UNITY POND

(LAKE WINNECOOK)

UNITY, BURNHAM,
& TROY, MAINE

WATERSHED-BASED MANAGEMENT PLAN

(2023-2032)

DECEMBER 2022

UNITY POND WATERSHED-BASED MANAGEMENT PLAN

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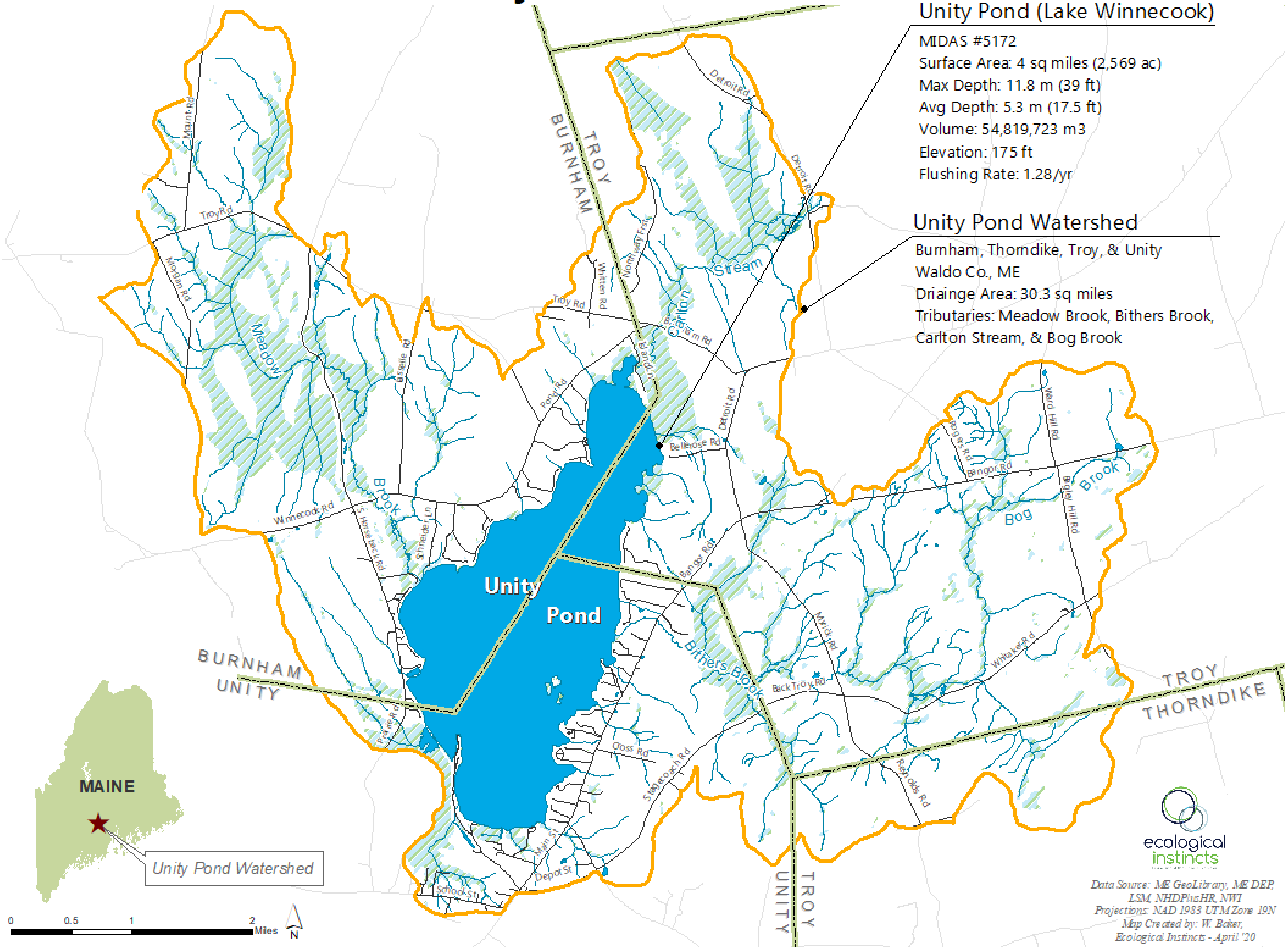
Cover Photo: *Sunrise on the Ice*
Photo Credit: *Nancy Tkachuk*

Unity Pond Direct Watershed



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Commonly Used Acronyms

The following are used throughout this document:

BMP	Best Management Practice
Chl-a	Chlorophyll a
DO	Dissolved Oxygen
FOLW	Friends of Lake Winnecook
HAB	Harmful Algal Bloom
LLRM	Lake Loading Response Model
LSM VLMP	Lake Stewards of Maine Volunteer Lake Monitoring Program
Maine DEP	Maine Department of Environmental Protection
NPS	Nonpoint Source (Pollution)
ppb	Parts Per Billion
ppm	Parts Per Million
SDT	Secchi Disk Transparency
TP/P	Total Phosphorus/Phosphorus
USDA/NRCS	U.S. Department of Agriculture/Natural Resources Conservation Service
US EPA	United States Environmental Protection Agency
WBMP	Watershed-Based Management Plan
WCSWCD	Waldo County Soil & Water Conservation District

UNITY POND WATERSHED-BASED MANAGEMENT PLAN (2023-2032)

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PURPOSE

Photo Credit: FOLW

The 2023 Unity Pond Watershed-Based Management Plan (WBMP) provides details about current water quality conditions, watershed characteristics, and steps that can be taken to improve water quality in Unity Pond over the next 10 years. The update supersedes the previous WBMP developed by Waldo County Soil & Water Conservation District (WCSWCD) in 2007. Implementation is estimated to cost $2.46 million through state, federal and local contributions over this time period. The plan outlines management strategies and an activity schedule (2023 – 2032), establishes water quality goals and objectives, and describes actions needed to achieve these goals. This includes strategies to:

A. **Reduce the external phosphorus load** by addressing existing nonpoint source (NPS) pollution in the direct watershed of Unity Pond and indirect watersheds including Carlton Pond, Sandy Stream, and Halfmoon Stream, and upgrading septic systems in order to reduce the probability of toxic blue-green algal blooms;
B. **Reduce the internal phosphorus load** by stripping phosphorus (P) from the water column and inactivating P in the sediments at the bottom of the lake that fuels algal growth;
C. **Prevent new sources** of NPS pollution from getting into Unity Pond by strengthening and enforcing existing municipal ordinances to prevent any increase in P loading from existing and future development, investing in land conservation, and focusing on climate change adaptation planning;
D. **Raise public awareness** about the connection between land use, phosphorus, and algae blooms and water quality improvement goals and strategies by increasing local education, outreach, and communication efforts to increase participation among municipalities and watershed residents;
E. **Build local capacity** through partnership building across multiple community groups, engaging steering committee members, and developing a robust fundraising strategy;
F. **Monitor and assess improvements** in Unity Pond's water quality over time. This includes monitoring in-lake water quality, streams, NPS pollution, invasive aquatic plants, and backflushing from Sandy Stream.

THE GOAL

A team of scientists and local stakeholders worked collaboratively over two years with input from the public to set a revised water quality goal for Unity Pond that would help improve water quality, reverse the long-term trend of declining water clarity, and reduce the probability of nuisance algal blooms. Findings from this evaluation indicate that reducing P loading from the direct watershed of Unity Pond alone will not achieve desired water quality conditions. Therefore, additional actions are needed to reduce P inputs from the indirect (upstream) watersheds and to inactivate P in the lake's sediments (internal load).

What P load reductions are needed to meet the goal?

A total P load reduction of 1,556 kg/yr is needed to achieve the water quality goal of 19 ppb set for this plan. This includes reducing the P load by 690 kg/yr in the direct watershed of Unity Pond, 14 kg/yr from septic systems, 121 kg/yr in the Carlton Pond indirect watershed, 11 kg/yr in the Sandy Stream/ Halfmoon Stream indirect watersheds, and 731 kg/yr by addressing the internal P load. These reductions are expected to **reduce the average in-lake total P concentration in Unity Pond by 8 ppb (currently at 27 ppb), reduce bloom probability by a third, and increase water clarity by more than a foot.** Achieving this goal will be a challenge and requires that the three primary P reduction strategies described above are completed simultaneously to be successful.

WATER QUALITY GOAL

Unity Pond exhibits improving water quality trends & reduced frequency of algal blooms

Current In-Lake Concentration= 27 ppb
In-Lake Phosphorus Goal= 19 ppb
Reduction In-Lake Concentration= 8 ppb

"P" REDUCTIONS NEEDED

Direct Watershed: - 704 kg/yr
- 690 kg/yr direct watershed
- 14 kg/yr septic systems

Indirect Watersheds: - 121 kg/yr
- 110 kg/yr Carlton Pond
-11 kg/yr Sandy Stream

Internal Load: - 731kg/yr
90% reduction of internal load

Timeframe: 2023- 2032

Projects: Erosion Control BMPs, LakeSmart, Septic Upgrades, Aluminum Treatment

What actions are needed to achieve the goal?

The Unity Pond WBMP outlines 95 individual action items within six core planning categories to achieve the water quality goal. Planning recommendations, developed with input from the project's steering committee, are outlined in the plan. The action plan provides current, science-based solutions for improving water quality in Unity Pond while simultaneously promoting communication between watershed groups, municipalities, residents, business owners, and agricultural producers. 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 six categories.

How will the plan be funded?

The 2023 Unity Pond WBMP is expected to cost **$2.46M over a 10-year period.** Therefore, a sustainable funding strategy is needed within the first year that includes diverse funding sources. The majority of fundraising will be completed by FOLW with support from watershed partners. The combined resources of state, federal, and local grants and contributions from and participation by municipalities, private landowners, and lake association members will be needed to support this monumental restoration effort.[1] The funding strategy will be revisited on at least an annual basis by an engaged steering committee. The action plan (Sections 7 & 8) is divided into the following six major planning objectives along with estimated load reductions and estimated costs to complete the work:

Planning Objective	Planning Action (2023-2032)	P Load Reduction Target	Estimated Cost
A	**Reduce the External P Load** (NPS sites, septic systems, LakeSmart, buffer campaign, upstream watersheds, agricultural BMPs)	825 kg/yr	$1,219,000
B	**Reduce the Internal P Load** (Sediment sampling and analysis, treatment plan and funding plan, permitting monitoring, low-dose aluminum treatment)	731 kg/yr	$731,400
C	**Prevent New Sources of NPS Pollution** (Municipal planning & enforcement, climate change adaptation, land conservation, etc.)	n/a	$234,000
D	**Education, Outreach & Communications** (Targeted outreach, aluminum treatment outreach, online videos, buffer campaign, LakeSmart, workshops, economic value, etc.)	n/a	$90,600
E	**Build Local Capacity** (Funding plan, steering committee, grant writing, relationship building- including Town government, contractors and scientists)	n/a	$40,000
F	**Long-Term Monitoring & Assessment** (Baseline monitoring, plankton and cyanobacteria, septic systems, NPS pollution, backflushing and stream monitoring, invasive plants)	n/a	$149,250
	TOTAL	**1,556 kg/yr**	**$2,464,250**

How will success be measured?

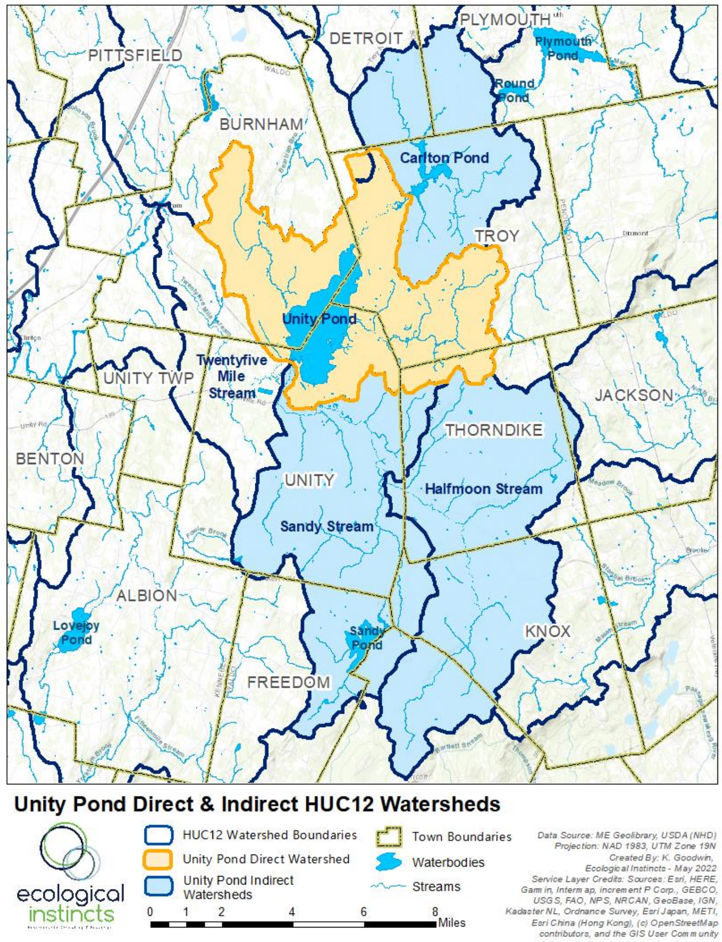
Environmental, social, and programmatic milestones were developed to reflect how well implementation activities are working and provide a means by which to track progress toward the

[1] Preliminary estimates suggest that approximately 50% of the cost of implementing the action plan will come from outside grant sources, 35% from local sources, and 15% from in-kind volunteer efforts.

established goals (Section 9). The steering committee will review the milestones on an annual basis, at a minimum, to determine if progress is being made, and will then determine if the watershed plan needs to be revised if the targets, including a decreasing P concentration or reduction in algal blooms, are not being met.

THE LAKE & WATERSHED

Unity Pond (MIDAS 5172)[2], also known as Lake Winnecook, is a 2,569-acre lake (Class GPA)[3] located in Waldo County, in the central Maine towns of Troy, Unity, and Burnham (right). The lake is naturally formed, eutrophic, and dimictic. There are four towns in the watershed with Troy making up the largest land area (41%) followed by Burnham (36%), Unity (19%), and Thorndike (5%). The largest areas of the lake are located in the towns of Unity (49%) and Burnham (40%).



The direct watershed drains approximately 30 mi^2 of the surrounding landscape. Tributaries that flow into the Unity Pond include Carlton Stream to the north, Bog Brook and Bithers Brook to the east, and Meadow Brook to the west, along with several unnamed small or intermittent streams.

Unity Pond has several indirect watersheds including Carlton Pond to the north (21.4 mi^2 watershed) that flows south into Unity Pond via Carlton Stream. Sandy Stream and Halfmoon Stream are also considered indirect watersheds of Unity Pond, but only during periods of heavy precipitation when Sandy Stream backflushes into Unity Pond. When backflushing, Unity Pond's watershed more than doubles in size due to the combined watershed areas of Halfmoon Stream and Sandy Stream (71.5 mi^2).[4]

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

[3] Defined by MRSA Title 38 §465-A, Maine Standards for Classification of Lakes and Ponds: Class GPA is the sole classification of Great Ponds (>10 acres) and natural lakes and ponds <10 acres in size.

[4] The watershed to lake ratio in the direct watershed is 7.5 compared to 31 when the indirect watersheds are included. Ratios between 20 – 50:1 are known for causing water quality problems if the land use is not natural and management is limited.

The watershed includes 100 miles of streams, 3,418 acres of wetlands, and 4,335 acres of riparian habitat along the edges of lakes, ponds, streams, and wetlands. Flooding of various intensities occurs regularly at Unity Pond, partially due to the unusual stream flow pattern and backflushing at the outlet stream. Water flowing out of Unity Pond flows south under the train trestle on the southwestern shore and into Sandy Stream, which flows into Twentyfive Mile Stream, which flows northwest to the Sebasticook River, and then south to the Kennebec River in Winslow, eventually flowing into the Gulf of Maine.

The lake's maximum depth is 11.8 m (39 ft), with an average depth of 5.3 m (17.5 ft) and a flushing rate of 1.28 flushes/year. The deepest location in the lake is near the lake's outlet on the southwest end of the lake, with a second, smaller "deep hole" further to the northeast. The elevation in the watershed ranges from 175 ft above sea level (lake level) to 620 ft in the southeast corner of the watershed.

What is the current status of development in the watershed?

A 2004 study reported 299 lots on the shoreline of Unity Pond including 286 with structures, 57% of which were estimated to be used seasonally, and 64% within 50 feet of the shoreline. An updated land cover analysis shows that forestland makes up the majority of the watershed (62%). Developed land (e.g., residential, commercial, roads) accounts for approximately 8% of the land area in the watershed, while agriculture accounts for another 8%. Wetlands and open water (not including the surface area of Unity Pond) account for the remaining 22% of the watershed area.

There are 66 miles of roads (~368 acres) in the watershed, many of which are unpaved gravel roads that service high-density residential development along the shoreline. Paved town and state roads in the watershed include Bangor Rd (Rt. 202) that provides access to the eastern shore, Detroit Rd (Rt. 220) to the northeast, Pond Rd and Horseback Road that provide access to private roads along the western shoreline, along with several other paved roads that cross the upper watershed.

Conservation land is limited to four fairly small areas of land in the direct watershed, three of which are under agricultural easements. The fourth consists of a portion of the Carlton Pond Waterfowl Production Area, which encompasses upstream Carlton Pond and its surrounding wetlands.

THE PROBLEM

Unity Pond has a history of severe annual summertime nuisance algal blooms which have been occuring for at least three decades, with some years being worse than others. Water quality has been in decline since at least the 1970s, including decreasing water clarity and loss of dissolved oxygen in deep areas of the lake.

As a result, Unity Pond is on the Maine DEP list of impaired lakes due to NPS pollution and internal sediment recycling of P. In 2004, United States Environmental Protection Agency (US EPA) approved a Total Maximum Daily Load (TMDL) report for Unity Pond which examined sources of P in the lake.

Though some historical sources of pollution to Unity Pond have been removed, including some intensive agriculture and point source pollution from a pea canning factory, the lake is currently threatened by NPS pollution from development, including agricultural development, residential and commercial development, and roads as well as legacy inputs that have built up in the lake's bottom sediments. In addition to Unity Pond being listed on the State's NPS Priority watersheds list as an impaired Lake, Unity Pond is also listed as "Most at Risk from New Development" under Chapter 502 of the Maine Stormwater Law because of its history of severe blooms and internal P recycling which makes it susceptible to additional sources of P.

A cyanobacteria bloom in Unity Pond in 2021. (Photo Credit: Dan Mcleod)

Water quality data have been collected consistently at the deepest location in the lake by Maine DEP and Lake Stewards of Maine Volunteer Lake Monitoring Program since 1977. In 2021, intensive monitoring was completed for the WBMP update by FOLW and Center for Wildlife Studies. Both recent and historical data were used to conduct a water quality trend analysis for Unity Pond including long-term (1977 – 2021) and short-term trends (2012-2021).

- **Minimum water clarity readings were less than 2 m** (depth threshold indicating a nuisance algal bloom is occurring) in 32 of the last 41 years of data collection, with the lowest (worst) clarity readings occurring between mid-July to early September.
- **Low levels of dissolved oxygen have been documented across 742 acres of the lake**, representing depths 7m and deeper beginning in June through September and resulting in the release of stored P in bottom sediments into the water column that fuel algal growth and spur cycles of internal P loading.
- **Average annual P, Chl-a, and water clarity readings signal eutrophic conditions** which will continue unless actions are taken to prevent P loading in the lake.
- **Of particular concern are the potential effects to public health from toxins produced by cyanobacteria** (blue-green algae) that have been documented in Unity Pond. Between 2014-2019 samples collected in the lake showed that maximum cyanotoxin (microcystin) concentrations exceeded US EPA's acceptable cyanotoxin levels for recreation in downwind scum samples. Cyanotoxin levels also exceeded the drinking water standard for non-school age children, school-age children, and adults at all stations.

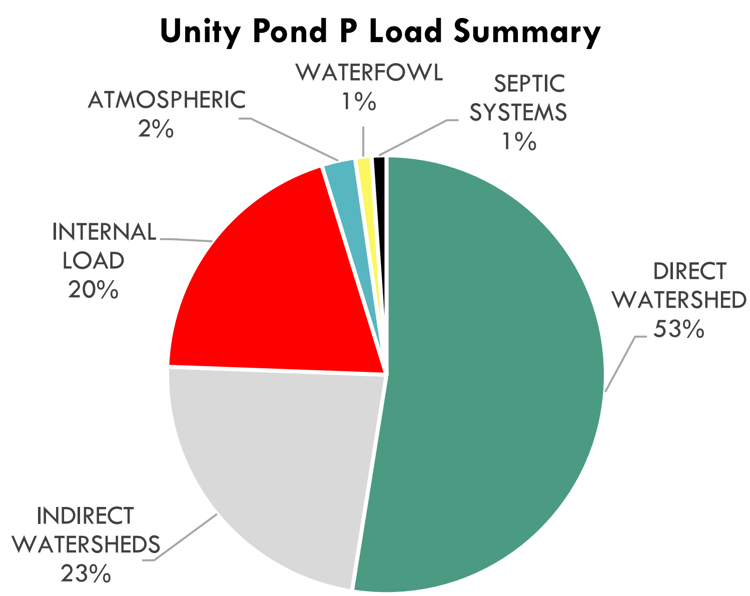
What are the trends?

Results of the water quality trends analysis indicate:

- **Water Clarity (1977 – 2021)-** A weak, but significant decrease in average annual water clarity between 1977 - 2021 (worsening of water clarity over time) with an average clarity of 2.3 m.

- **Water Clarity (2012 – 2021)-** However, over the last 10 years water clarity readings show a strong increasing trend (improving water clarity) along with a strong decreasing trend in Chlorophyll-a (average 14.9 ppb), an indirect measure of algal growth.
- **Phosphorus-** While the in-lake P concentration has increased from 22 ppb to 27 ppb over the historical monitoring period, there are no statistically significant P trends due to annual variability across years.
- **Conductivity** increased between 1977 – 2021, similar to trends statewide due to an increase in the use of road salts starting in the 1990s.
- **Alkalinity** decreased over the last 10 years which makes Unity Pond which could make the lake more susceptible to changes in pH in the lake should the trend continue.
- **Dissolved Oxygen-** No trends were found related to Anoxic Factor (AF) or Minimum Anoxic Depth (MAD) despite an observed change in MAD from a max of 12 m in 1981 to 8 m in 2021. However, **AF shifted above the threshold of AF=10 in 2001** which may signal a shift (increase) in the area of lake bottom exposed to low oxygen and the length of time anoxia is occurring during the open water season.

What are the primary sources of P?



Watershed modeling was used to estimate current sources of P in Unity Pond. The model estimates a total P load of 4,135 kg to Unity Pond annually. P loading from the watershed accounts for 76% of the total P load (53% from the direct watershed, and 23% from the indirect watersheds). Internal loading is estimated at 20% of the load (right). Atmospheric deposition, waterfowl, and septic systems account for the remaining 4% of the P load.[5]

Watershed modeling was also used to estimate pre-development water quality conditions in Unity Pond. The results of this analysis indicate that Unity Pond is a naturally mesotrophic (moderately productive) lake with an estimated in-lake TP concentration of 11 ppb. Changes in the landscape for agriculture, forestry, and residential and commercial development in the watershed and the shoreline, and modification of the lake's natural inlet (Sandy Stream) have resulted in a reduction in the lake's natural flushing rate, a doubling of the

[5] P loading estimates could vary by plus or minus 10-20% among years as a function of weather and measurement limitations. While the watershed load is a dominant source of P in Unity Pond, internal loading, which occurs in one season may represent the tipping point for summer algal blooms.

watershed's natural P load, and an increase in the concentration of P in the lake by more than double (currently 27 ppb). Setting a realistic water quality target that is closer to pre-development conditions will be a challenge that will require significant effort to address all sources of P given the present level of development in the watershed.

Why do we need to address nonpoint source pollution?

NPS pollution stemming from developed land in the watershed including active agriculture and forestry, residential development and commercial development (shoreline and non-shoreline development) and the roads, driveways, and septic systems that serve them, are the most significant threat to the water quality of Unity Pond. Combined, these sources of P account for 76% of the current P load, resulting in a long-term decline in water clarity and an increase in nuisance blue-green algal blooms. Addressing NPS pollution from watershed sources is an important part of a multi-step, multi-year process to make a significant difference to improve the current state of water quality in Unity Pond.

The 2021 watershed survey identified:

- **109 sites** across the watershed that are contributing P in stormwater runoff.
- The greatest number of sites (53%) were documented on residential properties along the shoreline, with the majority of sites located on the southeast shoreline in Unity and southwest shoreline in Burnham. Several other sites were documented outside the immediate shoreline along state/town roads.
- Private roads and driveways accounted for 34% of all sites.
- The survey reconfirmed previous studies **indicating a lack of adequate shoreline buffers on a significant number of residential properties on Unity Pond**.

The action plan includes strategies for **reducing the watershed load by 26%** which includes addressing 16 high-impact, 46 medium-impact, and 22 low-impact NPS sites over the next 10 years. The plan also targets **P reductions on agricultural land and active timber harvests as well as taking steps to mitigate impacts from "at-risk" septic systems** - specifically the 286 parcels likely to have a septic system on sensitive soils within the shoreland zone of Unity Pond that could result in short-circuiting of the leach field and may be contributing excess P to the lake via groundwater. The action plan recommends continuing to encourage shorefront property owners to participate in the FOLW LakeSmart program, with a **goal of 35% of shorefront properties participating in LakeSmart** by 2032.

Driveway erosion can result in significant delivery of P to Unity Pond.

Why do we need to address internal P loading?

Addressing watershed sources alone will not be enough to prevent recurring nuisance algal blooms in the lake but is one part of a larger effort to meet water quality goals to improve water quality. The plan must also include actions to address the internal load. Internal loading from sediments exposed to low oxygen is estimated to make up 20% of the P load and is a key factor in the dynamics causing elevated P in the lake during the summer. Importantly, decreasing P concentrations in Unity Pond will help reduce the probability of toxic blue-green algal blooms by providing less food for these P loving species. Adequate P reductions to significantly reduce the probability of algal blooms can't be achieved without also addressing the internal P load. A low-dose aluminum treatment will provide immediate relief from nuisance algal blooms while watershed work is underway and additional sediment data is being collected to determine how much aluminum is needed and the cost for a full treatment. **The action plan includes strategies for reducing the internal P load by 90%.**

What about future development & climate change?

Between 2008-2018 all four towns in the watershed experienced steady population growth, with the highest growth rate in the Town of Burnham (11%)- almost twice the increase for Waldo County. As water quality in the lake improves, Unity Pond will continue to be an even more desirable place to live and to visit, resulting in new development in the watershed.

Preventing new sources of P from getting into the lake is imperative to the success of the WBMP. Future development is estimated to increase the in-lake P concentration by 0.5 ppb. Climate change will only exacerbate the problem by increasing P loading by 2.5 ppb. Combined, climate change and future development scenarios are expected to result in almost as much new P being added to the lake as needs to be reduced in the direct and indirect watersheds. In other words, **if nothing is done to adapt to climate change and prevent new sources of P from getting into the lake, then much of the effort to reduce existing sources of P may be offset, and goals may not be achieved**. Prevention strategies will need to include more robust municipal planning and enforcement, ongoing public education, and land conservation.

ADMINISTERING THE PLAN

The Unity Pond WBMP provides a framework for improving water quality and preventing further water quality declines in Unity Pond so that the lake meets state water quality standards. The plan will be led by FOLW with guidance and support from a watershed steering committee comprised of WCSWCD, USDA/NRCS, the towns of Unity, Burnham, and Troy, Maine DEP, local businesses, and landowners. The formation of subcommittees that focus on the six main watershed action categories will result in more efficient implementation of the plan.

INCORPORATING US EPA'S 9 ELEMENTS

The US EPA has identified nine key elements that are critical for achieving improvements in water quality. An approved nine-element plan is a prerequisite for future federally funded work in impaired watersheds. The nine elements are designed to provide a robust framework by which to restore waters impaired by NPS pollution through characterization of the watershed, partnership building, development of an implementation plan (actions, schedule, costs), goal setting, and monitoring. The nine elements can be found in the following locations within the Unity Pond WBMP.

Planning Element	WBMP Section	Description
a) Identify Causes & Sources	Section 1	Highlights current programs and research that have helped frame the water quality problem.
	Section 2	Describes the characteristics of the lake and watershed that contribute to the changes in water quality.
	Section 3	Provides an analysis of water quality data to describe changes in water quality.
	Section 4	Provides an estimate of watershed loading including current and future sources of NPS pollution.
	Section 7 & Appx. E	Summarizes NPS sites in the Unity Pond watershed.
b) Estimated P Load Reductions expected from Planned Management Measures	Sections 4 & 6 & Appx. D	Provides an overview of water quality and phosphorus (P) reduction targets to reduce annual P loading to Unity Pond from the direct and indirect watersheds over the next ten years and methods used to estimate P reductions.
c) Description of Management Measures	Sections 6, 7 and 8	Identifies ways to achieve the estimated P load reduction and reach water quality targets described in (g) below. The action plan covers six major topic areas that focus on NPS pollution, including: mitigating the direct and indirect P load, addressing the internal load, preventing new sources of P, education and outreach, building local capacity, and conducting long-term monitoring and assessment.
d) Estimate of Technical and Financial Assistance	Sections 7 - 10	Provides a description of the associated costs, sources of funding, and organizations responsible for plan implementation. The estimated cost to address NPS pollution and reduce P in Unity Pond is estimated at $2,464,250 over the next ten years.
e) Information & Education & Outreach	Section 7	Describes how the education and outreach component of the plan should be implemented to enhance public understanding of the project. This includes leadership from watershed partners to promote lake/watershed stewardship.

Planning Element	WBMP Section	Description
f) Schedule for Addressing the NPS Management Measures	Sections 7 & 8	Provides a list of strategies and a set schedule that defines the timeline for each action. The schedule should be reviewed and adjusted by the steering committee on an annual basis.
g) Description of Interim Measurable Milestones	Section 9 (Tables 15 & 16)	Lists milestones that measure implementation success that will be tracked annually, makes the plan relevant, and helps promote implementation of action items. The milestones are broken down into two different categories: programmatic and social.
h) Set of criteria	Section 9 (Table 14)	Provides a list of criteria and benchmarks for determining whether load reductions are being achieved over time, and if substantial progress is being made towards water quality objectives. Environmental milestones are a direct measure of environmental conditions, such as improvement in water clarity to help determine whether this plan needs to be revised.
i) Monitoring Component	Section 8	Provides a description of planned monitoring activities for Unity Pond to evaluate the effectiveness of implementation efforts over time as measured against the criteria in (h) above.

1. Background

A blue-green algae bloom on the shoreline of Unity Pond in 2021. Photo Credit: FOLW

Unity Pond (aka Lake Winnecook), located in Unity, Burnham, and Troy, Maine (Figure 1) has a history of annual severe blue-green algae blooms in the late summer. Water quality has been in decline since at least the 1970s, including decreasing water clarity and a loss of dissolved oxygen in deep areas of the lake. Unity Pond is on the Maine DEP list of impaired lakes (303(d) list) due to nonpoint source (NPS) pollution and internal recycling of phosphorus (P). The impaired use is listed as primary contact recreation and persistent algal blooms. In 2004, US EPA approved a Total Maximum Daily Load (TMDL) report for Unity Pond which examined sources of P in the lake and set a goal for meeting water quality standards.

Though some historical sources of pollution to Unity Pond have been removed including some intensive agriculture and point source pollution from a pea canning factory, these legacy pollutants made their mark by building up a store of nutrients in the sediments at the bottom of the lake which fuels internal P recycling. The lake is currently threatened by NPS pollution from development, including agriculture, timber harvesting, residential and commercial development, and roads. In addition to being on the impaired lakes list, Unity Pond is also listed as "Most at Risk from New Development" under Chapter 502 of the Maine Stormwater Law because of its history of severe algal blooms and internal P recycling from the lake's bottom sediments.

In 2007, Maine DEP granted a subaward of US EPA Clean Water Act (CWA) section 604(b) funds to Waldo County Soil & Water Conservation District (WCSWCD) to develop a Watershed-Based Plan for Unity Pond. In conjunction with this report, WCSWCD worked with Maine DEP, The US Department of Agriculture's Natural Resources Conservation Service (USDA/NRCS), and other partners to complete two phases of watershed restoration projects between 2004 and 2008, funded partly by US EPA Clean Water Act (CWA) Section 319 funding. Along with installing best management practices (BMPs) at 31 NPS sites, the project aimed to build local support for protecting Unity Pond through education and outreach. More recently, a locally funded watershed survey was conducted to identify high priority NPS pollution sites in the watershed in order to reduce P loading to lake. The survey identified 109 NPS sites that are contributing to the current load of P in Unity Pond, making it clear that more work is needed to protect and improve water quality.

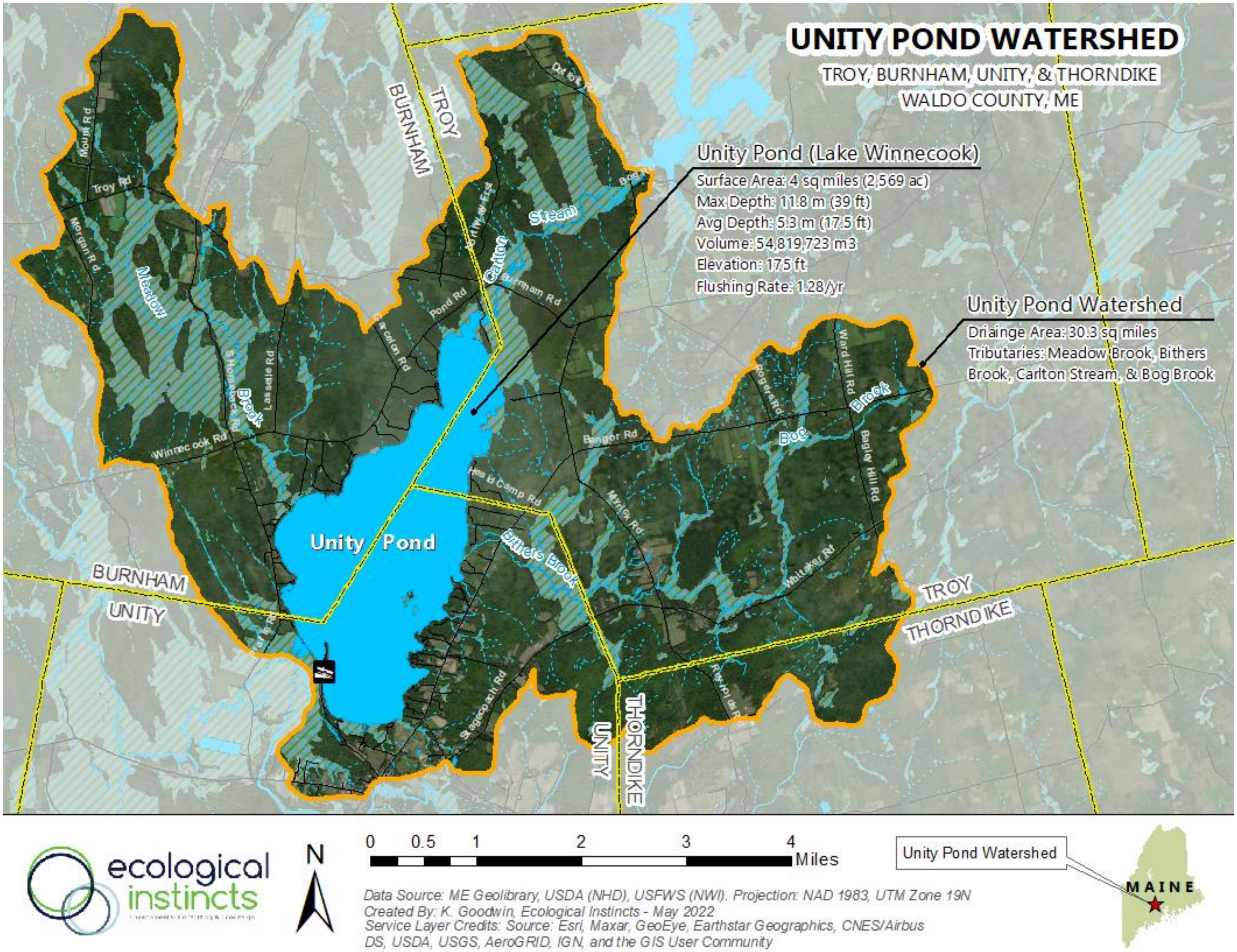


Figure 1. *Map of the Unity Pond direct watershed.*

Development of the Unity Pond Watershed-Based Management Plan (WBMP) included a water quality trend analysis utilizing the most current data available, watershed modeling- including an internal loading analysis, bathymetric mapping, a watershed survey, septic system survey, septic vulnerability analysis, development of updated watershed maps, multiple steering committee meetings to develop an updated action plan, and a public meeting to inform the community about the state of water quality and current actions needed to improve water quality over the next 10 years. Since P is the nutrient driving poor water quality in the lake, it was used as the primary parameter for setting the water quality goal.

PURPOSE

The 2023 Unity Pond WBMP provides details about current water quality conditions, watershed characteristics, and steps that can be taken to restore water quality in the lake over the next 10 years. The update supersedes the previous WBMP developed by WCSWCD in 2007. The plan is estimated to cost $2.46 million to complete through state, federal and local contributions over this time period. The plan outlines management strategies and an activity schedule (2023 – 2032), establishes water quality goals and objectives, and describes actions needed to achieve these goals. This includes strategies to:

1. **Reduce the external phosphorus load** by addressing NPS pollution in the direct watershed of Unity Pond and the indirect watersheds of Carlton Pond, Sandy Stream and Halfmoon Stream;
2. **Reduce the internal phosphorus load** through inactivation of P in bottom sediments;
3. **Prevent new sources** of NPS pollution from getting into Unity Pond by addressing new NPS sites, through land conservation, and through municipal ordinances and enforcement that address existing and future development and climate change adaptation;
4. **Raise public awareness** about lake restoration strategies by increasing local education, outreach, and communication efforts to increase participation among municipalities and watershed residents;
5. **Build local capacity** through partnership building across multiple community groups, engaging steering committee members, and developing a robust fundraising strategy;

WATERSHED PLANNING GOALS

(2023-2032)

1. **REDUCE P INPUTS FROM DEVELOPED LAND IN THE DIRECT & INDIRECT WATERSHEDS**
2. **REDUCE P FROM INTERNAL LOADING IN THE LAKE**
3. **REDUCE THE PROBABILITY OF ALGAL BLOOMS**
4. **IMPROVING WATER QUALITY TRENDS**

6. **Monitor and assess improvements** in Unity Pond's water quality over time. This includes annual baseline monitoring, plankton and cyanobacteria monitoring, assessing the current state of septic systems, tracking NPS pollution, understanding the influence of backflushing from Sandy Stream, stream monitoring, and monitoring for invasive aquatic plants.

STATEMENT OF GOAL

The goal of this plan is to improve water quality in Unity Pond by reducing phosphorus inputs to the lake from the direct and indirect watersheds and the internal load. Planning recommendations include reducing the phosphorus load by 1,556 kg/yr thereby reducing the average annual in-lake phosphorus concentration by 8 ppb over the next 10 years.

PLAN DEVELOPMENT & COMMUNITY PARTICIPATION

The 2023 Unity Pond WBMP update was developed with input from a diverse group of local stakeholders and scientists over a period of two years. Recommendations are the result of multiple steering committee meetings, technical advisory committee meetings and numerous subcommittee meetings (including backflushing, watershed survey, and outreach committees). The plan update was led by WCSWCD in partnership with FOLW, the towns of Unity and Burnham, the Center for Wildlife Studies (CWS), and Maine DEP. Technical support was provided by Ecological Instincts and Water Resource Services. Numerous volunteers participated in this project including a dozen watershed survey volunteers.

Community participation included volunteers assisting with the 2021 watershed survey, two public presentations at FOLW annual meetings (August 2021 & 2022), and a hybrid public meeting on October 27, 2022 to present the Unity Pond WBMP. The final public meeting was viewed by 45 online attendees and 25 in-person attendees. Postcards announcing the meeting were mailed to every shoreline property owner in addition to Facebook and newspaper announcements. The meeting highlighted the history of water quality and watershed planning efforts in the watershed as well current water quality trends and recommended actions needed to improve water quality. A link to the recording from the public meeting was posted to the FOLW website. The public meeting Q&A is provided in Appendix A.

WATERSHED PROJECTS, PROGRAMS & RESEARCH

Unity Pond is at the center of ongoing scientific research and monitoring as a result of many years of private/public partnerships involving numerous watershed partners effectively working together to document and understand the changes in the lake's water quality and identify the best ways to protect it. The list of projects below does not encompass all projects completed prior to the 2007 WBMP but represents recent or relevant watershed activities.

PLANNING/RESEARCH

(2004) Unity Pond Phosphorus Control Action Plan and Total Maximum Daily Load (PCAP-TMDL) Report- Funded in part by USEPA under Section 319 of the Clean Water Act, this project was administered by Maine DEP under contract with Unity College and the Maine Association of Conservation Districts (MACD) from 2000-2004. The project resulted in a comprehensive land use inventory, Phosphorus Control Action Plan and a TMDL report in addition to an assessment of the shoreline and a septic evaluation. An in-lake TP concentration of 15 ppb was selected as the water quality goal with a target phosphorus reduction of 759 kg annually to attain water quality standards and bloom-free conditions.

(2007) Unity Pond Watershed-Based Plan- Waldo County Soil & Water Conservation District (WCSWCD) developed a management plan for Unity Pond which set an interim P reduction target of 15%, or 225 kg/yr. Management recommendations to meet this goal included addressing 100% of farmland in row crops, tillage or corn; 30% of forestry land uses; 193 residential and 37 road NPS sites. The plan did not address internal loading.

(2019) Lake Winnecook Non-Paved Road Survey- WCSWCD in cooperation with FOLW completed a field assessment of unpaved roads in the Unity Pond watershed. Fifty-four roads were surveyed visually for issues that may lead to erosion and NPS pollution, including drainage issues, erosion at stream crossings, and road shape and substrate. Recommendations were made for each road where issues were found. Twenty roads were identified as needing improvements including nine ranked high priority.

(2021) Unity Pond Watershed Survey- FOLW led a locally funded watershed survey in May 2021 in collaboration with WCSWCD, watershed towns, Maine DEP, and Ecological Instincts. The survey documented a total of 109 different NPS pollution sites around the watershed that affect the water quality of Unity Pond (Maine DEP, 2021a). Sites were prioritized by a steering committee, and follow-up letters were mailed to landowners having an identified site. The survey was funded in part by CWA 604(b) grant funds.

CLEAN WATER ACT SECTION 319 FUNDS

Since 2004, two CWA Section 319 implementation grants (Phases I and II) have supported town road, private road, public access, and residential shoreline improvement projects in the Unity Pond watershed. Under these grants, a total of 31 BMPs were installed. These projects were estimated to have reduced annual pollutant loading to the lake by more than 950 tons of sediment and 1,000 pounds (450 kg) of P. Education and outreach to watershed residents and local stakeholders was also completed as part of these restoration projects, including hosting a workshop on NPS pollution for municipal officials and starting a watershed newsletter.[6]

LAKESMART

FOLW started a LakeSmart program in 2016 to provide technical assistance to landowners looking to reduce their lakeshore properties' impact on water quality. The program is currently run by FOLW with technical assistance from WCSWCD and support from Maine Lakes. Since the inception of the program 11 awards and 20 commendations have been issued. Property owners that make improvements to their property are helping reduce stormwater runoff (and resulting phosphorus) into the lake as well as improving wildlife habitat.

NATIONAL WATER QUALITY INITIATIVE (NWQI)

A National Water Quality Initiative resulted in $1.2M in federal funding for agricultural landowners to complete projects to protect water quality in the Unity Pond, Sandy Stream, and Halfmoon Stream watersheds between 2014-2016. Recommendations for reducing P from agricultural land over the next 10 years are presented in Section 7.

PUBLIC OUTREACH

FOLW is the primary entity conducting public outreach in the watershed. FOLW hosts an annual meeting each summer for all interested watershed residents, provides watershed updates on its website and Facebook page (1,000 followers), and distributes three annual newsletters to 300 shoreline property owners as well as an electronic copy of the newsletter to all FOLW members. FOLW also administers the LakeSmart program and the Courtesy Boat Inspection (CBI) program. The CBI program began in 2007 and operates with paid staff and volunteers conducting approximately 800 inspections annually at the public boat launch on Friday-Sunday from Memorial Day to Indigenous People's Day. FOLW also runs a $250 rebate program for landowners that install conservation practices on their property and a septic system replacement program that offers $500 to landowners willing to upgrade or replace an existing system in the shoreland zone. General and targeted outreach and education activities recommended for the next 10 years are presented in Section 7.

WATER QUALITY MONITORING

Water quality data have been collected at Unity Pond by Maine DEP and Lake Stewards of Maine Volunteer Lake Monitoring Program since 1977 in the deepest part of the lake (Station 1). Additional research has been conducted by Unity College and University of Maine over the past 10 years. Water quality will be discussed in Section 3.

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[6] Unity Pond Watershed NPS Restoration Project Phase I (2003R-19A) and Phase II (2006R-21) final project reports. Pollutant load reduction estimates for past 319 projects were calculated differently from the estimated load reductions in this plan.

2. Lake & Watershed Characteristics

Photo Credit: Steve Krautkremer

LAKE & WATERSHED FACTS

Watershed Towns:	**Troy, Unity, Thorndike, & Burnham, ME**
Watershed Area:	**30.3 mi^2**
Surface Area:	**4 mi^2 (2,569 acres)**
Max Depth:	**39 ft (11.8 m)**
Mean Depth:	**17.5 ft (5.3 m)**
Flushing Rate:	**1.28 flushes/yr**
Lake Elevation:	**175 ft**
Peak Elevation:	**620 ft**
Avg. Clarity:	**2.3 m**

Unity Pond (MIDAS 5172)[7], also known as Lake Winnecook, is a 2,569-acre lake (Class GPA)[8] located in Waldo County, in the central Maine towns of Troy, Unity, Thorndike, and Burnham (Figure 2). The lake is naturally formed (undammed), highly productive (eutrophic), and mixes twice each year in spring and fall (dimictic). There are four towns in the watershed with Troy making up the largest land area (41%) followed by Burnham (36%), Unity (19%), and Thorndike (5%).

The lake has a maximum depth of 11.8 m (39 ft), an average depth of 5.3 m (17.5 ft), and a flushing rate of 1.28 flushes/year, which is similar to the average for Maine lakes of 1-1.5 flushes/yr. The elevation in the watershed ranges from 175 ft above sea level (lake level) to 620 ft in the southeast corner of the watershed. The direct watershed drains approximately 30 mi^2 of the surrounding landscape. Tributaries that flow into the Unity Pond include Carlton Stream to the north, Bog Brook and Bithers Brook to the east, and Meadow Brook to the west, along with several unnamed small or intermittent streams.

Unity Pond has several indirect watersheds including Carlton Pond to the north (21.4 mi^2 watershed) that flows south into Unity Pond via Carlton Stream. Sandy Stream and Halfmoon Stream are also considered indirect watersheds of Unity Pond, but only during periods of heavy precipitation when Sandy Stream backflushes into Unity Pond. Along with Unity Pond being listed on the state's 303(d) list of impaired lakes, Carlton Pond is also listed as "Category 3" as of 2022 based on assessments of

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

[8] Defined by MRSA Title 38 §465-A, Maine Standards for Classification of Lakes and Ponds: Class GPA is the sole classification of Great Ponds (>10 acres) and natural lakes and ponds <10 acres in size.

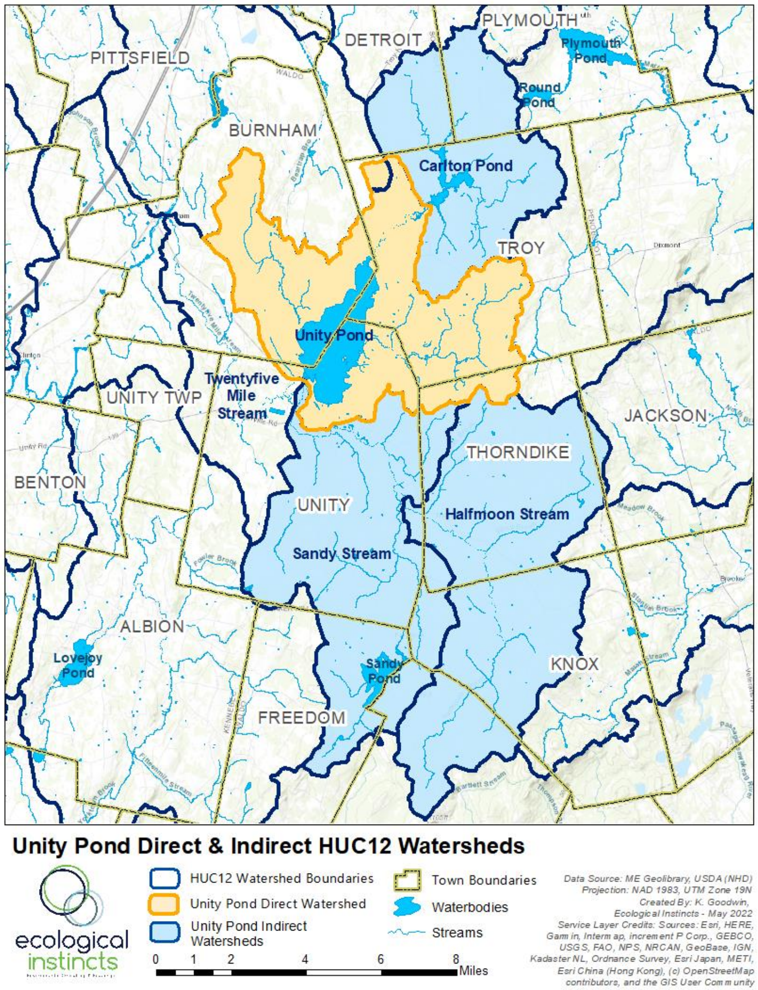

Figure 2. *Map of the Unity Pond direct and indirect watersheds.*

its benthic macroinvertebrate community. Category 3 water bodies have insufficient data to determine whether they are impaired, but it is assumed based on available data that one or more use may be impaired. Sections of Halfmoon Stream, which drains to Unity Pond during periods of backflushing through Sandy Stream, have been listed as impaired since 2014 based on assessments of the stream's algae community.

When backflushing from Sandy Stream occurs, Unity Pond's watershed more than doubles in size due to the combined watershed areas of Halfmoon Stream and Sandy Stream (71.5 mi^2).[9] Sandy Stream used to be the major inlet to Unity Pond with Twentyfive Mile Stream as the outlet. The hydrology at the inlet and outlet was modified following construction of the train trestle in 1870 that altered the natural flow at the outlet, creating a large wetland area, and diverting flow from Sandy Stream into Twentyfive mile stream and by-passing Unity Pond. Water flowing out of Unity Pond flows south under

[9] The watershed to lake ratio in Unity Pond's direct watershed is 7.5 compared to 31 when the indirect watersheds are included. Ratios between 20 – 50:1 are known for causing water quality problems if the land use is not natural and management is limited.

the trestle on the southwestern shore and into Sandy Stream and then into Twentyfive Mile Stream which flows northwest to the Sebasticook River and then south to the Kennebec River in Winslow, eventually flowing into the Atlantic Ocean.

The watershed includes 100 miles of streams, 3,418 acres of wetlands, and 4,335 acres of riparian habitat along the edges of lakes, ponds, streams, and wetlands. Flooding of various intensities occurs regularly at Unity Pond, partially due to the unusual stream flow pattern and backflushing at the outlet stream. According to a 1974 study of the Unity Pond watershed completed by Unity College, 55% of all "camps" were located within the 100-year floodplain (within 7 feet above the mean high water level) and about a third of camps were located within the five year floodplain (6.5 feet above the mean high water level) (Rabeni, 1974).

Sandy Stream & Train Trestle (Photo Credit: Alan Burton)

The 2004 Unity Pond TMDL reported 299 shoreline lots on Unity Pond including 286 with structures. Of these, 57% were estimated to be used seasonally (<90 days/year) and 64% were estimated to be within 50 feet of the shoreline. FOLW is in the process of developing a septic system database that will include an update on number of developed properties and age and distance of septic systems to the shoreline as part of the 2021 FOLW Septic Survey.

An updated land cover analysis for the Unity Pond watershed shows that forestland makes up the majority of the watershed area (62%), followed by wetlands and open water (not including the surface area of Unity Pond) at 22%. Developed land (e.g., residential, commercial, roads) accounts for approximately 8% of the land area in the watershed, while agriculture accounts for another 8%.

There are 66 miles of roads (~368 acres) in the watershed, many of which are unpaved gravel roads that service high-density residential development along the shoreline. Paved town and state roads in the watershed include Bangor Rd (Rt. 202) that provides access to the eastern shore, Detroit Rd (Rt. 220) to the northeast, Pond Rd and Horseback Road that provide access to private roads along the western shoreline, along with several other paved roads that cross the upper watershed.

There are two public swimming beaches at Unity Pond- Kanokolus Beach on the southwest shore in Unity, and the Burnham Town Beach south of Reynolds Corner. Public access is provided by two public boat launches- at Kanokolus Beach in Unity and a public launch on the western shore in Burnham. Private access is possible via a private carry-in launch located on Windmere Drive in Unity, and at numerous private roads and residences along the shoreline. Three boat launches provide access via Sandy Stream- Route 139 in Unity, the intersection of Route 202 and Quaker Hill Road (CWS), and on Halfmoon Stream at the Route 220 bridge in Thorndike. Unity College maintains a recreational area on Unity Pond known as 'The Field of Dreams' located on Bangor Road in Unity. The property provides water access for canoes and kayaks, jogging and walking paths, a playground, picnic area, tennis courts and ball fields.

There are four fairly small areas of conserved land in the lake's direct watershed, three of which are under agricultural easements. The fourth consists of a portion of the Carlton Pond Waterfowl Production Area, which encompasses Carlton Pond and its surrounding wetlands.

POPULATION, GROWTH, & MUNICIPAL ORDINANCES

POPULATION

Unity Pond provides excellent year-round recreational opportunities including swimming, fishing, and boating in the summer, and ice fishing, skiing, snowshoeing, and snowmobiling in the winter. Activities such as the annual fishing derby in the winter, and the return of seasonal residents in the summer play an important role in the local economy and is valued highly by residents of both the watershed and the surrounding area.

Unity Pond Annual Fishing Derby (Photo Credit: FOLW)

Landowners, businesses, and watershed towns will likely see a monetary benefit from improved water quality over time as more seasonal and year-round residents are attracted to the lake. Factors such as increased property values will also improve the town's tax base. A study on 36 Maine lakes found that lakes with 1 meter greater clarities have higher property values on the order of 2.6% - 6.5%. Similarly, lakes with a 1 meter decrease in minimum transparencies cause property values to decrease anywhere from 3.1% to 8.5% (Boyle and Bouchard, 2003).

Population and demographics are important factors in watershed planning because large increases in unplanned population growth, and consequently development, could negatively affect lake water quality. Conversion of seasonal or second homes to year-round homes would result in a significant change in use on the shoreline, increasing the potential for more stormwater runoff and impacts from septic systems among other factors.

According to the Maine Office of the State Economist, the population of Waldo County in 2018 was 39,867, representing an increase in population by 3% since 2008 (Maine State Economist, 2018a). This is a higher rate of growth than the total population of the State of Maine, which increased by only 1% between 2008 and 2018. The Maine State economist predicts that population growth will continue into the future, predicting continued growth for all three towns into 2023. These predictions do not take into account 2020 census numbers and effects of the COVID-19 pandemic, which has changed patterns of migration throughout the US, enabling some people to work remotely and driving movement to more rural areas (O'Hara, 2020).

Between 2008 and 2018, the population in the towns of Troy, Burnham, and Unity all increased slightly, with the highest growth rate (11%) in Burnham (Maine State Economist, 2018b). The populations of the towns of Troy and Unity increased by just 1% and 2%, respectively, over the same time period in line with the State as a whole, but slower than the increase for Waldo County (Table 1). These trends indicate that some towns in the watershed may develop more rapidly while others may continue to grow slowly.

Table 1. *Population demographics and 2023 projections for the towns of Troy, Burnham, and Unity, Waldo County, and the State of Maine. (Source: Maine State Economist)*

Town	Population				
	2008	2013	2018	Projected 2023	% Change 2008-2018
Troy	1,028	1,035	1,037	1,053	<1%
Burnham	1,170	1,180	1,299	1,311	11%
Unity	2,093	2,097	2,139	2,235	2%
Waldo County	38,680	39,025	39,867	41,313	3%
State of Maine	1,330,509	1,328,009	1,341,160	1,355,924	<1%

The exact amount of additional development may vary based on population growth and the amount of land protected as open space, zoning and other regulations, and socioeconomic factors.

MUNICIPAL ORDINANCES

Protecting natural resources starts with good municipal ordinances that meet or exceed the minimum state requirements. Ordinances that are up to date, provide clear consistent criteria and guidelines for development, and are adequately enforced provide the means by which to protect lake water quality through responsible development. As the watershed continues to develop over time, erosion from disturbed areas will deliver new and previously unaccounted for P into the lake, thereby affecting the success of planned management strategies to improve water quality.

Probably the most important ordinance for lake protection is administration and enforcement of local shoreland zoning regulations, required through the Mandatory Shoreland Zoning Act (MSZA). The State created Chapter 1000 Guidelines for Municipal Shoreland Zoning Ordinances[10] to provide guidance that towns can choose to use for their own ordinances, or as guidance for adopting more stringent ordinances- as long as they are equally or more effective in achieving the purposes of the MSZA.

***The shoreland zone** is defined as all land areas within 250 feet, horizontal distance, of the normal high-water line of any great pond or river, upland edge of a coastal wetland, including all areas affected by tidal action, upland edge of defined freshwater wetlands, and all land areas within 75 feet, horizontal distance, of the normal high-water line of certain streams.*

[10] A model regulation adopted in January 1988 and amended through January 2015.

A brief review of ordinances in the Unity Pond direct watershed indicates that all four towns have updated their shoreland zoning ordinance since the last update to the Chapter 1000 guidelines in 2015. The towns of Burnham and Unity which make up the greatest percentage of the lake area at 40% and 49%, enacted or updated their shoreland zoning ordinance in 2022 (Table 2). Unity and Thorndike also provide a copy of their land use ordinance and land use map on their website. Burnham does not have a land use ordinance but uses a general provisions ordinance. While the land use map was updated in 2021, it is not available online. Troy, which makes up the largest area of the watershed and 11% of the lake does not have a land use ordinance, a land use map, or a website.

***Table 2**. Status of shoreland zoning, land use ordinances, and comprehensive plans in the four towns in the Unity Pond watershed, and percentage of the lake and watershed area in each town.*

Town	% of W'shed	% of Lake	SLZ Ordinance	Land Use Ordinance	Land Use Map	Comp Plan
Burnham	36%	40%	Enacted May 2022	General Provisions Ordinance – Adopted 1996, revised June 2022	Updated 2021, not available online	n/a
Unity	19%	49%	2009, Updated June 2022	Adopted 1995, Revised 2011	1993- available online (black & white map)	1993- online
Thorndike	5%	0%	Enacted March 2017	Adopted March 1987, amended March 2016	Updated 2017, available online	1991- not online
Troy	41%	11%	March 2015	n/a	n/a	n/a

A more comprehensive review of town ordinances in each town should be completed to ensure that they meet the mininum requirements of the MSZA and to determine what improvements can be made to be more protective of water quality in the watershed. Towns should consider working collaboratively to develop consistent ordinance language across the watershed. Some examples of municipal ordinance improvements may include:

- Consider developing specific ordinances that address holding tanks, subdivisions, site plan review, and the new state requirement for septic system inspections at transfer of property.
- Consider amending ordinances that require impervious cover limitations and vegetated buffer requirements for new development, P control standards and/or low-impact development criteria for all new development in the shoreland zone. More than 50 Maine communities have adopted P control ordinances for all types of development including lake watersheds at risk from development.
- Consider amending ordinances to include additional protection for first-order streams (e.g. 75 ft. setback similar to the requirement for second order streams.)
- All four towns should have digitized land use maps and land use and shoreland zoning ordinances available on their website along with permit applications.
- All four towns should provide a link to the Friends of Lake Winnecook website.

- Towns should review whether current staffing is adequate for enforcing existing ordinances, and consider provisions for third party review and long-term maintenance as a requirement for all building permits.

Existing shoreline development on Unity Pond. (Photo Credit: FOLW)

Another important municipal document is the Comprehensive Plan. Comprehensive Plans outline a municipalities' goals, priorities, and vision for natural and cultural resource conservation, transportation, and land use patterns. While not state-mandated, towns with current Comprehensive Plans have a leg up when applying for state and federal grants and have additional legal benefits such as being able to impose a zoning ordinance beyond the state minimum for shoreland zoning, among other benefits. Comprehensive Plans can be helpful in bringing the community together for a common goal, creating a current inventory of natural resources, and providing the basis for making sound management decisions at the town level. As shown in Table 2, only Unity and Thorndike have Comprehensive Plans, both of which are out of date. Comprehensive Plans that are current and consistent with Maine's Growth Management Act[11] are listed on the Maine Department of Agriculture, Conservation & Forestry website.[12] All four towns should consider updating their Comprehensive Plan over the next 10 years and incorporate actions to improve water quality in Unity Pond.

Given the large areas of buildable land in the watershed and the potential increase in P from new development, there is an immediate need to reduce the amount of P getting to the lake from both existing development and future development. As the watershed continues to develop over time, erosion from disturbed areas will deliver new and previously unaccounted for P into the lake, thereby affecting the success of planned management strategies to improve water quality.

Proactive Planning- *Unity Pond needs strong leadership at the municipal level to ensure that all new development is protective of water quality, any modifications in the shoreland zone are strictly reviewed and rules are enforced, planning board members are educated on shoreland zoning requirements, code enforcement is adequately funded to minimize impacts from current and future development in the watershed, and mechanisms are in place to protect and conserve sensitive land in the watershed.*

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[11] 30-A MRSA, Chapter 187. Online: https://legislature.maine.gov/statutes/30-a/title30-Ach187sec0.html

[12] MDACF, Municipal Planning Assistance Program, https://www.maine.gov/dacf/municipalplanning/comp_plans/index.shtml

LAND COVER

Land cover is an important component of watershed modeling and can be used for identifying shifts in land cover types and tracking changes in development in a watershed over time. Unmanaged forests, for example, are natural filters for rainwater and deliver very little phosphorus downstream when it rains compared to more developed land cover types such as high and medium-density residential and commercial development and roads- all of which prevent rainwater from getting absorbed into the ground, resulting in increased runoff and delivery of P and other pollutants to the lake. To get a more accurate picture of the land cover in the Unity Pond watershed, an updated land cover layer was created by comparing 2004 Maine Land Cover Dataset (MeLCD) data with Google Earth and ArcMap aerial imagery taken in 2018. Polygons were manually edited to match the more recent aerial images, and assigned one of 16 different land cover types. Examples of how some areas were re-categorized are presented in Figure 3, below.

***Figure 3**. Example of aerial imagery (left), original MELCD land cover layer (middle), and updated land cover layer (right).*

Forestland (including recent timber harvesting at 6%) dominates the landscape, accounting for 62% of the land in the watershed (Figure 4 & Figure 5). The watershed also includes a significant amount of open water and wetlands (22% of the watershed, not including the area of the lake), much of which consists of forested wetlands around the north end of the lake and in the north end of the watershed. Agriculture, including row crops, grazing, and hayfield, makes up 8% of the watershed. Development, which makes up 6% of the watershed, is primarily located along major roadways and the the shoreline, with the highest concentration of commercial development located at the southern tip of the watershed in downtown Unity. Much of the development in the watershed is low or medium-density residential development. Roads, including state (Rt. 202 & 220), town, and private roads (including numerous gravel roads that provide access the shoreline) encircle the lake.

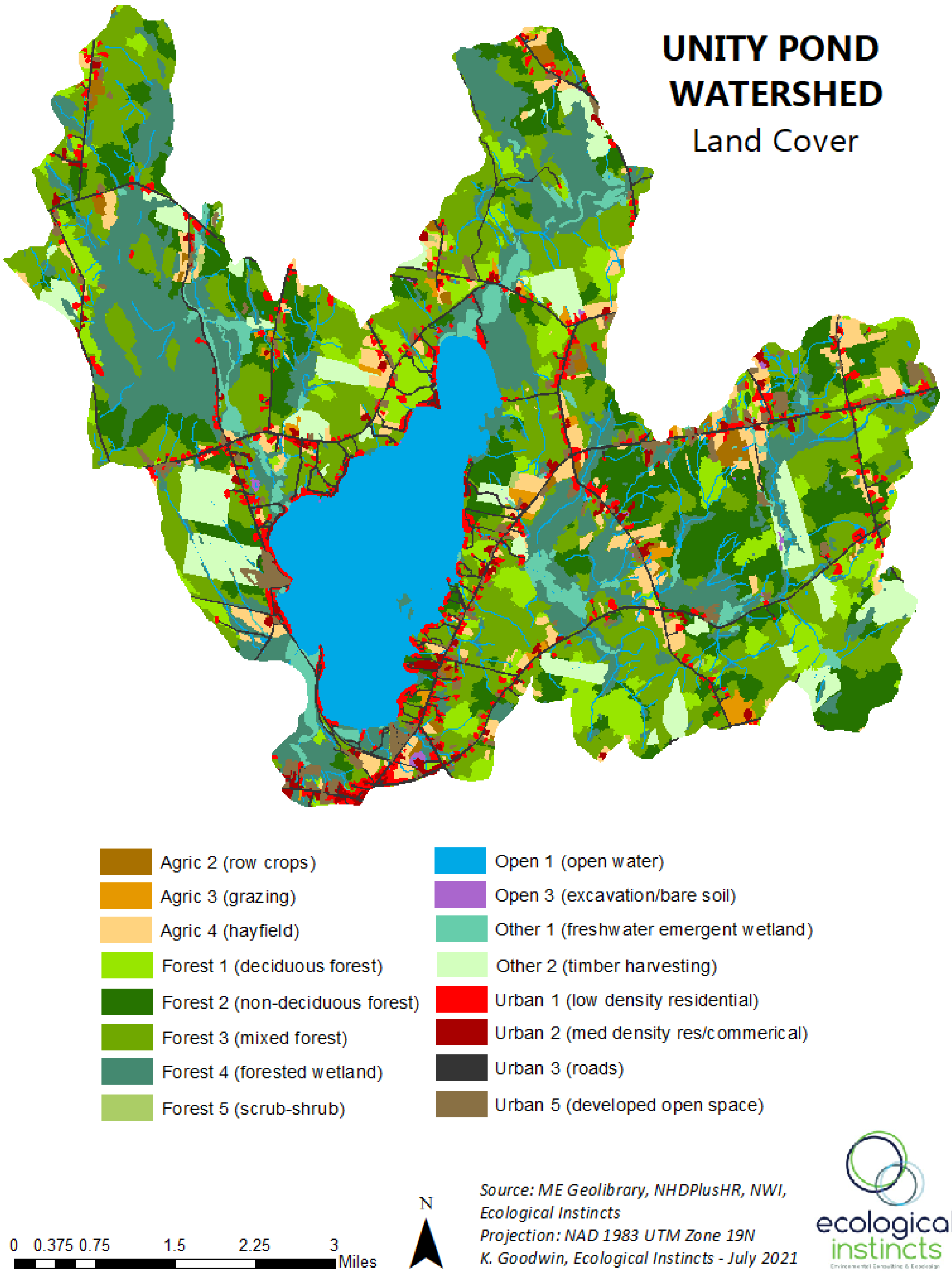

Figure 4. *Land cover in the Unity Pond direct watershed.*

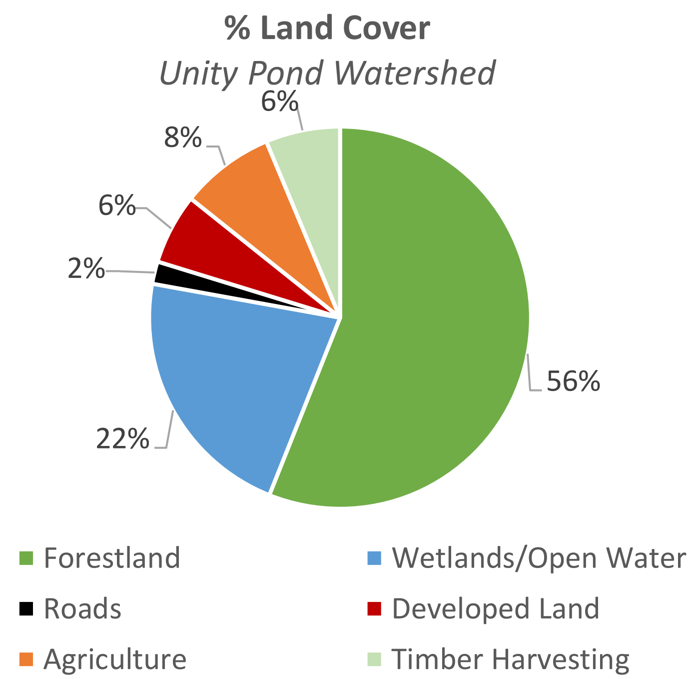

Figure 5. *Land cover by percent cover in the Unity Pond direct watershed.*

SOILS

Factors such as topography, soil type, erosive potential, and land alteration all influence the degree to which soil erosion occurs. The topography of the watershed is mostly flat, with extensive low, wetland areas and hills to the southwest and a maximum elevation of 620 feet.

Soils in the watershed are primarily derived from glacial till, a result of the glaciers that covered Maine more than 12,500 years ago. Soil associations are groups of soils with similar characteristics. The Unity Pond watershed is characterized by the Dixmont-Thorndike-Monarda-Burnham general soil association which consists of loamy soils formed in glacial till. This soil association comprises the northern and eastern portions of the watershed. Soils in the western and southwestern watershed are typified by the Swanville-Boothbay-Biddeford general soil association, which consist of clayey and loamy soils formed in glaciomarine or glaciolacustrine sediments (Ferwerda et. al., 1997).

The composition of each soil type dictates the amount of phosphorus, iron, and aluminum exported to the lake from the watershed soils, and therefore define the composition of sediment that has settled at the bottom of the lake.

AT-RISK SOILS AND SUBSURFACE WASTEWATER SYSTEMS

Soil type also affects the suitability for infrastructure, specifically for septic systems. Detailed information about the state of septic systems and their potential impact on the water quality does not currently exist for Unity Pond. Typically, the first step in targeting pollutants from failing, malfunctioning, or poorly designed systems is to develop a list of all septic systems within the shoreland zone and adjacent to tributaries draining to the lake.

Maine DEP (2021b) conducted a septic risk analysis of soils in the Unity Pond watershed. Coarse and shallow to bedrock soils are considered "at-risk soils", due to the rapid permeability of these soils that may result in septic system leach field effluent "short-circuiting" to groundwater. Short-circuiting occurs when septic tank effluent is not properly treated in the leach field because the soils are coarse and porous, which allows the effluent to move through them too quickly. Additionally, soils with shallow water tables and shallow-to-bedrock soils that abut or are hydrologically connected to the lake are also considered at-risk due to lack of treatment area where the leach field might rest on fractured bedrock resulting in no treatment of effluent before reaching groundwater which might then flow into the lake. These soil factors were mapped with tax maps to identify properties and septic systems that are located on the shoreline of the lake or its tributaries that also contain at-risk soils.

Soils in the watershed that are most susceptible to short-circuiting are presented in orange and red in Figure 6. The likelihood that a parcel identified as vulnerable to septic short-circuiting is developed was determined based whether there is an address associated with the parcel or not. If there is an address number, it is assumed that there is a house or building on the property, and likely also a septic system. Major outcomes of this analysis include (Table 3):

- There are 419 parcels located on these soil types and within 150′ of Unity Pond or 75′ of tributaries are considered a high priority for future subsurface wastewater investigations.
- At-risk soils encompass 6,670 acres, or about 34% of the watershed area.[13]
- Of the soils of concern, 88% by area are shallow-to-bedrock and only 11% are considered coarse and at high or very high risk for short circuiting.
- Approximately 70% of the high priority at-risk parcels were likely to contain a septic system in an at-risk soil.
- Of the four watershed towns, **Unity and Troy contained the most at-risk parcels**, closely followed by Burnham.
- The Town of Unity contained more parcels directly on the lake as well as more developed parcels within the buffer area than Troy and Burnham.
- The town of Thorndike had only 20 at-risk parcels, seven of which are estimated to be developed.

A recommendation for future assessment is to focus on the shoreline parcels on at-risk soils with likely septic systems in Unity (112 parcels), Troy (95 parcels), and Burnham (79 parcels). Town septic system permit records can be used to identify the location and age of septic systems on these parcels, allowing for further prioritization of parcels for on-the-ground inspection.

[13] Calculated as 19,414 acres, inclusive of waterbodies other than Unity Pond.

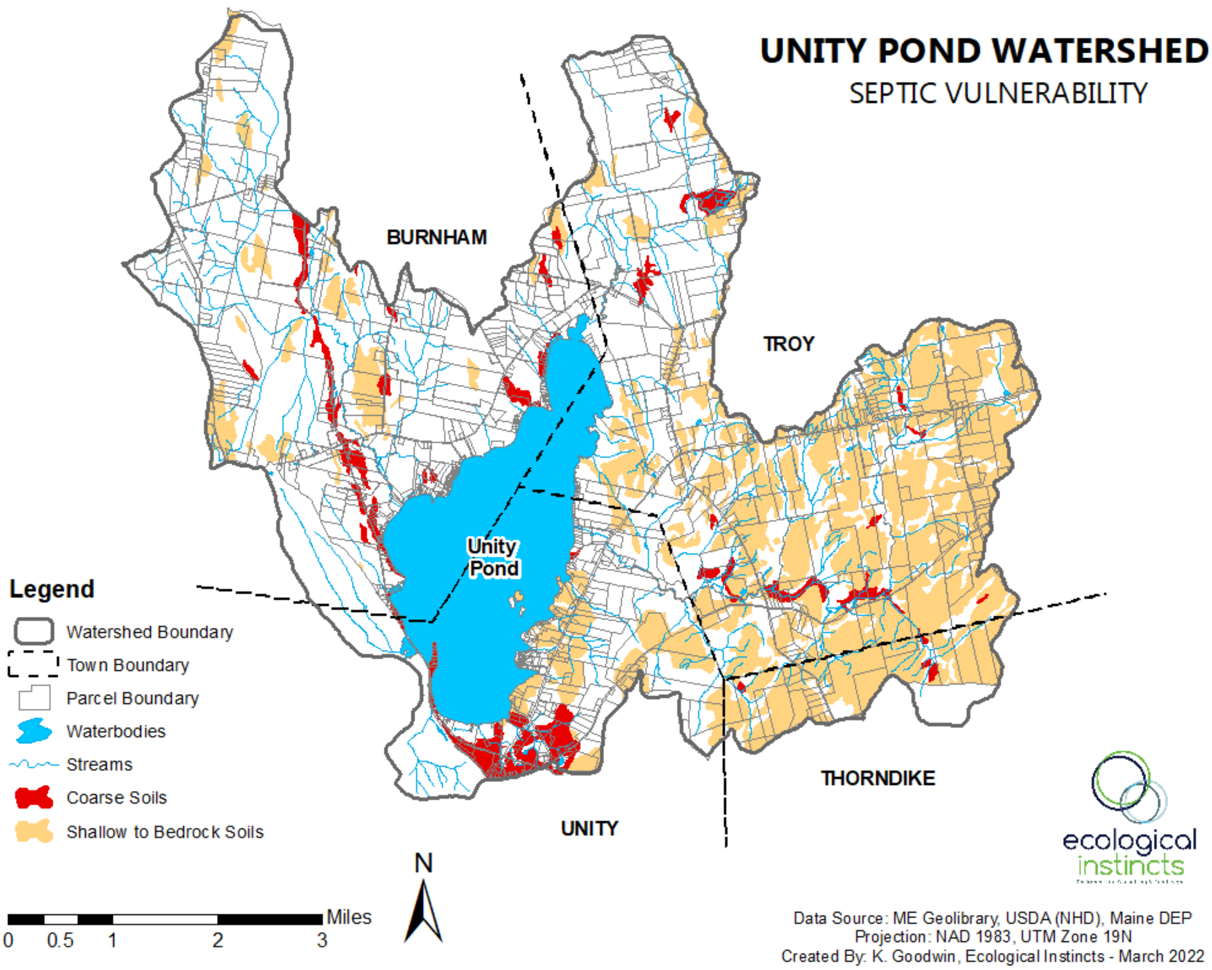

Figure 6. *At-risk soils and associated parcels in the Unity Pond direct watershed.*

Table 3. *Number of high priority parcels by town that are likely developed and undeveloped in the Unity Pond direct watershed (Source: Maine DEP)*

Town	Developed	Undeveloped	Total
Unity	112	37	149
Troy	95	52	147
Burnham	79	24	103
Thorndike	7	13	20
Total	**293**	**126**	**419**

Priority for Septic System Evaluations in the Unity Pond Watershed

1. Old systems (pre-1974) within the watershed, with priority to systems located on at-risk soils;
2. Systems (pre-1995) located on at-risk soils located within 250 feet of lake; and
3. Systems (pre-1995) located on at-risk soils within 75 feet of any tributary stream and/or wetland draining to Unity Pond.
4. Septic systems located in areas with a high groundwater table or in areas prone to flooding.

BATHYMETRY

The morphology (shape) and morphometry (measurement of shape) of lakes have been shown to be good predictors of water clarity and lake ecology, where large, deep lakes are typically clearer than small shallow lakes. Bathymetric data is useful for estimating the mass of P within each basin by depth, for assessing internal loading, and examining changes in the Anoxic Factor in the lake which requires a reliable bathymetric map. The most recent bathymetric map for Unity Pond was created by FOLW and Lakes Environmental Association (Figure 7). The deepest areas are located at the southwest end of the lake near the outlet to Sandy Stream, with a second smaller deep hole to the northeast near the middle of the lake. Both deep holes reach depths of over 11 m. Unity Pond is a fairly shallow lake, with three-quarters of the total volume of the lake in water shallower than 5 m. In comparison, roughly 9% of the lake area and 2% of the lake volume is in water deeper than 9 m, vs. 26% of the lake area and 10% of the lake volume in water deeper than 7m.

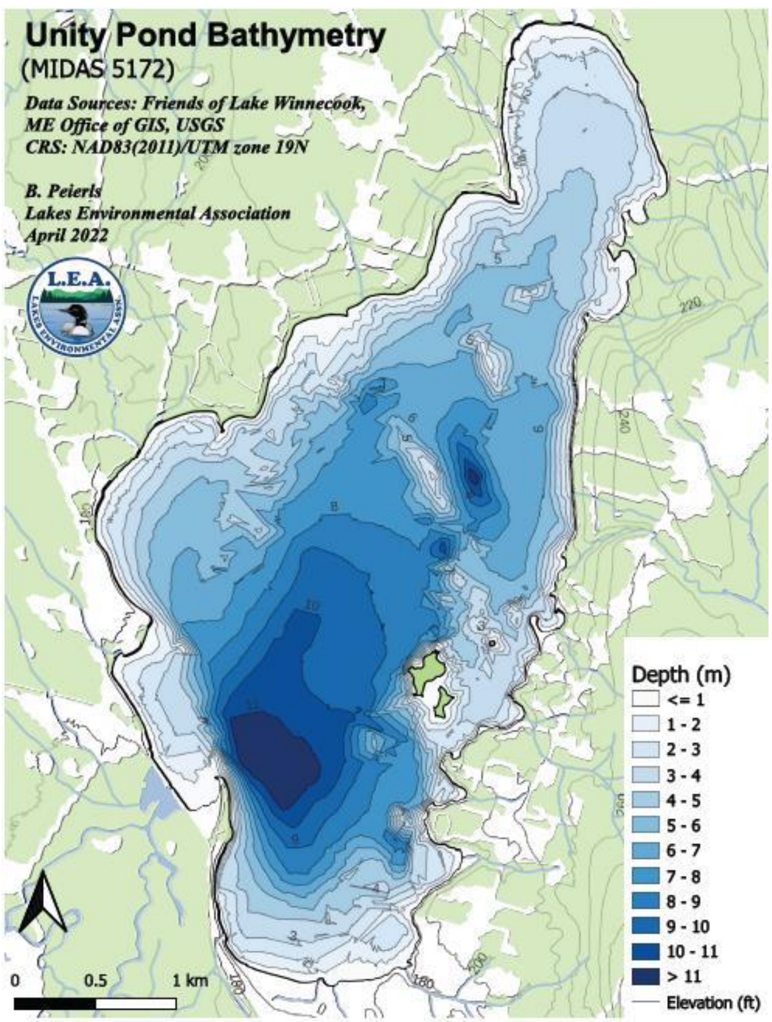

Figure 7. *Bathymetric map for Unity Pond. (Source: LEA)*

WATER RESOURCES AND WILDLIFE HABITAT

Fish and wildlife require suitable upland habitat, as well as healthy riparian buffers, wetlands, and large undeveloped habitat blocks strategically linked to provide movement of wildlife. An assessment of water resources and wildlife habitat was completed for the Unity Pond watershed (Figure 8 & Figure 9) using Beginning with Habitat (BwH) data.[14]

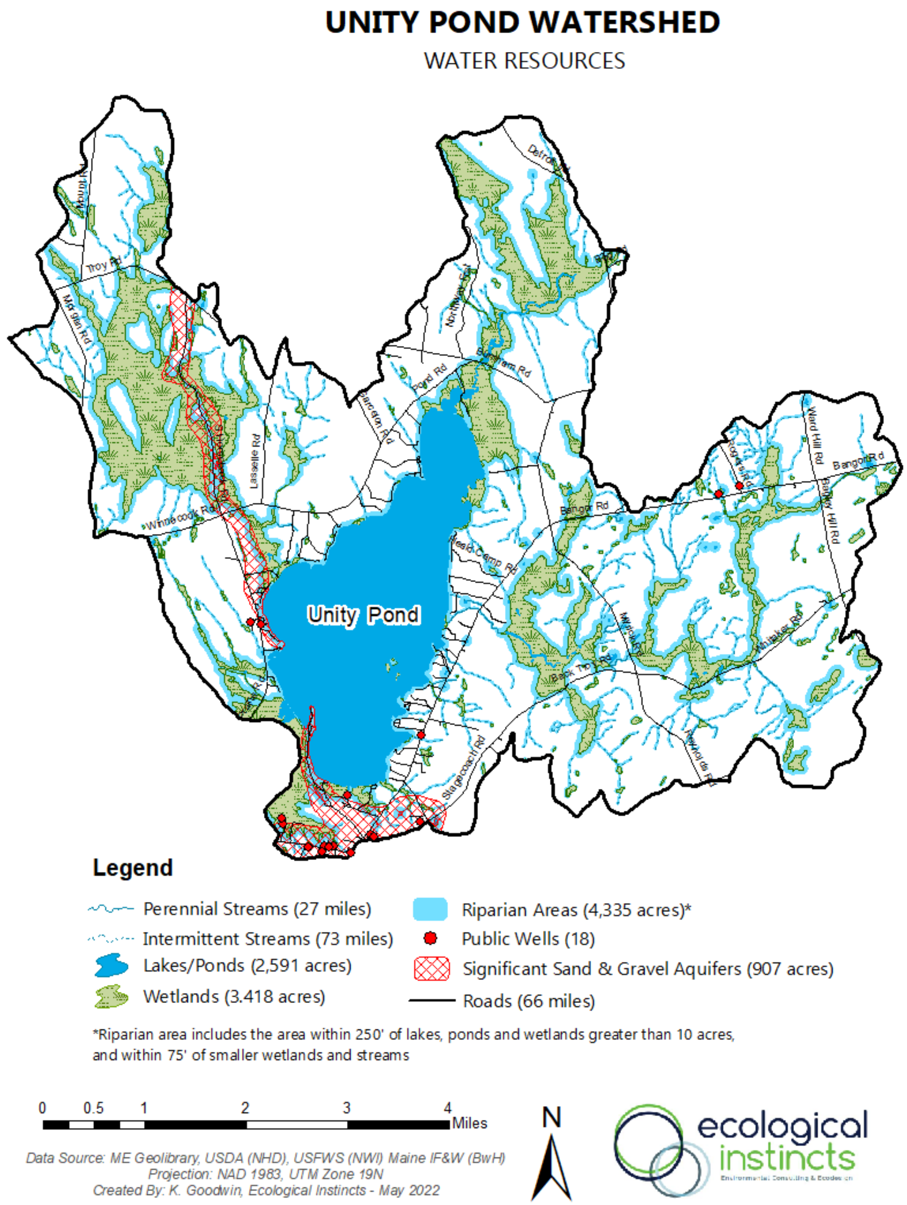

Figure 8. *Water resources in the Unity Pond direct watershed.*

Riparian habitat is the transitional area between aquatic habitats and dry, upland areas.

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[14] https://www.maine.gov/ifw/fish-wildlife/wildlife/beginning-with-habitat/index.html

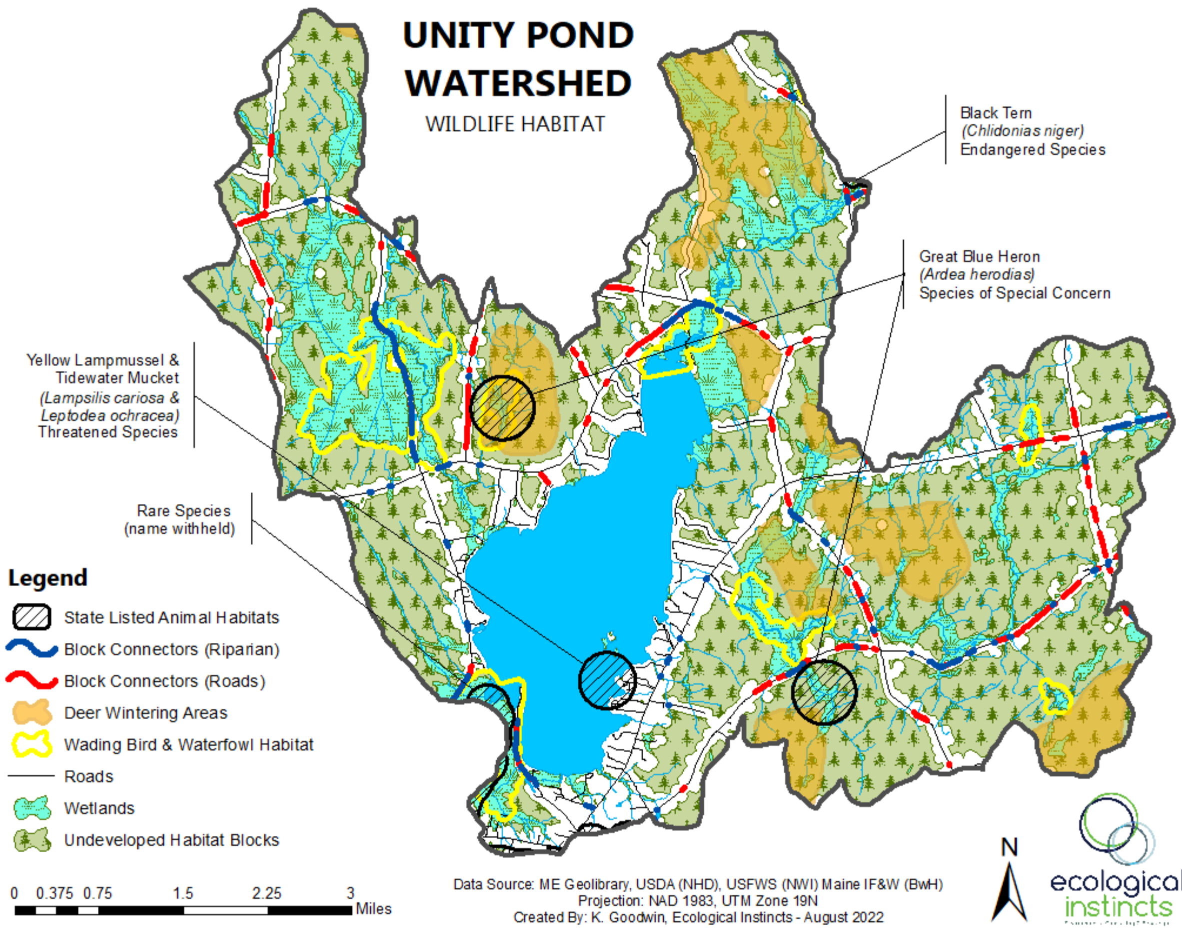


Figure 9. *Wildlife habitat in the Unity Pond direct watershed.*

Results of the assessment highlight the wealth of water resources in the watershed, including 3,418 acres of wetlands, 100 miles of streams, 2,591 acres of open water, and 4,335 acres of riparian habitat. Healthy riparian zones are not only important for water quality but are essential for more than 60 species of Maine wildlife, as more animals live in riparian zones than in any other habitat type in Maine, with hundreds of species depending on riparian zones for survival (ME Audubon, 2006). Sections of the riparian habitat in the watershed have been impacted by development and roads, especially along the shoreline. As development continues, this valuable habitat will diminish - underlining the need for strong protection of the shoreland zone and conservation of undeveloped land within the watershed.

The watershed provides habitat for rare plant and animal species of special concern. MDIF&W documented five occurrences of threatened, endangered, or species of special concern in the watershed, including great blue heron and black tern in wetlands surrounding the watershed, and yellow lampmussel and tidewater mucket in the lake itself (Figure 9). Other locally important wildlife species include the American eel (*Anguilla rostrata*) and the common loon (*Gavia immer*). A symbol of summertime on Maine lakes, loons are regularly present on Unity Pond, with 20 adult loons and 2 chicks counted on the lake in 2020 (ME Audubon, 2020).

According to Beginning with Habitat, large undeveloped forest blocks cover 14,092 acres of the watershed (73% of the watershed). There are six areas of inland wading bird and waterfowl habitat (IWWH) in the watershed, the largest of which surrounds a wetland area northwest of Unity Pond. The largest areas of deer wintering habitat are located to the north and east of the lake. **Protecting the land and water in the watershed is vital for maintaining this high-value wildlife habitat**.

FISHERIES

Unity Pond contains 20 species of fish including both native and introduced species (Table 4). The lake provides an excellent warm water fishery, including robust populations of largemouth and smallmouth bass, perch, and pickerel. Salmon were stocked into the lake briefly in the 1960s-70s, but the program failed to produce a viable salmon fishery due to the lack of deep, coldwater habitat and was discontinued. Brown trout and brook trout have also historically been stocked, but the trout stocking program was discontinued in 2013 due to poor trout survival and low catch rates by anglers.[15]

Alewife at the Benton Dam. (Photo Credit: FOLW)

Deeper areas in the water column experience low levels of dissolved oxygen (DO), which pose a problem for salmonid species like salmon and trout. Salmonids require dissolved oxygen levels above five ppm and will struggle to survive at lower oxygen levels. They also require cold temperatures, so their habitat is lakes is often reduced over the course of the summer by low oxygen extending from the bottom of the lake and increasing water temperatures from the top. Unity Pond is a fairly shallow lake and is not strongly stratified, which also contributes to a lack of deep coldwater habitat.

Twenty-three stream crossings were identified within the Unity Pond watershed by the Maine Stream Habitat Viewer.[16] Of these, eight are round culverts classified as barriers for fish passage, seven are potential barriers for fish passage, and another eight are not barriers to fish passage. Most of the major stream inlets provide adequate fish passage. There are also no barriers to fish passage on Twentyfive Mile Stream leaving Unity Pond or on the Sebasticook River below Twentyfive Mile Stream, providing passage for anadromous fish species like alewife.

[15] Personal communication. Jason Seiders, MDIFW. September 2022.
[16] https://webapps2.cgis-solutions.com/MaineStreamViewer/

Table 4. *Fish species in Unity Pond. (Source: MDIFW)*

Species	Scientific Name	Introduced
Sea-run Alewives	*Alosa pseudoharengus*	
Brown Bullhead	*Ameiurus nebulosus*	
American Eel	*Anguilla rostrata*	
White Sucker	*Catostomus commersoni*	
Northern Pike*	*Esox lucius*	*X*
Chain Pickerel	*Esox niger*	
Banded Killifish	*Fundulus diaphanus*	
Redbreast Sunfish	*Lepomis auritus*	
Green Sunfish*	*Lepomis cyanellus*	*X*
Pumpkinseed Sunfish	*Lepomis gibbosus*	
Cusk	*Lota*	
Common Shiner	*Luxilus cornutus*	
Smallmouth Bass	*Micropterus dolomieu*	
Largemouth Bass	*Micropterus salmoides*	*X*
White Perch	*Morone americana*	
Golden Shiner	*Notemigonus crysoleucas*	
Rainbow Smelt	*Osmerus mordax*	
Yellow Perch	*Perca flavescens*	*X*
Black Crappie	*Pomoxis nigromaculatus*	*X*
Brown Trout	*Salmo trutta*	
Brook Trout	*Salvelinus fontinalis*	
Fallfish	*Semotilus corporalis*	

**These species are unconfirmed in Unity Pond, meaning that there have been credible reported sightings, but these species have not been collected and confirmed by Maine DIFW.*

FISH CONSUMPTION ADVISORY (MERCURY & PFAS)

The Maine Center for Disease Control and Prevention (CDC) has posted a fish consumption advisory for all freshwater fish in inland waters in Maine due to mercury contamination. The advisory warns pregnant and nursing women, women who may get pregnant and children under age 8 not to east any freshwater fish from Maine's inland water except brook trout and landlocked salmon (one meal/month is safe). All other adults and children older than 8 can eat two freshwater fish meals/month and for brook trout and landlocked salmon the limit is one meal/week. Fish from the Sebasticook River (East Branch, West Branch & Main Stem) (Corinna/Hartland to Winslow) include a safe eating guideline of 2 fish meals/month due to high levels of PCBs, dioxins or DDT known to cause cancer and other health effects.

An emerging issue that pertains specifically to Unity Pond is PFAS (per- and polyfluoroalkyl substances). PFAS are a group of chemicals that have been used in household and industrial products since the 1940's to repel water and resist stains and grease. These chemicals have been found to persist for a very long time once released into the environment, and they can build up in the bodies of people and animals over time. Current research suggests that high levels of exposure to PFAS can have negative effects on human health, including increased risk of some cancers, lower infant birth rates, and reduction of the immune system's capacity to fight infections (Maine DHHS, 2017). More research is underway to better understand these health effects and how they are affected by different levels of exposure (USEPA, 2022).

Sources of PFAS in the environment include historical use of firefighting foams, industrial sites that used or processed PFAS, and fields with a history of land-spreading materials used for fertilizer that likely contained PFAS (Maine DHHS, 2017). In the Unity Pond watershed, there are 13 sites where sludge from either industrial paper mill wastes, or wastewater treatment plants has been spread on agricultural fields (Maine DEP, 2022). Both of these types of sludge are now known to be possible sources of PFAS and could be contributing to elevated PFAS levels in Unity Pond.

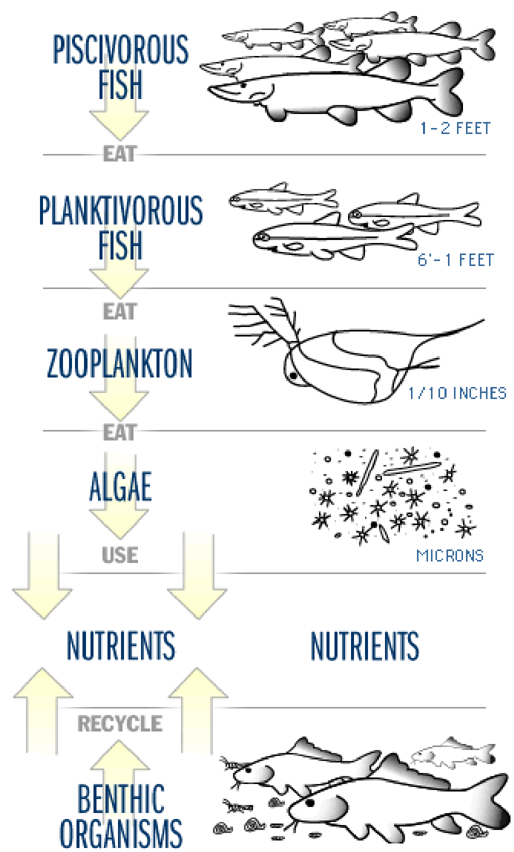
Fish that live in waterbodies contaminated with PFAS can accumulate the chemicals in their bodies. In May 2022, the Maine Center for Disease Control and Prevention (CDC) issued a PFAS Fish Consumption Advisory that included an advisory for Unity Pond. An advisory is issued for a waterbody if fish cannot be safely consumed at a rate of at least one meal per week, which corresponds to a fish tissue action level (FTAL) of 3.5 nanograms per gram (ng/g). Samples of black crappie and largemouth bass taken from Unity Pond in October 2021 were found to have FTAL levels much higher than this threshold. Because of this, the Maine CDC recommends a consumption rate of no more than 6 meals per year for black crappie, and no more than 12 meals per year (one per month) for all other fish species (Maine CDC, 2022).

INVASIVE AQUATIC PLANTS

To date, no invasive aquatic plant species have been documented in Unity Pond, although the numerous shallow areas and recreational uses make it highly susceptible to accidental introductions. Once invasive plant species become established in a new lake, they can be very difficult or impossible to eradicate, making prevention extremely important. Since 2007, FOLW has coordinated a Courtesy Boat Inspection (CBI) program which monitors boats coming in and out of the Kanokolus boat launch on the west side of Unity Pond. The program completes an average of 800 inspections each year.

PLANKTON AND CYANOBACTERIA

Tiny aquatic plants (algae, aka phytoplankton) and animals (zooplankton) are the primary and secondary source of food and energy in a lake food web and play a key role in lake ecosystems. Because plankton float in the water column, they influence the transparency of the water throughout the season and from year-to-year as these communities undergo both seasonal and annual growth cycles. These growth cycles vary over the course of the year as a result of changes in temperature, light and nutrient availability.



PHYTOPLANKTON

Phytoplankton are microscopic algae and bacteria that photosynthesize using the sun's energy to turn carbon dioxide, nutrients and water into food for organisms higher in the food web such as zooplankton and small fish. Phytoplankton are sensitive to changes in lake ecosystems. The effects of environmental and watershed impacts can often be detected in changes in the plankton community species composition, abundance, and biomass.

Phytoplankton samples were collected by Maine DEP over a three-year period from 2014-2016. Ongoing sampling of plankton species composition and abundance (including zooplankton) will improve our understanding of water quality changes, and track the successes of aluminum treatments and watershed improvement activities.

CYANOBACTERIA

Cyanobacteria are a type of phytoplankton present in Unity Pond and in lakes all around the world. Their presence, species composition, and abundance can be used as an indicator of water quality. Cyanobacteria are not like other 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.

Some forms of 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 P, and once in the upper waters, they can grow with adequate light. When cells die, some portion of the P is released into the upper waters that 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. Areas of fertile sediment subject to low oxygen that also recieve adequate light can be "nurseries" for cyanobacteria blooms. Consequently, release of P from sediment exposed to low oxygen can fuel blooms without dissolved P ever moving into the water column. THe cyanobacteria rising in the water column will cause an increase in measured P by virtue of what they bring with them from the bottom.

A cyanobacteria bloom in Unity Pond in 2021. (Photo Credit: Dan Mcleod)

The effects of toxins produced by cyanobacteria (cyanotoxins) on humans, domestic animals, and wildlife, is closely associated with the occurrence of Harmful Algal Blooms (HABs) (US EPA, 2019). The effects are well documented, and can affect kidney, brain, and liver function. Not all blue-green algae blooms are toxic. However, Microcystis is the most common bloom-forming genus,[17] and is almost always toxic (US EPA, 2017).

Microcystin (the cyanotoxin produced by Microcystis cyanobacteria) was studied in lakes throughout the state from 2014-2019. Unity Pond was one of four lakes selected for sampling due to its frequent algal blooms. The study documented the presence fo three species of cyanobacteria known for producing toxins (*Microcystis, Anabaena and Aphanizomenon*).

Results of cyanotoxin testing from samples collected in Unity Pond showed that maximum microcystin concentrations exceeded US EPA's acceptable cyanotoxin levels for recreation in downwind scum samples. Cyanotoxin levels also exceeded the drinking water standard for non-school age children, school-age children, and adults standard at all stations (Table 5).

Follow-up monitoring for cyanotoxins should be a public health priority at Unity Pond during the summer when the lake is experiencing an algal bloom. This would allow public officials to post advisory at public locations when cyanotoxins exceed US EPA guidelines. Several Maine communities have

The US EPA 10-day health advisory value for microcystin in **Drinking Water** is 0.3 µg/L for non-school-age children and 1.6 µg/L for school-age children and adults. US EPA criteria for microcystin in **Recreational Water** is 8 µg/L for all ages. These recommendations stem from studies that consider magnitude, duration and frequency of exposure that are considered protective of human health. For more information on how to avoid exposure, visit the following pages at the Maine DEP website:

https://www.maine.gov/dep/water/lakes/cyanobacteria.html

https://www.maine.gov/dep/water/lakes/algalbloom.html

17 *Dolichospermum* (also known as *Anabaena*) is most common in Maine.

initiated programs to inform the public about potential toxicity related to algal blooms. This includes testing the water for toxins during an algal bloom and posting signs at public beaches and boat launches.

Table 5. *Minimum, mean, median, and maximum microcystin levels recorded at different locations and depths in Unity Pond between 2014-2019. (Source: Maine DEP)*

		Deep Station		Downwind Station	
		Epilimnetic samples (ppb)	Top 3 meters of epilimnion (ppb)	Top 1 meter from area with 2 m depth (ppb)	Scum Samples (ppb)
Unity Pond (n=19)	Min	<0.1	<0.1	<0.1	4.1
	Mean	1.2	1.1	1.1	58
	Median	0.15	0.15	0.15	17
	Max	7.89	7	7.4	273

**Red font indicates cyanotoxin concentrations that exceed US EPA criteria for microcystin in drinking water or recreational water.*

Test results are not immediate, so general signage could be installed that alerts people to avoid swimming in the lake during algal blooms, when water is visibly green. Maine DEP and Maine CDC are in the process of deciding whether Maine will adopt the US EPA critical levels for microcystin and how a formal advisory process will be established in Maine. Rapid tests are currently being used by several watershed groups in Maine, with a cost between $30 - $50/test.

ZOOPLANKTON

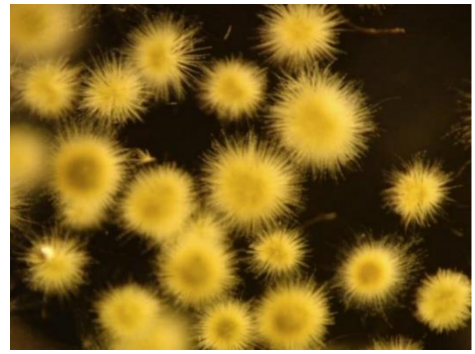
Zooplankton are microscopic animals that feed on phytoplankton, helping keep the algae biomass in balance (clearer lakes), and providing food for newly hatched fish each year. Zooplankton species can be grazers (feeding on phytoplankton) or predatory (feeding on smaller zooplankton). The species of zooplankton present in a lake generally remain stable over time, however, the appearance of new species or sudden changes in quantities of existing species can indicate changes in nutrient input, dominant fish species, aquatic invaders, or a pollution source.

Bosmina longirostris. (Source: CFB.UNH.edu)

Little is known about the makeup of the zooplankton community in Unity Pond due to lack of available data. However, there's a high likelihood of low biomass and small body size if alewife populations are large. Zooplankton play an important role in consuming algae. Future monitoring efforts should include zooplankton monitoring to establish a baseline for this important community.

GLOEOTRICHIA

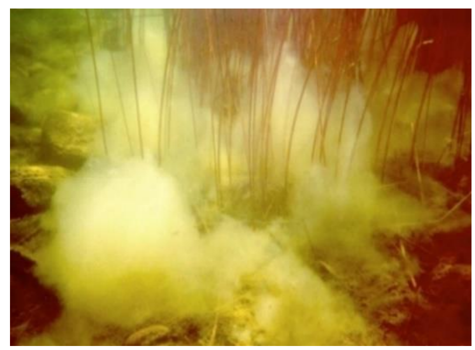
A type of cyanobacterium common in lakes across Maine is *Gloeotrichia echinulata* or *"Gloeo*", which forms small spheres and are big enough to be seen by the naked eye. *Gloeo* grows at the sediment-water interface and then rises through the water column to the surface waters where it completes its life cycle, dies, and sinks back down to the bottom of the lake where it will stay through the winter months until conditions are again suitable for growth (King & Laliberte, 2005). *Gloeo* grows in relatively shallow areas where lake sediments have abundant available P and there is also adequate light for photosynthesis. It has been observed in Maine lakes for many years, but blooms have increased in lakes throughout the northeast in the recent decades. *Gloeo* blooms have been observed in lakes all over the world with a wide range of trophic states and conditions. To date, there have not been any reports of *Gloeo* in Unity Pond, though there has been no formal survey to document its presence.



Gloeotrichia *echinulata (magnified)*
(Source: Jonathan Dufresne, UNH)

METAPHYTON

Metaphyton is filamentous algae typically found in wetlands, floodplains, and the littoral zones of lakes and ponds. It forms loosely aggregated masses or mats that are either attached to benthic substrates or suspended in the water column. Mats can rise to the water surface when oxygen bubbles form within the mass as a result of photosynthesis. Metaphyton begins to form within the littoral zone of a lake shortly after ice-out, persists through the summer months, and begins to degrade in late summer when they sink to the bottom to decompose. The species that make up metaphyton are not cyanobacteria and do not produce toxins.



Metaphyton mass. (Source: LSM, Betsy & Dick Enright.)

Maine DEP and LSM have received observational data and reports over the past decade from volunteer monitors and watershed associations suggesting a significant increase in metaphyton in Maine lakes. Though common throughout the state, implications of an increasing trend are not well understood. There is also limited understanding of the physical, chemical, and biological role these algae play in aquatic ecosystem (Shute & Wilson, 2013). LSM has developed a standardized monitoring protocol to help lake associations identify and document the location and density of metaphyton growth in their lake. The presence and extent of metaphyton in Unity Pond is currently unknown. A volunteer led survey of the littoral zone could be conducted in the future to document the extent of metaphyton and changes in metaphyton in shallow areas of the lake over time.

3. Water Quality Assessment

Water quality data has been collected consistently at Station 1 (Figure 10) beginning in 1977. There are four years in which no data is available (1979, 1980, 1982, 1985).

A water quality trend analysis was conducted for Station 1, which included analysis of the long-term (1977-2021) and short-term (last 10 years) dataset using data collected by certified monitors from Lake Stewards of Maine, and Maine DEP (Ecological Instincts, 2021a). A summary of results for the three primary trophic state indicators (water clarity, chlorophyll-a, and total phosphorus) at Station 1 is presented in Table 6.

Data for Station 2 is limited to four years (1977, 2000-2003). Due to limited data available for Station 2, it was not included in the trend analysis.

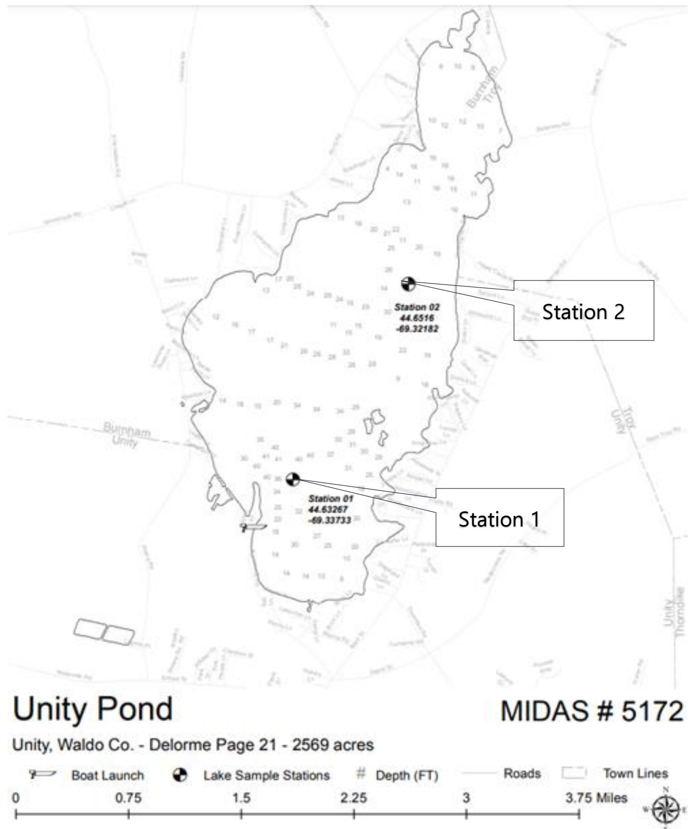


***Figure 10**. Water quality monitoring stations in Unity Pond. (Source: LakesofMaine.org)*

WATER QUALITY TRENDS

WATER CLARITY

Changes in water clarity are measured by slowly lowering a black and white Secchi disk into the water until it is no longer visible and recording the depth. Changes in clarity may be due to increased or decreased algal growth or the amount of dissolved or particulate materials in the lake, which makes it an important parameter to track in order to determine if water quality is improving or getting worse over time.

Water clarity readings in Unity Pond have been collected at Station 1 since 1977, with 41 years of data collected over the sampling period. The lowest water clarity on record was 0.8 m, recorded in August 2021, and the highest water clarity on record was 6.1 m, observed in 1978, with an average of 2.3m over this time period. The historical trend clearly shows a gradual decline in water clarity between 1977 – 1990 when algal blooms became an annual occurrence in Unity Pond. Statistically, there is a significant decrease in water clarity between 1977 – 2021. However, data collected over the past 10 years shows an improvement in water clarity (Figure 11). The observed improvement may be related to several years of drought conditions in Maine over the past five years. Less rainfall means that less P is being delivered to the lake in stormwater runoff. Watershed restoration efforts to reduce P loading on agricultural land through the NWQI over the past decade could also play a role in recent improvements. Long-term monitoring of SDT is an easy and reliable method for tracking changes in water quality over time.

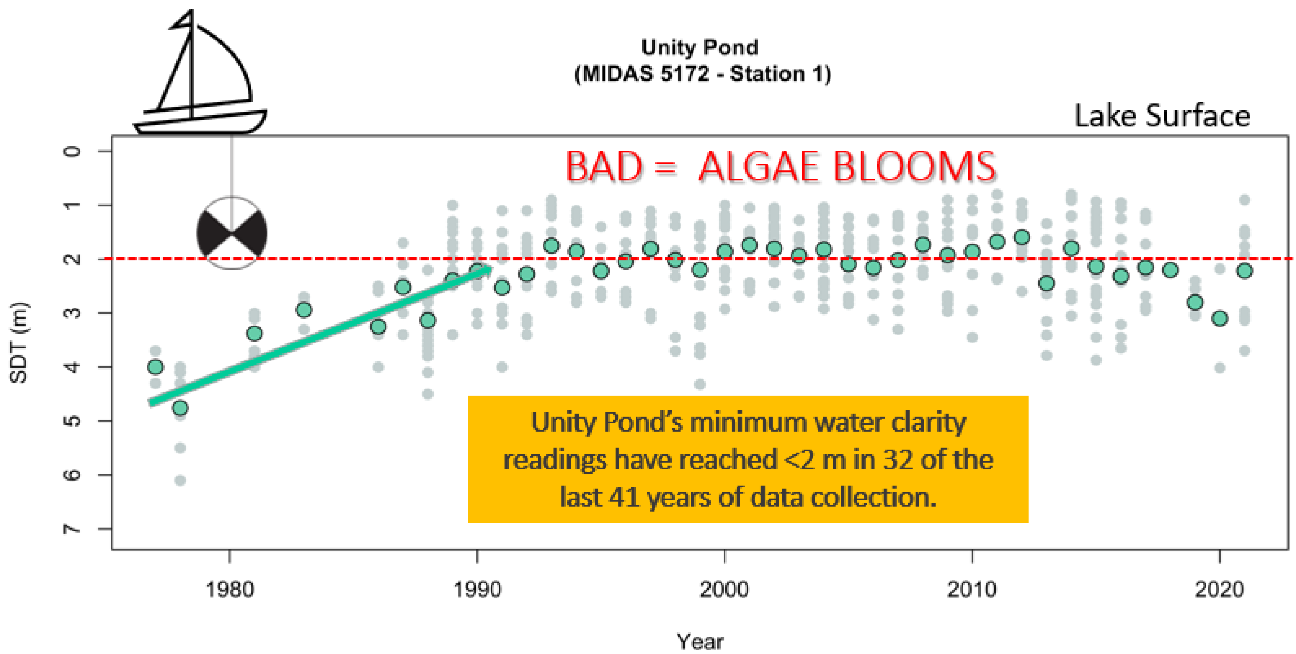


Figure 11. *Historical water clarity trend for Unity Pond 1977 – 2021. (Green circles indicate the average SDT reading for each year and gray circles represent the range in actual readings collected each year. SDT readings above the red line indicate algal bloom conditions.)*

Water clarity readings of 2 m or less indicate that an algal bloom is actively occurring in a lake. Water clarity readings in Unity Pond have fallen below 2 m in 32 of the 41 years on record (78%). Of the nine years with readings above 2 m, six were occurred between 1977-88, and three occurred in 2018-2020. With the exception of a few years over the historical sampling period, SDT readings <2 m typically begin in early July, with the lowest SDT readings in mid-July to mid-August when water temperatures are high and dissolved oxygen levels are low.

CHLOROPHYLL A

Chlorophyll A (Chl-a) is a measure of the green pigment found in all plants including microscopic plants such as algae. Therefore, Chl-a provides a relative estimate of algal biomass where higher Chl-a equates with a higher concentration of algae in the lake. Chl-a and water clarity often track closely since water clarity is an indirect measure of algal abundance. Chl-a is typically collected as an integrated core from the epilimnion as this is typically where temperatures are warmest, light penetration strongest, and where plants, including algae, grow.

The data range for chlorophyll-a (Chl-a) is 1977-2021 at Station 1, with 27 years of data collected over this period. The lowest Chl-a on record was 2.9 ppb, observed in July and September 1983. The highest Chl-a on record was 61 ppb, observed in August 2011. There was no significant long-term trend in Chl-a, but there is a **strong significant trend indicating decreasing Chl-a in the past 10 years**. Average Chl-a over the past 10 years is 14.9 ppb (Table 6).

Table 6. *Long and short-term trend analysis results for the three primary trophic state parameters in Unity Pond.*

Water Quality Parameter	Average Annual Water Quality	Trend (Long-Term)	Trend (10-Year)
Water Clarity (m) Long-term Average 10-year Average	**2.3** **2.3**	**Weak, but significant decrease in water clarity over long-term**	**Strong increasing trend over the past 10 years**
Chlorophyll A (ppb) Long-term Average 10-year Average	**17.5** **14.9**	No trend	**Strong decreasing trend over the past 10 years**
Total Phosphorus (Epilimnetic core) (ppb) Long-term Average 10-year Average	**22.4** **27.0**	No trend	No trend

TOTAL PHOSPHORUS

> ***Epilimnion*** **–** the upper layer of a thermally stratified lake. The epilimnion is typically warm as a result of the sun penetrating the water's surface and high in oxygen due to mixing from wind.

Total phosphorus (TP) is the total concentration of phosphorus including organic and inorganic forms. TP is one of the major nutrients needed for plant growth and is generally present in small amounts in freshwater, thereby limiting plant (and algae) growth. As TP increases in a lake, generally the amount of algae also increases. Humans add P to a lake through stormwater runoff, lawn or garden fertilizers, agricultural runoff and leaky or poorly maintained septic systems. P can also be released from the lake's bottom sediments when there is no oxygen at the sediment water interface (internal loading); it can eventually reach the upper layers of the lake profile through mixing or diffusion, where it fuels algal growth.

TP data used for this analysis include epilimnetic core samples collected by Maine DEP between 1977 – 2021, surface grabs collected from 1986-2021, and bottom grabs collected from 1981-2021. Epilimnetic TP has ranged from 11 ppb (June 1977) – 70 ppb (August 2016) with a long-term annual average of 22.4 ppb and a 10-year annual average of 27 ppb. For surface grabs, the lowest TP was 11 ppb, recorded in July 2012, and the highest value was 38 ppb, recorded in October 2021. The highest TP on record for bottom grabs was 271 ppb, recorded in August 2004. **There are no significant trends**

in epicore, surface grab, or bottom grab TP in either the long-term or short-term record. (Table 6). This may be a funtion of year-to-year variablility that obscures trends or a matter of conditions having achieved a stable, though undesirable level.

When compared to the numerical guidelines for evaluation of trophic state in Maine, Unity Pond is considered eutrophic. Eutrophic lakes have elevated nutrient levels and are highly productive. They tend to be murky and muddy, with elevated plant and algae growth. Unity Pond falls well within the eutrophic range for all three parameters (Table 7).

Table 7. *10-year averages for primary trophic state parameters in Unity Pond compared to numerical guidelines for evaluation of trophic status in Maine.*

	Unity Pond 10-Yr Average	ME DEP Trophic Status Indicators			Unity Pond Classification
		Oligotrophic	Mesotrophic	Eutrophic	
Water Clarity (m)	2.3	> 8	4 – 8	< 4	Eutrophic
Chlorophyll-a (ppb)	14.9	< 1.5	1.5 – 7	> 7	Eutrophic
Total Phosphorus (ppb)	27	< 4.5	4.5 – 20	> 20	Eutrophic

OTHER CHEMISTRY TRENDS

In addition to the three trophic state parameters described above, pH, color, conductivity, alkalinity, precipitation, and dissolved oxygen (presented below) were also evaluated for long and short-term water quality trends. **Conductivity has increased over the full time series as has precipitation while alkalinity has decreased over the last 10 years** (Ecological Instincts, 2021a)**.** The long-term increase in conductivity matches a statewide trend of increased conductivity in lakes, likely related to the use of road salts since the 1990s.

DISSOLVED OXYGEN & TEMPERATURE

Dissolved oxygen (DO) refers to concentration of oxygen dissolved in the water, which is vital to fish, zooplankton, vertebrates, and chemical reactions that support lake functioning. DO levels below 5 ppm can stress some species of coldwater fish, and over time reduce habitat for sensitive coldwater species. DO concentrations in lake water are influenced by several factors, including water temperature, stratification, concentration of algae and other plants in the water, decomposition, and the amount of nutrients and organic matter flowing into the lake as runoff from the watershed.

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

Summer DO concentrations can change dramatically with lake depth, as oxygen is produced in the top portion of the lake where sunlight drives photosynthesis and winds continuously mix water and air. Oxygen consumption dominates near the bottom of the lake where organic matter accumulates and decomposes. In seasonally stratified lakes, such as Unity Pond, the DO concentrations from top to bottom can be very different, with high levels of oxygen near the surface and little to no oxygen near the bottom, especially during the summer when water temperature and decomposition are at their highest. Stratification can prevent atmospheric oxygen (wind, wave mixing) from reaching the deep areas, cutting off the supply. In addition, microbial respiration (microbes breaking down decaying plant and animal matter) at the bottom of the lake consumes oxygen, the combination of which results in loss of DO in deep areas of the lake (anoxia). In Unity Pond, anoxia (DO <2 mg/L) occurs regularly between 7 m and the bottom covering an area of 742 acres (Figure 12).

Thermal stratification, anoxia, and sediment chemistry can result in the release of P from the sediments (internal loading) which can fuel algal growth and lead to persistent, recurring nuisance algal blooms.

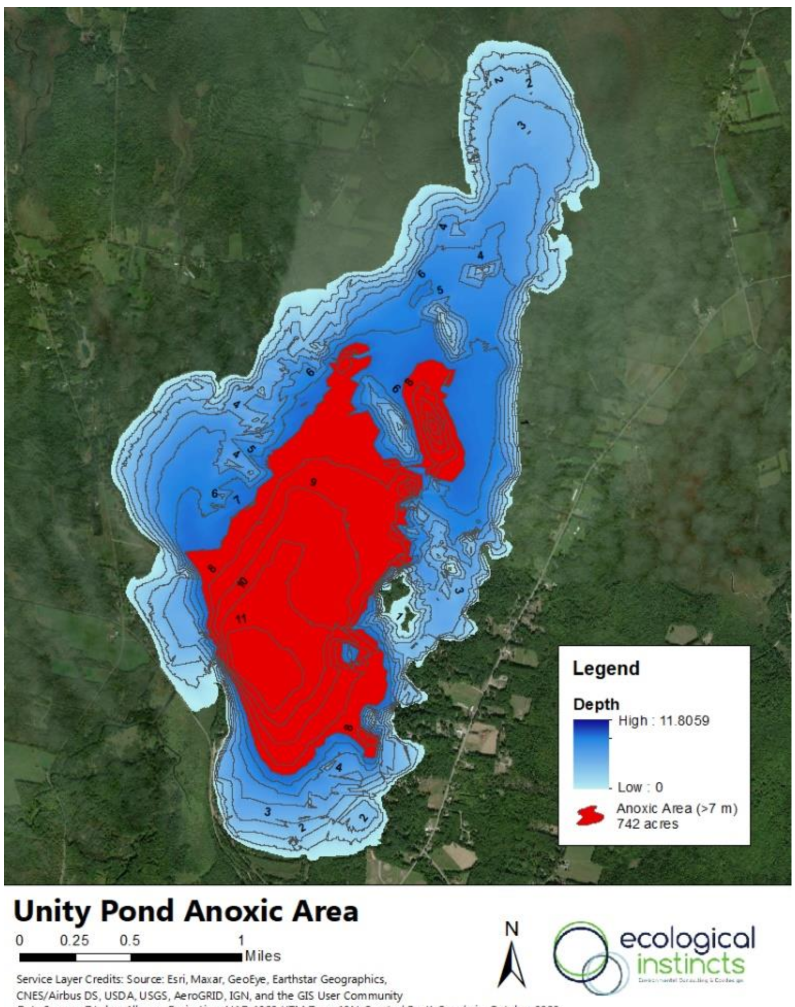


***Figure 12**. Anoxic area (red) in Unity Pond representing lake area >7m.*

Dissolved oxygen (DO) and temperature profiles have been collected at Station 1 since 1978, with 27 years of data over the historical monitoring period. Based on these data:

- Onset of anoxia typically occurs in June and continues through September.
- **Unity Pond does not strongly stratify.** Anoxia is often only detected at depths of 9 to 10 m, indicating that mixing by wind or other mechanisms may be an important mechanism for oxygenation in deeper water.
- Anoxia has occurred as shallow as 6 m, but more regularly at depths between 7 and 11 m with the **greatest extent of anoxia occurring at the highest frequency in August.**

A full summertime series of SDT, temperature, DO, and TP profiles was measured in 2021 (Figure 13). This dataset provides information about the current onset and extent of anoxia across the open water sampling season and throughout the water column. At Station 1, stratification begins in early June and continues until the lake begins to turn over (mix) in late September. The concentration of TP increases in the bottom waters during this period, and eventually reaches the upper waters, frequently resulting in lower water clarity readings in the late summer and fall months. In 2021:

- The greatest extent of anoxia occurred on August 21, 2021, reaching 8 m with the lowest corresponding SDT reading of 0.9 m and a TP concentration of 69 ppb at the bottom of the lake and 22 ppb at the surface.
- The highest TP concentration was recorded on September 3, 2021, with a reading of 120 ppb at the bottom of the lake and 26 ppb at the surface.
- Mixing occurred in late September which resulted in an increase in P at the surface and resulting P concentration of 38 ppb on October 15, 2021.

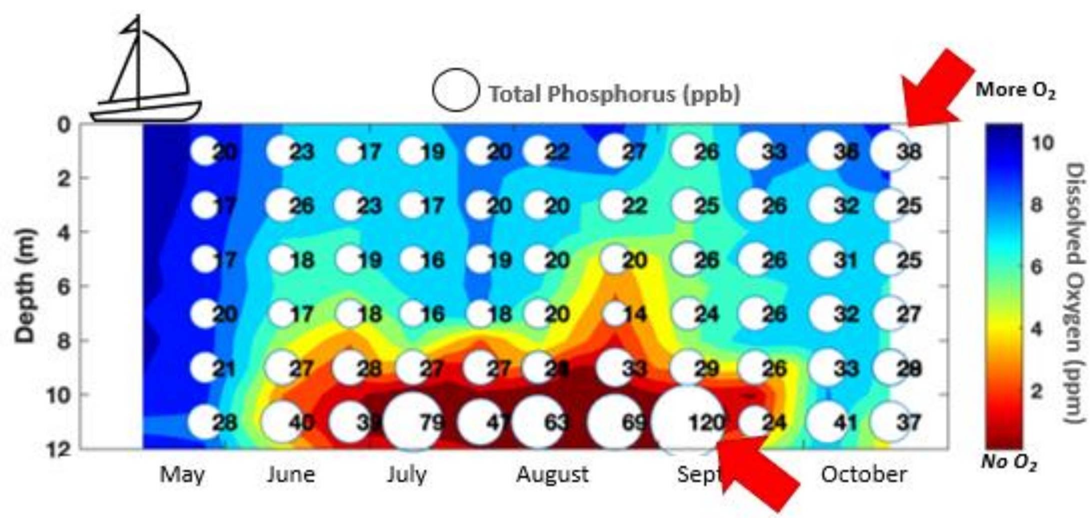


Figure 13. *2021 DO and TP concentrations by depth in Unity Pond, Station 1. (White circles and associated numbers represent the concentration of TP at each depth in the water column.)*

To evaluate trends in anoxia, anoxic factor (AF) and minimum anoxic depth (MAD) were calculated. AF is a metric that combines the volume of anoxic water (DO <2 mg/L) and the length of time that the lake is anoxic, while MAD is the shallowest depth where DO is <2 ppm. MAD is an indicator of the volume of anoxic water in a lake- the shallower the MAD, the larger the anoxic volume. Larger values of anoxic factor indicate poorer water quality. Profile measurements of dissolved oxygen were used to compute AF and MAD in a given year. As long as there were at least six profiles then AF could be calculated. There were only enough profiles to calculate AF for six years between 1986 and 2021. Data collected between 1978 – 2021 was used for MAD trends.

There was no significant trend in AF over the whole time series, but this is likely because there were only six years with enough data to compute AF. Notably, in 2001, AF shifted above the threshold of AF = 10, which is considered a water quality threshold. There was also no significant trend in MAD despite what appears to be a slight change in MAD from a maximum of 12 m in August 1981 to 8 m in 2021. Should AF increase and MAD decline, it could lead to an increase in the mass of P at the bottom of the lake due to the increased area of sediment exposed to anoxia and an increase in the length of time that P is available to algae during the growing season.

4. Watershed Modeling

The Lake Loading Response Model (LLRM) is an Excel-based model that uses environmental data to develop a water and P loading budget for lakes. Water and P 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 systems, and internal loading estimates, among other important information.

The following section provides an overview of the process by which these critical inputs were determined and utilized for the Unity Pond LLRM using available resources and presents predicted outputs including how much and where P is coming from in the watershed, as well as in-lake annual average predictions of TP, Chl-a, and SDT. The outcome of this model can be used to identify current and future pollution sources, estimate pollution limits, set water quality goals, provide insight on where future monitoring is needed, and guide prioritization of on-the-ground watershed improvement projects (Ecological Instincts, 2021b).

WATERSHED AND SUB-BASIN DELINEATIONS

Ten major basins were included in the model to estimate P loading at different scales within the Unity Pond watershed (Figure 14). The basin approach helps watershed managers prioritize on-the-ground conservation planning and target education and outreach in the basins that contribute the greatest amounts of P.

Sub-basin delineations were completed in ArcMap by Ecological Instincts (2021b). Larger drainage basins were divided into smaller sub-basins where one sub-basin passes through another sub-basin to help guide prioritization of areas with higher nutrient loads within a drainage basin. For Unity Pond, Basin 1 (Upper Meadow Brook) was set up to pass through Basin 2 (Lower Meadow Brook), Basin 8 (Bog Brook) passes through Basin 7 (Bithers Brook), and Basin 10 (Carlton Pond) passes through Basin 9 (Carlton Stream). The Carlton Pond (Carlton Bog) watershed is an indirect drainage to Unity Pond. Carlton Pond is a 412-acre, shallow pond (max depth 2m) with a large drainage area (21 mi^2) and a high flushing rate (19.4 flushes/yr). Sandy Stream was added to the model once backflushing had been confirmed and treated as a point source passing through the SE direct drainage (Basin 5) and assigned a flow equal to 5% of its expected annual flow at a P concentration of 50 ppb, reflecting storm inputs.

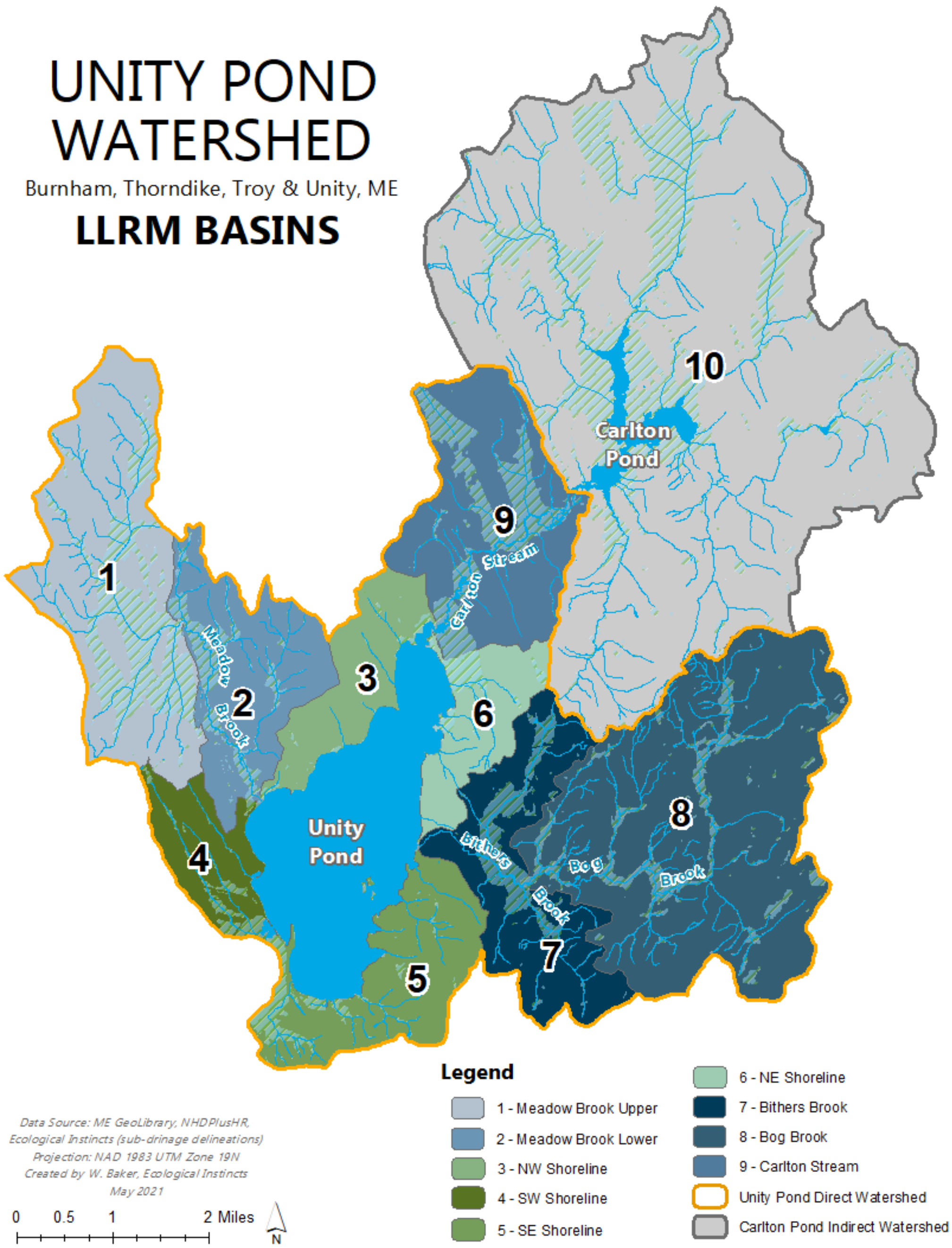


Figure 14. *Drainage basins used in the Unity Pond LLRM.*

LAND COVER

The drainage basins layer was combined with the updated land cover layer (Section 2) to create a land cover breakdown for each basin for use in the watershed model. Table 8 presents land cover types and their associated P export coefficients for the Unity Pond model while Figure 15 presents the percentage each landcover type in the direct watershed and its corresponding P load.

***Table 8**. Phosphorus coefficients and total land area each land cover types used in the Unity Pond LLRM.*

LAND COVER TYPE	Runoff P export coefficient	Baseflow P export coefficient	Area (hectares) Unity Pond Direct & Carlton Pond Indirect Watershed
Urban 1 (Low Density)	0.90	0.010	249
Urban 2 (Med Density Res/Comm)	1.00	0.010	94
Urban 3 (Roads)	1.25	0.010	229
Urban 5 (Mowed Fields)	1.10	0.010	137
Agric 2 (Row Crops)	2.00	0.010	221
Agric 3 (Pasture/Hayland)	0.80	0.010	739
Forest 1 (Upland Forest)	0.14	0.005	8373
Forest 4 (Forested Wetland)	0.12	0.005	2072
Forest 5 (Scrub Shrub)	0.12	0.005	61
Open 1 (Water) –*not including Unity Pond*	0.10	0.005	143
Open 3 (Bare/Excavation)	0.80	0.010	35
Other 1 (Freshwater Emergent Wetland)	0.20	0.005	562
Other 2 (Timber Harvesting)	1.10	0.005	496
TOTAL			**13,411**

Notably, developed land (development and roads) accounts for 8% of the land area in the direct watershed but accounts for close to a quarter (24%) of the total watershed P load (runoff and baseflow). Similarly, agricultural land accounts for 8% of the watershed and approximately 23% of the watershed P load. Timber harvesting is estimated at 6% of the land area and 20% of the P load from the watershed. On the other hand, undeveloped land, including forests and wetlands, cumulatively covers 78% of the watershed but only 33% of the watershed P load (Figure 15).

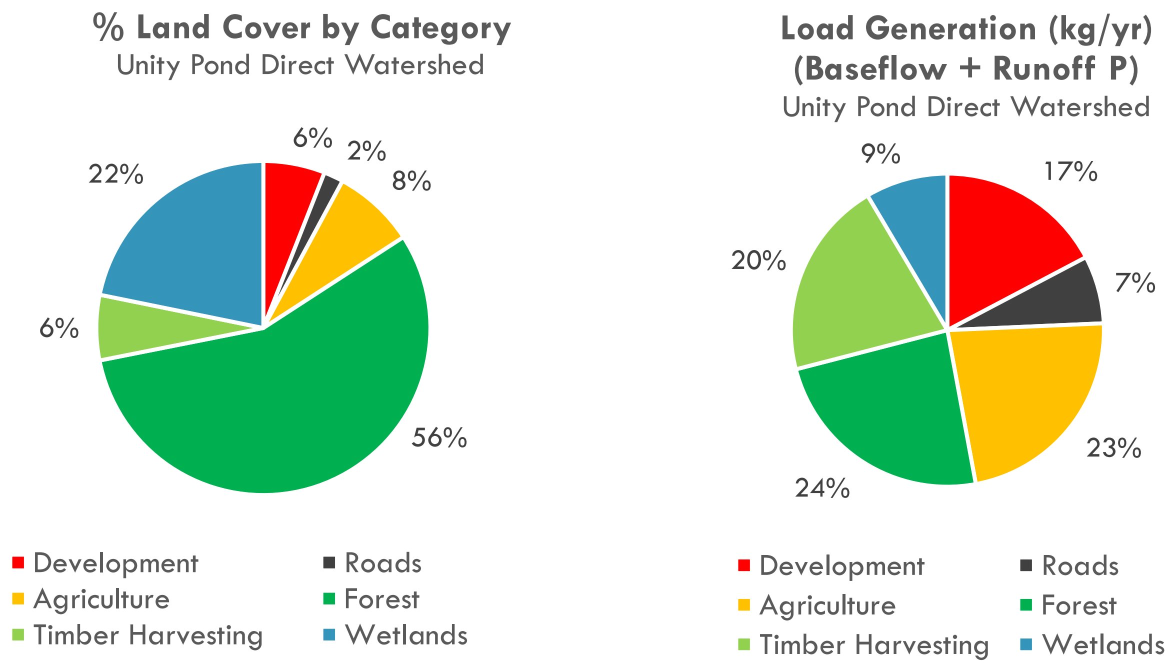


Figure 15. *Watershed land cover area by category (left) and TP load by land cover type (right) for the Unity Pond direct watershed.*

BACKFLUSHING FROM SANDY STREAM

Estimating basin loading for Unity Pond was complicated by the fact that Sandy Stream, which was at one time was the major inlet to Unity Pond, currently only flows into the lake during periods of high precipitation that cause backflushing from the wetland at the Unity Pond outlet. Having a better understanding of the frequency and intensity of backflushing would help to improve the accuracy of the model and understand how much P the Sandy Stream watershed is contributing to the overall P load in Unity Pond.

On April 15th 2021, Maine DEP placed an Acoustic Doppler Current Profiler (ADCP) in Sandy Stream downstream of the Unity Pond outlet to measure the direction and intensity of flow in and out of the lake. The ADCP collected data until June 12th, for a total of 58 days. A large storm delivered 1 inch of rain was recorded on May 1 which recorded a reversal of flow direction (backflushing) back into Unity Pond during this period Unity Pond (Figure 16). For modeling purposes, Sandy stream was treated as a point source passing through the southeast shoreline (Basin 5), and assigned a flow equal to 5% of the stream's expected annual flow at a P concentration of 50 ppb to reflect storm inputs. Due to the lack of a long-term dataset for backflushing, this is a very rough estimate.

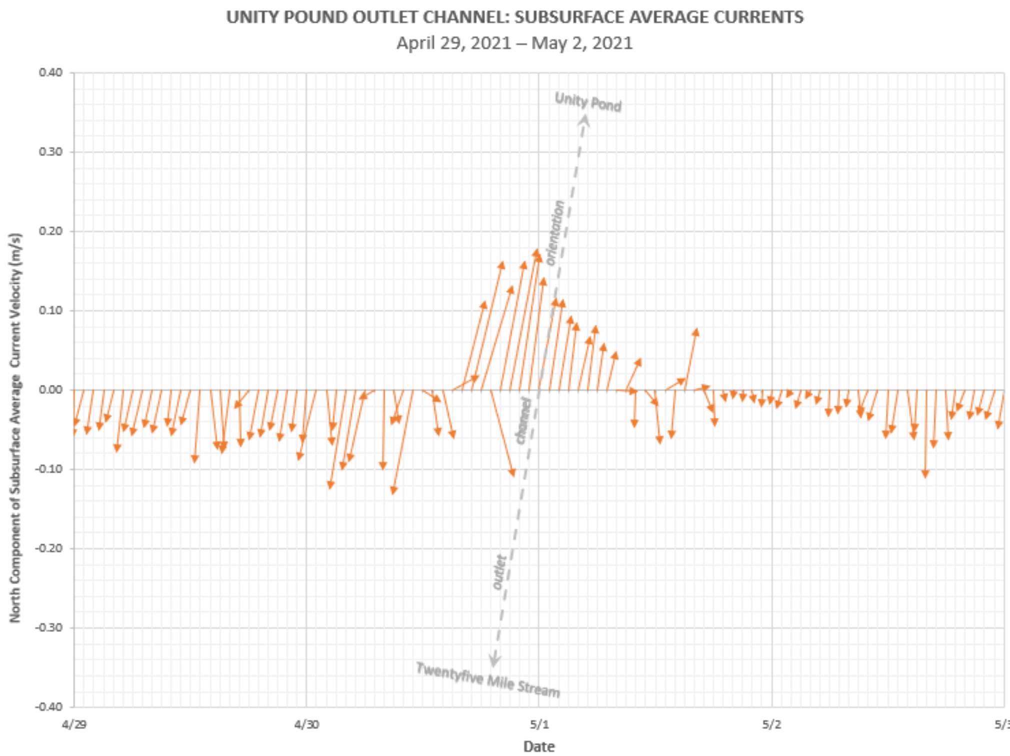


***Figure 16**. Flow intensity and direction measured in Sandy Stream between April 29 through May 3, 2021. (Up arrows indicate a change in flow direction from Sandy Stream into Unity Pond.)*

MODEL RESULTS

The current P load to Unity Pond is estimated at 4,135 kg/yr. The watershed load is the greatest source of P to Unity Pond, representing approximately 76% of the total P load (53% direct watershed, 23% indirect watersheds) followed by internal loading, which contributes approximately 20% of the total P load. Septic systems and waterfowl are each estimated at 1% of the P load, and the remaining 2% of the load comes from atmospheric deposition (Figure 17).

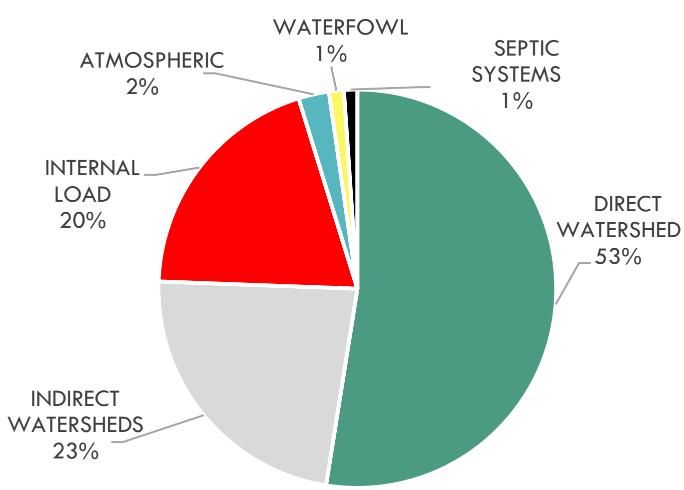


***Figure 17.** Percent of the total P load by category for Unity Pond.*

SUB-BASIN PHOSPHORUS LOADING

The Carlton Pond indirect watershed is the largest sub-basin and is estimated to contribute the largest total P load (785 kg/yr) to Unity Pond followed by the Bog Brook drainage (543 kg/yr)- the second largest drainage area, and the southeast shoreline (430 kg/yr)- which includes backflushing from Sandy Stream (169 kg/yr) (Table 9, Figure 18).

***Table 9**. Summary of land area and total phosphorus by sub-basin for Unity Pond.*

Sub-Basin	Basin Area (ha)	Total P Load (kg/yr)	P Load by Area (kg/ha/yr)
Basin 1- Meadow (Upper)	1,297	244	0.19
Basin 2-Meadow (Lower)	705	189	0.27
Basin 3- NW Shoreline	417	150	0.36
Basin 4- SW Shoreline	338	176	0.52
Basin 5- SE Shoreline	682	430	0.63
Basin 6- NE Shoreline	371	106	0.29
Basin 7- Bithers Brook	804	231	0.29
Basin 8- Bog Brook	2,206	543	0.25
Basin 9- Carlton Stream	1,036	270	0.26
Basin 10- Carlton Pond	5,554	785	0.14

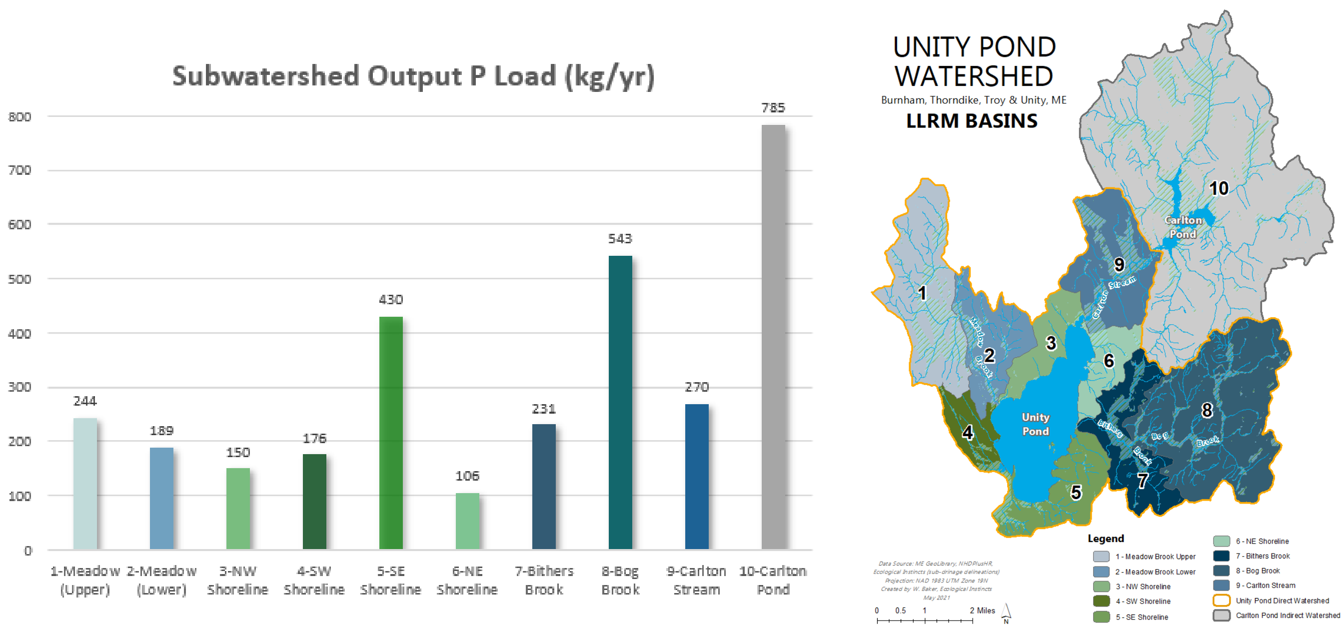


***Figure 18.** Total phosphorus load by sub-basin in the Unity Pond watershed.*

On an areal basis, the sub-basins with the greatest P load per hectare are located in the direct shoreline drainages including the southeast shoreline (Basin 5), southwest shoreline (Basin 4), and northwest shoreline (Basin 3) (Figure 19). Drainage areas directly adjacent to waterbodies do not have adequate treatment time and are often most desired for development in a lake watershed.

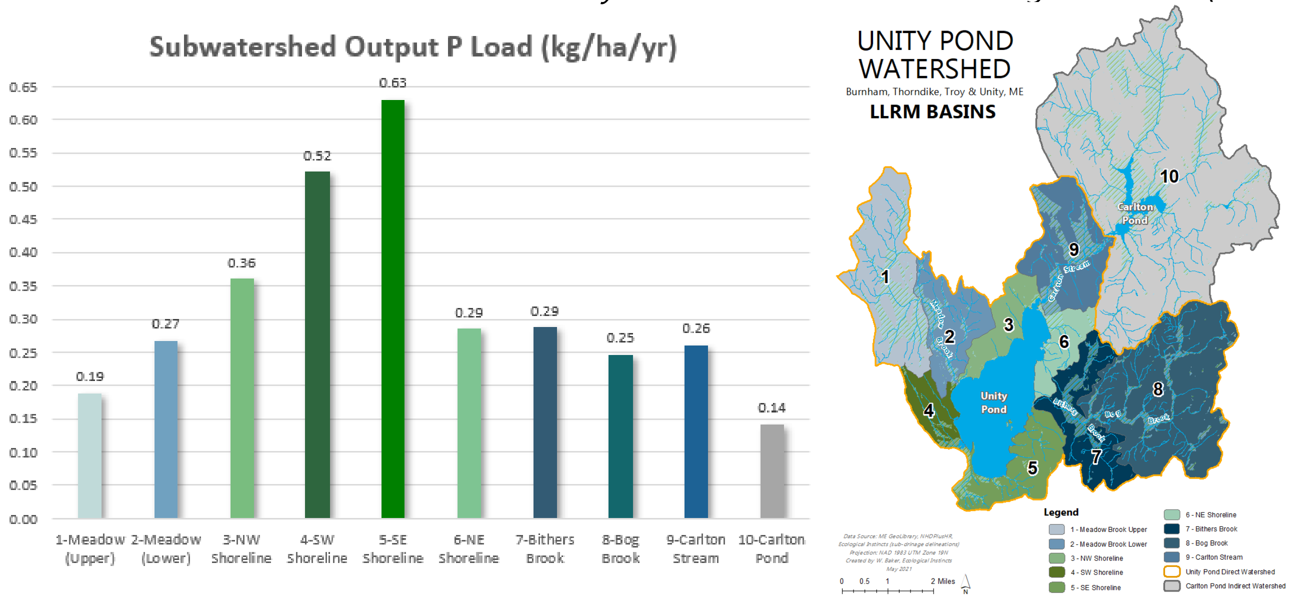


Figure 19. *Phosphorus load by sub-basin and area in the Unity Pond watershed.*

Generally, basins with high annual P export correspond with higher rates of development (i.e., shoreline development, roads, agriculture). This reinforces the fact that developed land, and other human-related impacts, can result in an increased export of P to the lake. These are also the areas with the greatest number of documented NPS sites from the 2021 watershed survey. Addressing erosion and nutrient management in these areas, including adding effective natural buffers to disturbed shorelines, will help reduce the amount of sediment and P entering the lake.

PRE-DEVELOPMENT (BACKGROUND CONDITIONS)

Once the model was calibrated for the current in-lake P concentration in Unity Pond (27 ppb), land cover and other factors that affect model estimates were adjusted to estimate pre-development (background conditions), representing the best possible water quality for the lake before the watershed was developed, and before the hydrology of Sandy Stream was altered. **The pre-development average watershed P load to Unity Pond is estimated at 2,183 kg/yr with a predicted in-lake TP concentration of 11 ppb- a P load that is approximately half of the current load** (Table 10, Figure 20). This exercise indicates a significant increase in not only the watershed P load to Unity Pond from pre-development to present, but also a significant increase in the internal P load. As shown in Table 10, the water load under pre-development conditions is higher than current conditions. This is due to adjusting the model so that 100% of the volume of Sandy Stream flowed into Unity Pond compared to 5% under current conditions. This increased the volume of water flowing into the lake prior to development and also influenced the lake's flushing rate. The model predicts a higher pre-development flushing rate of 2.4 flushes/year compared to 1.3 flushes/yr under current conditions.

Table 10. *Total phosphorus and water loading summary by source for Unity Pond.*

SOURCE CATEGORY	PRE-DEVELOPMENT			CURRENT			FUTURE		
	TP (kg/yr)	%	Water (m^3/yr)	TP (kg/yr)	%	Water (m^3/yr)	TP (kg/yr)	%	Water (m^3/yr)
ATMOSPHERIC	51	2%	10,972,179	103	2%	10,972,179	103	2%	12,070,855
INTERNAL	23	1%	0	812	20%	0	894	18%	0
WATERFOWL	50	2%	0	50	1%	0	50	1%	0
SEPTIC SYSTEM	0	0%	0	45	1%	37,228	45	1%	37,228
WATERSHED LOAD	2,058	94%	119,315,957	3,125	76%	59,292,785	3,845	78%	64,910,769
TOTAL LOAD TO LAKE	**2,183**	**100%**	**130,288,136**	**4,135**	**100%**	**70,302,192**	**4,936**	**100%**	**77,018,852**

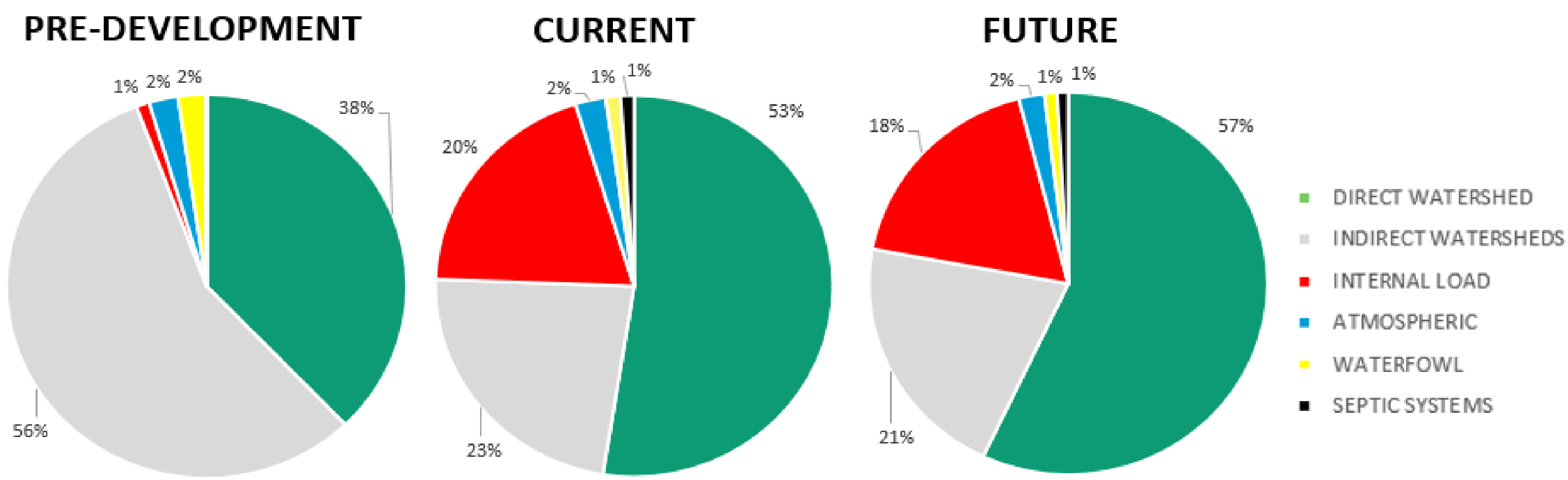


Figure 20. *Percentage of estimated total phosphorus loading (kg/yr) to Unity Pond by source for pre-development (left), current (center), and future conditions (development & climate change) (right).*

FUTURE DEVELOPMENT & CLIMATE CHANGE

Future development was added to the model as a 0.5 ppb increase based on previous estimates used in Maine, equivalent to 80 kg P/yr for Unity Pond. The approximate influence of climate change can be evaluated in the LLRM by varying the inputs in accordance with projected climate change effects, generally set at a 10-20% increase based on long-term trends of lakes in the northeast (see Section 5). Climate change influence on internal loading can be similarly evaluated by increasing the LLRM inputs in accordance with expected oxygen depletion rates, affected areas, and the period of release.

An increase of 639 kg P/yr is estimated from the watershed based on these conditions with an additional 82 kg/yr increase in the internal load based on a 10% increase in precipitation, runoff coefficients (for developed land cover types), to the overall watershed load, and to the affected area of the internal load. The modeled probability of experiencing an algal bloom under future development and climate change scenarios increases by 10% from current conditions (Table 12).

A conservative estimate of 80 kg/yr (or a 0.5 ppb in-lake concentration increase) was selected within the LLRM to reflect additional loading that could be expected from future development. In addition to new development on the shoreline, population growth (and an increase in the developed land area in watershed) is expected in the form of conversion of small seasonal camps to larger year-round homes on the shoreline and residential and commercial development outside of the shoreland zone, all of which will ultimately lead to new sources of P.

MODEL PREDICTIONS

There was no difference within the model between the observed mean TP in Unity Pond and the predicted mean TP (Table 11). However, the model predicted slightly lower than observed water clarity despite predicting better-than-observed Chl-a.[18] This suggests that other factors aside from P may be controlling observed water clarity.

***Table 11**. In-lake water quality predictions for Unity Pond.*

LLRM Water Quality Predictions	Mean TP (ppb)	Predicted Mean TP (ppb)	Mean Chl-a (ppb)	Predicted Mean Chl-a (ppb)	Mean SDT (m)	Predicted Mean SDT (m)
PRE-DEVELOPMENT	-	11	-	3.2	-	3.8
CURRENT	27	27	15	10.8	2.3	1.9
FUTURE	-	30	-	12.5	-	1.7

[18] The general empirical equations used in the LLRM do not fully account for all biogeochemical processes occurring within Unity Pond that contribute to the overall water quality.

In particular, processing of nutrients within the lake may vary substantially depending on biological components such as zooplankton and the fish community, neither of which are addressed in the model. Production of algae at the sediment-water interface could allow greater Chl-a than average upper water column P concentrations would suggest through the model.

For pre-development conditions, the model predicted substantially lower P and Chl-a concentrations and deeper mean water clarity compared to current conditions. These values fall within the bounds of the classification for a naturally mesotrophic lake.[19] The model predicted an increase in TP by 3 ppb, a 1.7 ppb increase in Chl-a, and a 0.2 m decrease in water clarity as a result of future development and climate change.

ASSESSMENT OF THE INTERNAL LOAD

An analysis of potential internal loading of P to Unity Pond was conducted by Water Resource Services, Inc. (2022) using all available water quality data collected between 1977 and 2021. There were several factors that made estimating internal loading in Unity Pond challenging:

1) There was limited sediment data available
2) The lake does not strongly stratify
3) The lake exhibits limited accumulation of P in deeper water
4) Anoxia is often only detected at depths greater than 9-10 m

However, there are indications of oxygen depletion at the sediment-water interface at depths as shallow as 6 m which allows P release from the sediment and uptake by algae, especially cyanobacteria that later form gas pockets in cells and rise into the water column which are difficult to quantify.

P MASS IN UNITY POND IN 2021

Data from 2021 were used to calculate the mass of P in discrete depth intervals within Unity Pond over time. In typical stratified lakes there is an accumulation of P in the deeper layers over the summer as internal loading proceeds, generally increasing oxygen is lost from the bottom up, with anoxia sometimes occurring near the thermocline. Unity Pond does not have a distinct thermocline, and while there is a temperature gradient from top to bottom that will resist mixing to some degree, only the very deepest water will remain unmixed for a significant length of time. Even these deepest waters may be mixed with sufficient wind. Because of this, there was very little accumulation of P in the deepest layers of the lake in 2021. However, a detectable increase in P mass was seen in the shallower depth intervals (0-6m) peaking at the end of September (Figure 21).

[19] Numerical guidelines for evaluation of trophic status in Maine lists mesotrophic lakes as having average SDT readings of 4-8 m, Chl-a from 1.5 – 7 ppb, and TP of 4.5 – 20 ppb. Current conditions in Unity Pond fall within the eutrophic classification due to elevated levels of TP>20 ppb, Chl-a >7 ppb and SDT <4 m.

The summer of 2021 was a relatively wet summer with July and September precipitation about twice the long-term average following a dry spring. The increase in P mass in the upper water column is most likely attributed to runoff from the watershed. The internal load in Unity Pond ranged from 712 – 792 kg/yr between June – September, some of which could be attributed to runoff.

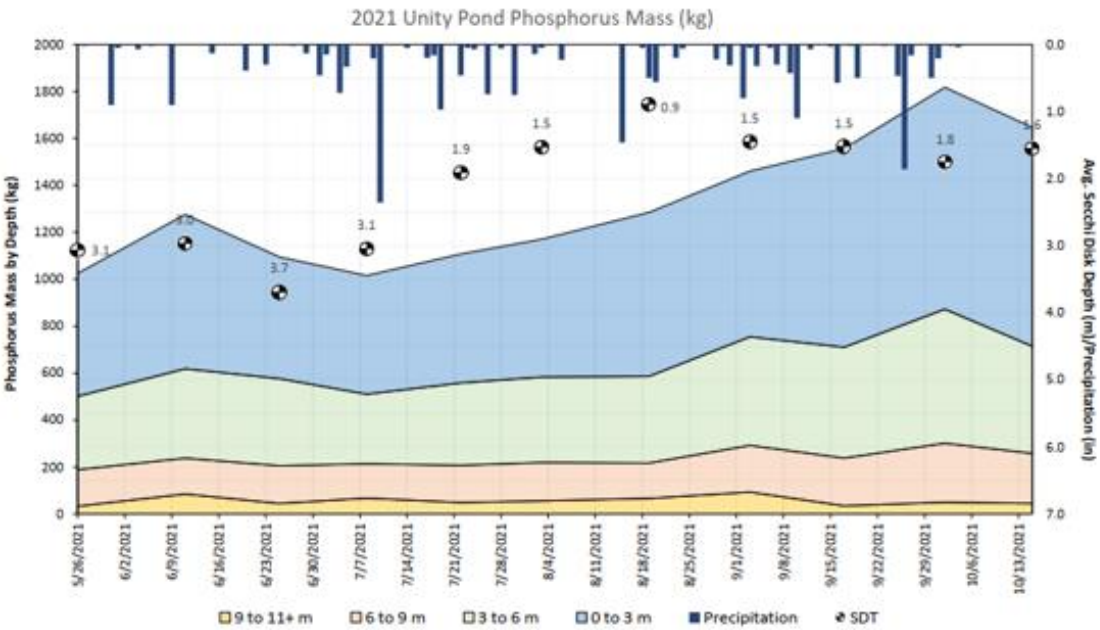


***Figure 21**. P Mass at different depths in Unity Pond between May- October 2021.*

While there are multiple ways by which internal loading of P can occur, the dominant one in New England is for P bound by iron (Fe) to be released under low oxygen conditions. Redox reactions result in both Fe and P being released into the overlying water. If a lake is stratified, much of the released P is trapped in the deeper water. If the distance between the point of anoxia (defined as DO<2 ppm) and the point of light penetration into the lake is far enough apart (at least 3 m), available P may not move upward and be used by algae. However, mixing events, algae that move in the water column, and algae that grow at the sediment-water interface with just enough light to grow can all result in internally loaded P reaching the upper waters. If the anoxic boundary extends upward to the point where light is available, mid-depth algal blooms may occur. Further, if the anoxic interface reaches the thermocline, diffusion and mixing of P into upper waters is expected. Weather patterns can create substantial variation among years, so the portion of internally loaded P that becomes part of the "effective" P load to the lake will also vary.

For Unity Pond, mixing is ongoing and substantial, and while low oxygen can occur as shallow as 6 m, there may be enough oxygen in the water at this depth to inactivate P released from the sediment before it can be thoroughly mixed into the water column and utilized by algae. However, it is far more likely that cyanobacteria are initiating growth at the sediment-water interface, taking up P as it is released but before it enters the oxygenated water column. In June and early July, the clarity is sufficient for enough light to penetrate to at least 9 m of water depth if not throughout the lake to the bottom. During July the cyanobacteria blooms commence, lowering clarity and stimulating further rises by cyanobacteria that have been growing on the bottom. The dominant genera found in Unity Pond (Dolichospermum, formerly known as Anabaena, Aphanizomenon, and Microcystis) are known to initiate growth at the sediment-water interface then rise in the water column to form blooms. The increase in P over the summer may therefore represent an accumulation of algae, especially cyanobacteria, and not simple release and mixing of inorganic P from the sediment. This is a common but understudied mechanism of eutrophication.

SEDIMENT PHOSPHORUS EVALUATION

The limited sediment data available for the sediment P evaluation included two samples collected at Station 1 by Maine DEP in 2011 and 2015. The solids and organic content of those samples were consistent with P-rich, oxygen-demanding sediment that could be expected to release substantial P when exposed to anoxia. Typically, lakes with Al:Fe ratios <3 and Al:P ratios <25 are more susceptible to internal P release. The DEP sediment data showed surface Al:Fe ratios of 1.9 and 1.3, and Al:P ratios of 10.7, well below the ratios that indicate susceptibility to internal P release. Sediment data was also collected and analyzed by Fitzgibbon (2015) and Amirbahman, et al. (2022) and found to have similar Al:Fe and Al:P ratios (1.6 and 11.65, respectively). Utilizing results of the 2021 P mass analysis and available sediment data, an estimated 1,066 kg of P is released from the sediments of Unity Pond each summer. However, **additional investigation of the complete extent of anoxia at the bottom of the lake is recommended** to improve P mass estimates in the sediment which would include collection of oxygen measurements right at the sediment-water interface. **Additional sediment testing at different depths across the lake will be essential for a more definitive estimate of internal loading.**

A third method for estimating internal loading is to model it based on assigned release rates and duration of release based using the available empirical data. WRS utilized the Lake Loading Response Model (LLRM), setting duration of anoxia at 90 days for the deepest area, 60 days for the intermediate area, and 30 days for the shallowest area. Release rates of 2 to 6 mg/m2/day were used for the shallowest to the deepest areas of the lake, respectively. Using this method, the LLRM estimates an **internal load of 812 kg/yr**, slightly lower than estimates from the sediment chemistry and slightly higher than the 2021 P mass estimates described above.

Best available estimates of internal P loading via release from sediments exposed to low oxygen indicate that **internal loading should be considered a significant source of P in Unity Pond. However, the watershed load as estimated by the watershed model is a much greater source of P to the lake**, representing 76% (3,125 kg/yr) of the total P load vs. 20% (812 kg/yr) from the internal load.

A preliminary evaluation of remediation options and costs for addressing the internal load was provided by WRS (2022). Options include circulation (oxygenation), P inactivation to treat incoming water high in P or to strip P from the water column, or P inactivation to bind P in surficial sediments. **The recommendation for Unity Pond is to utilize a low dose P inactivation treatment to strip P from the water column in late spring and gradually inactivate P in the surficial sediments.** The effects should be immediate, with the uppermost sediment P inactivated first and P in the water column reduced. A single treatment is estimated at $700,000 and should provide benefits for up to four years, improving conditions in the lake until watershed work is conducted and can begin to significantly reduce external loading.

WATER QUALITY TARGET SELECTION

The LLRM can be used not only to estimate pollutant loading to a lake, but also to evaluate possible water quality goals/targets for lake restoration projects. There are several alternative ways to proceed with water quality target selection. This includes setting a P target based on desired average Chl-a concentration or depth of water clarity, selecting a target based on achieving a desired chlorophyll-a or water clarity value at some high level of probability (e.g., 90% of the time), or calculating practical watershed P reductions (and resulting in-lake P concentration) that will result in meaningful water quality improvements, among other methods. The approach depends on the desired use of the resource as well as regulatory considerations.

For Unity Pond, with an estimated pre-development P concentration of 11 ppb, and a current P concentration of 27 ppb, the difference is quite large. However, moving the lake substantially toward pre-development conditions will be a challenge given the present level of development in the watershed and modification of the lake's natural inlet (Sandy Stream).

The LLRM was used to set an in-lake P target based on achievable P load reductions over the next 10 years (Table 12). **An in-lake TP concentration of 19 ppb was selected for Unity Pond.** Achieving this goal will require a reduction in the watershed load by 825 kg/yr (690 kg/yr direct watershed, 14 kg/yr septic systems, 121 kg/yr indirect watersheds), and reducing the internal P load by 90% (731 kg/yr). However, these reductions come with a cost. Addressing the internal load is estimated to cost $700,000 and may need to be repeated in 4 years (WRS, 2022). Improvements will be equally dependent on addressing a high proportion of watershed loading especially from shoreline development in the direct watershed and agriculture in the direct and indirect watersheds.

Table 12. *Modeled water quality and P loading predictions under future development and climate change scenarios, current conditions, various target load reduction conditions, and pre-development (background conditions) for Unity Pond.*

Predicted mean TP (ppb)	**30**	**27**	**24**	**19**	**15**	**11**
Difference (kg/yr) from Current Total P Load	*+801*	*0*	*-904*	*-1,556*	*-2,118*	*-1,952*
	Future Development & 10% Climate Change Scenario	**Current**	**Watershed Management (Scenario 1)** Direct watershed & Septic systems (22% Reduction)	**Lake & Watershed Management (Scenario 2)** Direct & Indirect Watersheds, Septic systems & Internal Load (38% Reduction)	**2004 TMDL WQ Target** Not feasible based on current watershed conditions (51% Reduction)	**Pre-Development** Background conditions represent a different hydrological flow regime
Atmospheric	103	103	103	103	103	51
Internal Load	894	812	812	81	81	23
Waterfowl	50	50	50	50	50	50
Septic Systems	45	45	31	31	23	0
Watershed Load	3,845	3,125	2,235	2,314	1,760	2,058
TOTAL LOAD TO LAKE (kg P/yr)	**4,936**	**4,135**	**3,231**	**2,579**	**2,017**	**2,183**
SDT Avg (m)	1.7	1.9	2.0	2.3	2.9	3.8
SDT Max (m)	3.8	3.9	4.0	4.2	4.6	5.1
Chl-a Avg (ppb)	12.5	10.8	9.4	7.0	5.1	3.2
Chl-a Max (ppb)	42	37	32	24	18	12
Bloom Probability	74%	64%	53%	31%	13%	2%
Flushing Rate (flushes/yr)	1.4	1.3				2.4

5. Climate Change Adaptation

Current Maine DEP guidance calls for developing watershed management plans that incorporate climate change considerations. This guidance would be addressed to a large extent by any plan that focuses on stormwater inputs and minimzing the internal P load. The primary climate change impacts on lakes are variation in precipitation and temperature. Higher precipitation periods, usually involving more intense storms, lead to more runoff and greater nutrient loading.

Photo Credit: Alan Burton

Higher (air and water) temperatures lead to earlier ice-out and later ice-in, resulting in longer and stronger stratification periods, which leads to increased algal growth, greater oxygen demand due to decomposition on the lake bottom, lower oxygen near the lake bottom, and increased P release from surficial sediments where iron is a major P binder (internal loading). Warmer water temperatures and increased P also favor invasive species, cyanobacteria, and harmful algal blooms (HABs) that produce toxins harmful to humans and wildlife. Increasing temperature and dissolved organic carbon (DOC) in lakes has a direct effect on thermal and biological dynamics, ultimately favoring nutrient-loving species (like toxin-producing cyanobacteria) over species adapted to cooler water temperatures.

Between 2015 – 2020, the Gulf of Maine experienced its warmest 5-year period on record (Pershing, et. al., 2021), warming at a rate seven times faster than the rest of the ocean. A 2020 report from the Maine Climate Council confirms that over the last several decades, air and surface water temperatures have been increasing in Maine. Surface water temperatures in northern New England increased 1.4 °F per decade from 1984-2014, which is faster than the worldwide average, with Maine lakes warming on average by nearly 5.5 °F during this time. Data also show that smaller lakes and ponds are warming more rapidly than larger lakes.

Movement toward bigger and more frequent storms presents another challenge for watershed management and exacerbates the internal loading problem as more intense rainfall will increase the amount of nutrient transport to the lake from the watershed via stormwater runoff that will be available for algal growth. P loading is very strongly connected to precipitation, and disrupting that relationship is not an easy task.

These climate-related changes are likely to exacerbate water quality issues in Unity Pond, necessitating additional P load reductions from watershed sources to offset the anticipated increases due to climate change. Though water quality in many Maine lakes has improved as a result of laws and regulations that protect water quality by mitigating the effects of human development, the effects of climate change threaten the effectiveness of these dated laws that may need adjusting to adequately protect natural resources in the future (MCC, 2020).

Watershed modeling estimates **an additional 721 kg P/yr could be delivered to Unity Pond due to climate change.**[20] It is important to remember that the watershed is not a static system, and the P load will continue increasing over time without taking actions to address these changes. The estimated increase above could be exceeded with just a few unforeseen large-scale climatic events that deliver a lot of sediment to the lake in a single pulse. Climate change adaptation planning, such as upgrading infrastructure on roads (i.e., undersized culverts), infiltrating stormwater runoff on commercial and residential properties, planting buffers, and conserving undeveloped land, can help to counteract the effects of the anticipated increase in precipitation. Infiltration of stormwater runoff reduces runoff volume, decreases P through filtration and adsorption, and importantly, decreases the temperature of the runoff water.

Current and future generations of lake users should expect to see warming air and water temperatures and an increase in precipitation and runoff in the watershed. Photo Credit: Dan Mcleod

A good starting point for adaptation planning includes formation of a Community Climate Change Committee and development of a Climate Change Action Plan that incorporates a watershed climate model. The plan would include a prioritized list of community actions using guidance from the Maine Climate Council and the Maine DEP's Adaptation Toolkit. A more detailed list of planning actions to mitigate the effects of climate change is presented in Section 7.

[20] Model inputs included a 10% increase in precipitation, 10% increase in runoff coefficients for developed land uses, an overall watershed load increase of 10% and a 10% increase in the affected area of internal loading. This includes an additional 82 kg/yr from internal loading.

6. Establishment of Water Quality Goals

Findings from the current evaluation of water quality data and watershed modeling echo the findings of the 2007 WBMP and 2004 TMDL- that reducing P loading from the direct watershed of Unity Pond will be essential to improving water quality. **This updated plan also acknowledges that the desired improvements will not be achieved by working in the direct watershed, <u>and that reducing P inputs in the indirect watersheds and reducing internal loading are a necessity</u>** for improving water quality.

WATER QUALITY GOAL

Unity Pond exhibits improving water quality trends & reduced frequency of algal blooms

Current In-Lake Concentration= 27 ppb

In-Lake Phosphorus Goal= 19 ppb

Reduction In-Lake Concentration= 8 ppb

"P" REDUCTIONS <u>NEEDED</u>

Direct Watershed: - 704 kg/yr
- 690 kg/yr direct watershed
- 14 kg/yr septic systems

Indirect Watersheds: - 121 kg/yr
- 110 kg/yr Carlton Pond
-11 kg/yr Sandy Stream

Internal Load: - 731kg/yr
90% reduction of internal load

Projects: Erosion Control BMPs, LakeSmart, Septic Upgrades, Aluminum Treatment

A team of scientists and local stakeholders worked collaboratively over several months to set a revised water quality goal for Unity Pond that would help stabilize and improve water quality trends in Unity Pond. Specifically, the committee reviewed the results of the water quality analysis (Ecological Instincts 2021a) and revised P loading estimates and future loading scenarios provided by WRS (2022). Previous watershed assessment work, including the 2021 watershed survey and NPS implementation projects, were evaluated to determine if revised water quality goals could be met based on past performance and proposed load reduction estimates.

The goal of this plan is to reduce the current P load by approximately 38% resulting in a reduction in the average annual in-lake TP concentration by 8 ppb (from 27 ppb to 19 ppb). This can be achieved by:

- Reducing the external load in the <u>direct and indirect watersheds</u> by 811 kg/yr;
- Reducing the <u>internal load</u> by 731 kg/yr;
- Reduce P loading from <u>septic systems</u> by 14 kg/yr.

7. Watershed Action Plan & Management Measures

The Unity Pond WBMP provides strategies for achieving the water quality goal. These recommendations are outlined in detail in the plan and were presented to the steering committee and the public for review and feedback. The action plan represents solutions for improving water quality in Unity Pond based on the best available science. The plan is divided into six major objectives (A-F), along with a schedule for completion, description of potential funding sources, and a list of project partners assigned to each task. The objectives focus on:

- **A) Reducing the External P Load**
- **B) Reducing the Internal P Load**
- **C) Preventing New Sources of NPS Pollution**
- **D) Education, Outreach & Communications**
- **E) Building Local Capacity**
- **F) Long-Term Monitoring & Assessment**

REDUCING THE EXTERNAL LOAD

Addressing NPS pollution from watershed sources is an important part of a multi-step, multi-year process to make a significant difference to improve the current state of water quality in Unity Pond. Addressing the external load will require ongoing work annually over the ten-year period and beyond, both in the direct and indirect watersheds. Success of this work will depend on cooperation from landowners, towns, and businesses to reduce the watershed load by 825 kg P/yr.

Load reductions were estimated for Unity Pond using three different models to develop the best estimates. A summary of methods for calculating load reductions is provided in Appendix D. The more conservative estimate from the LLRM was used for setting the water quality goal. While the DEP Relational Method estimated a slightly smaller load reduction, the method itself shines some light on the challenge ahead. This includes:

- **Agriculture**- Address 60% of row crops and hay/grazing land;
- **Urban Development-** Address 70% of low and medium-intensity residential and commercial development, 50% of developed open space, and 60% of roads;
- **Non-developed land-** Address 50% of recent timber harvests;
- **Septic Systems-** Address 75% septic systems on the shoreline;
- **Indirect Watersheds-** Address 8% of developed land in the Carlton Pond watershed and 20% from the Sandy Stream watershed.

WATERSHED NPS SITES

In 2021, volunteers and technical staff identified 109 sites across the watershed that contribute nonpoint source pollution to Unity Pond (Figure 22 & Appendix E). NPS sites were documented across nine different land-uses (Figure 23 & Table 13). The number of residential properties far outweighed the other land use types. The impact that documented NPS sites may have on the water quality of Unity Pond was determined during the survey based on the proximity to a waterbody and the magnitude of the problem. Factors such as slope, amount of eroding soil, and buffer size were also considered. While there were a total of 109 sites documented, only 16 rank high impact compared to 53 medium, and 40 low impact sites (Table 13).

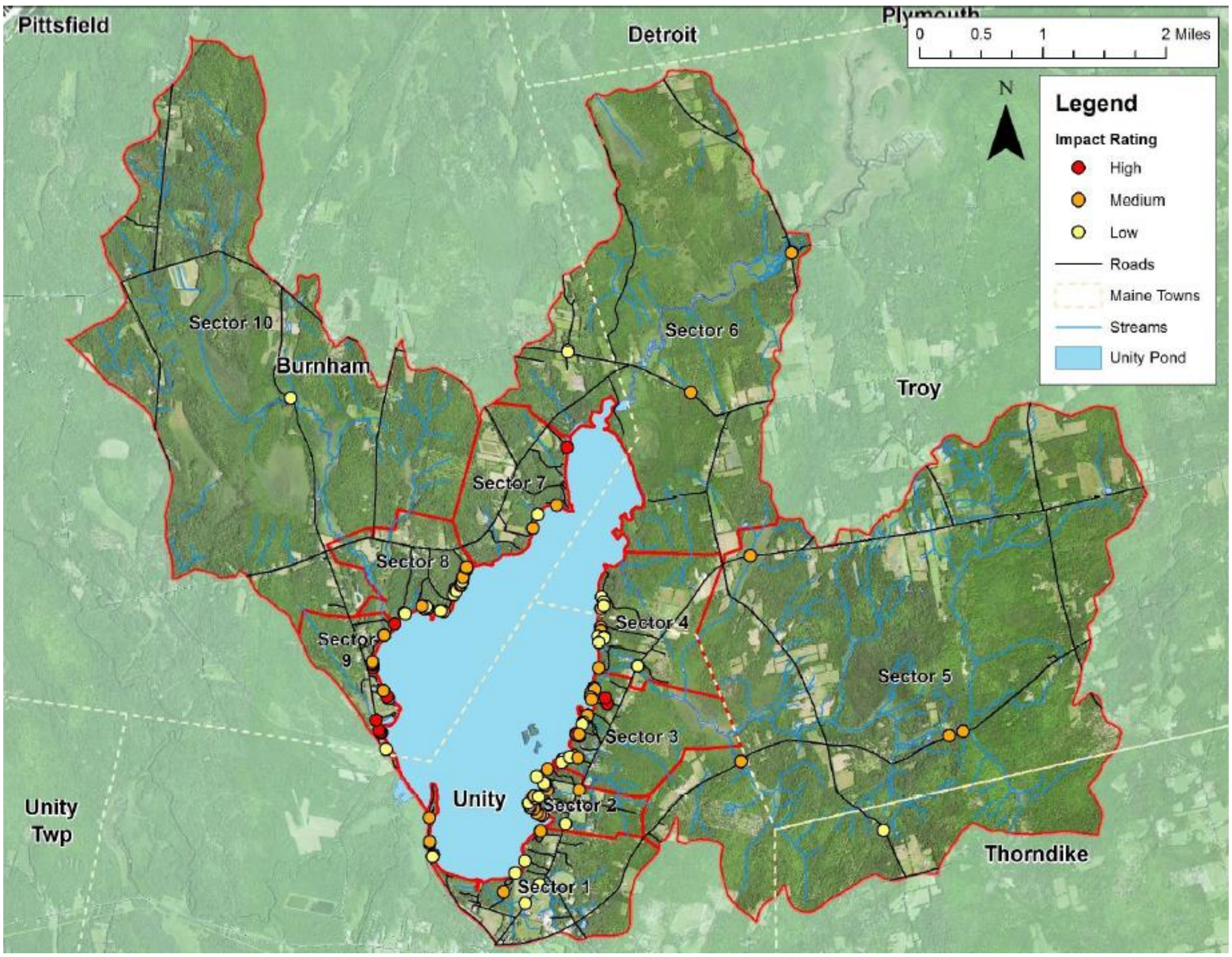


Figure 22. *Map of high, medium, and low-impact NPS sites from the 2021 Unity Pond watershed survey (Source: Maine DEP, 2021a).*

Residential NPS sites make up the greatest number of high, medium, and low impact sites, accounting for 53% of all sites, and 55% of the low-impact sites. Private roads and driveways make up the next largest category of NPS sites at 34% of all sites. Most of the road and driveway sites ranked low or medium impact, with only two high impact private road sites and one high impact state road sites.

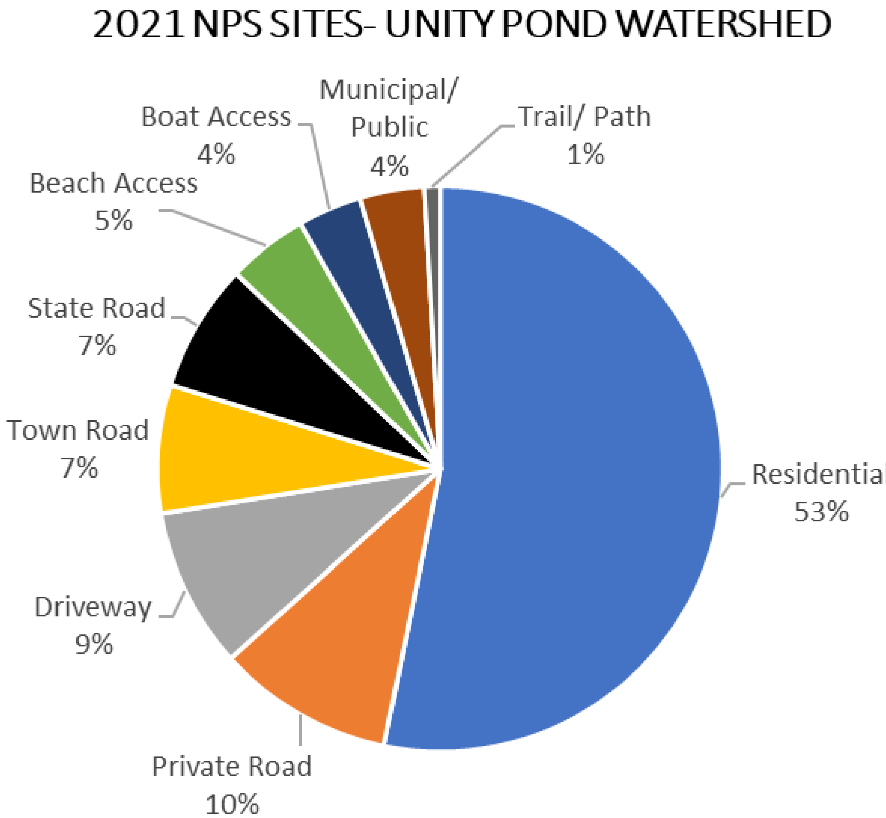


Figure 23. *Number of NPS sites identified in the Unity Pond watershed by land use type.*

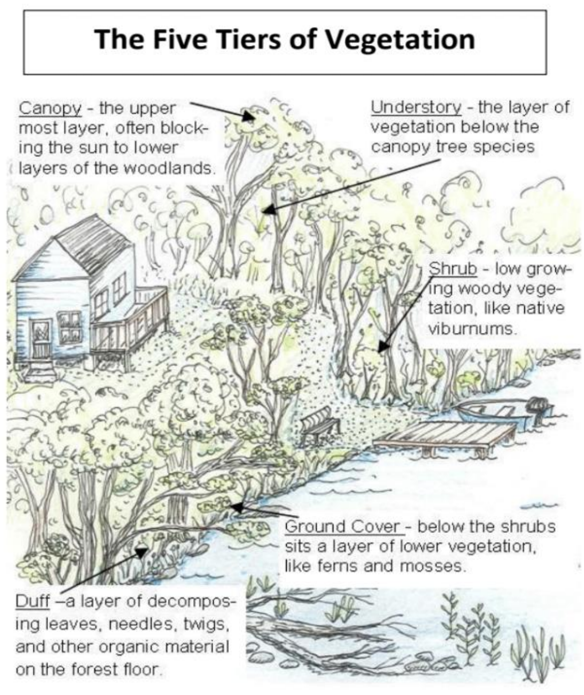
Table 13. *Summary of NPS sites in the Unity Pond watershed by land use and impact.*

Land Use	High Impact	Medium Impact	Low Impact	Total
Residential	9	27	22	**58**
Private Road	2	8	1	**11**
Driveway	0	4	6	**10**
Town Road	0	3	5	**8**
State Road	1	5	2	**8**
Beach Access	0	3	2	**5**
Boat Access	1	3	0	**4**
Municipal/ Public	3	0	1	**4**
Trail/ Path	0	0	1	**1**
Total	**16**	**53**	**40**	**109**

BUFFERS

Shoreline buffer installation on a lakefront property. (Source: https://www.uwp.edu)

Installing an effective shoreline buffer can be one of the easiest ways to help improve water quality. Natural vegetated shorelines are often the "last line of defense" for trapping and treating polluted stormwater runoff before it gets to the lake. A healthy, vegetated shoreline will not only act as a buffer between the lake and adjacent shoreline development but will also provide great benefit to wildlife as more species live in (and rely on) shoreline riparian zones than any other habitat type (Maine Audubon, 2006). Increasing development pressure throughout the watershed, and especially within the shoreland zone of Unity Pond, and the effects of climate change (more frequent and more intense precipitation and increased volume and velocity of stormwater runoff) means that healthy, vegetated shoreline buffers will be even more important for achieving water quality goals and maintaining a healthy lake ecosystem.



Example of an effective shoreline buffer with five tiers of vegetation. (Source: Maine Lakes)

The 2021 watershed survey documented a general lack of adequate buffers on developed shoreline properties. FOLW currently runs a LakeSmart program that has certified 11 properties and awarded commendations for 20 properties. This plan recommends continuing to encourage shorefront property owners to participate in the program, with the **goal of 35% of shorefront properties participating in LakeSmart by 2032**. LakeSmart currently requires a vegetative buffer zone that is at least 10-feet deep (on average) comprised of all three of the vegetation stand types (ground cover: <2 ft, small trees and shrubs: <6ft, and trees and large shrubs: >6ft) to ensure that stormwater runoff is captured and infiltrated within the buffer, raindrops are interrupted by overstory vegetation, and the overall function of the shoreline is maximized.

Outreach efforts will include a buffer campaign with easy-to-follow guidance for installing effective shoreline buffers highlighting the importance of **buffer quality**- as a healthy and functioning shoreline buffer includes more than just the installation of native plantings. The quality of the soil and a healthy duff layer is just as important when constructing an effective vegetated shoreline.

In addition to encouraging participation in the LakeSmart program, several phases of federal grants (particularly Clean Water Act Section 319 grants awarded by the US EPA to Maine DEP) will be sought to address high and medium impact sites on commercial properties, driveways, and residential properties on the shoreline, with a goal of addressing 16 high impact sites, 46 medium impact sites, and 22 low impact sites over the next 10 years.

AGRICULTURE AND FORESTRY

To complement the watershed survey, WCSWCD and USDA/NRCS teamed up with the Maine Forest Service to review active agriculture and forestry in the watershed (WCSWCD, 2022). Approximately seven recent forestry operations were identified from land cover data ranging in size from 20 – 80 acres each. The review indicates that the number of farms in the watershed have declined over time, with only a few remaining active farms in the direct watershed. Of the 1,549 acres of farmland in the direct watershed, a large percentage is "idle" land, meaning it is not actively used for hay or pasture but is still mowed at least annually to keep it open. NRCS estimates that only 150 acres of this land is active farmland consisting of dairy and beef production, pasture, hay, composting, and horses/hobby farms. Many of these farms already work with the NRCS to manage their land for nutrient management, livestock waste storage, soil health, grazing systems, and runoff prevention among other practices.

NRCS spent over $1.2M on agricultural projects in the watershed between 2014-2016 through the National Water Quality Initiative (NWQI). A total of 134 NRCS practices were applied in the watershed between 2007 and 2022 including agriculture and forestry practices. However, as described in the previous section, more work is needed to reduce P inputs from agricultural land in the direct and indirect watersheds in order to meet water quality goals. NRCS is working with seven producers interested in completing work in 2022 - 2023 and beyond, and efforts to expand programs in the Carlton Pond watershed are already underway to help meet planning objectives.

The following actions are recommended for reducing the external load by addressing NPS sites in the watershed. A detailed planning schedule, including potential funding sources, and estimated costs for 20 related actions is provided below.

ADDRESS DOCUMENTED NPS SITES
ACTION ITEMS & MANAGEMENT MEASURES

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
A. Reduce External Phosphorus Load (NPS Sites)					
A1	Reduce P export from agricultural land in the direct and indirect watersheds	Years 1-10	Farmers, USDA/NRCS, WCSWCD	FOLW, USDA/NRCS, US EPA (319), Maine DEP	$750,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
A2	Provide outreach to landowners regarding proper use of timber harvesting BMPs and conduct follow-up site visits for large harvests	Years 1-10	Maine Forest Service	MFS	n/a
A3	Review list of **69 high and medium priority sites outlined in the 2021 watershed survey** and develop a **candidate site list** for future 319 grant applications	Years 1-10	FOLW, Steering Committee	FOLW	$2,000
Address High Impact NPS Sites (16 sites)					
A4	Address NPS sites on residential properties ***Goal: 9 residential sites***	Years 1-6	FOLW, WCSWCD, private property owners	US EPA (319), Maine DEP, Landowners	$18,000
A5	Address NPS sites on private roads ***Goal: 2 private road sites***	Years 2-4	FOLW, WCSWCD, private property owners	US EPA (319), Maine DEP, Landowners	$20,000
A6	Address NPS sites on state roads ***Goal: 1 state road site***	Years 1-3	FOLW, Maine DOT	US EPA (319), Maine DEP, Maine DOT	$5,000
A7	Address NPS sites on boat access sites ***Goal: 1 boat access site***	Years 1-3	FOLW, WCSWCD, private property owners	US EPA (319), Maine DEP, Landowners	$2,000
A8	Address NPS sites on municipal/public sites ***Goal: 3 municipal/public sites***	Years 1-6	FOLW, WCSWCD, private property owners	US EPA (319), Maine DEP, Landowners	$9,000
Address Medium Impact NPS Sites (46 sites)					
A9	Address NPS sites on residential properties ***Goal: 20 residential sites***	Years 1-10	FOLW, landowners	US EPA (319), Maine DEP, landowners	$40,000
A10	Address NPS sites on private gravel roads ***Goal: 8 sites***	Years 3-9	FOLW, landowners	US EPA (319), Maine DEP, landowners, road associations	$40,000
A11	Address NPS sites on driveways ***Goal: 4 sites***	Years 1-6	FOLW, landowners	US EPA (319), Maine DEP, landowners	$20,000
A12	Address NPS sites on town roads ***Goal: 4 sites***	Years 1-6	FOLW, watershed towns	US EPA (319), Maine DEP, watershed towns	$32,000
A13	Address NPS sites on state roads ***Goal: 5 sites***	Years 3-6	FOLW, Maine DOT	US EPA (319), Maine DEP, Maine DOT	$50,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
A14	Address NPS sites on beach access sites ***Goal: 3 beach access sites***	Years 1-6	FOLW, landowners	US EPA (319), Maine DEP, landowners	$4,500
A15	Address NPS sites on boat access sites ***Goal: 3 sites***	Years 3-7	FOLW, landowners	US EPA (319), Maine DEP, landowners	$4,500
Address Low Impact Sites (22 sites)					
A16	Work with residential property owners to address low-impact residential NPS sites (including driveways, trails/paths, beach access, construction) ***Goal: Address 50% of low-impact residential related sites (16 sites)***	Years 5-10	FOLW, WCSWCD, landowners	US EPA (319), Maine DEP, landowners	$24,000
A17	Continue existing LakeSmart Program and encourage shorefront properties to become LakeSmart ***Goal: 35% (~105 properties) of shorefront property owners participating by 2032***	Years 1-10	FOLW, WCSWCD	FOLW, landowners, US EPA (319), Maine DEP	$13,500
A18	Work with road associations and homeowners to address low-impact private road sites ***Goal: Address 1 low-impact road site***	Years 5-10	FOLW, WCSWCD, landowners	Road Associations, private landowners	$5,000
A19	Address low-impact sites on town road and municipal/public sites ***Goal: Address 4 low-impact town road and municipal/public sites***	Years 7-10	FOLW, WCSWCD, watershed towns	FOLW, US EPA (319), watershed towns	$20,000
A20	Address low-impact sites on state roads ***Goal: Address low impact state road sites (2 sites)***	Years 7-10	FOLW, Maine DOT	US EPA (319), Maine DEP, Maine DOT	$10,000
External Phosphorus Load (NPS Sites) Subtotal					**$1,069,500**

SEPTIC SYSTEMS

While P loading from septic systems is estimated within the model to have a relatively small impact on water quality Unity Pond (1% of total P load), there are still many unknowns about their impact and the total load could actually be an order of magnitude larger. Just one or two failing septic systems leaching nutrient-rich wastewater into the lake could result in localized water quality problems. With 156 parcels located on sensitive soils in the shoreland zone of the lake, and reports of septic systems located in areas with high groundwater tables in flood-prone areas of the watershed, there is a high likelihood that septic systems are contributing more P to the lake than estimated.

Proposed load reduction targets from septic systems are conservative estimates that can be further refined when more information is available regarding the state of septic systems in the watershed. The following actions are recommended for reducing the external load from septic systems in the watershed. Inspections and upgrades to reduce P by 14 kg P/yr from septic systems is a goal of this plan. A detailed planning schedule, including potential funding sources, and estimated costs for eight related actions is provided below.

REDUCE NPS FROM SEPTIC SYSTEMS
ACTION ITEMS & MANAGEMENT MEASURES

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
Reduce NPS from Septic Systems					
A21	Utilize the State HHE 200 database and town records to create a septic system database and prioritized list of at-risk systems	Years 1-2	FOLW	Grants, FOLW	$5,000
A22	Target property owners located on parcels with **at risk soils and offer technical assistance** (293 developed properties in the shoreland zone). Cross reference with updated septic database to prioritize older systems.	Year 2-4	FOLW, watershed towns, Maine State Soil Scientist	Grants, FOLW	$2,500
A23	Offer landowners free septic evaluations & septic designs for high priority systems ***Goal: 20 free evaluations, 10 system designs***	Years 4-6	FOLW, WCSWCD, Site Evaluators	Grants, WCSWCD	$25,000
A24	Provide cost-share grants to assist landowners with replacing problem septic systems **Goal: 10 systems (targeted outreach to landowners with systems >20 years old and/or failing or malfunctioning systems)**	Years 4-10	FOLW, WCSWCD, DHHS, watershed towns	Grants, landowners, FOLW, WCSWCD	$100,000
A25	Conduct community outreach regarding **DEP Small Community Septic System grants** for malfunctioning systems to eligible landowners with high priority systems	Years 1-10	FOLW, Watershed Towns	Watershed Towns	$500
A26	Require **proof that septic systems have been installed to code** when properties change from seasonal to year-round status, and require replacement if proof is not available	Years 1-10	Watershed Towns	Watershed Towns	$1,500
A27	Create a system for adequately **tracking septic inspections** conducted for all real estate transactions in the shoreland zone;	Years 1-2	Watershed Towns	Watershed Towns	$5,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
A28	Create a permitting system and **registration requirement for rental properties on the shoreline** to minimize impacts from undersized septic systems	Years 2-4	Watershed Towns	Watershed Towns	$10,000
External Phosphorus Load (Septic Systems) Subtotal					**$149,500**
Reducing the External Load Total					**$1,219,000**

ADDRESSING THE INTERNAL LOAD

Addressing watershed sources alone will not be enough to prevent algal blooms in the lake but is one part of a larger effort to improve water quality. The plan must also include actions to address the internal load. Internal loading from sediments exposed to low oxygen is estimated to make up 20% of the P load in Unity Pond and is a key factor in the dynamics causing elevated P in the lake which fuels recurring nuisance algal blooms. *The internal load will need to be reduced to meet desired water quality targets and conditions in the lake*.

PRELIMINARY EVALUATION OF REMEDIATION OPTIONS

There are several ways to directly address algal blooms caused by internal P loading, but the focus of remediation should be on preventing blooms from occurring. P inactivation was recommended as the most cost effective and immediate method for addressing internal loading in Unity Pond.

A large barge is used to add alum to lakes with chronic internal P loading. (Photo credit, Georges Pond

Phosphorus inactivation can be used in three ways: to treat incoming water high in P, to strip P from the water column in a lake, or to bind P in surficial sediments and make reserves less susceptible to release under anoxia. All are applicable, but ultimately the most advantageous approach may be treatment of the sediment area subject to anoxia with a P binder such as aluminum. The track record for such treatments is favorable, including past efforts in Maine, and the empirical evidence that higher Al:Fe ratios in the sediment prevents P release also favors this approach. In Unity Pond, successful P inactivation of sediment under water >6 m deep could result in a reduction of at least 90% of the internal load. However, due to the fact that the watershed provides a much greater portion of the total load than internal loading, it is likely that a low-dose aluminum treatment would not last as long as intended as a consequence of ongoing external loading. A lower does treatment would strip the water column of P and inactivate the uppermost inch or so of sediment. This would provide benefits while watershed management proceeds but will have a relatively short duration of benefits, estimated at around 4 years.

Currently, there is limited sediment data available for Unity Pond. **The collection of additional sediment samples at different depths across the lake is necessary to fully understand the internal loading dynamics and also to determine the necessary dose of aluminum needed**.[21]

Aluminum is used extensively in water treatments worldwide. When applied in a lake, it is buffered to remain pH neutral and will not harm fish when applied properly. Fish and aquatic life surveys will be conducted before, during and after the treatment, as well as in-plume monitoring of pH, and floc evaluation during treatment to ensure that pH remains neutral, and coverage is as intended.

To reiterate, watershed management by itself will not achieve desired water quality conditions in Unity Pond but will provide protection for the future and increase the efficacy of an in-lake treatment which is necessary to meet the objective of minimizing algal blooms. The following actions are recommended for reducing the internal loading in Unity Pond. A detailed planning schedule, including potential funding sources, and estimated costs for six related actions is provided below.

REDUCE THE INTERNAL LOAD ACTION ITEMS & MANAGEMENT MEASURES					
Action Plan & Management Measures		**Schedule**	**Who**	**Potential Funding Sources**	**Estimated Cost** (10 years)
B. Internal Phosphorus Load in Unity Pond					
Conduct an Aluminum Treatment					
B1	Conduct **additional sediment sampling and analysis** before finalizing an aluminum treatment plan	Year 1	FOLW, DEP, TBD Lab	FOLW, grants, private donors	$10,000
B2	Develop final **treatment options and a funding plan** for inactivating P in the sediment	Year 1 - 2	FOLW, consultant	FOLW, consultant	$1,500
B3	Complete required **permitting** for aluminum treatment(s)	Year 3	FOLW, consultant, contractor	FOLW, consultant, US EPA (319), Maine DEP	$6,500 *(plus $793 annual permit fee)*
B4	Develop Request for Proposals (RFP) and **select contractor** for aluminum application(s)	Year 3	FOLW, consultant	FOLW	$1,000

[21] A lower does treatment could be conducted without additional testing, as it would not be expected to provide extended control, but even then additional sediment data would be helpful in planning where to treat and the estimated duration of benefits.

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
B5	Conduct a low-dose **aluminum treatment**	Years 4 - 5	FOLW, consultants	FOLW, watershed towns, US EPA (319), Maine DEP, private donors, landowners	$700,000
B6	Implement an **aluminum treatment monitoring plan** before and during treatment(s)	Years 4 - 5	FOLW, LSM, Maine DEP, consultants	FOLW, grants, private donors	$10,000
				Internal Phosphorus Load Total	**$731,400**

PREVENTING NEW SOURCES OF NPS POLLUTION

Preventing new sources of P from getting into the lake is imperative to the success of the management strategies described above. Future development is estimated to increase the total P load from the watershed by 80 kg/yr resulting in an increase in the in-lake P concentration by 0.5 ppb. Climate changes will only exacerbate the problem by increasing P loading by an additional 639 kg P/yr. Combined, climate change and future development scenarios result in almost as much new P being added to the lake than the P load reduction goals for in the direct and indirect watersheds. In other words, **if nothing is done to adapt to climate change and prevent new sources of P from getting into the lake, then much of the effort to reduce existing sources of P may be offset and goals may not be achieved.** As the water quality in the lake improves, Unity Pond will continue to be an even more desirable place to live and to visit, resulting in new development in the watershed. Prevention strategies will need to include more robust municipal planning and enforcement, ongoing public education, and land conservation.

FUTURE DEVELOPMENT, MUNICIPAL PLANNING & CONSERVATION

Towns in the watershed have taken steps to ensure ordinances are in place that help protect lake water quality. **However, all four towns in the watershed are lacking a current comprehensive plan or don't have one at all**, and several towns do not have ordinance information or land use maps available on their websites for easy access. A more detailed ordinance review is needed to determine if existing ordinances are aligned with the most current state standards, especially the shoreland zoning ordinance. Even in towns where ordinances are up to date it is likely that many older structures do not meet the current standards set by these ordinances. Along with new construction on the remaining undeveloped shoreline parcels, conversion of seasonal or second homes to year-round homes is the most likely shift in usage along the shoreline, thereby increasing the potential for additional stormwater runoff to the lake as a result of increased use (e.g., fertilizing, clearing vegetation, raking, compacted soil areas from vehicles and foot traffic), and related impacts from septic systems.

Ensuring that regulations are in place to address runoff from conversions of structures in the shoreland zone will be important for preventing new sources of P from getting into the lake. Protecting high-value riparian habitat through land conservation in order to safeguard small headwater streams and large areas of undeveloped forests should be a priority, as should land conservation.

Below are the major recommendations applicable to reducing impacts from future development. A detailed planning schedule, including potential funding sources, and estimated costs for nine related actions is provided below.

PREVENT NEW SOURCES OF NPS (FUTURE DEVELOPMENT) ACTION ITEMS & MANAGEMENT MEASURES					
Action Plan & Management Measures		**Schedule**	**Who**	**Potential Funding Sources**	**Estimated Cost** (10 years)
C. Prevent New Sources of NPS Pollution					
General Tasks					
C1	Attend regular Select Board meetings to update towns about watershed activities and needs Goal: Minimum 2 meetings/town/year	Years 1-10	FOLW	FOLW	$500
C2	Work with town officials on **winter sand and salt** issues including cleanup and ongoing road maintenance	Years 1-10	FOLW	Watershed Towns	$2,000
C3	Work with landowners/road associations to conduct regular road maintenance on **gravel roads**	Years 1-10	FOLW, WCSWCD	Road Associations	$1,000
C4	Work with local landscape nurseries to provide discounts for buffer plantings ***Goal: 1-2 local nurseries participating***	Years 1-10	FOLW, WCSWCD	FOLW, WCSWCD	$1,000
Future Development & Conservation					
C5	Investigate and report on an opportunity to create a Unity Pond Watershed Land Trust to identify, acquire and preserve land parcels in the watershed, when undeveloped over time, benefits water quality in the lake	Years 1-10	FOLW, local land trusts, watershed towns	Grants, donors	$3,000
Municipal Planning					
C6	Encourage towns to adequately enforce current ordinances	Years 1-10	FOLW	FOLW	$2,000
C7	Conduct a **review of current town ordinances** to determine what improvements can be made to be more protective of water quality in the watershed	Years 2-5	FOLW, towns, regional planning agency, Unity College, consultant	FOLW, towns, grants	$5,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
C8	Consider developing a **watershed-wide P control ordinance** for all new development (including single family residential units, roads, and seasonal to year-round conversions)	Years 3-5	FOLW, towns, consultant	FOLW, towns	$10,000
C9	Consider provisions for **3rd party site review**, and long-term maintenance as a requirement for building permits	Years 3-5	FOLW, towns, consultant	FOLW, towns	$2,000
Prevent New Sources of NPS (Future Development) Subtotal					**$26,500**

CLIMATE CHANGE

Watershed modeling estimates **an increase of 721 kg P/yr from the watershed and internal loading as a result of climate change.** Climate change adaptation planning, such as upgrading infrastructure on roads (i.e., undersized culverts), infiltrating stormwater runoff on commercial and residential properties, planting buffers, and conserving undeveloped land are a few ways to counteract the effects of the anticipated increase in precipitation. The following climate change activities should be factored into all future watershed planning activities. A detailed planning schedule, including potential funding sources, and estimated costs for the three actions is provided below.

PREVENT NEW SOURCES OF NPS (CLIMATE CHANGE)

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
Climate Change					
C10	Host **climate change workshops** or webinars to provide information about ways landowners can adapt to climate change and help protect water quality	Years 3-5	FOLW, WCSWCD, Unity College, consultant	Grants	$2,500
C11	Conduct a **stream-crossing survey** to assess whether culverts at road/stream crossings require upgrades	Years 3-5	FOLW, WCSWCD, Consultant, TNC	Grants, FOLW	$5,000
C12	Work with watershed towns and Maine DOT to apply for grants to fund and implement culvert upgrade projects	Years 5-10	FOLW, WCSWCD, towns, consultant	Grants, towns, Maine DOT, Maine DEP	$200,000
Prevent New Sources of NPS Pollution (Climate Change) Subtotal					**$207,500**
Prevent New Sources of NPS Pollution Total					**$234,000**

EDUCATION, OUTREACH & COMMUNICATIONS

Public education and outreach is an important and necessary component of meeting the water quality goals for the Unity Pond WBMP. Development of a comprehensive outreach strategy led by a steering committee consisting of watershed partners that are actively conducting outreach will streamline outreach messaging and increase participation in watershed planning activities.

FOLW is the primary entity conducting public outreach in the watershed. FOLW hosts an annual meeting every August for all interested watershed residents, provides watershed updates on its website, and distributes three newsletters each year. FOLW also administers the LakeSmart program and Courtesy Boat Inspection (CBI) program. Coordination with the watershed towns will help expand FOLW's existing outreach efforts so that all watershed residents are aware and involved in the process.

A detailed planning schedule, including potential funding sources, and estimated costs for each of the 22 education and outreach actions is provided below.

EDUCATION, OUTREACH & COMMUNICATIONS
ACTION ITEMS & MANAGEMENT MEASURES

	Action Plan & Management Measures	Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
D. Education, Outreach & Communications					
General Outreach					
D1	Develop an outreach strategy/**communications committee** to get the word out to the community; meet annually to discuss plan objectives	Years 1-10	FOLW, interested stakeholders	n/a	$0
D2	Develop and maintain a Unity Pond WBMP **web page** for the public to access information	Years 1-10	FOLW	FOLW	$5,000
D3	Keep partner **websites** updated regarding on-going monitoring efforts and NPS pollution projects	Years 1-10	FOLW, Towns	Towns, FOLW	$2,500
D4	Prepare and distribute **press releases** and **newsletter articles** about watershed improvement activities, grant projects, and successful projects (goal 2/year)	Years 1-10	FOLW	FOLW	$5,000
D5	Provide **welcome packets** to new property owners with water quality educational materials	Years 2-10	FOLW	FOLW	$5,000
D6	Develop an **online video series** of short educational clips that can be viewed by the public (including climate change)	Years 3-10	Outreach Committee, FOLW	Grants, FOLW	$5,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
D7	Work with **local realtors and towns** to track property transfers and subdivisions	Years 1-10	FOLW	FOLW	$10,000
Aluminum Treatment Outreach					
D8	Develop a Frequently Asked Questions (FAQ) page about aluminum treatments and post on partner websites that describes the process and addresses health and safety concerns	Year 1	FOLW, DEP, consultant	FOLW	$500
D9	Develop an **online educational video** pertaining to the need for an aluminum treatment that can be viewed by the public and help with fundraising efforts	Year 1-2	FOLW, Outreach Committee	Grants, FOLW	$5,000
Targeted Outreach					
D10	Follow-up with **educational materials for landowners with high-impact sites** (8 sites) **and medium-impact sites** (24 sites) to gauge interest in cost-sharing opportunities for a future 319 grant	Year 1-2	FOLW, WCSWCD	FOLW, Grants	$1,600
D11	Prepare a list of NPS sites on **town-owned properties** and work with towns on their annual budget planning (municipal sites and roads)	Years 1-10	FOLW, Towns	FOLW	$5,000
D12	Prepare educational materials for **LakeSmart** program	Years 1-10	FOLW, WCSWCD	FOLW, Maine Lakes, Grants	$5,000
D13	Prepare a list of NPS sites on **state roads** and meet with Maine DOT to discuss improvements	Years 1-10	FOLW, Towns, Maine DOT	FOLW	$500
D14	Meet with **road associations** with documented NPS problems to determine interest in future 319 grant cost-sharing opportunities	Years 1-10	FOLW, Road Associations	FOLW	$2,000
D15	Design a **Buffer Campaign** with easy to follow guidance/recipes for installing effective shoreline buffers	Years 2-5	FOLW, WCSWCD, Maine Lakes, Towns	FOLW, Grants	$5,000
D16	**Increase participation in NRCS agricultural programs** through newspaper articles, NRCS sponsored workshops, and targeted outreach throughout the watershed (goal 10 new participating landowners in Carlton Pond watershed)	Years 1 - 3	USDA/NRCS	USDA/NRCS	$6,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
D17	Conduct outreach to landowners/road associations to **promote use of bluestone surface gravel** for use on driveways and roads; identify roads where not currently used and provide **incentive** to switch over to new material	Years 1-10	FOLW, Road Associations, Landowners	FOLW, Grants	$5,000
Workshops					
D18	Host annual **gravel road workshops** in the watershed working directly with road associations (goal 1/year)	Years 1-10	FOLW, WCSWCD	FOLW, US EPA (319), Maine DEP	$5,000
D19	Host annual **buffer workshops** (goal 1/year)	Years 1-10	FOLW, WCSWCD	FOLW, Grants	$5,000
D20	Host annual **LakeSmart workshops** (goal 1/year)	Years 1-10	FOLW, WCSWCD	FOLW	$5,000
D21	Host annual **septic workshops** or **webinars** (goal 1/year)	Years 1-10	FOLW, WCSWCD	FOLW, Grants	$5,000
D22	Host **ordinance workshops** for landowners, developers, and realtors (goal 1)	Year 4	FOLW, Towns	FOLW, Grants	$2,500
			Education, Outreach & Communications Total		**$90,600**

BUILDING LOCAL CAPACITY

FOLW, in cooperation with watershed partners, will oversee plan implementation, which will require funding the plan, meeting annually with project partners, and strengthening relationships within the community among other tasks described below. A detailed planning schedule, including potential funding sources, and estimated costs for each of the 11 capacity building actions is provided below.

BUILD LOCAL CAPACITY
ACTION ITEMS & MANAGEMENT MEASURES

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
E. Build Local Capacity					
Fundraising					
E1	Develop and maintain a **fundraising committee** to help implement the plan	Years 1-10	FOLW, Stakeholders	FOLW	$1,000
E2	Apply for US EPA Clean Water Act Section 319 watershed implementation grants to address internal loading and NPS sites ***Goal: 4 phases of 319 implementation projects***	Years 1-10	FOLW, Consultant	FOLW	$12,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
E3	Create a sustainable funding plan to pay for the cost of an aluminum treatment, watershed implementation projects, erosion control program management, outreach and education, and long-term science and monitoring (***goal: $1,000,000 raised by 2026)***	Years 2-10	FOLW, consultant	FOLW, towns, private donors	$5,000
E4	Apply for other state, federal or private foundation **grants** that support planning recommendations	Years 2-10	FOLW, consultant	FOLW	$10,000
E5	Fundraise for **septic system cost-sharing grants**	Years 1-3	FOLW	FOLW, grants, watershed towns	$500
Steering Committee & Partnerships					
E6	Steering Committee to **meet annually** to discuss action items and goals	Years 1-10	FOLW	Steering Committee	$5,000
E7	Reach out to new potential Steering Committee members including town officials, local businesses, realtors, and septic inspectors	Years 1-10	FOLW, Steering Committee members	FOLW	$1,000
E8	Continue working with watershed towns to strengthen **stakeholder relationships** and bolster community support for restoration efforts	Years 1-10	FOLW	FOLW	$1,000
E9	Develop a comprehensive list of projects and an accessible **database** to track activities conducted by the numerous project partners that work in the watershed	Years 3-10	FOLW, consultant	FOLW, Grants	$2,500
E10	Meet with colleges and universities to **recruit professors and students** with skills sets for water quality monitoring & watershed management	Years 3-10	FOLW	FOLW	$1,500
E11	Meet with area **landscaping companies** to increase their capacity to do more erosion control work in the watershed and to educate them on LakeSmart practices	Years 3-10	FOLW	FOLW	$500
				Build Local Capacity Total	**$40,000**

8. Monitoring Activity, Frequency and Parameters

Maine water quality standards require Unity Pond to have a stable or improving trophic state and be free of culturally induced algal blooms. Measuring the water quality of the lake is a necessary component of successful watershed planning because results can be used to evaluate the effectiveness of watershed management measures. If improvements in water clarity, P, or other parameters are evident or if water quality is stable, then planning objectives are being met. If water quality gets worse, then additional management strategies may be needed.

FUTURE BASELINE MONITORING

An assessment of existing water quality monitoring data in Unity Pond was completed as part of the water quality analysis (1977 - 2021). The steering committee determined that ongoing annual monitoring efforts conducted by LSM volunteers and Maine DEP should continue over the next 10 years in order to assess and track annual changes in water quality and the effects of actions to reduce P loading in the lake. Future monitoring should include the following six measures detailed below.

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
F. Conduct Long-Term Monitoring & Assessment					
Baseline Lake Monitoring					
F1	Continue collecting annual **water quality data** to inform long-term management actions (April-October)	Years 1-10	FOLW, Maine DEP, volunteers	FOLW, private donors, towns, grants	$20,000
F2	Track and document the presence of **metaphyton**	Years 1-10	FOLW, volunteer monitors	FOLW, volunteers	$6,000
F3	Monitor **plankton** and **cyanobacteria** throughout the year	Years 1-10	FOLW	FOLW	$10,000
F4	Add annual baseline monitoring results to long-term data set and **update long and short-term trends analysis** to document any changes	Years 1-10	FOLW, DEP, consultant	FOLW	$3,750
F5	Monitor the extent of **anoxia** at the bottom of the lake and at intermediate depths; maintain trend analyses	Years 1-10	FOLW	FOLW	$10,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
F6	Conduct **winter sampling** for DO/Temp and P samples during ice-on	Years 1-10	FOLW, Maine DEP	FOLW	$2,500
				Baseline Monitoring Subtotal	**$52,250**

FOLW will continue to work with project partners including LSM volunteer water quality monitors and Maine DEP to conduct long-term water quality monitoring at Unity Pond, and to analyze the results of this data to inform future watershed management planning and assessment, and in-lake treatments.

NPS POLLUTION

Additional NPS assessments following the 2021 Watershed Survey will be beneficial for preventing new sources of NPS from getting into the lake, for protecting water quality, and protecting the investments made to address current sources of P in the lake. The actions below will track NPS pollution in the watershed over the next 10 years.

NPS ASSESSMENTS

ACTION ITEMS & MANAGEMENT MEASURES

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
NPS Pollution					
F7	Set up an **NPS Site Tracker** & update annually	Ongoing (Years 1-10)	FOLW, consultant	US EPA (319), FOLW	$5,000
F8	Conduct **site visits to logging sites** to better understand their impact on water quality; meet with the District Forester to strategize on ways to reduce P runoff from timber harvests	Years 1, 3, 5, 7, 9	FOLW, WCSWCD	FOLW	$1,500
F9	Conduct an informal watershed survey for **new NPS sites** 5 and 10 years after initial survey	Years 3 and 8	FOLW	FOLW, grants	$10,000
F10	Create an updated database of GIS-based **shoreline photos** and share with towns to assist with compliance in the shoreland zone; include documentation of buffer quality	Years 4-5	FOLW	FOLW, grants, towns	$10,000
				NPS Pollution Subtotal	**$26,500**

BACKFLUSHING & STREAM MONITORING

Currently, there is no reliable or consistent monitoring data available for the tributaries in the direct watershed or from backflushing into the lake from Sandy Stream. Therefore, a significant degree of uncertainty exists regarding P loading from upstream drainages. Documenting in-stream P concentrations in streams that drain to Unity Pond and determining the impact of backflushing will help inform future watershed planning in these drainages by determining to what extent runoff from streams and backflushing play a role in the P equation. Observed data can be incorporated into modeled predictions to better inform current watershed modeling.

Stream monitoring is recommended and should occur over a time frame of at least three years to develop a baseline P concentration for each tributary. Future stream monitoring and backflushing assessment actions include:

BACKFLUSHING & STREAM MONITORING ACTION ITEMS & MANAGEMENT MEASURES					
Action Plan & Management Measures		**Schedule**	**Who**	**Potential Funding Sources**	**Estimated Cost** (10 years)
Stream Monitoring					
F11	Collect additional backflushing and P data to determine P inputs to Unity Pond from Sandy Stream	Years 1-3	FOLW, Maine DEP, Volunteers, University of Maine, Unity College	Grants, FOLW	$25,000
F12	Collect **water quality data at targeted stream outlets** (ISCO samplers) to quantify P load from streams under different conditions throughout the year	Years 2-4 (3 Year Baseline)	FOLW, Maine DEP, Volunteers, Unity College	Grants, FOLW	$15,000
F13	Train volunteer **"stream watchers"** to take pictures during storms or install game cameras; set up online repository for uploading photos; work with Maine DEP to train volunteers on how to collect storm samples	Years 3-10	Maine DEP, FOLW, volunteers, Unity College	Grants, FOLW	$3,000
				Stream Monitoring Subtotal	**$43,000**

AQUATIC INVASIVE PLANTS & HABs

In a mesotrophic lake with a large littoral zone like Unity Pond, keeping aquatic invasive plants (AIP) out of the lake is a high priority. The following actions should be taken to prevent the introduction of AIP, and to monitor the presence of Harmful Algal Blooms (HABs):

AQUATIC INVASIVE PLANTS ACTION ITEMS & MANAGEMENT MEASURES:					
Action Plan & Management Measures		**Schedule**	**Who**	**Potential Funding Sources**	**Estimated Cost** (10 years)
Invasive Plant Monitoring					
F14	Participate in activities that support programs that prevent the spread of invasive aquatic plants to Unity Pond (e.g., CBI, volunteer invasive plant surveys, etc.)	Years 1-10	FOLW, volunteers, LSM	FOLW, State Funding	$20,000
F15	Develop and implement a volunteer **HAB monitoring protocol**	Years 1-10	FOLW, Maine DEP	FOLW	$5,000
Invasive Aquatic Plants Monitoring Subtotal					**$25,000**
Other					
F16	Consider developing a subcommittee to look at the **economic value of Unity Pond** that can be used for public outreach	Years 3-10	FOLW, towns, Unity College	FOLW, towns	$2,500
All Long-Term Monitoring & Assessment Total					**$149,250**

9. Measurable Milestones, Indicators & Benchmarks

FOLW volunteer monitor Steve Krautkremer and CWS scientist Dr. Jim Killarney measuring water quality in Unity Pond. Photo Credit: FOLW

The following section provides a list of interim, measurable milestones to document progress in implementing management strategies outlined in the action plan (Section 7 and Section 8). These milestones are designed to help keep project partners on schedule. Additional criteria are outlined to measure the effectiveness of the plan by documenting load reductions and changes in water quality over time, thus providing the means by which the steering committee can reflect on how well implementation efforts are working to reach established goals.

Environmental, social, and programmatic indicators and proposed benchmarks represent short-term (1-2 years), mid-term (3-5 years), and long-term (6-10 years) targets for improving the water quality in Unity 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 targets are not being met. This may include updating proposed management practices and the loading analysis, and/or reassessing the time it takes for P concentrations to respond to watershed management. This plan calls for large P reductions from both land and water, and ongoing monitoring to determine whether reductions are being achieved as the plan progresses will be essential to determining the success of management measures. In order to significantly reduce the probability of experiencing algal blooms, this plan aims **to improve the trophic state of Unity Pond from a eutrophic condition to a mesotrophic condition.**

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 14 outlines the water quality benchmarks, and interim targets for improving the water quality of Unity Pond over the next 10 years.

Social Milestones measure changes in social or cultural practices and behavior that lead to implementation of management measures and water quality improvements. Table 15 outlines the social indicators, benchmarks, and interim targets for the Unity Pond WBMP.

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 16 outlines the programmatic indicators, benchmarks, and interim targets for the Unity Pond WBMP.

Table 14. *Water quality benchmarks and interim targets for Unity Pond.*

Environmental Milestones			
Water Quality Benchmarks	***Interim Targets****		
	Years 1-2	*Years 3-5*	*Years 6-10*
a) P loading reductions from external sources (690 direct watershed, 121 kg indirect watersheds, 14 kg septic systems) **Current:** 3,170 kg/yr **Goal:** 2,345 kg P/yr (reduce by 825 kg P/yr)	3,120 kg/yr *(▼ 50 kg/yr)*	2,845 kg/yr *(▼ 325kg/yr)*	2,345 kg/yr *(▼ 825 kg/yr)*
b) P loading reductions from internal P loading **Current:** 812 kg/yr **Goal:** 81 kg P/yr (reduce by 731 kg P/yr)	812 kg/yr *(▼ 0 kg/yr)*	81 kg/yr *(▼ 731 kg/yr)*	81 kg/yr *(▼ 731 kg/yr)*
c) Decrease in average in-lake TP concentration **Current:** 27 ppb **Goal:** 19 ppb (reduce by 8 ppb)	26.5 ppb *(▼ 0.5 ppb)*	22 ppb *(▼ 5.0 ppb)*	19 ppb *(▼ 8 ppb)*
d) Increase in average water clarity **Current:** 2.3 ppb **Goal:** 2.7 ppb (reduce by 0.4 m)	2.4 m *(▲ 0.1 m)*	2.7 m *(▲ 0.4 m)*	2.7 m *(▲ 0.4 m)*
e) Decrease in Chl-a **Current:** 15 ppb **Goal:** 11 ppb (reduce by 4 ppb)	15 ppb *(▼ 0%)*	13 ppb *(▼ 2 ppb)*	11 ppb *(▼ 4 ppb)*
f) Decrease algal bloom probability **Current:** 64% **Goal:** 31% (reduce by 33%)	63% *(▼ 1%)*	44% *(▼ 20%)*	31% *(▼ 33%)*

** Benchmarks are cumulative unless otherwise noted. Years 1-2 (2023-2024); Years 3-5 (2025-2027); Years 6-10 (2028-2032). (▲▼) arrows indicate the expected change for each parameter up or down over the planning period.*

Table 15. *Social indicators, benchmarks, and interim targets for Unity Pond.*

Social Milestones			
Indicators	***Benchmarks & Interim Targets****		
	Years 1-2	*Years 3-5*	*Years 6-10*
a) Number of low-impact NPS sites addressed **Goal:** 22 low-impact sites	2 sites	5 sites *(7 total)*	15 sites *(22 total)*
b) Number of educational workshops held (road associations, homeowner associations, gravel road workshop, buffer workshop, boat tours, etc.)	8 workshops	13 workshops *(21 total)*	20 workshops *(41 total)*
c) Number of homeowners installing buffers through the Buffer Initiative **Goal:** 50 new or expanded shoreline buffers	n/a	20 buffers	30 buffers *(50 total)*

Social Milestones			
Indicators	***Benchmarks & Interim Targets****		
	Years 1-2	*Years 3-5*	*Years 6-10*
d) Number of LakeSmart site visits and new landowners participating (cumulative) **Goal:** 35% of landowners participating	15% of all shoreline properties	20% of all shoreline properties	35% of all shoreline properties
e) Number of landowners participating in septic system incentive program **Goal:** 20 evaluations, 10 septic designs, 10 upgrades	n/a	8 evaluations 4 designs 5 upgrades	20 evaluations 10 designs 10 upgrades
f) Number of "welcome packets" distributed to new property owners in the watershed	10 packets	20 packets	40 packets
g) Number of people viewing online video series	n/a	300 views	1000 views
h) Number of planning board/selectmen meetings attended to strengthen town ordinances and relationships with town officials **Goal:** 2 meetings/town/yr	6 meetings	9 meetings *(15 total)*	15 meetings *(30 total)*

** Benchmarks are cumulative unless otherwise noted. Years 1-2 (2023-2024); Years 3-5 (2025-2027); Years 6-10 (2028-2032).*

Table 16. *Programmatic indicators, benchmarks, and interim targets for Unity Pond.*

Programmatic Milestones			
Indicators	***Benchmarks & Interim Targets****		
	(Years 1-2)	*(Years 3-5)*	*(Years 6-10)*
a) Number of steering committee meetings **Goal:** 1 meeting/year	2 meetings (2 total)	3 meetings *(5 total)*	5 meetings *(10 total)*
b) Number of NPS sites addressed **Goal:** 16 high-impact, 46 medium-impact sites	11 sites	26 sites *(37 total)*	25 sites *(62 total)*
c) Increase in FOLW membership/donors **Current:** 33% of shoreline property owners **Goal:** 75% of shoreline property owners	40%	60%	75%
d) Amount of funding spent on water quality projects **Goal:** $2,456,250	$500,000	$1,000,000 *($1.5M total)*	$956,250 *($2.6M total)*
e) Number of ordinances improved that help protect water quality	0 ordinances	2 ordinances	4 ordinances

** Benchmarks are cumulative unless otherwise noted. Years 1-2 (2023-2024); Years 3-5 (2025-2027); Years 6-10 (2028-2032).*

POLLUTANT LOAD REDUCTIONS & COST ESTIMATES

The goal of this plan is to reduce P by approximately 38% (from 27 ppb to 19 ppb). This can be achieved by reducing the P load by 825 kg/yr from the direct watershed, upstream watersheds (including Carlton Pond and Sandy Stream/Halfmoon Stream) and septic systems, as well as reducing the internal P load in the lake by 731 kg/yr. The action plan is divided into six major objectives (A-F):

Table 17. Unity Pond planning objectives, P load reduction targets & cost.

Planning Objective	Planning Action (2023-2032)	P Load Reduction Target	Estimated Cost
A	**Reduce the External P Load** (NPS sites, septic systems, LakeSmart, buffer campaign, upstream watersheds, agricultural BMPs)	825 kg/yr	$1,219,000
B	**Reduce the Internal P Load** (Sediment sampling and analysis, treatment plan and funding plan, monitoring, aluminum treatment)	731 kg/yr	$731,400
C	**Prevent New Sources of NPS Pollution** (Municipal planning & enforcement, climate change adaptation, land conservation, etc.)	n/a	$234,000
D	**Education, Outreach & Communications** (Targeted outreach, aluminum treatment outreach, online videos, buffer campaign, LakeSmart, workshops, economic value, etc.)	n/a	$90,600
E	**Build Local Capacity** (Funding plan, steering committee, grant writing, relationship building- including Town government, contractors and scientists)	n/a	$40,000
F	**Long-Term Monitoring & Assessment** (Baseline monitoring, plankton and cyanobacteria, septic systems, NPS pollution, backflushing and stream monitoring, invasive plants)	n/a	$149,250
	TOTAL	**1,556 kg/yr**	**$2,464,250**

Preliminary estimates suggest that approximately 49% ($1.2M) of the cost of implementing the action plan will need to come from outside grant sources including Section 319 grants and USDA/NRCS, 43% ($1.1M) from local sources including towns and landowner contributions, and 15% ($367K) from in-kind volunteer efforts. The cost per kg P reduced is estimated at $1,575/kg P reduced. The cost for the low-dose aluminum treatment is $1,000/kg vs. the slightly higher cost of watershed work at $1,477/kg P.

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 P 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.

10. Plan Oversight, Partner Roles, and Funding

PLAN OVERSIGHT

Implementation of a 10-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 excellent candidates for the watershed plan steering committee. The committee will need to meet at least annually to update the action plan, to evaluate the plan's success, and to determine if the water quality goal is being met.

PARTNER ROLES

Friends of Lake Winnecook (FOLW) will oversee plan implementation and plan updates and oversee a fundraising campaign. FOLW will provide 319 grant management and administration, serve on the steering committee, provide outreach and education opportunities in the watershed, manage the LakeSmart, and CBI programs, and be the general liaison between all watershed partners and technical advisors.

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

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

Maine Lakes may provide support to the FOLW LakeSmart Program Manager to evaluate and certify properties and provide LakeSmart signs for landowners meeting certification requirements.

St. Joseph's College will assist with the analysis of sediments to help inform the aluminum treatment.

Towns of Unity, Burnham, and Troy 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 and LakeSmart programs. 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.

Unity College may provide technical assistance/research opportunities to further the plan.

University of Maine may provide support for research related to the influence of backflushing from Sandy Stream into Unity Pond.

USDA/Natural Resources Conservation Service will provide education and outreach, technical and financial assistance to agricultural producers in the watershed.

US Environmental Protection Agency (US EPA) will provide guidance on grant programs particularly Clean Water Act Section 319, work plan guidance, and selected project funding, pending acceptability of grant proposals, final workplans and availability of federal funds.

Waldo County Soil & Water Conservation District (WCSWCD) will work with FOLW to develop a schedule and plan for evaluating their progress, make itself available to FOLW for professional support and advisement for the WBMP and reach out to FOLW periodically to request updates in writing on specific targeted goals and benchmarks as well as provide updates to FOLW on WCSWCD programs that align with the WBMP.

ACTION PLAN IMPLEMENTATION & FUNDING

FOLW will develop and coordinate a public-private fundraising plan and will coordinate and implement the proposed action plan. Expected partners are local towns, Unity Barn Raisers, Maine DEP, WCSWCD, USDA/NRCS, landowners, road associations, businesses, and private donors.

Many of these partners have worked together for over 30 years. Accomplishments include developing and implementing the 2006 Unity Pond Watershed-Based Plan, which included completing two 319 implementation grants at Unity Pond since 2004; completing watershed surveys in 2001 and 2021, installing 134 conservation practices through USDA/NRCS since 2007, and collaborating on the 2023 Unity Pond WBMP. FOLW, WCSWCD, and local towns also have a long track record of working together on other successful programs including the FOLW septic replacement program, LakeSmart (2016-present), Courtesy Boat Inspections (2007-present), the annual loon count, and volunteer water quality monitoring.

There are a number of opportunities for acquiring funding to support implementation of the watershed management plan. The list below contains a few of the better-known State and Federal funding options. Additional support from private foundation grants, local fundraising efforts, monetary contributions by participating landowners, and financial support from municipal partners will be needed to adequately fund this plan.

- **Land for Maine's Future Program** – Funding for land conservation that provides multiple public and natural resource benefits. For more information: https://www.maine.gov/dacf/lmf/
- **Maine DEP Courtesy Boat Inspection (CBI) Program Grants** – A cost-share program to help fund locally-supported CBI programs. For more information: https://www.maine.gov/dep/water/grants/invasive/index.html

- **Maine DEP Invasive Aquatic Plant Removal Grants** – Administered by Maine DEP to assist communities planning and managing removal of invasive aquatic plant infestations. For more information: https://www.maine.gov/dep/water/grants/invasive/index.html
- **Maine DEP Small Community Grant Program (SCG)** – Administered by Maine DEP, this program provides grants to Municipalities to help replace malfunctioning septic systems that are polluting a waterbody or causing a public nuisance. For more information: https://www.maine.gov/dep/water/grants/scgp.html
- **Maine DEP Stream Crossing Upgrade Grant Program** – A competitive grant program for the upgrade of municipal culverts and stream crossings that improve fish and wildlife habitats and improve community safety. For more information: https://www.maine.gov/dep/land/grants/stream-crossing-upgrade.html
- **Maine DOT's Municipal Partnership Initiative (MPI)** – This program funds projects of municipal interest on state infrastructure working with Maine DOT as a partner to develop, fund, and build the project. For more information: https://www.maine.gov/mdot/pga/
- **Maine Governor's Office of Policy Innovation and the Future (GOPIF)** – Two types of grants are offered including Community Action Grants to support projects that reduce energy use and costs and/or make their community more resilient to climate change effects, such as flooding, extreme weather, drought, and public health impacts. For more information: https://www.maine.gov/future/climate/community-resilience-partnership/grants
- **Maine Natural Resource Conservation Program (MNRCP)** – A cooperative program between Maine DEP and US Army Corps of Engineers, administered by The Nature Conservancy, funding the restoration, enhancement, preservation, and creation of wetland habitat. For more information: https://www.maine.gov/dep/land/nrpa/ILF_and_NRCP/index.html
- **US EPA Clean Water Act (Section 319) Watershed Nonpoint Source (NPS) Grant Program** – Administered by Maine DEP, 319 grants assist communities implementing a watershed-based management plan for waters named on Maine DEP's NPS Priority Watershed List. For more information: https://www.maine.gov/dep/water/grants/319.html
- **US EPA/Maine Clean Water State Revolving Fund (CWSRF)** – Provides financial assistance for a wide range of water infrastructure projects including control of nonpoint sources of pollution, and other water quality projects. For more information: https://www.epa.gov/cwsrf/learn-about-clean-water-state-revolving-fund-cwsrf
- **USDA/NRCS Financial Assistance** – NRCS offers voluntary programs to eligible landowners and agricultural producers to provide financial and technical assistance to help manage natural resources including financial assistance to help plan and implement conservation practices that address natural resource concerns or opportunities to help save energy, improve soil, water, plant, air, animal and related resources on agricultural lands and non-industrial private forest land: https://www.nrcs.usda.gov/wps/portal/nrcs/main/me/programs/financial/

- **Maine Outdoor Heritage Fund** – The Maine Outdoor Heritage Fund (MOHF) helps fund critical wildlife and conservation projects throughout Maine. The purpose of MOHF is to conserve habitat, acquire and manage public lands, parks, conservation areas and facilities, to conserve endangered and threatened species, and to fund natural resources law enforcement. For more information: https://www.maine.gov/ifw/programs-resources/grants/outdoor-heritage-fund.html

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APPENDIX A. PUBLIC MEETING Q&A

Unity Pond Watershed-Based Management Plan Public Meeting

October 27, 2022 held both In-person and via Zoom

Q1: Can a lack of oxygen in the lake cause a fish kill?

A1: Fish kills can be caused by a variety of factors including lack of dissolved oxygen, a rapid increase in water temperature, pollution, and fish disease. Since anoxia often occurs in the deepest areas of the lake, many fish species can avoid low oxygen by swimming to shallower water if water temperature and dissolved oxygen levels support it. However, species that require cold water to survive are most affected by anoxia because they are limited to the deepest areas of the lake where water temperatures are coldest and won't be able to survive in warm surface water. When a large algal bloom is dying off, the decay process can deplete oxygen in the lake which can result in a fish kill. Fish kills often occur when water temperature rises rapidly at the surface, and/or when loss of oxygen occurs in deep areas of the lake and conditions at the surface are too warm or don't have enough oxygen. In shallower, productive lakes oxygen depletion throughout the water column under ice during the winter can cause lake wide fish kills. Parasites that infect the gills of fish can also result in fish kills as was seen on Threemile Pond and Webber Pond earlier this year.

Q2: Is there or should there be a warning system to inform the public when there are toxic algae blooms? Possibly a sign at the beaches?

A2: Yes, several Maine communities have initiated a toxic algal bloom warning program to inform the public about potential toxicity related to algal blooms. This includes testing the water for toxins during an algal bloom and posting signs at public beaches and boat launches. Test results are not immediate, so general signage could be installed that alerts people to avoid swimming in the lake during an algal blooms, when water is visibly green. Later this month, Maine DEP and Maine CDC will be discussing whether Maine will adopt the EPA critical levels for microcystin and how an advisory process will be established in Maine. Rapid tests are available but cost between $30 - $50 per test.

Q3: Some lake residents use filtered lake water for showering during the summer. Is it safe to do so during an algae bloom?

A3: There is a body of research that suggests that exposure to the algal toxin BMAA through inhalation carries a risk, especially for degenerative diseases like ALS. The linkage is not all that clear, but there is concern that bringing in cyanobacteria-laden water, heating it for a shower, then allowing the steam to be breathed could represent a risk. It is better to avoid bathing or showering in water containing cyanobacteria as skin contact with cyanobacteria may lead to skin irritation in sensitive individuals or other adverse health effects. If you must shower using lake water, keep the showers short and use the bathroom fan to remove moisture-laden air. Boiling water does not remove cyanotoxins and at-home filtration systems are not guaranteed to do the job although activated carbon filtration shows promise. Therefore, you should not use water for cooking if you observe algae because it is impossible to detect the presence of toxins in water by taste, odor or appearance. But bear in mind that toxins are not a guaranteed result of a bloom; the probability of having toxins is about 20%. Microcystin has been detected in Unity Pond during blooms. Extremely high concentrations have been measured in dense algal scums that collect along the shore in down-wind areas toward the end of the summer as algal populations begin to die.

Q4: What are the potential dangers of using alum to treat the lake?

A4: Alum, or aluminum sulfate, can be toxic outside the pH range of about 6-8. Fish kills have occurred where the dose was too high and buffering of the input was inadequate. Sodium aluminate is often used to offset the pH impact of alum in high dose treatments. Polyaluminum chloride can also be used, which has minimal impact on pH. In the last 22 years and a total of about 50 treatments, there have been no fish kills in New England because applicators have learned proper use. There have been some claims that aluminum has negative health effects, but they have largely been debunked. The aluminum also does not stay in the water column but settles quickly into the sediments and therefore would not affect swimmers.

Q5: Is there any possibility of re-routing Sandy Stream so that it flows directly into Unity Pond as it used to, thereby increasing the flushing rate and moving phosphorus out of the pond faster?

A5: Increasing the flushing rate would be unlikely to improve water quality unless the added water coming into the lake from Sandy Stream had significantly less phosphorus than the water flowing into the lake from the direct watershed. This would not be the case in this situation since the Sandy Stream watershed drains a large and highly agricultural area and is likely to have higher phosphorus concentrations than the lake. For flushing to work without decreasing the phosphorus concentration, water must be replaced about every two weeks, which is much more water than would be available in this case.

Q6: How do I go about getting my property LakeSmart certified?

A6: Contact Brian Levesque at Friends of Lake Winnecook (Email: friendsoflakewinnecook1@gmail.com) to schedule a free LakeSmart evaluation. The evaluation will outline steps you can take to become LakeSmart. A final determination on certification will be approved by Maine Lakes, the statewide entity that oversees the LakeSmart program.

Q7: How do we hold people accountable for their land and septic systems contributing to water quality issues?

A7: Lake and watershed protection is a voluntary process for a landowner, so each landowner must decide to do their part. The hope is that the poor water quality in the lake will be enough of an incentive for people to take action. There are many things that can affect water quality that are prohibited by local shoreland zoning ordinances. The Town of Unity just hired a new Code Enforcement Officer, who will hopefully help to deal with aging septic systems and other actions that negatively affect water quality.

Q8: What is being looked for during a LakeSmart visit?

A8: LakeSmart is a free and non-regulatory program that involves an evaluation of the developed areas on your property. The evaluation makes recommendations for preventing stormwater runoff from roofs and driveways and ensuring that there is an adequate vegetative buffer along the shoreline to prevent erosion and protect wildlife habitat.

Q9: What is the projected timeline for doing the aluminum treatment?

A9: Based on the current action plan, the aluminum treatment is planned for years 4-5 of the ten year watershed plan (2026 – 2027). This timeline is flexible but will depend on the results of follow-up sediment sampling and analysis, the ability to raise enough funding to complete the work, and approval of the permits to complete the work.

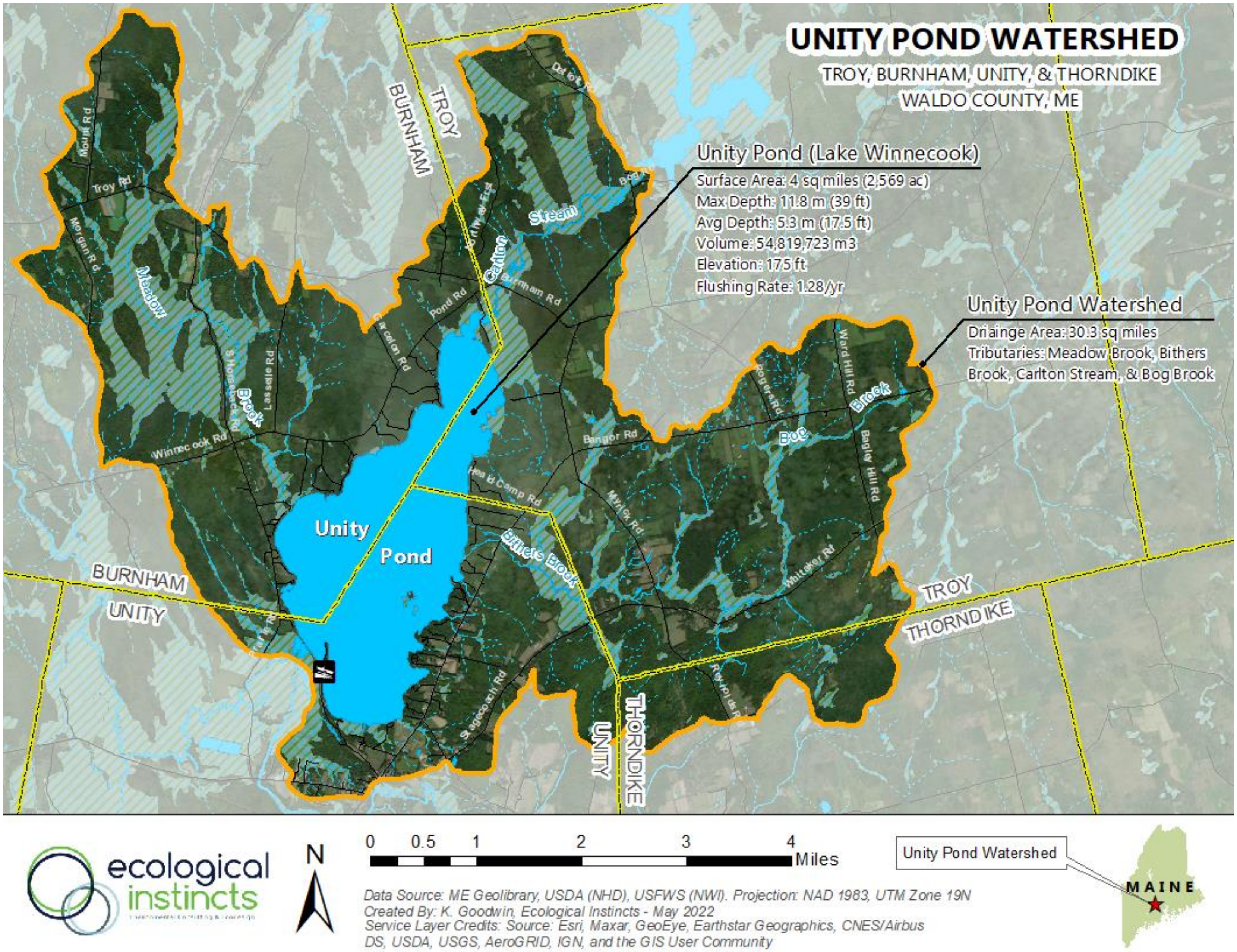
Q10: How long would an aluminum treatment remain effective for? How many treatments would have to be done after the initial treatment?

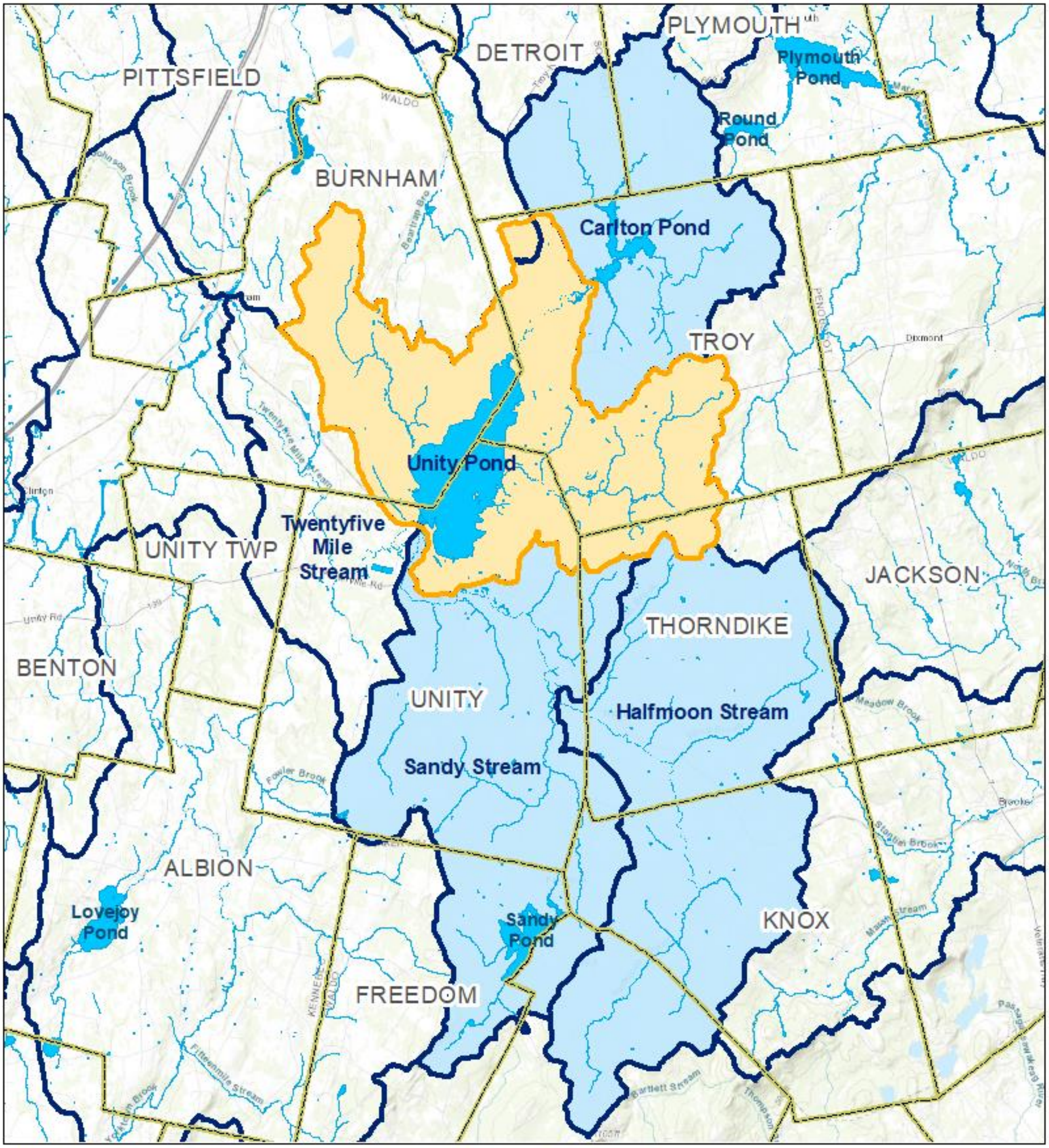
More data are needed about the lake sediments to fully answer these questions. An initial partial treatment would likely last around four years depending on how much pollution is continuing to come from the watershed. Most aluminum treatments on stratified lakes are intended to improve conditions for at least two decades, but actual results depend on site-specific details and dose.

APPENDIX B. OTHER MAJOR LLRM INPUTS

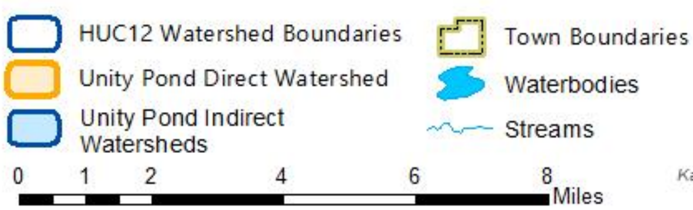
- *Annual precipitation* data were obtained from NOAA National Climatic Data Center (NCDC) Waterville, ME station (Station ID: USC00179151) for the ten year period 2012 – 2021 (42.1 in or 1.1 m).
- *Atmospheric deposition* a P export coefficient of 0.1 kg/ha/yr was used in the model, which aligns with coefficients being used in current LLRM models for other Maine lakes with mainly forested watersheds.
- *Lake area* and volume estimates were obtained from bathymetry data collected by FOLW in 2021 and processed by Lakes Environmental Association (LEA) in 2022.
- *Routing Pattern* is a feature within the LLRM that allows larger drainage basins to be divided into smaller sub-basins where one sub-basin passes through another sub-basin. This guides prioritization of areas with higher nutrient loads within a drainage basin. For Unity Pond, Basin 1 (Upper Meadow Brook) was set up to pass through Basin 2 (Lower Meadow Brook), Basin 8 (Bog Brook) passes through Basin 7 (Bithers Brook), and Basin 10 (Carlton Pond) passes through Basin 9 (Carlton Stream).
- *Septic system data* estimates were extrapolated from the 2004 TMDL, the FOLW septic survey mailed to shoreline property owners in 2021 and 2022, and input from local members of the Technical Advisory Committee. Information used for the model included the distance of the system from the shoreline, the approximate age of the system, and usage (seasonal vs. year-round and average occupants).
- *Water quality data* were obtained from Maine DEP and 2021 data collected by the Center for Wildlife Studies (CWS). The average annual in-lake P concentration used to calibrate the model is based on the recent 10-year annual average of epilimnetic core samples collected at Station 1.
- *Waterfowl counts* were obtained from Cornell eBird (260 birds annually). A slightly more conservative estimate of 250 birds was used in the model. Waterfowl can be a direct source of nutrients to lakes, however, if they are eating from the lake, and their waste returns to the lake, the net change may be less than might otherwise be assumed; however, the P excreted may be in a form that can readily be used by algae.
- *Internal phosphorus loading* was calculated by WRS, Inc. based on 2022 bathymetry data, 2012-2021 water quality data, 2021 P profile data collected by CWS, P mass calculations provided by Ecological Instincts, and historical sediment data provided by Maine DEP.
- *Backflushing from Sandy Stream* was estimated by WRS, Inc. Within the LLRM, Sandy Stream is treated as a point source passing through the SE direct drainage, assigned a flow equal to 5% of its expected annual flow at a P concentration of 50 ppb, reflecting storm inputs.

APPENDIX C. WATERSHED MAPS


UNITY POND WATERSHED
TROY, BURNHAM, UNITY, & THORNDIKE
WALDO COUNTY, ME
Unity Pond (Lake Winnecook)
Surface Area: 4 sq miles (2,569 ac)
Max Depth: 11.8 m (39 ft)
Avg Depth: 5.3 m (17.5 ft)
Volume: 54,819,723 m3
Elevation: 175 ft
Flushing Rate: 1.28/yr
Unity Pond Watershed
Driainge Area: 30.3 sq miles
Tributaries: Meadow Brook, Bithers Brook, Carlton Stream, & Bog Brook
Unity Pond
BURNHAM
UNITY
TROY
THORNDIKE
N
0 0.5 1 2 3 4 Miles
Unity Pond Watershed
MAINE
Data Source: ME Geolibrary, USDA (NHD), USFWS (NWI). Projection: NAD 1983, UTM Zone 19N
Created By: K. Goodwin, Ecological Instincts - May 2022
Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
ecological instincts

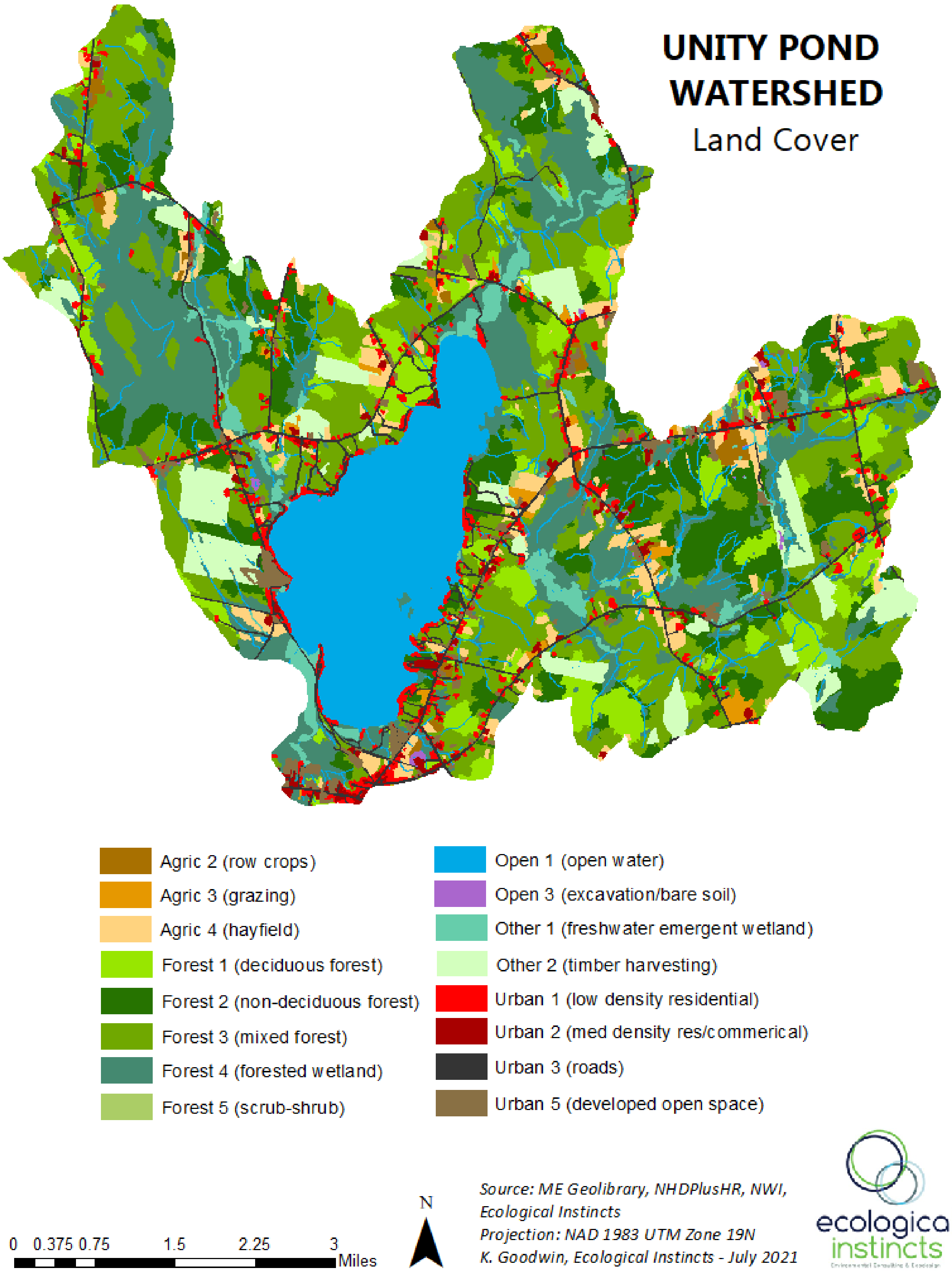


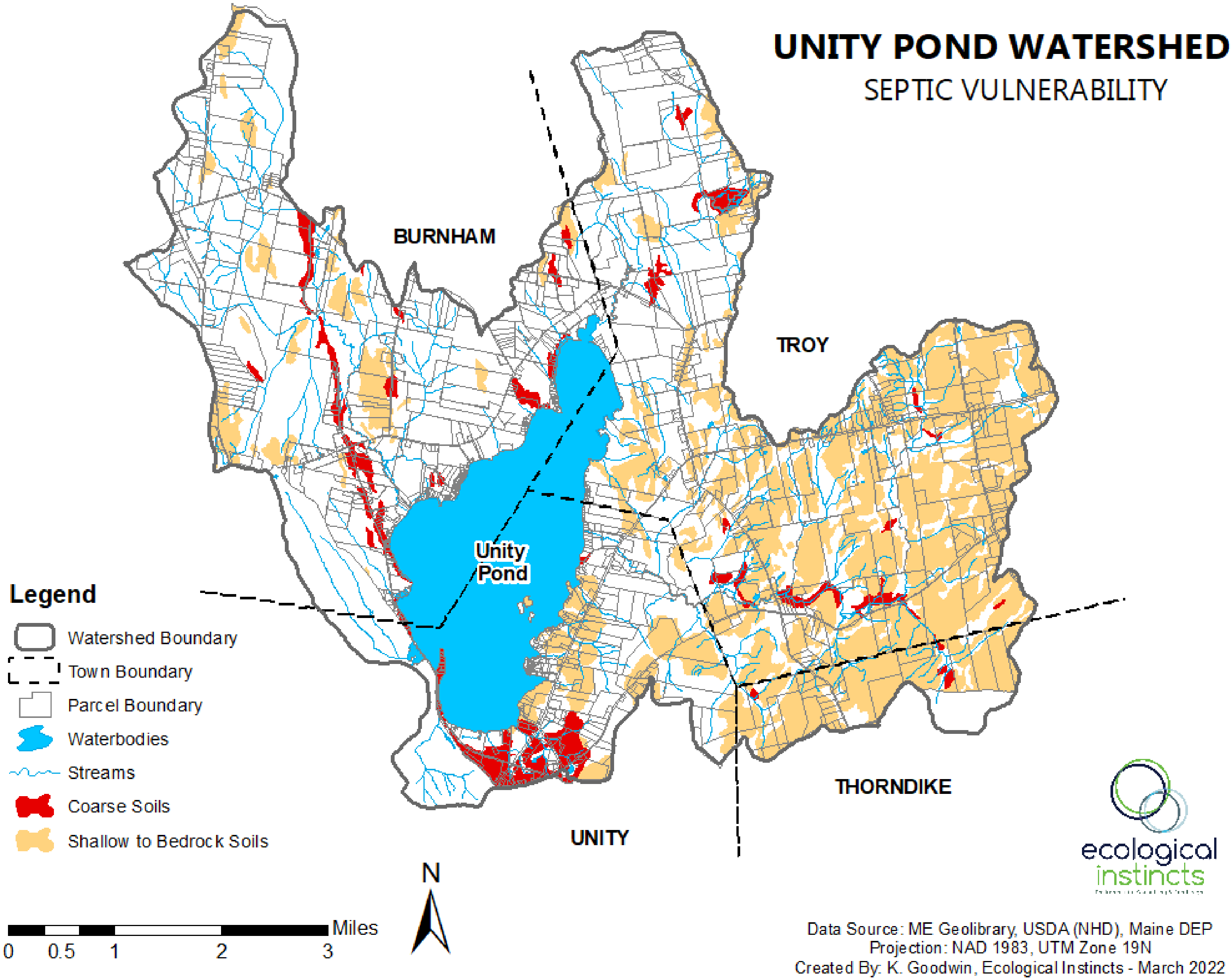
Unity Pond Direct & Indirect HUC12 Watersheds



ecological instincts

Data Source: ME Geolibrary, USDA (NHD)
Projection: NAD 1983, UTM Zone 19N
Created By: K. Goodwin,
Ecological Instincts - May 2022
Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

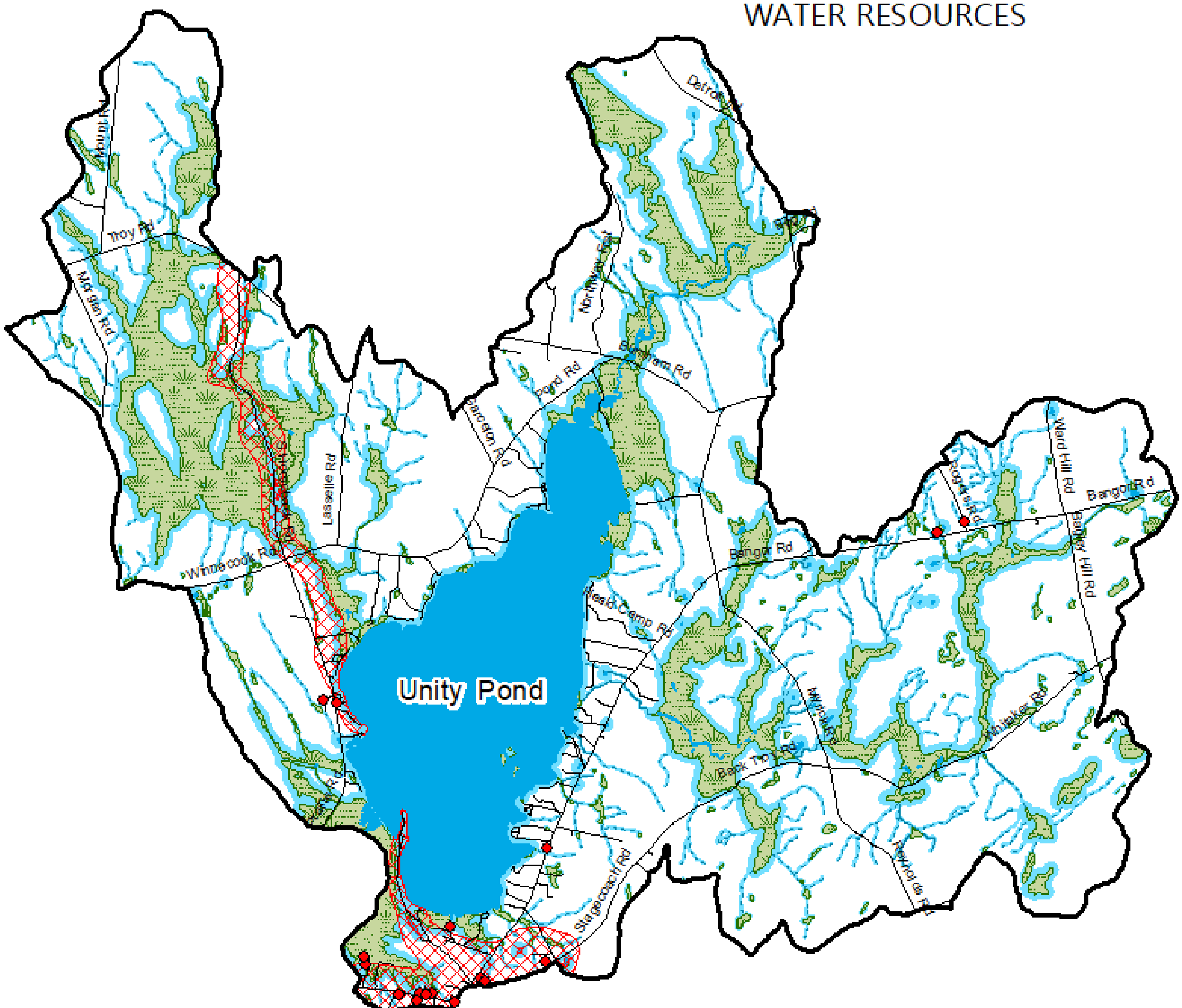

UNITY POND
WATERSHED
Land Cover
Agric 2 (row crops)
Agric 3 (grazing)
Agric 4 (hayfield)
Forest 1 (deciduous forest)
Forest 2 (non-deciduous forest)
Forest 3 (mixed forest)
Forest 4 (forested wetland)
Forest 5 (scrub-shrub)
Open 1 (open water)
Open 3 (excavation/bare soil)
Other 1 (freshwater emergent wetland)
Other 2 (timber harvesting)
Urban 1 (low density residential)
Urban 2 (med density res/commerical)
Urban 3 (roads)
Urban 5 (developed open space)
0 0.375 0.75 1.5 2.25 3
Miles
N
Source: ME Geolibrary, NHDPlusHR, NWI,
Ecological Instincts
Projection: NAD 1983 UTM Zone 19N
K. Goodwin, Ecological Instincts - July 2021
ecological instincts



UNITY POND WATERSHED
SEPTIC VULNERABILITY
BURNHAM
TROY
THORNDIKE
UNITY
Unity Pond
Legend
Watershed Boundary
Town Boundary
Parcel Boundary
Waterbodies
Streams
Coarse Soils
Shallow to Bedrock Soils
Miles
0
0.5
1
2
3
N
ecological instincts
Data Source: ME Geolibrary, USDA (NHD), Maine DEP
Projection: NAD 1983, UTM Zone 19N
Created By: K. Goodwin, Ecological Instincts - March 2022

UNITY POND WATERSHED

WATER RESOURCES



Legend

- Perennial Streams (27 miles)
- Intermittent Streams (73 miles)
- Lakes/Ponds (2,591 acres)
- Wetlands (3.418 acres)
- Riparian Areas (4,335 acres)*
- Public Wells (18)
- Significant Sand & Gravel Aquifers (907 acres)
- Roads (66 miles)

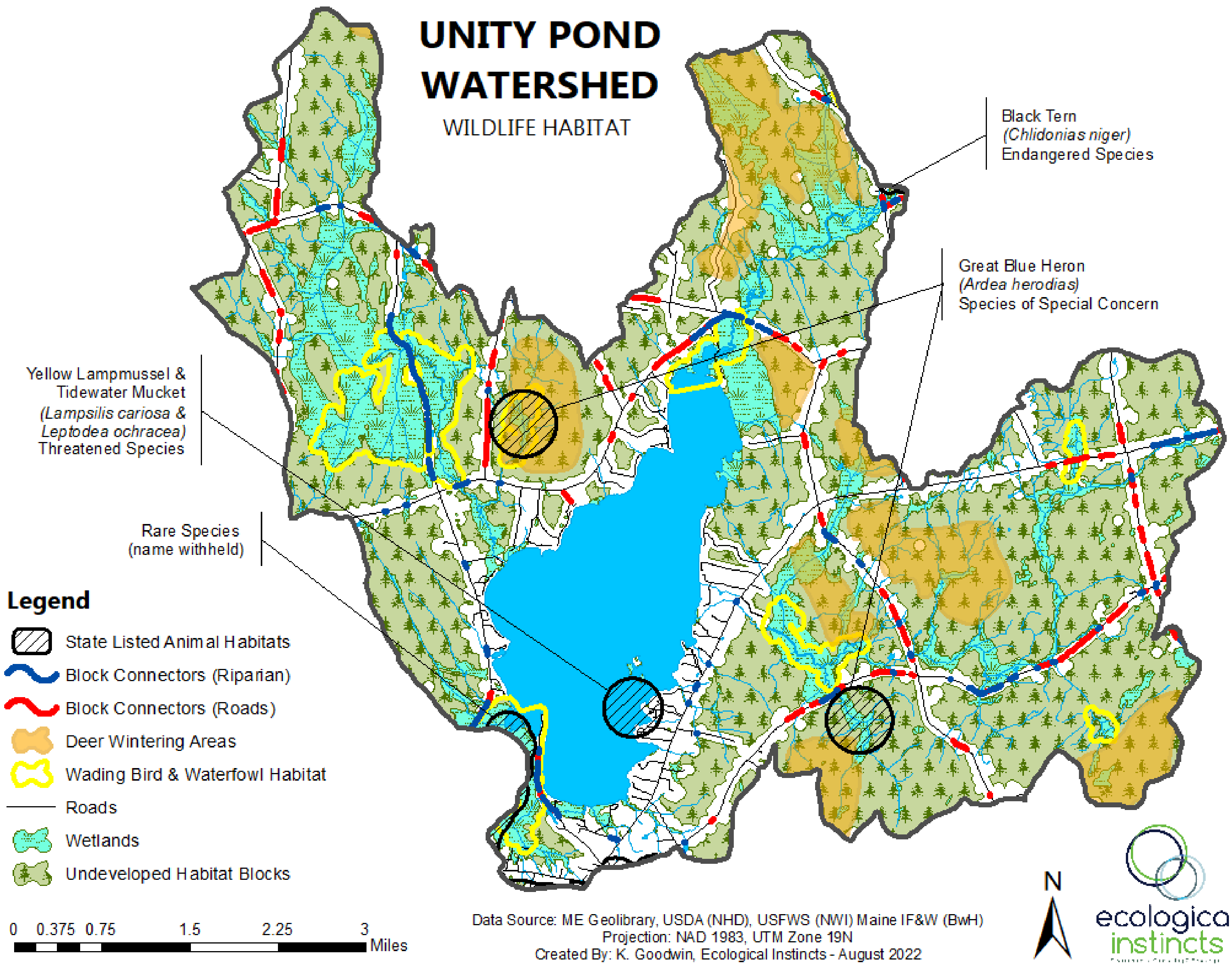
*Riparian area includes the area within 250' of lakes, ponds and wetlands greater than 10 acres, and within 75' of smaller wetlands and streams

0 0.5 1 2 3 4 Miles

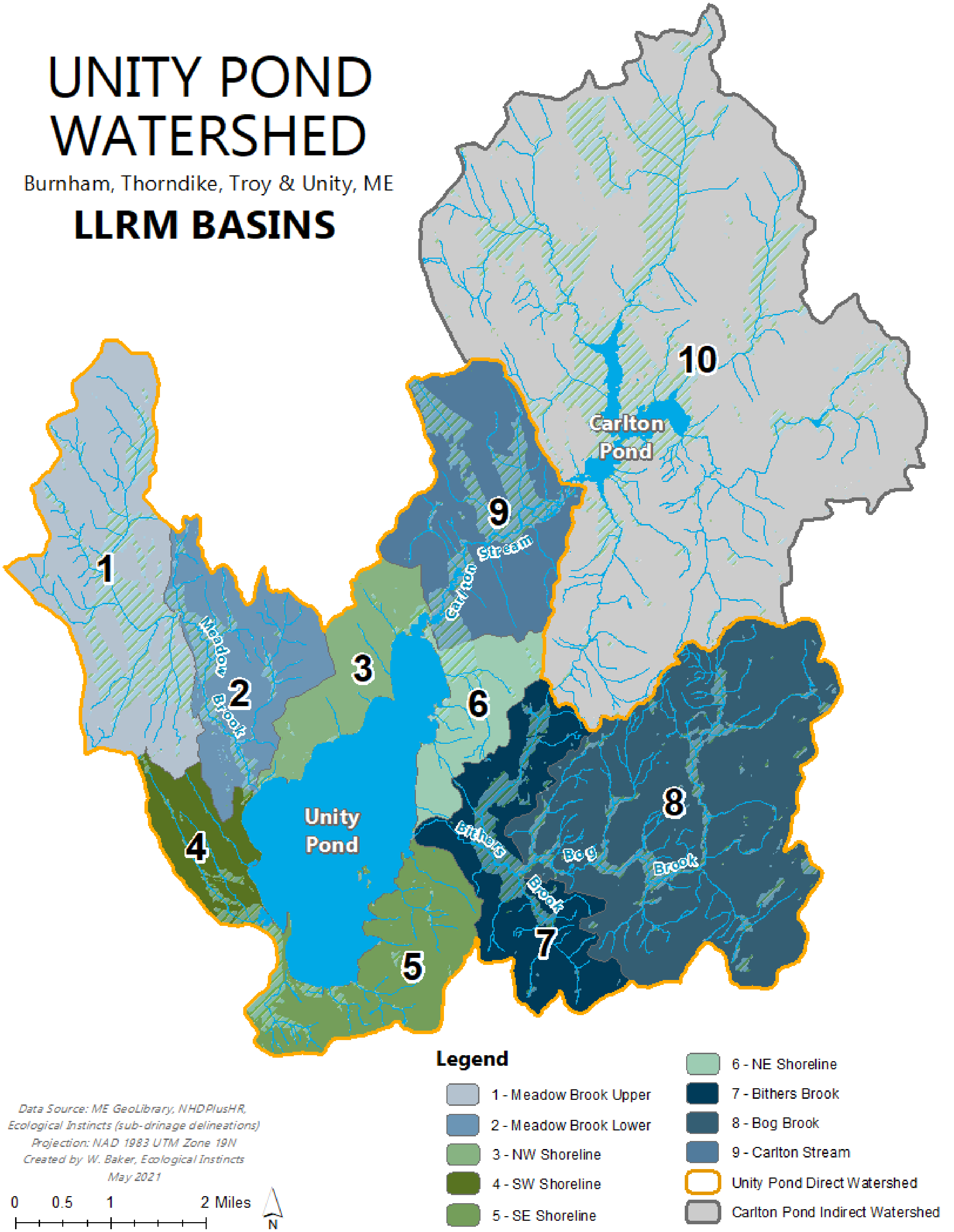
N

Data Source: ME Geolibrary, USDA (NHD), USFWS (NWI) Maine IF&W (BwH)
Projection: NAD 1983, UTM Zone 19N
Created By: K. Goodwin, Ecological Instincts - May 2022

ecological instincts



UNITY POND WATERSHED
WILDLIFE HABITAT
Black Tern
(Chlidonias niger)
Endangered Species
Great Blue Heron
(Ardea herodias)
Species of Special Concern
Yellow Lampmussel &
Tidewater Mucket
(Lampsilis cariosa &
Leptodea ochracea)
Threatened Species
Rare Species
(name withheld)
Legend
State Listed Animal Habitats
Block Connectors (Riparian)
Block Connectors (Roads)
Deer Wintering Areas
Wading Bird & Waterfowl Habitat
Roads
Wetlands
Undeveloped Habitat Blocks
0 0.375 0.75 1.5 2.25 3
Miles
Data Source: ME Geolibrary, USDA (NHD), USFWS (NWI) Maine IF&W (BwH)
Projection: NAD 1983, UTM Zone 19N
Created By: K. Goodwin, Ecological Instincts - August 2022
N
ecological
instincts


UNITY POND WATERSHED
Burnham, Thorndike, Troy & Unity, ME
LLRM BASINS
1
2
3
4
5
6
7
8
9
10
Meadow Brook
Carlton Stream
Carlton Pond
Unity Pond
Bithers Brook
Bog Brook
Legend
1 - Meadow Brook Upper
2 - Meadow Brook Lower
3 - NW Shoreline
4 - SW Shoreline
5 - SE Shoreline
6 - NE Shoreline
7 - Bithers Brook
8 - Bog Brook
9 - Carlton Stream
Unity Pond Direct Watershed
Carlton Pond Indirect Watershed
Data Source: ME GeoLibrary, NHDPlusHR, Ecological Instincts (sub-drinage delineations)
Projection: NAD 1983 UTM Zone 19N
Created by W. Baker, Ecological Instincts
May 2021
0 0.5 1 2 Miles
N

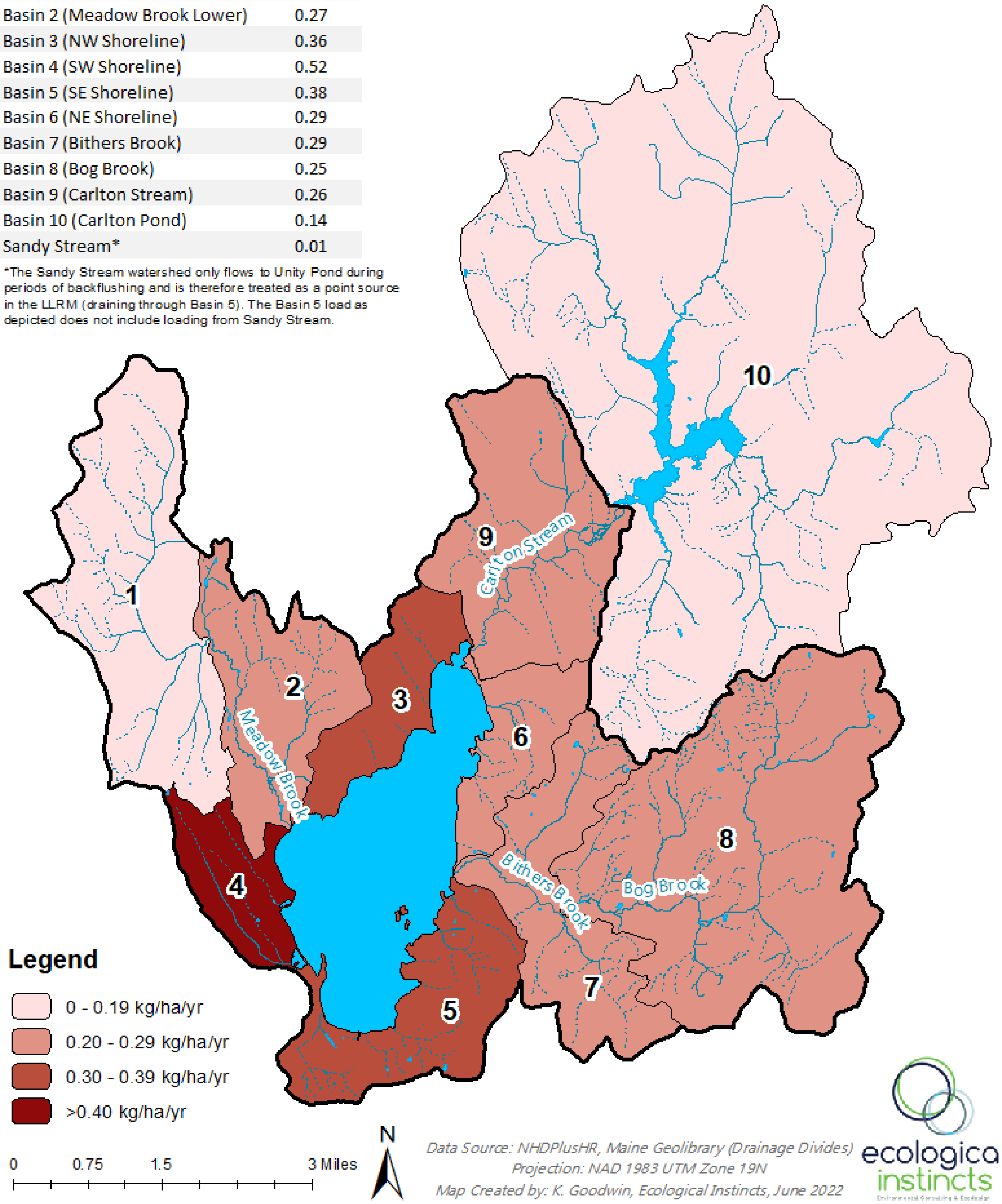
UNITY POND LLRM

P-load by Area (kg/ha/yr)

All Sub-Basins

Basin	kg/ha/yr
Basin 1 (Meadow Brook Upper)	0.19
Basin 2 (Meadow Brook Lower)	0.27
Basin 3 (NW Shoreline)	0.36
Basin 4 (SW Shoreline)	0.52
Basin 5 (SE Shoreline)	0.38
Basin 6 (NE Shoreline)	0.29
Basin 7 (Bithers Brook)	0.29
Basin 8 (Bog Brook)	0.25
Basin 9 (Carlton Stream)	0.26
Basin 10 (Carlton Pond)	0.14
Sandy Stream*	0.01

*The Sandy Stream watershed only flows to Unity Pond during periods of backflushing and is therefore treated as a point source in the LLRM (draining through Basin 5). The Basin 5 load as depicted does not include loading from Sandy Stream.

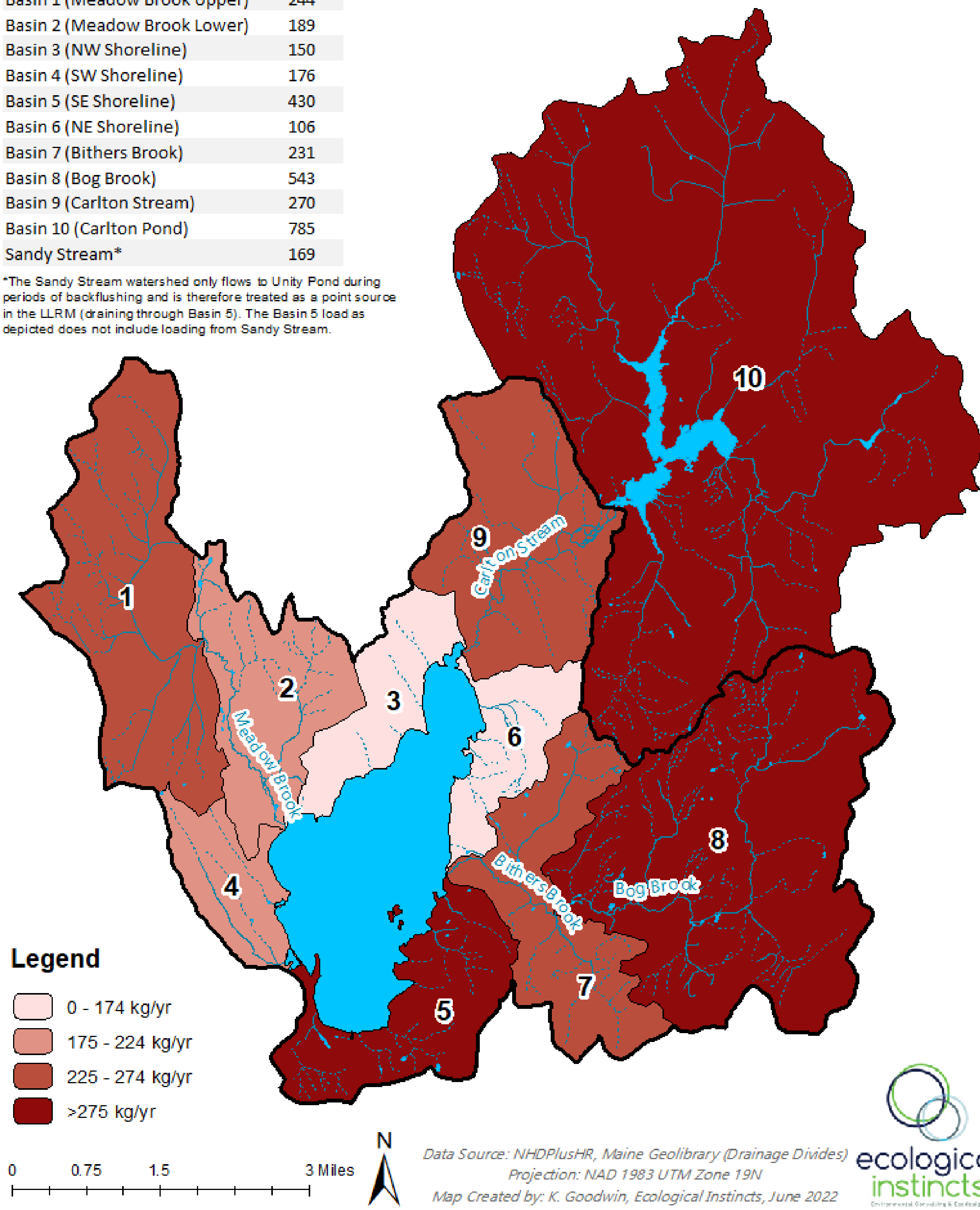


UNITY POND LLRM

P-load (kg/yr)
All Sub-Basins

Basin	kg/yr
Basin 1 (Meadow Brook Upper)	244
Basin 2 (Meadow Brook Lower)	189
Basin 3 (NW Shoreline)	150
Basin 4 (SW Shoreline)	176
Basin 5 (SE Shoreline)	430
Basin 6 (NE Shoreline)	106
Basin 7 (Bithers Brook)	231
Basin 8 (Bog Brook)	543
Basin 9 (Carlton Stream)	270
Basin 10 (Carlton Pond)	785
Sandy Stream*	169

*The Sandy Stream watershed only flows to Unity Pond during periods of backflushing and is therefore treated as a point source in the LLRM (draining through Basin 5). The Basin 5 load as depicted does not include loading from Sandy Stream.



Data Source: NHDPlusHR, Maine Geolibrary (Drainage Divides)
Projection: NAD 1983 UTM Zone 19N
Map Created by: K. Goodwin, Ecological Instincts, June 2022

APPENDIX D. Phosphorus Reduction Estimates Methods

Load reduction estimates for the 2023 Unity Pond WBMP were developed by Ecological Instincts for the Unity Pond WBMP update based on three methods including: 1) the US EPA Region 5 model to estimate P reductions that can be achieved by addressing NPS sites from the 2021 watershed survey, 2) Maine DEP Relational Method to provide a rough estimate of load reductions across all land cover types in the watershed as a percent of the total for each cover type, and 3) use of an empirical watershed model (Lake Loading Response Model) to finalize load reduction estimates, predict in-lake water quality conditions under different load reduction scenarios and provide water quality target scenarios for Steering Committee and Technical Advisory Committee members. Each step used to calculate load reductions was useful for preparing final load reduction estimates to help set the in-lake water quality target for Unity Pond over the next 10 years. A brief summary of each method is provided below.

1) Region 5 Model

The US EPA Region 5 (R5) Model[22] is an Excel spreadsheet-based model that provides estimates of sediment and nutrient load reductions from the implementation of Best Management Practices (BMPs). This method is used extensively for developing Pollutants Controlled Reports (PCR) for US EPA 319 grant projects. This method has been used to calculate load reduction estimates for several recent WBMP projects including the Great Pond WBMP, Long Pond WBMP, and China Lake WBMP.

R5 is used in this application using a desktop assessment of available watershed survey data (site description, land use type, problems/solutions, area of exposed soil, and photos of the sites). Rather than calculating soil loss estimates for 109 individual sites identified during the 2021 watershed survey, a subset of representative sites was selected based on the total number of sites (or percentage of sites) by land use type within each of the three impact categories (high, medium, or low). This included calculations for 100% of all high impact sites (16 sites), 25% of medium impact sites (13 sites), and 25% of low impact sites (10 sites).

Based on previous recommendations from Jeff Dennis (Maine DEP), a soil P concentration of 0.00012 lb. P/lb. soil was used in the model to calculate P reduction estimates. R5 defaults were used for the sediment and nitrogen values. R5 Gully Stabilization and Bank Stabilization estimates were used for all sites. Lateral Recession Rates (LRR) were entered into the model based on the site description and photographs for each site. BMP efficiency was set at 0.75 for Gully Stabilization sites and at 0.95 for Bank Stabilization sites for simplicity. A spreadsheet was prepared that includes variables used for each site and sorted by impact. The average of each parameter (sediment, P, N) was multiplied by the total number of sites by impact and then summed to develop final pollutant reduction estimates (37 tons/yr sediment, 3 kg/yr P, and 28 kg/yr N). for the NPS sites (Table D1).

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[22] https://www.epa.gov/nps/region-5-model-estimating-pollutant-load-reductions

Table D1. *Region 5 soil loss estimates for 2021 Unity Pond NPS sites.*

Total: High Impact Sites (16 sites)		
Sediment (t/yr.)	P (lbs./yr.)	N (lbs./yr.)
8.6	1.8	14.5
Total: Medium Impact Sites (53 sites)		
Sediment (t/yr.)	P (lbs./yr.)	N (lbs./yr.)
18.0	3.7	30.5
Total: Low Impact Sites (71 Sites)		
Sediment (t/yr.)	P (lbs./yr.)	N (lbs./yr.)
10.1	2.1	17.0

Total (P= lbs/yr)		
Sediment (t/yr.)	P (lbs./yr.)	N (lbs./yr.)
37	8	62
Total (P= kg/yr)		
Sediment (t/yr.)	P (kg/yr.)	N (kg/yr.)
37	3	28

Soil P Concentration (lb/lb soil) = 0.00012

1) **DEP Relational Method**

The *Relational Method for Estimating Required and Projected Load Reductions*[23] is the second method used to estimate potential load reductions that could be achieved in the Unity Pond watershed. This model estimates the percent of various sources of P in the watershed by land use type expressed as a fraction of the total contributing P sources times the fraction to be addressed times a BMP efficiency. The result is an estimate of the fraction of the load reduced for each land use type.

A land cover analysis was completed to calculate the area of each land cover type within the Unity Pond direct watershed using the MELCD (2004) land cover layer modified by Ecological Instincts (2021) by comparing the layer to aerial imagery and manually editing polygons. To estimate load reductions, the P export coefficient assigned to each land cover type in the empirical model was used to estimate the P load from each land cover type, and the fraction of the total P load for each land cover category was calculated (Table D2).3 "Fraction addressed" was applied to the P load for each land cover type (ranging from 50% for developed open space and timber harvesting to 75% for septic systems) and 100% for the internal load. BMP efficiencies were applied for each category based on various literature sources and values used for past WBMP projects. A BMP efficiency of 0.9 was applied for the internal load, representing a 90% reduction in the internal load. Other BMP efficiencies ranged from 0.37 (row crops) to 0.78 (timber harvesting). The fractions addressed were multiplied by the BMP efficiencies to calculate the P load reduction by category (Table D3). A separate tab was prepared to estimate potential load reductions in the indirect watershed of Carlton Pond using the same method. The total

[23] Jeff Dennis, Division of Watershed Management, MEDEP, n.d.

fraction that could be reduced in the watershed based on the conditions above was estimated at 1,356 kg P/yr, or 33% of the total load.

Table D2. *Values used for the DEP Relational Method for the Unity Pond Watershed*

LC Type	P Export Coefficient (kg/ha/yr)	Total area (ha)	P Load (kg/yr)	Fraction of Load
Hay/Grazing	0.80	542	433	0.086
Row Crop	2.00	85	169	0.034
Developed, Low Intensity	0.90	237	213	0.042
Developed, Medium Intensity	1.00	87	87	0.017
Developed Open Space	1.10	136	150	0.030
Roads	1.25	149	186	0.037
Upland Forest	0.14	4397	616	0.122
Open Water	0.10	49	5	0.001
Scrub/Shrub	0.12	6	1	0.000
Barren Land (Rock/Sand/Clay)	0.80	8	6	0.001
Forested Wetlands	0.12	1482	178	0.035
Emergent Herbaceous Wetlands	0.20	182	36	0.007
Recent Timber Harvesting	2.00	496	992	0.197
Sandy Stream (point source)			169	0.034
Carlton Pond (Indirect)			785	0.156
Septic Systems			45	0.009
Waterfowl			50	0.010
Atmospheric			103	0.020
Internal			812	0.161
TOTAL		**7857**	**5038**	**1.000**

2) <u>Empirical Model Application</u>

The Relational Method helped guide relative load reduction estimates for use in the empirical model. Within the empirical model, the following reductions were applied: direct watershed (690 kg/yr), upstream indirect watersheds of Carlton Pond and Sandy Stream (110 and 11 kg/yr, respectively), internal loading (731 kg/yr), and septic systems (14 kg/yr).

Table D3: *DEP Relational Method for estimating phosphorus reductions in the Unity Pond watershed.*[24]

UNITY POND

Source Type	Sub-type	Fraction of total load	Fraction Addressed	Expected BMP Efficiency	Load Fraction Reduced	Total P Reduced (kg/yr)
Agriculture						
	Row Crop	0.034	0.6	0.37	0.7%	30.9
	Hay/Grazing	0.086	0.6	0.45	2.3%	96.1
						127
Urban Development						
	Low Intensity Development	0.042	0.7	0.42	1.2%	51.5
	Medium Intensity Development/Com	0.017	0.7	0.40	0.5%	20.1
	Developed Open Space	0.030	0.5	0.40	0.6%	24.6
	Roads	0.037	0.6	0.40	0.9%	36.7
	Excavated Land (Rock/Sand/Clay)	0.001	0	0.40	0.0%	0.0
						133
Non-Developed Land						
	Unmanaged Forest	0.122	0	0	0.0%	
	Timber Harvesting	0.197	0.5	0.78	7.7%	**318**
	Open Water	0.001	0	0	0.0%	
	Scrub/Shrub	0.000	0	0	0.0%	
	Emergent Wetlands	0.007	0	0	0.0%	
	Forested Wetlands	0.035	0	0	0.0%	
Other Load Types						
Atmospheric		0.020	0	0	0.0%	
Waterfowl		0.010	0	0	0.0%	
Septic Systems		0.009	0.75	0.5	0.3%	**14**
Internal		0.161	1	0.9	17.7%	**732**
Carlton Pond		0.156	0.082	0.4	0.5%	**110**
Sandy Stream		0.034	0.2	0.4	0.3%	**11**
	Total	**1.00**			**33%**	**1356**

Load Reduction	kg/yr
TP Export Load kg TP (current)	4135
TP Export Loading Target	2779
TP Reduction Needed	**1356**
% Reduction Possible	**33%**

Direct watershed= 690 kg/yr
Internal Loading= 731 kg/yr
Septic Systems= 14 kg/yr
Carlton (indirect)= 110 kg/yr
Sandy Stream (indirect)= 11 kg/yr
Total= 1,556 kg P/yr

Notes:
The Maine DEP Relational Method (above) was used to provide rough estimates for possible load reductions for use in the LLRM to set water quality targets. Therefore, the TP Loading Target and Reducation Target above do not match with final load reduction targets used in the WBMP.
The US EPA Region 5 model was used to calculate soil loss estimates for 2021 watershed survey sites.
Refer to Summary (P Conc=0.00012) tab in this spreadsheet or *UnityPond_SoilLossEst_29March22*

[24] Values on lower right indicate final P reduction values by source used in the empirical model and vary slightly from the output of the Relational Method

The total estimated P load reduction for Unity Pond from the empirical model is 1,556 kg/yr, a reduction of 38% from the current estimated load of 4,135 kg/yr. This reduction is estimated to result in an 8 ppb decrease in the annual average in-lake TP concentration (from 27 ppb to 19 ppb). The probability of Unity Pond experiencing an algal bloom would decrease from 64% to 31%, water clarity is expected to improve by 0.4 m, and Chl-a is expected to decrease by 3.8 ppb. An overview of the empirical modeling outputs under different management scenarios is provided in Table D4.

Table D5. *Empirical modeling scenarios used to set the water quality target for the Unity Pond WBMP.*[25]

Unity Pond Water Quality Targets

In-lake P concentration	**11**	**30**	**27**	**24**	**20**	**19** ★	**15**
Reduction (kg/yr) from Current Total P Load	*-1952*	*+801*	*0*	*-904*	*-1435*	*-1556*	*-2118*
	Background Conditions	**Future Development/ 10% Climate Change Scenario**	**Current**	**Watershed management (Direct watershed) & Septic systems (22% Reduction)**	**Watershed management (Direct watersheds), Septic systems & Internal Load (35% Reduction)**	**Watershed management (Direct & Indirect watersheds), Septic systems & Internal Load (38% Reduction)**	**2004 TMDL WQ Target (51% Reduction)**
Atmospheric	51	103	**103**	103	103	103	103
Internal Load	23	894	**812**	812	81	81	81
Waterfowl	50	50	**50**	50	50	50	50
Septic Systems	0	45	**45**	31	31	31	23
Watershed Load	2058	3845	**3125**	2235	2435	2314	1760
TOTAL LOAD TO LAKE	**2183**	**4936**	**4135**	**3231**	**2700**	**2579**	**2017**
SDT Avg	3.8	1.7	**1.9**	2.0	2.3	2.3	2.9
SDT Max	5.1	3.8	**3.9**	4.0	4.2	4.2	4.6
Chl-a Avg	3.2	12.5	**10.8**	9.4	7.5	7.0	5.1
Chl-a Max	12	42	**37**	32	26	24	18
Bloom Probability	2%	74%	**64%**	53%	35%	31%	13%
Flushing Rate	**2.4**	**1.4**	**1.3**				

[25] Various modeling scenarios were prepared to assess load reductions including the 2004 TMDL target which was determined not to be feasible based on current lake and watershed conditions. Future development and background conditions were also estimated (increased load) which are described in the Unity Pond LLRM Memo prepared by Ecological Instincts

APPENDIX E. UNITY POND NPS SITES

UNITY POND NPS SITES (Maine DEP, 2021a)

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.

Sector & Site	Flow path to lake	Land use	Problem	Recommendations	Impact Rating	Cost to Fix	Technical Level
1-01	Directly into lake	Residential	Surface Erosion-Rill, Shoreline-Lack of Shoreline Vegetation, Shoreline-Undercut, Shoreline-Inadequate Shoreline Vegetation, Shoreline-Erosion	Add to Buffer, Establish Buffer	High	Medium	Low
1-02	Minimal Vegetation	Residential	Surface Erosion-Sheet, Shoreline-Lack of Shoreline Vegetation	Vegetate Ditch, Armor with Stone, Drywell @ gutter downspout, Add to Buffer, Establish Buffer, Rain Garden, Mulch/Erosion Control Mix	Low	Medium	Medium
1-03	Directly into lake	Driveway	Road Shoulder Erosion-Sheet	Vegetate Ditch, Armor with Stone, Vegetate Shoulder	Low	Medium	Low
1-04	Directly into lake	Residential	Road Shoulder Erosion-Gully, Soil-Bare, Shoreline-Erosion	Vegetate Shoulder, Stabilize Foot Path, Define Foot Path, Erosion Control Mulch, Infiltration Steps, Establish Buffer, Reseed bare soil & thinning grass, Mulch/Erosion Control Mix	Medium	Medium	Medium
1-05	Minimal Vegetation	Town Road	Surface Erosion-Sheet, Road Shoulder Erosion-Rill	Build Up Road, Reshape (Crown), Add gravel	Medium	High	High
1-06	Minimal Vegetation	Residential	Surface Erosion-Sheet	Stabilize Foot Path, Define Foot Path, Erosion Control Mulch, Establish Buffer, Add to Buffer, Reseed bare soil & thinning grass	Low	Low	Low
1-07	Stream	Town Road	Culvert-Crushed Broken, Culvert-Unstable inlet/outlet	Replace Culvert, Armor Culvert Inlet/Outlet	Low	High	High
1-11	Stream	Private Road	Surface Erosion-Gully, Culvert-Unstable inlet/outlet	Armor Culvert Inlet/Outlet, Lengthen Culvert, Replace Culvert, Install Plunge Pool	Medium	Medium	Medium
1-12	Directly into lake	Beach Access	Shoreline-Unstable Access	Stabilize Foot Path, Infiltration Steps	Low	Low	Low
1-13	Ditch	Municipal / Public	Culvert-Crushed Broken, Culvert-Unstable inlet/outlet, Road Shoulder Erosion-Gully	Replace Culvert	Low	Medium	Low
2-00	Directly into lake	Residential	Surface Erosion-Gully	Infiltration Steps, Install Runoff Diverter (waterbar)	Medium	Medium	Medium
2-01	Directly into lake	Residential	Surface Erosion-Sheet, Shoreline-Erosion	Add to Buffer, Mulch/Erosion Control Mix	Medium	Low	Low
2-02	Directly into lake	Residential	Surface Erosion-Gully	Establish Buffer, Install Runoff Diverter (waterbar)	Medium	Medium	Low
2-03	Directly into lake	Residential	Roof Runoff Erosion	Infiltration Trench @ roof dripline, Drywell @ gutter downspout	Medium	Medium	Medium

Sector & Site	Flow path to lake	Land use	Problem	Recommendations	Impact Rating	Cost to Fix	Technical Level
2-04	Directly into lake	Residential	Surface Erosion-Sheet, Soil-Bare, Roof Runoff Erosion	Infiltration Trench @ roof dripline, mulch/ECM, reseed bare soil & thinning grass	Medium	Medium	Medium
2-05	Directly into lake	Residential	Surface Erosion-Sheet	Establish Buffer, Install Runoff Diverter (waterbar)	Low	Low	Low
2-06	Directly into lake	Residential	Roof Runoff Erosion, Other: Construction erosion- septic	Seed/Hay, Infiltration Trench @ roof dripline	Medium	Medium	Medium
2-07	Directly into lake	Residential	Surface Erosion-Sheet	Establish Buffer, Install Runoff Diverter (waterbar)	Low	Low	Low
2-08	Directly into lake	Residential	Surface Erosion-Sheet	Infiltration Steps, Install Runoff Diverter (waterbar) , Establish Buffer, Install Runoff Diverter (waterbar)	Medium	Medium	Medium
2-09	Directly into lake	Residential	Shoreline-Lack of Shoreline Vegetation, Shoreline-Erosion	Add to Buffer, Install Runoff Diverter (waterbar)	Medium	Medium	Medium
2-10	Directly into lake	Residential	Surface Erosion-Sheet, Roof Runoff Erosion	Infiltration Steps, Install Runoff Diverter (waterbar)	Low	Low	Medium
2-11	Directly into lake	Residential	Surface Erosion-Rill, Roof Runoff Erosion	Install Runoff Diverter (waterbar), Infiltration Steps, Infiltration Trench @ roof dripline, Install Runoff Diverter (waterbar), Mulch/Erosion Control Mix	Medium	Medium	Medium
2-12	Directly into lake	Residential	Shoreline-Lack of Shoreline Vegetation, Roof Runoff Erosion	Establish Buffer, Infiltration Trench	Low	Low	Low
2-13	Directly into lake	Residential	Shoreline-Lack of Shoreline Vegetation, Shoreline-Erosion	Establish Buffer, Install Runoff Diverter (waterbar)	Low	Low	Low
2-14	Directly into lake	Residential	Surface Erosion-Sheet, Shoreline-Lack of Shoreline Vegetation	Establish Buffer	Low	Low	Low
2-15	Directly into lake	Residential	Surface Erosion-Sheet	Infiltration Steps, Install Runoff Diverter (waterbar), Erosion Control Mulch	Medium	Medium	Medium
2-16	Ditch	State Road	Culvert-Unstable inlet/outlet	Install Plunge Pool	Medium	Low	Low
2-17	Stream	State Road	Culvert-Unstable inlet/outlet	Install Plunge Pool	Low	Low	Low
3-01	Directly into lake	Residential	Surface Erosion-Sheet, Soil-Bare, Shoreline-Lack of Shoreline Vegetation	Define Foot Path, Erosion Control Mulch, Establish Buffer, No Raking, Reseed bare soil & thinning grass	Low	Medium	Low
3-02	Directly into lake	Boat Access	Surface Erosion-Gully, Surface Erosion-Rill, Soil-Bare, Shoreline-Erosion, Shoreline-Unstable Access	Build Up Road, Add gravel, Reshape (Crown), Install Runoff Diverters-Waterbar, Install Runoff Diverters-Rubber Razor	Medium	Medium	Medium
3-03	Directly into lake	Residential	Surface Erosion-Rill, Soil-Bare	Define Foot Path, Erosion Control Mulch, No Raking, Reseed bare soil & thinning grass	Medium	Medium	Low
3-04	Directly into lake	Private Road	Surface Erosion-Rill, Surface Erosion-Sheet, Road Shoulder Erosion-Rill	Remove Grader/Plow Berms, Add gravel to road, Build Up, Reshape (Crown), Vegetate Shoulder, Install Runoff Diverters-Broad-based Dip	Medium	Medium	Medium

Sector & Site	Flow path to lake	Land use	Problem	Recommendations	Impact Rating	Cost to Fix	Technical Level
3-05	Directly into lake	Residential	Surface Erosion-Sheet, Surface Erosion-Rill, Shoreline-Lack of Shoreline Vegetation, Shoreline-Erosion, Shoreline-Unstable Access	Establish Buffer	Medium	Medium	Medium
3-06	Directly into lake	Boat Access	Surface Erosion-Rill, Surface Erosion-Sheet, Road Shoulder Erosion-Rill, Road Shoulder Erosion-Sheet, Shoreline-Erosion, Shoreline-Unstable Access	Build Up Road, Add gravel, Install Runoff Diverter (waterbar)	Medium	Medium	Medium
3-07	Directly into lake	Private Road	Surface Erosion-Rill, Surface Erosion-Sheet, Roadside Plow/Grader Berm	Remove Grader/Plow Berms, Build Up Road, Add gravel, Reshape (Crown)	High	High	Medium
3-08	Directly into lake	Private Road	Surface Erosion-Rill, Surface Erosion-Sheet, Roadside Plow/Grader Berm	Add gravel to road, Reshape (Crown) Road	High	High	Medium
3-09	Directly into lake	Driveway	Surface Erosion-Gully	Add gravel to road, Install Runoff Diverter (waterbar)	Medium	Medium	Medium
3-10	Directly into lake	Private Road	Surface Erosion-Gully, Roadside Plow/Grader Berm	Add gravel to road, Install Runoff Diverters-Broad-based Dip, Install Runoff Diverters-Waterbar	Medium	High	Medium
3-11	Directly into lake	Residential	Surface Erosion-Sheet, Soil-Bare	Stabilize Foot Path, Define Foot Path, Infiltration Steps, Erosion Control Mulch, Mulch/Erosion Control Mix	Low	Low	Low
3-12	Directly into lake	Residential	Surface Erosion-Sheet, Soil-Bare	Establish Buffer, No Raking, Reseed bare soil & thinning grass, Mulch/Erosion Control Mix	Low	Low	Low
3-13	Directly into lake	Beach Access	Surface Erosion-Gully	Reshape (Crown) Road, Install Runoff Diverters-Waterbar	Medium	Medium	Low
3-14	Directly into lake	Residential	Surface Erosion-Sheet, Surface Erosion-Rill, Soil-Bare, Shoreline-Inadequate Shoreline Vegetation, Shoreline-Erosion, Shoreline-Unstable Access	Reseed bare soil & thinning grass, Add to Buffer, No Raking, Mulch/Erosion Control Mix	Medium	Low	Medium
3-15	Directly into lake	Residential	Shoreline-Undercut, Shoreline-Inadequate Shoreline Vegetation, Shoreline-Erosion	Establish Buffer, Rip Rap	High	High	High
3-16	Minimal Vegetation	Driveway	Surface Erosion-Sheet, Surface Erosion-Rill	Add gravel to road, Reshape (Crown) Road, Mulch/Erosion Control Mix	Medium	Medium	Low
3-17	Directly into lake	Residential	Surface Erosion-Rill, Surface Erosion-Sheet, Soil-Bare, Shoreline-Erosion	Stabilize Foot Path, Install Runoff Diverter (waterbar), Reseed bare soil & thinning grass, No Raking, Add to Buffer, Install Runoff Diverter (waterbar), Mulch/Erosion Control Mix	Medium	Low	Low

Sector & Site	Flow path to lake	Land use	Problem	Recommendations	Impact Rating	Cost to Fix	Technical Level
3-18	Directly into lake	Residential	Surface Erosion-Sheet, Shoreline-Lack of Shoreline Vegetation	Add to Buffer, No Raking, Reseed bare soil & thinning grass, Mulch/Erosion Control Mix, Install Runoff Diverter (waterbar)	Low	Low	Low
3-19	Directly into lake	Driveway	Surface Erosion-Sheet, Surface Erosion-Rill	Reshape (Crown) Road, Install Runoff Diverters-Rubber Razor	Low	Low	Low
3-20	Directly into lake	Residential	Surface Erosion-Sheet, Soil-Bare	Stabilize Foot Path, Establish Buffer, Mulch/Erosion Control Mix	Low	Low	Low
3-21	Stream	Private Road	Culvert-Unstable inlet/outlet, Culvert-Crushed Broken, Road Shoulder Erosion-Sheet, Road Shoulder Erosion-Rill	Replace Culvert, Armor Culvert Inlet/Outlet, Lengthen Culvert	Medium	High	Medium
4-00	Directly into lake	Residential	Surface Erosion-Sheet	Infiltration Steps, Install Runoff Diverter (waterbar), Erosion Control Mulch, Establish Buffer	Medium	Medium	Medium
4-01	Stream	State Road	Road Shoulder Erosion-Rill, Shoreline-Erosion	Build Up Road, Pave, Rip Rap	Low	Low	Low
4-01a	Minimal Vegetation	Residential	Surface Erosion-Rill, Soil-Delta in Stream/Lake, Roof Runoff Erosion	Vegetate Ditch, Armor with Stone, Infiltration Trench @ roof dripline, Drywell @ gutter downspout, Rain Barrel, Add to Buffer, Install Runoff Diverter (waterbar), Mulch/Erosion Control Mix, Rain Garden	Low	Low	Low
4-02	Ditch	Private Road	Surface Erosion-Gully, Culvert-Unstable inlet/outlet, Culvert-Clogged, Ditch-Gully Erosion, Ditch-Bank Failure, Road Shoulder Erosion-Sheet, Soil-Bare	Armor Culvert Inlet/Outlet, Remove Clog, Install Plunge Pool, Armor Ditch with Stone, Reshape Ditch, Remove debris/sediment, Install Sediment Pools	Low	Low	Low
4-03	Minimal Vegetation	Residential	Surface Erosion-Gully, Roof Runoff Erosion	Infiltration Trench @ roof dripline, Drywell @ gutter downspout, Rain Barrel	Medium	Low	Low
4-04	Minimal Vegetation	Driveway	Surface Erosion-Sheet, Ditch-Undersized, Ditch-Sheet Erosion, Road Shoulder Erosion-Sheet, Roof Runoff Erosion	Install Ditch, Install Check Dams, Reshape (Crown) Road, Vegetate Shoulder, Install Catch Basin, Install Runoff Diverters-Open Top Culvert, Install Runoff Diverters-Rubber Razor, Infiltration Trench @ roof dripline, Drywell @ gutter downspout, Rain Barrel, Install Runoff Diverter (waterbar), Mulch/Erosion Control Mix, Rain Garden, Infiltration Trench	Low	Medium	Medium
4-05	Minimal Vegetation	Private Road	Surface Erosion-Gully, Culvert-Undersized, Ditch-Bank Failure, Ditch-Gully Erosion, Ditch-Undersized, Road Shoulder Erosion-Sheet, Soil-Bare	Install Culvert, Armor with Stone, Reshape Ditch, Install Check Dams, Add gravel to road, Install Runoff Diverters-Broad-based Dip, Reshape (Crown) Road, Install Catch Basin, Install Runoff Diverters-Open Top Culvert, Install Runoff Diverters-Rubber Razor, Install Runoff Diverters-Waterbar	Medium	Medium	Medium

Sector & Site	Flow path to lake	Land use	Problem	Recommendations	Impact Rating	Cost to Fix	Technical Level
4-06	Ditch	Private Road	Surface Erosion-Gully, Culvert-Unstable inlet/outlet, Culvert-Undersized, Ditch-Gully Erosion, Ditch-Bank Failure, Ditch-Undersized, Road Shoulder Erosion-Gully, Soil-Bare	Armor Culvert Inlet/Outlet, Install Plunge Pool, Vegetate Ditch, Armor with Stone, Remove debris/sediment	Medium	Medium	Low
4-07	Directly into lake	Residential	Surface Erosion-Sheet, Shoreline-Lack of Shoreline Vegetation, Roof Runoff Erosion	Establish Buffer, Install Runoff Diverter (waterbar), Rain Garden, Water Retention Swales, Rip Rap	Low	Low	Low
4-08	Ditch	Residential	Surface Erosion-Gully, Culvert-Unstable inlet/outlet, Culvert-Undersized, Ditch-Gully Erosion, Road Shoulder Erosion-Sheet, Soil-Bare	Armor Culvert Inlet/Outlet, Install Plunge Pool, Vegetate Ditch, Armor with Stone, Reshape Ditch	Medium	Medium	Low
4-09	Directly into lake	Residential	Surface Erosion-Sheet, Shoreline-Lack of Shoreline Vegetation, Roof Runoff Erosion	Infiltration Trench @ roof dripline, Drywell @ gutter downspout, Rain Barrel, Establish Buffer, Rain Garden, Install Runoff Diverter (waterbar), Rip Rap	Low	Low	Low
4-10	Directly into lake	Residential	Surface Erosion-Sheet, Shoreline-Lack of Shoreline Vegetation, Shoreline-Inadequate Shoreline Vegetation, Shoreline-Erosion	Define Foot Path, Establish Buffer, Add to Buffer, Rain Garden	Low	Low	Low
5-01	Stream	Town Road	Culvert-Clogged, Culvert-Unstable inlet/outlet, Other: potholes	Remove Culvert Clog, Armor Culvert Inlet/Outlet, Reshape (Crown) Road	Medium	Medium	Medium
5-02	Stream	Town Road	Road Shoulder Erosion-Rill, Soil-Bare, Other: steep unstable bank where culvert is	Armor Culvert Inlet/Outlet	Low	Medium	Medium
5-03	Stream	Driveway	Surface Erosion-Gully, Other: stream crosing on driveway- did not investigate but may need attention.	Build Up Road, Add gravel, Reshape (Crown), Install Runoff Diverters-Rubber Razor	Medium	Medium	Medium
5-04	Stream	Town Road	Culvert-Unstable inlet/outlet, Road Shoulder Erosion-Rill, Road Shoulder Erosion-Gully	Armor Culvert Inlet/Outlet, Install Ditch, Install Sediment Pools, Vegetate Shoulder	Medium	Medium	Medium
5-05	Stream	State Road	Culvert-Crushed Broken, Culvert-Undersized, Culvert-Unstable inlet/outlet, Other: culvert totally rusted out	Replace Culvert, Armor Culvert Inlet/Outlet, Enlarge Culvert, Lengthen Culvert	Medium	High	Medium
6-01	Stream	State Road	Surface Erosion-Sheet, Ditch-Undersized, Road Shoulder Erosion-Sheet	Rip Rap	Medium	Low	Medium

Sector & Site	Flow path to lake	Land use	Problem	Recommendations	Impact Rating	Cost to Fix	Technical Level
6-02	Stream	State Road	Surface Erosion-Gully, Road Shoulder Erosion-Sheet	Install Ditch, Install Sediment Pools	Medium	Medium	Medium
6-03	Ditch	State Road	Surface Erosion-Sheet, Ditch-Sheet Erosion, Road Shoulder Erosion-Sheet	Vegetate Ditch, Reshape Ditch, Armor with Stone	Medium	Medium	High
6-04	Ditch	Town Road	Surface Erosion-Sheet, Ditch-Bank Failure	Vegetate Ditch, Armor with Stone, Reshape Ditch, Remove Invasive Plants	Low	Medium	Medium
6-05	Ditch	Town Road	Ditch-Sheet Erosion, Road Shoulder Erosion-Sheet	Armor Culvert Inlet/Outlet, Vegetate Ditch, Armor with Stone, Vegetate Shoulder, Remove Invasive Plants	Low	Low	Medium
7-01	Directly into lake	Residential	Surface Erosion-Gully, Ditch-Gully Erosion	Armor with Stone, Install Turnouts	High	Medium	Medium
7-02	Directly into lake	Beach Access	Surface Erosion-Rill, Soil-Bare, Shoreline-Erosion, Shoreline-Unstable Access	Define Foot Path, Stabilize Foot Path, Establish Buffer	Medium	Medium	Low
7-03	Ditch	Residential	Surface Erosion-Rill, Ditch-Rill Erosion	Vegetate Ditch, Armor with Stone	Medium	Medium	Medium
7-04	Directly into lake	Residential	Ditch-Sheet Erosion, Ditch-Rill Erosion	Vegetate, Rain Garden	Low	Low	Low
8-01	Directly into lake	Residential	Surface Erosion-Sheet, Soil-Bare, Shoreline-Unstable Access	Define Foot Path, Erosion Control Mulch, Infiltration Steps, Add to Buffer, Reseed bare soil & thinning grass	Low	Low	Low
8-02	Directly into lake	Private Road	Surface Erosion-Rill, Culvert-Unstable inlet/outlet, Culvert-Undersized, Other: Drainage possibly former stream downcutting. Heavy flow in spring and road overtopping. Erosion on downstream side of culvert.	Enlarge Culvert, Armor Culvert Inlet/Outlet, Replace Culvert, Armor Ditch with Stone, Install Check Dams	Medium	High	Medium
8-03	Minimal Vegetation	Boat Access	Surface Erosion-Gully, Soil-Bare, Shoreline-Erosion, Shoreline-Unstable Access, Other: Grassy orivate boat launch wet and impacted by vehicles creating ruts.	Stabilize	High	Medium	Medium
8-04	Directly into lake	Residential	Surface Erosion-Sheet, Soil-Bare, Shoreline-Lack of Shoreline Vegetation, Other: Bare soil in planting area above riprap.	Add to Buffer, Reseed bare soil & thinning grass, Mulch/Erosion Control Mix	Low	Low	Low
8-05	Directly into lake	Driveway	Surface Erosion-Sheet, Soil-Bare, Shoreline-Lack of Shoreline Vegetation, Other: Dirt brought in for driveway and	Establish Buffer, Reseed bare soil & thinning grass	Low	Low	Low

Sector & Site	Flow path to lake	Land use	Problem	Recommendations	Impact Rating	Cost to Fix	Technical Level
			lawn but not seeded and loose dirt close to lake.				
8-06	Minimal Vegetation	Residential	Surface Erosion-Rill, Soil-Bare, Shoreline-Undercut, Shoreline-Lack of Shoreline Vegetation, Shoreline-Inadequate Shoreline Vegetation, Shoreline-Unstable Access, Roof Runoff Erosion	Infiltration Trench @ roof dripline, Establish Buffer, Rain Garden	Medium	Medium	Medium
8-07	Minimal Vegetation	Residential	Surface Erosion-Sheet, Soil-Bare, Shoreline-Inadequate Shoreline Vegetation, Shoreline-Lack of Shoreline Vegetation, Shoreline-Erosion, Roof Runoff Erosion	Drywell @ gutter downspout, Rain Barrel, Establish Buffer, Reseed bare soil & thinning grass, No Raking	Low	Low	Low
8-08	Directly into lake	Residential	Surface Erosion-Gully, Shoreline-Undercut, Shoreline-Inadequate Shoreline Vegetation	Add to Buffer, Rip Rap	High	High	Medium
8-08a	Minimal Vegetation	Boat Access	Surface Erosion-Rill, Soil-Bare, Shoreline-Undercut, Shoreline-Unstable Access, Shoreline-Erosion, Other: Uncovered sand pile	Infiltration Steps, Define Foot Path, Erosion Control Mulch, Establish Buffer, Reseed bare soil & thinning grass	Medium	Medium	Medium
8-09	Minimal Vegetation	Driveway	Surface Erosion-Sheet, Soil-Bare, Other: Extended driveway/boat launch all the way to shoreline.	Install Runoff Diverters-Rubber Razor	Low	Low	Medium
8-10	Stream	Private Road	Culvert-Unstable inlet/outlet, Other: Culvert misaligned	Armor Culvert Inlet/Outlet	Medium	Low	Low
8-11	Minimal Vegetation	Residential	Surface Erosion-Gully, Shoreline-Undercut, Shoreline-Lack of Shoreline Vegetation, Shoreline-Erosion	Establish Buffer, Rip Rap	Medium	High	Medium
8-12	Directly into lake	Beach Access	Surface Erosion-Sheet, Soil-Bare, Shoreline-Unstable Access	Define Foot Path, Erosion Control Mulch, Infiltration Steps, Establish Buffer, No Raking, Reseed bare soil & thinning grass	Low	Low	Low
8-13	Directly into lake	Residential	Surface Erosion-Rill, Soil-Bare, Shoreline-Undercut, Shoreline-Unstable Access, Shoreline-Lack of Shoreline Vegetation, Shoreline-Erosion, Other: Firepit ash close to shore	Define Foot Path, Erosion Control Mulch, Establish Buffer, No Raking, Reseed bare soil & thinning grass	Medium	Low	Medium

Sector & Site	Flow path to lake	Land use	Problem	Recommendations	Impact Rating	Cost to Fix	Technical Level
8-14	Directly into lake	Beach Access	Surface Erosion-Rill, Soil-Bare, Shoreline-Unstable Access, Shoreline-Inadequate Shoreline Vegetation, Shoreline-Erosion, Shoreline-Undercut, Other: Sheet erosion over bare soil in yard	Define Foot Path, Erosion Control Mulch, Infiltration Steps, Establish Buffer, No Raking, Reseed bare soil & thinning grass, Rip Rap, Mulch/Erosion Control Mix	Medium	Medium	Medium
8-15	Minimal Vegetation	Driveway	Surface Erosion-Sheet, Soil-Bare	Install Runoff Diverters-Open Top Culvert, Add gravel	Low	Medium	Medium
8-16	Minimal Vegetation	Driveway	Surface Erosion-Sheet	Install Runoff Diverters-Rubber Razor	Medium	Medium	Medium
8A-01	Directly into lake	Residential	Surface Erosion-Sheet,Surface Erosion-Gully, Soil-Bare, Shoreline-Inadequate Shoreline Vegetation	Establish Buffer, Add to Buffer, No Raking, Reseed bare soil & thinning grass, Water Retention Swales, Mulch/Erosion Control Mix	High	Low	Low
8A-02	Directly into lake	Residential	Surface Erosion-Sheet, Soil-Bare, Shoreline-Inadequate Shoreline Vegetation	No Raking, Reseed bare soil & thinning grass	Low	Low	Low
9-01	Directly into lake	Trail or Path	Surface Erosion-Sheet, Shoreline-Inadequate Shoreline Vegetation	Install Runoff Diverters-Broad-based Dip , Define Foot Path, Infiltration Steps, Establish Buffer	Low	Low	Medium
9-02	Directly into lake	Municipal / Public	Surface Erosion-Gully, Culvert-Unstable inlet/outlet, Ditch-Bank Failure, Ditch-Gully Erosion, Road Shoulder Erosion-Sheet, Soil-Winter Sand, Shoreline-Lack of Shoreline Vegetation, Shoreline-Inadequate Shoreline Vegetation, Shoreline-Erosion, Shoreline-Unstable Access	Install Plunge Pool, Vegetate Ditch, Armor Ditch with Stone, Reshape Ditch, Install Check Dams, Install Sediment Pools, Establish Buffer	High	High	High
9-03	Directly into lake	Municipal / Public	Surface Erosion-Gully, Surface Erosion-Sheet, Soil-Bare, Shoreline-Lack of Shoreline Vegetation, Shoreline-Erosion	Establish Buffer, Mulch/Erosion Control Mix, Rip Rap	High	High	High
9-04	Directly into lake	Residential	Surface Erosion-Gully, Soil-Bare, Shoreline-Lack of Shoreline Vegetation, Shoreline-Inadequate Shoreline Vegetation, Shoreline-Erosion	Add to Buffer, Establish Buffer, Rip Rap	High	High	High
9-05	Directly into lake	State Road	Surface Erosion-Sheet, Culvert-Unstable inlet/outlet, Road Shoulder Erosion-Rill, Road Shoulder Erosion-Sheet, Soil-Bare	Armor Culvert Inlet/Outlet, Install Plunge Pool, Remove debris/sediment, Reshape Ditch, Rip Rap	High	High	High
9-06	Directly into lake	Residential	Shoreline-Undercut, Shoreline-Lack of Shoreline Vegetation, Shoreline-Erosion,	Establish Buffer, Add to Buffer	Medium	Medium	Medium

Sector & Site	Flow path to lake	Land use	Problem	Recommendations	Impact Rating	Cost to Fix	Technica l Level
			Shoreline-Inadequate Shoreline Vegetation				
9-07	Directly into lake	Residential	Surface Erosion-Sheet, Shoreline-Undercut, Shoreline-Lack of Shoreline Vegetation, Shoreline-Inadequate Shoreline Vegetation, Shoreline-Erosion, Roof Runoff Erosion	Establish Buffer, Add to Buffer, Rip Rap	High	Medium	Medium
9-08	Directly into lake	Residential	Surface Erosion-Sheet, Shoreline-Undercut, Shoreline-Lack of Shoreline Vegetation, Shoreline-Inadequate Shoreline Vegetation, Shoreline-Erosion, Roof Runoff Erosion	Infiltration Trench @ roof dripline, Drywell @ gutter downspout	Medium	High	High
9-09	Directly into lake	Municipal / Public	Surface Erosion-Rill, Shoreline-Undercut, Shoreline-Inadequate Shoreline Vegetation, Shoreline-Erosion	Rip Rap	High	High	High
9-10	Directly into lake	Residential	Surface Erosion-Sheet, Shoreline-Undercut, Shoreline-Lack of Shoreline Vegetation, Shoreline-Erosion	Rip Rap	High	High	High
9-11	Directly into lake	Residential	Surface Erosion-Sheet, Shoreline-Undercut, Shoreline-Erosion, Shoreline-Lack of Shoreline Vegetation	Add to Buffer, Reseed bare soil & thinning grass, Mulch/Erosion Control Mix	Medium	Medium	Medium
9-12	Directly into lake	Residential	Surface Erosion-Sheet	Define Foot Path, Stabilize Foot Path, Infiltration Steps, Erosion Control Mulch	Medium	Medium	Medium
9-12a	Minimal Vegetation	Residential	Surface Erosion-Sheet, Soil-Bare, Shoreline-Lack of Shoreline Vegetation, Shoreline-Inadequate Shoreline Vegetation, Shoreline-Erosion	Add to Buffer, Establish Buffer, Rip Rap	Medium	Medium	Medium
9-13	Directly into lake	Residential	Surface Erosion-Sheet, Surface Erosion-Gully, Surface Erosion-Rill, Shoreline-Undercut, Shoreline-Lack of Shoreline Vegetation, Shoreline-Erosion	Add to Buffer, Establish Buffer, Rip Rap	High	High	High
10-01	Stream	Town Road	Culvert-Undersized, Culvert-Unstable inlet/outlet, Road Shoulder Erosion-Sheet, Agriculture-Manure Washing off Site	Enlarge Culvert, Armor Culvert Inlet/Outlet	Low	Medium	Medium