Lake Alma Nutrient Assessment and Management Recommendations

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and

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Contents

1. Introduction

USEPA is providing technical assistance to Ohio to advance the State's nutrient reduction efforts, specifically focusing on reducing the occurrence and impact of harmful algal blooms (HABs) in inland lakes with a priority for lakes that are sources of drinking water. This conceptual lake management plan has been developed as a part of that effort for Lake Alma, in southern Ohio (Figure 1). The lake management plan includes the following:

- Evaluation of the available water quality data for the lake and its tributaries;
- Assessment of current data gaps and monitoring recommendations for filling those gaps;
- Evaluation of the available data relative to the potential for HABs;
- Recommendations for managing nutrient loads to the lake from the watershed as well as internal loading to the lake to maintain water quality and limit the occurrence of HABs.

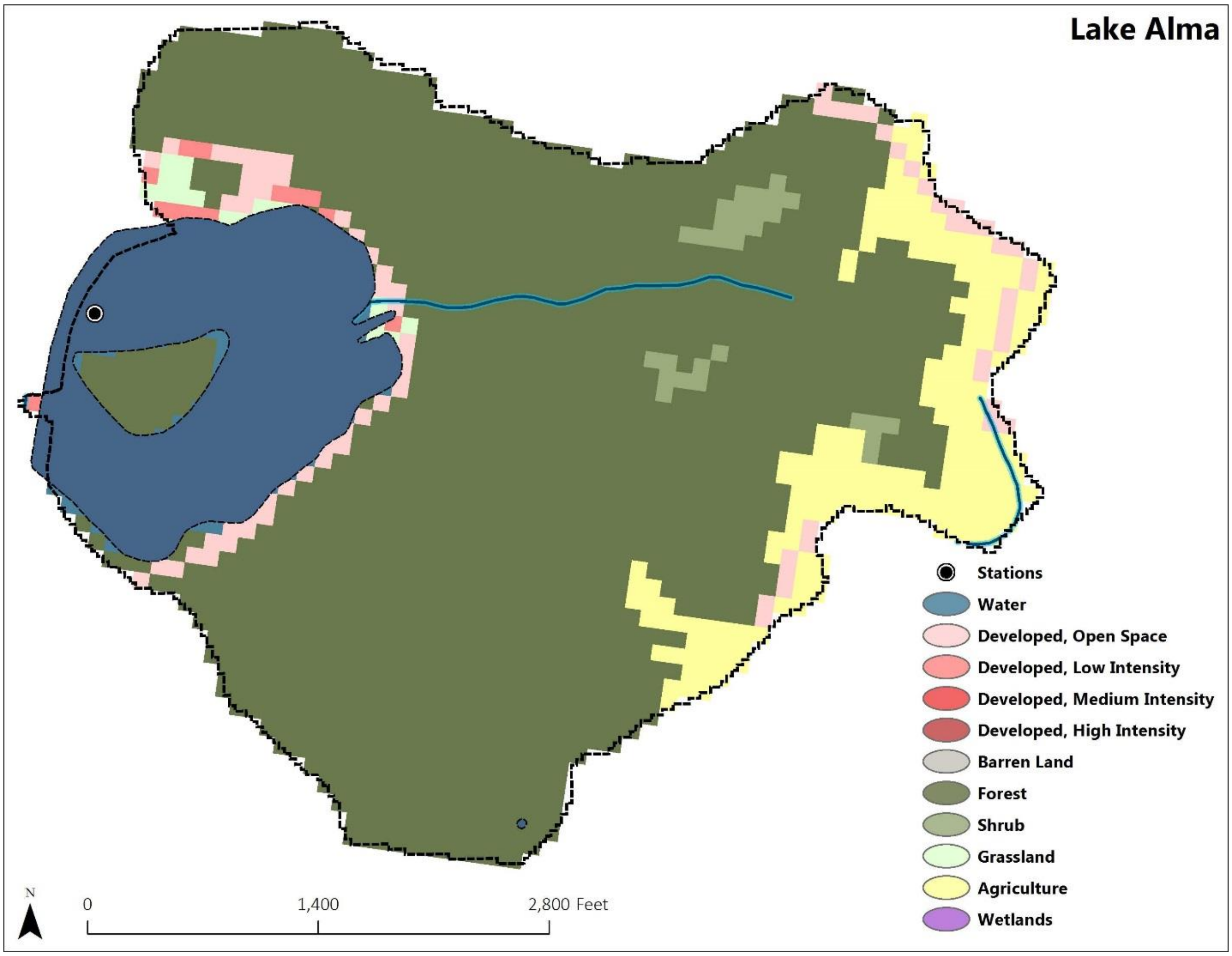

Figure 1. Lake Alma Watershed.

2. Background

Lake Alma is located on the border of Vinton County and Jackson County in southern Ohio, approximately 60 miles southwest of Columbus, Ohio. The lake has a surface area of 64 acres, a mean depth of approximately 2.5 meters (m), and 1.5 miles of peripheral shoreline (Figure 2). The lake also has a small island with 0.5 miles of shoreline.

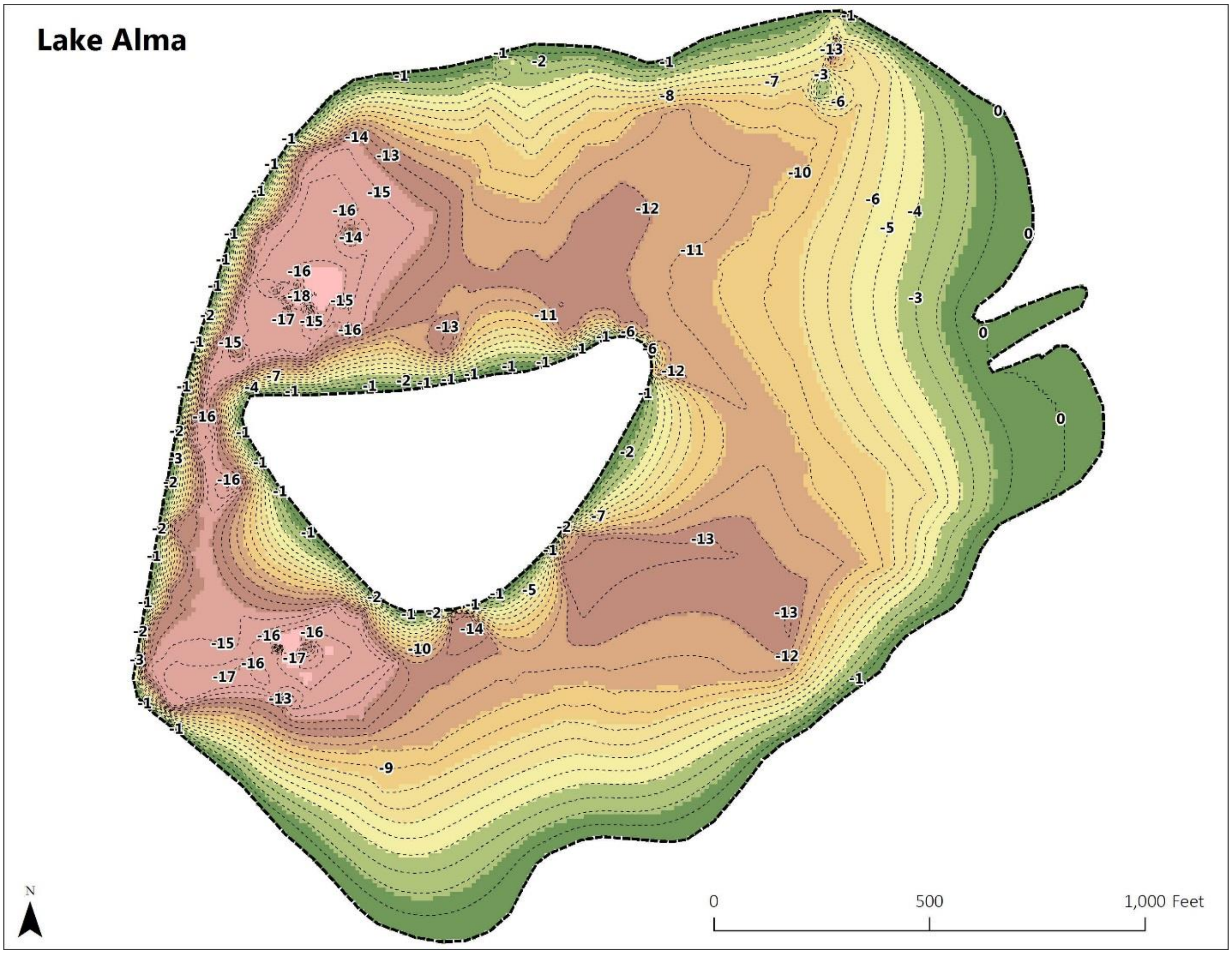

Figure 2. Lake Alma Bathymetric Map.

In 1901, C.K. Davis, a wealthy coal operator, dammed Little Raccoon Creek to form Lake Alma (Shaver, 2013). In 1903, he constructed an amusement park on the lake's island. "The park boasted a large dance pavilion, an outdoor theater, a merry-go-round, and several other rides). This attraction prospered only until 1910, and the property was later purchased by the city of Wellston to serve as a municipal water supply" (ODNR, 2016). The city occasionally withdraws water from the lake and treats it for drinking water, and leases the area to the Ohio Department of Natural Resources (ODNR) Division of Parks and Recreation for operation as a state park.

Lake Alma State Park is a popular site for summer recreation. The park has two camping areas with 64 electric and 10 non-electric sites (ODNR, 2016). Pets are permitted at all camp sites. Vault latrines are located near both camping areas and by the north picnic shelter. Construction of a shower house with flushable toilets and a new dump station will be completed in spring 2016. Sewage is pumped to the Village of Hamden for treatment. Drinking water is provided on-site (although not from the lake). Recreational facilities include playgrounds, hiking trails, a nature center, picnic areas, an amphitheater, fishing access sites, a swimming area, and a public boat ramp. Only non-motorized boats (paddled or powered by electric motors) are permitted on the lake. Boats, kayaks, and canoes are available to rent at the camp office. All portions of the park are accessible by a road that encircles the lake. State route 349 runs along the western shore of the lake, overtop the dam. Parking and picnic sites are distributed around the lake. The public beach is located on the north side of the lake, as is the boat ramp.

In spring and summer 2014, several capital improvement projects were completed at Lake Alma State Park. The bridge to the island from the western shore of the lake was replaced, and a walking path was constructed along state route 349 to allow pedestrians to safely access the bridge from nearby parking areas. In addition, trees were removed from the dam for safety, and the spillway of the dam was renovated.

The Lake Alma watershed is 455 acres, and is predominantly forested (71%), with mixed oak composition (Figure 1; NLCD, 2011). Lake Alma itself makes up 13 percent of the watershed by area, and the open space and low intensity development associated with the state park comprise an additional 4 percent. The eastern portion of the watershed contains some shrub/scrub land (1.4%), as well as agricultural land, consisting of cultivated crop land (7%) and pasture land (2%).

Lake Alma is part of the larger Raccoon Creek watershed. Historically, this region of Ohio was home to a booming mining industry. “From 1818 to the turn of the century, thousands of acres of woodlands were cut to fuel the 46 regional furnaces. At its peak in the mid-1800s, Ohio was the nation's leading producer of iron for implements and weapons” (ODNR 2016). Bedrock along Raccoon Creek was quarried for millstones, helping to alleviate the regional dependence upon imported French and Pennsylvania stone (ODNR 2016). The Raccoon Creek quarry was one of only eight millstone manufacturers in Ohio in the mid-1800s (ODNR 2016). As a result of this mining legacy, two impoundments remain in the eastern part of the watershed on the hillside above Lake Alma. In the mid-1990s, heavy rainfall caused these impoundments to be breached on two occasions. The resulting runoff drained into Lake Alma, and contributed high loads of sediment to the lake.

Current lake management efforts are limited. In recent years, the lake has twice been stocked with triploid grass carp to control aquatic vegetation. The aquatic vegetation in the lake is also controlled with chemicals (e.g., Sonar, Reward, Cutrine, Rodeo or glyphosate equivalent), which are applied by licensed applicators. Lake levels were also drawn down during the winter of 2015-2016. Note that in order for a lake drawdown to be effective at controlling aquatic macrophythes in shallow lakes, the dewatered sediment must freeze and desiccate (no snow cover) to a sediment depth of 20 to 30 cm; otherwise the plants will survive.

3. Evaluation of Existing Water Quality

Tetra Tech reviewed and evaluated all the available water quality monitoring data for Lake Alma, both recent (2015) and historical. All information provided by Ohio EPA and/or gathered by Tetra Tech was used to further understand and assess the dynamics of nutrient loading to Lake Alma as well as to identify where more information needs to be collected to refine any potential management strategies.

3.1. Assessment of Existing Water Quality and Nutrient Dynamics

Water quality monitoring at Lake Alma was most recently conducted in September and October 2015 by the Ohio EPA Central District Office Division of Surface Water (CDO-DSW). On both dates, monitoring efforts included in-situ measurements of water transparency, temperature, conductivity, dissolved oxygen, and pH and the collection of water samples for nutrient and algal toxins analysis. Previous water quality monitoring efforts include water sampling for algal toxins analysis earlier in summer 2015 and during the summers of 2014 and 2013 by the ODNR and the Ohio EPA Southeastern District Office Division of Drinking and Ground Waters (SEDO-DDAGW). In addition, water transparency and surface concentrations of chlorophyll (chl) and total phosphorus (TP) were measured in May and August 1980, also by Ohio EPA. Water samples collected by the Ohio EPA in 2015 were collected at one main lake station (L-1), the location of which is shown in Figure 1. Water samples collected by the ODNR (for algal toxins analysis only) were collected at the west park beach. Water samples collected by the Ohio EPA SEDO-DDAGW were collected from the north Lake Alma intake for the Wellston water treatment plant.

3.1.1. Lake Alma Water Quality

Lake Alma is a shallow lake, with a mean depth of 2.5 m. Nonetheless, the lake was stratified in both September and October, 2015, with a distinct thermocline and a rapid decline in concentrations of dissolved oxygen (DO) below 3.5 to 4 m (Figure 3 and Figure 4).

There is very limited recent or historical water quality data for Lake Alma. In 1980, surface concentrations of TP were 10 µg/L in May and 20 µg/L in August (Table 1). In those same two months, respectively, surface concentrations of chl were 9.6 µg/L and 6.2 µg/L, and water transparency was 4.4 m and 2.0 m. These levels indicate that the lake was mesotrophic at the time.

The results from 2015 monitoring efforts are less conclusive. When the lake was sampled in September and October, 2015, concentrations of chl at the surface were 16.9 µg/L and 20.5 µg/L and water transparency was 1.65 m and 1.97 m (on 9/17/15 and 10/1/15, respectively; Table 1). On both dates, concentrations of TP were below the detection limit of 10 µg/L. Total phosphorus concentrations near the bottom, however, were much higher, at 27 µg/L in September and 674 µg/L in August (Table 1).

There is some concern that the 2015 TP data may be an underestimate of actual phosphorus concentrations in Lake Alma. The reported total concentrations of phosphorus in the water samples collected on 9/17 (from the surface) and on 10/1 (from the bottom) were less than the measured concentrations of ortho-phosphorus (soluble phosphorus) in those same samples (Table 1). This indicates that TP concentrations were underestimated because ortho-phosphorus is a fraction of TP and a part cannot be greater than the whole. On 10/1, concentrations for both phosphorus and nitrogen species were extremely high, an order of magnitude higher than samples collected previously in September or historically. This data is suspect given these high concentrations and could indicate that the deep sample may have been contaminated with bottom sediments. For both sets of recent data, the underestimated surface TP concentrations, if assumed to be half the detection limit (5 µg/L), skew the computed chl:TP ratios, which at 3.4 for September and 4.1 for October are much higher than the average global chl:TP ratio for lakes, which is 0.25 to 0.35 (Cooke et al., 2005). Even in a highly productive (eutrophic to hyper-eutrophic) lake/reservoir, the chl:TP ratios is typically only near or as high as 1.0. The markedly high computed chl:TP ratios for Lake Alma therefore suggest that in light of the measured concentrations of chl, the measured TP values are low.

The observed water transparency levels and measured concentrations of chl at the surface together suggest that the lake is currently mesoeutrophic, even though the low TP concentrations are not in line with this assessment. Overall, it is difficult to assess the ecological condition of Lake Alma without a larger and more robust water quality dataset for the period of stratification. Nonetheless, the existing data generally suggest that water quality in Lake Alma is moderate or mesotrophic and possibly borderline eutrophic.

The available algal toxins data for Lake Alma suggest that nutrient concentrations in Lake Alma are not yet high enough to cause excessive algal production. Nutrient concentrations can become elevated if lakes experience high periodic or continuous rates of internal or external loading. High nutrient levels fuel the production of cyanobacteria, such as microcystin, and lead to the formation of HABs. Such blooms produce neurotoxins that can cause illness in humans and can kill small animals, such as pets.

In water bodies across the state, regular water quality testing is conducted to monitor levels of known toxins that are produced by algal blooms. In Lake Alma, water samples for algal toxins analysis were collected during the following months: July, 2013; July and August, 2014; and August, September, and October, 2015. As reported above, water samples were collected by ODNR and by two divisions of the Ohio EPA: CDO-DSW and SEDO-DDAGW. Samples were collected at the park beach (2013, 2014, 2015), from the Wellston water treatment plant intake in the northern portion of Lake Alma (2014), and from a third lake site (2015). Samples were analyzed for concentrations of microcystins (2013, 2014, 2015), saxitoxin (2014, 2015), and cylindrospermopsin (2014, 2015). Levels of all three parameters were below detection limits at all three sites in all years except for in September 2015, when the concentration of microcystin was at the detection limit. All samples were analyzed by the Ohio EPA Division of Environmental Services. In 2010, there was report of two dog deaths that may have been related to algal toxin exposure but not confirmed. Samples taken in August and September 2010 revealed the presence of cylindrospermopsin and anatoxin-a and in October saxitoxin was detected.

Table 1. Historical and Recent Water Quality Data for Lake Alma.

Date	Depth	Total Phosphorus (µg/L)	Ortho-Phosphorus (µg/L)	TKN (mg/L)	NO_2+NO_3 (mg/L)	NH_4 (mg/L)	Chl (µg/L)	Secchi (m)	Chl:TP
5/1/1980	surface	10					9.6	4.40	0.96
8/18/1980	surface	20					6.2	2.00	0.31
9/17/2015	0.5	5 (ND)[1]	11.1	1.13	0.05 (ND)	0.025 (ND)	16.9	1.65	3.38[2]
9/17/2015	4.8	27[1]	17.1	1.53	0.05 (ND)	0.914			
10/1/2015	0.5	5 (ND)[1]	2.4	0.74	0.05 (ND)	0.087	20.5	1.97	4.10[1]
10/1/2015	5	674[1]	733.6[3]	6.78	0.11	6.03			

[1]TP data are likely underestimations of true concentrations (see section 3.1.1)
[2]Calculated using 5 µg/L, half the detection limit.
[3]Sample possibly contaminated by bottom sediments.

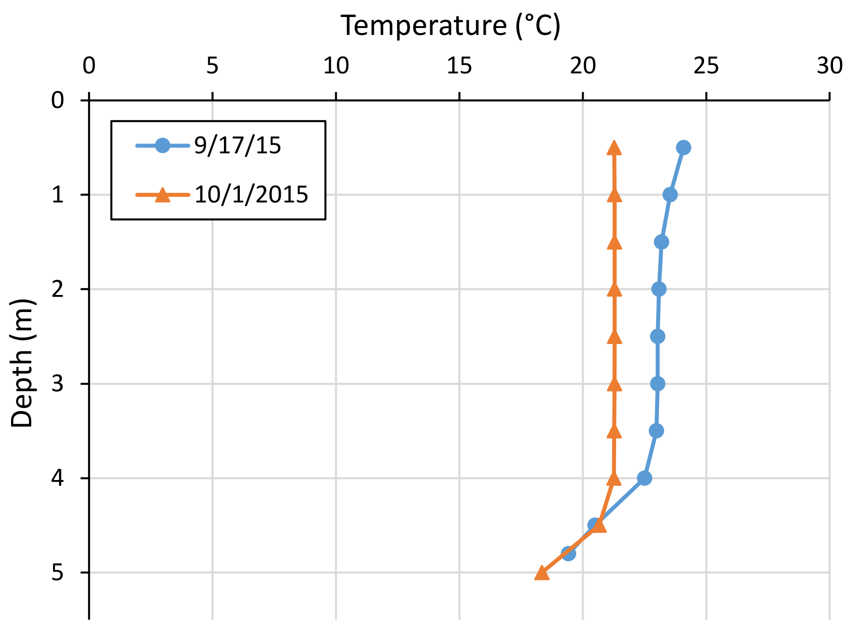

Figure 3. Temperature Profiles in Lake Alma, September and October, 2015.

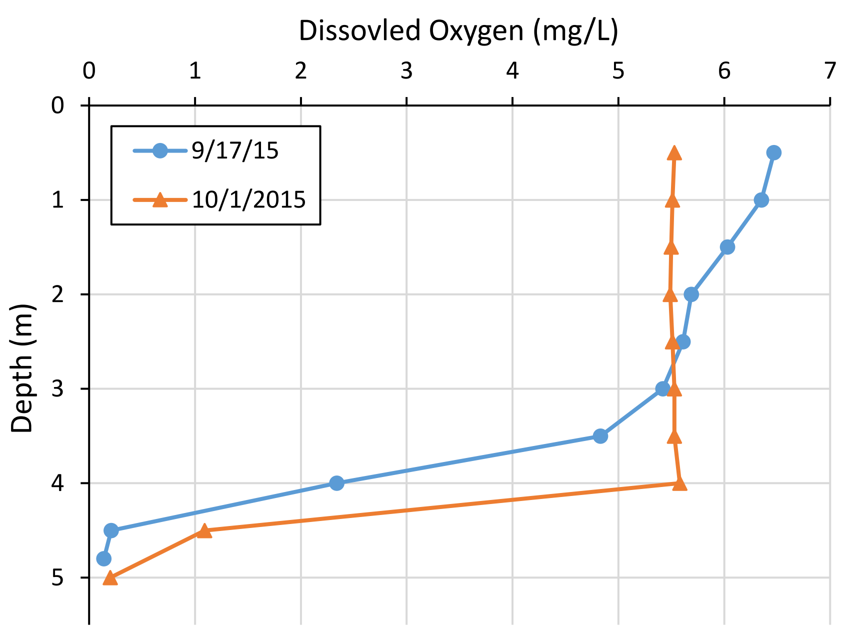

Figure 4. Dissolved Oxygen Profiles in Lake Alma, September and October, 2015.

3.1.2. Lake Alma Tributary Water Quality

Little Raccoon Creek, which was dammed to form the lake, is the only tributary to Lake Alma (Figure 1; Shaver, 2013). No water samples have been collected from this tributary, and the rate at which it discharges into Lake Alma is unknown. Recent inquires to ODNR indicate that the lake's main source of water is from precipitation and/or groundwater; however, quantities of either are unknown.

3.1.3. Lake Alma Nutrient Dynamics

To understand the magnitude and timing of external and internal phosphorus loading into Lake Alma, a phosphorus mass balance model should be developed for the lake. A mass balance model is a valuable tool for understanding the dynamics, timing, fate, and transport of phosphorus within a lake, and can help to determine the driving factor of nuisance algal blooms, if any occur. Once the mass balance model is calibrated for sedimentation and internal loading, the model can then be used to run restoration scenarios to evaluate the effectiveness of potential lake management alternatives relating to whole-watershed and in-lake activities.

Due to the limited amount of water quality and hydrology data for Lake Alma, and the lack of data from its outflow, a phosphorus mass balance model could not be developed. However, a general understanding of phosphorus loading is possible based on the available water quality data and the known characteristics of the watershed.

3.1.3.1. Watershed Nutrient Loading

The Lake Alma watershed is largely forested, with some development around the lake itself within the state park boundaries (Figure 1 and Table 2). Since there is no tributary inflow data for the Lake Alma watershed, the Spreadsheet Tool for Estimating Pollutant Load (STEPL) spreadsheet model was used to estimate nutrient loads according to the relative distribution of land uses within the watershed. STEPL employs simple algorithms to calculate annual nutrient and sediment loads based on soil characteristics, land use data, and precipitation records.

Table 2. Land Uses within the Lake Alma Watershed (Source: 2011 National Land Cover Database or NLCD)

NLCD Land Use	STEPL Land Use	Percentage (%)	Acres
Open Water	Omitted	13	59.2
Dev. Open Space	Urban	4	18.2
Developed Low Intensity	Urban	1.6	7.3
Mixed Forest	Forest	71	323.1
Pasture/Hay	Pasture	2	9.1
Cultivated Crops	Cropland	7	31.9
Shrub/Scrub	Pasture	1.4	6.4

Results from the STEPL model (Spreadsheet Tool for Estimating Pollutant Loads) for the Lake Alma Watershed are presented in Table 3. The model estimated that cropland is the form of land use that contributes the largest external load of phosphorus to Lake Alma (341 lb/yr, or 69% of the total load). Watershed nutrient loading could be estimated more precisely if water quality and flow data were available for the small inflow into Lake Alma or any overland flow that may occur during storm events.

Nutrient loading from groundwater is also unknown at this time. Estimates of groundwater inflows as well as groundwater nutrient concentrations would be needed to determine loading.

Table 3. STEPL Total Phosphorus Loading Estimates for Lake Alma Watershed

STEPL Land Use	Total Phosphorus Load (lb/yr)	Total Phosphorus Load (kg/yr)	Percent (%)
Urban	30.2	13.7	6.1
Cropland	340.8	154.6	68.7
Pastureland	38.5	17.5	7.8
Forest	86.4	39.2	17.4
Total	495.9	224.9	100

3.1.3.2. In-Lake Nutrient Dynamics

Based on the two available samples, there does appear to be a significant difference between surface and bottom TP concentrations in Lake Alma. Internal phosphorus mechanisms in Lake Alma most likely include the classic sediment release through iron-redox reactions, cyanobacteria uptake and migration, bacteria mineralization of sediment phosphorus, and bioturbation via grass carp or other aquatic organisms. Given the low DO concentrations observed in September and October 2015 it is assumed that internal loading of phosphorus is occurring at Lake Alma and, given the small watershed and lack of major inflow, internal loading is most likely the dominant source of loading to Lake Alma. Without additional lake phosphorus samples as well as a phosphorus mass balance model, the magnitude and timing of the internal loading, however, cannot be determined.

3.2. Data Gaps Assessment

A review of recent and historical data for Lake Alma revealed that there are fairly substantial data gaps associated with both hydrology and water quality. The largest data gap is the limited amount of reliable lake water quality data. There has been no consistent monitoring of water quality in Lake Alma. While samples were collected twice at the end of summer 2015 (on 9/17 and 10/1), the only prior data were from 1980. In addition, the 2015 results for total phosphorus appear to be inaccurate (as detailed in section 3.1.1), further limiting our assessment of Lake Alma. Additional data collected from multiple depths at station L-1 at regular intervals (monthly or bi-weekly) are necessary to accurately evaluate nutrient dynamics within the lake and to develop a phosphorus mass balance model. Without a better understanding of lake water quality and internal phosphorus loading, recommendations for lake management strategies cannot be specified.

There is little definite information about the hydrology of the Lake Alma watershed, although precipitation and groundwater have been cited as the primary sources of water to the lake. No lake level data or records of outflow exist. The lack of flow data and general understanding of the hydrology/hydraulics of the lake and its watershed make it challenging to determine external phosphorus loading and evaluate potential watershed best management practices (BMPs). General assumptions can be made based on land use categories and simple loading estimates; however, watershed BMPs should not be recommended without a greater understanding of external nutrient loading magnitude, timing, and location. In order to better assess external nutrient loads to the lake, water quality and flow data for the small inflow into Lake Alma are needed, as are samples and flow estimates of any overland flow that may occur during storm events.

There is also a need for additional data on the type and aerial coverage of both submersed and emergent rooted plants in the lake. Survey data would allow for a more comprehensive understanding of phosphorus cycling and primary production within the lake.

Lastly, the potential for future HAB production in Lake Alma could be monitored and assessed if phytoplankton samples were collected in conjunction with scheduled water quality monitoring.

4. Evaluation of Potential Management Actions

4.1. Recommended Future Monitoring Activities

After a review of the existing water quality data available for Lake Alma, Tetra Tech recommends that a monitoring program be implemented which includes the following elements:

1. Tetra Tech strongly encourages Ohio EPA to collect monthly to twice monthly samples in Lake Alma from March through October. Twice monthly samples would be most beneficial during the critical growing season months of May through September. During each sampling event, water samples should be collected at Station L-1 at both 0.5 m from the surface and 0.5 m from the bottom. *In-situ* measurements of temperature, DO, pH, specific conductivity should be recorded at 0.5 m increments throughout the water column as water samples are collected. Secchi disk depth should be measured and recorded at the same time. Water samples should be analyzed for, at a minimum, TP, SRP, total nitrogen (TN), nitrate+nitrite, ammonia, and chl. Tetra Tech also recommends that Ohio EPA collect monthly samples for phytoplankton analysis. There currently is no information on the phytoplankton community composition and abundance within Lake Alma. Ohio EPA should continue to test for cyanotoxins (Microcystin, etc.) if cyanobacteria blooms or surface scums are observed, or if chlorophyll concentrations exceed 10 μg/l within Lake Alma.

2. Tetra Tech recommends that Ohio DNR/Ohio EPA install and operate level loggers in the lake near the dam as well as in the outlet structure to obtain accurate records of both lake level and outflow. There is currently no available information on lake level or on how much water leaves the lake. Understanding the water budget and hydraulic flushing rate of the lake is critical for determining the most effective ways to manage excess nutrients and improve water quality.

3. Tetra Tech recommends that Ohio EPA collect monthly water quality samples in Little Raccoon Creek, if flowing at the time of lake sample collection. These monthly samples should be collected during baseflow conditions and should be analyzed for the same water quality parameters as lake samples, with the exception of chl. Tetra Tech recommends Ohio EPA also collect two to three water quality samples during storm events to capture runoff conditions within the watershed. At the time of any water quality sample, flow measurements should also be recorded within the tributaries.

4. Tetra Tech encourages Ohio EPA to install the necessary equipment to obtain continuous flow data for the small inflow into Lake Alma. There is a significant lack of information about the hydrology of the watershed and the water budget for Lake Alma. Data from the continuous flow data logger will improve our understanding of how much surface water enters Lake Alma, and will help to refine estimates of external loading of phosphorus from the watershed. This will allow for a more targeted approach for reducing that load, if deemed necessary.

5. Tetra Tech recommends that at least 20 percent of phosphorus and chl samples be split so they can be analyzed by an independent laboratory in addition to the Ohio EPA laboratory.

6. It is recommended an annual aquatic plant survey be conducted in August to map the relative community structure, density and coverage of the macrophytes within the lake in order to better understand the nutrient utilization and cycling within the lake.

4.2. Potential Nutrient Management Strategies

This section presents potential nutrient management strategies for the watershed as well as Lake Alma.

4.2.1. Watershed Nutrient Reduction Strategies

It is premature to identify specific nutrient reduction strategies for the Lake Alma watershed until there is better information on how loads from the watershed compare to internal loading. It is possible that loads from the watershed are not a significantly contributing factor to nutrient conditions within the lake. In the meantime typical “good practices” (e.g., implementing good nutrient management; use of cover crops; no-till or reduced tillage) should be promoted for the agricultural and urban land uses within the watershed.

4.2.2. In-Lake Nutrient Reduction Strategies

In-lake nutrient reduction strategies may be necessary in Lake Alma if it is determined that internal loading of phosphorus is leading to an excessive nutrient load and is subsequently degrading water quality. As mentioned previously, internal loading is suspected but cannot be confirmed based on the available data. There are several in-lake nutrient reduction strategies that can be assessed and evaluated for Lake Alma including dredging, nutrient inactivation by alum, and aeration/circulation, as well as shoreline maintenance, waterfowl management, and aquatic plant control. However, until at least one year of water quality and flow data have been collected and analyzed, the need for in-lake nutrient reduction cannot be determined and recommendations for lake management practices cannot be specified.

5. Conclusions

The limited available data suggest that Lake Alma water quality is moderate or mesotrophic and possibly borderline eutrophic. This indicates that the lake may be experiencing some water quality problems, including the potential for toxic algal blooms, as the presence of toxins has been documented. Additional data are needed to refine this assessment and to predict the level of management activity needed in both the watershed and in-lake to meet management goals for water quality and recreational uses.

6. References

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7. Glossary of Terms

The following definitions describe keywords used in this plan.

Term	Definition
Abundance	An ecological concept referring to the relative representation of a species in a particular ecosystem. It is usually measured as the large number of individuals found per sample.
Algae[1]	Small aquatic plants that occur as single cells, colonies, or filaments. They contain chlorophyll, but lack special water-carrying tissues. Through the process of photosynthesis, algae produce most of the food and oxygen in water environments.
Algal bloom	Rapid growth of algae populations in response to eutrophic conditions.
Alum[2]	Aluminum sulfate, an aluminum salt, that is used to lower lake P content by removing phosphorus in the water column (through chemical precipitation) and by retarding release of mobile P from lake sediments (P inactivation). Alum (aluminum sulfate) is added to the water column to form aluminum phosphate and a colloidal aluminum hydroxide floc to which certain phosphorus fractions are bound. The aluminum hydroxide floc settles to the sediment and continues to sorb and retain phosphorus.
Anoxic	Characterized by very low concentrations of dissolved oxygen (< 2 mg/L DO).
Bathymetric survey[1]	A survey of the bottom contours of a lake; can be used to calculate lake volume.
Benthic[3]	Associated with the lake bottom.
Biomass[1]	The weight of biological matter. Standing crop is the amount of biomass (e.g., fish or algae) in a body of water at a given time. Often measured in terms of grams per square meter of surface.

Term	Definition
Bioturbation	Increase in water turbidity by aquatic organisms activates, such as mixing sediments into the water column
Chlorophyll[1]	A green pigment in algae and other green plants that is essential for the conversion of sunlight, carbon dioxide, and water to sugar.
Chlorophyll a[1]	A type of chlorophyll present in all types of algae, sometimes in direct proportion to the biomass of algae.
Decomposition[1]	The transformation of organic molecules (e.g., sugar) to inorganic molecules (e.g., carbon dioxide and water) through biological and non-biological processes.
Ecosystem	A system formed by the interaction of a community of organisms with each other and the environment.
Epilimnion[3, 4]	The upper, warm, lighter, homogeneous layer of a lake.
Eutrophic[2]	A eutrophic lake is rich in nutrients and organic materials. Excessive loading of plant nutrients, organic matter, and silt cause increased primary producer biomass, reduced water clarity, good growing conditions for nuisance species, and usually decreased lake volumes.
Eutrophication[1, 2]	The process of physical, chemical, and biological changes associated with nutrient, organic matter and silt enrichment and sedimentation of a lake that cause a water body to age and become eutrophic. Symptoms include dissolved oxygen depletions and fish kills.
External loading[1]	The total amount of material (sediment, nutrients, oxygen-demanding material) brought into the lake by inflowing streams, runoff, direct discharge through pipes, groundwater, the air, and other sources over a specific period of time.
Flushing rate[1]	The rate at which water enters and leaves a lake relative to lake volume, usually expressed as the time needed to replace the lake volume with inflowing water.
Habitat	An area where a plant or animal species lives, grows, and reproduces, and the environment that satisfies their life requirements.
Hyper-eutrophic	Characterized by severely eutrophic conditions and excessive primary production.
Hypolimnion[4]	The lower, fairly homogeneous cold layer of a lake.
In-situ	On site, within the water.
Internal nutrient cycling[1]	Transformation of nutrient such as nitrogen or phosphorus from biological to inorganic forms through decomposition, occurring within the lake itself.
Internal nutrient loading	The total amount of nutrients released into the water column over a specific period of time as a result of nutrient recycling from sediments, wind resuspension, mineralization of nutrients, macrophyte senescence, and decomposition of organic material.
Loading	*See external loading and internal nutrient loading.*
Macrophyte[2]	Rooted emergent, floating, and submersed vascular plants.

Term	Definition
Mesotrophic[1]	The medium range of eutrophication.
Natural resources	Landforms, soils, waters, and their associated flora and fauna.
Nonpoint source[1]	Pollution that cannot be traced to specific origin or starting point, but seems to flow from many different sources. Non-point source pollutants are generally carried off the land by stormwater runoff.
Nutrient[1]	An element or chemical essential to life, such as carbon, oxygen, nitrogen, and phosphorus. Nutrients promote growth and repair the natural destruction of organic life.
Organic matter[1]	Molecules manufactured by plants and animals and containing linked carbon atoms and elements such as hydrogen, oxygen, nitrogen, sulfur, and phosphorus.
pH[1, 3]	A measure of the concentration of hydrogen ions in a substance (the negative log of the hydrogen-ion concentration), which ranges from very acid (pH = 1) to very alkaline (pH = 14). pH 7 is neutral and most lake waters range between 6 and 9. pH values less than 6 are considered acidic, and most life forms cannot survive at pH of 4.0 or lower.
Photosynthesis[1]	A chemical reaction that occurs only in plants. Plants use a green pigment called chlorophyll to convert water and carbon dioxide into cellular material and oxygen in the presence of light. Hence, photosynthesis occurs only during daylight hours.
Phytoplankton[1]	Microscopic algae and microbes that float freely in open water of lakes. In some lakes, they provide the primary base of the food chain for all animals. They also produce oxygen by a process called photosynthesis.
Point source[1]	Pollution discharged into water bodies from specific, identifiable pipes or points, such as an industrial facility or municipal sewage treatment plant.
Primary productivity[1]	The rate at which algae and macrophytes fix or convert light, water, and carbon dioxide to sugar in plant cells.
Residence time[1]	The amount of time required to completely replace the lake's current volume of water with and equal volume of "new" water.
Respiration[1]	Process by which organic matter is oxidized by organisms, including plants, animals, and bacteria. The process releases energy, carbon dioxide, and water. Respiration occurs at all depths in a lake and is not dependent on light.
Runoff[1]	That portion of precipitation that flows over the land carrying with it such substances as soil, oil, trash, and other particulate and dissolved materials until it ultimately reaches streams, rivers, lakes, or other water bodies.
Secchi depth[1]	A measure of transparency of water (the ability of light to penetrate water) obtained by lowering a black and white disk (Secchi disk, 20 cm in diameter) into water until it is no longer visible. Measure in units of meters or feet.
Sediment[1]	Bottom material in a lake that has been deposited after the formation of a lake basin. It originates from remains of aquatic organisms, chemical precipitation of dissolved minerals, and erosion of surrounding lands.

Term	Definition
Senescence	The deterioration of plant cells with age.
Soluble	Able to be dissolved in water.
Stratification[1]	Process in which several horizontal water layers of difference density may form in some lakes. During stratification, the bottom pass (hypolimnion) is cool, high in nutrients, low in light, low in productivity, and low in dissolved oxygen. The top mass (epilimnion) is warm, higher in dissolved oxygen, light, and production, but lower (normally) in nutrients. The sharp boundary between the two masses is called a thermocline.
Thermocline[3]	A transitional layer between the epilimnion and the hypolimnion, the rate of temperature change with depth is greatest in this layer.
Turbid[1]	Thick or cloudy with sediment or other suspended material, such as algae.
Turbidity[7, 8]	A measurement of the degree to which the transmission of light through water is restricted due to scattering and absorption. The higher the intensity of scattered light, the higher the turbidity. Turbidity is influenced by concentrations of suspended sediment as well as concentrations of algae and colloidal matter.
Water column[1]	Water in the lake between the interface with the atmosphere at the surface and the interface with the sediment layer at the bottom.
Watershed[1]	A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.
Wetlands	Areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Note: Sources for definitions:

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6 – National Oceanic and Atmospheric Administration (NOAA). 2015. Frequently Asked Questions (FAQs) about SQuiRTs, NOAA Office of Response and Restoration, http://response.restoration.noaa.gov/environmental-restoration/environmental-assessment-tools/squirt-cards-faq.html.

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8 – Allan, J.D., and M.M. Castillo. 2007. Stream Ecology: Structure and Function of Running Waters, 2nd ed., Springer, The Netherlands.