Nippo Lake Watershed Restoration Plan

Photo: Sally Soule, NHDES

Nippo Lake Association
NH Department of Environmental Services

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ACRONYMS

Acronym	**Definition**
ALU	Aquatic Life Use
AUID	Assessment Unit Identification
BMPs	Best Management Practices
Chl-a	Chlorophyll-*a*
CWA	Clean Water Act
DKWRC	DK Water Resource Consulting
FC	Fish consumption
ha	Hectare
HWG	Horsley Witten Group
kg	Kilogram
LLMP	Lay Lakes Monitoring Program
LLRM	Lake Loading Response Model
m	Meter
MS4	Municipal Separate Storm Sewer System
NHDES	New Hampshire Department of Environmental Services
NHFG	New Hampshire Fish and Game Department
NLA	Nippo Lake Association
NLCD	National Land Cover Database
NWI	National Wetland Inventory
PCR	Primary Contact Recreation
ppb	Parts per billion
QAPP	Quality Assurance Project Plan
SDT	Secchi disk transparency
SOAK	Soak Up the Rain
SWM	Stormwater Management
TMDL	Total Maximum Daily Load
TP	Total phosphorus
UNH	University of New Hampshire
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

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1. INTRODUCTION

Nippo Lake is a mesotrophic, eighty-five-acre body of water located in Barrington, New Hampshire having a mean depth of twenty feet. Epilimnetic total phosphorus monitoring from 1982 – 2015 has shown a significant increase, with Nippo Lake briefly crossing into eutrophic (more productive) territory in 1995 and regularly since 2010. Additionally, average Secchi disk transparency (SDT) depth has significantly decreased from 1982 – 2015, and hypolimnetic total phosphorus below 10 meters has significantly increased in this same time period. In the summer of 2010, Nippo Lake experienced a cyanobacteria bloom—the first such bloom observed. Subsequent cyanobacteria blooms have been observed annually since 2010 (Figure 1.). The lake is on the state's list of impaired waters for Primary Contact Recreation (swimming) due to the occurrence of cyanobacteria blooms (NHDES, 2019a).

Cyanobacteria blooms pose a serious threat to human health and the quality of life watershed residents depend upon relative to enjoyment of the lake. The blooms are driven by an increase in nutrients, primarily phosphorus, delivered to the lake via various sources and pathways including stormwater runoff, septic systems, soil erosion, fertilizers, and internal cycling. Additional phosphorus sources include wetlands, tributaries, and atmospheric deposition.

The Nippo Lake Association (NLA) seeks to better understand and manage sources of phosphorus loading to the lake to reduce and eliminate the intensity and frequency of cyanobacteria blooms. To achieve this goal, the NLA in cooperation with the New Hampshire Department of Environmental Services (NHDES) established a partnership to develop a watershed restoration plan for the lake. The plan identifies sources of pollutant loading, and recommends management actions for reducing loading to the lake. The plan incorporates nine key watershed planning elements required by the U.S. Environmental Protection Agency (USEPA) and the NHDES for future implementation funding eligibility and consideration.

2. STATEMENT OF PURPOSE

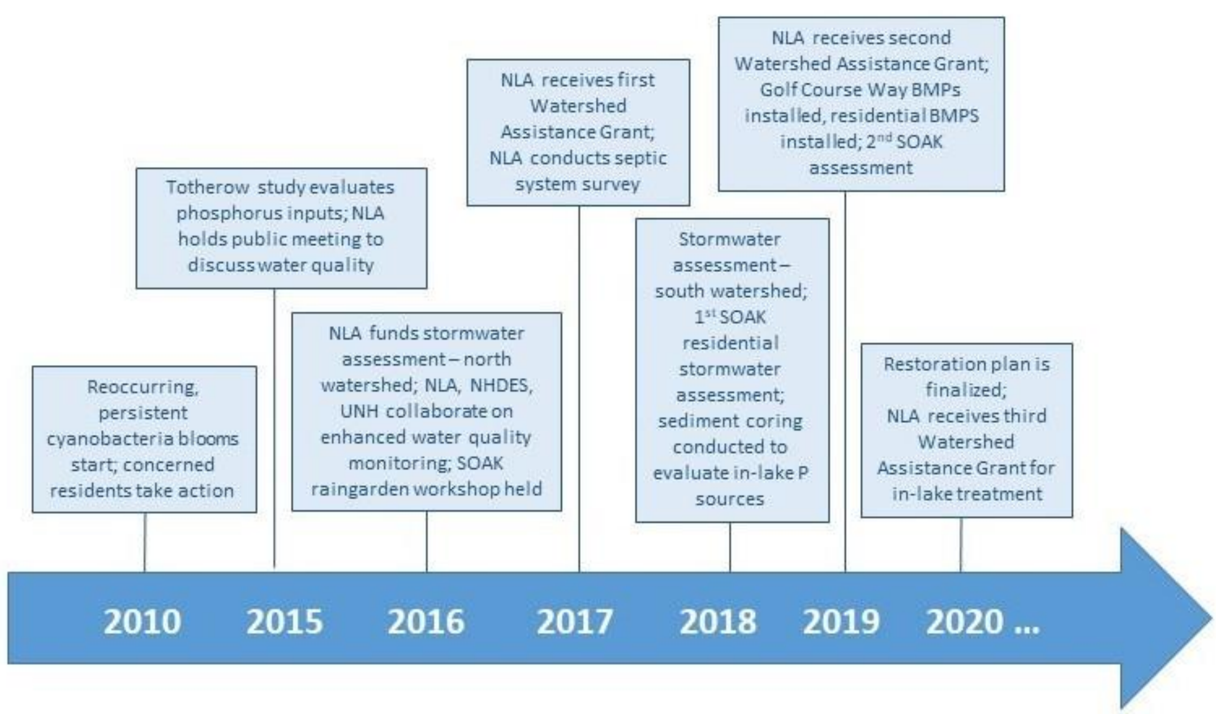
The *Nippo Lake Watershed Restoration Plan* describes the water quality conditions, watershed characteristics, and sources of phosphorus to Nippo Lake; plus, identifies steps for restoring lake quality. The plan establishes water quality goals, outlines nutrient management approaches, and describes actions for meeting restoration goals. Management actions for improving water quality are also described. The plan is the culmination of sustained efforts conducted under the leadership of the NLA in cooperation with its local and state partners (Figure 1). The *Nippo Lake Watershed Restoration Plan* will provide guidance for collaborative, engaged lake restoration.

The plan summarizes water quality data, watershed survey information, and lake loading modeling output to develop actions and recommendations for reducing pollutant loading to the lake. The purpose of the plan is to:

- Identify and quantify sources of pollutant loading to the lake
- Determine actions needed to reduce pollution loading and prevent cyanobacteria blooms

The adaptive management approach described in the plan enables project partners to conduct restoration activities in a stepwise manner; however, it recognizes that the lake cannot be restored with a single restoration action or within an immediate timeframe. Implementation of this approach will ensure that as restoration activities are conducted, lake response is monitored, and success is documented.

Figure 1. Nippo Lake watershed restoration project – recent timeline



3. PLAN DEVELOPMENT PROCESS

The watershed planning process uses a series of cooperative, iterative steps to characterize existing watershed conditions, identify and prioritize problems, define management objectives, develop protection or remediation strategies, and implement and adapt selected actions as necessary (USEPA, 2008). The NLA received funding in 2017 from the NH Department of Environmental Services (NHDES) Watershed Assistance Grants program to develop a watershed restoration plan for the lake. To develop the plan, NLA engaged several partners including NHDES, DK Water Resource Consulting (DKWRC), and the Horsley Witten Group (HWG). Additionally, NLA worked with local volunteers and lake association members to collect water quality data and watershed information to include in the plan. The plan includes USEPA's nine key "a- i" planning elements to restore waters impaired by nonpoint source (NPS) pollution. Table 1 describes each element and the relevant section in the plan where the element can be found.

Table 1. USEPA's nine elements of watershed planning

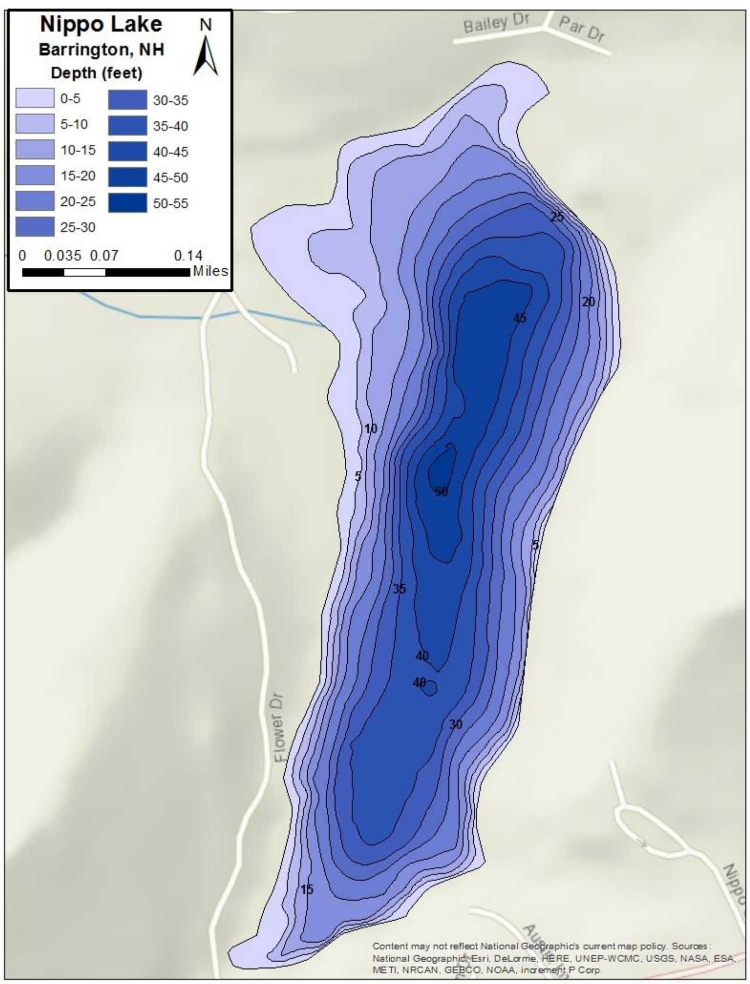
Element	Plan Section	Element Description
a	6	Identify causes and sources of pollution
b	7	Estimate pollution load reductions needed for restoration
c	8	Identify actions needed to reduce pollution
d	8	Estimate costs and authority to implement restoration actions
e	8	Implement outreach and education to support restoration
f	9	Restoration schedule
g	9	Milestones – interim measures to show implementation progress
h	10	Success indicators and evaluation – criteria to show restoration success
i	11	Monitoring plan

4. WATERBODY AND WATERSHED CHARACTERISTICS

Nippo Lake and its watershed exists entirely in the Town of Barrington, New Hampshire. The lake is located at 330 feet above sea level (fasl). The lake's watershed area consists of 294 acres of hilly terrain characterized by steep, mostly forested slopes that run down to the lake shore. The lake is bounded on the northeast by Mount Misery (520 fasl); and on the southwest by Nippo Hill (582 fasl).

Nippo Lake is approximately 0.77 miles long and 0.3 miles wide at its maximum. The lake has two miles of shoreline. The surface area of Nippo Lake is 85 acres with a mean depth of 20 feet and a maximum depth of 54 feet at the deepest spot in the lake (Figure 2). Nippo Lake experiences thermal stratification in the summer with an epilimnion (upper layer), metalimnion (middle layer), and hypolimnion (deepest layer) established from June through fall turnover, which typically occurs in October. The lake contains 567.3 million gallons of water, and the lake water volume flushes completely every two and a half years. The NHDES classification for the lake is mesotrophic (NHDES, 2004).

Figure 2. Bathymetric map of Nippo Lake



Water is delivered to the lake via ground water springs located deep within the lake, surface runoff, and from precipitation falling directly on the lake's surface. A small tributary exists at the southern end of the lake. Flow from this small stream originates in a wetland south of Route 202 and enters the lake south of Harlan Drive. The outlet of Nippo Lake, Nippo Brook, is located on the northwest shore of the lake. Water exiting Nippo Lake flows to the Isinglass River which joins the Cocheco River. These waters then flow to the Piscataqua River and ultimately, to the Atlantic Ocean.

Nippo Brook (Photo source: NLA)

Nippo Pond* Dam

A dam has existed at the outlet of Nippo Lake for at least one-hundred years. The dam's original purpose was to deliver water down Nippo Brook to the Isinglass River and then on to various manufacturing mills in Dover, New Hampshire. The current dam was built in 1935 and re-built in 1950. The dam is owned and operated by NHDES. The dam is classified as low hazard and NHDES lists the current purpose for the dam as "recreational." The dam has a height of nine feet and a length of 215 feet (NHDES, 1989). It is an earthen dam with flashboards to control water level. The NHDES Dam Bureau initiates a seasonal lake drawdown annually in October. The typical depth of the drawdown for Nippo Lake is two feet from the normal full pond level. Lake drawdown is conducted each fall to reduce winter ice damage to shoreline properties and to reduce spring flooding.

***Note:** NHDES Dam Bureau and Watershed Management Bureau records show the lake's name as "Nippo Pond"; however, in local usage, the lake is referred to as Nippo Lake. This plan will use the local name – Nippo Lake, except when referring to the name of the dam.

Surficial Geology and Soils

The surficial geology in the watershed consists mainly of alluvial material deposited 12,000 years ago at the end of the Great Ice Age. This material is characterized by unconsolidated materials, typically silt, clay, sand, and gravel. Soils of the Nippo Lake watershed consist of rocky, sandy, and fine loam soil types such as Acton, Charlton, and Gloucester (USDA, 1977). The soils are mostly well drained with pockets of poorly drained soils in the northwest lake shore section near the outlet of the lake. Steep slopes dominate many areas of the watershed. Slopes in the watershed vary from zero percent to 60 percent with many slopes tending toward greater than eight percent. A soil report for the Nippo Lake watershed is included as Appendix A of the plan.

Habitat

The *New Hampshire Wildlife Action Plan* indicates that the Nippo Lake watershed contains habitat considered to be of the highest ranked type in the state (NHFG, 2015). Mammals, reptiles, birds, insects and fish benefit from the watershed's rich natural resources. Endangered species in the watershed include the Common Loon and spotted turtle. Anecdotal reports from lakeshore residents indicate that Common Loons have nested and raised young on the lake for many years. Fish species in the lake include largemouth bass, smallmouth bass, yellow perch, Eastern chain pickerel, and sunfish. According to local residents, stocking of Eastern Brook Trout was conducted in the 1980s, but the fish no longer appear to be present in the lake.

Shoreline vegetation, Nippo Lake (Photo: Sally Soule, NHDES)

Forest types in the Nippo Lake watershed include hemlock-hardwood-pine forest in the east and south, and Appalachian oak-pine in the northern section. Tree species for these forest types include white pine, Eastern hemlock, maples, and oaks. The lake's shoreline contains a diversity of native shrubs including button bush, high bush blueberry, and sweet pepperbush. Aquatic plants include scattered populations of vegetation such as sedges, pipewort, pickerel weed, and pondweed.

Watershed Land Use

Land use in the watershed consists of undeveloped, forested land with some residential and commercial properties. Residential land use consists of a mix of seasonal and year-round homes along the shoreline and a development of year-round homes at the northwestern end of the lake. Many seasonal cottage sites around the lake were developed in the 1950s. Homes in the watershed utilize individual sewage disposal systems for wastewater treatment. A portion of an active golf course is located in the northern section of the watershed. Sustainable forestry operations exist in areas of the watershed. Roads in the watershed consist of mostly private gravel roads that are owner-maintained. Several large, undeveloped parcels of land remain in the watershed. Historic watershed land uses include farming and tree harvesting.

Land conservation continues to be of keen interest for the NLA as a strategy for managing watershed land use change and reducing future nutrient loads to the lake. The Southeast Land Trust (SELT) has conserved several large parcels of land just to the east of the watershed boundary including Stonehouse Forest. A portion of this conservation land includes a small marsh area located in the southeast corner of the Nippo Lake watershed near Harlan Drive. This marsh is the headwaters of a small tributary that flows to the lake.

David Dickson, Vice President of the Nippo Lake Association, provided the following summary of historical land uses and development in the watershed:

On the northeast side of the lake, much of the abutting land is owned by two property owners. The land remains undeveloped. The eastern most portion of the watershed was farm land for a period of time in the early 1900s. The cultivated area was to the north of the dirt road now known as Nippo Court. This area was also used as a chicken farm for a very brief time around 1930. Sometime in 1930s the land was clear cut. Records show that most cottage lots on the east side were subdivided and developed between 1948 and 1950.

In the North Cove area of the lake, cottages on the lake at the base of Golf Course Way were established in or around the 1950s. Camp Don Bosco, which was owned by the Catholic Diocese of Boston, was situated on land in the western area of the cove. The camp closed in the late 1980s and the land was sold, subdivided, and developed as Lakeview Estates in 2004. The development has restrictions on motorized vehicle and boat access, a common beach area, and a conservation area managed by the Barrington Conservation Commission of the lake. A wildlife corridor is west of the development.

The South Cove area off Harlan Drive was recently developed. Until then it was undeveloped. There were only two homes adjacent to the end of Harlan Drive - one built in 1980 and the other several years before. Land that abuts the development to the east of Flower Drive was purchased in 1978.

The west side of the lake was developed much later then the east side. It is believed that the oldest developed property in this area was built prior to 1950.

5. ASSESSMENT OF WATER QUALITY

This section provides an overview of New Hampshire's water quality standards and criteria that apply to Nippo Lake, the methodologies used by the State to assess water quality, and a summary of lake water quality conditions for parameters of concern. The State's assessment process and lake water quality parameters of concern – phosphorus and chlorophyll-*a* – provide a foundation for the watershed restoration plan's water quality goals and restoration success indicators. The water quality goals and success indicators serve as targets for measuring restoration success.

5.1 Applicable Water Quality Standards and Criteria

The State of New Hampshire is required to follow federal regulations under the Clean Water Act (CWA) with some flexibility as to how those regulations are enacted. The Federal CWA, the NH RSA 485-A Water Pollution and Waste Control Statute, and the NH Surface Water Quality Regulations (Env-Wq 1700) are the regulatory basis for governing water quality protection in New Hampshire. These regulations form the basis for New Hampshire's regulatory and permitting programs related to surface waters. States are required to submit biennial water quality status reports to Congress via the USEPA. The reports provide an inventory of all waters assessed by the state and indicate which waterbodies exceed or meet the state's water quality standards. These reports are commonly referred to as the "Section 303(d) Surface Water Quality List" and the "Section 305 (b) Report" respectively.

New Hampshire's water quality standards are composed of three parts: designated uses, water quality criteria, and antidegradation. The standards provide a baseline measure of the quality that surface waters must meet to support designated uses. The standards are the "yardstick" for identifying water quality problems and for determining the effectiveness of state regulatory pollution control and prevention programs. The CWA requires states to determine designated uses for all surface waters within the state's jurisdiction. Designated uses are the desirable activities and services that surface waters should be able to support, and include uses for aquatic life, fish consumption, shellfish consumption, drinking water supply, primary contact recreation (swimming), secondary contact recreation (boating and fishing), and wildlife (Table 2). Surface waters can have multiple designated uses.

Table 2. Designated Uses for New Hampshire Surface Waters

Water quality criteria are designed to protect the designated uses of New Hampshire surface waters. If the existing water quality meets or is better than the water quality criteria, the waterbody supports its designated use(s). If the waterbody does not meet water quality criteria, then it is considered impaired for its designated use(s). Water quality criteria for each classification and designated use in New Hampshire can be found in RSA 485 A:8, IV and in the State's surface water quality regulations (NHDES, 2018b). The third and final component is antidegradation, which are provisions designed to preserve and protect the existing beneficial uses and to minimize degradation of the State's surface waters (Env-Wq 1700).

Table 2. Designated Uses

Designated Use	NHDES Definition	Applicable Surface Waters
Aquatic Life Use	Waters that provide suitable chemical and physical conditions for supporting a balanced, integrated and adaptive community of aquatic organisms.	All surface waters
Fish Consumption	Waters that support fish free from contamination at levels that pose a human health risk to consumers.	All surface waters
Shellfish Consumption	Waters that support a population of shellfish free from toxicants and pathogens that could pose a human health risk to consumers.	All tidal surface waters
Drinking Water Supply After Adequate Treatment	Waters that with adequate treatment will be suitable for human intake and meet state/federal drinking water regulations.	All surface waters
Primary Contact Recreation	Waters suitable for recreational uses that require or are likely to result in full body contact and/or incidental ingestion of water.	All surface waters
Secondary Contact Recreation	Waters that support recreational uses that involve minor contact with the water.	All surface waters
Wildlife	Waters that provide suitable physical and chemical conditions in the water and the riparian corridor to support wildlife as well as aquatic life.	All surface waters

An impaired waterbody is defined as a waterbody that does not meet water quality criteria that support its designated use. The criteria might be numeric and specify concentration, duration, and recurrence intervals for various parameters, or they might be narrative and describe required conditions such as the absence of scum, sludge, odors, or toxic substances. If the waterbody is impaired, the state will place it on the section 303(d) list (NHDES, 2019b). According to the 2018 303(d) list of impaired or threatened waters, Nippo Lake is listed as impaired for Aquatic Life Use due to low pH levels, for Fish Consumption due to elevated mercury concentrations, and for Primary Contact Recreation due to recurring cyanobacteria blooms (Figure 3).

Figure 3. Nippo Lake, 2018 305(b)/303(d) Report Card

Assessment Unit ID NHLAK600030605-01
Assessment Unit Name NIPPO POND
Primary Town BARRINGTON

Size 85.1160 ACRES
Beach N
Assessment Unit Category*~ 5-M

2018, 305(b)/303(d) - All Reviewed Parameters by Assessment Unit

Designated Use Description	*Desig. Use Category	Parameter Name	Parameter Threatened (Y/N)	Last Sample	Last Exceed	Parameter Category*	TMDL Priority
Aquatic Life Integrity	4A-P	ALKALINITY, CARBONATE AS CACO3	N	2005	2005	3-ND	
		CHLORIDE	N	2017	N/A	2-G	
		CHLOROPHYLL-A	N	2016	NLV	2-M	
		DISSOLVED OXYGEN SATURATION	N	2017	2017	3-PNS	
		OXYGEN, DISSOLVED	N	2017	2017	3-PNS	
		PHOSPHORUS (TOTAL)	N	2016	NLV	2-M	
		TURBIDITY	N	2017	2014	3-PAS	
		pH	N	2017	2017	4A-P	
Fish Consumption	4A-M	Mercury	N			4A-M	
Potential Drinking Water Supply	2-G	ESCHERICHIA COLI	N	2004	2004	3-ND	
		SULFATES	N	2005	N/A	3-ND	
Primary Contact Recreation	5-M	CHLOROPHYLL-A	N	2016	1991	2-G	
		Cyanobacteria hepatotoxic microcystins	N	2018	2015	5-M	LOW
		ESCHERICHIA COLI	N	2004	N/A	3-ND	
Secondary Contact Recreation	3-ND	ESCHERICHIA COLI	N	2004	N/A	3-ND	
Wildlife	3-ND						

Severe	Poor	Likely Bad	No Data	Likely Good	Marginal	Good
Not Supporting, Severe	Not Supporting, Marginal	Insufficient Information – Potentially Full Supporting	No Data	Insufficient Information – Potentially Full Supporting	Full Support, Marginal	Full Support, Good

*DES Categories; 2-G = Supports Parameter well above criteria, 2-M = Supports Parameter marginally above criteria, 2-OBS = Exceeds WQ criteria but natural therefore not a WQ exceedence, 3-ND = Insufficient Information/No data, 3-PAS= Insufficient Information/Potentially Attaining Standard, 3-PNS= Insufficient Information/Potentially Not Attaining Standard, (4A=Impaired/TMDL Completed, 4B=Impaired/Other Measure will rectify Impairment, 4C=Impaired/Non-Pollutant, 5=Impaired/TMDL needed) M=Marginal Impairment, P=Severe Impairment, T=Threatened (http://des.nh.gov/organization/divisions/water/wmb/swqa/index.htm)

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Although total phosphorus and chlorophyll-*a* are listed as supporting of their designated uses, this watershed restoration plan focuses on both parameters because of the cascading influence from increased phosphorus feeding and fueling cyanobacteria blooms. Additionally, recent chlorophyll-*a* concentrations have been documented at levels higher than what is associated with Nippo Lake's trophic class. Trophic class is a determination of the lake's productivity or degree of eutrophication. Chlorophyll-*a* is a measure of green pigment used for photosynthesis and is found in all plants – including microscopic plants such as algae and cyanobacteria. Therefore, chlorophyll-*a* is used as a measure of algal abundance and lake productivity.

The focus of this watershed restoration plan is to address parameters that accelerate cyanobacteria blooms in the lake or are indicators of conditions that could affect blooms. Such parameters include: Secchi disk transparency, total phosphorus, chlorophyll-*a*, dissolved oxygen, and in-lake sediment quality.

In New Hampshire, all surface waters are also legislatively classified as Class A or Class B, most of which are Class B (Table 2; Env-Wq 1700). Nippo Lake is classified as Class B (Table 3). Water quality criteria are then developed to protect those designated uses. Depending on the designated use and type of waterbody, water quality criteria can become more or less strict if the waterbody is classified as either Class A or B. Nippo Lake is a Class B surface water.

Table 3. New Hampshire surface water classifications

Classification	Description (RSA 485-A:8)
Class A	These are generally of the highest quality and are considered potentially usable for water supply after adequate treatment. Discharge of sewage or wastes is prohibited to waters of this classification.
Class B	Of the second highest quality, these waters are considered acceptable for fishing, swimming and other recreational purposes, and, after adequate treatment, for use as water supplies.

Source: Adapted from the 2018 New Hampshire Consolidated Assessment and Listing Methodology

Designated Use: Aquatic Life Integrity (ALI)

Criteria for ALI ensure that waters provide suitable habitat for the survival and reproduction of desirable fish, shellfish, and other aquatic organisms. For ALI assessment, the State has narrative nutrient criteria with a numeric translator or threshold, consisting of a “nutrient indicator” (i.e. total phosphorus) and a “response indicator” (i.e. chlorophyll-*a*). The nutrient and response indicators are intricately linked since increased total phosphorus loading frequently results in greater algal concentrations. Additional cascading influences from increased phosphorus and/or chlorophyll-*a* can be decreased dissolved oxygen levels in the waterbody, as well as decreased water clarity, changes in aquatic species composition, and algal or cyanobacteria blooms.

Aquatic Life Integrity criteria vary by trophic state, since each trophic state has a certain algal biomass (chlorophyll-*a*) that represents a balanced, integrated, and adaptive community (Table 4). Exceedances of the chlorophyll-*a* criterion suggest that the algal community is out of balance. Since phosphorus is the primary limiting nutrient for growth of freshwater algae (chlorophyll-*a*), total phosphorus is included in this assessment process. For ALI assessment, total phosphorus and chlorophyll-*a* are combined per the decision matrix presented in Table 5. The chlorophyll-*a* concentration will dictate the assessment if both chlorophyll-*a* and total phosphorus data are available and the assessments differ.

It is important to note that although Nippo Lake does not currently exceed the state’s criteria for nutrients, NLA and its project partners used the ALI nutrient parameters and criteria as shown in Table 4 to perform an assessment to set the water quality goals and restoration success indicators for this watershed restoration plan.

Table 4. Aquatic Life Integrity nutrient criteria by trophic class in New Hampshire
TP = total phosphorus.

Chl-*a* = chlorophyll-*a*, a surrogate measure for algal concentration

Trophic State	TP (ppb)	Chl-*a* (ppb)
Oligotrophic	< 8.0	< 3.3
Mesotrophic	> 8.0 - 12.0	> 3.3 - 5.0
Eutrophic	> 12.0 - 28.0	> 5.0 - 11.0

Source: Adapted from the 2018 New Hampshire Consolidated Assessment and Listing Methodology

Table 5. Decision matrix for Aquatic Life Integrity assessment in New Hampshire
TP = total phosphorus

Chl-*a* = chlorophyll-*a*, a surrogate measure for algal concentration

Nutrient Assessments	TP Threshold Exceeded	TP Threshold NOT Exceeded	Insufficient Information for TP
Chl-*a* Threshold Exceeded	Impaired	Impaired	Impaired
Chl-*a* Threshold Not Exceeded	Potential Non-support	Supporting	Supporting
Insufficient Information for Chl-*a*	Insufficient Information	Insufficient Information	Insufficient Information

Source: Adapted from the 2018 New Hampshire Consolidated Assessment and Listing Methodology

From 1974 to 2010, and from 2013 to 2019, NHDES conducted trophic surveys on waterbodies across the state to determine trophic status. Trophic status is a classification system that categorizes the degree of eutrophication of a waterbody as either oligotrophic, mesotrophic, or eutrophic depending upon their varying levels of productivity, clarity, macrophyte densities, hypolimnetic oxygen concentrations, and other diagnostic parameters and indicators. Generally, oligotrophic waterbodies are less productive or have less nutrients, and are known for having clear water, few macrophytes, high dissolved oxygen levels, and low levels of phosphorus and chlorophyll-*a*. Eutrophic lakes are highly productive and have more nutrients, more turbid water, low dissolved oxygen levels, and many macrophytes. Mesotrophic lakes are in-between or in transition between Oligotrophic and Eutrophic conditions. NHDES assesses waterbody trophic status by the water transparency, chlorophyll-*a* levels, macrophyte density, and dissolved oxygen concentration.

Water quality assessments in New Hampshire are based on the highest trophic status reported for a lake; therefore, when NHDES conducts assessments, Nippo Lake is considered a mesotrophic waterbody. This means that in-lake water quality concentrations such as total phosphorus, chlorophyll-*a*, dissolved oxygen, and other water quality parameters should be consistent with the thresholds set for mesotrophic waterbodies.

Nippo Lake has been assessed twice under NHDES's trophic survey program, in 1982 and 2004. It was determined to be mesotrophic in both surveys.

Designated Use: Fish Consumption (FC)
In the Northeast, over 10,000 lakes, ponds, and reservoirs, and over 46,000 river miles are listed as impaired for fish consumption primarily due to atmospheric deposition of mercury. A Total Maximum Daily Load (TMDL) document was generated in 2007 for affected New Hampshire waterbodies to establish allowable pollutant loading from all contributing sources at a level necessary to achieve the applicable water quality standard. As the cause of the impairment is due primarily to atmospheric deposition of mercury and the CWA requirement of a TMDL has been satisfied, the FC Designated Use is not a focus of this document.

Collecting water quality samples, Nippo Lake (Photo: NHDES)

Designated Use: Primary Contact Recreation (PCR)
The definition of PCR is "Waters suitable for recreational uses that require or are likely to result in full body contact and/or incidental ingestion of water." This use applies to all surface waters in the state. The narrative criteria for PCR can be found in Env-Wq 1703.03, 'General Water Quality Criteria' and reads, "All surface waters shall be free from substances in kind or quantity that: a)settle to form harmful benthic deposits; b) float as foam, debris, scum or other visible substances; c) produce odor, color, taste or turbidity that is not naturally occurring and would rend the surface water unsuitable for its designated uses; d) result in the dominance of nuisance species; e) interfere with recreation activities."

Nutrient response indicators chlorophyll-a and cyanobacteria scums are used as secondary indicators for PCR assessments. These indicators provide reasonable evidence to classify the designated use as "not supporting," but cannot result in a "fully supporting" designation. In order to make a full support designation, concentrations must be below the state water quality criteria. Elevated chlorophyll-*a* concentrations or the presence of cyanobacteria scums interfere with aesthetic enjoyment, swimming, and may pose a health hazard. Chlorophyll-*a* concentrations greater than or equal to 15 ppb or cyanobacteria scums are considered "not supporting" for this designated use.

Nippo Lake was listed as impaired for PCR due to cyanobacteria blooms in 2012 and has remained impaired in subsequent 303(d) listings.

Antidegradation Provisions

The Antidegradation Provision (Env-Wq 1708) in New Hampshire's water quality regulations serves to protect or improve the quality of the State's waters. The provision outlines limitations or reductions for future pollutant loading. Certain development projects (e.g. projects that require Alteration of Terrain

Permits or 401 Water Quality Certification) may be subject to an Antidegradation Review to ensure compliance with the State's water quality regulations.

Water Quality Standards and Criteria Summary for Nippo Lake

In summary, the 2018 305(b)/303(d) Surface Water Quality Report found that designated uses Aquatic Life Integrity (ALI), Fish Consumption (FC) and Primary Contact Recreation (PCR) were of concern; however, the focus of this watershed plan is on water quality parameters and activities that will reduce the frequency and intensity of cyanobacteria blooms including total phosphorus and chlorophyll-*a*.

5.2 Nippo Lake Water Quality Summary

Volunteers have partnered with the University of New Hampshire (UNH) Center for Freshwater Biology – Lakes Lay Monitoring Program (LLMP) since 1986 to collect water quality data from Nippo Lake. Additionally, Nippo Lake has been surveyed by NHDES under its Lake Trophic Survey Program in 1982 and 2004. It was rated mesotrophic in both surveys.

NHDES summarized historical data on total phosphorus concentration, chlorophyll-*a* concentration, Secchi disk transparency, and specific conductance in a 2015 summary report (Appendix B). The summary report found that total phosphorus was significantly increasing in the epilimnion, metalimnion, and in the hypolimnion below ten meters. Chlorophyll-*a* concentration was found to not significantly vary; however, Secchi disk transparency significantly decreased while specific conductance significantly increased (worsened).

The 2015 report informed stakeholders of water quality trends in Nippo Lake and helped identify data gaps that led to an enhanced sampling strategy for the field season of 2016. In a partnership among NHDES, LLMP, and NLA, water quality monitoring at Nippo Lake's deep spot location was scheduled every two weeks from ice out to fall turnover. Due to differences in sampling methodology, UNH agreed to collect water samples consistent with NHDES sampling methodology. NHDES was responsible for sampling from ice out through May and again from September to fall turnover. UNH LLMP in cooperation with the NLA were responsible for sampling June through August. Additionally, NHDES deployed a pressure transducer in a ditch adjacent to Golf Course Way, a gravel road adjacent to the lake that was experiencing severe erosion, to monitor how often water flowed through the ditch. NHDES also committed to opportunistically collect flow and total phosphorus measurements in the ditch during a storm event as time and resources permitted. UNH LLMP personnel also conducted deep spot sampling consistent with LLMP methodology.

Sampling Methods

During sample events led by UNH or NHDES personnel, the Nippo Lake deep spot was located, the sampling vessel was anchored, and a one-meter increment dissolved oxygen/ temperature profile was collected. From the profile, stratification between thermal layers was determined based on whether or not a >1˚C change in temperature from one meter to the next was present. If the water column was not stratified (e.g. immediately after ice out), the water column was divided into thirds and a water sample was collected from each section using a Kemmerer bottle.

If the water column was stratified (e.g. throughout the summer), the epilimnion, metalimnion, and hypolimnion layers were identified and water samples were collected from the epilimnion and hypolimnion using a Kemmerer bottle. Water samples from the metalimnion were occasionally collected but not required. Samples were tested for total phosphorus. Epilimnetic samples helped inform the LLRM calculations, and the hypolimnetic samples helped estimate the internal phosphorus load. A mid-metalimnion composite was collected to determine chlorophyll-*a* concentration, as well as a mid-metalimnion plankton haul. Secchi disk transparency depth with and without a viewscope was collected during each sample event. Sampling methodology and sample processing were done according to NHDES's Lake Assessment Program Quality Assurance Project Plan (LAP QAPP). Additionally, a bathymetric map of Nippo Lake was generated by NHDES staff.

Golf Course Way

At the outset of this project, Golf Course Way, a gravel road located in the northern portion of the watershed, experienced severe erosion during rain storms. Concerns about the amount of phosphorus contribution to the lake from road runoff led to efforts to quantify phosphorus loading at this location.

Sediment plume – Golf Course Way (Photo: NLA)

Two pressure transducers were deployed at Golf Course Way from March 30, 2016 to December 9, 2016. The first pressure transducer was secured on a cinder block and placed at the bottom of the steep section of Golf Course Way in a roadside drainage ditch. The second pressure transducer was deployed approximately twenty feet away in a tree.

Both pressure transducers collected temperature and barometric pressure. The difference between the pressure readings of the two sensors was used to determine water level.

On October 28, 2016, favorable timing and resources permitted NHDES to monitor a storm event at Golf Course Way. NHDES staff members collected a flow measurement and a water sample every half hour from 7:30 am to 12:30 pm, when the majority of the rain fell. All water samples were processed for TP concentration and turbidity. The storm dropped 1.23 inches of rain on October 28 alone and 2.11 inches overall throughout the full duration of the storm. NHDES estimated that this single rain event deposited approximately 0.09 kg TP into Nippo Lake.

Tributary and Outlet Sampling
The northwest outlet of Nippo Lake was sampled for total phosphorus three times in 2016 and 2017. Total phosphorus values ranged from 11.8 – 12.9 µg/L. A small inlet at the southern end of the lake was sampled twice during the same time period and had slightly higher total phosphorus values, ranging from 24.2 – 27.8 µg/L.

Secchi Disk Transparency (SDT)
Secchi disk transparency (SDT) is a vertical measure of water transparency (the ability of light to penetrate water) obtained by lowering a black and white disk into the water until it is no longer visible. Occasionally, a viewscope, which is a long tube with clear plastic on one end, is used to help collect SDT. The viewscope helps remove environmental factors such as sun glare or wave action, which can affect SDT readings. Collecting SDT with and without a viewscope gives a range of best and worst case water transparency. For Nippo Lake, SDT was collected with and without a viewscope. Measuring SDT is one of the most useful ways to determine whether a lake is changing from year to year. Changes in transparency result from changes in algal growth, particulate load, or water color. Increasing sediment and/or nutrient load to a lake can increase algal growth, resulting in a decrease in water clarity.

During the 2016 sample season, SDT in Nippo Lake ranged from 2.1 m to 7.3 m, with an average of 4.67 m and a median of 4.75 m. The state SDT median is 3.2 m. A SDT of greater than 4.0 m is generally associated with oligotrophic waterbodies. While this indicates that SDT is high in Nippo Lake, the 2015 summary report did find that SDT has significantly declined (Appendix B). Figure 4 shows Chl-*a* and Secchi disk transparency from the 2016 sampling season.

Chlorophyll-*a* concentration
Chlorophyll-*a* (Chl-*a*) is a measurement of the green pigment used for photosynthesis, and is found in all plants (including microscopic plants such as algae and photosynthesizing bacteria such as cyanobacteria). Chl-*a* is used as an estimate of algal abundance or lake productivity – higher Chl-*a* equates to a greater amount of algae and/or cyanobacteria in a waterbody. Chl-*a* concentrations are believed to be related to phosphorus concentrations, where increased concentrations of phosphorus result in increased algal growth.

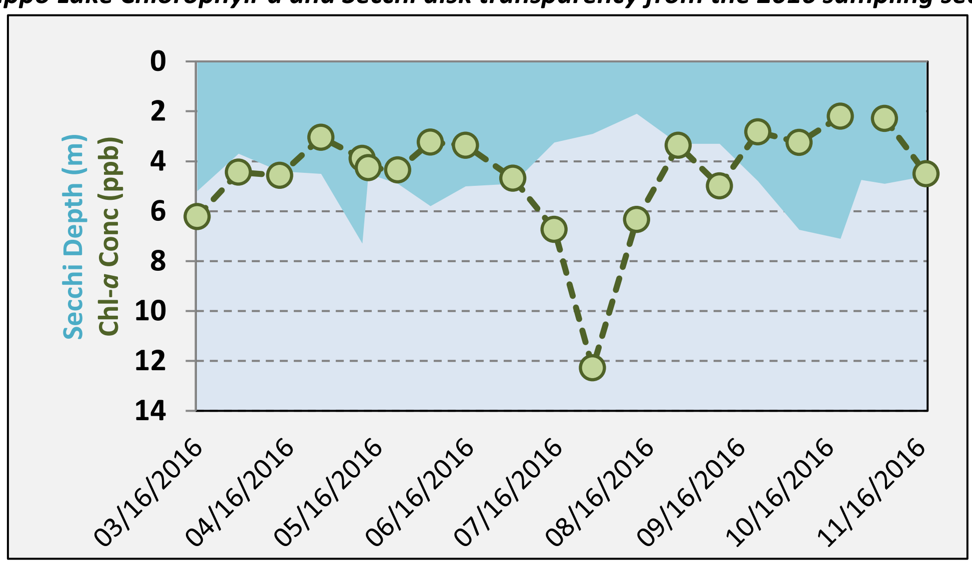
During the 2016 field season, Chl-*a* ranged from 2.2 ppb to 12.3 ppb with an average of 4.5 ppb and a median of 4.3 ppb. As mentioned previously, ALI nutrient criteria are driven by trophic class, and mesotrophic lakes are expected to have Chl-*a* concentrations from greater than 3.3 ppb to 5.0 ppb. The 2016 sample season recorded four sample events where the Chl-*a* concentration was above 5.0 ppb (Table 6).

A cyanobacteria bloom was detected in Nippo Lake during the 2016 field season and on July 29th NHDES issued a cynaobacteria advisory for Nippo Lake after analyzing a sample from July 28th, which corresponded with the highest Chl-*a* concentration recorded that year. The NHDES will issue advisories if a potential toxin-producing cyanobacterial scum is present and cell dominance is greater than 50 percent of the sample total cell count OR the cyanobacteria cell count is greater than 70,000 cells per ml of water.

Table 6. Nippo Lake Chl-a concentrations by sample date (concentrations above 5.00 ppb are italicized and emboldened)

Sample Date	Chl-a (ppb)
03/16/2016	***6.23***
03/30/2016	4.45
04/13/2016	4.57
04/27/2016	3.05
05/11/2016	3.89
05/13/2016	4.26
05/23/2016	4.36
06/03/2016	3.23
06/15/2016	3.37
07/01/2016	4.69
07/15/2016	***6.73***
07/28/2016	***12.28***
08/12/2016	***6.34***
08/26/2016	3.37
09/09/2016	4.99
09/22/2016	2.83
10/06/2016	3.25
10/20/2016	2.20
11/04/2016	2.29
11/18/2016	4.51

Figure 4. Nippo Lake Chlorophyll-a and Secchi disk transparency from the 2016 sampling season



The 2015 summary report did not find a statistically significant change in Nippo Lake's Chl-*a* concentration from 1986 to 2015 (Appendix B). However, the majority of the data were collected through UNH LLMP, which only collects a water sample from an epilimnetic composite to calculate Chl-*a* concentration. NHDES employs a slightly different methodology, collecting a mid-metalimnion composite sample to determine Chl-*a* concentration, as an increase in algal concentration is typically present in a lake's middle layer. This difference in sampling methodology may be why significant increases in Chl-*a* concentrations were not recorded.

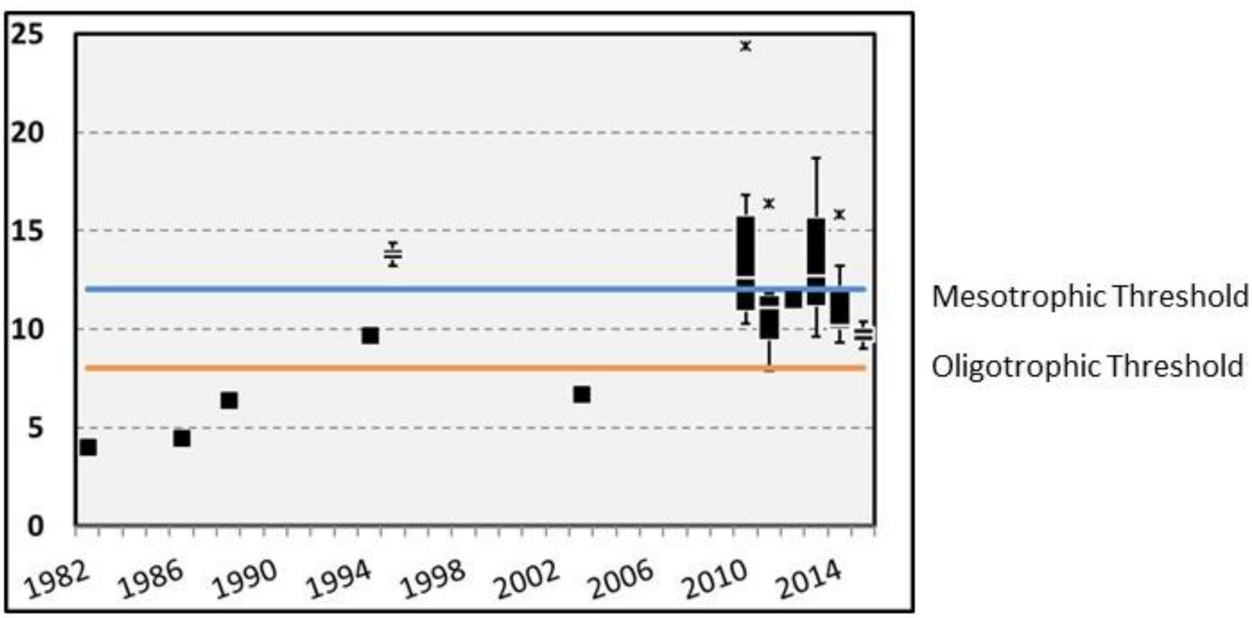
Total Phosphorus

Phosphorus is one of the major nutrients needed for plant growth in freshwater systems. Total phosphorus (TP) is the total concentration of phosphorus found in the water, including organic and inorganic forms. Phosphorus is transported to lakes via watershed sources and pathways, atmospheric deposition, and wildlife. Additionally, low dissolved oxygen, or anoxia, can release phosphorus to the water column from lake sediments. As phosphorus concentrations increase in a lake, the amount of algal growth also increases and cyanobacteria blooms may become more frequent.

For New Hampshire lakes, the median summer epilimnetic TP is 12.0 parts per billion (PPB), while the average TP concentration for White Mountain region lakes is 8.0 ppb (NHDES, 2015). Epilimnetic total phosphorus concentrations in Nippo Lake from 1982 to 2015 ranged from 4.0 ppb to 24.4 ppb with a median concentration of 10.5 ppb.

Figure 5. Historical epilimnetic TP (ug/L) in Nippo Lake

The orange line represents the TP threshold for oligotrophic lakes (8.0 µg/L) and the blue line represents the TP threshold for mesotrophic lakes (12.0 µg/L). TP values above the blue line are considered eutrophic.



Source: NHDES

Dissolved Oxygen

Dissolved oxygen (DO) is the concentration of oxygen dissolved in the lake's water and is essential for supporting aquatic life and chemical processes that sustain lake functioning. If oxygen levels fall to exceedingly low levels, the lake can become anoxic which is harmful to aquatic life. Additionally, when anoxia occurs deep in the lake, sediments can release phosphorus to the water column where it becomes available for algal uptake. Dissolved oxygen levels in the lake respond to various factors including nutrient inputs to the lake from anthropogenic and natural watershed sources, temperature, plants, and algae.

Dissolved oxygen concentrations often change with lake depth. For deeper lakes, such as Nippo Lake, oxygen is produced in the top layer of the lake where sunlight drives photosynthesis, but is consumed near the bottom of the lake where organic material decomposes. Dissolved oxygen levels lower than 5 mg/L are stressful to aquatic life. As DO levels drop lower and an anoxic state is reached, phosphorus can be released from the lake's benthic sediments – a phenomenon referred to as internal loading as the lake feeds itself internally.

Dissolved oxygen and temperature profiles have been periodically collected at Nippo Lake's deep spot since 1986. Levels in the hypolimnion have ranged from around 3 mg/L in 1986 to 0.9 mg/L in 2013 (at around ten meters). In 2016, a DO profile taken by NHDES staff shows that the lake was experiencing anoxia at nine meters. These low levels of DO in the lake's hypolimnion confirm that at times, anoxia is present in the deepest area of the lake indicating that internal loading could be a factor in nutrient loading to the lake.

Cyanobacteria

Cyanobacteria are a type of bacteria that obtain energy through photosynthesis. Cyanobacteria are present in all lakes, however, their abundance increases as nutrients (e.g. phosphorus) increase. Other conditions that may accelerate cyanobacteria blooms include temperature, sunlight, and activities that suspend sediment in the water column such as wind and motorboat activity. There are eight known types of cyanobacteria in New Hampshire: *Anabaena (Dolichospermum)*, *Aphanizomenon, Coelospharium, Gloeotrichia, Lyngba, Merismopedia,* and *Microcystis*. Some cyanobacteria produce toxins which can sicken humans, domestic animals, and livestock.

Cyanobacteria bloom, Nippo Lake
(Photo: Lynda Brushett, NLA)

Cyanobacteria are a concern in Nippo Lake for several reasons – potential health effects for humans and animals, lake aesthetics, and economic impacts tied to blooms. The frequency and intensity of the blooms is likely tied to phosphorus loading to the lake from watershed and internal sources. Nippo Lake is currently on the State's 303(d) list of impaired waters for Primary Contact Recreation (swimming) due to reoccurring cyanobacteria blooms. Table 7 provides a summary of reported blooms on Nippo Lake between 2010 and 2019.

Table 7. Reported cyanobacteria blooms on Nippo Lake between 2010 and 2019 – UNH and NHDES

Reported Bloom	Sample Collected	Genera	Cell Count	Comments
June 17, 2010	Yes	Anabaena/ Dolichospermum	86,500 cells/mL	Microcystins < recommended maximum levels
July 30, 2013	No	Oscillatoria and Anabaena/ Dolichospermum	N/A	-
September 30, 2013	No	Anabaena/ Dolichospermum	N/A	Surface film
November 17, 2013	No	Unknown	N/A	Not verified, but photos suggest a late season bloom
August 11, 2014	Yes	Anabaena/ Dolichospermum	18,000 cells/mL	Filamentous algae was also observed
August 19, 2014	Yes	Anabaena/ Dolichospermum	Phycocyanin concentrations exceeded 100,000 cells/mL	-
August 5, 2015	Yes	Unknown picoplankton	170,000 cells/mL	-
August 18, 2015	Yes	Small cyanobacteria	300,000 cells/mL	-
June 3, 2016	Yes	Anabaena/ Dolichospermum	50,000 cells/mL	-
July 28, 2016	Yes	Picocyanobacteria	230,000 cells/mL	Advisory issued
May 29, 2018	Yes	Anabaena/ Dolichospermum	N/A	Sampled after bloom conditions
June 7, 2018	Yes	Anabaena/ Dolichospermum	100 cells/mL	Microcystin levels < detectable limits
July 23, 2018	Yes	Anabaena/ Dolichospermum	750 cells/mL	Microcystin levels < detectable limits
August 26, 2019	Yes	Picocyanobacteria	200,000 cells/mL	Advisory issued; in effect until 9/23/2019

Sources: NHDES and UNH Center for Freshwater Biology

Summary of Water Quality Analysis

The water quality analysis for Nippo Lake focused on in-lake water quality parameters that provide an important foundation for the establishment of a water quality goal to guide restoration for Nippo Lake: Secchi disk transparency, chlorophyll-*a,* and total phosphorus. The water quality analysis of these three core parameters, coupled with the review of dissolved oxygen data and reported cyanobacteria blooms, indicate that the lake is experiencing declining water quality trends. To prevent cyanobacteria blooms, phosphorus reductions are needed. If phosphorus inputs continue at the present rate, or increase, toxic cyanobacteria blooms will continue and may become more frequent and intense. The watershed restoration plan for the lake will establish a water quality goal and provide recommendations for management actions to reduce phosphorus loading to the lake such that cyanobacteria blooms are prevented or eliminated.

6. POLLUTION CAUSES AND SOURCES: NUTRIENT INPUTS AND LAKE RESPONSE

To identify restoration approaches for the lake, two key questions must be answered:

- How much phosphorus is entering the lake?
- Where is the phosphorus coming from?

To help answer these questions, NLA and NHDES representatives conducted a lake loading modeling analysis to identify the sources, pathways, and amount of phosphorus loading that will need to be controlled to achieve pollutant load reductions necessary for water quality improvement.

6.1 Lake Loading Response Modeling

The Lake Loading Response Model (LLRM) is an Excel-based model that incorporates data on land cover, watershed boundaries, point sources, septic systems, waterfowl, rainfall, and an estimate of internal lake loading with coefficients and equations from scientific literature on lakes and nutrient cycles to trace water and phosphorus loads in the form of mass and concentration from various pollutant sources in the watershed (AECOM, 2011). It combines several models from scientific literature into one predictive phosphorus concentration with estimated phosphorus sources divided into five categories: atmospheric deposition, internal loading, waterfowl, septic systems, and watershed. The target watershed can be further subdivided into multiple subwatersheds to better track phosphorus sources. The model can also make predictions about chlorophyll-*a* concentrations and Secchi Disk Transparency readings based on the estimated phosphorus loading.

The Nippo Lake LLRM phosphorus sources were divided into six categories: atmospheric deposition, internal loading, waterfowl, septic systems, and two subwatersheds. Due to concern over pollutant load from the gravel road Golf Course Way, the north end of the lake was delineated as a separate subwatershed from the remaining watershed. In the model, the two subwatersheds are referred to as "Watershed – Boat Ramp" which is the northern subwatershed that includes Golf Course Way and "Watershed – Nippo Lake" which is the eastern, western, and southern areas of the remaining watershed. Both watersheds directly drain to Nippo Lake.

Data for the model were provided from NHDES and UNH LLMP. Deep spot data spanned from 2010 to 2016, which included 92 chlorophyll-*a* samples and 62 total phosphorus samples. Two total phosphorus measurements for the inlet were from 2016 and 2017, and thirteen total phosphorus measurements for the outlet were collected between 2011 – 2017.

Modeling inputs and categories are described in the following sections: Atmospheric Deposition, Internal Load, Waterfowl, Septic Systems, and Watershed Loads

Atmospheric Deposition

To estimate phosphorus loading from atmospheric deposition in the model, the lake volume was determined from a lake bathymetry survey compiled in 2016 using a Lawrence fathometer. Lake area was determined from NHDES's 2016 Assessment Unit Identification (AUID) layer of New Hampshire waterbodies. Precipitation was determined using a publically available 1983 United States Geological

Survey (USGS) precipitation contour map of New England. The phosphorus coefficient (kg/ha/yr), a.k.a. the estimated phosphorus entering the lake via atmospheric deposition, was taken from a Newfound Lake study (UNH Center for Freshwater Biology, 2013).

Internal Load

The area of lake potentially impacted by internal loading was determined by estimating total in-lake phosphorus for each 2016 sample date using TP samples, the dissolved oxygen/temperature profile, and the area of each 1-meter lake layer. The total phosphorus load during fully mixed conditions was subtracted from the total phosphorus load of each sample event that occurred under stratified conditions to determine which sample event had the greatest increase in estimated TP. The maximum internal load was determined to be 16.5 kg TP. The associated dissolved oxygen/ temperature profile indicated Nippo Lake was anoxic at nine meters. Because anoxic conditions are associated with internal TP loading, the lake area at a depth of nine meters was incorporated into the LLRM.

Waterfowl

Waterfowl data for LLRM input were collected by NHDES staff on each sampling event as well as local knowledge. Mallard ducks were often observed on the lake and a nesting pair of loons was reported by local residents. The LLRM phosphorus coefficient for cormorants was substituted for loons, based on their similar diets, and both coefficients were taken from Scherer et al. 1995.

Septic Systems

The Nippo Lake Association conducted a voluntary septic system survey of residents who reside within the Nippo Lake watershed during the summer of 2017 (Appendix C). Fifty-five responses were recorded representing 90 percent of watershed residents. Based on the survey responses, the septic system section of the LLRM distinguished between occupation seasonality (year round, limited year round, more than one season, seasonal, and minimal occupation), distance of the septic system to the lake (< 75’, 75’ – 125’, and 125’ – 250’), and number of people per dwelling. The estimated amount of TP from each category was modified based on the information provided, with higher levels of TP estimated for septic systems that were closer to the lake or used more frequently.

Watershed Loads

For modeling purposes, the northern end of the lake, which includes Golf Course Way, was delineated as the boat launch subwatershed. Golf Course Way is a private, gravel road that often washed out and transported sediment to the lake during rain events. The 2011 National Land Cover Database (NLCD) was used to determined land use type. Golf Course Way was separately delineated to account for in-situ TP measurements collected during a storm event on October 28, 2016.

The remaining portion of the watershed includes the remainder of the lake’s watershed as well as an inlet and outlet. This subwatershed drains directly to the lake and was delineated as the Nippo Lake subwatershed. The 2011 National Land Cover Database was used to determined land use type. A pasture area for horses was observed on the western side of the watershed that was not encapsulated by the NLCD; therefore, that area was approximately delineated in Google Earth and added as a

"Grazing" category to the land use types. Additionally, a wetland at the southern end of the subwatershed was mislabeled as "Developed, Open Space." By using the National Wetland Inventory (NWI) GIS layer, the wetland within the watershed was delineated and added as "Forested Wetland" to the land use categories.

6.2 Lake Loading Response Modeling results

The LLRM determined that the total amount of TP loading from all watershed sources is 37.5 kg/yr, with the greatest source of TP to Nippo Lake being from watershed sources of loading – the Nippo Lake subwatershed (30.8%) and the Boat Ramp watershed (12.8%). Internal loading, is the second largest source to Nippo Lake and accounts for 34.3% of all TP (Table 8). The smallest TP loads to the lake were from Atmospheric Deposition (10.1%), Septic Systems (7.5%), and Waterfowl (4.5%) Table 8 presents the TP and water loading to Nippo Lake from each source. The predicted, modeled in-lake concentration of TP was 10.9 ppb and the predicted, modeled chlorophyll-*a* concentration was 3.5 µg/L.

Table 8. Current Total phosphorus (TP) and water loading by summary source for Nippo Lake

Loads to Nippo Lake	TP (kg/yr)	TP (%)	Water (m^3/yr)	Water (%)
Internal Loading	12.9	34.3	NA	NA
Watershed – Nippo Lake	11.6	30.8	550320	53.3
Watershed – Boat Launch	4.8	12.8	122781	11.9
Atmospheric Deposition	3.8	10.1	355,667	34.4
Septic Systems	2.8	7.5	4677	0.5
Waterfowl	1.7	4.5	NA	NA
Total Load to Nippo Lake	**37.5**	**100**	**1,033,444**	**100.0**

6.3 Historical Lake Loading Response Modeling

Once the LLRM for Nippo Lake was calibrated for current in-lake phosphorus concentration, manipulations could be made to estimate historical phosphorus loading, a.k.a. what in-lake phosphorus concentration was before development. To predict the historical phosphorus load, NHDES personnel manipulated the model so that all development was converted back to natural vegetation, septic system inputs were set to zero, and internal loading estimates were removed. This is assuming the anoxic in-lake conditions are the result of excess pollutant loading from historical and current human activities in the watershed.

With septic system inputs and internal loading removed, coupled with pre-development land use, the estimated total amount of TP loading to the watershed was 10.6 kg/yr This represents a 26.9 kg/yr decrease from the current load estimate (Table 9). Estimated in-lake TP under historical conditions was 2.9 ppb and accounts for an 8.0 ppb decrease from Nippo Lake today. Current TP load to the lake is approximately 350% greater than the historical load.

Table 9. Historical total phosphorus (TP) and water loading summary by source for Nippo Lake

Loads to Nippo Lake	TP (kg/yr)	TP (%)	Water (m^3/yr)	Water (%)
Atmospheric Deposition	3.8	36.0	355,667	34.6
Watershed -Nippo Lake	3.7	35.0	550302	53.5
Waterfowl	1.7	16.0	NA	NA
Watershed - Boat Ramp	1.4	13.0	122068	11.9
Internal Loading	0.0	0.0	NA	NA
Septic Systems	0.0	0.0	0	0.0
Total Load to Nippo Lake	10.6	100	1,028,038	100.0

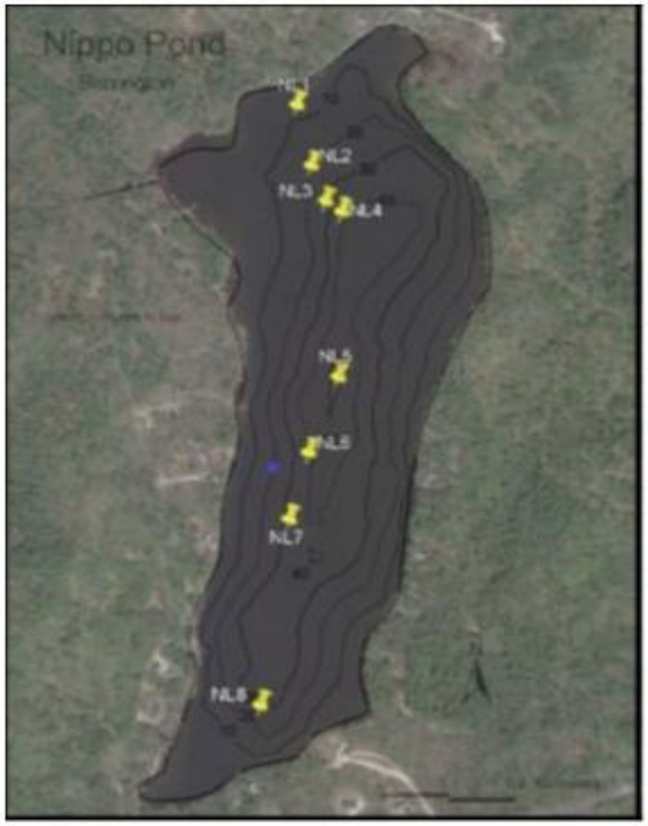
In summary, modeling results for Nippo Lake indicate that watershed and internal sources of loading deliver the greatest amount of phosphorus to the lake. Taking steps to identify and implement management approaches to reduce phosphorus loading from these sources will enable NLA to move forward toward achieving restoration success.

6.4 Evaluation of Internal Loading from Sediments

Internal phosphorus loading is a process by which phosphorus is released from bottom sediments when water near the sediments of a lake experiences low dissolved oxygen concentrations. Once released, phosphorus can concentrate in the lower water level (i.e. hypolimnion). This excess phosphorus becomes available to upper water layers and algae via spring or fall turnover, the deepening of the epilimnion as stratification changes, or the ability of particular types of algae, such as cyanobacteria, to determine their position in the water column and access the nutrient pool. Occasionally, other processes result in internal loading, but none of these are relevant to the Nippo Lake situation where anoxic conditions release sediment-bound phosphorus that drives internal loading.

The LLRM provided an estimate of internal phosphorus loading to the lake (12.9 kg/yr; see Section 6.1.8 for more details); however, to support the LLRM results and more accurately quantify the amount and categories of phosphorus in Nippo Lake sediments, a sediment sampling program was developed through collaboration among NHDES, DK Water Resource Consulting (DKWRC), and NLA. Sediment sampling was conducted on July 31, 2018. Field personnel included staff members from NHDES, DKWRC, and NLA volunteers. Eight samples and one duplicate sample were collected from eight locations at the lake, which spanned from north to south and varied by depth. Sediment sampling locations are depicted in Figure 6. Stations were chosen to provide a representation of sediment conditions at all depths throughout the lake. A QAPP was developed, reviewed, and approved to guide this work (the QAPP is on file at NHDES).

Figure 6. ***Sediment sampling locations – Nippo Lake***



The phosphorus in the sampled sediment from Nippo Lake was reported in four categories where each category represents a functional group which indicates how tightly the phosphorus is bound to the sediments and under what conditions it might be released to the water column and therefore available for algal uptake (Table 10.). The measured amount of each category present in the sampled lake sediments provides an understanding of the quantity of phosphorus that may be released to the water column and the conditions that may trigger its release. This information is critical for moving forward to develop a management plan to control phosphorus release from sediment sources.

Table 10. Phosphorus categories and conditions for release

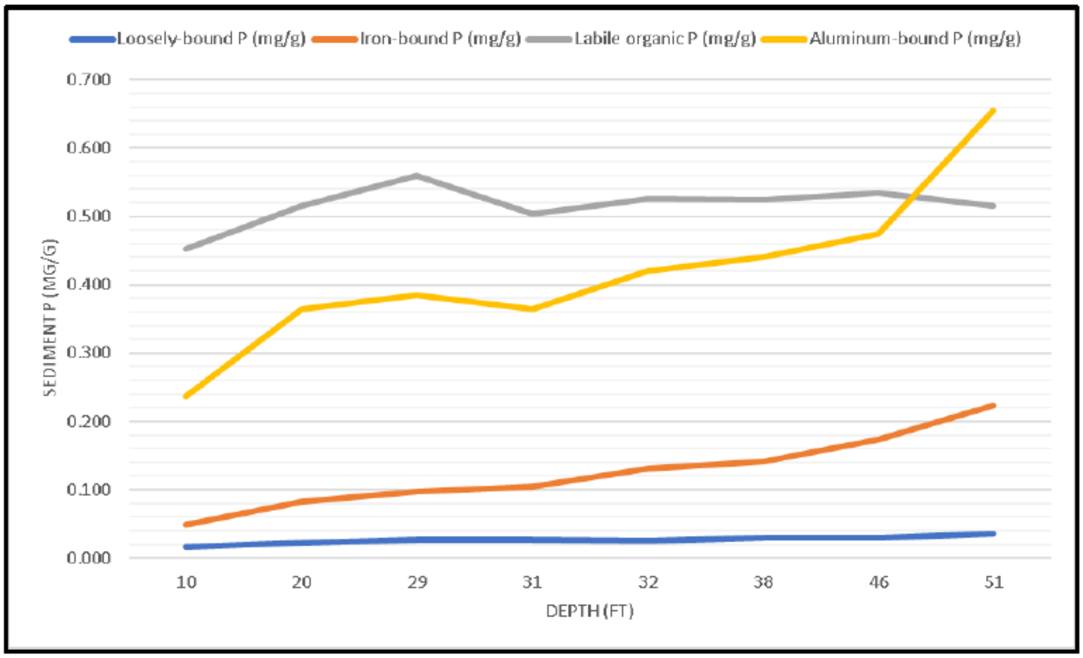
P category	Conditions for release
Loosely bound	Readily available
Iron bound	Released under low oxygen
Labile organic	Released as organic material decays
Aluminum bound	Permanently bound – not released
Other forms*	Generally not mobile

*Calcium bound mineral P and organic P

The sediment sampling and characterization results showed that the concentration of loosely bound phosphorus is relatively low at all depths (Figure 7). Iron bound phosphorus is relatively low at shallow stations and becomes progressively higher at deeper stations. Labile organic P is relatively consistent across stations. Aluminum bound phosphorus is also higher at deeper stations than shallow stations. As a result of the uneven distribution of both iron and aluminum bound phosphorus with depth, total phosphorus in the sediment is lowest in shallow water and highest in deep water. This is to be expected as sediments tend to redistribute deeper in a lake over time along the slope of the bottom (DKWRC, 2019).

Dissolved oxygen profiles taken in 2016 show that Nippo Lake experiences anoxia below 9 meters in the summer. As a result of the anoxia, a portion of the loosely bound, iron bound, and, to a lesser extent, labile organic, phosphorus is released to the water column in the deep layers of the lake. This phosphorus is transported to the epilimnion through diffusion, wind mixing and deepening of the epilimnion where it can be taken up by algae.

Figure 7. Fractions of sediment phosphorus by water depth – Nippo Lake



Source: DKWRC, 2019

The depth and concentration of sediment phosphorus were used to estimate the mass of phosphorus released from the lake sediments by depth, area, and category (Table 11). This information is critical for use in future efforts to identify methods for controlling internal loading from the sediments.

Table 11. Estimated phosphorus mass in sediments below selected water depths in Nippo Lake

Water Depth (m)	Water Depth (ft)	Area (acres)	Area (hectares)	Loosely Bound P + Iron Bound P in upper 10 cm of sediments (kg)	Loosely Bound P + Iron Bound P + Labile Organic P in upper 10 cm of sediments (kg)
9	30	27	11	224	857
7	23	42	17	326	1314
3	10	65	26	462	2029
0	0	85	35	606	2663

Source: modified from DKWRC, 2019

The estimate of internal load used in the LLRM was generated by estimating accumulation of phosphorus in the hypolimnetic volume below 9 meters and assuming that 75 percent of that gross internal load would be available for algal growth by the following growing season or 12.9 kg. The gross internal load estimate was 17.2 kg/yr.

To further quantify and refine the LLRM estimate of internal phosphorus loading, the modeling results can be cross-checked by evaluating potential release from the measured sediment reserves below 9 meters. Because iron bound phosphorus and loosely bound phosphorus are the most readily available, they are appropriate to use for this estimate. Not all of the 224 kg of available sediment phosphorus below 9 meters will be released in any year. Typically, just a portion of the available sediment is released to become part of the effective load to the lake. For Nippo Lake, the sediment study assumed a release rate of release of ten percent due to due to the low potential for substantial wind mixing due to the steep watershed and the depth of the lake relative to its size. Using a potential transfer rate of ten percent per year equates to an internal load of 22.4 kg/yr, which is slightly higher than the gross estimate made from the hypolimnetic accumulation calculation done for the LLRM, but probably within the range of year to year variability. This rate of internal load is supported by observed data on accumulation of phosphorus in deeper waters of the lake during summer when oxygen levels are low.

Additionally, the sediment data suggest that there are considerable available phosphorus reserves in areas where the water does not become anoxic, leaving open the possibility that the contributory area is, at times, greater than the area below 9 meters. Release of that sediment phosphorus is greatly depressed by the presence of oxygen (which keeps phosphorus bound to iron and insoluble), so the contribution of the additional areas is likely to be low as long as oxygen is present. A shift in the depth of anoxia would change this situation.

Management Implications

The information obtained from the sediment sampling program confirms what the modeling indicates – the presence of sufficient mobile sediment phosphorus likely supports substantial internal loading in Nippo Lake. It also provides estimates of the mass of phosphorus that would need to be inactivated in order to reduce the internal load. The sediment data can be used to develop appropriate strategies for treatment of the internal load and for developing cost estimates for in-lake treatment strategies.

Given that the LLRM modeling and sediment sampling results for Nippo Lake indicate that watershed sources and internal loading deliver significant amounts of phosphorus to the lake, it is understood that both external and internal sources of phosphorus will need to be controlled in order to meet the lake's water quality goal. The success and longevity of any internal load treatment is highly dependent on the actions undertaken to reduce the external watershed load. It is also dependent on control of future sources of phosphorus from the watershed.

7. ESTIMATE POLLUTANT LOAD REDUCTIONS: WATER QUALITY GOAL

A key component of watershed planning involves setting a water quality goal for the lake. The goal serves as a benchmark for achieving pollutant load reductions and measuring restoration success. For Nippo Lake, restoration success means reducing the amount of phosphorus delivered to the lake such that the frequency of cyanobacteria blooms is reduced or eliminated.

The process of setting a water quality goal for Nippo Lake was guided by the water quality data review and the LLRM output. The Nippo Lake project team met as a group on March 8, 2018 to review relevant technical information and set a water quality goal for the lake. During the meeting, the group agreed that the ultimate goal of the restoration project is to reduce the frequency of cyanobacteria blooms as much as possible.

To achieve this result, the project team set a phosphorus reduction goal that would bring the in-lake concentration down from 10.9 µg/L to 7.2 µg/L, which is an in-lake concentration more typically seen in oligotrophic lakes. When phosphorus inputs to the lake are reduced such that the in-lake phosphorus concentration is 7.2 µg/L, cyanobacteria blooms will be less frequent, and chlorophyll-*a* concentrations will drop. The lake will then meet NLA's restoration goal and will likely attain water quality standards for impaired designated uses and parameters for lake nutrients and cyanobacteria.

In summary, to attain the restoration goal set by the project team, the amount of phosphorus getting to the lake will be reduced by 33% which equates to achieving average in-lake phosphorus concentration reductions from 10.9 µg/L to 7.2 µg/L. This can likely be met by preventing 27 pounds of phosphorus from reaching the lake annually (Figure 8).

Figure 8. Nippo Lake water quality goal

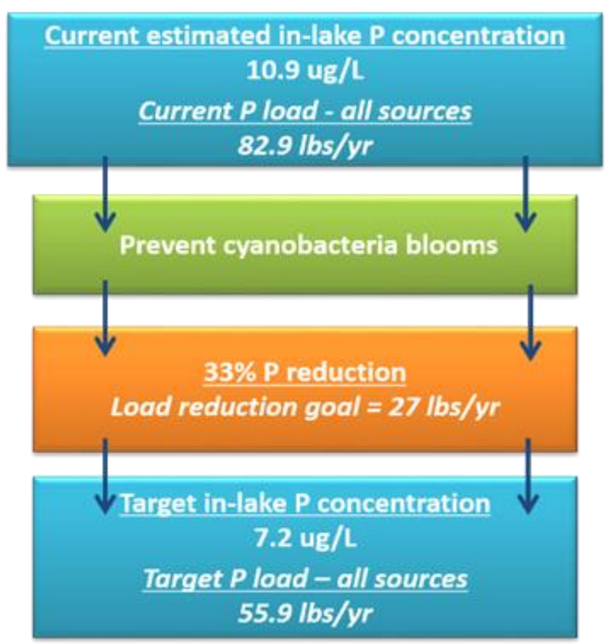


Table 12. illustrates that as phosphorus entering the lake is reduced, in-lake phosphorus concentrations drop and the cyanobacteria bloom probability is reduced.

Table 12. Phosphorus load, in-lake response, and bloom probability for Nippo Lake

Current Condition: P load (all sources), in-lake concentration, and bloom probability			
Existing load P lbs/yr	**Estimated In-lake concentration (µg/L)**	**Probability of Bloom**	**Estimated days/yr bloom**
82.9	10.9	5.1%	18.6
Estimated Restoration Response: P reductions, in-lake concentration, and bloom probability			
Lbs/yr P removed from existing load	**Estimated In-lake concentration (µg/L) after load reduction**	**Probability of Bloom**	**Est days/yr**
0.5	10.8	5.0%	18.3
2.9	10.5	4.5%	16.4
4.9	10.2	4.0%	14.6
7.5	9.9	3.5%	12.8
10	9.6	3.0%	11.0
13	9.1	2.5%	9.1
16.3	8.7	2.0%	7.3
20.1	8.2	1.5%	5.5
25.2	7.5	1.0%	3.7
27.0	7.2	0.8%	2.9
29.3	7.0	0.7%	2.6
31.8	6.6	0.5%	1.8
42.4	5.2	0.1%	0.4

Management Implications

To reach the target in-lake phosphorus concentration of 7.2 µg/L, phosphorus load reductions will be required from watershed sources and internal sources.

8. ACTION PLAN TO CONTROL PHOSPHORUS LOADING

This section presents recommendations for management strategies to control and reduce phosphorus loading to the lake. The Action Plan presents management actions for controlling phosphorus loading among the following five action plan categories:

- Category 1: Stormwater Management
- Category 2: Septic Systems
- Category 3: Internal Loading Controls
- Category 4: Watershed Outreach
- Category 5: Watershed Land Conservation

Management measures to address sources of phosphorus are presented for each action plan category; including a description of the approach, location, costs, partners, and pollution load reduction estimates. A list of priority actions for implementation is presented at the end of the Action Plan.

Action Plan Category 1: Stormwater Management

Controlling stormwater runoff is a priority management strategy for reducing watershed sources of phosphorus loading to Nippo Lake. The NLA worked with the Horsley Witten Group (HWG) to assess and identify stormwater management (SWM) opportunities in the northern and southern portions of the watershed. The NLA also worked in partnership with the NHDES Soak Up the Rain (SOAK) program to conduct on-the-ground watershed assessments to identify opportunities for stormwater management on residential properties. Recommendations from each stormwater assessment are summarized below.

SWM 1: Northern Drainage

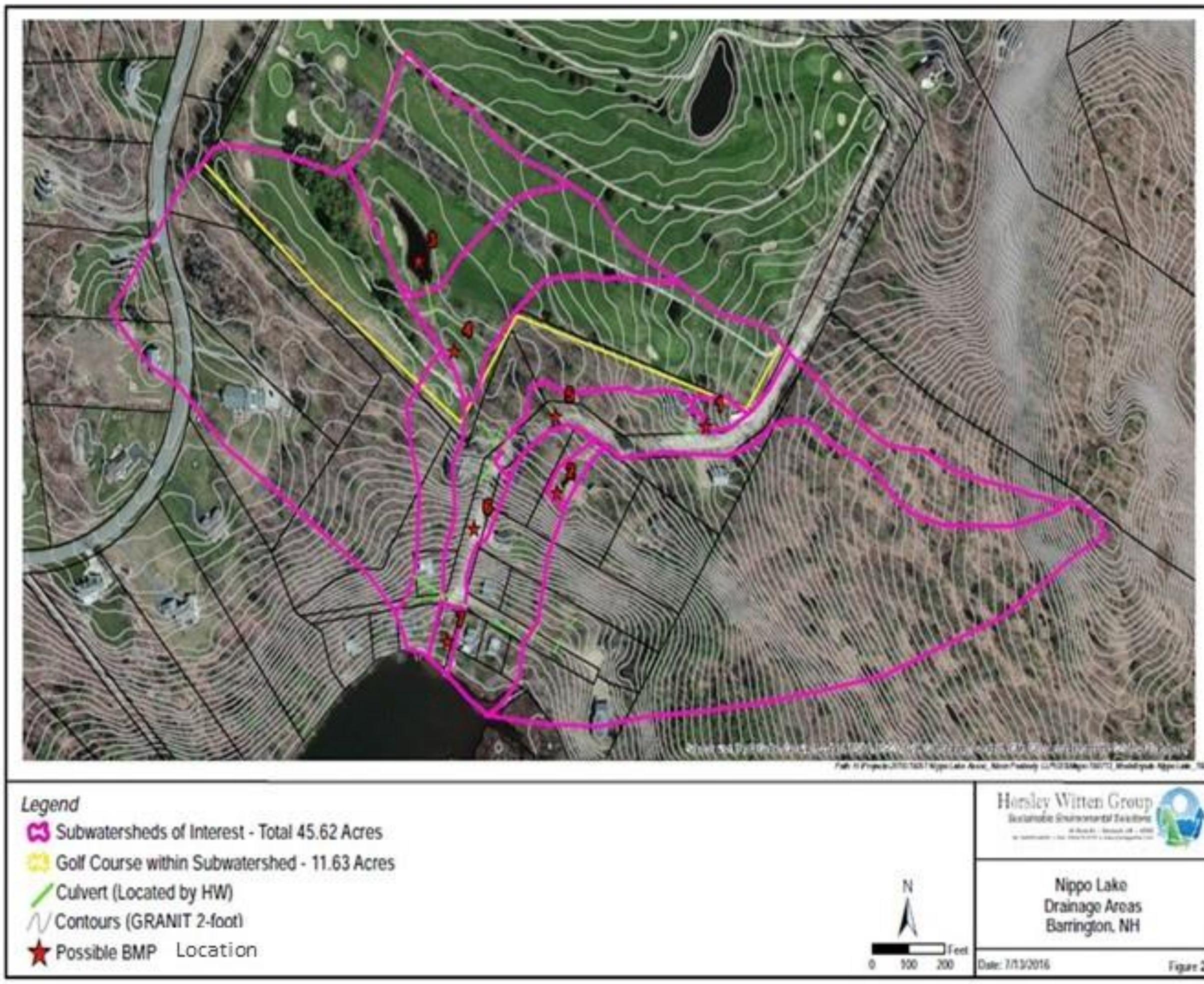
In 2016, the HWG completed a stormwater assessment for the northern end of the lake to identify and propose cost-effective opportunities to reduce stormwater runoff and phosphorus loading to Nippo Lake. Results from the assessment are summarized below in Table 13. Figure 9 shows possible locations for the best management practices (BMPs) presented in the summary table.

A summary of HWG's field findings and BMP retrofit concepts for the northern drainage stormwater assessment is included in this plan as Appendix E.

Table 13. Summary of stormwater BMP opportunities for the northern drainage

	BMP Description	Lead Partners	Estimated Cost	Results
BMP-1	Raingarden	Homeowner, SOAK, NLA	$1,000 – $3,000	If BMPs 1 -7 are implemented as proposed, phosphorus reductions could equal 18 lbs/yr.
BMP-2	Raingarden	Homeowner, SOAK, NLA	$1,000 – $3,000	
BMP-3	Pond retrofit	Landowner	$10,000 -$15,000	
BMP-4	Wet swale retrofit	Landowner	$10,000 - $15,000	
BMP-5	Water bars/check dams	Road owner with NLA	$15,000 – $20,000	
BMP-6	Pave road section	Road owner with NLA	$20,000	
BMP-7	Vegetated wet swale	Landowner	$1,000 – $3,000	

Figure 9. Map of stormwater BMP opportunities in the northern drainage



Note: In June 2019, BMPs 5 and 6 were installed to control runoff from Golf Course Way, a gravel road. BMP 1 – a residential raingarden, was installed in 2016.

SWM 2: Southern Drainage

In 2018, HWG performed an assessment in the southern portion of the watershed to identify opportunities to reduce stormwater runoff and phosphorus loading. Much of the assessment focused on private roads and related drainage features that potentially contribute phosphorus to the lake.
Three BMP sites were identified to manage runoff from 11.2 acres of the southern drainage assessment area through implementation of bioretention, wet swales, and pretreatment practices. Further, watershed-wide BMPs were identified that could be implemented by residents on private properties through programs such as NHDES's Soak Up the Rain (SOAK) program, as well as operations and maintenance practices for unpaved roads (Table 14).

A summary of HWG's field findings and BMP retrofit concepts for the southern drainage area is included in the plan as Appendix F.

Table 14. Summary of stormwater BMP opportunities for the southern drainage

Description		**Lead Partners**	**Estimated Cost**	**Priority**	**Results: Pollutant removal phosphorus - lbs/yr**
NL-FLDR-1	Sediment forebay	Property owner	$1,000 – $4,000	Low	0
NL-FLDR-2	Vegetated wet swale	Road owner/property owner	$4,000 - $6,000	Medium	0.4
NL-FLDR-3	Bioretention swale	Road owner	$12,000 – $15,000	High	0.9
NL-FLDR-4	Residential BMPs	Property owners and NHDES Soak Up the Rain program	Variable	Medium	TBD
NL-FLDR-5	Unpaved road maintenance	Road owners	TBD	High	TBD

Note: During the summer of 2019, the Flower Drive Association implemented several recommended measures to control erosion and stormwater runoff from Flower Drive including drainage improvements, road resurfacing, and grading.

SWM 3: Residential Properties

In 2018 and 2019, the NHDES Soak Up the Rain (SOAK) program partnered with the NLA and watershed residents to conduct a voluntary residential stormwater assessment to opportunities to reduce phosphorus loading to the lake from residential properties. The assessment focused on properties closest to the lake with the potential to directly contribute runoff. Twenty-six properties were assessed.

Rubber razor installation, Nippo Lake (Photo: Rob Livingston, NHDES)

Recommendations were developed for twenty-two properties shown during the assessment to have potential for stormwater management projects (Appendix G). Four properties appeared to be stable and did not need management recommendations. One property was under construction at the time of the assessment.

The NLA is committed to working with residents to install the proposed solutions for managing stormwater runoff from these properties which include:

- Shoreline buffer plantings
- Dripline infiltration trenches

- Water diversion devices
- Raingardens
- Infiltration steps

In July of 2019, several NLA members worked together to install a rubber razor water diversion device at a property located on Sarah Lane. This project was highly successful and served as a way to demonstrate to property owners around the lake that simple solutions can be installed by homeowners to manage stormwater runoff from their land.

Appendix G includes a summary table describing the results of the SOAK residential stormwater assessment and includes an example write-up for a surveyed property.

Due to the small drainage areas for each property, the estimated phosphorus load reductions achieved for a single SOAK installation are not high (~ 0.10 – 0.20 lbs/yr per installation); however, as solutions are implemented around the lake over time, load reductions will add up. Small, simple changes in residential property management can have a big impact on water quality (NHDES, 2016).

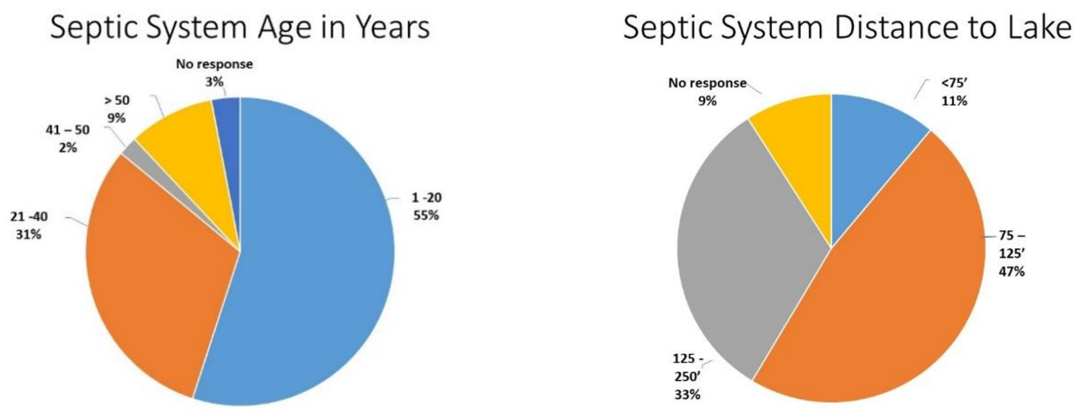
Action Plan Category 2: Septic Systems

Septic systems function to treat wastewater to protect human health and water quality. However, systems that are poorly maintained, older, and those that are located without adequate separation to groundwater present a risk to the health of Nippo Lake. When onsite systems do not function properly it is likely that either they were installed before current standards were in effect (1967) or they were not properly designed, sited, constructed or maintained. NHDES estimates that between eight and ten percent of current septic system approvals address repair or replacement of existing systems (NHDES, 2020). As a result of a law (RSA 485-A:39) passed in 1993, evaluation of systems within 200 feet of a great pond or fourth order or higher river is required before the property changes hands; however, upgrading substandard systems is not required.

The LLRM for Nippo Lake shows that individual wastewater systems contribute roughly six pounds per year of phosphorus to the lake. Phosphorus loading from septic systems can be addressed and reduced through various mechanisms including programs to promote septic pumping, replacement of older systems, and outreach to residents regarding proper septic system use and maintenance.

The Nippo Lake Association conducted a septic survey in 2017 to develop a better understanding of the age, usage, and location of septic systems in the watershed. Survey results were gathered on-line and through in-person interviews with homeowners. Survey responses were provided by fifty-five homeowners, or 90 percent of the homeowners in the watershed. Survey questions included age of septic system, proximity to the lake, occupancy rate, use (year round, seasonal, etc.), and pump out frequency. Results from the survey show that close to half of the systems are over 20 years old and are located less than 125 feet from the lake (Figure 10). Septic system usage responses included 33 households reporting one to two people using the system, 18 households reporting three to four people, and one homeowner reported five to six people using the system when occupying the house (three respondents did not provide an answer to this question). (Appendix C – 2017 Nippo Lake Septic System Survey SUMMARY).

Figure 10. Nippo Lake septic system survey results



Modest reductions in phosphorus loading to the lake could be achieved if homeowners take responsibility to inspect their septic systems and conduct necessary maintenance or upgrades. The NLA will use information gathered during the septic system survey to further efforts to reduce phosphorus loading from septic systems. Management measures to control phosphorus loading from septic systems include outreach, septic system pump-outs, and replacement of older systems (Table 15).

Table 15. Management actions to reduce phosphorus loading from septic systems

Action Item	Description	Lead Partner	Estimated Cost	Results
Septic system outreach	Provide information about proper septic system operation and maintenance	NLA	$500	Based on outcomes from other New Hampshire septic system replacement projects, upgrades could result in 1.0 to 2.0 lbs/yr of Phosphorus removed per upgraded system.
Pump-out program	Coordinate group discounts for septic system pumping in the watershed	NLA	n/a	
Septic system upgrades	Identify, prioritize and upgrade older septic systems within 50 feet of the lake	NLA	$4,000 - $10,000 per system	

Note: In 2019, an innovative septic system treatment technology was installed at a residence located on Nippo Court. The technology improves septic system functioning and reduces pollutant loading to the lake. Additionally, in 2019, NHDES developed a septic system prioritization and ranking spreadsheet to help identify systems for potential improvements, outreach, pump-outs, etc.

Action Plan Category 3: Internal Phosphorus Loading Controls

Information obtained from the Nippo Lake sediment sampling program confirms the presence of sufficient mobilization of phosphorus from sediment to support substantial internal loading of phosphorus in Nippo Lake. It also provides estimates of the mass of phosphorus that would need to be inactivated in order to reduce the internal load. These data can be used to develop appropriate strategies for treatment of the internal load and develop cost estimates for in-lake treatment strategies. The NLA understands, however, that the success and longevity of any internal loading treatment is highly dependent on actions currently being undertaken to reduce the external watershed load. It is also dependent on control of future sources of phosphorus from the watershed.

Internal phosphorus loading control methods to be evaluated include:

- Dredging
- Phosphorus inactivation
- Oxygenation
- Filtration

Results: Treatment strategies such as in-lake control through the use of techniques to inactivate phosphorus in sediments, could result in a pollutant removal efficiency of 80 to 90 percent which could result in removal of at least 20 pounds per year of in-lake phosphorus.

Action Plan Category 4: Watershed Outreach

Education and outreach activities are vital components for watershed protection and improvement. NLA has an established capacity and ability to connect with watershed residents about important lake topics. The NLA conducts outreach to association members and watershed residents regularly through various channels including e-mail list serve messages, annual meetings and social events, social media, press releases and more. The Nippo Lake watershed is small, neighbors on the lake know one another, and NLA does a highly effective job communicating about lake management issues and opportunities. The NLA will continue to use its established approaches to encourage participation in restoration activities.

Outreach topics will include: septic system maintenance, residential stormwater management, fertilizer best practices, lake friendly boating, road maintenance, and other topics as needed.

The NLA will continue to provide educational information to residents and project partners through established channels as summarized in Table 16.

Table 16. Nippo Lake education and outreach action matrix

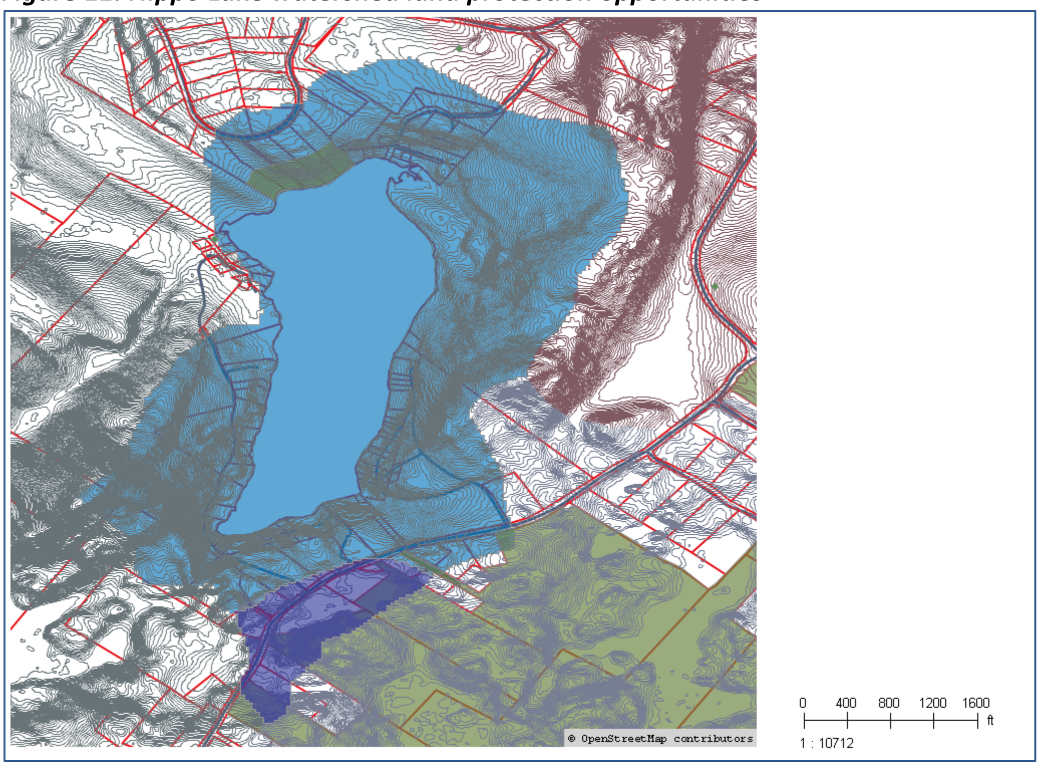
Outreach Actions	Schedule	Description
Member meetings	June	Meetings to include following topics: • Review of Lay Lakes Monitoring Report from the prior summer. • Presentations from UNH, NHDES or others on water quality, watershed goals and plans, in-lake treatment, and shorefront remediation. Review state boating regulations and NLA boating practices, including inspection and cleaning procedures for visiting water craft. Discuss findings and implications for lake use. • Review NHDES information on invasive species and procedures for photographing, collecting and having suspect plant material analyzed and identified. • Publicize meeting though e-mail, postcards and social media
Annual meetings	August	• Lake monitors will provide updates on sampling activities, water quality and alert members to any issues requiring immediate action. • Presentations by UNH on key areas of watershed concerns. • Reports on boating, shoreline remediation, raingarden activity in-lake treatment, and other topics to educate residents on best practices for lakeside living that promote water quality.
E-mail/list serve/ Facebook	Weekly May-October, opportunistic communication November -April	• Topics include: lake friendly landscaping, best boating practices, water quality monitoring updates, loon and chick news, cyanobacteria information and alerts, pesticide use, tree and bush cutting regulations, whys and wherefores of shoreline buffers, prevention of stormwater runoff, septic system maintenance, in-lake treatment, and efforts to restore water quality updates.
Special events/presentations	As needed though the year	• Special topics related to lake issues such as loon behavior, results of water quality testing, aquatic invasive plant and animal species, raingarden training and more.
Website	Year round	• General information about the lake, watershed plan, lake studies, BMPs – including in-lake treatment, and other documents.
Road association meetings	May	• Review of gravel road upkeep practices, culvert and ditch maintenance and budget for improvements such as paving, swales and culvert replacements.
Fertilizer outreach	Summer	• Provide outreach to property owners regarding application of and commitment to use “phosphorus free” fertilizers containing no more than 0.67% phosphorus (2017, USEPA).

Action Plan Category 5: Nippo Lake Watershed Land Protection

Land conservation can be an effective tool to limit or reduce nutrient loading from land development activities in the Nippo Lake watershed. Strategies for protecting land include conservation easements, fee-simple land purchases, deed restrictions, tax incentives, and other methods. The NLA recognizes the need to protect land around the lake as a measure to control and reduce nutrient loading; the NLA will continue to work on land conservation efforts to protect land in the watershed.

The approximately 294 acre Nippo Lake watershed is small, steep and bowl shaped. The watershed is largely forested, undeveloped (except for cottages and roads along the lake shorefront) and owned in large blocks by only four families. At the south end of the lake the watershed overlaps with the 1,500 acre conserved Stonehouse Forest owned by the Southeast Land Trust (SELT). See purple area in Figure 11. The small geographic size of the watershed coupled with local land ownership patterns, opportunities exist to protect land in the watershed.

Figure 11. Nippo Lake watershed land protection opportunities



Data source: USGS *Map produced by Charlie Briggs, NLA*

The water resources and wildlife values for undeveloped watershed properties are high, making them good candidates for conservation. To ensure the lasting impact of all the resources that have been invested in restoring the quality of Nippo Lake, protection of the watershed from development that would impair the lake is critical to long term sustainability of the lake and success of the watershed plan.

Table 17 offers a summary of land protection actions NLA will take to protect land in the watershed.

Table 17. Nippo Lake watershed land protection actions

Action Item	Description	Lead	Estimated Cost	Results
Identify potential land conservation projects	Coordinate with watershed landowners to identify potential land conservation projects and seek funding to implement projects	NLA	N/A	Projects and funding are identified
Landowner outreach	Conduct outreach to watershed landowners to discuss conservation options	NLA	$200	Landowners are aware of conservation options and tools for land protection
Land conservation coordination	Coordinate with Southeast Land Trust, Barrington Conservation Commission, Great Bay Resource Protection Partnership and other partners to implement land conservation measures and projects	NLA	$5,000	Partners coordinate to implement measures to protect land in the watershed, including wetlands and wildlife assessments and other pre conservation requirements
Land conservation	Coordinate with partners and landowners to conserve watershed land	NLA	Unknown at this time	Permanent protection of the watershed

Action Plan Implementation – Summary

For implementation planning purposes, Table 18 below provides a summary and priority ranking of implementation actions. Ranks were determined by evaluating cost, phosphorus removal rates, and implementation capacity.

Table 18. Nippo Lake watershed implementation actions

Description	Location	Proposed Approach	Estimated Cost	Estimated P reduction (lbs/yr)	Lead Partner	Priority Ranking
Stormwater management	North watershed	Treat runoff from Golf Course Way	$40,000 - $80,000	8 - 10	NLA and road owner	High
	South watershed	Address runoff from private roads	$1,000 - $5,000	3 - 5	Road owners	Medium
	Residential properties	Implement 4 – 8 residential BMPs	$2,000	0.20 - 1	Property owners, SOAK, and NLA	High
Septic system upgrades	As identified	Upgrade 4 -8 older systems within 50 feet of the lake	$120,000	2 - 5	Property owners	Medium
Internal loading controls	In-lake	Manage internal phosphorus loading	$200,000	20	NLA in partnership with NHDES	High
Watershed outreach	Shoreline properties	Conduct outreach to lakefront property owners	<$100	N/A	NLA in partnership with watershed residents	Medium
Fertilizer outreach	Shoreline properties with turf	Conduct outreach to lakefront property owners regarding use of phosphorus free fertilizers	<$100	~ 1.80	NLA in partnership with watershed residents	Low
Watershed Land Protection	As identified	Work with landowners to protect and conserve land	Project dependent	N/A	NLA, landowners, and others	High

9. MILESTONES AND SCHEDULE

A description of interim, measurable milestones for determining if NPS management measures are being implemented, is presented in Table 19.

Table 19. Nippo Lake watershed implementation milestones

Management Measure	Milestones
Watershed plan development	• Plan is published and available
Structural BMP implementation	• Number of BMPs implemented and pollutant load reduction estimates documented • Operation and maintenance plans developed and tracked
In-lake control implementation	• In-lake control methods, costs, and approach documented • Approval obtained from NHDES for selected in-lake controls • In-lake control methods deployed and documented • Effectiveness monitoring is conducted and reported
Non-structural BMP implementation	• Number of outreach materials and events produced • Number of participants in outreach events
Water quality monitoring	• Monitoring conducted annually and reports/data submitted to NHDES
Implementation tracking	• Plan implementation progress tracked and reported to stakeholders every two years • Adaptive management approaches developed, if needed

An Implementation Schedule for the Nippo Lake Restoration Plan is presented in Table 20. The schedule will be evaluated annually and revised as needed according to actual progress.

Table 20. Nippo Lake Watershed Restoration Plan implementation schedule

Implementation Task	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
1.0 Finalize Nippo Lake restoration plan and distribute											
2.0 Implement structural BMPs											
2.1 Round 1 BMP implementation											
2.2 Round 2 BMP implementation											
2.3 Round 3 BMP implementation											
2.4 BMP operation and maintenance tracking											
3.0 Implement in-lake management BMPs											
3.1 Final technical review and approach											
3.2 Approval											
3.3 Funding plan in place											
3.4 Implementation											
3.5 Effectiveness monitoring											
4.0 Implement non-structural BMPs (outreach)											
5.0 Implement land conservation activities											
6.0 Monitor water quality											
7.0 Review progress and report to project partners											

10. SUCCESS INDICATORS AND EVALUATION

As discussed in Section 7, the current average epilimnetic in-lake phosphorus concentration for Nippo Lake is 10.9 µg/L. The recommended epilimnetic in-lake concentration target for Nippo Lake is 7.2 µg/L. To meet this goal, the annual phosphorus load to the lake from all sources needs to be reduced by approximately 27lbs/yr. To determine if lake management measures are successful, the restoration indicators and targets shown in Table 21 will be measured and tracked as the restoration plan is implemented to determine if substantial progress is being made towards attaining the plan's water quality goal.

The water quality goal established for the plan provides a framework for establishing numeric and narrative restoration indicators to 1) measure whether the in-lake phosphorus concentration becomes lower as restoration measures are implemented, and 2) track the frequency of cyanobacteria blooms to determine if bloom frequency is reduced as phosphorus loads decline.

If regular progress reporting as shown in Table 20 – Implementation Schedule shows that the restoration targets are not being met, NLA will convene the project partners and develop adaptive management approaches for meeting water quality goals and standards.

Table 20. Restoration indicators and targets

Indicator	***Target*** ***1– 2 years***	***3 – 6 years***	***7 – 10 years***
Reduction of in-lake phosphorus concentration **Numeric goal: 7.2 µg/L**	25% of goal 9.9 µg/L	75% of goal 8.1 µg/L	100% of goal 7.2 µg/L
Algal bloom probability is reduced from 5.1% **Narrative goal: No reported blooms**	3.0%	1.5%	0.8%

11. WATER QUALITY MONITORING

Water quality monitoring is critical for evaluating the effectiveness of watershed restoration and improvement activities and to determine if nutrient load reductions are being achieved. The NLA, in coordination with the UNH LLMP has been monitoring water quality at the deep spot monthly from May to September in Nippo Lake since 1986.

Core water quality monitoring parameters include:

- Chlorophyll-*a*
- Dissolved oxygen
- pH
- Secchi disk transparency
- Specific conductance
- Temperature
- Total phosphorus

As the restoration plan is implemented, the NLA will continue to monitor lake water quality in order to track changes in water quality over time and measure success toward meeting the water quality goal. Additionally, efforts to observe and document cyanobacteria blooms will continue.

As watershed restoration activities are implemented, NLA will coordinate with UNH LLMP and NHDES to determine if LLMP monitoring frequency, location and parameters need to be adjusted in order to best measure success. The monitoring approach will be adaptive and driven by the need to document success toward achieving the water quality goal for Nippo Lake.

12. SUMMARY

The goal of the Nippo Lake Watershed Restoration Plan is to reduce the frequency of nuisance algal blooms in the lake by reducing the in-lake total phosphorus concentration by 3.7 ppb; a 33% reduction. This will require removal of 27 pounds of phosphorus from the current estimated watershed and internal loads to the lake. If the restoration actions proposed in this plan are implemented as described, it is possible that the load reductions needed to meet the water quality goal will be achieved.

The Nippo Lake Association is committed to implementing this watershed restoration plan to attain and sustain the desired water quality for the lake. Going forward, implementation will require continued collaboration among watershed residents, landowners, town commissions, state and federal agencies, UNH, non-profit land conservation organizations, and other partners who all share an interest in improving water quality for this valuable resource.

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