NYSOGS Project #47173, Nutrient Inactivant Pilot Study Monitoring Project Quality Assurance Project Plan

Effective: April 1, 2022
Expires: April 1, 2023

New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233-0001

Prepared by:
LimnoTech
501 Avis Dr
Ann Arbor, MI 48018

Under Contract to:
Ramboll Americas Engineering Solutions
Harro East Building
400 Andres St. Suite 710
Rochester, NY 14604

This document has been prepared according to the United States Environmental Protection Agency publication *EPA Requirements for Quality Assurance Project Plans* dated March 2001 (QA/R-5).

Abstract: This document details a quality assurance plan to guide the successful implementation of NYOGS Project #47173 Nutrient Inactivant Pilot Study. This project is a pilot study designed to evaluate aluminum sulfate, or alum, as a nutrient mitigation strategy to reduce internal nutrient loading of phosphorus from lake bottom sediments. This project includes sample collection from Honeoye Lake to support an alum dosing treatment design and pre-, mid-, and post-application monitoring of sediment and water quality in the Honeoye Lake to observe the environmental impacts of the alum dose. Monitoring elements include discrete laboratory analysis and field measurement of standard limnologic metrics. Treatment dosing design includes target dose determination based on the mass of phosphorus in the water column and the phosphorus fractions in the sediments that are susceptible to diffusion from the sediments.. Project staging and site access will be coordinated through the Office of Parks, Recreation, and Historic Preservation at Honeoye Lake State Boat Launch.

A PROJECT MANAGEMENT

A1. Approval/Acceptance Sheet

This quality assurance project plan (QAPP) will be approved prior to the start of work.

04/04/2022

Stephanie June – Project Manager Date
New York Department of Environmental Conservation

Carolyn Dunderdale, LA Digitally signed by Carolyn Dunderdale, LA
Date: 2022.04.04 13:47:09-04'00'

Carolyn Dunderdale – Contract Manager Date
New York Department of Environmental Conservation

4/4/2022

Dendy Lofton – Project Quality Assurance Officer Date
Stantec

4/4/2022

Anthony Eallonardo – Project Manager Date
Ramboll

4/4/2022

Ben Crary – Project Manager Date
LimnoTech

03/30/2022

Lindsey DeLuna – Quality Assurance Officer Date
NYSDEC DOW

QAPP Update Log

Prepared/Revised By:	Date:	Revision No:	Summary of Changes:
Ben Crary	2022-01-17	1.0	Drafted

'No substantive changes' may be listed to reflect updating of references, correcting typographical errors, and clarifying certain language to make the document more useful and effective.

A2. Table of Contents

List of Tables

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A3. Distribution List

The following individuals are to receive a copy of the approved QAPP including any revisions in order to complete their role in this project.

Table 1: QAPP Distribution List

Name	Title	Organization	Document type
Stephanie June	Project Manager	NYSDEC	Electronic
Carolyn Dunderdale	Contract Manager	NYSOGS	Electronic
Dendy Lofton	QA Officer and Project Manager	Stantec	Electronic
Anthony Eallonardo	Project Manager	Ramboll	Electronic
Ben Crary	Project Manager	LimnoTech	Electronic
Veronica Davies	Project Engineer	Ramboll	Electronic
David Matthews	Laboratory Manager	Upstate Freshwater Institute	Electronic
Janice Jaeger	Project Manager	ALS Environmental	Electronic

A4. Project/ Task Organization

The following individuals or groups will actively participate in this project and its oversight:

Stephanie June, Project Manager, *stephanie.june@dec.ny.gov; (518) 402-9255*

Responsibilities

1. Oversees coordination of interactions with Ramboll, Stantec, LimnoTech, and other contracted labs and field staff.
2. Oversees project strategy and overall design, including site location, parameter selection, and sampling frequency.
3. Coordinates mobilization and set-up. Coordinates activities of mid-application sampling contractor on Honeoye Lake during the alum treatment to avoid application conflicts.
4. Facilitates access and permit acquisition, if necessary

Carolyn Dunderdale, Contract Manager, *carolyn.dunderdale@ogs.ny.gov; (518) 474-5100*

Responsibilities

1. Oversees contractor performance in meeting NYSDEC goals and objectives for this project.

Dendy Lofton, Quality Assurance Officer and Stantec Project Manager

Oversees the Quality Assurance activities of this project and oversees all Stantec work. *dendy.lofton@stantec.com; 763-252-6959*

Responsibilities

1. Ensures field procedures, analytical methods, and quality assurance/quality control requirements are consistent with project objectives and are clearly documented in the QAPP.
2. Reviews all project documentation; field data sheets, calibration records, laboratory reports to see if quality control criteria specified in the QAPP were achieved.
3. Directs protective actions to address inconsistencies, issues, or problems identified from review.
4. Provides expertise regarding analytical and QA/QC issues.
5. Provides technical expertise regarding sampling design analysis.

Anthony Eallonardo, Ramboll Project Manager

Specific coordination, oversight, and implementation as it pertains to site selection, water quality monitoring, and contractor coordination. *tony.eallonardo@ramboll.com; 315-430-0667*

Responsibilities

1. Oversees all subcontractor responsibilities, including budget, scheduling, and deliverables.
2. Coordinates writing of QAPP with NYSDEC.
3. Supports sampling design.
4. Facilitates sample bottle acquisition for field staff.
5. Reviews qualifications of all individuals involved in this project for proper training to fulfill their assigned role and understand and follow the protocols as detailed in this QAPP.

Ben Crary, LimnoTech Project Manager

Development and writing of the QAPP with NYSDEC. *bcrary@limno.com; 651-219-4078*

1. Drafts QAPP language in coordination with NYSDEC, Ramboll, and Stantec.
2. Maintains the official approved QAPP and any subsequent revisions.
3. Coordinates the development of the sampling design.
4. Assists with data quality review and reporting.
5. Coordinates QAPP review efforts.

Veronica Davies, Ramboll Project Engineer

Responsible for management of all data collected or produced with the project.
veronica.davies@ramboll.com; 856-470-0072

Responsibilities

1. Receives and coordinates the storage of all field and analytical data.
2. Distributes the data to appropriate project team members.

David Matthews, Laboratory Manager, *damatthews@upstatefreshwater.org; (315) 431-4962*

Management of laboratory related responsibilities.

Responsibilities

1. Oversees contractor performance in meeting NYSDEC goals and objectives for this project.
2. Coordinates delivery of sampling containers to contracted field teams.

Janice Jaeger, Project Manager, *janice.jaeger@alsglobal.com; (585) 672-7472*

Management of laboratory related responsibilities.

Responsibilities

1. Analyzes total and dissolved metals concentrations as a subcontractor to UFI

Lindsey DeLuna, Quality Assurance Officer, lindsey.deluna@dec.ny.gov*; (518)402-9252*

Responsibilities

1. Provides expertise regarding analytical and QA/QC Issues.
2. Reviews for approval the QA project plan to verify that those elements outlined in the *EPA Requirements for QA Project Plans (QA/R-5)* are successfully discussed prior to the start of any project related activities.

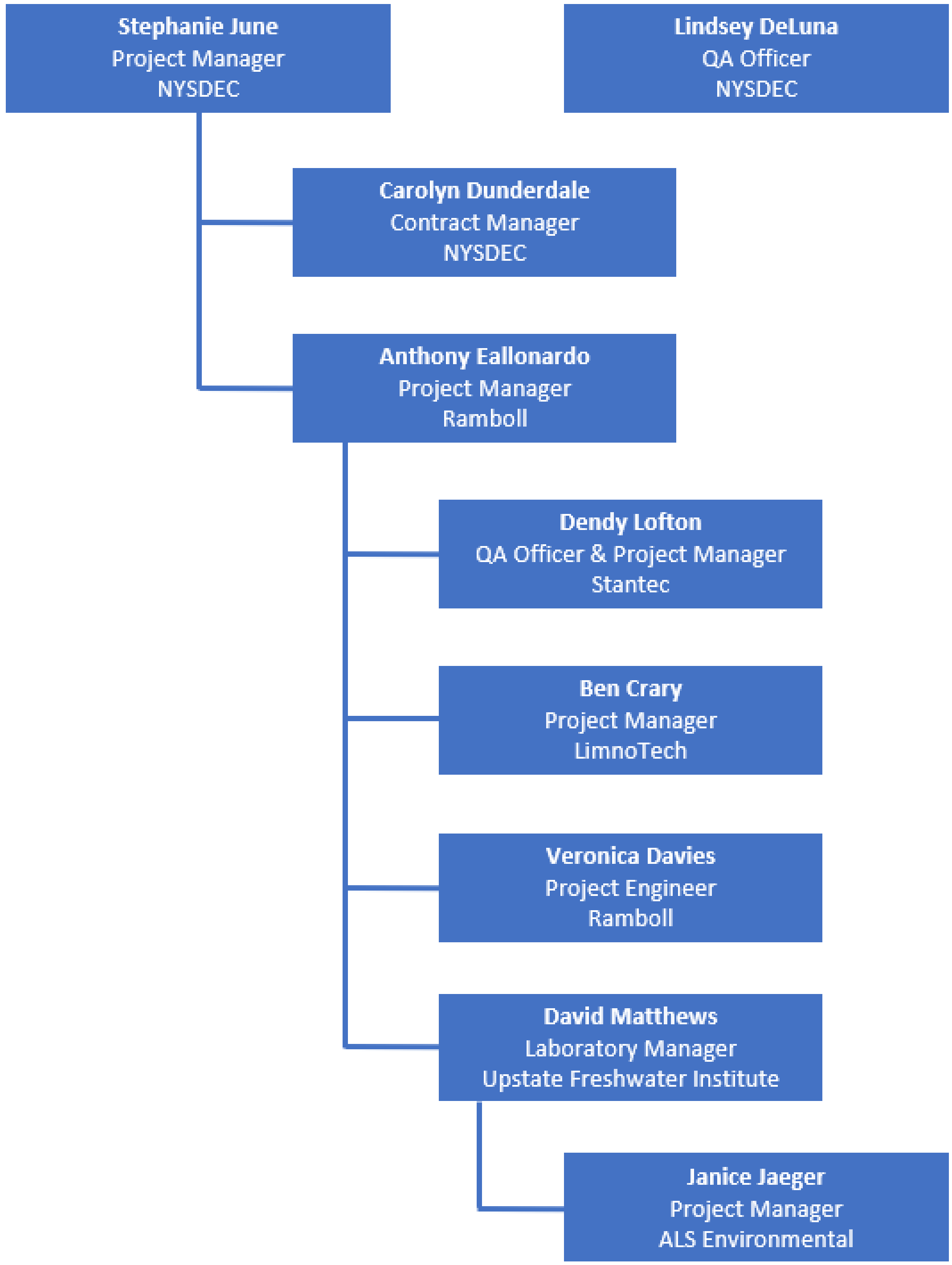

Figure 1: Project Organizational Chart

A5. Problem Definition/Background

New York State (NYS) is looking to better understand potential management actions to control excessive internal phosphorus loading that impacts ponds, lakes, and reservoirs. Excess phosphorus within lakes can lead to water quality impairments that may result in the production of disinfection byproducts, dangerous compounds in treated drinking water, and the degradation of aesthetic and property values, which in turn can result in adverse impacts to the environment and human health. Nutrient inactivants, such as alum, (i.e., internal nutrient control substances) are products introduced to a waterbody that physically bind and reduce the amount of available phosphorus present in the water column and the sediment, particularly as external sources of nutrients are being managed.

At this time, the use of nutrient inactivants in NYS is not permittable. This project is an action that will be undertaken by NYS in an effort to further inform the development of a nutrient inactivant policy, if determined appropriate. Findings from the project will be used to confirm efficacy of sequestering excess phosphorus, and establish criteria around potential nutrient inactivant treatments in the future, including but not limited to the time of year of treatment, a permitting pathway, monitoring requirements, etc.

Project benefits include an expected reduction in hypolimnetic and epilimnetic phosphorus levels, through mitigation of sediment phosphorus release, which is a substantial proportion of the total phosphorus load to Honeoye Lake. This project supports efforts to bring impaired waterbodies into compliance with water quality standards, and protect designated uses, including as sources of potable water, recreation, and fishing.

Honeoye Lake, one of the eleven Finger Lakes, is a valued recreational asset of NYS, but it is currently impaired due to high phosphorus concentrations, with internal phosphorus loading accounting for up to 93% of the annual total phosphorus load[1]. Such water quality conditions compromise the ability of waters to meet or attain designated uses, and can contribute to the occurrence of harmful algal blooms (HABs[2]). Honeoye Lake has lost over 100 beach days due to HABs since 2012, and the total maximum daily load (TMDL) identified internal phosphorus loading to the lake as the primary driver of HABs. In this pilot study, an alum dose will be developed and applied to Honeoye Lake to reduce internal phosphorus loading, and the lake's biological and chemical response to the application will be monitored.

Data will be collected to support the design and development of the alum treatment strategy, monitor conditions preceding, during, and immediately following the treatment, and evaluate the performance of the treatment. This QAPP will help lay out the guidelines by which the data collected and analyzed for this project are valid and verifiable.

Treatment and specific application details are not included in this QAPP, but will be outlined in a services procurement contract through NYS Office of General Services (Project # 47173). A site plan and any required local permits will be appended to this document with additional

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[1] Total Maximum Load for Total Phosphorus Honeoye Lake (https://www.dec.ny.gov/docs/water_pdf/tmdlhoneoyeaug2019.pdf)

[2] HABS Action Plan – Honeoye Lake (https://www.dec.ny.gov/docs/water_pdf/honeoyehabplan.pdf)

details when available. Work shall not proceed without approval of this QAPP. Work shall not proceed without all parties, including the site owner, agreeing to the site mobilization, demonstration execution, and demobilization plans.

A6. Project/Task Description

Project Overview

The overall goals and objectives of the monitoring component of this project are to provide comprehensive data to fully design, execute, and evaluate an alum treatment on Honeoye Lake. Data will be collected for three purposes:

1. Evaluate baseline conditions to support an alum treatment design ("Treatment Design Support Data Collection")
2. Monitor pre- and post-treatment conditions to evaluate treatment efficacy ("Pre- and Post-Application Data Collection")
3. Monitor conditions during treatment in compliance with permit conditions ("Mid-Application Data Collection")

Baseline sediment and water quality sampling will directly support the design of the alum dose. Additional water quality and sediment sampling will monitor the immediate and short-term effect of the alum application. Monitoring that occurs during the alum application will be performed to confirm that in-lake water quality conditions, primarily pH, are optimal for the treatment to be conducted successfully and are in accordance with permit conditions and/or water quality standards.

The sediment collection strategy has been designed to be representative of lake conditions across multiple water depths, which can then support development of an appropriate and robust alum treatment design. There are no standardized protocols that specify the number of sediment samples required for development of a phosphorus inactivation strategy using alum. The sediment data collection is usually based on best professional judgement to determine the number of samples to be considered to be spatially representative of the areas assuming to be releasing phosphorus (Rydin and Welch 1999; Cooke et al. 2005). The number of sediment cores and their locations described in this QAPP will provide understanding of the spatial characteristics of sediment phosphorus across the lake. An external check of eight other alum application projects from throughout the United States were evaluated for their predesign core sampling totals (the max number of sediment cores sampled for a given project was 10) and sampling rate per acre (median core sampling rate was approximately 0.012/acre). These findings, along with a review of the bathymetry in Honeoye Lake were used to inform the sediment core sampling intensity described in this QAPP.

Pre-, mid-, and post-application monitoring will occur in five monitoring zones (delineated by depth and latitude) to characterize water quality and sediment conditions spatially across the entire lake before, during, and after treatment (Figure 2). Monitoring at all locations will include characterizations at multiple depths to provide vertical resolution of conditions. A detailed description of the monitoring design, including analytical parameters and sampling locations is provided in Section B1.

Information collected during the project will be used to help evaluate the effectiveness and appropriateness of nutrient inactivant use in NYS. Evaluation of effectiveness will include, but not be limited to:

a) Determine Honeoye Lake specific alum dose:
   i. Collect treatment design monitoring data as prescribed in this QAPP.
      1. The primary intent of this data collection (i.e., sediment core, water quality, field measurements) is to support the establishment of a lake and depth specific alum dosing.
   ii. Optimization of chemical dosing and verification of water quality through sediment testing.
      1. Conduct sediment collection and laboratory analyses to quantify sediment phosphorus fractions, which will be used to calculate the appropriate alum dose.
      2. Conduct jar test to determine maximum alum dose before pH drops below 6.0, which will be used to inform the addition of a buffer to the alum treatment.

b) Calculate an alum dose sufficient to sequester internal phosphorus loading from Honeoye Lake sediments for at least five years.

c) Proof of concept of fall, large-lake nutrient inactivant treatment:
   i. Safe and successful coordination and operation of barges; execution of alum application under fall weather conditions (e.g., cooler temperatures).
   ii. Adherence to permit conditions regarding application rate, target treatment area, monitoring, and water quality limits or standard compliance.
      1. Collect pre, mid, and post-application monitoring data as prescribed in this QAPP and outlined in applicable permits.
      2. The primary intent of in-situ field measurements (i.e., pH, dissolved oxygen) and water sample collection (i.e., phosphorus, aluminum) collected during pre, mid, and post-application is to comply with permit conditions and/or water quality standards. Ecological factors and pre-application conditions will be considered when interpreting the impact of dosing on any changes to water quality.

d) Evaluate short-term (within 7 days) treatment efficacy of nutrient inactivants:
   i. Reduction in water quality phosphorus concentrations.
      1. Documentation of changes in water quality parameter concentrations (Total Phosphorus, Soluble Reactive Phosphorus, Total Dissolved Phosphorus) pre- (one day before) and post-application (seven days after), calculated by the difference between post and pre-treatment values and testing the significance of that difference by parametric

(e.g., paired t-test) or analogous non-parametric tests (e.g., Wilcoxon Signed-Rank Test) if parametric assumptions are violated.)

a. Alternative Hypothesis (H_1): The nutrient inactivant treatment will result in a practical reduction of epilimnetic Total Phosphorus concentrations to below the water quality guidance value (i.e., 20 ug/L) post-treatment, across monitoring zones. This test assumes that there will be no external loading that could influence epilimnetic Phosphorus concentration following treatment.

b. H_1: The treatment will result in a statistically significant (α = 0.05) reduction and/or at least 50% reduction in Soluble Reactive Phosphorus, Total Dissolved Phosphorus in the epilimnion and the hypolimnion between pre- and post-treatment, across monitoring zones.

2. Documentation of conditions in the *in situ* sonde-measured water quality parameters mid-application, at the end of each day, for trending and general characterization of treatment effects within monitoring zones throughout the project.

ii. Aluminum concentrations remain within water quality standards.

1. H_1: The nutrient inactivant treatment will result in documented concentrations of aluminum parameter concentrations from the water column within applicable water quality standards. Note that total and/or dissolved aluminum are expected to increase slightly as a result of the addition of aluminum sulfate (alum) to the lake but are expected to fall within water quality standards within approximately three days following the application. Vertical and horizontal mixing will influence how quickly water column aluminum concentrations drop to ambient conditions.

iii. The treatment is expected to have no significant biological impacts or deterioration of water quality, as prescribed in the permit conditions:

1. H_1: The nutrient inactivant treatment will not result in the following impacts during mid-treatment or post-treatment: fish kill, dissolved oxygen depression, toxic pH conditions.

2. H_1: The nutrient inactivant treatment will not result in ecologically significant phytoplankton or zooplankton community change during mid-treatment or post-treatment compared to pre-treatment. The identification and enumeration of plankton should not result in non-detects.

iv. Documentation of the above conditions will be reported to the Program Manager, reported as prescribed in issued permits, and will inform potential policy development.

v. Long-term evaluation of the nutrient inactivant treatment is outside of the scope of this project plan; water quality sampling in Summer 2023 will be assumed through a DEC monitoring program.

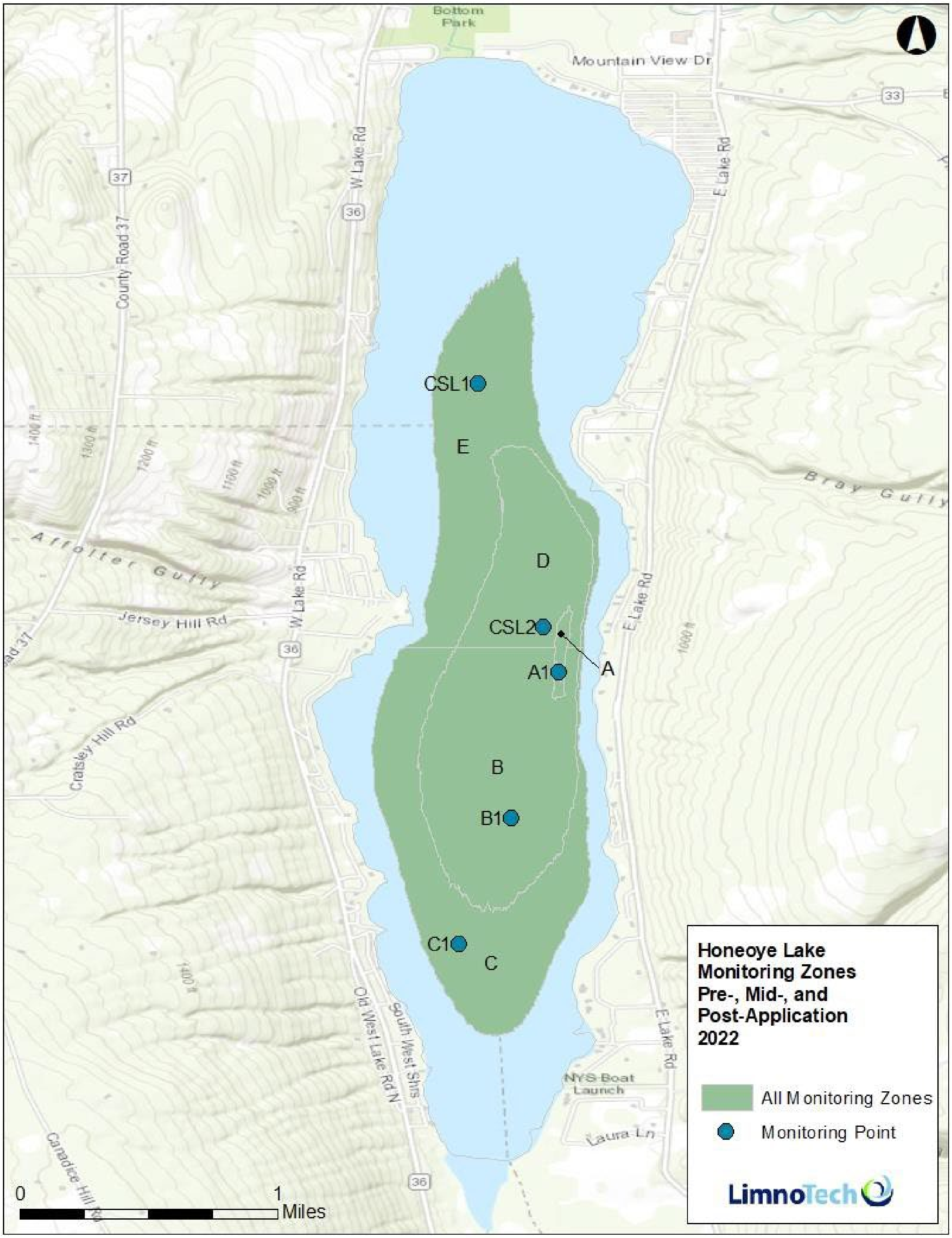

Figure 2: Delineated monitoring zones (A-E) for this study. Zone A represents all area greater than 30' in depth. Zones B and D represent all area between 25' and 30' in depth. Zones C and E represent all area between 20' and 25' in depth.

Project summary and work schedule

The table below outlines tasks and timelines for completion

Table 2: Deliverables and Timelines

Task	Task Description	Anticipated Start Date	Anticipated End Date	Actual Completion Date
QAPP finalized approved/ accepted	Submitted QAPP for approval /acceptance by designated individuals from section A1.	2/15/2022	3/18/2022	
Design Support Sampling	Collect sediment and water quality samples to support alum treatment design	4/4/2022	5/6/2022	
Design Treatment Strategy	Use sample data to design a treatment strategy	4/25/2022	9/27/22	
Pre-Treatment Sampling	Collect sediment and water quality samples to monitor short-term impact of treatment	11/1/2022	11/1/2022	
Mid-Treatment Monitoring	Collect water quality samples and take *in-situ* measurements during treatment	11/2/2022	11/29/2022	
Post-Treatment Sampling	Collect sediment and water quality samples to monitor short-term impact of treatment	12/6/2022	12/6/2022	
Submission of Data and Reports	Submission of all reports and monitoring data	2/8/2023	2/8/2023	

A7. Quality Objectives and Criteria

Quality objectives

Data of known and documented quality is essential to the success of this project. An effective treatment design and study relies on representative and accurate data produced during this project. The procedures in this QAPP are intended to ensure that the data produced from this project are consistent with best-practices and industry standards. Specific data quality objectives are described below.

Data Quality Objectives

The project will utilize lab specific method detection limits (MDL) and QA/QC limits. The data quality indicators of precision, accuracy, representativeness, comparability, completeness, and sensitivity will be measured (when applicable) from data collected from chemical analyses of samples collected. Data quality objectives for indicator are described below.

- Precision provides information about the consistency of the application of project methods by measuring the same characteristic over repeated measurements. It is expressed in terms of the relative percent difference (RPD) between two measurements (A and B), and is computed as follows:

  $$RPD = \frac{(A - B) \times 100}{(A + B)/2}$$

  Precision will be measured using a duplicate sample. Duplicate samples will be collected once per day at a rotating but predetermined water quality sampling location. Duplicates will be collected for each water quality parameter using the identical sampling equipment and procedures. The data quality objective for precision is less than or equal to 20% relative percent difference on duplicate samples.

DUAR
[Include outcomes of quality assurance measures]

- Bias/Accuracy is a measure of confidence that describes how close a measurement is to its “true” value. This project will ensure field accuracy by following field instrument calibration and following the prescribed sample collection, sample handling and field measurement protocols as outlined in Section B.

  Contract laboratories will undertake their own QA/QC procedures, and typically spike at least 5% of the samples with a known aliquot of the parameter and carried through the analysis process as a matrix spike. Analytical laboratory accuracy is determined by the percent recovery of the target analyte in spiked samples and by recoveries of the surrogates in all samples and QC samples. Accuracy is calculated as follows:

  $$\%R = \frac{\text{Analyzed value}}{\text{true value}} \times 100$$

DUAR [Include outcomes of quality assurance measures]

- Representativeness of samples in this project is defined as being able to represent conditions in different regions of the lake. Representativeness will be accomplished in this project by collecting multiple water quality and sediment samples within designated zones in the lake (Figure 2). Zone A represents all area greater than 30' in depth. Zones B and D represent all area between 25' and 30' in depth. Zones C and E represent all area between 20' and 25' in depth.

DUAR [Include outcomes of quality assurance measures]

- Completeness is the comparison of the amount of useable data collected against the amount of data required to meet project objectives. To meet project needs, a data quality objective of eighty-five (85%) of samples at a site are successfully analyzed and reported. Therefore, when safety or environmental issues prevent sampling, additional or re-sampling may be required to obtain a complete data set.

DUAR [Include outcomes of quality assurance measures]

- Comparability is the degree to which data can be confidently compared to another dataset. For this project, comparability will be achieved through using standard field sampling techniques to collect water and sediment samples and measurements and by obtaining analytical data from those samples following standardized methods for chemical analysis and reporting protocols. Complete field documentation using standardized data collection templates will support the assessment of comparability.

DUAR [Include outcomes of quality assurance measures]

- Sensitivity is the ability of a method to detect and quantify a parameter. As it pertains to analytical methods, sensitivity is defined as the lowest concentration that can be distinguished from background noise. Sensitivity is measured by method detection limit (MDL) determinations. Each contract laboratory will determine MDLs by following procedures specified in EPA 821-R016-006. The MDL is the minimum measured concentration that can be distinguished from the method blank results with 99% confidence.

DUAR [Include outcomes of quality assurance measures]

Any limitations on the use of the environmental data collected as part of this project will include:

- Application of data qualifiers. How to determine which data qualifiers to apply is outlined in Section D1.
- A final project report that summaries the identification of all data limitations.
- Documentation of project evaluation of data limitations will be noted in the Data Useability Assessment Report (DUAR).

See Section B.5 Quality Control for details on frequency, location, and acceptance criteria of quality control samples.

DUAR
[Identify any criteria that were not met and/or limitations on the use of the data]

A8. Special Training/Certification

The Project Manager and Contract Manager are jointly responsible for verifying that all personnel involved with data generation (including agency personnel, contractors, and partners) have the necessary experience and training (both technical and quality assurance) to successfully complete their tasks and functions.

Health and Safety Plans for field staff are appended to this document (Appendix C). Field staff must review and sign off on the safety plan prior to initiating field work. A mandatory pre-task meeting will also be held with all field staff to review the sampling scope of work, procedures and safety requirements. Notes from this meeting will memorialize participants and subjects discussed.

The successful execution of this QAPP depends on the ability of project partners to complete their goals and objectives. The following experience and expertise are required for this project:

- Any field staff who will be collecting water quality samples, sediment samples, and *in-situ* measurements must have experience collecting aquatic samples.
- At least one member of each sampling team that operates a boat must have received boat operator certification training.
- At least one member of each sampling team must have experience collecting aquatic samples and hold a BS in civil engineering, environmental engineering, environmental sciences, limnology, or another related field.

- The Project Manager and LimnoTech Project Manager will be responsible for delivering a copy this QAPP to all individuals involved with the project. All individuals must be familiar with this document and the following specified SOPs so that there is proper adherence to the procedures throughout the duration of the project.
- Field data, sample collection methodologies, and laboratory techniques are consistent with the procedures detailed in the following documents:
    - NYSDEC SOP-GEN- #103: Sampling equipment cleaning

- NYSDEC SOP-GEN- #101: Sample Handling, Transport, and Chain of Custody
- NYSDEC SOP-AMB- #203: Lake sampling

A9. Documents and Records

The Project Manager will be the custodian of all records related to the project. Records related to this project that will be retained include this QAPP and the following:

- all paperwork, field logs, and other documents related to sample collection;
- all sample chains of custody and shipping forms;
- all sample reports and electronic data deliveries of analytical results; and
- all field measurement reports and data deliveries of field observations.

Report format/information

Field measurements will be collected, stored, and transferred electronically. Field logs and observations may be recorded on paper by the contracted field teams. Field logs will be transferred to the Project Manager and Ramboll Project Manager before the completion of the project. Data will be made available to the Project Manager at any time upon request.

Document/record control

The Project Manager and QA Officer will be jointly responsible for maintaining current versions of all data and deliverables related to this project.

The LimnoTech Project Manager will be responsible for maintaining and distributing the current version of this document. All QAPP revisions or updates must be reviewed and approved by all staff identified on the original approved QAPP or their designee.

Other records/documents

All design and data reports produced as part of this project will be stored electronically with this QAPP and the data files generated as part of this project. The Project Manager will manage the storage of all relevant documents.

Storage of project information

Records will be stored in the following locations:

- Hard copies of field data collection sheets (if applicable) will be held by all contractors and delivered to the Project Manager at the completion of the project.
- Electronic files will be stored on the NYDEC network with routine electronic backups. Records will be retained for at least 10 years beyond the completion of the project.

B DATA GENERATION AND ACQUISITION

B1. Sampling Process Design (Experimental Design)

Monitoring and data collection will take place to support and monitor the effectiveness of an alum treatment in Honeoye Lake. There are three monitoring phases, and each has a specific goal:

- Evaluate baseline conditions to support an alum treatment design (“Treatment Design Support Data Collection”)
- Monitor pre- and post-treatment conditions to evaluate treatment efficacy (“Pre- and Post-Application Data Collection”)
- Monitor conditions during treatment in compliance with permit conditions (“Mid-Application Data Collection”)

The extent of data collection for each of these phases is described below.

<u>Treatment Design Support Data Collection –</u>

A qualified contract field crew will collect sediment cores and water quality samples for analysis to support the design and development of the alum treatment strategy. Sediment cores, water column samples, and field measurements will all be collected during this phase. A single raw sample will also be collected to measure pH buffering capacity. Samples will be collected from a boat in April, 2022. If ice conditions pose a safety risk, samples will be collected from a boat as early as conditions allow.

A summary of all measurements and samples that will be collected to support the treatment design is provided in Table 3.

Table 3: Treatment Design Data Collection

Com-ponent	Sampling Locations	Vertical Description	Parameters	Frequency	Duplicates	Total Samples	DUAR *Sampled as planned or note exceptions*
Sediment Cores	Sites 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12, as identified on Figure 3 and Table 5	0-10 cm at 5 cm intervals (i.e. 0-5 cm and 5-10 cm sections)	Moisture content, Wet bulk density, Dry bulk density, Organic content, Loosely-bound P, Iron-bound P, Aluminum-bound P, Calcium-bound P, Labile Organic P, Total Fe, Total Al	Once	Field duplicates will be collected at Sites 2, 6, and 11	*(15 cores including duplicates) x 2 intervals =* **30 samples**	
Water Quality	Within monitoring zones A , B, C, D , and E as identified on Figure 2, Table 4	1 m below water surface, 1 m above sediment	Total P, Dissolved P, Total Al, Dissolved Al, Alkalinity, pH	Once	A field duplicate will be collected within zone D (@ CSL2)	*(5 locations + 1 duplicate) x 2 depths =* 12 samples	
Buffering Capacity	Within monitoring zone A at A1 as identified on Figure 2, Table 4	1 m below water surface	pH buffering capacity via titration	Once	No duplicates will be taken	1 sample	
Field Measure-ments	Within monitoring zones A , B, C, D , and E as identified on Figure 2, Table 4	1 m depth profile	pH, DO, Temperature, Conductivity	Once	No field measure-ment duplicates will be taken	5 depth profiles	

The sediment cores and water quality samples will be spatially distributed throughout the lake to collect representative data at various depth ranges. Twelve core locations were chosen to capture information that will support dosing in three depth ranges: 20-25’, 25-30’, and >30’ (Figure 3, Table 5).

A single water sample will be collected in Zone A (at location A1) to support a buffering capacity titration. The lake is assumed to be well-mixed horizontally and vertically at the time of sampling, and therefore a single sample will be representative of the lake's buffering capacity.

Two total water quality samples will be collected within the 20-25' depth range (one int Zone C at C1 and one in Zone E at CSL1; Figure 2, Table 4). Two total water quality samples will be collected within the 25-30' depth range (one in Zone B at B1 and one in Zone D at CSL2; Figure 2, Table 4). One water quality sample will be collected in the greater than 30' depth range (in Zone A at A1; Figure 2, Table 4). Sampling zones are shown in Figure 2.

Samples collected within Zone D and Zone E will be collected at the CSL2 and CSL1 long-term monitoring stations, respectively.

Table 4: Zone Monitoring Locations

Monitoring Location	Latitude	Longitude
Zone A (A1)	42.74882	-77.50786
Zone B (B1)	42.74056	-77.51053
Zone C (C1)	42.73351	-77.51345
Zone D (CSL2)	42.75130	-77.50870
Zone E (CSL1)	42.76503	-77.51238

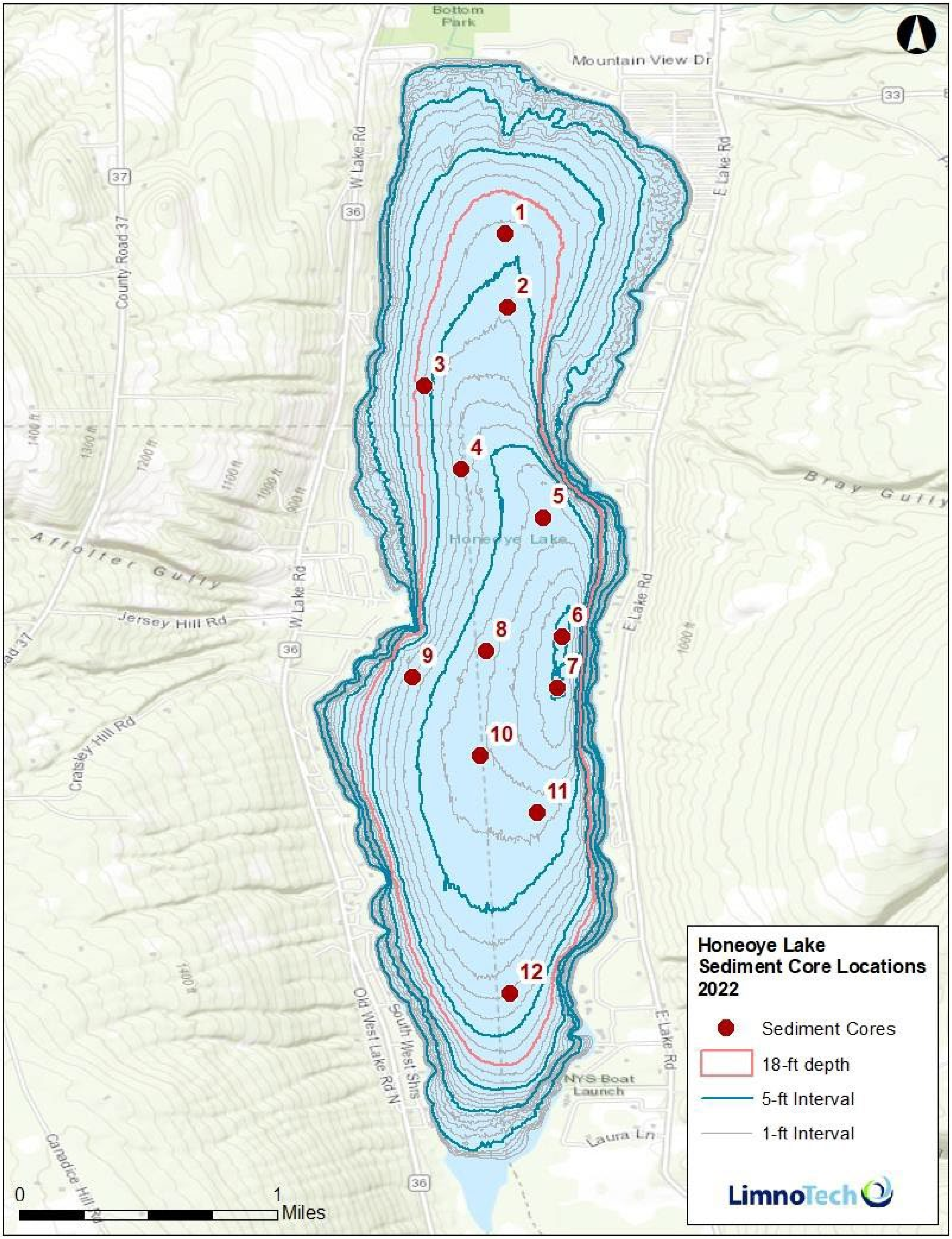

Figure 3: Sediment core sampling locations to support treatment design.

Sediment cores will be collected to a vertical sediment depth of 10 cm segregated into two 5 cm intervals. Each sediment depth interval will be homogenized and shipped to a contracted laboratory for analysis. Similarly, water quality samples will be collected from surface and deep water layers, the conditions of which can vary significantly under stratified conditions. The vertical distribution of both sediment and water chemistry will help inform an efficient and appropriate alum dose.

Table 5: Sediment Core Locations

Location Map ID (Figure 3)	Latitude	Longitude
1	42.7734	-77.5109
2	42.7693	-77.5108
3	42.7649	-77.5154
4	42.7602	-77.5134
5	42.7575	-77.5087
6	42.7508	-77.5077
7	42.7479	-77.5079
8	42.75	-77.5119
9	42.7486	-77.516
10	42.7442	-77.5123
11	42.7409	-77.5091
12	42.7308	-77.5106

Pre- & Post-Application Data Collection –

A qualified contractor will collect sediment cores and collect water quality samples before and after the alum treatment to monitor the effect of the alum dose on the lake and sediments.

The day prior to treatment, depth profiles and field measurements will be collected to measure and document existing conditions, grab samples will be collected to evaluate water chemistry and biological indicators, and sediment samples will be collected to measure physical characteristics. The same set of samples and measurements will be taken from approximately the same location seven days after the completion of the treatment.

Measurements and locations are described in Table 6. Samples will be collected in the five monitoring zones that were defined for the treatment design support phase (Figure 2). These zones cover three depth ranges: 20-25’, 25-30’, and >30’. Two samples (one in the northern half, one in the southern half) will be collected within the 20-25’ and 25-30’ zones, and an additional sample will be collected in the >30’ zone.

Table 6: Pre- & Post Application Data Collection

Com-ponent	**Sampling Locations**	**Vertical Description**	**Parameters**	**Sampling Frequency**	**Duplicates**	**Total Samples**	**DUAR** ***Sampled as planned or note exceptions***
Field Measure-ments	Within monitoring zones A , B, C, D, and E as identified on Figure 2; Table 4	1 m vertical depth profile	pH, DO, Temperature, Conductivity	Twice (one day prior + 7 days after treatment)	No field measure-ment duplicates will be taken	*5 locations x frequency =* **10 depth profiles**	
Field Measure-ments	Within monitoring zones A , B, C, D, and E as identified on Figure 2; Table 4	Surface	Secchi depth, user perceived water quality,	Twice (one day prior + 7 days after treatment)	No field measure-ment duplicates will be taken	*5 locations x frequency =* **10 obser-vations**	
Water Quality	Within monitoring zones A , B, C, D, and E as identified on Figure 2; Table 4	1 m below surface water, 1 m above sediment	Total P, Soluble Reactive P, Total Dissolved P, Total Al, Dissolved Al	Twice (one day prior + 7 days after treatment)	A field duplicate will be collected within zone D (@ CSL2)	*(5 locations + 1 duplicate) x number of depths x frequency =* ***24 samples***	
Biology	Within monitoring zone D and E as identified on Figure 2; Table 4	Surface	Zooplankton, Phytoplankton	Twice (one day prior + 7 days after treatment)	No biological duplicates will be collected	2 *locations x frequency =* **4 samples**	

Sediment Samples[1]	Within monitoring zones A , B, C, D, and E as identified on Figure 2; Table 4	Sedimen t surficial grab sample	Moisture content, Wet bulk density, Dry bulk density, Organic content, Loosely-bound P, Iron-bound P, Aluminum-bound P, Calcium-bound P, Labile Organic P, Total Fe, Total Al	Twice (one day prior + 7 days after treatment)	One duplicate will be collected within monitoring zone D @ CSL2	(5 locations + 1 duplicate) x 2 times = **12 samples**	

[1]The effect of alum on sediment chemistry and physical characteristics is expected to be difficult to quantify seven days following the treatment. The release and diffusion of iron-bound phosphorus depends on microbial reactions that are influenced by local environmental factors (e.g. temperature, dissolved oxygen), and therefore, the phosphorus fractionation is not expected to be dramatically altered within 7 days following the addition of alum. Spatial variability of sediments chemistry is also naturally high, and differences between pre- and post-application samples may be high due to sediment heterogeneity. The pre- and post- samples will provide a good baseline assessment of the sediment characteristics that can be referenced in future studies.

Mid-Application Data Collection –

A qualified contractor will collect field measurements during the treatment to monitor the immediate water quality and biological impact.. Samples will be collected in the five monitoring zones that were defined for the treatment design support phase (Figure 2). These zones cover three depth ranges: 20-25’, 25-30’, and >30’. Two samples (one in the northern half, one in the southern half) will be collected within the 20-25’ and 25-30’ zones, and an additional sample will be collected in the >30’ zone.

Before application: At the start of each day, in-situ measurements will be taken to verify that pH levels are within the specified range of pH 6-9 for the treatment. Measurements will be taken at multiple locations, as indicated in .

During application: During the treatment, three depth profile measurements will be taken per day at multiple representative locations within treated monitoring zones, as indicated in Table 7 and Figure 2. Field data will also be collected concurrently to identify possible quality and biological impacts, as indicated in Table 7. All data collection performed according to the details outlined in Table 7 will be conducted in a manner that does not interfere with the contracted applicator. The contracted alum applicator will also be required to monitor pH in real-time during the treatment. During application, monitoring is intended to meet permitting conditions, and actual locations may vary as they are dependent on the targeted treatment area for that day. The treatment zone may span multiple monitoring zones; therefore, the actual monitoring location will be as representative of the zone as possible, i.e., deepest, centrally located.

After application: At the end of the day, after alum application has been halted, depth profiles and field measurements will be collected to monitor conditions. Grab samples will also be collected to evaluate water chemistry and biological indicators. Measurements and locations are described in Table 6.

In general, samples should be collected in a routine order, beginning in the northern zones and finishing in the southern zones. The sampling contractor must coordinate with the Project Manager to avoid conflict with the alum application.

Table 7: Mid-Application Data Collection

Comp-onent	**Sampling Locations**	**Vertical Description**	**Parameters**	**Sampling Frequency**	**Duplicates**	**Total Samples**	**DUAR** ***Sampled as planned or note exceptions***
Field Measure-ments (Before Treatment Each Day)	Within monitoring zones A , B, C, D , and E as identified on Figure 2; Table 4	1 m depth profile	pH, DO, Temperature, Conductivity	Once daily during treatment	No field measure-ment duplicates will be taken	5 locations x 10 days = **50 depth profiles**	
Field Measure-ments (During Treatment Each Day)	Representa tive site within monitoring zones A , B, C, D, and E as identified on Figure 2; Table 4	1 m depth profile	pH, DO, Temperature, Conductivity	Thrice daily during treatment	No field measure-ment duplicates will be taken	5 locations x 3 profiles x 10 days = **apx. 150 depth profiles**	
Field Measure-ments (During Treatment Each Day)	Representa tive site within monitoring zones A , B, C, D, and E as identified on Figure 2; Table 4	Surface	Secchi depth, user perceived water quality, biological impacts	Thrice daily during application	No field measure-ment duplicates will be taken	5 locations x 3 measure-ments x 10 days = **apx. 150 obser-vations**	

Comp-onent	**Sampling Locations**	**Vertical Description**	**Parameters**	**Sampling Frequency**	**Duplicates**	**Total Samples**	**DUAR** ***Sampled as planned or note exceptions***
Field Measure-ments (After Treatment Each Day)	Within monitoring zones A , B, C, D, and E as identified on Figure 2; Table 4	1 m depth profile	pH, DO, Temperature, Conductivity	Once daily during treatment	No field measure-ment duplicates will be taken	5 locations x 10 days = **50 depth profiles**	
Field Measure-ments (After Treatment Each Day)	Within monitoring zones A , B, C, D, and E as identified on Figure 2; Table 4	Surface	Secchi depth, user perceived water quality, biological impacts	Once daily during treatment	No field measure-ment duplicates will be taken	5 locations x 10 days = **50 depth profiles**	
Water Quality (After Treatment Each Day)	Within monitoring zones A , B, C, D, and E as identified on Figure 2; Table 4	1 m below surface, 1 m above sediment	Total P, Soluble Reactive P, Total Dissolved P, Total Al, Dissolved Al	Once daily during treatment	A field duplicate will be collected within zone D (@ CSL2)	(5 locations + 1 duplicate) x 10 days = 60 samples	
Biology (After Treatment Each Day)	Within monitoring zone D and E as identified on Figure 2; Table 4	Surface	Zooplankton, Phytoplankton	Once daily during treatment	No biological duplicates will be collected	2 locations x 10 days = **20 samples**	

DUAR

[Note if there were any changes from the planned sample design. If it simplifies your explanation, please create new DUAR boxes below the text where the change occurred. If no changes were required, state “Sampling design was followed as described above.”]

B2. Sampling Methods

Samples and measurements will be taken throughout this project at the locations described in Table 5 and Figure 2. A handheld global positioning system (GPS) unit with accuracy of within 3 meters will be used to locate each of the sampling locations. For samples that are taken at a non-discrete location within zones A-E, field logs will be used to document the coordinates where each sample was taken.

All sample containers will be provided from the analytical laboratory for each analysis. If the laboratory does not provide sampling bottles for a given analyses, the Ramboll Project Manager and contractors will be jointly responsible for acquiring sampling containers that meet laboratory descriptions.

At the start of each sampling day, all sampling equipment will be cleaned with phosphate-free detergent, rinsed with potable water, and rinsed with distilled water.

Sediment Core Collection:

Sediment cores will be collected using a metal gravity coring device equipped with polycarbonate tubes to collect intact sediment cores. Sediment collection will occur after ice-out. Sediment samples of the top 0-10 cm will be collected using a gravity coring device at the twelve locations listed in Table 5. Samples will be split into 0-5 cm and 5-10 cm sections, homogenized, and transferred into pre-prepared sample containers and maintained under chain of custody through delivery to the lab

All equipment that is used to section, homogenize, and transfer core samples will be washed with phosphate-free detergent and rinsed with lake water between each use.

Surface Sediment Collection:

Surface sediment samples will be collected by a stainless steel, self-tripping, Petite Ponar grab sampler, or similar device. Each grab sample will be emptied into a stainless steel receptacle, mixed until the sediment is thoroughly homogenized, and transferred into the pre-prepared sample containers using a stainless steel spoon or similar instrument.

All sample containers will be transferred to ice as soon as possible following collection and held according to the laboratory specifications.

The ponar, receptacle, mixing device, and transferring instrument will all be washed thoroughly with phosphate-free detergent and rinsed with lake water following each use at each sampling location.

Water Quality Sample Collection:

Water samples will be collected from a boat with a Van Dorn or other depth-discrete limnological sampling device. All sample bottles or containers will be cleaned and preserved as identified in 40 CFR Part 136 or prescribed by the analytical laboratory. Sample bottles will be filled directly from the sampling device at the location of sampling.

Sample bottles will be transferred to coolers on ice as soon as possible following collection and held according to the laboratory specifications.

The sampling device will be rinsed with distilled water after samples are collected at each station. At the arrival of each sampling location, the device will be rinsed in lake on the side of the boat opposite of which sampling will occur.

In-situ Measurements & Observations:

Water temperature, pH, dissolved oxygen, and conductivity profiles will be measured with a multi-parameter probe (YSI EXO handheld, YSI ProQuatro Multiparameter Meter, or other comparable handheld device) *in situ* from a boat. The probe will be lowered from the surface at 1-m intervals to approximately 1-m from the sediment surface while avoiding contact with the lake bottom. At each interval, the readings for each parameter will be allowed to stabilize before measurements are recorded.

A standard 20-cm Secchi disk will be used to measure water clarity on the shady side of the boat. Two readings will be collected and averaged together. The first reading will be taken by recording the depth at which the disk is no longer visible when lowered from the surface. The second reading will be taken by recording the depth at which the disk becomes visible when raised to the surface.

User perceived water quality will be recorded according to standard survey protocols.

Phytoplankton

Water samples for phytoplankton analysis will be collected using a vertical plankton two net at each collection location. The net will be conical and approximately 0.13-meter in diameter, with a 63-micrometer mesh. The tow will begin at a depth that is twice the Secchi disk depth.

Samples will be washed into 75-ml glass bottles by rinsing the outside of the net with lake water and preserved with Lugol's solution or similar preservative provided by the laboratory (Table 8) Samples will be stored at room temperature and held in the dark.

Zooplankton

Water samples for zooplankton analysis will be collected using a vertical tow net at each collection location. The net will be a 0.3-0.5-meter diameter conical net with a 153 micrometer mesh. The tow will be taken from 1 foot above the lake bottom at a rate of approximately 0.5-1 m/sec.

Samples will be washed into 125-ml bottles by rinsing the outside of the netting with lake water to concentrate the sample. Sample bottles will be filled from the cod end until halfway filled. Ten to fifteen ml of cold club soda will be added to narcotize the sample. Sample bottles will be filled with a formalin buffer solution so that the resulting sample volume has a formalin concentration of 4-5%.

Samples will be preserved and held according to laboratory requirements (Table 8).

DUAR
[Note if there were any changes from the planned sample design. If it simplifies your explanation, please create new DUAR boxes below the text where the change occurred. If no changes were required, state "Sampling Methods were followed as described above."]

B3. Sample Handling and Custody

Samples will be collected in accordance to the methods described in Section B.2. All sample bottles will be labeled in the field with the following information:

- Sample ID
- Sample date (month/day/year) & time,
- Sample location/zone
- Project ID
- Company/sampler initials.

Sample IDs will be defined by the station name (core # or zone), date (mmddyy), type (sc = sediment core, ss = sediment surface, sw = surface water, dw = deep water, p=phytoplankton, z=zooplankton), and daily sequence. Daily sequence will begin with 1 and count upwards. For example, the second water sample collected 1-m above the lake bottom on November 1st, 2022 in Zone B would have the sample ID, 'B-110122-dw-2'. All labels will be completed with indelible ink.

- Preservative will be added to sample bottles as appropriate (Table 8). All samples will be packed into iced coolers for transport to the analytical laboratory. A chain-of-custody will be completed and accompany samples until they are received by the laboratory. An example chain of custody is provided in (Appendix A:

Example Chain of Custody), however, the chain of custody provided by the analytical laboratory should be used if provided.

A summary of general sampling handling and custody requirements, by sample type/parameters, is presented in Table 8. All container, volume or mass, preservation, and holding time requirements from the contracted lab will be followed, with the condition that they meet EPA guidelines[3]. The LimnoTech Project Manager, Ramboll Project Manager, and

[3] EPA. 2015. Federal Register 40 CFR Part 136 – Guidelines for Establishing Test Procedures for the Analysis of Pollutants. US Environmental Protection Agency, Water Programs, Washington, DC. http://www.ecfr.gov/cgi-bin/text-idx?SID=e409ed089dfb378924589b2b47d84a5a&mc=true&node=pt40.23.136&rgn=div5.

QA Officer will be jointly responsible for approving and updating the QAPP with all current sampling and handling requirements in conjunction with the contracted lab.

Table 8: General sample handling and preservations requirements

Sample Type	Parameters	Container Type[1]	Field Preservation	Lab Preservation	Holding Time
Sediment Core	Moisture content	4 oz jar	Not applicable	Not applicable	7 days from extrusion
Sediment Core	Wet bulk density	2 lb plastic bag	Not applicable	Not applicable	7 days from extrusion
Sediment Core	Dry bulk density	2 lb plastic bag	Not applicable	Not applicable	7 days from extrusion
Sediment Core	Organic content	4 oz jar	On Ice	Hold at 4°C	7 days from extrusion
Sediment Core	Loosely-bound P	Sterile whirl-pak or plastic bag	On Ice	Hold at 4°C	28 days from extraction
Sediment Core	Iron-bound P	Sterile whirl-pak or plastic bag	On Ice	Hold at 4°C	28 days from extraction
Sediment Core	Aluminum-bound P	Sterile whirl-pak or plastic bag	On Ice	Hold at 4°C	28 days from extraction
Sediment Core	Calcium Bound P	Sterile whirl-pak or	On Ice	Hold at 4°C	28 days from extraction
Sediment Core	Labile Organic P	Sterile whirl-pak or plastic bag	On Ice	Hold at 4°C	28 days from extraction
Sediment Core	Total Fe	Sterile whirl-pak or plastic bag	On Ice	Hold at 4°C	180 days from extraction
Sediment Core	Total Al	Sterile whirl-pak or plastic	On Ice	Hold at 4°C	180 days from extraction
Sediment (Surficial)	Total P	Sterile whirl-pak or plastic bag	On Ice	Hold at 4°C	28 days
Sediment (Surficial)	Grain size distribution	Sterile whirl-pak or plastic bag	On Ice	Hold at 4°C	6 months
Water Quality	Total P	HDPE bottle	H_2SO_4, On Ice	Hold at 4°C	28 days
Water Quality	Total Al	HDPE bottle	HNO_3, On Ice	Hold at 4°C	6 months
Water Quality	Dissolved Al	HDPE bottle	HNO_3, On Ice	Hold at 4°C	6 months
Water Quality	Alkalinity	HDPE bottle	On Ice	Hold at 4°C	14 days
Water	Soluble Reactive P	HDPE bottle	On Ice	Hold at 4°C	48 hours[2]

Quality					
Water Quality	Total Dissolved P	HDPE bottle	On Ice	Filter, hold at 4°C	28 days
Water Quality	pH	4 oz jar	On Ice	Hold at 4°C	24 hours
Buffering Capacity	Buffering Capacity	1 L HDPE bottle	On Ice	Hold at 4°C	48 hours
Biological	Zooplankton	125 ml HDPE bottle	4-5% formalin	Hold at 4°C	30 days
Biological	Phytoplankton	75 ml glass bottle	Lugols solution	Hold at room temperature in dark.	30 days

[1] Sampling containers may be provided by contracted lab

[2]Sample must be filtered within 15 minutes from collection

Results from all sample analysis will be delivered, with of an anticipated lab turnaround time of one month, to the Project Manager and Data Analysis and Data Manager for use and storage (see Section B10). Analytical labs will deliver results for each sample ID in an electronic data delivery. Field measurements recorded on paper will be transcribed by the contractor and delivered in an electronic format to the Project Manager and Data Analysis and Data Manager. All hardcopies will be scanned and delivered as part of this transmittal. The Data Analysis and Data Manager will be responsible for distributing the sample results to all team members.

B4. Analytical Methods

All analytical methods will be conducted by laboratories that are certified by NYS Department of Health Environmental Laboratory Approval Program per NYS Public Health Law 502. The table below summarizes the analytical methods to be used for surface water and sediment analysis (Table 9). Upstate Freshwater Institute (UFI), a NELAC/NELAP accredited laboratory in the State of New York (NY Laboratory ID No. 11462) will be the primary laboratory for all analysis in this project. ALS Environmental in Rochester (ALS; NY Laboratory ID No. 10145) will analyze total and dissolved metals concentrations as a subcontractor to UFI. The Laboratory Manager and LimnoTech Project Manager will be jointly responsible for identifying certified laboratories to conduct any analyses that UFI cannot perform. Any additional certified laboratories that are used for this project will be communicated to the NYSDEC Project Manager and noted in the final reports.

Inactivation of sediment phosphorus is based on the pool of phosphorus that is most likely to be released during anoxic conditions. Therefore, the mass of aluminum required to inactivate the sediment phosphorus is based on the pool of redox-sensitive P and labile organic P in the sediments (Rydin and Welch 1999; Cooke et al. 2005; Huser et al. 2016). The Redox-P pool is comprised of the loosely-bound P and iron-bound P fractions, and is the mass of phosphorus that is most likely to undergo reduction-oxidation reactions leading to diffusive flux of P from the sediments. The mass of the labile organic P pool can be converted to soluble inorganic P through bacterial mineralization, so this portion is also considered in the alum dose calculations in organic-rich sediments. Because rates of mineralization vary spatially and temporally, 30% of organic pool is typically factored into the dose equations in organic rich sediments. The mass of phosphorus from these different pools are collectively referred to as the Bio-labile P, which serves as the basis for determining the total mass of aluminum required to inactivate the sediments. The phosphorus sequential extraction generally follows the analytical procedures in Psenner et al (1984) or some modified version of that protocol. The analytical extraction also results in quantification of pools of phosphorus that are considered to recalcitrant under standard environmental conditions and thus are not likely to be mobilized/diffused from the sediments (e.g. aluminum-bound P and calcium-bound P).

Sediment core analysis and dose determination prescribed here follow commonly applied methodologies as described in Rydin and Welch (1999) and Cooke et al. (2005).. Sediment core analysis will involve the following steps:

- Collect representative sediment cores and section into the specified depth intervals for lab analyses.
- Quantify iron-bound P and loosely-bound P (collectively referred to as the redox-P or mobile P pool) according to Psenner et al (1984), or similarly adapted protocols.
- Measure remaining phosphorus fractionation pools (organic-bound P, aluminum-bound P, calcium-bound P) according to analytical protocols for sequential extraction of phosphorus pools (Table 9).
- Measure bulk density and moisture content of sediment samples using standard laboratory procedures.

Alum dose determination will follow the protocols outlined in Rydin and Welch (1999) and Cooke et al. (2005), which generally involve the following steps:

- Determine need for a buffered alum treatment based on alkalinity and pH data.
- Determine ratio of Al added to Al-P formation expected based on sediment chemistry and target treatment longevity.
- Calculate required mass of aluminum (Al) to treat mass of P measured in sediments and water column P.
- Determine alum dose based on concentrations of biological labile P and determined ratio of Al added:Al-P formed, sediment area targeted for treatment, and water volume.
    - o

Table 9: Analytical methods for surface water and sediment

Sample Type	Parameter	Approved Test Procedures[1]	Acceptable Reporting Limit (RL)[1]	Laboratory
Sediment Core	Moisture Content	ASTM D2216-19	0.1% by weight	UFI
Sediment Core	Wet bulk density	ASTM D7263-21	0.1 PCF	UFI
Sediment Core	Dry bulk density	ASTM D7263-21	0.1 PCF	UFI
Sediment Core	Organic content	EPA 160.4	10 mg/kg	UFI
Sediment Core	Loosely-bound P	Sodium chloride extraction/centrifuge/filter/colorimetry	0.02 mg/kg	UFI
Sediment Core	Iron-bound P	Bicarbonate-Dithionite oxidation/centrifuge/filter/colorime	0.02 mg/kg	UFI

		try		
Sediment Core	Aluminum-bound P	Sodium hydroxide extraction/centrifuge/filter/colorimetry	0.02g mg/kg	UFI
Sediment Core	Calcium-bound P	HCl extraction/centrifuge/filter/colorimetry	0.02g mg/kg	UFI
Sediment Core	Labile Organic P	Ashed/hydrochloric acid extraction/centrifuge/filter/colorimetry	0.02 mg/L	UFI
Sediment Core	Total Fe	EPA 6010	MRL = 20 mg/kg, MDL = 13 mg/kg	ALS
Sediment Core	Total Al	EPA 6010	MRL = 20 mg/kg, MDL = 12 mg/kg	ALS
Sediment (Surficial)	Total P (non-aqueous)	SM 4500-P- 2011	0.02 mg/kg	UFI
Sediment (Surficial)	Grain size distribution	ASTM D422 or D4464	0.10%	Laboratory not yet identified
Water Quality	Total P	SM 4500-P- 2011	LOQ = 0.0045mgP/L, LOD = 0.0015 mg P/L	UFI
Water Quality	Total Al	EPA 200.8	MRL= 0.010 mg/L, MDL = 0.0023 mg/L	ALS
Water Quality	Dissolved Al	EPA 200.8	MRL= 0.010 mg/L, MDL = 0.0023 mg/L	ALS
Water Quality	Alkalinity	SM 2320 B-2011	20 mg CaCO3/L	UFI
Water Quality	Soluble Reactive P	SM 4500-P- 2011	LOQ = 0.0018 mg P/L, LOD = 0.0006 mg P/L	UFI
Water Quality	Total Dissolved P	SM 4500-P- 2011	LOQ = 0.0045 mg P/L, LOD = 0.0015 mg P/L	UFI
Water Quality Buffering Capacity Biological	pH Buffering Capacity Zooplankton	SM 4500-H+ B-2011 Titration - 1.25 g Al/L solution of $Al_2(SO_4)_3 \cdot 18\ H_2O$ Cell enumeration and genus level identification	Not applicable Not applicable Not applicable	UFI UFI UFI
Biological	Phytoplankton	Cell enumeration and genus level identification	Not applicable	UFI
Field Measurement	pH	Electrometric, Field Meter	Not applicable	*In situ*
Field Measurement	DO	Electrode, Field Meter	Not applicable	*In situ*
Field Measurement	Water Temperature	Electrode, Field Meter	Not applicable	*In situ*
Field Measurement	Conductivity	Platinum Electrode, Field Meter	Not applicable	*In situ*
Field Measurement	Secchi Depth	NALMS 1995	Not applicable	*In situ*

[1] The Ramboll Project Manager, LimnoTech Project Manager, and QA Officer are jointly responsible for confirming acceptable laboratory methods and RLs when the contracted labs are identified.

B5. Quality Control

The quality portion of the project's quality control methodology is designed to establish and maintain standards that will ensure the validity of the data. The Ramboll Project Manager, LimnoTech Project Manager, and QA Officer are jointly responsible for maintaining internal quality control as part of the overall quality control system. Overall quality assurance is achieved by implementation of the data quality objectives and the data evaluation measures described below.

All sample collection for this project will be performed by subcontracted field crews that are trained to conduct sediment, water quality, and biological sampling. All subcontracted field crews will be under the supervision of the Ramboll Project Manager. All laboratory analysis will be performed by Upstate Freshwater Institute (UFI), a NELAC/NELAP accredited laboratory in the State of New York (NY Laboratory ID No. 11462), ALS Environmental in Rochester (NY Laboratory ID No. 11462), or another accredited subcontracted laboratory. In addition the quality control measures described here, UFI and ALS implement their own robust quality control programs.

A summary of the field and laboratory quality control samples and analysis which will be implemented are provided in Table 10 and Table 11, below. The data obtained from these QC procedures are used to estimate the quality of analytical data, identify deficiencies, determine need for corrective actions for deficiencies, and interpret results after corrective actions were taken.

Table 10: Field quality control

Field Duplicate	Replicate aliquot of the same sample taken through the entire analytical procedure	Refer to Table 3, Table 6, and Table 7 for parameter specific field duplicate frequency	Relative percent difference (RPD) between 1^{st} and 2^{nd} samples	30%[1]

[1]The QA officer has the authority to modify this criterion after viewing the complete results. Lake sediments can be extremely heterogenous, and a 30% RDP may not indicate that field activities did not meet quality standards.

Table 11: Parameter specific laboratory quality control

Sample Type	Parameter	Approved Test Procedures[1]	Method Blanks		Matrix Spikes/Verification Standards		Laboratory Duplicates	
			Frequency	QC Criteria	Frequency	QC Criteria	Frequency	QC Criteria
Sediment Core	Organic content	ASTM D2216-19	1 with each batch of samples not to exceed 20 samples	< RL	n/a	n/a	1 with each batch of samples not to exceed 20 samples	RPD < 20%
Sediment Core	P Fractionation Sequence	Refer to Table 9	1 with each analytical batch of samples	<1/2 RL	n/a	n/a	1 with each batch of samples not to exceed 20 samples	RSD = 15%
Sediment Core	Total Fe	EPA 6010C	5%	< RL	5%	70-130%	5% MSD	RPD < 20%
Sediment Core	Total Al	EPA 6010C	5%	< RL	5%	70-130%	5% MSD	RPD < 20%
Sediment (Surficial)	Total P (non-aqueous)	SM 4500-P -2011	1 with each analytical batch of samples	≤1/2 RL	MS: 1 with each batch of samples not to exceed 20 samples VS: 1 with each batch of samples not to exceed 10 samples	MS 85-115% VS 90-110%	1 with each batch of samples not to exceed 20 samples	RPD < 15%
Water Quality	Total P	SM 4500-P -2011	1 with each analytical batch of	≤1/2 RL	MS: 1 with each batch of samples not to exceed 20 samples VS: 1 with each batch	MS 85-115% VS 90-110%	1 with each batch of samples not to exceed 20 samples	RPD < 15%

Sample Type	**Parameter**	**Approved Test Procedures[1]**	**Method Blanks**		**Matrix Spikes/Verification Standards**		**Laboratory Duplicates**	
			Frequency	QC Criteria	Frequency	QC Criteria	Frequency	QC Criteria
					of samples not to exceed 10 samples			
Water Quality	Total Al	EPA 200.8	5%	< RL	10%	70%-130%	10% MSD	RPD < 20%
Water Quality	Dissolved Al	EPA 200.8	5%	< RL	10%	70%-130%	10% MSD	RPD < 20%
Water Quality	Alkalinity	SM 2320 B-2011	not applicable	not applicable	not applicable	not applicable	1 with each batch of samples not to exceed 20 samples	RPD < 15%
Water Quality	Soluble Reactive P	SM 4500-P -2011	1 with each analytical batch of samples	≤1/2 RL	MS: 1 with each batch of samples not to exceed 20 samples VS: 1 with each batch of samples not to exceed 10 samples	MS 85-115% VS 90-110%	1 with each batch of samples not to exceed 20 samples	RPD < 15%
Water Quality	Total Dissolved P	SM 4500-P -2011	1 with each analytical batch of samples	≤1/2 RL	MS: 1 with each batch of samples not to exceed 20 samples VS: 1 with each batch of samples not to	MS 85-115% VS 90-110%	1 with each batch of samples not to exceed 20 samples	RPD < 15%

Sample Type	**Parameter**	**Approved Test Procedures[1]**	**Method Blanks**		**Matrix Spikes/Verification Standards**		**Laboratory Duplicates**	
			Frequency	QC Criteria	Frequency	QC Criteria	Frequency	QC Criteria
					exceed 10 samples			

[1]Physical parameters measured from sediment cores are not subject to method blanks, spikes, or duplicates. These parameters are not included in this table.

If QC rules are broken the analysis is halted, the samples are rerun, or the data may be accepted and flagged appropriately. Some examples of this are: a single measurement outside the control limits, 2-3 measurements between the warning and control limits, several consecutive measurements all steadily increasing or decreasing, or an obvious non-random pattern.

Data anomalies

The Ramboll Project Manager, LimnoTech Project Manager, and QA Officer will jointly review the data produced in this project, focusing on anomalies and omissions in the data. Variation of duplicate, matrix spike and equipment blank values for each parameter must not exceed the acceptable ranges discussed in Table 10 and Table 11. Issues with any data results will be reported to the QA Officer, Project Manager, and NYSDEC.

DUAR
[Note any issues and corrective actions taken. If it simplifies your explanation, please create new DUAR boxes below the text where the change occurred. If no issues were identified, state "No issues identified, and no corrective actions taken."]

B6. Instrument/Equipment Testing, Inspection, and Maintenance

For instruments operated by/in the analytical laboratory, testing, inspection, and maintenance will be performed in accordance with guidelines detailed by the analytical methods and NYSDOH ELAP certification requirements.

Field Instruments and Equipment

All equipment necessary for field monitoring (e.g. meters, collection devices, vehicles) will be operated according to the applicable method specifications and manufacturer's specifications. Handheld YSI (or comparable replacement) multiparameter probes and all field equipment will be calibrated and maintained in accordance with manufacturer's recommendations (Appendix B). Multiparameter sensor modules will be replaced within 12 months prior to use, or at the manufacturer's recommendation. Contracted field staff will be responsible for testing, inspection, and maintenance of all field equipment, as necessary and per the manufacturer recommendations. The Ramboll Project Manager will be responsible for making sure spare parts are available for all field instruments.

All actions regarding testing, inspection, and/or maintenance of equipment during the project will be documented.

DUAR

[Note any issues and corrective actions taken. If it simplifies your explanation, please create new DUAR boxes below the text where the change occurred. If no issues were identified, state “No data issues identified, and no corrective actions taken.”]

B7. Instrument/Equipment Calibration and Frequency

For instruments operated by/in the analytical laboratory, calibrations and confirmations of calibration will be performed in accordance with guidelines detailed by the analytical methods and NYSDOH ELAP certification requirements.

All equipment necessary for field monitoring (e.g. field equipment, multiparameter probes, field analysis, laboratory equipment) will be operated according to the applicable method specifications and manufacturer’s specifications. Contractors will be responsible for testing and calibration.

Multiparameter field meters that measure pH will be calibrated within 1 week of use or at manufacturer’s specification. Multiparameter field meters that measure conductivity will be calibrated within two weeks of use or at manufacturer’s specification. Multiparameter field meters that measure dissolved oxygen will be calibrated each day the meter is used or at the manufacturer’s specification. Electrode field meters that measure water temperature will be calibrated at the manufacturer’s recommendation.

All field meter calibrations will be tested prior to use. The Project Manager will be responsible for ensuring testing and calibration actions are recorded in daily logs.

B8. Inspection/Acceptance for Supplies and Consumables

Bottles and sample containers will be obtained from the contract laboratory for all water quality analytical services.

Sample containers for sediment samples will be provided by Stantec for the Design Support sampling and the contracted sampling team for the Pre- and Post-Application monitoring and Mid-Application monitoring. The Project Manager, Laboratory Manager, and contracted field staff will be jointly responsible for obtaining and ensuring the integrity of other project consumables.

Prior to each sampling event, all supplies and consumables will be inspected to ensure that they are clean and uncontaminated, in sufficient quantity, and that no anomalies exist.

DUAR

[Note any issues and corrective actions taken. If it simplifies your explanation, please create new DUAR boxes below the text where the change occurred. If no issues were identified, state "No data issues identified, and no corrective actions taken."]

B9. Non-Direct Measurements (i.e., Secondary Data)

All non-direct measurements that may be used in this pilot project are described in Table 122.

Table 12: Non-Direct Measurements (i.e., Secondary Data)

Data Sources	Intended Use	Rationale for Use	Acceptance Criteria
NYDEC	Surface water pH, alkalinity, and total phosphorus data may be used to supplement the Design Support monitoring dataset. The pH and alkalinity data will be used to assess whether treatment needs to be buffered. Total phosphorus will be used to support alum dose calculations.	Recently collected data (within the last 5 years) will be used to verify that data collected during this project represents the full range of normally measured conditions.	Laboratory analysis must have been performed by a NYS DOH ELAP accredited laboratory under the guidelines of a an approved QAPP. Equivalent laboratory accreditation may be deemed appropriate by the QA Officer.
Honeoye Lake Watershed Task Force	Bathymetric data, bottom hardness, macrophyte biovolume will supplement the sediment analytical data collected under the protocols outline in this QAPP. These data will support the spatial component of the treatment design.	These data were collected using a GPS/Depth Finder every five seconds along east-west transects spaced approximately 200' apart.	Bathymetric maps have been created using the BioBase lake mapping service.

Key resources/support facilities needed

The Project Manager does not anticipate any obstacles to this approach. Project staging and site access will be coordinated through the Office of Parks, Recreation, and Historic Preservation (OPRHP) at Honeoye Lake State Boat Launch in Honeoye, New York. The Project Manager will secure the required OPRHP research permit for the proposed project to stage at the State Park prior to project start.

The State of New York claims sovereign title to the bed of Honeoye Lake below the low water mark. OGS has jurisdiction of all sovereign owned lands, and State Asset and Land Management manages those lands under water.

Determining limits to validity and operating conditions

Only the QA Officer will be authorized to remove an entry of direct and non-direct measurement data for the purposes of this project. A summary of any and all exclusions will be included in the final report. Substantial exclusions of non-direct measurements are not anticipated.

B10. Data Management

All data obtained for this project will be compiled and placed in a centralized location. All data produced during this project will be stored on a cloud server (e.g. Microsoft SharePoint) during duration of the project and transferred to a physical server operated by NYSDEC upon the completion of the project. Analytical results will be accepted from laboratories in an electronic format. Field logs and any physical copies of measurements will transcribed into electronic data structures. All data will be maintained for at least 10 years beyond the completion of the project. The Project Manager will be responsible for overall data management.

> DUAR
>
> [Include any changes to the project strategy for managing data and outcomes from the changes. If it simplifies your explanation, please create new DUAR boxes below the text where the change occurred. If no changes were required, state “Data management was followed as described above.”]

C ASSESSMENT/OVERSIGHT

C1. Assessment and Response Actions

Due to the limited scope of this project, audits by the QA staff are not required. As desired, the NYSDEC Project Manager and/or QA Officer may be present during site setup, site operations, and site deconstruction and conduct reviews of the data generated.

Deviation from intended plans and procedures should be noted by the person observing the deviation and reported to the QA Officer. The QA Officer shall develop a corrective action plan to ensure that future sampling and analysis are conducted in accordance with the QA procedures presented in this QAPP. All deviations from intended plans and procedures are to be recorded in the appropriate field or laboratory notes. Work on this project will be temporarily suspended under the following conditions: water temperature less than 4ºC (or 42º F); sustained winds of 15 mph or higher expected the day of application; sustained heavy rains (greater than 1”) expected the day of application; at least 72 hours after a significant rain event (0.5” over a 24 hour period); and/or significant rain event (greater than 1”) expected within 48-hours following application; violations of conditions, criteria, or standards specified by attained permits.

Revisions to the Quality Assurance Project Plan are to be approved by the Ramboll Project Manager, LimnoTech Project Manager, QA Officer, and the Project Manager, who will notify those on the distribution list of the revision.

C2. Reports to Management

All reporting and project deliverables will be compliant with the specifications, timeframes and reporting format outlined in the contract between Ramboll, NYSOGS and NYSDEC (summarized in Table 13). Publication or distribution of any data results or subsequent reports must be approved by NYSDEC.

Table 13: Project QA Status Reports

Type of Report	Frequency	Preparer	Recipients
QAPP	Once, prior to the start to work on the project	LimnoTech, Stantec	See Distribution list Section A4
Amended or updated QAPP	As changes or modifications are made	LimnoTech	All recipients of original QAPP
Progress Report	Following each sampling event	Ramboll, LimnoTech, Stantec	NYSDEC

D DATA REVIEW AND EVALUATION

D1. Data Review, Verification and Validation

This QAPP shall govern the operation of the project at all times. The NYSDEC, QA Officer, and Project Managers from Ramboll and LimnoTech will jointly review data as received by any parties in relation to the field measurements, analytical measurements, and assessment methods, primarily focusing on anomalies and omissions in the data. Problems observed in laboratory data will be brought to the attention of the contract manager and/or QA staff for further review. Data anomalies and deviations from the quality control will be addressed as detailed in this QAPP.

Sediment and water quality results generated by the analytical laboratories are reviewed at three stages. First, the analytical laboratory will implement laboratory specific protocols will ensure the quality and validity of the data. Second, the Ramboll Project Manager, and LimnoTech Project Manager will review data results when received from the analytical laboratory. Third, the QA Officer will evaluate all quality control data results to quantify the overall precision, accuracy, and completeness and validity of the sampling data.

For field measurements, results generated are reviewed first by Ramboll and Stantec field staff during the input of the data into an electronic format. This review includes confirmation of suspect values and the possible qualification of the results. The data will be secondarily reviewed by the QA Officer and Ramboll Project Manager to evaluate quality control data results to quantify the overall precision, accuracy, and completeness and validity of the sampling data.

NYSDEC will receive and review sediment, water quality, and field measurements following the verification and validation by the QA Officer, Ramboll Project Manager, and LimnoTech Project Manager.

D2. Verification and Validation Methods

Data from this project will be verified and validated by the teams indicated above. Data for each of the parameters will be compared with the respective detection limits, precision and accuracy; the analytical laboratory performs these comparisons on results that they generate.

If data validity cannot be verified, this information will be noted in the final QA/QC report. Uncertainty in the data allowed for use in the project end product will be limited to that found acceptable in the data verification and validation process.

The methods used to calculate precision, accuracy, completeness, and comparability of the project data are shown below. Acceptable levels of data validation and verification are presented in Section B5.

a) Precision: the degree to which two measurements are in agreement. This is evaluated by calculating the relative percent difference (RPD). RPD = [(reference – observed)/reference]*100
b) Accuracy: the degree of agreement between a sample and an accepted reference (true) value. Accuracy = observed value – true value (sign of result (+ or -) indicates direction of sample bias where "+" is biased high and "–"is biased low)
c) Completeness: the number of valid measurements taken from the number of total measurements taken during the entire project. % completeness = (valid measurements/total number of measurements)*100

d) Comparability: achieved by adherence to routine sampling and analytical methods, sampling handling, holding times, using consistent measurement units, and consistent rule sets for reporting information.
e) Representativeness: addressed by using standard sampling protocols in regard to sample location within the treatment system and frequency of sampling (for temporal representativeness).

D3. Evaluating Data in Terms of User Needs

The data produced in this project will be used by the Project Manager, QA Officer, LimnoTech Project Manager, and Ramboll Project Manager will be used to accomplish three data use goals:

- Develop a treatment strategy for the use of alum in Honeoye Lake. This will include estimating the dose of alum that should be applied to the lake.
- Monitor and characterize the in-lake conditions during application.
- Evaluate the short-term impacts of the alum application on the lake. This includes monitoring for biological, water quality, and sediment changes.

For all goals, the Project Manager and QA Officer are jointly responsible for meeting the data quality objectives in this QAPP for each of these applications. The QA officer has the authority to omit data that do not meet these objectives. The Project Manager has the authority and responsibility to implement and ensure corrective actions are followed.

E References

Cooke, G.D., E.B. Welch, S.A. Peterson, and S.A. Nicholes. 2005. Restoration and Management of Lakes and Reservoirs, 3rd Edition. CRC Press, Taylor & Francis Group, Boca Raton, Florida.

New York State Department of Environmental Conservation. Harmful Algal Bloom Action Plan Honeoye Lake. https://www.dec.ny.gov/docs/water_pdf/honeoyehabplan.pdf

Psenner, R., R. Pucsko, and M. Sager. 1984. Fractionation or organic and inorganic phosphorus compounds in lake sediments. An attempt to characterize ecologically important fractions. *Arch. Hydrobiol. Supplement* 70: 111-155.

Rydin, E. and E.B. Welch. 1999. Dosing alum to Wisconsin lake sediments based on in vitro formation of aluminum bound phosphate. Lake and Reservoir Management 15(4): 324-331.

U.S. Environmental Protection Agency (USEPA) & New York State Department of Environmental Conservation. 2019. Total Maximum Daily Load for Total Phosphorus Honeoye Lake Ontario County, New York.
https://www.dec.ny.gov/docs/water_pdf/tmdlhoneoyeaug2019.pdf

<u>Appendices:</u>

Appendix A:

Example Chain of Custody

Appendix B

YSI EXO Handheld Multiparameter Probe Operation Guide

Appendix C

Ramboll Pre-Work JSA for Environmental Investigations

Stantec Health, Safety, Security, and Environment Safe Work Practice – Water and Boat Safety, SWP-513

Appendix D

NYSDEC Standard Operating Procedures

- SOP #103: Sampling equipment cleaning. Most Recent ≥ V21.1.
- SOP #101: Sample Handling, Transport, and Chain of Custody. Most Recent ≥ V22.1.
- SOP #203: Collection of Lake Water Quality Samples. Most Recent ≥ V22.1.

Appendix A.

LimnoTech
Water Environment | Scientists Engineers

Central Regional Office
7300 Hudson Blvd, Ste 295
Oakdale, MN 55128
Contact: Dendy Lofton 612-749-7593

Send samples to:

CHAIN OF CUSTODY RECORD

PROJ. NO.	PROJECT NAME:					Sample Matrix [1]	# of Containers	List of Parameters						REMARKS
SAMPLERS: *(Signature)*														
SAMPLE #	DATE (mmddyy)	TIME (0000)	COMP.	GRAB	STATION LOCATION									

Relinquished by: *(Signature)*	DATE	TIME	Received by: *(Signature)*	Shipping Carrier:		
Relinquished by: *(Signature)*	DATE	TIME	Received by: *(Signature)*	Tracking #:		
Relinquished by: *(Signature)*	DATE	TIME	Received by: *(Signature)*	DATE	TIME	TurnaroundTime:

[1] W=Water, S=Sediment, So=Soil