoxic conditions (no oxygen) 1 m above the sediment (Figure 8).

Anoxia is followed by mixing events that transport phosphorus released from the sediment into the water column at average concentrations >26 ppb. The release of phosphorus fuels algae blooms

[19] The lake's flushing rate was updated based on modeling conducted by WRS and FBE in 2017 as part of the East Pond WBMP update.

which result in Secchi measurements between 1 and 3 m that continue to stay low until fall mixing when average phosphorus concentrations fall back to around 12 ppb. Figure 8 (top) shows the relationship between temperature and SDT in East Pond. East Pond remained mixed (purple areas) until stratification set in around day 155 through 170, and 200.

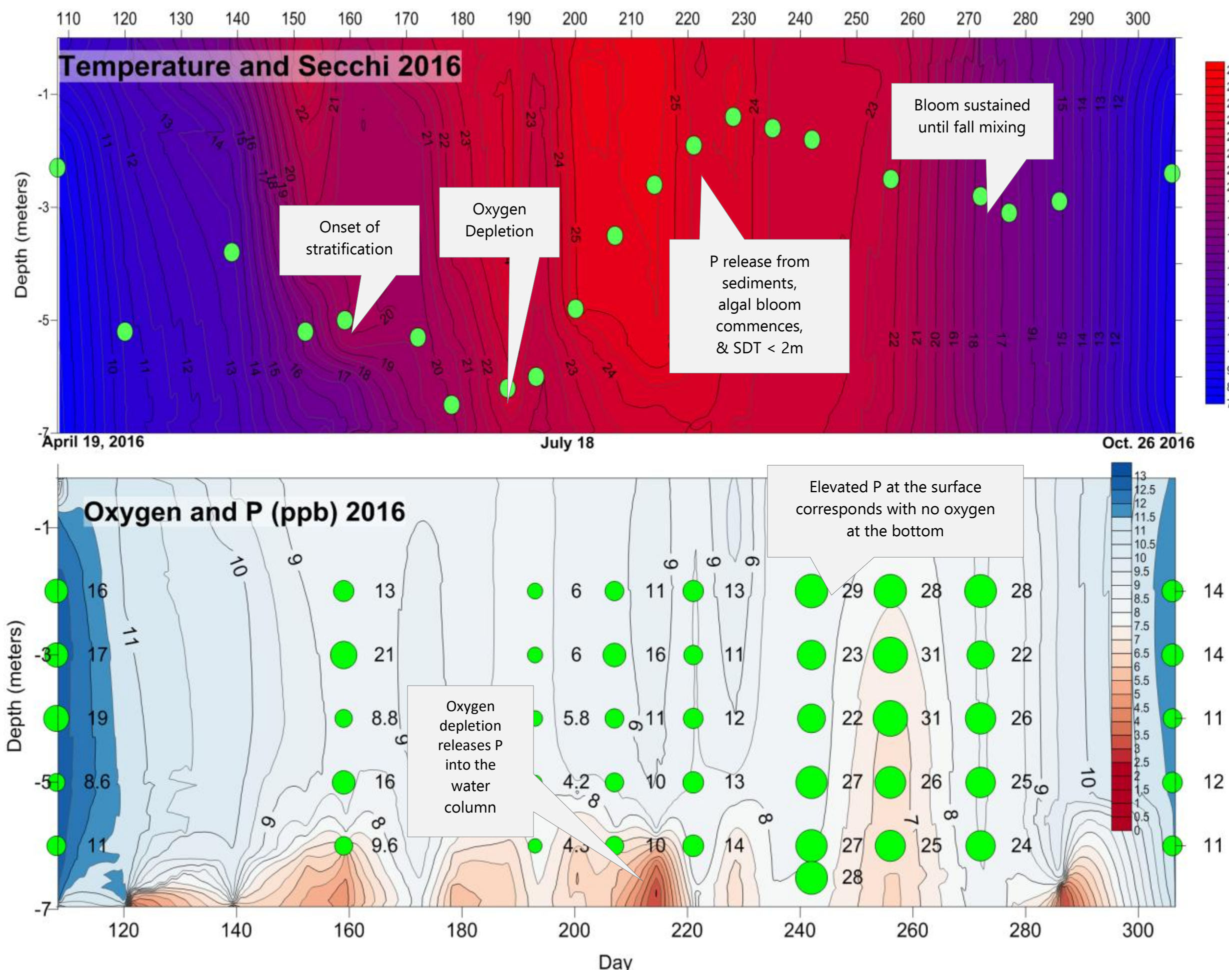


Figure 8. Temperature and Secchi profile with Oxygen and Phosphorus at East Pond Station 1 in 2016 (Source: Colby College).

Each of these short-lived stratifications created anoxic conditions 1 m above the sediment, followed by a mixing event (Figure 8, bottom). The final mixing event around day 230 released phosphorus from the sediment into the water column at average concentrations >26 ppb that continued through fall mixing when average phosphorus concentrations fell to 12 ppb.

Like some other freshwater lakes, rainfall, or lack thereof, can have a significant effect on water quality in East Pond, where wet years result in shallow SDT readings and high phosphorus concentrations, and dry years result in deep SDT readings and low phosphorus concentrations. Table 5 (below), provides an overview of water quality indicators for the past ten years highlighting the repeated bloom period during late summer on East Pond.

Table 5. Ten-year summary of water quality in East Pond (2007-2016).

Year	Algal Bloom?	Avg. SDT (m)	SDT Range (m)	Total	Chl-*a* (ppb)	*Trophic Index	**Date of first bloom (SDT < 2m)
2007	Yes	4.4	1.0 - 6.9	16.2	4.7	54	September 2
2008	Yes	4.0	1.9 - 6.8	11.0	14	63	August 10
2009	Yes	4.3	0.8 - 5.7	16.7	10.9	59	September 15
2010	Yes	2.2	0.5 - 4.4	25.7	17.8	91	July 6
2011	?	4.9	2.1-7.2	16.4	8.2	91	----
2012	Yes	4.1	0.6 - 6.8	18.0	13.9	55	August 4
2013	No	4.4	3.2 - 5.9	15.7	5	66	----
2014	Yes	3.1	0.8 - 6.6	18.8	15.1	54	August 11
2015	Yes	3.7	1.5 - 6.3	17.1	8.1	68	September 9
2016	Yes	3.6	1.3 - 6.0	38.0	25	70	August 9

* TSI based on SDT_TSI

** Date of first bloom based on SDT < 2m. SDT readings are collected every 2 weeks; therefore the bloom may have occurred anytime from the date listed to the previous sampling event.

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.

Total Phosphorus (TP): The total concentration of phosphorus found in the water, including organic and inorganic forms. TP is one of the major nutrients needed for plant growth. It is generally present in small amounts and limits plant growth 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.

Chlorophyll-*a* (Chl-*a*): A measurement of 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 amount of algae in the lake.

Specific Conductivity: This parameter is directly related to the level of dissolved ions in the water. Higher levels of conductivity may indicate a greater concentration of pollutants in the water.

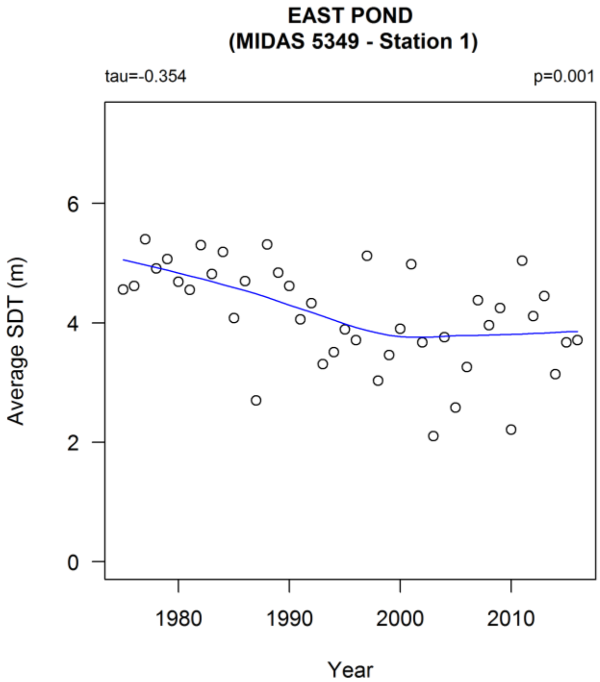
Maine DEP recently conducted a classification and condition analysis for Maine lakes (Maine DEP 2017c). Based on this analysis, East Pond is classified as an "interior pond", and its watershed is in the "altered" category due to the level of human activity it contains. Table 6 (below) presents the ranges of water quality parameters observed in interior ponds for each condition class.

Table 6. Interior Pond Lake Type: Water Quality Parameter Ranges (Maine DEP).

	Condition Classes			*East Pond*
Parameter	**Reference**	**Average**	**Altered**	
Secchi Disk Transparency (m)	≥ 4.5	4.5 - 4.8	< 4.8	**4.0**
Total Phosphorus - Epilimnion Core (ppb)	< 10.0	10.0 - 14.2	≥ 14.2	**19**
Chlorophyll-*a* (ppb)	< 4.6	4.6 - 5.7	≥ 5.7	**11.3**
Specific Conductivity (µS/cm)	< 23.9	23.9 - 49.6	≥ 49.6	**40**

Interestingly, East Pond has high mean total phosphorus and chlorophyll-*a* concentrations compared to other lakes of its type; yet mean SDT is considered average for its type. This is likely due to fluctuations in water clarity throughout the year. Late summer SDT means for East Pond (August and September) are much lower than annual means over the historical time period (1975-2006), as well as for the last ten years (2007-2016) at 3.5 m and 2.7 m, respectively. Specific conductivity is average for the lake type, but lower than in other interior ponds with 'altered' watersheds. This parameter is directly related to the level of dissolved ions in the water. Higher levels of conductivity may indicate a greater concentration of contaminants such as road salt that indicate human activity in the watershed.

A statistical analysis was conducted by Maine DEP to determine whether the water clarity in East Pond has changed over time. Both short (2007-2016), and long-term (1975-2016) trends were examined. Results of the Mann-Kendall trend tests indicate a significant downward trend in average



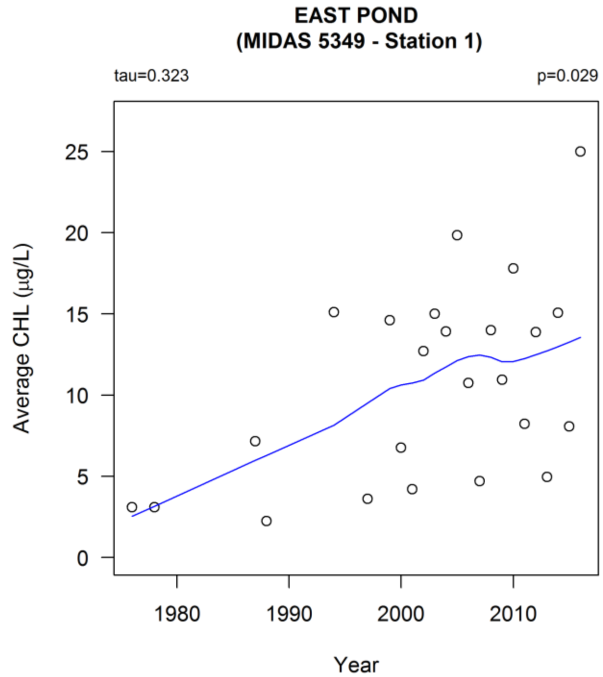


Figure 9A & 9B. Trend plots of long-term SDT (left) and Chl-a data (right) for East Pond, Station 1, with results of Mann-Kendall Trend Tests (Source: Maine DEP).

SDT (lower water clarity over time) (Figure 9A), as well as a significant increase in Chl-*a* (increasing algal density) over the historical sampling period (Figure 9B). 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. Figure 9b shows the variability in the data (large spread). No significant results were indicated for total phosphorus (short or long-term), indicating that phosphorus levels have remained stable over the historical sampling period. Similarly, the short-term SDT data suggests a stable trend in clarity (Figure 10).

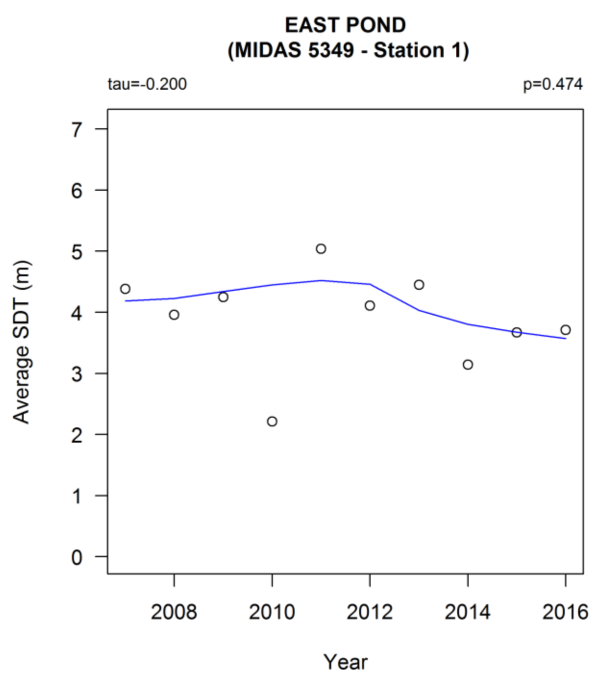


Figure 10. A Mann-Kendall trend test showing lack of significant change in the mean annual SDT data over the past ten years (Source: Maine DEP).

One interesting result of this analysis is the short-term Chl-*a* results (Figure 11). While not significant statistically, the data show a pattern of alternately high and low annual means, repeated from year to year over the 10-year period. A more in-depth look at the data is needed to better understand this trend. This may include looking at when the samples were collected, how many samples were collected, and what the length of the bloom period was. Table 1 may shed some light into this pattern; some years blooms start in early to mid-summer and last through September (higher average Chl-*a*) vs. other years where blooms don't begin until late summer or early fall (fewer high readings over the sampling season).

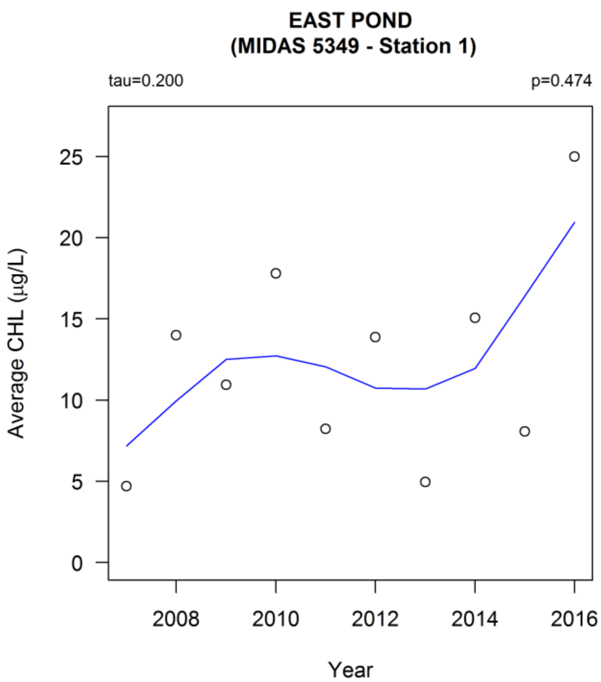


Figure 11. A Mann-Kendall trend test using Chl-a data collected in East Pond over the past 10-years showing alternating high/low pattern in the annual mean. (Source: Maine DEP).

Table 7 (next page) and Appendix C provide an overview of the statistical analysis for both short and long-term water quality data trends in East Pond for parameters in which adequate data was available to run the tests. Short and long-term SDT trends for Station 2 are presented in Attachment 1; there were no significant findings for Station 2.

Table 7. Statistical significance of long and short-term water quality data in East Pond, Station 1.

Water Quality Parameter	*Long-Term Trend (1975-2016)	Short-Term Trend (2007-2016)	**Comments
Secchi Disk Transparency (SDT)	**significantly decreasing (declining water quality)**	**no significant trend**	The long-term trend is toward declining water clarity, but may be influenced by changes in timing (longer sampling period) and frequency of sampling (more samples collected in recent years). The short-term trend is somewhat variable, but relatively stable between 3 and 5 meters.
Total Phosphorus (TP)	**no significant trend**	**no significant trend**	Phosphorus results show a high degree of variability due to the shallow nature of the lake, which results in mixing and variability throughout the season.
Chlorophyll-*a* (Chl-*a*)	**significantly increasing (declining water quality)**	**no significant trend**	The long-term trend shows an increase in Chl-*a* over time, yet there is a large spread in the data. Short-term data are highly variable and exhibit a high/low pattern from year to year.

* Non-significant trends ($p > 0.05$) can be a result of stable data or if the results are to variable to determine a trend.
** See Appendix C for graphical representations of Mann-Kendall trend tests for each data set.

Volunteers from the East Pond Association collect water clarity data to track long-term changes in the water quality of the lake. Over the years, the East Pond Association has worked collaboratively with the Maine DEP, University of Maine, and Colby to better understand the physical, chemical, and biological conditions that result in recurrent nuisance algal blooms. Colby College is finishing up an intensive three-year water quality sampling initiative which includes weekly Secchi disk measurements, sediment and phytoplankton sampling, as well as water chemistry. Results of this work have been extremely beneficial for understanding lake processes to identify the best watershed management strategies for the lake over the next 10 years.

4. WATERSHED MODELING

Understanding the contribution of phosphorus loading from both external and internal sources is important for determining where to focus watershed management activities that reduce phosphorus in East Pond. The Lake Loading Response Model (LLRM) is an Excel-based model that was used to develop a water and phosphorus loading budget for East Pond. 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 detailed and accurate information about the waterbody, including the type and area of land cover, water quality data, lake volume, septic system and internal loading estimates, etc.

Table 8. Land cover phosphorus export coefficients and land cover areas for East Pond.

LAND COVER TYPE	Runoff P export coefficient	Baseflow P export coefficient	Area (hectares)	% of Total Area
Urban 1 (Low Density Residential)	0.79	0.010	84.3	8%
Urban 2 (Mid Density Residential/Commercial)	1.40	0.010	33.0	3%
Urban 3 (Roads)	0.30	0.010	4.7	0.4%
Urban 4 (Industrial)	1.40	0.010	0.6	0.1%
Urban 5 (Mowed Fields)	1.40	0.010	19.7	2%
Agric 1 (Cover Crop)	0.80	0.010	0.0	0%
Agric 2 (Row Crop)	2.20	0.010	0.2	0.02%
Agric 3 (Grazing)	0.80	0.010	3.2	0.3%
Agric 4 (Hayfield)	0.37	0.010	0.7	0.1%
Forest 1 (Deciduous)	0.03	0.004	63.1	6%
Forest 2 (Non-Deciduous)	0.03	0.004	172.7	16%
Forest 3 (Mixed)	0.03	0.004	436.3	39%
Forest 4 (Wetland)	0.03	0.004	56.3	5%
Open 1 (Other Water) *-not including East Pond*	0.02	0.004	10.4	1%
Open 2 (Meadow/Clearing)	0.03	0.004	1.7	0.2%
Other 1 (Logged)	0.20	0.004	197.6	18%
Other 2 (Unpaved Road)	0.83	0.010	25.6	2%
		TOTAL	**1,110**	

While the percent of developed land in the watershed may seem inconsequential compared to the watershed area as a whole, 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. In the case of East Pond, the developed area of 15% results in 71% of the watershed's total phosphorus (TP) load; a fraction of the TP load from the other land cover types (Figure 12).

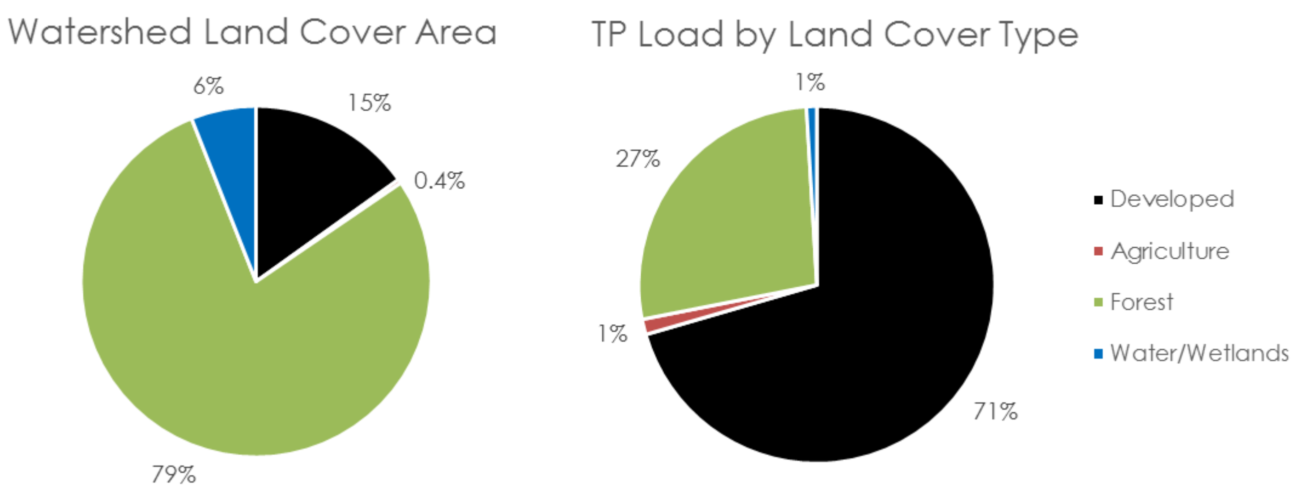


Figure 12. Watershed land cover area by general category (developed, agriculture, forest, and water/wetlands) and total phosphorus (TP) load by general land cover type.

The watershed load in phosphorus mass by area (kg/ha/year) is relatively high, which is expected given the small watershed area (compared to lake area), and short hydrologic residence time on urban and agricultural land cover in the watershed (FB Environmental, 2017). The model estimates 199 kg of phosphorus are delivered to East Pond each year (Table 9).

Table 9. Summary of total phosphorus (TP) loading for the East Pond watershed (watershed load).

EAST POND WATERHED	**WATERSHED LOAD**				
	Land Area (ha)	Water Flow (cu.m/yr)	Calculated P Concentration (mg/L)	P mass (kg/yr)	P mass by area (kg/ha/yr)
Current	1,110	7,297,430	0.027	199	0.18

The watershed load is an important component of the total phosphorus load, yet it is not the only source of phosphorus, and certainly not the most important current source of phosphorus in East Pond. The phosphorus loading summary for East Pond points to the internal load as contributing close to half of the phosphorus in East Pond (49%), followed by the watershed load (25%), and atmospheric deposition (17%). Septic systems (6%) and waterfowl (3%) make up the remaining phosphorus load to East Pond (Table 10). A total of 808 kg of phosphorus is estimated to enter East Pond each year from both internal (phosphorus released from the sediment), and external sources (watershed, atmosphere, septic systems, waterfowl).

Table 10. Total phosphorus (TP) and water loading summary for East Pond listed from highest to lowest phosphorus input.

INPUT CATEGORY	**CURRENT**		
	TP (kg/yr)	**%**	**WATER (m^3/yr)**
INTERNAL LOAD	400	49%	-
WATERSHED LOAD	199	25%	7,297,430
ATMOSPHERIC	139	17%	5,050,524
SEPTIC SYSTEMS	49	6%	37,613
WATERFOWL	21	3%	-
TOTAL LOAD TO LAKE	**808**	**100%**	**12,369,512**

High internal phosphorus loading in East Pond is not a new finding, and the biomanipulation project attempted to address it, though not successfully. An internal load of 400 kg/yr from 1.7 to 3.64 million m^2 of pond bottom, spread over 60 to 100 days in summer, would equate to a release rate of 1.1 to 3.9 $mg/m^2/day$, well within the expected range for East Pond based on the literature (WRS, 2016).

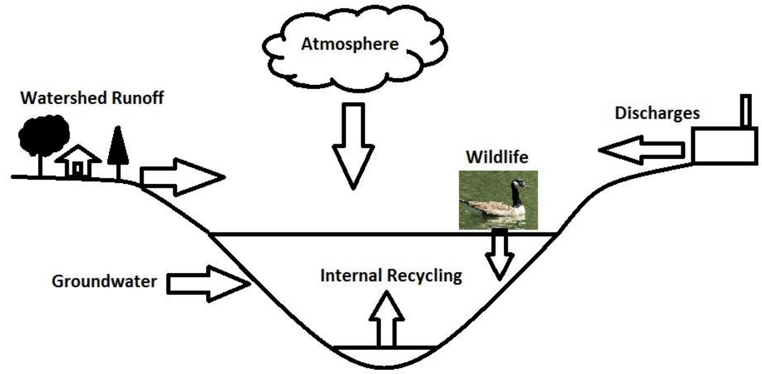


Diagram of potential pollutant loading sources. (Source: WRS, 2016)

Internal loading can involve multiple processes such as release of nutrients by aquatic plants, resuspension of sediment from wind, and/or decay of organic matter in shallow water. However, substantial internal loading is a function of release of phosphorus from iron complexes under anoxic conditions (no dissolved oxgyen) near the sediment-water interface, usually in deeper water below the thermocline (but can occur anywhere that the surficial sediment goes anoxic) (Wagner, 2016).

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 East Pond is high.

Anoxia occurs 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. Release of phosphorus from iron-bound forms in the lake's sediments is related to the concentration of iron-bound phosphorus and the extent and duration of anoxia. Once stratification sets up, it becomes difficult for oxygen from the surface of the lake to reach deep areas, and decomposition of organic matter at the bottom accelerates as water temperatures rise. Oxygen near the bottom is used up first and is not replaced. Iron-bound phosphorus is released when bottom sediments are exposed to anoxia. The actual release is a complex chemical process related to redox potential and 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.

Results of the watershed loading model indicate that addressing the internal load should be given high priority for this watershed management plan. However, addressing watershed load and septic system inputs (atmospheric deposition and natural inputs from waterfowl are difficult to manage and not a high priority), are 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.

5. ESTABLISHMENT OF WATER QUALITY GOALS

The East Pond Water Quality Review Committee and the Steering Committee reviewed and discussed the results of relevant documents developed over the two-year planning period in order to update the water quality goal for East Pond. Specifically, the committees reviewed the results of water quality data analyses conducted by Ecological Instincts, Maine DEP and Colby College, watershed modeling conducted by FB Environmental, the feasibility study and alternatives analysis conducted by WRS, and the sediment analysis and backflushing study of the Serpentine Stream conducted by Colby College. Previous work in the watershed including previous federal Clean Water Act Section 319 grant work was factored into the decision making process, as was the probability that water quality goals could be met based on estimated load reductions.

GOAL

East Pond Meets State Water Quality Standards & is Free of Nuisance Algal Blooms

In-Lake P = 11 ppb
Annual P Load ~ 398 kg/yr

INTERNAL LOAD

Reduction: 80-90% (320-360 kg/yr)
Project: Alum Treatment
Timeframe: 2018 - 2019

EXTERNAL LOAD

Reduction: 15-25% (30-50 kg/yr)
Projects: 319, YCC, LakeSmart, Septics
Timeframe: 2018 - 2027

The 2001 East Pond TMDL set a goal of reducing the total phosphorus load in East Pond to 389 kg/yr with a numeric water quality target of 15 ppb total phosphorus. After reviewing available data for East Pond, the Water Quality Review Committee determined that the water quality target set by the TMDL is higher than necessary based on proposed watershed management strategies outlined in this plan that address both the internal (400 kg/yr) and watershed (199 kg/yr) phosphorus load. Reducing the internal load by 80 - 90% (320 - 360 kg/yr), and the external load by 15 - 25% (30 - 50 kg/yr) will result in a reduction of the total phosphorus load to East Pond by 43 - 51% or approximately 350 - 410 kg/yr. These reductions are expected to result in a reduction of the in-lake total phosphorus concentration to 11-12 ppb, increase summer water clarity readings to between 3.4 m - 5.0 m (11.2 ft- 16.4 ft), and reduce the probability of algal blooms to between 1 - 5%.[20]

ADDRESSING THE INTERNAL LOAD

The internal loading and alum treatment diagnostic and feasibility study conducted by WRS provided recommendations for inactivating phosphorus in East Pond's sediments by treatment with alum. The rational for this treatment is clearly evident by the fact that water quality is not improving because watershed runoff controls alone cannot solve the problem once "appreciable reserves of available phosphorus" have accumulated in the lake. East Pond has experienced more frequent and more severe cyanobacteria blooms over the past 20 years, and will only 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 11). The East Pond alum treatment will be the largest alum project undertaken in Maine to date.

Table 11. List of Maine lakes 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	TBD

The goal of the East 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 80-90% of the internal phosphorus load in the lake by inactivating phosphorus in the deepest areas of the lake where anoxia is occurring (>5m). Conservatively, a reduction of 80% would equate to a reduction of 320 kg P/yr, reducing the internal load from 400 kg/yr to 80 kg/yr.

[20]Predicted phosphorus and water clarity measurements are based on estimated P load reductions entered into the 'Predictions' tab in the LLRM. Average late summer (August-September) water clarity over the last ten years (2007-2016) is 2.7 m.

The area of the lake to be treated and the treatment dose are subject to additional lab investigations. Colby will be leading lab assays (jar testing) with support from Maine DEP and WRS using sediment collected from the bottom of East Pond. Results of these tests will determine the overall area to be treated and aluminum doses, as well as final costs to complete the treatment. Current management recommendations (pre-jar testing) include treating all areas in East Pond deeper than 5 m with a dose of aluminum between 18 - 33 g/m2, though dosing may vary based on depth intervals. This is an area of approximately 676 acres (Figure 13), and is estimated to cost between $800,000 - $900,000 for a one time treatment. Monitoring will be conducted before, during and after the alum treatment.

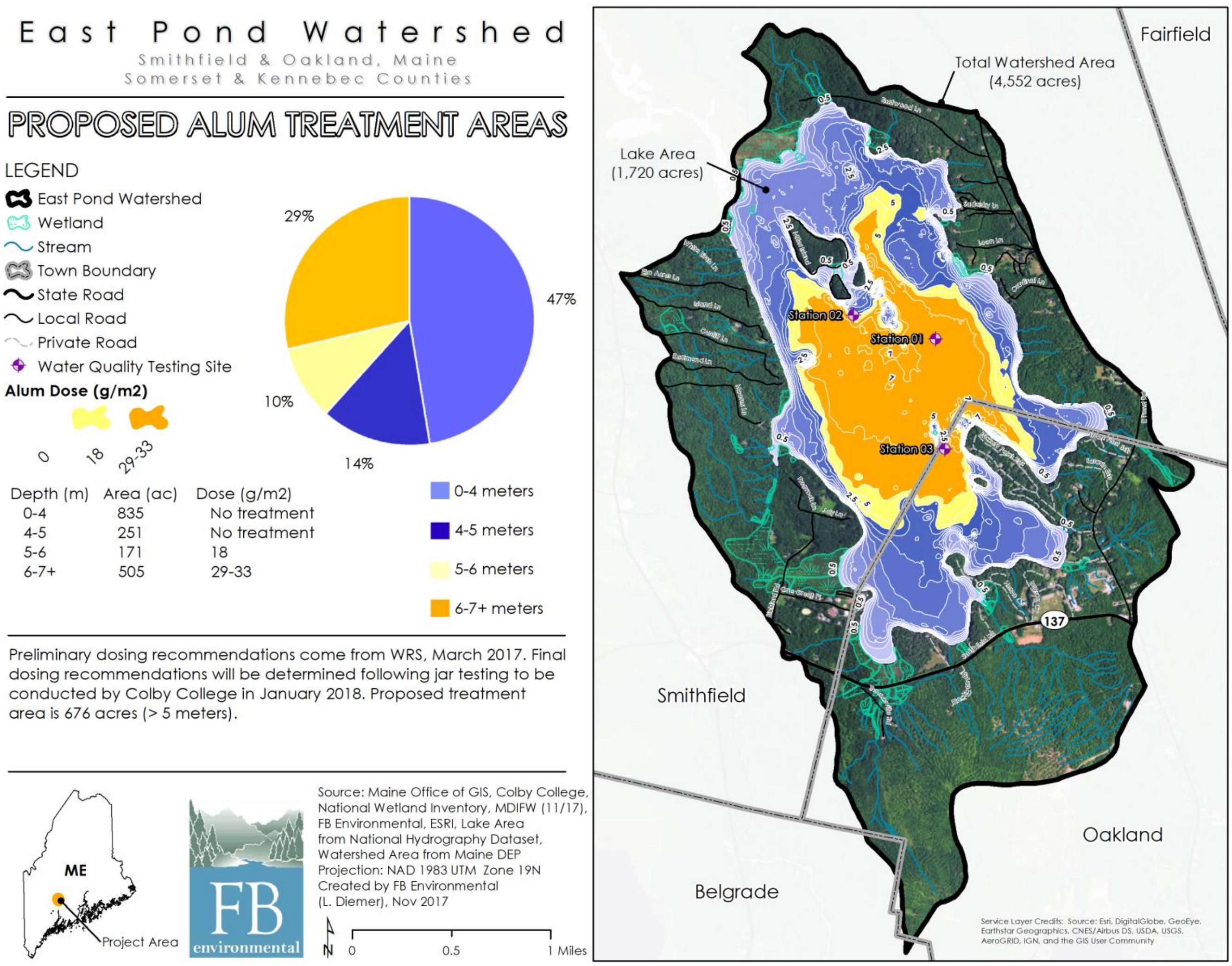


Figure 13. Proposed alum treatment areas and dosage for East Pond.

Information about the alum treatment was presented at the 2017 East Pond Association annual meeting, and to Steering Committee members representing the towns of Smithfield and Oakland and members of the public. Additional public outreach is planned for early 2018 (see Action Plan). In response to questions raised by the public regarding the alum treatment, the East Pond Association developed a frequently asked questions (FAQ) document that addresses topics including aluminum toxicity, treatment area, longevity of treatment, etc. The FAQ is available to the public on the association's website, and in Appendix C.

Adding alum to East Pond is planned for the spring of 2018. Effects of the alum treatment should be apparent during the first year, with more noticeable affects the following year. Post-alum treatment monitoring will help determine if additional alum is needed to treat other areas of the lake (e.g. 4-5m). It is expected that the effectiveness of an alum treatment on East Pond will be sustained for 10-20 years. Permitting is currently underway.

ADDRESSING THE EXTERNAL LOAD

Addressing the internal load is just one part of a multi-step process to improve the water quality in East 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 30 - 40 kg/yr. Previous watershed implementation projects funded through the US EPA 319 grant program addressed 64 NPS sites and reduced the watershed phosphorus load by a similar quantity (31 kg /yr).

Extending a shoreline buffer is one of many ways landowners can do their part to protect East Pond. (Photo: East Pond Association)

Watershed NPS Sites

A follow-up to the 2014 East Pond Watershed survey determined that of the original 102 sites surveyed, only 81 still need to be fixed.[21] Ten of the original sites have been addressed through YCC or LakeSmart projects including one by the Town of Smithfield, and ten were found to have no impact (lack of buffer but no active erosion).

The majority of these sites are located on private residential property (Figure 14), and rank low impact (58). A smaller portion of the sites ranked medium (19) or high (4) impact (see Appendix A).

[21] The 102 sites does not include the sites documented in the Serpentine Stream watershed. These will be addressed through efforts of the North Pond Association. Follow-up survey work was completed by BRCA and Maine DEP in the fall of 2017.

These findings suggest the need for a commitment from residential property owners to do their part to improve water quality and to protect the close to $1 million investment in treating the internal load. The watershed action plan (Table 12) outlines the strategies and cost for reducing the watershed load from NPS sites in the watershed:

- Apply for Section 319 funding to address the four (4) high impact NPS sites;
- Utilize the BRCA Youth Conservation Corps (YCC) and Section 319 grant funding to address 19 medium impact sites;
- Work with the six (6) large commercial camp owners to address documented NPS sites and help them become LakeSmart;
- Target shorefront property owners to become LakeSmart- goal 50% of shoreline properties are LakeSmart by 2027 (currently 10%).

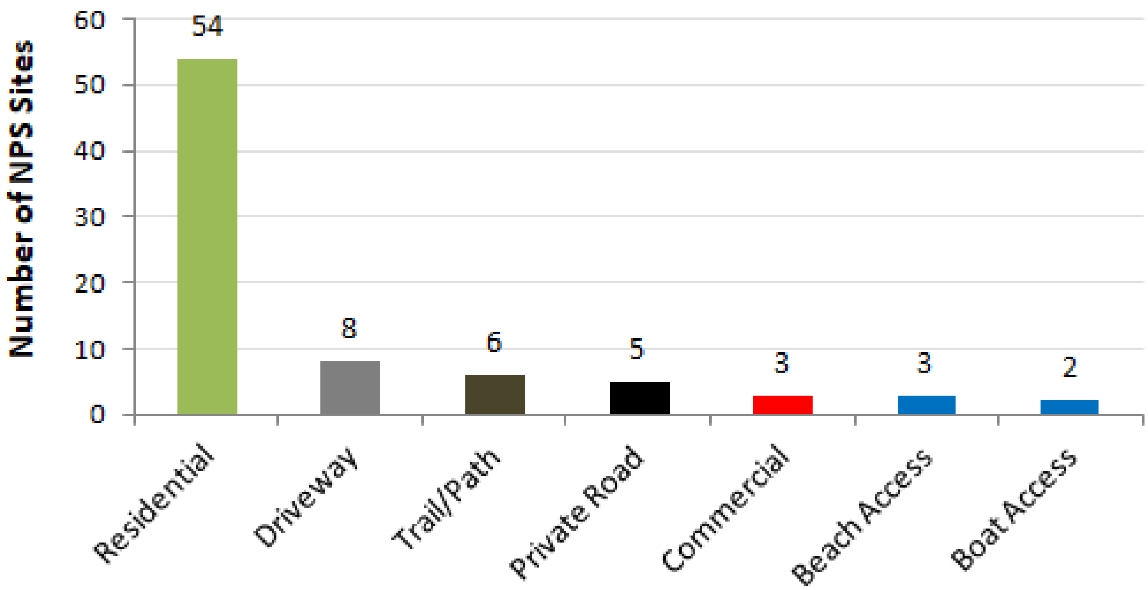
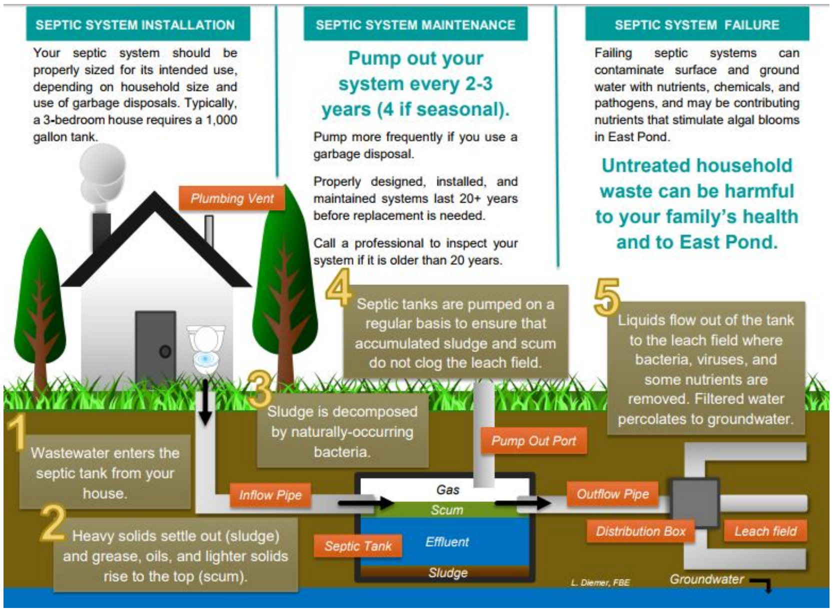


Figure 14. Number of NPS sites in the East Pond Watershed by land-use type (Updated October 2017).

Septic Systems

While phosphorus loading from septic systems appears to have a small impact on the water quality of East 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 East Pond with a goal of reducing the phosphorus load by 10-20% (5 - 10 kg /yr):

- Develop an online septic survey and follow-up with a door-to-door survey;
- Offer landowners free septic evaluations and septic designs for high priority systems identified during the septic survey with a goal of 30 free evaluations and 10 free designs.



The East Pond Association developed and distributed septic system information to all landowners in the watershed in 2014. (Source: East Pond Association)

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, East 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 and ensure timely enforcement of current rules that protect water quality;
- 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 12. East Pond Watershed Action Plan & Management Measures.

Action Plan & Management Measures	Schedule	Who	Potential Funding Sources	Estimated Cost
Address the Internal Phosphorus Load in East Pond (Load Reduction ~ 320 - 360 kg/yr)				
Conduct Alum Treatment				
Complete required permitting for 2018 alum treatment	Year 1	BRCA, contractor	Landowners, East Pond Assoc., US EPA (319), Maine DEP, BRCA	$2,000
Raise funds for alum treatment	Year 1	East Pond Assoc., BRCA	Towns, Private Donors, Landowners	$500
Develop Request for Proposals (RFP) and select contractor for spring application	Year 1	BRCA, contractor	Landowners, East Pond Assoc., US EPA (319), Maine DEP, BRCA	$1,000
Conduct alum treatment	Year 1	BRCA, contractor	US EPA (319), Towns, Private Donors, Landowners	$900,000
Conduct monitoring for pH and wildlife during alum treatment	Year 1	BRCA, consultant	Private donors	$1,500
Conduct ongoing annual monitoring following the alum treatment	Years 1-3	BRCA, consultant	Private donors	$10,000
Address the External Phosphorus Load in East Pond (Load Reduction ~ 30 - 40 kg/yr)				
Address High Impact NPS Sites				
Apply for Section 319 Grant Funding to Address High Impact Sites Identified in the Watershed Survey **Goal:** 4 Sites	Years 2-4	BRCA	Towns, US EPA (319), Maine DEP	$20,000
Address Medium Impact NPS Sites				
Utilize the BRCA Youth Conservation Corps and Section 319 Grant Funding to Address Medium Impact Sites **Goal:** 19 Sites	Years 2-6	BRCA	Grants, Towns, US EPA (319), East Pond Assoc., Landowners	$28,500
Address Low Impact NPS Sites				
Utilize the BRCA Youth Conservation Corps and LakeSmart to Address Low Impact Sites **Goal:** 58 Sites	Years 1-10	BRCA YCC & LakeSmart, Landowners	Landowners, Towns, US EPA (319), Maine DEP	$45,000
Target large commercial camps for LakeSmart Certification **Goal:** 6 camps	Years 1-4	East Pond Assoc., BRCA	East Pond Assoc., Landowners	$15,000
Target shorefront properties to become LakeSmart **Goal:** 50% of shorefront property owners participating	Years 3-10	East Pond Assoc.	East Pond Assoc., landowners	$20,000

Action Plan & Management Measures	Schedule	Who	Potential Funding Sources	Estimated Cost
Reduce NPS from Septic Systems				
Meet with the Maine State Soil Scientist to identify potential high impact areas for septic systems. Determine if re-deployment of soil sensors is useful.	Year 2	BRCA, Colby, Maine State Soil Scientist	Grants, Colby	$2,500
Update septic system data base following annual requests from towns for septic system upgrade information	Year 2	East Pond Assoc., Colby, BRCA	East Pond Assoc., Towns, Grants	$2,500
Develop an online septic survey and mail a copy to all shoreline residents	Year 3	East Pond Assoc.	East Pond Assoc., Membership	$1,000
Conduct a follow-up door-to-door survey to property owners that did not respond to initial mailing	Year 3	East Pond Assoc.	East Pond Assoc., grants	$2,500
Offer landowners free septic evaluations & septic designs for high priority systems identified during the survey **Goal:** 30 free evaluations, 10 system designs	Years 3-4	East Pond Assoc., town plumbing inspectors	Grants	$15,000
Provide cost-share grants to assist landowners with replacing failing septic systems **Goal:** 5 systems	Years 4-6	East Pond Assoc., BRCA, DHHS, Towns	Grants	$75,000
Education, Outreach & Communications				
Conduct community meetings to inform residents about the alum treatment **Goal:** 3 meetings	Year 1	BRCA, East Pond Assoc., Colby, contractor	Grants	$1,000
Prepare and distribute educational materials about the alum treatment	Year 1-2	BRCA, East Pond Assoc., Towns	Grants	$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	BRCA, East Pond Assoc.	Grants	$250
Keep websites updated regarding alum treatment and on-going monitoring efforts	Ongoing Years 1-10	East Pond Assoc., BRCA, Towns	Operating funds	$1,000
Prevent New Sources of NPS Pollution				
Attend regular planning board meetings to update watershed towns on watershed activities and needs **Goal:** Minimum 2 meetings/yr	Ongoing Years 1-10	BRCA, East Pond Assoc.	n/a	n/a
Work with the state and town officials to promote cleaning up winter sand and ongoing road maintenance (see comment)	Ongoing Years 1-10	East Pond Assoc., BRCA	n/a	n/a
Work with town planning boards to strengthen town ordinances and ensure timely enforcement of current rules that protect water quality	Ongoing Years 1-10	East Pond Assoc., BRCA	n/a	n/a

Action Plan & Management Measures	Schedule	Who	Potential Funding Sources	Estimated Cost
Conduct a build-out analysis to determine suitable areas for future development and areas for conservation	Year 2-3	East Pond Assoc.	East Pond Assoc., grant	$2,500
Build Local Capacity				
Steering Committee to meet once/year to discuss action items and goals	Annually Years 1-10	East Pond Assoc., 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 treatments **Goal:** $1,500,000 raised by 2028	Year 1-2	East Pond Assoc., BRCA	East Pond Assoc.	$5,000
Apply for US EPA Clean Water Act Section 319 watershed implementation grants to address high & medium impact NPS sites	Year 2	BRCA	US EPA (319)	$1,500
Apply for other state, federal or private foundation grants that support planning recommendations	Ongoing Years 1-10	BRCA	East Pond Assoc.	$1,500
Conduct Long-Term Monitoring & Assessment				
Continue collecting intensive baseline water quality data	Ongoing Years 1-10	Colby, Maine DEP, Volunteers	Private donors, grants, MLRC, Colby	$15,000/year
Track and document the presence, toxicity, and duration of algal blooms	Annually Years 1-10	East Pond Assoc., Colby, volunteers	East Pond Assoc.	n/a
Set up NPS Site Tracker & update annually	Ongoing Years 1-10	BRCA	US EPA (319)	$500/yr
Continue ongoing CBI at boat launches, and invasive plant surveys	Ongoing Years 1-10	East Pond Assoc., BRCA	BRCA, East Pond Assoc., Towns, Businesses, Grants	$12,000/yr
Continue collecting data in the Serpentine to inform backflushing study	Year 1	East Pond Assoc., BRCA	n/a	$2,500/yr
Collect water quality samples from the Serpentine during rain events	Year 2-3	BRCA	Grants	$5,000
Investigate dam management strategies including water-level monitoring and need for dam modification to enhance water quality improvement efforts	Years 2-4	BRCA, East Pond Assoc., Colby	Grant	$5,000 - $10,000
Conduct research on the total assessed value of lakeshore properties before and after alum treatment using real estate transaction values	Year 1, Year 10	Colby, Towns	Colby	$5,000
Photo document shoreline using drones and make information available to project partners **Goal:** every 3-5 years	Years 1, 5, 10	Colby	Colby	$10,000

6. MONITORING ACTIVITY, FREQUENCY AND PARAMETERS

Collecting Secchi disk transparency readings on East Pond. (Photo: Logan Parker)

Maine water quality criteria requires East 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.

An assessment of existing water quality monitoring in East Pond was completed as part of the water quality analysis, and through the development of a Sampling and Analysis Plan (SAP). The SAP, which was approved by Maine DEP, describes sampling methodology and quality assurance/quality control procedures used by the Colby College Water Quality Research Team to ensure that data collected on East Pond meets the criteria set by the State for use in the State's water quality data base (Ecological Instincts, 2017). Samples are collected at Sample Station 1 from mid-May to mid-November.

The Water Quality Technical Review Committee determined that ongoing baseline monitoring (less sediment sampling) should continue on East 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. Baseline monitoring will include:

- **Water Clarity, Temperature, Dissolved Oxygen, Chlorophyll-*a*, and pH** collected weekly.
- **Nutrients and Metals** collected biweekly at 2m, 3m, 4m, 5m, 6m, 7m, where the deepest sample is approximately 1m from the bottom (dependent on lake volume), using a Van Dorn sampler.
- **Phytoplankton** collected monthly at 2m and analyzed using the FlowCam. 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 and sent to HETL from the same horizontal grab sample collected for nutrient analysis above. (The number of duplicate samples that will be collected will be dependent on available funding and SAP protocols.)
- **Water levels in the Serpentine** will be measured using three pressure transducers (Onset U20-001-04) deployed in the Serpentine Stream from mid-May until mid-September in 2018-2019. Grab samples will be collected during rain events.

Additional monitoring and assessment beyond baseline monitoring will include tracking the presence, toxicity and duration of algal blooms, CBI monitoring at the boat launch, photo documentation of the shoreline, and documenting changes in water level at the dam. A description of these activities, relevant milestones, schedule and cost are presented in the Action Plan (Table 12).

The East Pond Association will continue to work with project partners including VLMP water quality monitors, Colby College, Maine DEP, BRCA and the towns of Smithfield and Oakland to conduct long-term water quality monitoring on East Pond, and to analyze the results of this data to inform future watershed management planning.

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 12). 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: Logan Parker)

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 East 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 13 (below) outlines the water quality benchmarks, and interim targets for improving water quality of East Pond over the next 10 years.

Table 13. 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:** 2.7 m **Goal:** 4.0 - 4.3 m	4.0 m *(↑1.3 m)*	4.2 m *(↑0.2 m)*	4.3 m *(↑0.1 m)*
b) Phosphorus loading reductions from both internal and external phosphorus sources **Goal:** Reduce P by 350 - 410 kg P/yr	↓360 kg P	375 kg *(↓ 15 kg P/yr)*	390 kg P *(↓ 15 kg P/yr)*
c) Decrease in average in-lake total phosphorus concentration **Current:** 19 ppb **Goal:** 11 - 12 ppb	12 ppb *(↓ 7 ppb)*	11.5 ppb *(↓ 0.5 ppb)*	11.1 ppb *(↓ 0.4 ppb)*
d) Increase in dissolved oxygen levels in deep areas of the lake/decrease in the area of anoxia **Goal:** 80% decrease in anoxic factor	80% decrease in area of anoxia	80% decrease in area of anoxia	80% decrease in area of anoxia

** Benchmarks are cumulative unless otherwise noted. Years 1-2 (2018-2019); Years 3-5 (2020-2022); Years 6-10 (2023-2027)*

Social Milestones measure changes in social or cultural practices and behavior that lead to implementation of management measures and water quality improvement. Table 14 (below) outlines the social indicators, benchmarks and interim targets for the East Pond Watershed-Based Plan.

Table 14. 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 though YCC and cost-sharing grants **Goal:** 58 Low & Medium Impact Sites	10 sites *(10 sites total)*	*30 sites (40 sites total)*	*18 sites (58 sites total)*
b) Number of LakeSmart site visits and new LakeSmart certifications (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:** 50 kg P/yr	15 kg P/yr	25 kg P/yr *(40 kg P total)*	10 kg P/yr *(50 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 (2018-2019); Years 3-5 (2020-2022); Years 6-10 (2023-2027).*

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 15 (below) outlines the programmatic indicators, benchmarks and interim targets for the East Pond Watershed-Based Plan.

Table 15. 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	670 acres	n/a	n/a
b) Number of NPS sites addressed **Goal:** 81 sites	10 sites *(10 total)*	40 sites *(50 total)*	31 sites *(81 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:** $1,600,000	$1,250,000	$200,000 *($1,450,000 total)*	$150,000 *($1,600,000 total)*
e) Number of 319 projects to address high & medium impact sites & to support YCC projects **Goal:** 4 high impact and 19 medium impact sites	Phase IV	Phase V	Phase VI

** Benchmarks are cumulative unless otherwise noted. Years 1-2 (2018-2019); Years 3-5 (2020-2022); Years 6-10 (2023-2027)*

8. POLLUTANT LOAD REDUCTIONS & COST ESTIMATES

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

Table 16. East 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)	320 - 360 kg/yr	\$800,000 - \$950,000
2	**Address the External P Load** (NPS Sites, Septic Systems, YCC, LakeSmart, Education & Outreach)	30 - 50 kg/yr	\$200,000 - \$250,000
3	**Prevent New Sources of NPS Pollution** (Build-out, Land Conservation, Ordinances, Enforcement)	TBD	\$10,000 - \$15,000
4	**Build Local Capacity** (Funding Plan, Steering Committee, Grant Writing)	n/a	\$5,000 - \$6,500
5	**Long-Term Monitoring & Assessment** (Baseline Monitoring, algal bloom tracking, etc.)	n/a	\$300,000 - \$355,000
	TOTAL	**350 - 410 kg/yr**	**\$1.3 - \$1.6 million**

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.

Belgrade Regional Conservation Alliance (BRCA) may provide technical assistance to the East Pond Association, landowners and towns to complete NPS projects, coordinate YCC projects, assist with land conservation, planning and research projects, grant writing and monitoring, and serve on the watershed steering committee.

Colby College will continue collecting baseline water quality data and conducting research to inform project partners about changes in water quality over time. Colby can provide students to assist with developing a septic database, tracking changes in property values, and documenting shoreline conditions. Colby will also serve on the watershed steering committee.

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

Kennebec County Soil & Water Conservation District (KCSWCD) may provide technical assistance, including engineering assistance for road projects and pollutant load reduction calculations.

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 YCC 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 319 grant program. Maine DEP will also serve on the steering committee.

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

Towns of Smithfield & Oakland 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 towns 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. East Pond NPS Sites (Updated October 2017).

EAST POND NPS SITES (Updated October 2017)

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.

Cost of NPS Sites: The estimated cost of NPS sites is determined in the field based on the types of problems identified, and the number and types of recommendations. Low cost sites are typically documented on residential sites that only need a few low cost BMPs (less than $500). Medium cost sites are typically associated with road and driveways, ranging in cost from $500 to $2,500, and high cost refers to sites that require heavy equipment or engineering to complete (> $2,500).

Site	Location	Flow into lake via	Land Use	Problems	Slope	Recommendations	Impact	Cost
1-01	168 Eastwood Lane	Directly to lake	Residential	Slight surface erosion, bare soil	Steep	Stabilize foot path with ECM, install runoff diverter/water bar	Low	Low
1-02	128 Eastwood Lane	Minimal Vegetation	Residential	Slight surface erosion	Steep	Install runoff diverter/water bar	Low	Low
1-03	34 Eastwood Lane	Directly to lake	Residential	Slight surface erosion, moderate ditch erosion in remnant channel, bare soil, inadequate shoreline vegetation, shoreline erosion	Moderate	Install turnouts, stabilize foot path, establish buffer, add to buffer, reseed bare soil and thinning grass, keep grass taller	Medium	Low
1-08	77 Cardinal Lane	Directly to lake	Residential	Moderate surface erosion, slight surface erosion, bare soil, inadequate shoreline vegetation	Moderate	Install rubber razor, establish buffer	Medium	Medium
1-11	76 Cardinal Lane	Directly to lake	Residential	Moderate surface erosion, bare soil, lack of shoreline vegetation, shoreline erosion	Moderate	Establish buffer, stabilize shoreline	Medium	Low

Site	Location	Flow into lake via	Land Use	Problems	Slope	Recommendations	Impact	Cost
1-13	Cardinal Lane (in general)	Directly to lake	Private Rd	Moderate surface erosion, turnouts are bare soil, road has been crowned recently, undersized culverts at base of road	Steep	Add gravel to road/driveways, install catch basin, install runoff diverters, install rubber razor, enlarge culverts, install large plunge pool/level spreader at base of hill	Medium	Low
2-01	219 Brickett Pt.	Directly to lake	Residential	Slight surface erosion, some bare soil	Steep	Define footpath, mulch/ECM, establish buffer, add to buffer	Low	Medium
2-02	P.O box 60, Oakland	Directly to lake	Residential	Lack of shoreline vegetation, lawn to the lake	Moderate	Establish buffer, add to buffer	No Impact	Low
2-03	187 Brickett Pt.	Directly to lake	Driveway	Driveway diversion at end	Moderate	Install runoff diverter or water bar	Low	Medium
2-05	173 Brickett Pt.	Directly to lake	Driveway		Moderate	Install runoff diverters/water bar	Low	Low
2-11	By 66 Brickett Pt.		Private road	Moderate road shoulder erosion, rubber razor not functional	Moderate	Reshape(crown) road, grade road, replace rubber razor.	Medium	Medium
2-12	Boat Launch	Directly to lake	Boat access	Moderate surface erosion, beach breakout caused by beaver dam	Flat	Need beaver deterrent (beaver deceiver) to prevent dam and beaver washout	Medium	Low
2-28	Rocky Shores Rd.	Directly to lake	Private Road	Slight to moderate surface erosion	Flat to moderate	Install turnouts, install ditch, add gravel to road, reshape (crown) road, grade road	Medium	Low
2-50	225 Brickett Pt.	Minimal veg.	Residential	Slight surface erosion, bare soil, inadequate shoreline vegetation	Moderate	Infiltration steps, add to buffer, reseed bare soil and thinning grass	Low	Low
2-51	233 Brickett Pt.	Directly to lake	Residential	Slight surface erosion, bare soil, inadequate shoreline vegetation	Moderate	Infiltration steps, mulch/erosion control mix	Low	Low

Site	Location	Flow into lake via	Land Use	Problems	Slope	Recommendations	Impact	Cost
2-52	237 Brickett Pt.	Directly to lake	Residential	Slight surface erosion, bare soil, inadequate shoreline vegetation	Moderate	Define foot path with ECM for wheelchair use, infiltration trench at garage roof drip line, mulch/erosion control mix on Lower drive area, add to buffer	Medium	Low
2-53	241 Brickett Pt.	Directly to lake	Driveway/ Residential	Moderate surface erosion, bare soil	Moderate	Add new surface material (gravel or ECM), cover driveway with ECM or bluestone, roof dripline planters	Medium	Medium
2-54		Directly to lake	Residential	Undercut shoreline, lack of shoreline vegetation, unstable access		Infiltration trench at roof drip line, establish buffer, no raking	Low	Medium
2-55	244 Brickett Pt.	Minimal veg.	Driveway/ Residential	Bare soil	Moderate	Define parking area ad resurface	Low	High
2-56	Brickett Pt.		Residential	Moderate surface erosion, bare soil, roof runoff erosion, lack of shoreline vegetation	Moderate	Infiltration steps below parking area, infiltration trench at roof drip line, mulch/EMC, establish buffer, no raking	Medium	High
2-59	236 Brickett Pt.	Directly to lake	Residential (old boat launch)	Slight surface erosion, lack of shoreline vegetation	Moderate	Install runoff diverters, establish buffer, hazardous materials (gas tank, paint exp.)	Low	High
2-60	265 Brickett Pt.	Directly to lake	Residential	Slight surface erosion, bare soil	Moderate	Install runoff diverters, mulch/ECM	Low	Low
2-61	279 Brickett Pt.	Directly to lake	Residential	Unstable access/dock area, inadequate shoreline vegetation	Moderate	Add to buffer, stabilize shoreline at dock with rock and vegetation	Low	Low
2-62	285+ 283 Brickett Pt.	Directly to lake	Residential	Roof runoff erosion, inadequate shoreline vegetation	Moderate	Infiltration trench at roof drip line, add to buffer	Low	Medium
2-65	427 Brickett Pt.	Directly to lake	Residential	Slight surface erosion, gutter piped to lake	Moderate	Drywell at gutter downspout, add to buffer	Low	Medium

Site	Location	Flow into lake via	Land Use	Problems	Slope	Recommendations	Impact	Cost
2-66	In front of Cormier Property 429 Brickett Pt.)	Directly to lake	Beach Access (Private)	Bare soil, shoreline erosion	Moderate	Mulch/ECM, add to buffer	Low	Low
2-68	433 Brickett Pt.	Directly to lake	Residential	Slight surface erosion, inadequate shoreline vegetation, driveway runoff diverter could possibly be added not flowing to lake, paint bucket	Moderate	Install runoff diverter, establish buffer	Low	Medium
2-69	435 Brickett Pt.	Minimal veg.	Residential	Inadequate shoreline vegetation, artificial beach?	Moderate	Add to buffer	Low	Medium
2-70	437 Brickett Pt.	Minimal veg.	Residential	Bare soil, lack of shoreline vegetation, pet waste	Moderate	Mulch/ECM, establish buffer, reseed bare soil and thinning grass, pick up pet waste, add razor bar to driveway	Low	Medium
2-71	443 Brickett Pt.	Directly to lake	Residential	Moderate surface erosion, roof runoff erosion, unstable access	Moderate	Add new surface material (gravel), stabilize footpath, drywell at gutter downspout, mulch/ECM, stabilize shoreline at footpath on shore	Low	Medium
2-71B	450 Brickett Pt	Directly to lake	Residential (2 waterfront adjacent/same treatment	Slight surface erosion, bare soil (flower garden area), inadequate shoreline vegetation	Moderate	Define footpath, install runoff diverter, establish buffer	Low	Medium
2-72	453 Brickett Pt.	Directly to lake	Residential	Slight surface erosion, roof runoff erosion, inadequate shoreline vegetation		Add new surface material (gravel), drywell at gutter downspout, establish buffer, reseed bare soil and thinning grass	Low	Medium

Site	Location	Flow into lake via	Land Use	Problems	Slope	Recommendations	Impact	Cost
2-73	455 Brickett Pt.	Directly to lake	Driveway	Moderate surface erosion	Steep	Add new surface material (gravel), install runoff diverters, rain garden at base of slope	High	Medium
2-74			Residential	Bare soil, lack of shoreline vegetation	Steep	Potential septic issue, rain garden at base of slope, infiltration trench at roof drip line	Medium	High
2-75	471 Brickett Pt.	Directly to lake	Residential	Inadequate shoreline vegetation, unstable access	Steep	Establish buffer, stabilize shore access	Low	Medium
2-76	475 Brickett Pt.	Directly to lake	Residential	Surface erosion	Steep	Infiltration steps (basic 2-3)	Low	Low
2-77	479 Brickett Pt.	Directly to lake	Residential/ trail or path	Bare soil, roof runoff erosion, inadequate shoreline vegetation	Steep	Infiltration steps, drywell at gutter downspout, add to buffer	Low	Low
2-78	40 Brickett Pt.	Directly to lake	Residential	Bare soil, undercut shoreline, inadequate shoreline vegetation, unstable access	Steep	Add to buffer, stabilize shore access, short retaining wall below fire pit or grass berm Lower on slope	Low	Medium
2-80	Common access lot	Directly to lake	Residential	Undercut shoreline, lack of shoreline vegetation, shoreline erosion, unstable access	Moderate	Establish buffer, stabilize shore on left facing lake	Medium	Medium
2-81	282 Brickett Pt.	Stream/ditch ?	Residential	Slight surface erosion, bare soil	Flat	No raking, reseed bare soil and thinning grass, lots of bare soil adjacent to channel crossing multiple properties to lake	Medium	Low

Site	Location	Flow into lake via	Land Use	Problems	Slope	Recommendations	Impact	Cost
2-83	252 Brickett Pt.	Indirectly to lake (neighbors driveway)	Driveway/ Residential	Slight surface erosion in front, moderate surface erosion in rear, bare soil	Moderate	Add new surface material (gravel) front and back driveways, install runoff diverter and seed/mulch/ECM bare areas. Currently no lake impact, but future potential.	Low	Low
3-01	84 Heron Cove	Directly to lake	Residential	Moderate surface erosion	Flat	Armor ditch with stone	Low	Low
3-02	54 Benson Cove	Directly to lake	Beach Access	Slight surface erosion, lack of shoreline vegetation	Moderate	Establish buffer, mulch	Low	Low
3-03	54 Benson Cove Rd.	Directly to lake	Trail or path	Moderate surface erosion, bare soil, shoreline erosion, large pile pondweed next to lake	Flat	Define footpath, mulch, install runoff diverter below pavement, reposition gutter downspout to trench, mulch/ECM, rain garden, pile pondweed back in woods	Low	Low
3-04	58 Benson Rd	Directly to lake	Residential	Roof runoff erosion	Flat	Infiltration trench at roof drip line, drywell at gutter downspout or rain barrel	Low	Low
3-05	58 Benson Rd	Directly to lake	Trail or path	Slight surface erosion	Moderate	Define footpath, stabilize footpath, mulch/ECM	Low	Low
3-06	Benson Cove	Directly to lake	Beach Access	Delta in stream/lake (small), roof runoff erosion, undercut shoreline, shoreline erosion	Moderate	Armor culvert, mulch/ECM	Low	Low
3-07	Benson Cove	Directly to lake	Residential	Roof runoff erosion	Moderate	Infiltration trench at roof drip line, drywell at gutter downspout	Low	Low
3-08	78 Benson Cove	Directly to lake	Residential	Lack of shoreline vegetation, unstable access	Moderate	Mulch/ECM, establish buffer, add to buffer	Low	Low

Site	Location	Flow into lake via	Land Use	Problems	Slope	Recommendations	Impact	Cost
3-09	80 Benson Cove	Directly to lake	Residential	Slight surface erosion, roof runoff erosion, lack of shoreline vegetation	Moderate	Install water bar, define footpath, infiltration trench at roof drip line, mulch/ECM, establish buffer	Low	Low
3-10	82 Benson Cove	Directly to lake	Driveway/ Residential	Moderate surface erosion, slight road shoulder erosion, roof runoff erosion, lack of shoreline vegetation	Moderate	Install water bar at end of driveway near house, define footpath, install infiltration trench at roof drip line connecting to water bar, drywell at gutter downspout, mulch/ECM, establish buffer on shoreline	Low	Medium
3-11	84 Benson Rd	Directly to lake	Residential	Moderate surface erosion, bare soil, lack of shoreline vegetation, inadequate shoreline vegetation, shoreline erosion, cat litter found in gully	Moderate	armor culvert under footbridge, stabilize footpath if need access (unsure of land use), install runoff diverter, mulch/ECM, rain garden, establish buffer	Low	Medium
3-12	74 Heron Cove	Directly to lake	Residential	Slight surface erosion, inadequate shoreline vegetation, exposed roots	Moderate	Mulch/ECM, add to buffer, riprap left backside of house	Low	Low
3-13	103 Heron Cove	Directly to lake	Residential	Roof runoff erosion	Moderate	Stabilize and define footpath, mulch/ECM, enhance buffer	Low	Low
3-14	107 Heron Cove	Directly to lake	Residential	Moderate surface erosion, bare soil, lack of shoreline vegetation, shoreline erosion, unstable access	Moderate	Armor shoreline, mulch/EMC/gravel?	Low	Low

Site	Location	Flow into lake via	Land Use	Problems	Slope	Recommendations	Impact	Cost
3-15	152 Heron Cove	Directly to lake	Residential	Moderate surface erosion, bare soil	Moderate	Define footpath, stabilize footpath, install water bar, mulch/ECM, add to buffer along shore	Low	Low
3-16	116 Heron Cove	Directly to lake	Residential	Slight surface erosion, bare soil, shoreline erosion, unstable access to shore	Flat	Armor shoreline, define footpath, mulch/ECM	Low	Low
3-17	207 Heron Cove	Directly to lake	Residential	Slight surface erosion, undercut shoreline, lack of shoreline vegetation, unstable access to shore	Moderate	Armor shoreline, infiltration trench at roof drip line, mulch/ECM	Low	Medium
3-18	208 Heron Cove	Directly to lake	Residential	Slight surface erosion, undercut shoreline, unstable shore access, lack of shoreline vegetation	Flat	Armor shoreline, add to buffer, mulch/ECM	Medium	Low
3-19	29 Sunset Blvd	Minimal veg.	Residential	Moderate surface erosion, bare soil, roof runoff erosion, lack of shoreline vegetation	Flat	Stabilize footpath, infiltration trench at roof drip line, mulch/ECM, no raking, reseed bare soil and thinning grass	Low	Medium
3-21	26 Sunset Bvld	Directly to lake	Residential	Slight surface erosion, lack of shoreline vegetation, unstable access to shore, inadequate shoreline vegetation	Moderate	Armor shoreline, install water bar to boat/walking access to dock, mulch/ECM in upper grass area in trees, establish buffer, add to buffer	Low	Low

Site	Location	Flow into lake via	Land Use	Problems	Slope	Recommendations	Impact	Cost
3-22	Sunset Bvld (26 II)	Directly to lake	Residential	Slight surface erosion, undercut shoreline, shoreline erosion, lack of shoreline vegetation, inadequate shoreline vegetation	Moderate	Mulch/ECM walking area near house, establish buffer, add to buffer	Low	Low
3-23	Alden Camps (field)	Ditch/Minimal vegetation	Commercial (Camp)	Slight surface erosion, large lawn drains to lake	Flat	Install ditch, install infiltration trench, State soil scientist (Dave Rocque) recommended diversion of field runoff to Rt 137 as possible (drainage tiles)	High	Low
3-24	Alden Camps - beach	Directly to lake, minimal vegetation	Commercial (camp), beach access, trail or path	Slight to moderate surface erosion, bare soil, unstable inlet, crushed/broken culvert, area has several flows from woods and is used by ATVs to access beach	Flat to moderate	replace culvert, install ditch (upland), stabilize foot path, needs ditching/armoring, may be able to put runoff into adjacent wetlands	High	Low
3-25	Alden Camps-camp sites (one of several)	Directly to lake, minimal vegetation (path)	Trail or path	Moderate surface erosion, bare soil, at several places berms are needed to catch water/runoff before it gets to lake (mulch is washing off hill)	Flat to moderate	Install runoff diverters, install berms, establish buffer	Low	Medium
3-26	Alden Camps	Directly to lake	Private Road/Commercial	Slight surface erosion, slight road shoulder erosion, lengthen rubber razor across full road	Moderate	Install turnouts, install ditch, reshape (crown) road, install runoff diverters	High	Low

Site	Location	Flow into lake via	Land Use	Problems	Slope	Recommendations	Impact	Cost
3-27	Manitou Camp	Directly to lake	Commercial	Slight surface erosion, bare soil	Flat to moderate	Infiltration trench, water retention swales, mulch/stabilize path, establish buffer	Medium	Low
4-03a	133 Bickford Rd	Directly to lake	Residential	Slight surface erosion	Flat	Rain garden, establish buffer, no raking, reseed bare soil and thinning grass	Medium	Medium
4-03b	133 Bickford Rd		Driveway	No cover on culvert	Flat	Cover culvert	Low	Low
4-05	139 Bickford Rd	Minimal Veg.	Residential	Slight surface erosion	Moderate	Mulch/ECM	Low	Low
4-06	139 Bickford Rd		Residential	Moderate surface erosion	Moderate	Define footpath, stabilize footpath, mulch/ECM	Low	Medium
4-07	151 Bickford Rd		Trail or path	Moderate surface erosion	Moderate	Stabilize trail, install runoff diverter/water bar	Low	Low
4-08	39 Jolly Lane	Directly to lake	Trail or path	Slight surface erosion	Moderate	Install runoff diverter/water bar at top of trail, mulch/ECM, infiltration trench, establish buffer	Low	Low
4-09	39 Frog Rock Lane	Directly to lake	Residential	Slight surface erosion	Flat	Mulch/ECM	Low	Low
4-10	199 Cunliff Lane		Residential	Uncovered pile of soil	Flat	Mulch/ECM	Low	Low
4-11	178 Cunliff Lane		Trail or path	Slight surface erosion, culvert	Flat	Stabilize footpath, mulch/ECM	Low	Low
4-12	186 Island Lane		Residential	Bare soil	Flat	Mulch or vegetated areas of bare soil	Low	Medium
4-14	Island Lane	Directly to lake	Residential	Shoreline erosion, bare soil	Flat	Stabilize bare soil, establish buffer	Low	Low
4-16	176 Island Lane		Residential	Roof runoff erosion	Flat	Drywell at gutter downspout, rain garden	Low	Medium

Site	Location	Flow into lake via	Land Use	Problems	Slope	Recommendations	Impact	Cost
4-17	170 Island Lane		Private Road	Moderate surface erosion, roof runoff erosion	Moderate	Build-up road, add gravel, install runoff diverters/rubber razor/water, infiltration trench at roof drip line	Medium	Low
4-18	170 Island Lane	Directly to lake	Boat access	Moderate surface erosion, roof runoff erosion	Moderate	Add gravel to road, vegetate shoulder, install open top culvert/rubber razor, infiltration trench at roof drip line	Medium	Low

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 IN-LAKE PHYSICAL CONTROLS	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
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 growth can be limited by	♦ 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 ♦ Interference with recreation or other

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
	nutrient availability		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
13) Sediment oxidation	♦ Addition of oxidants, binders and pH adjustors to oxidize sediment ♦ Binding of phosphorus is	♦ Can reduce phosphorus supply to algae ♦ Can alter N:P ratios in water column	♦ Possible impacts on benthic biota ♦ Longevity of effects not well known

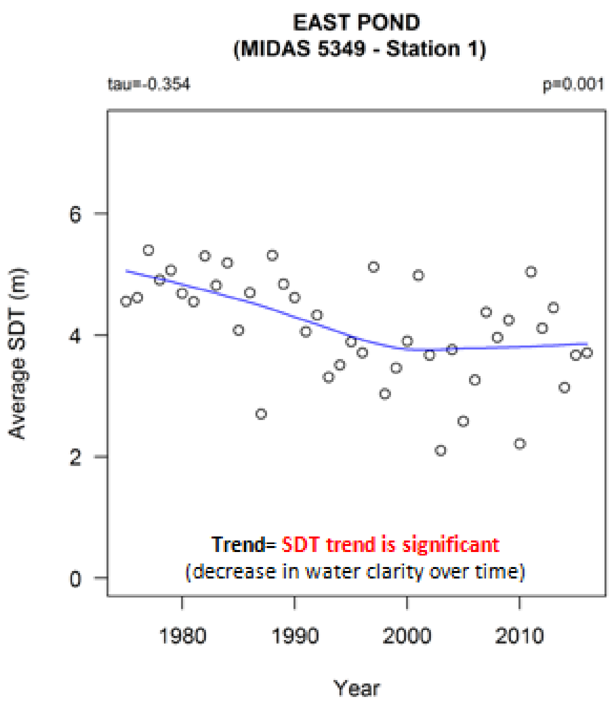
OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
	enhanced ♦ Denitrification is stimulated	♦ May decrease sediment oxygen demand	♦ Possible source of nitrogen for blue-green algae
14) Settling agents	♦ Closely aligned with phosphorus inactivation, but can be used to reduce algae directly too ♦ Lime, alum 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 less desirable forms
16.a) Herbivorous fish	♦ Stocking of fish that eat algae	♦ Converts algae directly into potentially harvestable fish ♦ Grazing pressure can be adjusted through stocking rate	♦ Typically requires introduction of non-native species ♦ Difficult to control over long term ♦ Smaller algal forms may be benefited and bloom

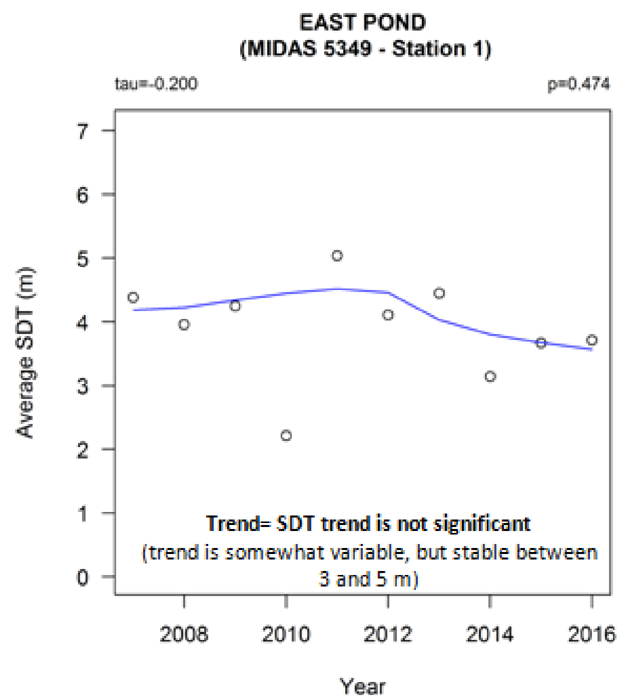
OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
16.b) Herbivorous zooplankton	♦ Reduction in planktivorous fish to promote grazing pressure by zooplankton ♦ May involve stocking piscivores or removing planktivores ♦ May also involve stocking zooplankton or establishing refugia	♦ Converts algae indirectly 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 ♦ Chemical inhibition of algae may occur through substances released by other organisms	♦ 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 depression of oxygen levels
20a) Plantings for nutrient control	♦ Plant growths of sufficient density may	♦ Productivity and associated habitat	♦ Vascular plants may achieve nuisance

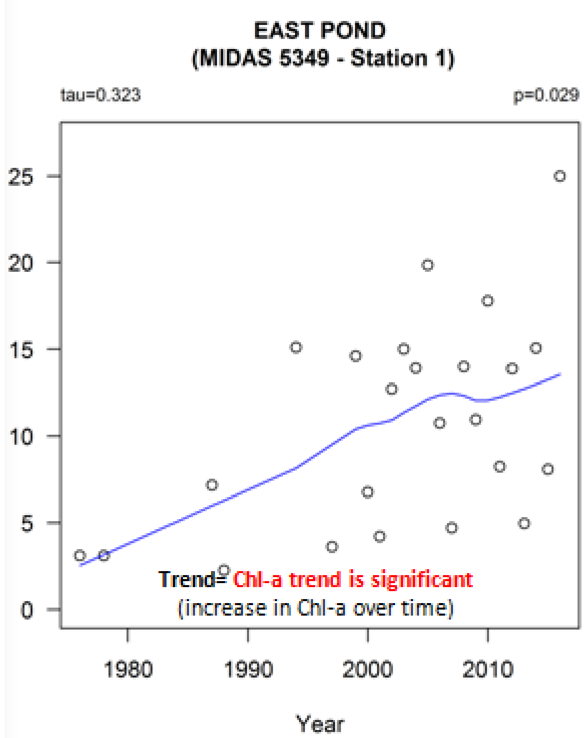
OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
	limit algal access to nutrients ♦ Plants can exude allelopathic substances which inhibit algal growth ♦ Portable plant "pods" , floating islands, or other structures can be installed	value can remain high without algal blooms ♦ Can be managed to limit interference with recreation and provide habitat ♦ Wetland cells in or adjacent to the lake can minimize nutrient inputs	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

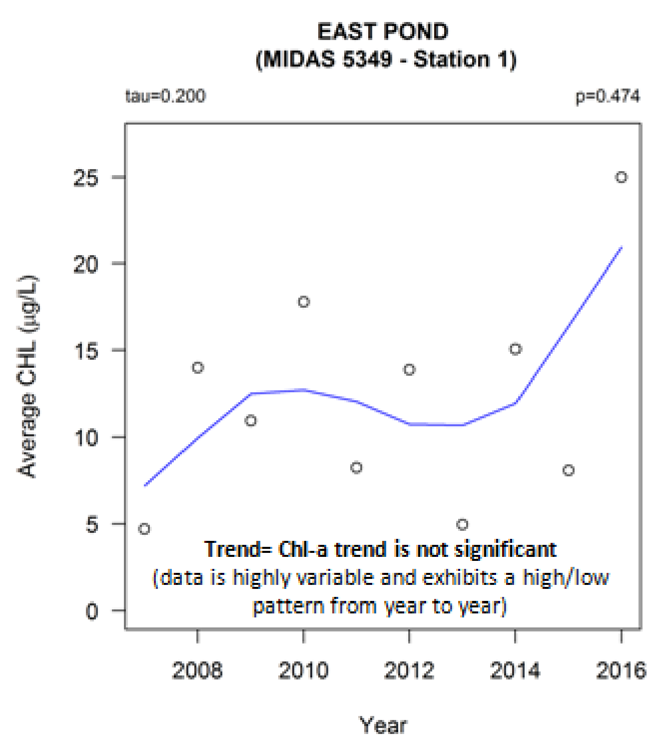
APPENDIX C. Water Quality Trends for East Pond.

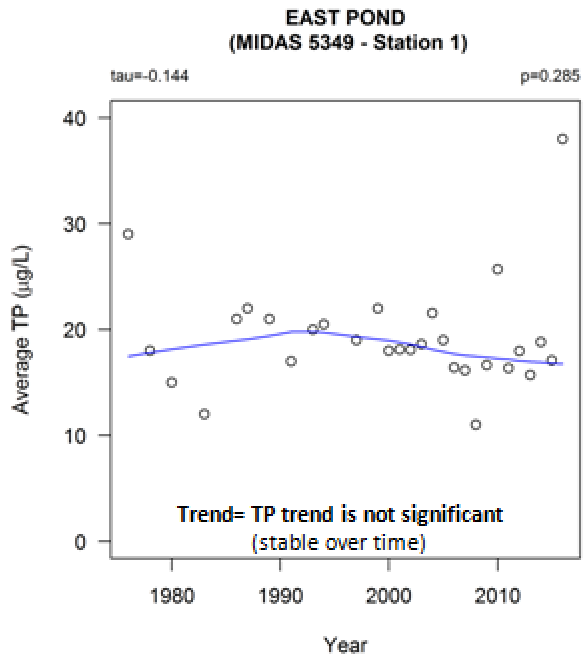
Data range 1975-2016. Analysis conducted by Jeremy Deeds, Maine DEP in November 2017.

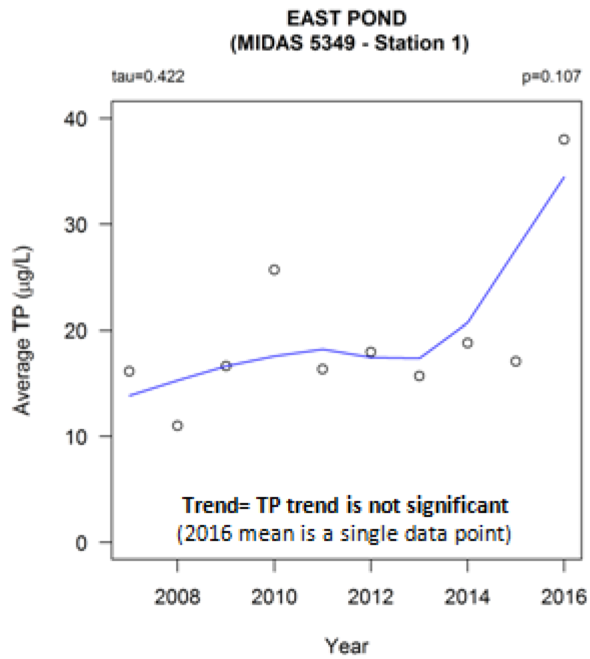


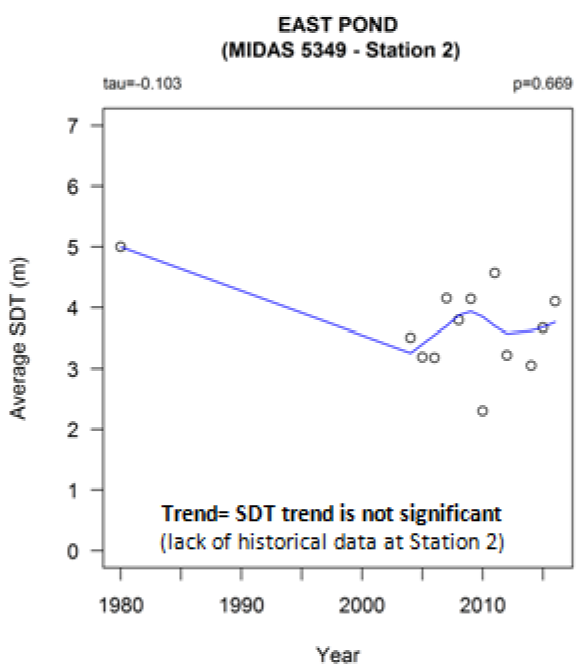


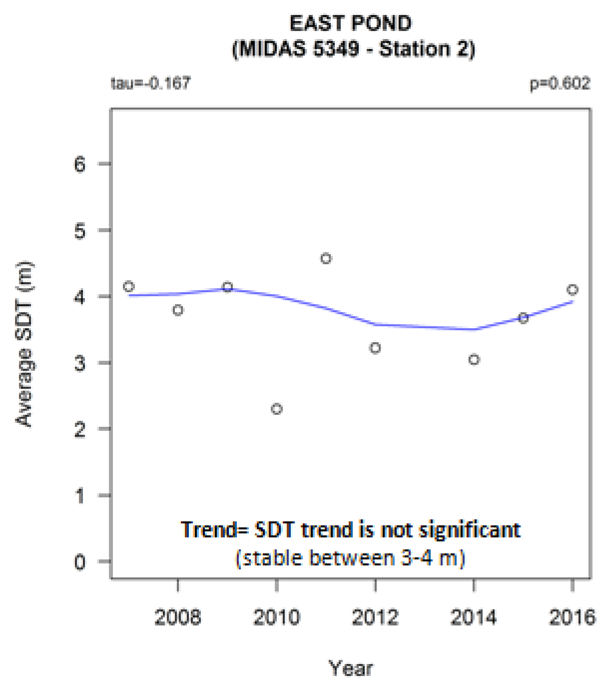





EAST POND
(MIDAS 5349 - Station 1)
tau=-0.144
p=0.285
Average TP (µg/L)
Year
Trend= TP trend is not significant
(stable over time)


EAST POND
(MIDAS 5349 - Station 1)
tau=0.422
p=0.107
Average TP (µg/L)
Year
Trend= TP trend is not significant
(2016 mean is a single data point)


EAST POND
(MIDAS 5349 - Station 2)
tau=-0.103
p=0.669
Average SDT (m)
Year
Trend= SDT trend is not significant
(lack of historical data at Station 2)


EAST POND
(MIDAS 5349 - Station 2)
tau=-0.167
p=0.602
Average SDT (m)
Year
Trend= SDT trend is not significant
(stable between 3-4 m)

APPENDIX D. East Pond FAQ.

EAST POND WATERSHED PLAN UPDATE – FREQUENTLY ASKED QUESTIONS (FAQs)

The following document contains a list of questions and answers related to the East Pond Watershed Management Plan update and proposed alum treatment. Questions were received at the June 26, 2017 Steering Committee Meeting, at the July 19, 2017 East Pond Association Annual Meeting, and by email. The purpose of this document is to provide a list of FAQs that the public can refer to. (Note: This is intended to be a working document and will be periodically updated to include additional questions that come up during the remainder of the watershed planning process.)

Questions	Answers
Longevity of Treatment. How long will the alum treatment last?	It is expected to result in improved water quality for a period of 10-20 years. The success of the treatment is dependent on using the correct dose and ensuring that new phosphorus from the watershed is managed. Ongoing watershed erosion control projects reduce external phosphorus loading and will extend the longevity of an alum treatment.
Success of Alum. Why might the alum treatment on East Pond be more successful than on some other lakes?	The depth of water in East Pond is important to the success of an alum treatment. East Pond is deep enough to stratify and release phosphorus from sediments each summer. Alum binds phosphorus as it is released resulting in less food for algae. In shallower lakes, alum treatments have been less successful, or have lasted for a shorter duration. To calibrate the correct dose of aluminum needed to get the desired results, additional sediment tests will be conducted in Colby College labs fall 2017, in consultation with Maine DEP and outside consultants.
Alum Timeline. Is the 2018/2019 alum treatment timeline realistic to account for the fundraising and public outreach needed?	The Steering Committee is working on developing a project calendar that outlines the timing of public meetings, permitting, and application. Permitting takes 90 days once submitted to Maine DEP. The current plan is to apply for a permit in fall 2017 for approval in early 2018 to get contractors and consultants lined up for a spring 2018 application. Monitoring will take place over the following 5-10 years. The goal is to treat in 2018, but if the funds haven't been raised, or if public support has not been built, then treatment could be delayed until spring 2019.

Questions	**Answers**
Alternatives to Alum. Has an alternatives analysis been completed to ensure the public that this is the best course of action?	Watershed erosion control projects have been implemented since 2001 and are important but not sufficient to prevent algal blooms – they reduce external phosphorus loading but do not prevent internal loading. The 2007 East Pond Watershed Plan suggested three treatment options to address internal loading which accounts for 50% of the phosphorus in the lake: aeration, biomanipulation (fish removal), and alum. Aeration was not recommended because of high costs, the number of aerators that would need to be deployed on the lake surface, and ongoing management and equipment maintenance. Biomanipulation was tried from 2007-2012 and was not successful. Alum treatment is the most promising treatment for addressing the internal load and has been recommended by Maine DEP and outside consultants. Alum treatments have been conducted on over 250 lakes worldwide and on four lakes in Maine. All Maine lakes were treated over 20 years ago, and 3 of 4 were successful – the one that was not successful was under-dosed. Alum treatments are at a similar cost to aeration/oxygenation but are applied once and do not require ongoing equipment maintenance and management.
Downstream Lakes. What does treating the internal load in East Pond do to downstream lakes such as North Pond and Great Pond?	Because East Pond is the first lake in the chain of lakes, treating East Pond will help downstream lakes. Less P upstream results in less P downstream.
Sediment Aluminum. Is it true that East Pond doesn't have a natural supply of Aluminum in the sediments?	No, the sediments in East Pond naturally contain aluminum, but the aluminum-to-iron ratio is not great enough to prevent internal loading. Iron-bound phosphorus is released under conditions of low dissolved oxygen. Increasing the amount of aluminum, which holds onto P under low oxygen conditions, will prevent the release of phosphorus into the water column, and will reduce algal blooms.

Questions	Answers
Alum Process. What is the process for the alum treatment?	Following approval of permits and selection of contractors, alum will be applied in the lake in early spring (following ice out) at a currently estimated rate of 30g/m2 with approximately 20-50 acres treated per day. Buoys will be placed around the treatment area each day to discourage boating in the treatment area. Application will not occur during high wind or rain events to prevent drift outside of the treatment area. Only the deepest area of the lake will be treated.
Motor Boats. Will motor boats affect the alum treatment?	No. In this application, only the deepest part of East Pond will be treated, the areas below 20'. Boats can stir up water up to 15', so it is unlikely it will have any affect.
Aluminum Side Effects. Are there side effects from the Alum Treatment?	There are no known side effects to people or fish when proper dosing rates, application and monitoring are used. The pH of the water is monitored closely during application to protect fish and other aquatic life. Alum is used extensively by municipal water treatment plants to remove phosphorus and sediments to create potable water.
Springs. Is it true that East Pond is fed by underwater springs? How will this be affected by the alum treatment?	Yes, East Pond is fed by groundwater via springs and has no permanent flowing streams into the lake. This results in a low flushing rate (0.4/year). Groundwater seepage in lakes is greatest at the edge of the lake and diminishes as it gets deeper, disappearing after a few feet of muck accumulation. A significant amount of water actually coming into a lake from a "spring" is rare and should not be affected by the alum treatment. Springs will not affect the effectiveness of an alum treatment.
Alum & Plants. Can the alum treatment be affected by plants releasing phosphorus into the water column when they die?	Macrophytes (large plants) are not significant at the depths that the treatment will be applied (<20') due to lack of available sunlight. However, plants do take up phosphorus and release P into the water column when they die. This was not factored into the dosing estimate but does not appear to be a large component of the estimated P load to the lake.

Questions	Answers
Dam Management. Will lowering the water in the lake by adjusting the dam help with flushing phosphorus out of the lake?	This option will be considered, but would take decades to flush the lake given the current configuration of the dam. Based on the low flushing rate, and lack of tributaries flowing into the lake, the residence time would not support a significant draw down because it would take a long time for the lake to refill. Dam management may help extend the longevity of an alum treatment by several years.
Backflushing. What is being done to understand the role of the Serpentine in the delivery of phosphorus ("backflushing")? Why isn't this factored into the model?	Colby is in the second year of collecting flow data in the Serpentine Stream. 2016 was a dry year and did not show much backflushing from the Serpentine to East Pond, which may be the result of little rainfall. Heavier rainfall in the spring of 2017 should benefit this study to help understand the significance of backflushing. The Steering Committee has agreed that looking into dam management, and specifically draw down as a management action, should be listed as an action item in the watershed plan. Backflushing is not factored into the watershed loading model because there is not currently enough data. The model can be updated later to account for the Serpentine following additional study.
Water Quality Changes. What are the driving factors for the changes in water quality in East Pond over the past 20+ years?	Weather and climate are important drivers of the changes in lakes in Maine, New England and beyond. The data show warmer summer conditions. Warmer temperatures favor blue/green algae. An increase in temperature of 10 degrees C will double the metabolic processes in lakes resulting in more algae. Addition of phosphorus from developed land (roads, buildings, driveways, septic systems) all contribute to increased phosphorus load that feeds algae in the lake.
Health Effects of Algae. We pull water out of the lake for showering and have to leave our camp when the blooms occur. Is the algae problem (cyanobacteria) in East Pond getting worse?	The occurrence of algal blooms in East Pond will not improve without addressing the internal load. The problem of internal recycling is a self-sustaining cycle that cannot be broken without significant management measures such as an alum treatment. The effects of toxins produced by cyanobacteria (blue-green algae), to humans, domestic animals and wildlife, known as Harmful Algal Blooms (HABs), are well documented. However, not all blue-green algae blooms are toxic. Both Maine DEP and US EPA are monitoring HABs in Maine lakes. Data collected on 24 Maine lakes between 2008-2009 documented HABs in 50% of all samples, but only three samples exceeded drinking water guidelines. Warmer air temperatures result in warmer lake water that favors the growth of cyanobacteria. For more information on HABs in Maine lakes see: http://www.maine.gov/dep/water/lakes/cyanobacteria.htm

Questions	Answers
Dissolved Oxygen. What lowers the oxygen level near the sediment?	Oxygen (O2) depletion typically is most prevalent in the summer, but can also happen in the winter. In summer, stratification sets up in the lake by which the surface water gets warmer than the water at the bottom of the lake. Stratification prevents atmospheric O2 (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 low DO.
Treatment Area. How can we be so sure that the model is correct and doing just the deep parts of the lake will be sufficient?	Loading estimates for external and internal phosphorus loading are supported by the water quality monitoring data. Treatment of the deep area is designed to be ~80% effective in treating the internal load. Alum treatment is cumulative, meaning that additional benefit can be gained by treating additional areas beyond the deepest part of the lake; however, shallow areas are prone to mixing by wind, waves and boats that can affect the efficacy of the alum application by resuspending sediments. Resuspension is unlikely to occur in depths >15 feet.
Fundraising. To put the treatment cost in perspective for homeowners, what is the total annual tax on lake properties? What fraction of the town's funding comes from lake properties?	Lake front properties account for 26% of the property tax base in Oakland (2016: $133 million) and for about 45% of the property tax base in Smithfield (2017: $47 million).

Questions	Answers
Urgency. Why is it imperative to do this now?	The alum treatment was a management recommendation in the 2007 East Pond Watershed Plan. The 2017 Watershed Plan update has prioritized the alum treatment for the next 10-year planning cycle. A significant source of funding from Maine DEP may be available in 2018-2019 to support this effort and may not be available in the future. Not doing anything to address the internal loading problem in East Pond will result in ongoing and persistent algal blooms for the foreseeable future.
Alum Removal. Does the Aluminum have to be removed in the future?	No. Alum binds phosphorus in the sediments at the bottom of the lake where it will stay indefinitely or until it is covered with new sediment.