# Quality Assurance Project Plan
# Canandaigua Lake Monitoring Program

## May 2019

Canandaigua Lake Watershed Council and Ontario County

Prepared by:

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**Agency:** **Canandaigua Lake Watershed Council**
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### QAPP Update Log

| Prepared/Revised By: | Date: | Revision No: | Summary of Changes: |
|---|---|---|---|
| Kevin Olvany | May 17, 2019 | 0 | original |

*This document was prepared to provide a quality assurance/quality control framework for water quality data collected from the FLLOWPA Program. This document guides NYSDEC employees who manage this program to ensure that the data collected are of suitable quality to meet minimum NYSDEC QA criteria so that data may be used to augment NYSDEC data sets. Separate QAPP documents are produced by each Project Manager and must satisfy the requirements of this document. All questions and comments concerning this document should be forwarded to Aimee Clinkhammer, Division of Water, Finger Lakes Watershed Hub, NYS Department of Environmental Conservation, 615 Erie Blvd West, Syracuse, NY 13204.*

*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).*

# Introduction/Abstract

This Quality Assurance Project Plan has been prepared to meet the Quality Assurance/Quality Control requirements for the Canandaigua Lake Monitoring Program. This project is a continuation of a long-term monitoring program that has been conducted for the last 20+ years to assess the health of the lake over time. Our monitoring program also periodically expands to include parameters that address new and emerging threats to the lake.

This document was prepared to provide a quality assurance/quality control framework for FLLOWPA projects. This document guides the FLLOWPA Project Manager and key personnel to ensure that the quality assurance documentation is of sufficient quality to meet minimum NYSDEC QA criteria to support data usability determinations by the end users. This QAPP documents the project goals and objectives, standard operating procedures, sampling methods, data review and evaluation procedures, and QC methods that will be used in the data collection process.

# A. Project Management

## A1. Approval Signatures

sign here ____________________ 6/27/19
Date

**Project Manager**
**Kevin Olvany, Canandaigua Lake Watershed Council**

sign here ____________________ 7/02/19
Date

**FLLOWPA Coordinator, Kristy LaManche**
**Finger Lakes Lake Ontario Watershed Protection Alliance**

sign here ____________________ 6/19/19
Date

**FLLOWPA Program Manager, Aimee Clinkhammer, Division of Water, Finger Lakes Watershed Hub, NYSDEC**

sign here ____________________ 5-30-19
Date

**FLLOWPA Quality Assurance Manager, Anthony Prestigiacomo, Division of Water, Finger Lakes Watershed Hub, NYSDEC**

sign here ____________________ 12/12/19
Date

**Laboratory Manager**
**David Prichard, Life Science Laboratories, Inc.**

This QAPP will be *accepted* by NYSDEC Division of Water, Quality Assurance Officer (QAO) or their designee before work will begin on this project.

## A2. Table of Contents



## A3. Distribution List

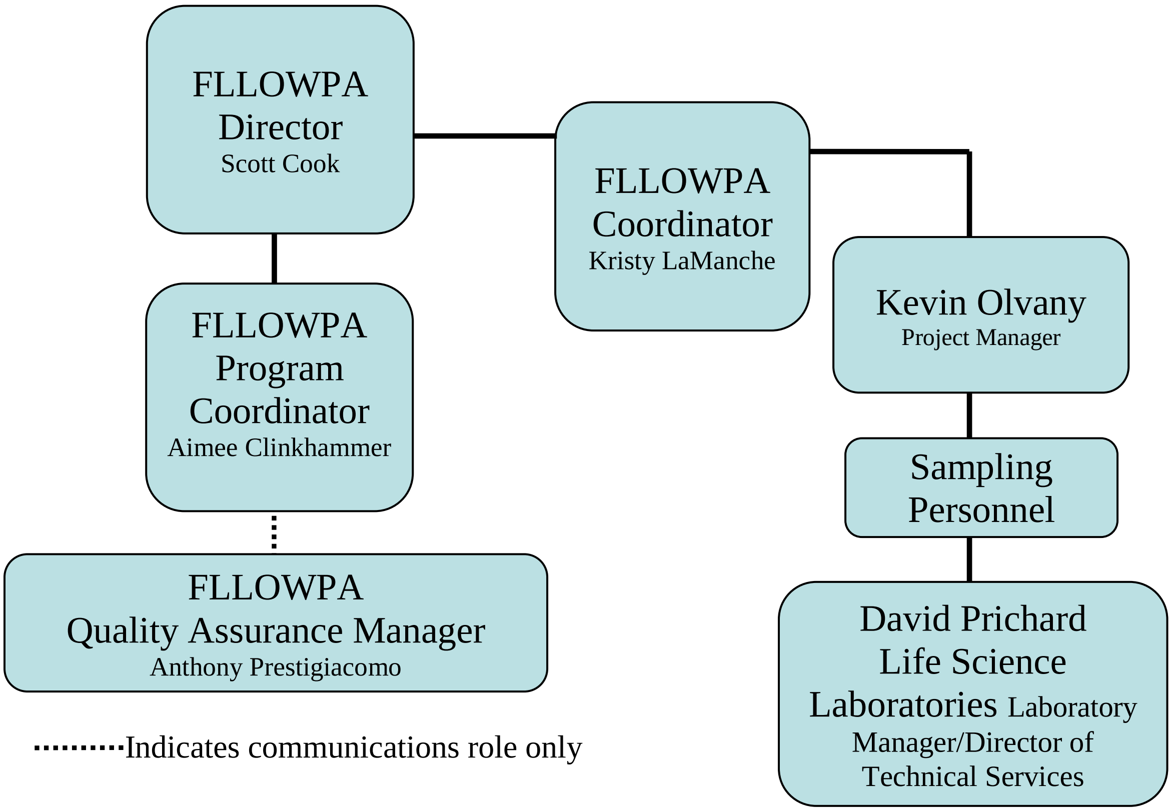
The following individuals must receive a copy of the ***accepted*** QAPP to complete their role in this project. Copies will be distributed electronically, and all sampling personnel will keep a hard copy in sampling vehicles. Project planning involved data users and technical staff. Changes to planning and project documents will receive technical and management review by the Project Manager.

| Title | Name | Organization | Email | |
|---|---|---|---|---|
| FLLOWPA Coordinator (FC) | Kristy LaManche | FLLOWPA | | Electronic |
| Project Manager (PM) | Kevin Olvany | Canandaigua Lake Watershed Council | Kevin.olvany@canandaiguanewyork.gov | Hardcopy/electronic |
| Additional key personnel: | Patricia Thompson | Finger Lakes Community College | Patricia.thompson@flcc.edu | Hardcopy/electronic |
| | Lisa Cleckner | Finger Lakes Institute | cleckner@hws.edu | Hardcopy/electronic |
| | Kimberly McGarry | Canandaigua Lake Watershed Council | kmcgarry@canandaiguanewyork.gov | Electronic |
| Laboratory Manager/Director of Technical Services | David Prichard | Life Science Laboratories, Inc (ELAP # 10248) | pricharddj@lsl-inc.com | Hardcopy/electronic |
| FLLOWPA Program Manager (NFPM) | Aimee Clinkhammer | NYSDEC | aimee.clinkhammer@dec.ny.gov | Electronic |
| FLLOWPA Program Director (NFPD) | Scott Cook | NYSDEC | scott.cook@dec.ny.gov | Electronic |
| FLLOWPA Quality Assurance Manager (QAM) | Anthony Prestigiacomo | NYSDEC | anthony.prestigiacomo@dec.ny.gov | Electronic |
| NYSDEC Quality Assurance Officer | Rose Ann Garry | NYSDEC | roseann.garry@dec.ny.gov | Electronic |

## A4. Program Management / Organization

The following outline describes the responsibilities and roles of staff who actively participate in this project and its oversight:

**Figure 1.** Organization Chart



***New York State Department of Environmental Conservation***

**Aimee Clinkhammer**
**Title/Affiliation:** FLLOWPA Program Coordinator (PM)
**Address:** 615 Erie Blvd West, Syracuse, NY 13204
**Phone No.:** (315) 426-7507
**E-mail:** aimee.clinkhammer@dec.ny.gov
**Responsibilities:**

- develop the FLLOWPA Quality Assurance Management Plan (QAMP) with the FLLOWPA QAM.
- provide relevant SOPs and training materials to FLLOWPA participants
- review water quality and quality control data results for adherence to project QAPPs in coordination with the FLLOWPA QAM.
- work with FLLOWPA PD and QAM and FLLOWPA Coordinator to conduct DEC program reviews and implement modifications
- disseminate FLLOWPA data sets to NYSDEC Water Assessment and Implementation Section for use in Consolidated Assessment Listing Methodology (CALM) and Priority Waterbody List/Waterbody Inventory (PWL/WI) evaluation

**Scott Cook**
**Title/Affiliation:** FLLOWPA Program Director (PD)
**Address:** 615 Erie Blvd West, Syracuse, NY 13204
**Phone No.:** (315) 426-7502
**E-mail:** scott.cook@dec.ny.gov
**Responsibilities:**

- oversee Program Administration
- review FLLOWPA Member County Workplans
- manage Quality Assurance and Quality Control Measures

**Anthony Prestigiacomo**
**Title/Affiliation:** FLLOWPA Quality Assurance Manager (QAM)
**Address:** 615 Erie Blvd West, Syracuse, NY 13204
**Phone No.:** (315) 426-7452
**E-mail:** anthony.prestigiacomo@dec.ny.gov
**Responsibilities:**

- provide technical assistance to FNPM and FNPD in reviewing and approving QAPPs
- provide technical guidance on the approval of member county workplans and amendments

**Lewis McCaffrey**
**Title/Affiliation:** NYSDEC Technical Coordinator
**Address:** 615 Erie Blvd West, Syracuse, NY 13204

**Phone No.:** (315) 426-7514
**E-mail:** lewis.mccaffrey@dec.ny.gov
**Responsibilities:**
- provide technical guidance on the approval of member county workplans and amendments

**<u>Rose Ann Garry</u>**
**Title/Affiliation:** Quality Assurance Officer (QAO), NYSDEC Division of Water Standards and Analytical Support Section
**Address:** 625 Broadway, Albany, New York 12233-0001
**Phone No.:** (518) 402 - 8159
**E-mail:** roseann.garry@dec.ny.gov
**Responsibilities:**
- oversee Division of Water Quality Assurance activities, and is not subject to the authority of any persons connected to the project, provide expertise regarding analytical and QA/QC Issues
- review the QAMP to verify that those elements outlined in the EPA Requirements for QA Project Plans (QA/R-5) are successfully discussed

***Finger Lakes-Lake Ontario Watershed Alliance (FLLOWPA)***

**<u>Kristy LaManche</u>**
**Title/Affiliation:** FLLOWPA Coordinator (FC)
**Address:** Water Resources Board, Oswego County Soil and Water Conservation District; 3105 NY-3, Fulton, NY 13069
**Phone No.:** (315) 673-7148
**E-mail:** klama3481@gmail.com
**Responsibilities:**
- Coordinate participation logistics of FLLOWPA member counties
- Review and keep record of all submitted QAPPs from member counties
- Review data and usability submissions from FLLOWPA partners, submit FLLOWPA data to FLLOWPA Program Coordinator

***Canandaigua Lake Watershed Council***

**<u>Kevin Olvany</u>**
**Title/Affiliation:** Project manager and Watershed Program Manager at the Canandaigua Lake Watershed Council
**Address:** 205 Saltonstall Street, Canandaigua, NY 14424
**Phone No.:** (585) 396-3630
**E-mail:** Kevin.olvany@canandaiguanewyork.gov
**Responsibilities:**
- planning, coordination, and oversight of the project including sampling strategy and overall monitoring network design, including sampling site location, parameter selection, and sampling frequency
- supervision of field samplers including occasional and appropriate program reviews and implement modifications to enhance monitoring effort as necessary

- coordinate sampling logistics (including paperwork) between sampling staff and the analytic laboratories

**Patricia Thompson**
**Title/Affiliation:** Instructor of Environmental Conservation at Finger Lakes Community College
**Address:** 3325 Marvin Sands Road, Canandaigua, NY 14424
**Phone No.:** (585) 785-1645
**E-mail:** Patricia.thompson@flcc.edu
**Responsibilities:**
- receive and maintain all equipment, supplies, and materials; contact the Project Manager to report equipment breakage, supplies shortages, or other problems and deliver samples to analytical laboratory
- collect all water quality and field data in accordance with sampling design and approved methods
- conduct chlorophyll *a* analysis according to methodology

**Lisa Cleckner**
**Title/Affiliation:** FLI Director, Finger Lakes Institute
**Address:** 601 South Main Street, Geneva, NY 14456
**Phone No.:** (315) 781-4381
**E-mail:** cleckner@hws.edu
**Responsibilities:**
- oversees field technicians collecting field data using the Fluoroprobe
- ensures all data is collected in accordance with sampling design and approved methods

***Life Science Laboratories, Inc***

**David Prichard**
**Title/Affiliation:** Laboratory Manager, **Director of Technical Services, Life Science Laboratories, Inc., NYSDOH ELAP certification number 10248**
**Address:** 5854 Butternut Drive, East Syracuse, NY 13057
**Phone No.:** (315) 445-1900
**E-mail:** pricharddj@lsl-inc.com
**Responsibilities:** maintenance of NYS DOHELAP certification and all associated activities (NY Laboratory ID No. **10248**; EPA Laboratory Code NY01042)
- oversee laboratory analyses and for quality control requirements, procedures and completing required documentation
- oversight of all laboratory staff and their activities
- routine laboratory data reporting of analytical results

## A5. Background – Description of Problem

The goal of Canandaigua Lake Monitoring Project is to provide an annual assessment and long-term analysis of the lake's health. The project is a continuation of our long-term monitoring program that has been conducted on the lake for the last 20+ years. Our program consists of monthly sampling from spring through fall at 6 locations on the lake representing various lake conditions- 2 in mid-lake open water areas, 2 in the near shore area near tributaries and 2 in the near shore area further from the influence of tributaries. We focus on key indicators of lake health, including temperature, dissolved oxygen, pH, conductivity, Secchi disk depth, chlorophyll *a*, and nutrients. This long-term dataset has been key to evaluating potential causes of harmful algae blooms, impacts of land use change on water quality, and the influence of invasive species on lake health. The data is also used to inform the public and local municipal officials on the overall water quality of the lake and is used to conjunction with the 2014 Comprehensive Update to the Canandaigua Lake Watershed Management Plan to identify potential water quality projects.

Canandaigua Lake experienced its first large harmful algae bloom in 2015 and has had blooms of varying degree in every subsequent year. Our monitoring program has expanded to better understand harmful algae dynamics on the lake and potential causes of blooms. In 2018, the lake monitoring program expanded to include additional near shore samples for nutrient analysis to assess the role of nutrients on harmful algae blooms. We also began collecting blue green algae cell counts in the open water areas using a YSI probe as an early indicator for potential blooms. Beginning in 2019, the Finger Lakes Institute will partner with the Canandaigua Lake Watershed Council to monitor blue green algae concentrations throughout the water column using a Fluoroprobe. The Watershed Council also plans to purchase a bbe AlgaeTorch in 2019 to further monitor harmful algae dynamics. Recent research across the Finger Lakes has shown the potential influence of seiches on harmful algae, so we plan to install a thermistor array in 2019 to continuously monitor the temperature profile in the lake. Our monitoring program will continue to monitor harmful algae and potential contributing factors to aid in understanding causes and potential solutions.

The primary objectives of this sampling project are to:

1. Satisfy quality assurance requirements through the completion of this QAPP and the adherence to NYSDEC ***accepted*** sampling methods, sample handling, and data management protocols. This will allow the resulting data to be used for multiple purposes within and external to the NYSDEC.
2. Provide assessment and quantification of water quality conditions, based on the collection of sufficient data and information in the lake.

The secondary objectives of this sampling project are to:

1. Collect coincident field measurements, such as temperature, conductivity, pH, dissolved oxygen and blue green algae cell counts, to provide additional data for lake assessment.

## A6. Project/Task Description

Our monitoring program will continue to assess lake health through our 6 long-term monitoring sites. These sites were selected 20+ years ago to intentionally represent a range of conditions on the lake, including mid-lake open water conditions (DR and SP), near shore conditions associated the mouths of tributaries (WR and FB), and near shore conditions further from the influence of tributaries (VV and HP). Through these 6 monitoring locations, we have incorporated some replication while sample collection is still logistically feasible. Monitoring at these 6 sites contributes additional data to the long-term dataset to analyze trends in water quality and assess overall lake health.

Lake monitoring will be conducted one day each month to capture general seasonal variations in lake water quality, typically from May to October but with the option to include April and November. Whenever possible, lake monitoring will be conducted during clear weather conditions and from mid- to late morning to reduce time of day as a variable.

Over the last 3 to 4 years, our northeast near shore site (FB-2) showed consistent elevated phosphorus levels. To further analyze in-lake factors contributing to blue green algae blooms, ten additional near-shore samples were taken in 2018 and analyzed for phosphorus to see if elevated phosphorus levels are observed elsewhere. We will continue this program in 2019. However, near shore sampling locations may be amended to reflect current lake conditions or concerns by watershed staff. These extra near shore samples will be collected during the summer months in conjunction with the long-term monitoring program.

Samples will be collected through a partnership between the Canandaigua Lake Watershed Council and Finger Lakes Community College, who have been involved in the lake monitoring program for 20+ years. Sites to be sampled are listed in Table 1, with the schedule provided in Table 2. Chemistry samples and field data will be collected, documented, handled, and shipped to an NYSDOH ELAP-certified laboratory for analysis as per the "Quality Assurance Management Plan for the Finger Lakes-Lake Ontario Watershed Protection Alliance (FLLOWPA)" in Table 1. Samples will be analyzed for chlorophyll *a*, which is not a certified parameter, by Finger Lakes Community College. In addition, a Yellow Springs Instrument 6920V2 water quality sonde and a 650 data logger will be utilized for in-situ monitoring at the open water sites for dissolved oxygen, temperature, water pH, conductivity, % oxygen saturation, and blue green algae cell count.

The monitoring program has expanded in recent years due to the emergence of harmful algae blooms on the lake. Beginning in 2019, the Watershed Council and Association are partnering with the Finger Lakes Institute to field monitor harmful algae concentrations using a Fluoroprobe. The Watershed Council also plans to purchase a bbe AlgaeTorch to further increase monitoring of harmful algae dynamics. The Fluoroprobe and AlgaeTorch both have the ability to collect profile data and use the same technology, so these instruments will be used in combination to collect data at various depths to better understand harmful algae dynamics throughout the water column. This monitoring will take place throughout the lake, but an emphasis will be placed on water depths and locations correlated with private water supply intakes. The baseline plan is to collect data on a weekly basis during the late summer and early fall, with additional work by the AlgaeTorch. However, the exact dates, frequency and locations for in-lake Fluoroprobe and AlgaeTorch monitoring will reflect current conditions and concerns based on the Watershed Program Manager's assessment. The Fluoroprobe and AlgaeTorch will be calibrated, maintained and utilized per the manufacturer's instructions.

Recent research has shown the potential influence of seiches on harmful algae blooms. In 2019, we will begin collecting continuous temperature profile data using a thermistor array developed by Karl Hanafin of Intelilake.com. It will monitor temperature at 1-meter intervals from the bottom of the lake to approximately 5 meters below the water surface at 15 minute intervals. We are working with a shoreline property owner with a logistically feasible site (needs a power source and wifi on the shoreline and appropriate shoreline depth) located approximately 100 yards south of the City's Water Treatment Plant. The thermistor array will be installed in approximately 75 to 80 feet of water depth approximately 800 to 900 feet from shore. The thermistor array will be anchored to the bottom of the lake, so the depth from the surface will fluctuate with the minor summer changes (< 1-foot range) in lake level.

Sites to be sampled are listed in Table 1, with the schedule provided in Table 2.

Table 1. Proposed Sampling Locations, Justifications, and Data collection

| **Site Code** | **Sampling Location** | **GPS Coordinates** | | **Sample Justification** | **Field Measurements** | **Water Chemistry[1]** |
|---|---|---|---|---|---|---|
| | | **North** | **West** | | | |
| WR | West River | 42.670 | -77.359 | Long term sampling location in the lake near the mouth of a significant tributary, West River<br><br>To assess the impact of the largest subwatershed on lake quality | | nutrients - grab sample at 2 m;<br><br>chlorophyll *a* - vertically integrated sample |
| FB | Fall Brook | 42.870 | -77.258 | Long term sampling location in the lake near the mouth of a significant tributary, Fall Brook<br><br>To assess the impact of a significant tributary on lake quality | | nutrients - grab sample at 2 m;<br><br>chlorophyll *a* - vertically integrated sample |
| VV | Vine Valley | 42.723 | -77.329 | Long term sampling location in the near shore area further from the influence of tributaries<br><br>To assess general shoreline conditions | | nutrients - grab sample at 2 m;<br><br>chlorophyll *a* - vertically integrated sample |
| HP | Hope Point | 42.843 | -77.280 | Long term sampling location in the near shore area further from the influence of tributaries | | nutrients - grab sample at 2 m; |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | To assess general shoreline conditions | | chlorophyll *a* - vertically integrated sample |
| SP | Seneca Point | 42.741 | -77.331 | Long term sampling location in mid-lake open water<br><br>To assess open water conditions and understand extent of vertical water quality variability and lake stratification | Multiprobe - Collect at 1 m intervals from surface to 15 m (or lower if necessary), then 5 m intervals from 15 m to the maximum potential depth of 55 m - dissolved oxygen, temperature, conductivity, % oxygen saturation, blue green algae cell count<br><br>Secchi depth | nutrients - grab sample at 2, 25 & 50 m;<br><br>chlorophyll *a* - vertically integrated sample |
| DR | Deep Run | 42.819 | -77.273 | Long term sampling location in mid-lake open water<br><br>To assess open water conditions and understand extent of vertical water quality variability and lake stratification | Multiprobe - Collect at 1 m intervals from surface to 15 m (or lower if necessary), then 5 m intervals from 15 m to the maximum potential depth of 55 m - dissolved oxygen, temperature, conductivity, % oxygen saturation, blue green algae cell count<br><br>Secchi depth | nutrients - grab sample at 2, 25 & 50 m;<br><br>chlorophyll a - vertically integrated sample |
| See map of potential locations | Near shore areas – exact locations will be determined based on conditions | | | To assess nutrient concentrations in the near shore area to determine if elevated concentrations are found along the shoreline and could potentially contribute to harmful algae blooms | | nutrients - grab sample at 2 m |

| | | | | | | |
|---|---|---|---|---|---|---|
| | ~ 100 yards south of the City's Water Treatment Plant | | | To assess temperature dynamics in the water column, including thermocline depth and seiches | Thermistor array from lake bottom to ~15 feet below lake surface | |
| | To be determined based on lake conditions | | | To assess harmful algae dynamics throughout the water column | Fluoroprobe and AlgaeTorch profile | |

The Project Manager and partners have experience performing all required field data collection procedures and will ensure that all Sampling Personnel are trained in the skills needed to complete this project. For more information, see Section A8.

**Table 2: Project Schedule**

| **Task** | **Anticipated Completion Date** |
|---|---|
| QAPP Completion and Approval | May initially- every 5 years after 2019 or as the monitoring program changes |
| Sample Collection Commencement | Data collection for this project will begin after only the final approval of this Quality Assurance Project Plan.<br><br>Anticipate sampling in late May 2019 to continue long term dataset |
| Sample Collection End | December 10 each year |
| Data and Final Report Submitted | February 1 each year |

The FLLOWPA Program provides approximately $10,000 towards lake and tributary monitoring on Canandaigua Lake. The Canandaigua Lake Watershed Council, along with additional funding sources, also provide financial support to the monitoring program. The Canandaigua Lake Watershed Council also provides significant staff time towards the monitoring program.

## A7. Quality Objectives and Criteria

The overall quality assurance objective is to develop and implement field and sampling procedures that are of known and documented quality. The contract lab, **Life Science Laboratory, Inc., NYSDOH ELAP Certification Number 10248** has developed and implemented quality control procedures on laboratory samples for certified parameters that will be applied to this study. Data Quality Objectives (DQOs; Table 3) are used as qualitative and quantitative descriptors in interpreting the degree of acceptability or utility of data. The DQOs listed are sufficient to confirm that the type and quality of data being used in this project are obtained and will support project validation/verification (Section D). While unforeseen now, any limitations on the use of the data collected as part of this project will be identified and documented.

These data quality requirements are consistent with those used in other water quality monitoring programs conducted by the NYSDEC, other state agencies and non-government partners, and are consistent with requirements provided by USEPA. These also satisfy the data requirements associated with the state water quality standards, 6 NYCRR Part 703.

**Table 3:** Data Quality Objectives and Assessments

| **Data Quality Objective (DQOs)** | **Description** | **Assessment (calculation)** | **Acceptability Criteria** |
|---|---|---|---|
| *Precision* | the degree in which two measurements agree | Relative Percent Difference (RPD) | **RPD ≤ 20%** |
| *Accuracy/bias* | the degree of agreement between a sample and a true value or an accepted reference | 1. Field blanks<br>2. Matrix spikes (MS)<br>3. Laboratory control samples (LCS) | **All FB samples ≤ LOQ** |
| *Representativeness* | degree to which samples accurately and precisely represent environmental conditions | 1. Site selection criteria used matches project goals.<br>2. Relative Percent Difference (RPD). | **RPD ≤ 20%** |
| *Completeness* | the number of valid measurements taken from the number of total measurements taken in the entire project | verified from data sampling plan, data deliverables and completed COC | **Completeness ≥ 90 %** |
| *Comparability* | confidence with which one set of data can be compared to another | comparison of two data sets | Adherence to QAPP and standard analytical methods, holding times, consistent detection limits, common units and consistent rules for reporting |

| Data Quality Objective (DQOs) | Description | Assessment (calculation) | Acceptability Criteria |
|---|---|---|---|
| *Detection/ Quantification* | Levels of Detection (LOD) and quantification (LOQ) for a specific method and matrix | For methods with no published detection limit, Laboratory calculated LOD/LOQ are used. | Acceptable criteria can be found in 2016 EPA Method detection limit procedure, revision 2. |

Section B5 describe DQO calculation procedures.

## A8 Training Requirements/Certifications

The Program Manager will ensure that all individuals involved with the project receive and are familiar with this QAPP and to the relevant standard operating procedures, to ensure proper adherence to sampling procedures prior to the start of work. The Program Manager and professionals from FLCC and FLI have extensive experience with sampling and field data collection. They have been collecting lake data for many years and do not require any additional training to continue this project.

Training is the responsibility of the Project Manager and is required for all new field staff involved in the current project to ensure the proper collection and handling of samples. Training of field staff will include a review of sampling methodology by the Project Manager or appropriate professional. Training of individuals employed by contract laboratories for processing water samples is the responsibility of the contract laboratories and must be done according to their procedures.

Effective communication will be critical, to discuss any problems that arise with sampling procedures or equipment. In order to solve problems during the sampling season, the Project Manager will contact the NYSDEC FLLOWPA Program Coordinator, Aimee Clinkhammer through email (aimme.clinkhammer@dec.ny.gov). Communication will be conducted as needed, to make sure equipment is performing properly and to discuss any other issues.

**Health and Safety**

Safety is more important than the task. If for any reason conditions at the monitoring site are considered unsafe as determined by the field staff, sampling will be suspended, and the staff will leave the site. The following points should be considered when collecting samples.

*Cautions*

1. Staff will provide the Project Manager adequate notice of sampling times and contact information (i.e., cell phone numbers of samplers),
2. Always work with at least one partner,
3. Never boat in unsafe conditions,
4. Be aware of other boaters or people recreating on the lake,
5. Wear and maintain personal protective equipment (PPE) to prevent hypothermia, heat exhaustion, sunstroke, drowning, insect bites, or other dangers,

6. Never eat and/or drink when collecting and handling samples,
7. Always wash hands before and after collecting and handling samples,
8. Cover all personal cuts and abrasions before sampling,
9. Be fully aware of all lines of communication that address emergency and safety situations.

## A9. Documentation and Records

### FLLOWPA Project QAPP

- This QAPP must be ***accepted*** by all parties listed on the Approval page before work may begin. ***Accepted*** QAPPs are added as electronic pdf documents to workplans,
- ***Accepted*** QAPPs may be updated to reflect changes in the project. The revised QAPP must have a new version # recorded, approved and sent to all individuals on the distribution list,
- Any changes to a Project QAPP after it is finalized are approved are recorded as a new version #.

**Site Locations and Codes**

Sample sites selected for this project by the Project Manager and Finger Lakes Community College include the 6 long-term sites on Canandaigua Lake where monitoring has been conducted for the last 20+ years. Additional near shore sites will be monitored during the summer months for nutrients and their locations will be selected by the Project Manager based on water quality concerns and current conditions on Canandaigua Lake. The Fluoroprobe and AlgeTorch sampling sites will be based on current conditions and will be selected by the Project Manager and FLI staff. The thermistor array will be installed approximately 100 yards south of the City's Water Treatment Plant where electricity and wifi are available on shore and in an area with 75 to 80 feet of water depth. Individual sites and justifications are presented in Table 1. The analytes to be determined from samples taken at these sites are those needed to further the project objectives.

Site Codes must follow the following format:

for example, a sample collected on June 1, 2019 from Deep Lake in Niagara county:

(e.g., 20190601_FONTA_Deep-WS)

yyyymmdd_Fcccc_sssss-WS

| | |
|---|---|
| yyyy | four-digit year |
| mm | two-digit month |
| dd | two-digit day |
| F | abbreviation for FLLOWPA |
| cccc | four letter abbreviation for County |
| sssss | five letter code for Site name |
| WS | indicates a water sample |
| QC | Quality Control sample-duplicate |
| B | Blank |

**Analytical Laboratory Results for Water**

A record of the sample collection will be kept on laboratory Chain of Custody (CoC) forms which will be completed during sample collection and relinquished to the laboratory upon sample submittal. CoCs contain all information required to reconstruct the origination of each sample. Data packages from the contract lab will be delivered to the Project Manager, in accordance with the requirements of this QAPP and the contract laboratory's standard operating procedure. As per requirements, the "official" laboratory data reports to project partners will be in electronic form (submitted as a PDF). Data will be transcribed to Excel and both pdfs and Excel formats will be submitted to FLLOWPA and NYSDEC. Laboratory data reports will include all analyses, calibration, lab QC, and any corrective actions. An example of a CoC is provided in the Appendix. Complete data packages are required to provide data validation capability. Data packages are delivered to the FLLOWPA Coordinator.

**Field Results**

Field data generated in this project will be recorded on field sheets. Within 72 hours of completion of the sampling day, Finger Lakes Community College will transfer field data into spreadsheets featuring the long-term dataset. The field data will be relinquished to the Project Manager as requested during the field season. At the end of the field season, Finger Lakes Community College will provide the Watershed Council with an electronic version of the long-term dataset, including the current field season and documentation of field comments.

Field data collected on the Fluoroprobe must be downloaded onto a computer. Finger Lakes Institute will download data within 24 hours of data collection and will transfer field notes into an electronic format. The output files will be relinquished to the Project Manager as requested. An electronic copy of the fluoroprobe output will be stored at the Watershed Council. The AlgaeTorch data will be downloaded by the Watershed Council within 24 hours of data collection and will be stored at the Watershed Council.

Thermistor array data must be downloaded onto a computer. The Watershed Council will store output files and will transfer any field notes into an electronic format.

**Report format/information**

All results will be summarized in a final report to be prepared by the Project Manager, Finger Lakes Community College and Finger Lakes Institute in the form of a powerpoint presentation. The final report will include all field and laboratory QA/QC results analyzed during this study. An evaluation of how QA/QC objectives were or were not met will be included in the final report. The final report will include a summary and discussion of analytical results for those parameters included in Tables 4. The final report will be made available electronically to the Project Quality Assurance Officer for independent review to ensure data meet stated (and acceptable) quality requirements. Hard copies of this report will be made available upon request.

**Document/record control**

The Project Manager is responsible for preparation, maintenance, updates, and distribution of this QAPP. The FLLOWPA Coordinator has ultimate responsibility for all changes to records and documents whether handwritten or electronic. Field documents and laboratory COCs will be recorded in indelible ink **immediately after sample collection**, and changes to such data records will be made by drawing a single line through the error and initialed by the responsible person. At the end of the project, all field and laboratory results generated as part of tasks listed in Section A6 will be reported to the Project Manager for dissemination to various stakeholders and partners. Other technical memoranda may be written and distributed as needed during the project (typically transmitted to project partners by e-mail). All deliverables for this project (for example: summary report, PowerPoint presentation, data report) will be submitted in electronic format to project partners).

**Storage of project information**

Field data collected will be entered into Excel workbooks and stored on the Project Manager's computer. All hardcopies of field documents will be stored at the organization responsible for collecting data, which includes the Watershed Council, Finger Lakes Community College, and Finger Lakes Institute. Hardcopy laboratory records will be put into project notebooks at the Canandaigua Lake Watershed Council. All field data and laboratory data and reports and electronic data will remain secure on password protected computer for **at least five years** after the completion of the project. If hardcopy documents must be destroyed, disposition will be by shredding. The Project Manager and the FLLOWPA Coordinator shall retain copies of all management reports, memoranda, and all correspondence between NYSDEC as identified in Section A4. Records of written correspondence, internal notes, e-mails and communications between the team members and other project members will be kept for a **minimum of five years** as required by the project reporting requirements.

This QAPP is an FLLOWPA controlled-document. Revised releases will be made known by an increment in revision number. After approval by the appropriate persons, the revised QAPP will be sent to each person on the distribution list. The Project Manager is responsible for preparation, maintenance, updates, and distribution of this QAPP. Data generated through FLLOWPA must be reviewed and consented by NYSDEC prior to its distribution or publication. Interim data may be presented to the public prior to NYSDEC consent during the field season in response to water quality inquiries from the public or for educational purposes but must be qualified as interim.

# B. Data Generation and Acquisition

## B1. Sampling Process / Experimental Design

This project will collect data at 6 long-term sampling sites representing a range of lake conditions, including open water, near shores areas associated with tributaries, and near shore areas further from the influence of tributaries.  These sites have been monitored for 20+ years and continuation at these sites is essential for understanding long-term trends in water quality and assessing lake health. Sampling will occur monthly from May through October, with the possibility to include April and November based on lake conditions.

At all of the 6 long-term sampling locations, we will collect a grab sample for nutrients at 2 meters using a Van Dorn sampler and a vertically integrated sample through the photic zone for chlorophyll *a* using flexible tubing. The open water sites will have additional grab samples for nutrients at 25 meters and 50 meters using the Van Dorn sampler. In addition, a Yellow Springs Instrument 6920V2 water quality sonde and a 650 data logger are utilized for in-situ monitoring at the open water sites for dissolved oxygen, temperature, water pH, conductivity, specific conductance, % oxygen saturation, and blue green algae cell count. The YSI data will be collected at 1-meter intervals from the surface to 15 meters (or lower if the thermocline drops below 15 meters), and then at 5-meter intervals from 15 meters to the maximum potential depth of 55 meters.

This project will also collect samples at additional near shore sites to further understand nutrient dynamics that may contribute to harmful algae blooms. The extra near shore samples will be collected as part of the monthly sampling program during summer months based on lake conditions. The samples will include grab samples collected with a Van Dorn sampler at 2 meter depth and analyzed for nutrients.

Samples for laboratory analyses at select locations and depths (Table 1) will be collected with a Van Dorn sampler at the designated locations over the project interval (Table 2). Chemistry samples that are deemed critical (quantitative) analyses are presented in Section B4 (Table 4). Field QC samples will be discussed further in Section B5.

To further understand harmful algae dynamics, a Fluoroprobe and AlgaeTorch will be utilized to collect harmful algae profile data. The basic plan is to collect data weekly with the Fluoroprobe from late summer through early fall and to collect additional data using the AlgaeTorch. However, the exact dates, locations and frequency will be based on lake conditions. Because harmful algae concentrates and disperses quickly, site locations will be selected to represent a range of conditions, such as worst case scenario dense blooms to dots in the water column. The monitoring will occur at numerous locations and depths throughout the lake. The monitoring will also focus on water depths and locations that correlate with private water intakes to better understand potential risk to private water supplies.

Recent research has shown that seiches and lake temperature dynamics may influence harmful algae blooms. A thermistor array will be installed in the lake at approximately 75 to 80 feet of water depth to capture these dynamics. The thermistor array will collect temperature data every meter from the bottom of the lake to approximately 5 meters below the lake surface. The thermistor array is anchored to the bottom of the lake, so the exact distance below the surface will change with the minor fluctuations in lake level. Temperature will be collected at approximately 15 minute increments. The data will be available in real-time, as it will be sent via wifi to Karl Hanafin's website and will be accessed by the Watershed Council.

## B2. Sampling Methods

Sampling methods for water chemistry collections and field measurements are consistent with standard water quality investigation techniques. The specific methods used for this project are discussed below.

**Bottle Preparation and Labeling**

Pre-cleaned bottles will be provided by the contract laboratory prior to each sampling event. These bottles will be stored in a cooler in a location free from dust, water, or other potential contamination. Sample bottles will be waterproof, legible, and labeled in permanent marker or indelible ink with information required to properly identify the sample location (yyyymmdd_Fcccc_sssss-WS). Minimum information to be provided with allow the sample to be paired with its record on the event Chain of Custody.

*Bottle Labeling*

1. Sample ID (yyyymmdd_Fcccc_sssss-WS)
2. Sampling time (in military time) rounded to the nearest 10-minute mark,
3. Analytes to be measured,
4. Apply the label to the sample bottle, not to the sample bottle cap

**Water Sample Collection**

Samples will be collected in an accurate, representative, and consistent manner following standard water quality investigation techniques. Chemistry samples will be collected at 2 meter depth, with additional samples at 25 and 50 meter depths in the open water monitoring sites. Field equipment will be maintained as per NYSDEC SOPs 211-19 “Use, Calibration, Maintenance and Storage of multi-probe meters used to measure water quality parameters” and 103-19 “Equipment Decontamination/Cleaning”. A summary of the methods used for this project are provided below.

The following steps should be followed for all types of samples prior to sample collection: (1) verify what, if any, field processing requirements are needed for the constituents to be analyzed, (2) assemble and collect equipment necessary for sample collection, handling and transport, (3) prepare documentation (COC, field sheets) pertaining to sample collection, handling, and transport, (4) pre-label collection bottles and sample bottles if applicable, (5) establish and maintain a clean working area if applicable, and (6) rinse with ambient water prior to sample collection any collection equipment (e.g., Kemmerer).

*Sample Collection, General*

1. **This QAPP must be *accepted*** before the start of the Project,
2. Sampling personnel must wear new, clean gloves at each sampling location. If gloves become contaminated, they must be replaced,
3. Verify sampling location with GPS or maps. Any deviations from the designated sampling locations or protocol will be made on the field document sheets,

*Equipment Blank Sample Collection*

**To collect an equipment blank, the sampler uses laboratory grade deionized water sent from the laboratory through all the steps and equipment required to collect a water column chemistry sample.**

1. Rinse the sampling device with deionized clean water
2. Fill the sampling device with deionized clean water
3. Uncap the Equipment Blank bottle(s)
4. Pour directly from the device into the sample bottle.
5. Place in cooler on ice and handle in a manner consistent with samples.

*Sample Collection, Direct Grab (NYSDEC SOP#203-19, Section 12.3- Discrete Sampling with Kemmerer Bottles pg. 11)*

1. Using a properly decontaminated Van Dorn sampler, set the pre-calibrated sampling device so that the sampling end stoppers are positioned away from the sampling tube, allowing the sampled substance to easily pass through the tube.
2. Lower the sampling device to the pre-determined depth. Surface samples are collected at a depth of 2 meters. In the open water sites, samples are also taken at 25 meters and 50 meters below the surface, which is as close to the bottom as possible with equipment. Avoid bottom disturbance to prevent sediment introduction into the sample. Any samples with visible suspended sediment must be discarded and the sample must be recollected, unless visual observations of the sampling environment indicate high ambient turbidity.
3. When the Van Dorn sampler is at the required depth, send down the messenger to close the sampling device.
4. Retrieve the sampler and discharge the first 10 to 20 mL of sample to clear any potential contamination on the valve and, if not already fully decontaminated, the compositing container. If suspended sediment is visible in the sample and not in the ambient environment prior to collecting the same, the sample will be discarded and re-collected.
5. Transfer the remaining sample to the appropriate container(s).
6. Record the sample information in the field notebook.
7. The duplicate will be collected in a manner consistent with the parent sample collection (Section B5).

*Water Transparency Measurements with a Secchi Disk (NYSDEC SOP#203-19, Section 12.10- Water Transparency Measurements with a Secchi Disk pg. 16)*

1. A Secchi disk is used to measure water transparency as a surrogate for turbidity in ponded waters. Water clarity can be determined if measured transparency exceeds the water depth at the sampling site and if there is sufficient sunlight to illuminate the water column above the lowered disk.
2. Sampling procedures are as follows:
3. Lower the disk over the shady side of the boat until the disk just disappears from site. Record this depth to the nearest 0.1 meter.
4. Lower the disk one meter below the depth recorded in step 12.10.2.1. Raise the disk until the disk reappears in sight, and record to the nearest 0.1 meter. If this measurement varies from the first measurement by more than 0.5 meters or 10% of the depth in step 12.10.2.1, whichever is greater, repeat step 12.10.2.1 and this step.
5. Determine the reported Secchi disk transparency by computing the average of steps 12.10.2.1 and 12.10.2.2.

**Collection of Field Parameters**

Field data collection

1. Yellow Springs Instrument 6920V2 water quality sonde and a 650 data logger are utilized for in-situ monitoring at the open water sites for dissolved oxygen, temperature, water pH, conductivity, % oxygen saturation, and blue green algae cell count.
2. Lower probe to as deep as it will go (up to 55 meters.)
3. Allow probe to stabilize.
4. Record parameters at each depth on field data sheet, allowing probe to stabilize between each reading.

Fluoroprobe and AlgaeTorch

1. The Fluoroprobe and AlgaeTorch automatically collects data when in water. The probe will be slowly lowered through the water column to collect data at each sampling site.
2. The Fluoroprobe and AlgaeTorch will be used to analyze general dynamics through the water column in a variety of conditions from dense surface blooms to just visible dots. We will collect data from the surface through the thermocline.
3. To analyze the potential risks to private water supplies, the Fluoroprobe and AlageTorch will collect data at the approximate depth of private intakes and locations of private water supplies.

Thermistor Array

1. Data will automatically be collected at approximately 15 minute increments. When the battery gets low, it will automatically change the frequency to every 30 minutes. The unit will attempt to connect to the wifi 10 times. If it cannot connect, the data will not be collected.

**Preparation of data collection instruments**
The YSI multiprobe will be calibrated, maintained and deployed according to the manufacturer's instructions by Finger Lakes Community College. The Fluoroprobe will be calibrated, maintained and deployed according to the manufacturer's instructions by Finger Lakes Institute. The thermistor array will be installed, maintained and deployed according to the manufacturer's instructions by the Watershed Council.

All field instruments will be calibrated, maintained and deployed as per NYSDEC SOP 211-19 "Use, Calibration, Maintenance and Storage of multi-probe meters used to measure water quality parameters".

## B3. Sample Handling / Custody Procedures

Sample handling and custody procedures for this project will be conducted in a manner described by NYSDEC SOP 101-19 "Sample Handling, Transport, and Chain-of-Custody" is summarized below.

*Sample Handling and Storage*

1. Samples will be filled in accordance to the procedures described in Section B2,
2. Samples requiring preservation will be preserved according to the appropriate method (Table 4),

3. After collection, CoCs will be completed. Upon completion, samples will be packed in ice in a clean cooler and stored dark ≤6 °C in the field and then transferred to a refrigerated cooler until delivery to the contract lab,
4. Samples will be delivered to the contract laboratory within the standard method's allowable holding time.

*Chain of Custody and Laboratory Submission*

A COC must be filled out immediately after sample collection and must accompany the sample from collection through analysis and reporting. A sample is considered to be in custody when: (1) it is secured or kept in a safe area to prevent tampering, or (2) it is in one's actual physical possession or view. As few people as possible should handle the sample(s) prior to receipt by laboratory personnel. Whenever sample(s) is/are transferred from one individual's possession to another individual's, the chain-of-custody record form must be signed and dated to record the transfer. Whenever sample(s) is/are transferred to a common carrier, the shipper's copy of the shipping documents should be retained as part of the chain of custody documentation.

COCs are completely and legibly completed by the FLLOWPA participants. Upon arrival at the laboratory, the COC is signed by the laboratory manager. These forms are used to establish an intact continuous record of the physical possession, storage and disposal of collected samples and aliquots. The COC follows each sample that comes into the laboratory for analysis. This is necessary to preserve the traceability of samples and identify individuals who physically handled individual samples through the life cycle of the sample. The sample delivery person should retain a copy of the chain-of-custody record as these will become part of the permanent record and submit the copy to the Project Manager. The chain of custody and laboratory submission form must contain the name, address, and telephone number of the sample collector and should always accompany the sample(s) during transport.

**Data Entry QA procedures**

Entering hand-written field data into the Excel spreadsheets will be completed by the Project Manager, Finger Lakes Community College or Finger Lakes Institute within 72 hours of collection. The Excel spreadsheet will be a continuous record created to include data organized into columns and rows and will contain all pertinent information from the field documentation including: (1) sample date and time, (2) sample location and ID, (3) site conditions and notes, and (4) other field notes. Data will be verified by double checking electronic copies with original field documents. Any suspected errors will be discussed with samplers.

## B4. Analytical Methods

Analytical methods for both field and laboratory analyses are listed in Table 4. Samples will be analyzed at **Life Science Laboratories, Inc (ELAP ID 10248) for all certified parameters.** Chlorophyll *a* samples, which is not a certified parameter, are processed at Finger Lakes Community College's facility using the following procedure:

Samples are stored on ice in a cooler in a one liter plastic dark bottle and are processed the same day they are collected. Samples are filtered using a vacuum flask and filter apparatus fitted with a 0.8 um filter. Filters are dissolved in 10 mL of 90% alkaline acetone in combination with maceration using a glass stir rod. Samples are processed using a PerkinElmer UV/VIS Spectrometer, Lambda XLS unit set to a wavelength of 663 nm. The machine is zeroed before analyzing each sample using a cuvette filled with acetone as a blank.

All final analytical results including QC results will be provided to the Project Manager upon completion of the project by **February 1**.

## B5. Quality Control

An integral part of sample quality is the collection of representative samples, those that accurately describe the characteristics of the waterbody being studied. Collected samples must accurately represent the waterbody and be unaffected by collection procedures, sample preservation, or sample handling. The analytical laboratory is responsible for maintaining internal quality control as a part of their quality assurance and lab QC analyses will be performed on aliquots of the parent sample bottle. Sample results comparability is maintained by use of established site selection, sampling, and analytical methods. To ensure that sampling standards are being met**, blanks and field duplicate samples** are collected as part of water chemistry sampling protocols.

**Table 4:** Parameters, analytical specifications, QA/QC requirements, and laboratories processing samples.

| | | | | | | Calibration | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ***Parameter*** | ***Laboratory*** | ***Method*** | ***Precision*** | ***Accuracy*** | ***Initial*** | ***Ongoing*** | ***Blanks*** | ***Method Detection Limit*** | ***Reporting Limit*** |
| *Field* | *Water Temperature* | *In-situ* | *YSI multiprobe* | *0.01 deg C* | *±0.15 deg C* | *Factory set* | | | *- 5 to 50 deg C* | |
| | *Conductivity* | *In-situ* | *YSI multiprobe* | *0.001 to 0.1 mS/cm* | *±0.5% of reading +0.001 mS/cm* | *1 day before deployment* | | | *0 to 100 mS/cm* | |
| | *pH* | *In-situ* | *YSI multiprobe* | *0.01 5unit* | *±0.2* | *1 day before deployment* | | | *0 to 14* | |
| | *% oxygen saturation* | *In-situ* | *YSI multiprobe* | *0.1%* | *±1% of reading or air saturation* | *1 day before deployment* | | | *0 to 500%* | |
| | *Dissolved oxygen* | *In-situ* | *YSI multiprobe* | *0.01 mg/L* | *±0.1 mg/L or 1% or reading* | *1 day before deployment* | | | *0 to 50 mg/L* | |
| | *Blue-green algae phycocyanin* | *In-situ* | *YSI multiprobe* | *1 cell/mL or 0.1 RFU* | | *1 day before deployment (zero): annually with Rhodamine dye* | | | *0 to 280,000 cells/mL; 0 to 100 RFU* | *~220 cells* |
| | *Blue green algae concentration* | *In-situ* | *Fluoroprobe* | *0.01 µg/L chlorophyll-a* | *0.01 µg/L chlorophyll-a* | *Factory set* | | | *0 to 200 µg/L chlorophyll-a* | *200 µg/L chlorophyll-a* |
| | *Water temperature* | *In-situ* | *Thermistor array* | | *For temp range 0˚C to 30˚C in the mode we are* | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *using without calibration. 3sigma: +0.16˚C/-0.05˚C* | | | | | |
| *Analytical* | *Chlorophyll a* | *Finger Lakes Community College* | *Alkaline acetone method (Wetzel and Likens 1991)* | *± 1 nm* | *± 2 nm* | *Automatic when turned on* | | *Before each sample is analyzed* | *1100 nm* | *190-1100 nm* |
| | | | | | | | | | | |
| | | | | | | | | | | |

The table below outlines parameters, analytical specifications, QA/QC requirements from Life Science Laboratories.

| | Analytical | | | | Calibration | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | Laboratory | Method | Precision Limit (freq=per 20 samples) | LCS Accuracy Limit (freq=per 20 samples) | Calibration Frequency | Initial ICV Accuracy Limit (freq=per day) | Ongoing CCV Accuracy Limit (freq=per 10 samples) | ICB/CCB Limit (freq=per 10 samples) | Method Blank Limit (freq=per 20 samples) | Method Detection Limit | LOQ Reporting Limit |
| Low Level Phosphorus, Total | Life Science Laboratories | EPA 365.3 | 20 RPD | +/-10% | 1 | +/-10% | +/-10% | <0.002 mg/l | <0.002 mg/l | n/a | 0.002 mg/l |
| Low Level Phosphorus, Dissolved | Life Science Laboratories | EPA 365.3 | 20 RPD | +/-10% | 1 | +/-10% | +/-10% | <0.002 mg/l | <0.002 mg/l | n/a | 0.002 mg/l |
| Ammonia | Life Science Laboratories | EPA 350.1 Rev.2.0 | 20 RPD | +/-10% | 2 | +/-10% | +/-10% | <0.2 mg/l | <0.2 mg/l | n/a | <0.2 mg/l |
| TKN | Life Science Laboratories | EPA 351.2 Rev.2.0 | 20 RPD | +/-10% | 2 | +/-10% | +/-10% | <0.2 mg/l | <0.2 mg/l | n/a | <0.2 mg/l |
| Nitrate | Life Science Laboratories | EPA 300.0 Rev.2.1 | 20 RPD | +/-10% | 3 | +/-10% | +/-10% | <0.05 mg/l | <0.05 mg/l | n/a | 0.05 mg/l |
| Nitrite | Life Science Laboratories | EPA 300.0 Rev.2.1 | 20 RPD | +/-10% | 3 | +/-10% | +/-10% | <0.05 mg/l | <0.05 mg/l | n/a | 0.05 mg/l |

1 = Calibration is done Annually, or when ICV starts failing
2 = Calibration is done Daily, or when ICV starts failing
3 = Calibration is done Quarterly, or when ICV starts failing
4 = Balance is calibrated Daily, before use.

RPD = Relative Percent Difference
LCS = Laboratory Control sample (Blank Spike)
ICV = Initial Calibration Verification
CCV = Continuing Calibration Verification
ICB/CCB = Initial and Continuing Calibration Blanks

LOQ = Limit of Quantitation (We will not be reporting any results below this value)

**Blanks and Duplicates**
Field blanks and field duplicates will be collected at a frequency of one sample per sampling trip for nutrient analysis and at a rate of 10% of the total number of samples for all other analyses and are analyzed for the same nutrients as the project samples (Table 4 will be used to assess adherence to DQOs (Table 3).

**A. Precision**
Precision can be defined as the relative uncertainty about a given measurement and is determined by replicate analyses. Duplicate samples will be collected at a frequency corresponding to one per sampling trip for nutrient analysis and at a rate of 10% of the total number of samples for all other analyses. ***The DQO for precision is ≤ 20% RPD on duplicate samples. Any sample violating this DQO will be investigated to determine the reason for violation.***

**B. Accuracy**
Accuracy can be defined as the absolute uncertainty about the true value. Acceptability of sample results will be based upon the accuracy criteria detailed in Table 3. Blank samples are collected to measure the amount of contaminant concentration introduced because of sampling related activity. ***The DQO for accuracy is that all FB less than the LOQ. Any FB ≥ LOQ must be flagged as questionable.***

Matrix Spike and duplicate matrix spike samples are collected along with regular water quality samples and spiked in the analytic laboratory with a known concentration of analyte. The samples are then analyzed to determine the accuracy (percent recovery) of the analytic results for a given matrix. Matrix spike and duplicate matrix spike samples will be collected at a frequency corresponding to five percent (5%) per batch consisting of multiple laboratory client's samples.

**D. Representativeness**
Representativeness in water column samples is attained by selection of proper sampling equipment to obtain an integrated sample of water from a cross section of the waterbody, as well as from different depths. ***The DQO for representativeness is ≤ 20% RPD on duplicate samples. Any sample violating this DQO will be investigated to determine the reason for violation.***

**E. Completeness**
Completeness can be defined as the percentage of acceptable data necessary to accomplish the study objectives. Due to the high cost of sample analysis and the limited number of samples to be collected, it is important that staff strictly adhere to all QA criteria to accomplish the survey objectives. ***The DQO for completeness is 90% successful analysis and reporting.***

**F. Comparability**
Comparability is the confidence with which one set of data can be compared to another. It is achieved by adherence to this QAPP and standard analytical methods, holding times, consistent detection limits, common units and consistent rules for reporting.

**G. Detection and quantifications**
LOD (Level of Detection)– for a specific method and matrix, minimum concentration an analyte can be determined to be significantly different from a blank. LOQ (Level of Quantification)– concentration level above which values are associated with a high degree of confidence.

**Data anomalies**
Occasionally data may be collected that appears to be erroneous. The first step is to verify that there was not a transcription, data entry, calculation, or cut and paste error. This can be accomplished by going back to the source documents (e.g., field sheets or laboratory bench sheets) and verifying against the original data. It is possible that a data point is an outlier and should be excluded from further analyses; this will be noted in the spreadsheet/database record. It is also possible that the observation is an outlier but is correct (for instance an exceptionally high turbidity reading may be the result of a record rain storm) but is still correct. In this instance, the analyst will use their best judgement as to how to present the data

If a sample was not collected in the field or run in the laboratory, then there will be missing data in the database. This type of error is handled by placing a note in the comment field on the field sheet (if it was a field error) or in the database comment field if it was related to a lost sample in the laboratory. In both cases, a brief explanation of why the sample was lost will be made.

## B6. Instrument/Equipment Testing, Inspection, and Maintenance
Numerous pieces of field equipment will be used on this project. The owner of each piece of equipment will be responsible for its proper operation and function, including:

- Yellow Springs Instrument 6920V2 water quality sonde and a 650 data logger (Finger Lakes Community College)
- Van Dorn sampler (Finger Lakes Community College)
- Integrated water column sampler – flexible tubing (Finger Lakes Community College)
- Fluoroprobe (Finger Lakes Institute)
- AlgaeTorch (Watershed Council – to be purchased in 2019)
- Thermistor array (Watershed Council)

Field instruments and equipment testing, inspection and maintenance will be performed in this program as per NYSDEC SOP #103-19, “Equipment Decontamination/Cleaning” and per the manufacturer’s instructions. All calibration and maintenance records will be maintained by the Project Manager or equipment owner and will made in indelible ink and kept in a project notebook. Any deviations from standard operating procedures will be noted and included in the final report and all records will be made available upon request.

**Storage**
All sampling bottles and equipment related to sampling will be stored and maintained by sampling staff so that the results obtained from their use will not be questioned. Prior to use, all equipment will be checked to ensure good operating conditions and cleanliness. After sampling, has been completed, the equipment will be cleaned

(as described below) and kept ready for use. Manufacturer's specifications will be followed in carrying out routine maintenance.

**Cleaning**
All sampling equipment (buckets, churn, sampler, etc.) will be well cleaned with a distilled (de-ionized) water wash before and after each day's use. At each sampling station, field equipment will be rinsed with ambient water before a sample is collected and lab equipment is rinsed with distilled water after sampling is completed so equipment will be ready for use at the next monitoring location. The equipment may be washed every two weeks using a nutrient free detergent and water scrub followed by a distilled water rinse as needed. Whenever equipment is cleaned with a phosphate free detergent a notation is made in the equipment's log book.

## B7. Instrument/Equipment Calibration and Frequency

Calibration of equipment will be done at according to manufacturer's recommendations (all field equipment used can be found in the Appendix) and NYSDEC SOPs 211-19 "Use, Calibration, Maintenance and Storage of multi-probe meters used to measure water quality parameters" and 103-19 "Equipment Decontamination/Cleaning". All calibration results will be recorded in a bound log book. The YSI multiprobe is calibrated the day prior to sampling following the manufacturer's protocol. Briefly, this entails a 2-point calibration for pH using a 4 and 10 buffer solution. The dissolved oxygen probe is calibrated using a calibration cup at 100% saturation. The conductivity probe is calibrated with a YSI standard of 10,000 um/cm concentration. The blue green algae probe is calibrated to 0 and to a rhodamine dye annually. The YSI multiprobe is maintained according to the manufacturer's recommendations. This includes replacing the optical DO membrane assembly on the YSI Optical DO sensor annually. All calibration results for the FluoroProbe are stored in the Finger Lakes Institute Water Quality laboratory. The FluoroProbe is operated and maintained according to the manufacturer's recommendations and uses a factory set calibration as listed in the bbe FluoroProbe User Manual Version 2.6 E2, October 2017 (bbe Moldaenke GmbH, Preetzer Chaussee177, 24222 Schwentinental, Germany, +49 (0) 431/380 400). Maintenance and calibration is performed on the FluoroProbe by the manufacturer every 2 years. Ongoing maintenance by FLI includes regular cleaning of FluoroProbe windows and unit, inspection of all torque points within the unit, greasing of unit connection port, and inspection of unit for signs of physical damage. The AlgaeTorch will be maintained, calibrated and operated by the Watershed Council according to the manufacturer's recommendations. Deficiencies in calibration and maintenance of all equipment are resolved on a case by case basis. The actual maintenance, calibration, and log keeping of all equipment work performed upon it is the responsibility of the Project Manager.

Laboratories conducting analyses should maintain appropriate service contracts for laboratory instruments and perform routine instrument maintenance at intervals suggested by the manufacturer or by internal laboratory SOP.

## B8. Inspection/Acceptance of Supplies and Consumables

The Project Manager will inspect supplies and consumables upon arrival of new materials and immediately before their use in the field or laboratory. For newly arrived supplies and consumables all materials must be in their original packaging and free of noticeable damages. For materials already obtained and ready for use, no noticeable defects will be allowed. The Project Manager is responsible for ensuring the quality of all supplies and consumables.

### B9. Non-Direct Measurements

This program will not utilize secondary data.

### B10. Data Management

The Project Manager, Finger Lakes Community College and Finger Lakes Institute will be responsible for entering all field information into Excel spreadsheets. The Project Manager will also receive electronic data packets from the analytical laboratory via email and review for completeness and accuracy. Hard copies of field forms or lab results will be kept in a secure location in the Project Manager's, Finger Lakes Community College's or Finger Lakes Institute's office. Electronic copies of data will be stored on the Project Manager's password protected work computer.

Data and supporting documentation from contract laboratories will be reported electronically to FLLOWPA in a complete data document either on CD or via a link to the laboratory secure data repository. The data documents include summaries of data validation conducted by the analytical laboratory. Inconsistencies in the data files are flagged for review and correction by the Project Manager. Once the sample collection information (station, date, time, parameter) has been verified, the water quality result values are reviewed. Values are compared against assessment criteria, including established parameter-specific limits. If reported values exceed the established limit, the result is flagged for further investigation.

Investigation of laboratory values may result in confirmation of the results by the analytical laboratory, comparison of the value against other results from the same site, inserting an appropriate data qualifier, and/or accepting the value without qualification.

Laboratory analytical data will be delivered electronically and hard copy to the NYSDEC Project Manager. Electronic data will be in a form of a .csv file importable to an Excel spreadsheet containing the validated laboratory data. A data narrative including analyst comments, and explanation of qualifiers and a listing of methods that are NELAC accredited are also required to be provided by the analytical reporting laboratory or organization. All reports, records and data are to be sent to the Project Manager. Data generated through FLLOWPA must be reviewed and consented by NYSDEC prior to its distribution or publication. Interim data may be presented to the public prior to NYSDEC consent during the field season in response to water quality inquiries from the public or for educational purposes but must be qualified as interim. After the final submission of reports and datasets to the NYSDEC, FLLOWPA Project Managers will manage their data in accordance with FLLOWPA requirements.

## C. Assessment and Oversight

Each FLLOWPA project will be audited at two stages: (1) QAPP and workplan development and (2) the FC and/or FNPM will audit 10% of projects each year.

## C1. Assessment and Response Actions

The Project Manager will thoroughly brief project implementation staff before and after beginning their respective implementation tasks, to identify emerging/unanticipated problems and take corrective action, if necessary. Also, contract laboratory staff will notify the Project Manager of any unanticipated problems that may arise during this project and any corrective actions taken will be documented.

**Corrective Action**

The Project Manager will thoroughly brief project implementation staff before and after beginning their respective implementation tasks, to identify emerging/unanticipated problems and take corrective action, if necessary. Also, contract laboratory staff will notify the Project Manager of any unanticipated problems that may arise during this project and any corrective actions taken will be documented.

## C2. Reports to Management

The Project Manager will perform a data validation review on each chemical matrix for this project. This evaluation together with the analysis of the completeness, precision, and accuracy of the program will provide a level of confidence to the data set and to the interpretations and conclusions drawn from the data.

A final report in powerpoint will be coordinated by the Project Manager which will contain a summary of the data collected including an Excel spreadsheet with data and quality objective metrics (e.g., precision, accuracy, etc.). The report will present observations, draw conclusions, identify data gaps, and describe any limitations in the way the data may be used based on QC results and stated DQOs. No other reporting is required for this project. NYSDEC will store electronic copies of project information including data as per the NYSDEC records retention policy.

**Table 5.** Project QA Status Reports

| Type of Report | Frequency | Preparer | Recipients |
|---|---|---|---|
| QAPP | Once, before primary data collection begins | **Canandaigua Lake Watershed Council, Project Manager** | **All recipients of original QAPP** |
| Final Project Report including all data generated in project | Once, upon completion | **Canandaigua Lake Watershed Council and Finger Lakes Community College** | **Finger Lakes Community College, FLLOWPA, Ontario County, Finger Lakes Institute** |

# D. DATA REVIEW AND EVALUATION

## D1. Data Review, Verification and Validation

This QAPP shall govern the operation of the project always. Each responsible party listed in Section A4 shall adhere to the procedural requirements of the QAPP and ensure that subordinate personnel do likewise. Data will not be published in any form until the validation review is completed.

All the responsible persons listed in Section A4 shall participate in the review of the QAPP. The Project Manager is responsible for determining that data is of adequate quality to support this project. The project will be modified as directed by the Project Manager. The Project Manager shall be responsible for the implementation of changes to the project and shall document the effective date of all changes made. Any significant changes will be noted in the next progress report and shall be considered an amendment to the QAPP. All verification and validation methods will be noted in the analysis provided in the final project report.

## D2. Verification and Validation Methods

Data results generated by this program will be reviewed at three separate stages. First, analytical laboratory staff follows specific laboratory protocols to assure the quality and validity of the data. Second, the Program Manager will review data results during the processing of the electronic data files including checking deliverables against the original COCs. This review includes confirmation of suspect values and the possible qualification of data results. For the third stage, the Project Manager will perform a data validation review and will evaluate the completeness, precision, and accuracy for the Program (below).

25% of the data will be verified and validated by the Project Manager to determine its validity prior to use and distribution. Data for each of the parameters will be compared with the detection limits and precision/accuracy data provided in Section B5; the analytical laboratory performs these comparisons on results that they generate. Those data not meeting the previously identified criteria for precision, accuracy and blank values (Section A6-A7) will be re-analyzed where possible or flagged if additional sample material is not available. An indication as to why flagged data did not meet the minimum QA criteria will be provided. If data validity cannot be verified, these data will be qualified in the database. An indication as to why qualified data did not meet the minimum QA criteria will be provided. This information will be noted in the final QA/QC report.

## D3. Evaluating Data in Terms of User Needs

This section of the QAPP addresses issues of whether data collected during field sampling meet data quality objectives in Section B5 and Table 4. Each data type is reviewed for adequacy in terms of precision, accuracy, representativeness, completeness and comparability by appropriate the Project Manager and Project Quality Assurance Officer.

**Reconciliation with use Requirements**

As noted in Section C, uncertainty in the data allowed for use in the monitoring programs end product will be limited to that found acceptable in the data verification and validation process. This section of the QAPP addresses issues of whether data collected during field sampling meet data quality objectives.

**Meeting and reporting needs of your project**

This section of the QAPP addresses issues of whether data collected during field sampling meet data quality objectives. The Project Manager will document all analyses and assumptions as necessary in project related memos. If any data type fails to meet the data quality objectives outlined in Table 4 or Section B5, the reasons for failure will be determined by the Project Manager and will be included in the final report. Any data type that fails a data quality objective will be flagged and documented in the datafile or any accompanying report. The Project Manager will document all analyses and assumptions as necessary in project related memos.

**Mathematical and statistical methods**
Acceptable levels of data validation and verification are presented in Section B5.

**Approach to managing unusable data**
It is expected that data collected as part of this project will meet the requirements for usability. Data that do not meet requirements for precision, accuracy, completeness or comparability will be carefully evaluated by the Project Manager (in consultation with the contract lab or NYSDEC staff if necessary) for deviations from laboratory and accepted paradigms. If warranted these data will be removed from the data set, by the Project Manager, with appropriate comments regarding decision process for removal.

**Reporting**
After the above QC calculations and examinations have been performed for all media, the results will be summarized in a final report. The QA/QC section of the final report will include a discussion and summary of the DQOs observed during the study. Any restrictions or limitations on the data will be linked with the dataset and indicated in any documentation resulting from the data. Project reports will be approved by the Project Manager and FLLOWPA Coordinator prior to distribution.

## References

NYSDEC. 2019 Quality Assurance Management Plan for the Finger Lakes-Lake Ontario Watershed Protection Alliance (FLLOWPA), Division of Water, New York State Department of Environmental Conservation, 615 Erie Blvd West, Syracuse, New York.

NYSDEC. June 2019. Standard Operating Procedure: Collection of Lake Water Quality Samples, NYSDEC SOP #203-19. Division of Water, New York State Department of Environmental Conservation, 625 Broadway, Albany, New York.

NYSDEC. April 2019. Calibration, Maintenance and Storage of multiprobe meters used to measure water quality parameters. NYSDEC SOP #211-19. Division of Water, New York State Department of Environmental Conservation, 625 Broadway, Albany, New York.

NYSDEC. March 2019. Standard Operating Procedure: Sample Handling, Transport, and Chain of Custody, NYSDEC SOP #101-19. Division of Water, New York State Department of Environmental Conservation, 625 Broadway, Albany, New York.

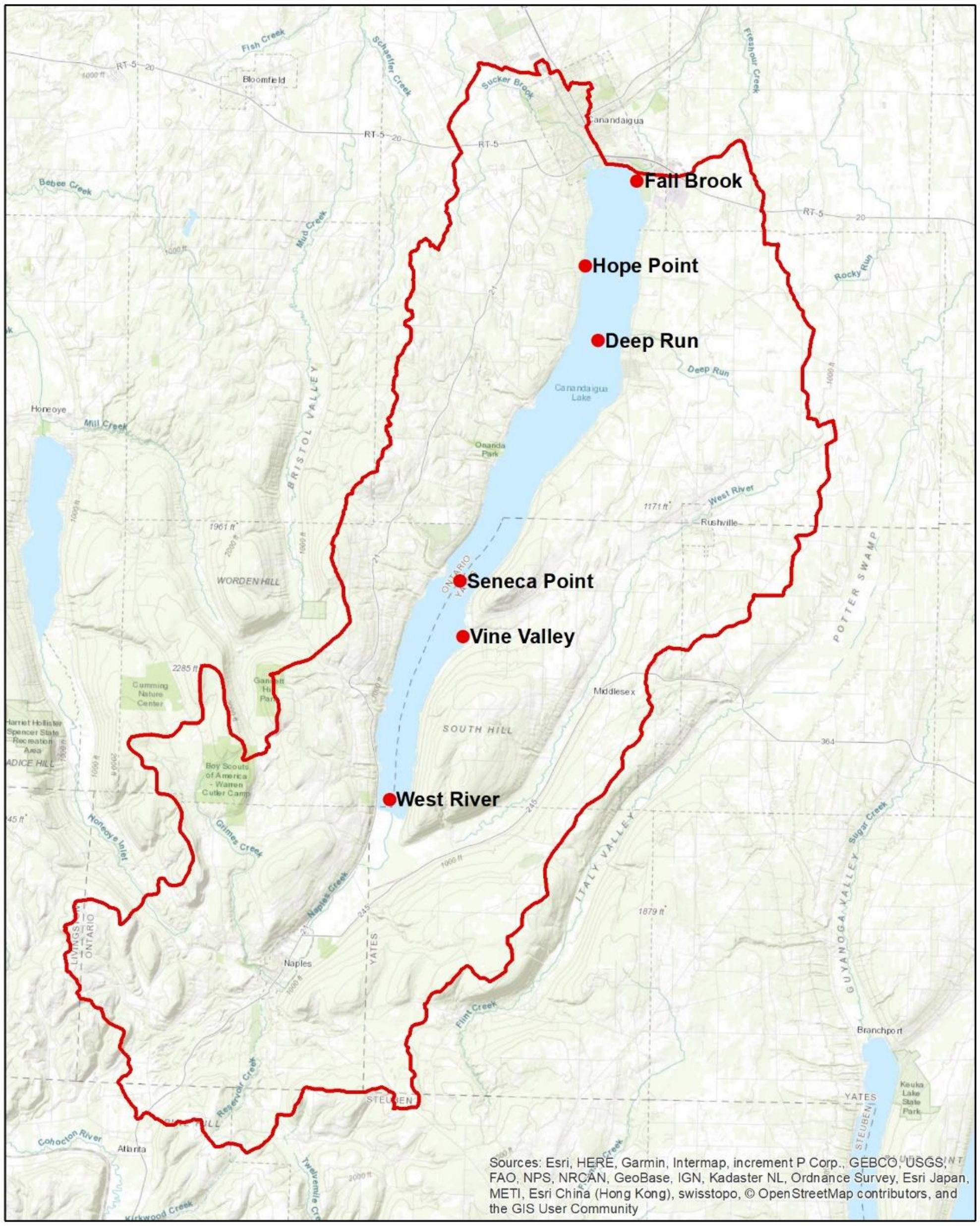
NYSDEC. March 2019. Standard Operating Procedure: Sampling Equipment Decontamination/Cleaning, NYSDEC SOP #103-19. Division of Water, New York State Department of Environmental Conservation, 625 Broadway, Albany, New York.

NYSDEC. May 2019. Standard Operating Procedure: Data Handling and Archival, NYSDEC SOP #102-11. Division of Water, New York State Department of Environmental Conservation, 625 Broadway, Albany, New York.

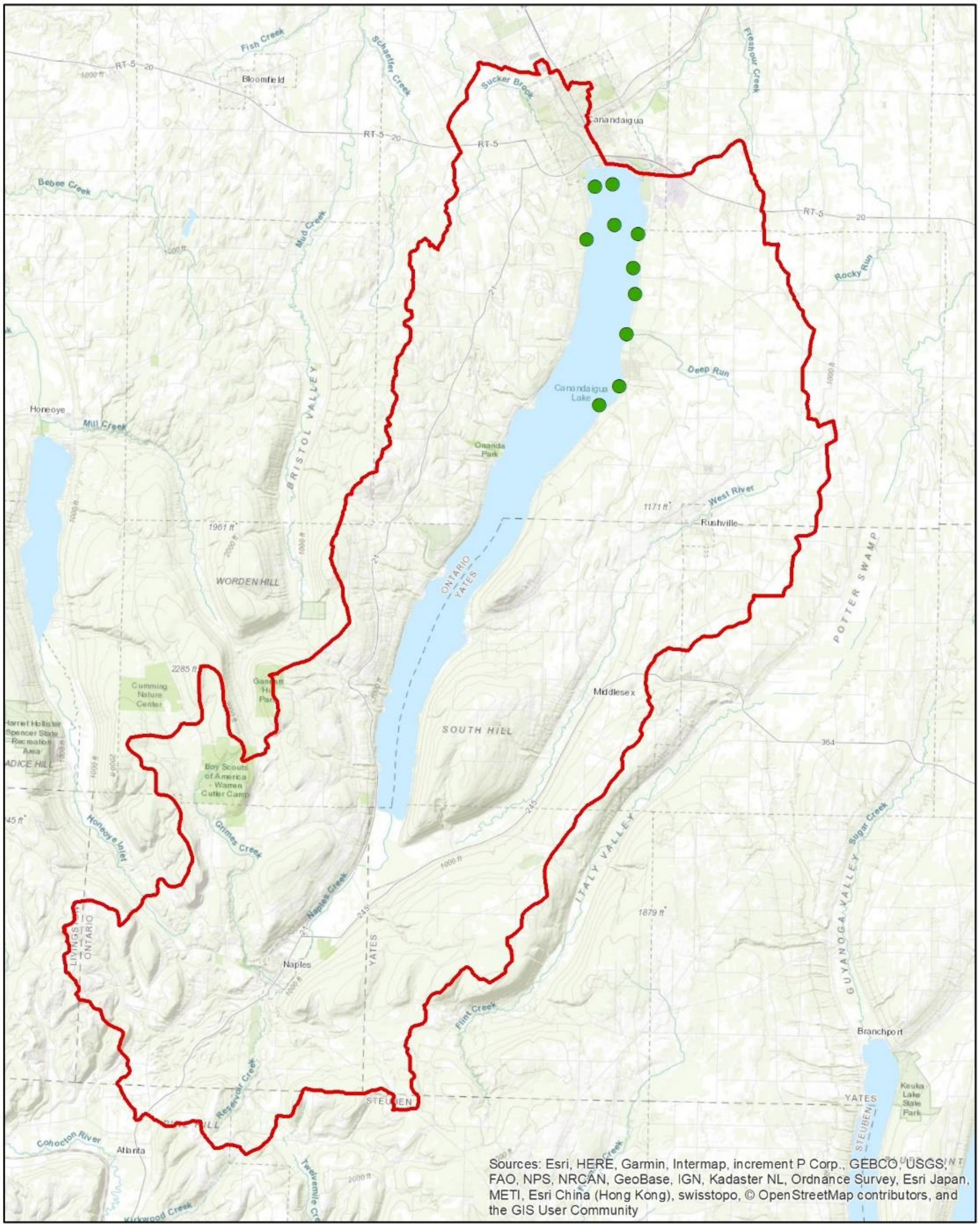
NYSDEC. May 2015. Consolidated Assessment and Listing Methodology. Division of Water, New York State Department of Environmental Conservation, 625 Broadway, Albany, New York.

# Appendix 1. Maps of Site Locations

Canandaigua Lake Long-Term Monitoring Sites



Canandaigua Lake Potential Summer Near-Shore Monitoring Sites



# Appendix 2. Example Chain of Custody Forms

Life Science Laboratories, Inc.
5854 Butternut Drive
East Syracuse, NY 13057
Phone # (315) 445-1900 Telefax # (315) 445-1104

## Chain of Custody Record

| | | | |
|---|---|---|---|
| Client: | Phone # | Contact Person: | LSL Project #: |
| Address: | Fax # | | Client's Site I.D.: |
| | Email: | | |
| | Authorization: | | Client's Project I.D.: |

| LSL Sample Number | Client's Sample Identifications | Sample Date | Sample Time | Type | | Matrix | Preserv. Added | Containers | | Analyses | Free Cl (mg/L) | Pres. Check |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | grab | comp. | | | # | size/type | | | |
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Notes and Hazard identifications:

| *Custody Transfers* | | Date | Time |
|---|---|---|---|
| Sampled By: | Received By: | | |
| Relinquished By: | Received By: | | |
| Relinquished By: | Received for Lab By: | | |

Shipment Method: Samples Received Intact: Y N

# Appendix 3. Example Field Form

FIELD DATA FORM Recorder: ____________________

Water Body: Canandaigua Lake Station: ____________________ Date: ____________

Time: ____________ Air Temp (C): ____________ Wind: ____________ Sky: ____________

Secchi Disk (m): ____________ Substrate: ____________________ Total Depth (m): ____________

Comments: ________________________________________

| Total Depth | Temp. (C) | Conductivity (mS/cm)c | Specific Conductance (uS/cm) | pH | % oxygen saturation | D.O. (mg/L) | BGA Cell Count | Comments |
|---|---|---|---|---|---|---|---|---|
| 55 | | | | | | | | |
| 50 | | | | | | | | |
| 45 | | | | | | | | |
| 40 | | | | | | | | |
| 35 | | | | | | | | |
| 30 | | | | | | | | |
| 25 | | | | | | | | |
| 20 | | | | | | | | |
| 15 | | | | | | | | |
| 14 | | | | | | | | |
| 13 | | | | | | | | |
| 12 | | | | | | | | |
| 11 | | | | | | | | |

SHEET 1 of 2

1

FIELD DATA FORM Recorder: ____________________________

Water Body: __Canandaigua Lake____ Station: ______________________________________ Date: ____________________

Time: _______________________ Air Temp (C): ________________ Wind: _______________________ Sky: ________________________

Secchi Disk (m): _________________ Substrate: ________________________________ Total Depth (m): _________________

Comments: ________________________________________________________________________________________________________

| Total Depth | Temp. (C) | Conductivity (mS/cm)c | Specific Conductance (uS/cm) | pH | % oxygen saturation | D.O. (mg/L) | BGA Cell Count | Comments |
|---|---|---|---|---|---|---|---|---|
| 10 | | | | | | | | |
| 9 | | | | | | | | |
| 8 | | | | | | | | |
| 7 | | | | | | | | |
| 6 | | | | | | | | |
| 5 | | | | | | | | |
| 4 | | | | | | | | |
| 3 | | | | | | | | |
| 2 | | | | | | | | |
| 1 | | | | | | | | |
| 0 | | | | | | | | |

SHEET 2 of 2

2

Canandaigua Lake Field Sampling Checklist Date: ______________________

1. West River (time sampled: _________________)
   - ☐ Integrated sample for chlorophyll
   - ☐ 2m Van Dorn sample

| Site Notes: |
|---|
| |

2. Vine Valley (time sampled: _________________)
   - ☐ Integrated sample for chlorophyll
   - ☐ 2m Van Dorn sample

| Site Notes: |
|---|
| |

3. Seneca Point (time sampled: _________________)
   - ☐ Secchi
   - ☐ Integrated sample for chlorophyll
   - ☐ 2m Van Dorn sample
   - ☐ 25 m Van Dorn sample
   - ☐ 50 m Van Dorn sample
   - ☐ YSI profile (1-15, 20 – 55 by 5's)

| Site Notes: |
|---|
| |

4. Deep Run (time sampled: ________________)
   - ☐ Secchi
   - ☐ Integrated sample for chlorophyll
   - ☐ 2m Van Dorn sample
   - ☐ 25 m Van Dorn sample
   - ☐ 50 m Van Dorn sample
   - ☐ YSI profile (1-15, 20 – 55 by 5's)

| Site Notes: |
|---|
| |

5. Hope Point (time sampled: ________________)
   - ☐ Integrated sample for chlorophyll
   - ☐ 2m Van Dorn sample

| Site Notes: |
|---|
| |

6. Fall Brook (time sampled: ________________)
   - ☐ Integrated sample for chlorophyll
   - ☐ 2m Van Dorn sample

| Site Notes: |
|---|
| |

## Appendix 4. Field Equipment Used in this Project

Equipment List:

Secchi Disk

Van Dorn Sampler – used for collecting all samples for nutrient analysis

Flexible tubing – used for collecting an integrated chlorophyll *a* sample

Yellow Springs Instrument 6920V2 water quality sonde with a 650 data logger equipped with ROX Optical Dissolved Oxygen Sensor, Blue Green Algae Phycocyanin Fluorescence Sensor, and Combo pH/ORP Field-replaceable 6-series probe

Fluoroprobe

AlgaeTorch

Thermistor array

# Amended Quality Assurance Project Plan
# Canandaigua Lake Watershed SWAT Model
# April 2020
# Updated March 2021
# Amended April 2022
# Signed May 2023

Canandaigua Lake Watershed Council

In partnership with the Cornell University Soil and Water Lab

Prepared by:

**Name:** **Kevin Olvany and Kim McGarry**

**Agency:** **Canandaigua Lake Watershed Council**

**Address:** **205 Saltonstall Street, Canandaigua, NY 14424**

**Phone:** **(585) 396-3630**

**Email:** **Kevin.olvany@canandaiguanewyork.gov**

## QAPP Update Log

| Prepared/Revised By: | Date: | Revision No: | Summary of Changes: |
|---|---|---|---|
| **Kevin Olvany** | **4/1/2020** | **0** | **Original** |
| Kevin Olvany | 3/6/2021 | 1 | Language clarification, updates to model set-up and calibration methodology, pre-QAPP data validation methodology |
| Kevin Olvany | 4/3/2022 | 2 | Amendments to reflect final calibration and validation methodology |

*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).*

This document is a summary of project modifications from the Quality Assurance Project Plan (QAPP) for Canandaigua Lake Watershed SWAT Model, April 2020 - Updated March 2021. This modified QAPP documents the substantive changes to the original modeling project that were made throughout its completion. Any and all changes to the original project QAPP were made with participation from the original planners, or their delegates, and the final modeling project was determined to meet the end users' needs while maintaining most of the original project quality acceptability criteria. The amendments were made and agreed to in April 2022. The signatures below are dated 2023 because it reflects the time when the modeling report was finalized and final 9E appendix materials were organized. Changes to the QAPP are listed within each section to which the modifications apply. Final model results will be documented in a modeling report to be completed at the end of the project.

By signing below, the project participants certify that the changes to the original project were made with their knowledge and participation and that the changes adopted to complete the project allow for the attainment of original project goal – SWAT model development and use in the completion of an acceptable Nine Element Plan for the Canandaigua Lake watershed.

Kevin Olvany — 5/3/2023
sign here

**Project Manager** — **Date**
**Kevin Olvany, Watershed Program Manager**
**Canandaigua Lake Watershed Council**

Todd Walter — 5/3/2023

**Dr. M. Todd Walter, Professor** — **Date**
**Cornell University**

m.sepehr — 5/3/23
sign here

**Mahnaz Sepehrmanesh, PhD Student** — **Date**
**Cornell University**

7/25/2023
sign here

**Anthony Prestigiacomo, Research Scientist** — **Date**
**NYS DEC Finger Lakes Watershed Hub**

Lindsey DeLuna — 07/28/2023
sign here

**Lindsey DeLuna, AQAO** — **Date**
**NYS DEC Division of Water**

## ABSTRACT

This document details a quality assurance project plan to guide the successful implementation of the Canandaigua Lake Watershed Soil and Water Assessment Tool (SWAT) Model. The purpose of the model is to assess pollutant loading to Canandaigua Lake and estimate load reductions associated with best management practice implementation. The modeling results will be support the Canandaigua Lake Watershed Nine Element Plan.

This QAPP documents the project goals and objectives, project organization, tasks, quality objectives and model testing, calibration and validation and was approved before work began on the project.

## 1.0 PROJECT MANAGEMENT

### 1.1 Title and Approval Page

**Canandaigua Lake Watershed SWAT Model**
**Quality Assurance Project Plan**
**April 2020**
**Canandaigua Lake Watershed Council**
**205 Saltonstall Street, Canandaigua, NY 14424**

Approvals Signature (required prior to project start):[1]

sign here — 5/13/2021

**Project Manager** — **Date**
**Kevin Olvany, Watershed Program Manager**
**Canandaigua Lake Watershed Council**

sign here — 5/13/2012

**Dr. M. Todd Walter, Professor** — **Date**
**Cornell University**

sign here — 5/13/2021

**Mahnaz Sepehrmanesh, PhD Student** — **Date**
**Cornell University**

sign here — 05/13/2021

**Anthony Prestigiacomo, Research Scientist** — **Date**
**NYS DEC Finger Lakes Watershed Hub**

sign here — 05-13-2021

**Rose Ann Garry** — **Date**
**Quality Assurance Officer (QAO), NYSDEC Division of Water**
**Standards and Analytical Support Section**

[1] Original QAPP signatures

## 1.2 Table of Contents



## 1.3 Distribution List

The following individuals must receive a copy of the approved QAPP in order to complete their role in this project. Copies will be distributed electronically unless otherwise noted. All personnel will keep a hard copy for reference.

| Name | Title (relative to project) | Organization | Contact Information | Document Type |
|---|---|---|---|---|
| Rose Ann Garry | QA Officer | NYSDEC | roseann.garry@dec.ny.gov (518) 402 - 8159 | Hardcopy and Electronic |
| Anthony Prestigiacomo | Overall Project Coordinator | NYS DEC Finger Lakes Watershed Hub | anthony.prestigiacomo@dec.ny.gov (315) 426-7452 | Hardcopy and Electronic |
| Kevin Olvany | Project Manager | Canandaigua Lake Watershed Council | Kevin.olvany@canandaiguanewyork.gov (585) 396-3630 | Hardcopy and Electronic |
| Kim McGarry | Technician | Canandaigua Lake | kmcgarry@canandaiguanewyork.gov | Electronic |

| | | | | |
|---|---|---|---|---|
| | | Watershed Council | | |
| Todd Walter | Contractor Project Manager / Lead Modeler | Cornell University Soil and Water Lab | Mtw5@cornell.edu (607) 255-2488 | Hardcopy and Electronic |
| Mahnaz Sepehrmanesh | Modeler | Cornell University Soil and Water Lab | ms3549@cornell.edu | Electronic |
| Lauren Townley | Project Oversight | NYSDEC | lauren.townley@dec.ny.gov | Electronic[1] |
| Katherine Hogle | Project Oversight | NYSDOS | katherine.hogle@dos.ny.gov | Electronic[1] |

1 Project oversight and grant administration.

**Distribution List:** No changes.

## 1.4 Project Organization

The Canandaigua Lake Watershed Council is responsible for the design and execution of this project. Any changes to this planning document or associative components will receive technical and managerial review by the Project Manager, and the Project Quality Assurance Officer. Review is subject to conformity to expectations. The following organizations will actively participate in this project:

- NYSDEC
- Canandaigua Lake Watershed Council
- Cornell University

***New York State Department of Environmental Conservation (NYSDEC)***

**Rose Ann Garry**
**Title/Affiliation:** Quality Assurance Officer, NYSDEC Division of Water Standards and Analytical Support Section
**Address:** 625 Broadway, Albany, New York 12233-0001
**Phone No.:** (518) 402 - 8159
**E-mail:** roseann.garry@dec.ny.gov
**Responsibilities:**

- oversee Division of Water Quality Assurance activities, and is not subject to the authority of any persons connected to the project, provide expertise regarding analytical and QA/QC Issues
- review the QA project plan to verify that those elements outlined in the EPA Requirements for QA Project Plans (QA/R-5) are successfully discussed
- review and final approval of project quality assurance plan

**Anthony Prestigiacomo**
**Title/Affiliation:** Overall Project Coordinator

Research Scientist, Division of Water, Finger Lakes Watershed Hub
**Address:** 615 Erie Blvd West, Syracuse, NY, 13204
**Phone No.:** (315) 426-7452
**E-mail:** Anthony.Prestigiacomo@dec.ny.gov
**Responsibilities:**

- Project coordination
- Provide technical review of project work plan
- Review summary presentation
- Approve final modeling report

***Canandaigua Lake Watershed Council (CLWC)***

**Kevin Olvany**
**Title/Affiliation:** Project Manager
Watershed Program Manager, Canandaigua Lake Watershed Council
**Address:** 205 Saltonstall Street, Canandaigua, NY 14424
**Phone No.:** (585) 396-3630
**E-mail:** kevin.olvany@canandaiguanewyork.gov
**Responsibilities:**

- Will develop the workplan and be the responsible official for overseeing the overall projects and budgets, as well as tasking contractors with work required to complete projects. He/she will communicate project needs to the contractor's project manager.
- Determine project and model strategy, including design, model setup and objectives.
- Will be responsible for developing and maintaining the QA Project Plan. He may provide technical input.
- Determine modeling scenarios for future best management practices
- Responsible for communication with other project partners (NYSDEC, Cornell University)
- Provide assistance on final modeling report

**Kim McGarry**
**Title/Affiliation:** Technician
Watershed Program Technician, Canandaigua Lake Watershed Council
**Address:** 205 Saltonstall Street, Canandaigua, NY 14424
**Phone No.:** (585) 396-3630
**E-mail:** kmcgarry@canandaiguanewyork.gov
**Responsibilities:**

- Will provide assistance on the overall projects and budgets, including workplan review, communication with contractor's project manager and providing technical input on model development and report writing assistance

***Cornell University Soil and Water Lab***

**Dr. M. Todd Walter**
**Title/Affiliation:** Contractor Project Manager/Lead Modeler
Professor, Cornell University, Department of Biological and Environmental Engineering, Soil and Water Laboratory
**Address:** Cornell University, 232 Riley Robb, Ithaca, NY 14853-5701
**Phone No.:** (607) 255-2488
**E-mail:** mtw5@cornell.edu

**Responsibilities:**

- Will have overall responsibility for assigning appropriate personnel to complete the tasks included in this plan. He will ensure that the project budget is adhered to. He will communicate with the Project Manager on work accomplished in this plan and any problems or deviations that need to be resolved.
- Will oversee all students and staff of the Cornell University Soil and Water Lab that will work on the model.
- Will provide technical input on model calibration/validation procedures
- Will ensure the modeling adheres to this QAPP and will meet the criteria for use in an EPA 9 Element Plan.
- Review and edit final modeling report

**Mahnaz Sepehrmanesh**
**Title/Affiliation:** Modeler
PhD Student, Cornell University, Department of Biological and Environmental Engineering, Soil and Water Laboratory
**Address:** Cornell University, Riley Robb, Ithaca, NY 14853-5701
**Phone No.:**
**E-mail:** ms3549@cornell.edu
**Responsibilities:**

- Complete model while adhering to this QAPP, including set up, calibration and validation
- Data analysis for model coefficient development and conduct model calibration and validation
- Conduct model simulations under the guidance of the Lead Modeler and Project Manager
- Complete draft modeling report

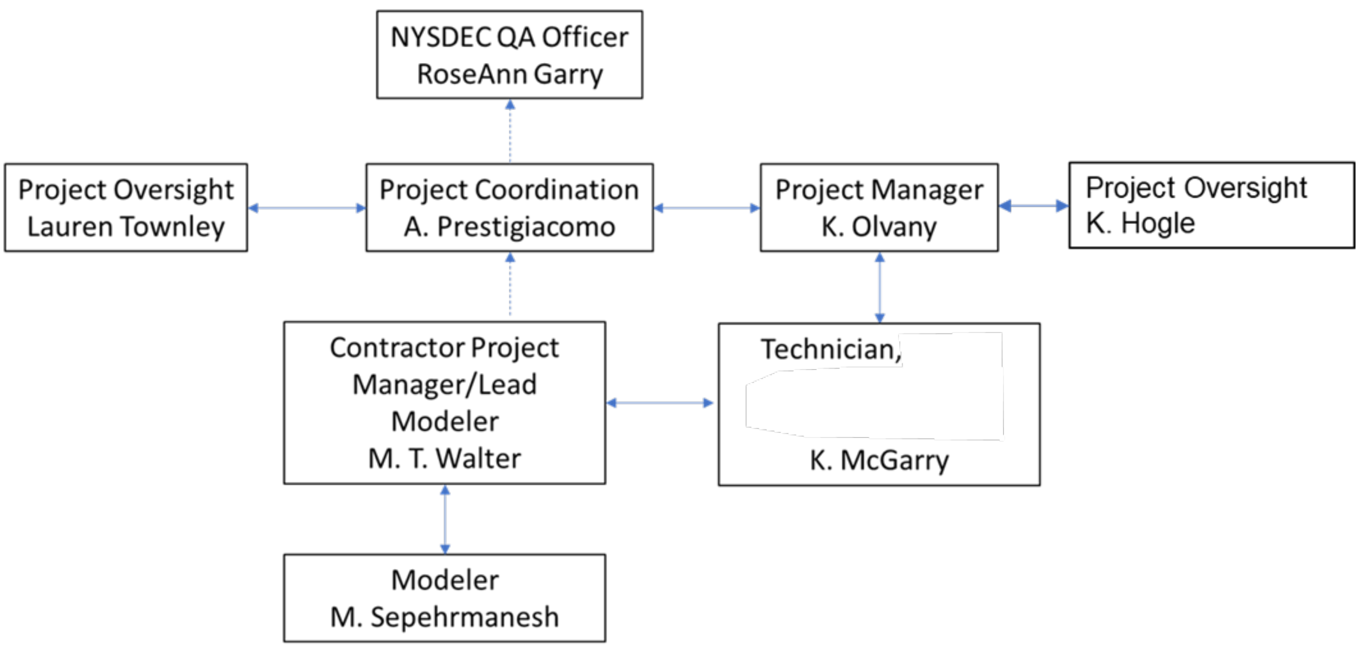


**Figure 1. Project Organizational Chart**

Changes to planning and project documents will receive technical and management review by the Project Manager. Project planning will involve data users including technical staff and review of this QAPP is subject to conformity to expectations for the project.

| |
|---|
| **Project Organization:** No changes. |

## 1.5 Problem Definition/Background

Canandaigua Lake is a critical asset to our community, providing drinking water, recreational opportunities, a critical tax base, and a high quality of life. Watershed management and planning efforts for the last 20 years have sought to protect the lake from existing and emerging threats to ensure the lake and its watershed will continue to support a vast array of ecosystem services. Non-point source pollution continues to be the major source of concern for the lake. Specifically, nutrient pollution contributes to harmful algal blooms and nuisance weed growth, impacting drinking water quality and recreational opportunities. Modeling will provide information on relative loading of nutrients throughout the watershed and will inform watershed managers on the scale and scope of best management practices needed to reduce nutrient loading to the lake. The results of the model will be utilized as an addendum for the 2014 Comprehensive Update to the Canandaigua Lake Watershed Management Plan to meet the requirements of an EPA Nine Element Plan. Therefore, the goal of the Canandaigua Lake Watershed SWAT Model is to assess nutrient and sediment loading under current conditions and predict potential load reductions from the implementation of best management practices.

The Canandaigua Lake Watershed Council leads lake and watershed monitoring and management efforts. The Council has monitored base flow and storm events on 17 major tributaries for nutrients and suspended sediment for the past 20 years and has conducted segment analysis on numerous tributaries. Monitoring is the best tool for understanding nutrient dynamics within the watershed, because it provides actual concentrations and has greater potential to account for all of the nuances of land use and management, weather, soil conditions, and topography. However, monitoring will never be able to capture the pollutant dynamics from every gully or stream reach over the breadth of storm and melt events that occur in a year given that the watershed is approximately 109,000 acres and has hundreds of miles of tributaries. The SWAT model will complement monitoring data to further our understanding of nutrient and sediment loading over a longer time period and at a higher geographic resolution. The model will highlight specific subwatersheds that contribute relatively large loads to the lake and help prioritize areas for management (i.e., critical source areas (CSAs)).

The watershed model will be utilized to evaluate the potential benefits from best management practices. First, best management practices will be modeled across the watershed to assess the scale and scope required for discernible nutrient reductions when compared to modeled existing conditions. Implementation is voluntary, so this is just an evaluation of potential benefits for different levels of implementation. Second, we will utilize the model to assess the benefits of specific projects in the future.

The modeling results will be utilized to complete an addendum to the existing watershed management plan to meet the 9 Element Plan criteria. NYS DEC staff analyzed our watershed management plan on June 8, 2017 and determined that modeling was needed to achieve Element B (expected load reductions for solutions identified). Nine Element Plans are becoming a higher priority for funding best management practices, and we need to maximize water quality funding to build resiliency against harmful algal blooms.

| |
|---|
| **Problem Definition/Background:** No changes. |

## 1.6 Project/Task Description and Schedule

The overarching project goal is to complete a Soil and Water Assessment Tool (SWAT) watershed model for the Canandaigua Lake watershed to identify sources of nutrient and sediments to the lake. SWAT was chosen primarily because it is widely used for such applications and accepted for 9E and TMDL projects. Also, SWAT estimates a uniquely wide range of important water quality analytes and is flexible enough to capture the region's somewhat unique hydrology. The Cornell Soil and Water Lab has been using this model for several years within central NY, so there is institutional expertise and an established network of modelers from previous projects who can provide support. The SWAT model will be used to estimate nutrient (phosphorus and nitrogen) and sediment inputs to Canandaigua Lake which will be key information for the management of the watershed and Canandaigua Lake water quality, including HABs. Model results will also be used to complete a 9 Element Plan. The project's tasks are described below. Together, these tasks will result in a tested model of sufficient quality that will be focused on quantifying the nutrient and sediment loading to Canandaigua Lake. These tasks are listed below with task details outlined in the subsequent sub-sections.

A. Satisfy quality assurance (QA) requirements through the preparation of an approvable QAPP, and execution of the various QA elements stipulated therein,
B. Data compilation and quality review for initial model setup, model calibration, and model validation and facilitate additional data collection if necessary. This will be done using the Secondary_Data_Matrix_Modeling_NYSDEC2019.xlsx template provided by NYSDEC,
C. Set-up, calibrate, and testing of a SWAT model to achieve the overarching objective (above). The model will have enough spatial resolution for proper and effective watershed management decisions,
D. Development of hydrology and nutrient loading drivers for the model calibration year and selected validation year(s),
E. Conduct model simulations under NYSDEC guidance, and
F. Prepare final modeling report

Project Tasks

This section expands on the tasks, listed above, providing related sub-tasks or components.

A. Satisfy quality assurance (QA) requirements through the preparation of an approvable QAPP (this document), (Spring 2020)
B. Data compilation and quality review (Spring 2020)
    a. All sources of data will be documented and summarized in the final report, including source, process for verification, validation, and final usability assessment of model input, calibration, and validation datasets
    b. Summary will, at a minimum, include: agency responsible for collection, data type (field or laboratory), appropriate metadata (i.e., dates, station number, physical locations, notes, etc.), ELAP and/or NELAC certifications for laboratory analysis, data use as it pertains to the modeling project (e.g., initial setup, calibration, etc.), QAPP and/or project numbers that the data were collected under (if applicable).

  c. Utilize NYSDEC Secondary_Data_Matrix_Modeling_NYSDEC2019.xlsx template
C. Set-up, calibrate, and testing of a SWAT model (Spring 2020)
  a. Soil and Water Assessment Tool, 2012, version 10.21
  b. Utilize existing modeling efforts in the Canandaigua Lake watershed to guide SWAT setup,
  c. Set-up Hydrologic Response Units (HRUs) to accurately reflect watershed characteristics and allow for effective watershed management
  d. Acquire model input information for multiple years and establish appropriate data file
  e. Specify meteorological conditions - air temperature, wind speed and direction, dew point temperature and precipitation.
D. Development of external loading drivers for the model calibration year selected and validation year(s). (TBD based on data availability and quality) (Summer and Fall 2020)
  a. Flow. Estimates will be made using a combination of existing modeling, USGS, CLWC or academic gage data, and point discharge measurements.
  b. Nutrient concentrations. As part of Objective B, nutrient data usability will be determined by all parties involved in this project (Section 1.3) after the approval of this QAPP and completion of the NYSDEC Secondary Data Matrix Modeling_
E. Conduct model simulations under NYSDEC guidance (Summer and Fall 2020), and
  a. A limited number of simulations will be conducted under NYSDEC guidance where various best management practices will be theoretically implemented in SWAT in order to evaluate the resulting loading reductions
F. Prepare final modeling report (Winter 2020)
  a. The report will summarize the development and testing of the sub-models and overall modeling project (see Section 5).

A description of the SWAT model and preliminary approaches to model setup and calibration are provided in the Table below. These are subject to change upon secondary data evaluation and review.

| **Model Selection** | **Description** |
| --- | --- |
| Model name, version number, source | Soil and Water Assessment Tool, 2012, version 10.21 |
| Preliminary data evaluation and gap analysis | **Existing data for consideration include:**<br>**Basin Hydrology:**<br><u>1. Lake Mass Balance Model</u><br>● Developed by Watershed Council. Approved by DEC as part of a Water Supply Permit Application. Data are available from 2000 to 2009. Permit ID: 8-3202-00016/00003 - 2011 |

| Model Selection | Description |
|---|---|
| | ● Daily watershed inflows were developed during this time period using measured data.<br>● Will be used to estimate entire flow budget to Canandaigua Lake to calibrate SWAT model<br>● Represents a wide range of weather and seasonal conditions<br>● The Lake Mass Balance Model utilizes measured data from reputable sources, including: daily lake level as measured using the USGS lake gage that is managed by the City of Canandaigua, precipitation from 5 official gages- data came from the Northeast Regional Climate Center, outlet flow from USGS gage and feeder canal gage, daily water withdrawal from 6 purveyors, and pan evaporation rates from the Northeast Regional Climate Center and converted to lake evaporation based on literature review<br><br>Individual Sub-basin Hydrology<br><br>1. Stream stage from Deep Run utilizing pressure transducers and velocity measurements collected under the Canandaigua Lake Watershed Tributary Monitoring FLLOWPA QAPP (2019)<br><br>2. USGS gage on the West River in the Town of Middlesex in April 2019 (04234398)<br><br>3. Instantaneous discharge measurements from NYSDEC 2019 monitoring. Approximately 15 discharge measurements from Naples Creek, Fall Brook, and Sucker Brook.<br><br>4. Finger Lakes Community College recently installed a pressure transducer in Fall Brook, which may be used if necessary and if it meets CLWC and DEC's quality requirements. CLWC may take discharge measurements to develop the rating curve.<br><br>**Total Phosphorus, Nitrate/Nitrite, and Suspended Solids:**<br><br>Baseflow and storm event water quality monitoring by CLWC |

| Model Selection | Description |
| --- | --- |
| | • Total phosphorus, nitrate/nitrite and suspended solids data were analyzed at a NYSDOH ELAP certified lab and collected by SUNY Brockport (1997-2001) and CLWC staff (2002-2019)<br>• Methodologies detailed in 2005 and 2009 Watershed Council/FLCC reports and 2014 Watershed Plan. Brockport produced reports in 1999, 2000 and 2001 for the data they collected. Methodologies were detailed in those reports as well.<br>• QAPP developed for FLLOWPA funding in 2015 and updated in 2018. The 2019 accepted QAPP follows the new FLLOWPA template for tributary monitoring and is being updated in 2020 to reflect minor changes to the FLLOWPA template. The QAPPs outline the existing sampling methodologies that have been in place since the beginning of the sampling program.<br>• Report for data - https://docs.wixstatic.com/ugd/a5c0cd_055cc8bbc2d1404db6611203d86438d9.pdf<br>• Monitored 17 major tributaries that cover approximately 70% of the watershed and are well mapped during storm events for total phosphorus, TSS and nitrate/nitrite (majority of samples from 1997 to 2017) - most storms were sampled from 2010 and earlier<br>• Completed 12 baseline samples in 2007/2008 on those same 17 streams<br>• Final data usability will be assessed using DEC Secondary Matrix and Data Usability Report<br><br>Baseflow and storm event water quality monitoring by NYS DEC<br>• NYSDEC Rapid Assessment Surveys in 2019 on the West River, Sucker Brook, Fall Brook, and Naples Creek<br><br>Segment analysis monitoring by CLWC<br>• Deep Run and Fall Brook – Samples collected from 2016 -2018 during 5 storm events. Approximately 10 segments per stream were sampled. All data were analyzed at a NYSDOH ELAP certified lab, were collected by CLWC staff and was covered by FLLOWPA funding QAPP.<br>• Sucker Brook - Sampled at 23 locations from Sept. 2008 – July 2010 (N=7 sampling events). Analytes were TP, TKN, NOx, TSS.<br>• Eelpot Creek - Sampled at 11 locations from Sept. 2006 – Feb. 2009 (N=7 sampling events). Analytes were TP, NOx, TSS. |

| **Model Selection** | **Description** |
|---|---|
| | |
| New data collection if existing data is insufficient or outdated. | New data to be collected and/or acquired includes:<br>● Extension of the Lake Mass Balance Model<br>    o Will utilize the same approach to increase the record to include 2009 to 2020 for model validation<br>● Continuation of stream gages by USGS and CLWC<br>● Continuation of base flow and storm event monitoring by CLWC<br>    o The goal is to collect samples from 5 baseflow and 4 storm events at 5 locations in 2020, however, the number and location of samples will depend on weather conditions and runoff patterns<br>    o Utilizes a NYSDOH ELAP certified lab and is covered by the Canandaigua Lake Watershed Tributary Monitoring QAPP (accepted FLLOWPA template 2019 with minor updates in 2020)<br>● Continuation of NYSDEC Rapid Assessment Surveys<br><br>After the Secondary Evaluation Matrix is complete, project partners will decide if additional hydrological or nutrient data is required for calibration/validation. |
| Setup Timeframe | More information on model calibration and validation is detailed in Section 4.<br><br>Model Setup and Calibration – Rainfall-Runoff Parameters:<br>2000-2008 daily data from a DEC-approved Lake Mass Balance Model, as part of a Water Supply Permit Application, will be used to calibrate the SWAT model. These data span an acceptable time span to capture weather variability and allows for a model warm up period. The 2000 data will be used for model warm up. The 2001 to 2008 data will be used for model calibration of rainfall-runoff parameters.<br><br>Model Validation – Rainfall-Runoff Parameters:<br>The expanded lake mass balance model for 2009 to 2020 will be used for validation. This data has a much longer time period than our direct stream discharge measurements, which allows us to capture more year to year variability for the validation process. We will use the direct stream stage and/or discharge data as an additional, secondary validation step to confirm the mass balance model methodology provided acceptable model calibration and validation. For this second |

| **Model Selection** | **Description** |
|---|---|
| | validation step, we will use discharge from the USGS gage in the West River from April 2019 to 2020. |

Model Setup and Calibration – Nutrients and Suspended Solids:

Total suspended solids, total phosphorus, and nitrate/nitrite from the CLWC tributary dataset will be used for model set up. Approximately 70% of the samples from this dataset will be used for initial model set up, where the goal is to reduce the initial (and wide) ranges for parameters that control water quality constituents within SWAT, but not to identify the optimal parameter values of the model. That is, the CLWC data will only be used to reduce the initial uncertainty of SWAT parameters and identify behavioral parameter values that lead to plausible model simulations (i.e. rule out ranges of SWAT parameter that perform very poorly with respect to CLWC data). Then, model calibration will be run on the model using the following data: 1) NYS DEC Rapid Assessment Surveys from 4 locations from 2019 and 2) samples collected through the CLWC monitoring program in 2020. The calibration data will meet all of the QA/QC measures required by DEC. The calibration will further refine the behavioral parameter ranges identified in model set up and tailor the final parameter values to the DEC-approved data. If necessary, a final calibration step will utilize both datasets and the identified parameter ranges.

Model Validation – Nutrients and Suspended Solids:

The remaining 30% of the data from the CLWC monitoring dataset (from before 2020) will be used for model validation for total phosphorus, suspended solids and nitrate/nitrite. The DEC 2020 data will also be used in validation.

Summary:

| | Calibration | Validation |
|---|---|---|
| Discharge | • Inflow to the lake (2000-2008) | • Inflow to the lake (2009-2020)<br>• USGS Gage at West River (2019-2020)<br>• |
| Water Quality | • 70% of CLWC data at 17 tributaries (2001-2007) - Model Set Up | • Remaining 30% of CLWC data at 17 tributaries (2008-2016) |

<table>
<tr><th>Model Selection</th><th>Description</th></tr>
<tr><td></td><td><table><tr><td></td><td>• DEC data at 4 sampling location (2019) and DEC-approved data that will be collected by CLWC (2020) - Calibration</td><td>• DEC data at 4 sampling locations (2020)</td></tr></table></td></tr>
<tr><td>Basin characteristics</td><td>The 2014 Comprehensive Update to the Canandaigua Lake Watershed Management Plan provides a summary of the watershed characteristics. The plan can be found at: https://docs.wixstatic.com/ugd/a5c0cd_a3ab4bacf88f4f1898dd38435c60e50c.pdf.<br><br>Briefly, the Canandaigua Lake watershed is approximately 109,000 acres, and the soils, slopes and land cover vary throughout this large geographic area. The far majority of soils fall into the C or D hydrologic soil groups and are therefore prone to runoff. The topography ranges from steep cliffs to very flat areas. The watershed contains a mixture of forest, agriculture, densely populated areas and rural residential areas.<br><br>The SWAT model will delineate the watershed sub-basins based on DEM topography and with constraints placed at water quality sampling locations.</td></tr>
<tr><td>Major streams</td><td>The Canandaigua Lake Watershed is broken into 34 major subwatersheds, including both stream drainage basins and direct drainage basins (areas that encompass multiple gullies that outlet directly into the lake). Seventeen of these sub-watersheds are monitored as part of the long term monitoring program and encompass more than 70% of the watershed area.<br><br>The SWAT model will break down the Canandaigua Lake watershed into more than 34 subwatersheds. However, the model sub-basins will incorporate the 17 major subwatersheds from the monitoring program to allow water quality data to be used in model calibration.<br><br>The Canandaigua Lake Watershed is a HUC 10 watershed (Canandaigua Lake - 0414020102). The National Watershed Boundary dataset breaks down the Canandaigua Lake Watershed into 5 HUC 12 subwatersheds, including:</td></tr>
</table>

| Model Selection | Description |
|---|---|
| | • Sucker Brook – Canandaigua Lake (041402010401)<br>• Deep Run – Canandaigua Lake (041402010205)<br>• West River (041402010203)<br>• Bristol Springs – Canandaigua Lake (041402010204)<br>• Naples Creek (041402010202) |
| Sub-basins | It is estimated that the SWAT model will utilize approximately 142 sub-basins. The goal is to delineate sub-basins that correspond to approximately 1000 HRUs across the entire watershed and have on average 1 to 10 HRUs per sub-basin. This level of modeling resolution balances the need for detailed model results for planning and management purposes with the computing requirements needed for additional sub-basins and HRUs.<br><br>Sub-basin delineation will incorporate the 17 subwatersheds utilized in the Canandaigua Lake tributary monitoring program. This will allow for easier calibration of water quality parameters. |
| Meteorology | All meteorological data will be retrieved from the National Climate Data Center land-based station archive. CANANDAIGUA 3 S station will be used for air temperature.<br><br>For the SWAT model, 4 weather stations will be used, including: Canandaigua 3 S, Dansville, Hemlock, and Pen Yan.<br><br>The Mass Balance Model (used in calibration and validation) utilizes an average precipitation from 5 stations, including Canandaigua 3 S, Hemlock, Geneva Research Farm, Bristol Harbor, and Dansville.<br><br>There are 4 other stations, CANANDAIGUA 2.6 SSW, BRISTOL HARBOUR, BRISTOL SPRINGS, and GANNETT HILL, close by that can be used as the model input if additional data is needed. |

| **Model Selection** | **Description** |
|---|---|
| +Land uses | The model will utilize the 2016 National Land Cover Dataset. However, additional land cover data is available to utilize in the model, if necessary, to achieve model quality control results, including:<br><br>- 2011 Canandaigua Lake Watershed Land Cover Dataset (NLCD2011)<br>- Local highly detailed 2004 land cover dataset for the watershed<br>- Local highly detailed 2018 land cover dataset for the watershed |
| Slope classes | 5 slope categories will be used in model set up: 0-1%, 1-5%, 5-10%, 10-20%, >20%. Fewer categories cannot represent the watershed appropriately and more than 5 classes will not be practical in SWAT modelling. |
| Manure spreading assumptions and schedules | We will use general assumptions for farming practices across the Finger Lakes Region. As a baseline, manure spreading assumptions and schedules will be based on Menzies Pluer et al. 2019. This study worked with Cornell Pro-Dairy to develop generalized manure spreading amounts and schedules for the Fall Creek subwatershed of Cayuga Lake. These spreading amounts and schedules will be modified with local information from our Soil and Water Conservation Districts and rates utilized in other Finger Lakes SWAT models. |
| Urban/residential assumptions, Other | We will utilize general assumptions for residential practices across the Finger Lakes Region. Residential wastewater will be lumped together at the sub-basin level. |

Project Deliverables

SWAT will be applied to the entire ~109,000 acre watershed for Canandaigua Lake. This modeling project will include the following products:

- Calibrated and validated SWAT 2012 model for the Canandaigua Lake watershed
- Stream discharge on a daily time step for existing conditions for each sub basin
- Estimates of concentration and loading of suspended sediment, nitrogen, and phosphorus at a daily time step for existing conditions for each sub basin

- Stream flow and concentration and loading of sediment, nitrogen and phosphorus on a daily time step under various best management practice scenarios

**Project/Task Description and Schedule:** Changes to this section are as follow:

The project timeline was extended from Winter 2020 to Spring 2022. This SWAT model utilized a novel approach for stream flow. This required extra model testing. The model took 2 weeks to run for each test/calibration run, so this additional testing/calibration added a significant amount of time onto the modeling process.

The original methodology included a model set up period using 70% of the CLWC water quality data, model calibration using the DEC 2019 and CLWC 2020 water quality data, and a final calibration step using all of the water quality data combined. Because the DEC 2019 and CLWC 2020 had a limited amount of data, this 3-step approach produced poor model performance. Therefore, the modeling team calibrated the model for flow, total phosphorus, nitrate/nitrite, and total suspended solids in one step using the lake mass balance model from 2000 to 2008, 70% of the CLWC water quality data (2001 to 2007), the DEC 2019 water quality data, and the CLWC 2020 water quality data. This methodology resulted in better model performance. This approach balanced using QAPP-approved data with the pre-DEC-QAPP data that covered a larger geographic area and a wider breadth of weather and runoff conditions. The DUAR included in the Appendix provided evidence to support the use of the pre-DEC-QAPP data in the model.

For the SWAT model, all 4 weather stations, Canandaigua 3 S, Dansville, Hemlock, and Pen Yan, have been used for air temperature.

To calculate nutrient loads at tributary locations, we initially proposed to use flow estimates from the water balance model, scaled to the drainage area of each tributary location, as the flow data used in the load calculation. However, the noise present in the daily water balance model estimates of flow was significant, leading to load estimates that likely deviated significantly from their true values. Therefore, to calculate load, we used SWAT estimated flow at each tributary location in the load calculation. A comparison of SWAT simulated flow to the USGS gage data at West River showed that the SWAT simulated flow performed well at the subwatershed level (NSE for monthly flow was 0.67).

## 1.7 Quality Objectives and Criteria for Measurement Data and Models

Streamflow, meteorology, physical parameters (land use, slope, etc.) and field parameters do not require analysis by a NYSDOH ELAP certified laboratory. The initial construction of the model (model setup and testing) may occur with appropriately vetted data, however, all accompanying documentation will include language clearly specifying its status as draft pending final calibration using data that was analyzed by a NYSDOH ELAP certified laboratory. To be accepted as complete, the SWAT model will be calibrated and validated using chemistry data that were analyzed by a NYSDOH ELAP certified laboratory.

The overall project quality assurance objective is to setup, calibrate, and validate a watershed hydrology and water quality model that can assist in the development of a 9 Element Plan Addendum to the 2014 Comprehensive Update to the Canandaigua Lake Watershed Management Plan. Models are only a representation of reality, as it is impossible to account for all of the nuances of land cover, artificial and natural drainage patterns, and soil conditions. Understanding these limitations, the objective of this modeling project are to 1) assess relative pollutant loading to Canandaigua Lake from subwatersheds to highlight and prioritize areas for management, 2) gain an understanding of the scope and scale of best management practices required to reduce nutrient and sediment loading to the lake, and 3) meet the criteria for a 9 Element Plan.

For data analysis and modeling, the Data Quality Objectives (DQOs) are qualitative and quantitative statements that:

- clarify the intended use of data,
- define the type of data needed to support a decision,
- identify the conditions of collecting the data

The data quality objectives for input data and model output outlined below reflect the overall project objectives. These objectives will be achieved by: (1) using existing literature values or ranges for model setup, (2) experience of the modelers acquired from developing SWAT models from the Finger Lakes region, and (3) by using established metrics of model performance to complete model development.

The DQOs for input data for the model are:

- Data quality for key model inputs (e.g., meteorological, hydrological, external constituent loads) will be representative to support specification of representative driving conditions within the watershed model.
- Data quality for model variable(s) will be representative to provide a robust test of model performance.
- Data quality for variables will be representative seasonally and for multiple years

While the watershed modeling group at Cornell strives to create and utilize models that require little direct calibration, the SWAT model must be calibrated so that the output for stream flow and pollutant concentrations match existing records. The SWAT model is robust and is regularly used across New York State to assess pollutant loading to lakes. However, there are limitations in representing the true physical and biological processes in a watershed. These limitations are well-understood in the modeling community and will be summarized in the final report.

The DQOs for model output (e.g., predictions, simulations) include both qualitative and quantitative perspectives.

- Output will be consistent with well accepted mass balance constraints
- Patterns of output in time and space will be consistent with the topographic and biogeochemical features of the watershed
- Appropriate responses of the model to reasonable variations in model inputs
- Performance, according to metrics widely reported in similar modeling initiatives, is consistent with levels reported for other similar efforts

In watershed modeling, it is most important to obtain a good calibration of the streamflow, because it has a much larger impact on nutrient and sediment loading than changes in concentrations. We will run a sensitivity analysis to determine which model parameters have the largest impact on calibration.

To assess model performance for streamflow, our primary objective function will be the Nash-Suttcliffe Efficiency (NSE). The NSE assesses how well the model predicts measured data, as compared to the mean of the measured data. A value of 1 equates to a perfect fit between model output and observed data, while a negative value indicates the overall mean better predicts measured data than the model. Ideally, we would like to achieve a Nash-Sutcliffe Efficiency (NSE) greater than 0.36 for modeling at the daily time step for discharge, a threshold commonly agreed to indicate satisfactory calibration/validation (Tang et al. 2012).

One unique aspect of this specific project is that there are very few tributary discharge measurements so we will calibrate SWAT to an overall watershed water budget developed by the Watershed Council and approved by DEC as part of a Water Supply Permit Application (Permit ID: 8-3202-00016/00003 - 2011). There is substantial reduced precision in these calibration data because, for example, the lake water level, which was used to approximate changes in internal storage, is influenced by non-water budget factors like wind. Thus, we acknowledge that we may have difficulty achieving our target NSE value.

The model will also be calibrated for total suspended solids (TSS), total phosphorus (TP), and nitrate (N). Based on our previous modeling experiences and the literature, we expect the NSE for water quality parameters to be lower than the NSE for modeled flow (e.g., Knighton et al. 2017). Our target NSE values are based on a SWAT synthesis by Chaubey and Migliaccio (2021) and the Cornell Soil and Water Lab's most recently published SWAT study by Menzies et al. (2019). Based these, our target NSE values relative to our flow NSE values are: TSS NSE = 0.71 Flow NSE, TP NSE = 0.70 Flow NSE, and N = 0.60 Flow NSE – Note: we removed all published NSE values that were negative in developing these thresholds. Using our flow NSE = 0.36, the corresponding pollutant NSE values would be: TSS NSE = 0.26, TP NSE = 0.25, and N NSE = 0.22.

All software to be used for this project (SWAT and SWAT_CUP) are developed, maintained and version controlled by external organizations. We will not be performing software-update QA/QC as part of this project.

**Quality Objectives and Criteria for Measurement Data and Models:**

Our goals for model performance were flow NSE = 0.36, TSS NSE = 0.26, TP NSE = 0.25, and N NSE = 0.22. We needed to balance the performance across all 4 parameters. Calibration attempts that achieved a high NSE value for daily flow resulted in poor model performance for the water quality parameters. This is very likely because daily flow is inferred from a water balance model (i.e., not observed), and there is a significant amount of noise in those data. Therefore, we decided to highlight monthly flow performance as a measure of model skill for this variable. The NSE for monthly flow was 0.43.

The water quality data was collected at the sub-basin level and for individual storm events, so it was important to ensure processes at this smaller spatial and temporal scale were captured by the model during the calibration process. Ultimately, we selected a calibration that had an NSE of 0.33 for phosphorus and 0.5 for nitrogen, meeting our previous targets. However, the model was not able to achieve the NSE of 0.26 for total suspended solids. The modeled total suspended solids was much lower than observed values on a number of occasions. Nuances at the very small scale, such as an eroding stream bank, roadside ditch or concentrated flow through a field, can result in significant sediment loads but aren't captured by the model. Overall, the model performed at the level necessary to assess loading sources and best management practices. The model captured seasonal fluctuations and differences among subwatersheds.

### 1.7.1 Objectives and Project Decisions

As stated in Section 1.6, the objectives of this modeling project are to 1) assess relative pollutant loading to Canandaigua Lake from subwatersheds to highlight and prioritize areas for management, 2) gain an understanding of the scope and scale of best management practices required to reduce nutrient and sediment loading to the lake, and 3) meet the criteria for a 9 Element Plan. The quality objectives driving model development reflect the overall project objectives.

| |
|---|
| **Objectives and Project Decisions:** No changes. |

### 1.7.2 New Data Measurement Performance Criteria/Existing Data Acceptance Criteria

As discussed in detail in Section 2.1, all data utilized in this project are considered non-direct measurements because they were collected under previous projects, under separate QAPPs or by a governmental entity that conducts its own quality control. The DEC Secondary Data Matrix outlines specific criteria used to determine if secondary input data meets data quality objectives. This includes information on methodology, documentation, QA/QC procedures and documentation, and an overall assessment of data quality. The DEC, Cornell and Canandaigua Lake Watershed Council will jointly determine the usability of evaluated data sets.

| |
|---|
| **New Data Measurement Performance Criteria/Existing Data Acceptance Criteria:** No changes. |

## 1.8 Special Training Requirements/Certification

No further training is needed by CLWC or Cornell modeling staff. Dr. Walter and his lab have highly specialized expertise in their respective modeling and data analysis tasks. They have completed the SWAT model for other New York State lakes. The staff has been involved in watershed data analysis and SWAT model development and calibration for many years.

| |
|---|
| **Special Training Requirements/Certification:** No changes. |

## 1.9 Documents and Records

The data analysis and modeling teams will be responsible for documenting analyses, model development, testing, and findings, data files and software. Each modeling staff member will be responsible for documenting all assumptions and supporting analyses. Progress will be documented as part of the technical meetings between technical staff and Project Manager. Record keeping for each step of the modeling process will consist of various types of information, in the form of progress presentations and multiple forms of graphics. Examples are given below:

Documentation for the SWAT model will include, at a minimum, the following:

- model assumptions
- parameters and rate constants and their source
- land use and management practice assumptions (e.g., manure management within CAFO and AFO-sized farms)

- conceptual model designs and evolution (for each model tested, a short description of what was tested and why it was not chosen)
- input used, their sources, and any action to compensate for missing data
- setup input and output files
- calibration and verification files (predicted vs. observed)
- model assessment values (e.g. Nash-Suttcliffe Efficiency)

All files from the modeling study will be maintained for auditing purposes and post-project reuse, including

- source code and executable code
- output from model runs
- interpretation of output
- setup and testing procedures and results
- Input GIS layers and datasets

No modifications of code are expected for this project. However, if any modifications are necessary, all modifications of the source code will be tested and documented in internal memos. Such modifications would be tested throughout the setup process by experienced modelers reviewing the model output to determine that it demonstrates expected behavior and responds in the expected manner for each model run.

At completion of the model, all project records, documents, and files will be transmitted to the Canandaigua Lake Watershed Council. Final reports will be distributed to the Department of Environmental Conservation and Department of State and will be stored by the Canandaigua Lake Watershed Council. The final report will be submitted in electronic format. All electronic records discussed in this section will be stored on a secure server, write protected, and backed up for a period of five years beyond completion of the project.

**Documents and Records:** No changes.

## 1.9.1 QA Project Plan Distribution

Any changes in this QAPP during the study period will be documented and noted in the revision table at the beginning of this document. After approval by the appropriate persons, the revised QAPP will be sent to each person listed on the distribution list. This QAPP is a controlled document and will be managed by the Project Manager. The QAPP will be reviewed as needed.

**QA Project Plan Distribution:** No changes.

# 2.0 DATA GENERATION AND ACQUISITION

## 2.1 Data Acquisition Requirements (Non-Direct Measurements)

The water quality component of SWAT will only be calibrated and validated using chemistry data that was analyzed by a NYSDOH ELAP certified laboratory.

The SWAT model requires a variety of spatial, weather, land management, and field data for the setup, calibration and validation process. All of the data utilized in this model is considered secondary, as it was collected for a separate project, was collected by a separate agency, or is covered under a separate QAPP. The Lake Mass Balance Model will be used for model setup, calibration and validation, with the model setup/calibration period from 2000 to 2008, and the model validation from 2009 to 2020. The model will utilize 70% of the CLWC tributary monitoring dataset for model set up, with calibration using the DEC Rapid Assessment Survey from 2019 and the CLWC monitoring data from 2020. Calibration data meets DEC QA/QC standards. If necessary, a final calibration step will utilize both datasets and the identified parameter ranges. The remaining 30% of the CLWC monitoring data will be used for model validation, along with the DEC Rapid Assessment Survey from 2020. See Section 4.0 for the full methodology.

All of the secondary data will be assessed by the Canandaigua Lake Watershed Council, Cornell University, and NYS DEC using the DEC Secondary Data Matrix. This matrix covers the source, analytical metric and description, data history and location, quality assessment/quality control documentation, and a formal assessment based on these criteria. Only data that is deemed to be acceptable through this process will be utilized for model setup, calibration and validation. All input data and associated project and quality objectives are summarized below.

The following are non-direct measurements required for the SWAT model setup in the Canandaigua Lake Watershed:

| **Type of Input Data** | **Use** | **Data used in model** | **Additional data available if needed** | **Source** |
|---|---|---|---|---|
| Land surface elevation model | establish elevation of HRUs and slope | USGS DEM | LiDAR data provided by Canandaigua Lake Watershed Council | USGS |
| Land cover | Model set up | NLCD 2016 | Local land use maps provided by Canandaigua Lake Watershed Council for 2004 and 2018 | Multi-Resolution Land Characteristics Consortium (federal agencies) |
| Soil type | Model set up | STATSGO - Preloaded into SWAT model | | |
| Dairy Manure Application Rates | Water chemistry calibration | Generalized assumptions for the | | Menzies Pluer et al. 2019 |

| | | | | |
|---|---|---|---|---|
| | | Finger Lakes Region utilized in other SWAT models using Menzies Pluer et al. 2019 as a baseline and updated with local knowledge from Soil and Water Conservation Districts and rates utilized in other Finger Lakes SWAT models. | | |
| Fertilizer | Water chemistry calibration | Generalized assumptions for the Finger Lakes Region utilized in other SWAT models | | |
| Air temperature (min and max) | Model set up - hydrology | NCDC CANANDAIGUA 3 S station | Numerous other stations available - CANANDAIGUA 2.6 SSW, BRISTOL HARBOUR, BRISTOL SPRINGS, and GANNETT HILL | NCDC |
| Precipitation | Model set up - hydrology | 4 Stations - Canandaigua 3 S, Hemlock, Pen Yan and Dansville | | NCDC |

The following procedures will be used in the acquisition and use evaluation of secondary data in this modeling project.

A literature review and data search will be conducted to review and locate potential sources of data for use in model development/setup. Documented sources of data will include published peer-reviewed manuscripts, published reports, or from documented academic research. The data will be assembled in a matrix of all available information and data sets according to the NYSDEC Secondary Data Evaluation for Modeling Matrix Template (NYSDEC 2019). The first step is to define and describe the data of interest, including:

1. Analytical metrics of interest and their description
    - Parameter and matrix (e.g., nitrate, water sample)
    - Laboratory/Field
    - Measurement Type

- Describe Data Type (if Misc)
- Analysis Method
- Laboratory Name/ID

The above must be known and documented for any data set to be considered for use in this project. These categories are key to building the foundation upon which to verify, validate, and assess the soundness, applicability and utility of secondary data for this project (USEPA 2003a).

In addition:

1. The water quality component of the model will only be calibrated and validated using chemistry data that was analyzed by a NYSDOH ELAP certified laboratory. The name of the laboratory used to analyze the data must be provided with the NYSDOH ELAP accreditation number.
2. The methods used to measure the parameter of interest must be recognized by the EPA (40 CFR-Part 136), NYSDOH, or NYSDEC as official field or laboratory methods to be considered for as secondary data for any NYSDEC project (https://www.epa.gov/cwamethods).

The second step is to describe the data's history and location of collection. This is critical to ensure that the data is consistent with the current project needs. The following categories will be documented for all secondary data under consideration:

2. Data History and Location

- Waterbody/Watershed
- WI/PWL Segment ID
- Site Name and Description
- Latitude, Longitude
- Year(s)
- Program Description and Original Data Use
- Data Source
- Funding Source

The above must be known and documented for any data set to be considered for use in this project. These categories are key to building the foundation upon which to and assess applicability, utility, traceability and bias of secondary data for this project (USEPA, 2003b). In addition:

1. The physical location of the data must be verifiable for consideration of use in this project; including system and site name, GPS coordinates or a physical description or address sufficient to verify the data's source, and the NYSDEC Waterbody Inventory/Priority Water Body ID number and URL link. Also, the dates and times of collection, original program description and original data use will be documented to determine usability for the current project.
2. If the original collection location and/or original data use is inconsistent with this project, the data will not be used. As an example, if the data was collected near a SPDES discharge outfall that is unrepresentative of the waterbody being modeled, this data will be excluded from use as it is unrepresentative of the waterbody.
3. The organization responsible for collecting the data and the funding source must be known and verified.

3. Quality Assessment and Quality Control Documentation

It is expected that the data compiled will be in various states of QA/QC documentation and acceptability. Listed below are the items that will be reviewed as part of this project's QA/QC evaluation:

- QAPP or DUAR

- Quality Assessment/ Quality Control Samples
- Field Notes
- Link to Reports

As a critical component of any data being considered, the QA/QC review will be described as part of the Secondary Data Evaluation for Modeling Matrix Template (NYSDEC, 2019) and the lack of sufficient QA/QC documentation will influence final data usability. Reference or hyperlinks to the original data and reports must be included in the final assembled data matrix to allow for traceability.

If a data set lacks a full QC evaluation, water quality data may be used for model setup, testing, and validation if it can be determined that the data is of sufficient quality through graphical and statistical analysis compared to data of known quality. Specifically, the DEC 2019-2020 and the CWLC 2020 water quality datasets meet all of the quality control criteria for DEC through approved QAPPs and will serve as the accepted datasets for comparison. The 2001 to 2018 CLWC water quality samples were run at a NYSDOH ELAP certified lab and have all of the documentation on location, collector, and methodology. However, this dataset lacked field/equipment blanks and duplicates. Therefore, we will need to validate this dataset for use in the model for model testing, set up and validation. Specifically, we will conduct the following to validate the dataset:

- Equipment blanks and duplicates collected by CLWC in 2020 under an approved QAPP meets quality criteria. The same person collected the samples using the same methodology as the 2001 to 2018 dataset. This result provides some confidence that the older dataset would have similar quality to that of the contemporary program.
- We will statistically compare baseflow water quality samples between the two datasets. Monthly baseflow samples were collected by CLWC in 2007 and 2008, but lacked the duplicates and blanks required by DEC. Subsequent baseflow water quality samples were collected by CLWC and DEC in 2019 and 2020 that meet the quality control requirements outlined in DEC-approved QAPPs. The comparison will be conducted for 5 subwatersheds using the Mann Whitney U Test to test for statistically significant differences in the median concentrations on each. The older dataset will be considered usable if it is statistically similar to the dataset collected under the approved QAPP. A comparison of water quality data during baseflow conditions is important, as it substantially reduces the inherent variability of rainfall distribution in the watershed, timing of sample collection, etc, that can impact storm and melt event sample concentrations.
- Due to the inherent variability found during storm event sampling, we will evaluate the storm/melt event datasets through a qualitative, visual assessment of concentration verses flow plots for each parameter. We will assess whether the 2001 to 2018 CLWC dataset had consistent characteristics to the 2020 CLWC and 2019-2020 DEC datasets by plotting concentrations versus the simulated flow. We will look to see if these two datasets provide visually consistent characteristics in terms of range of parameter concentrations at different levels of stream flow. We will compare data from all of the subwatersheds and then will also focus on individual subwatersheds that were included in both datasets. The older dataset will be considered usable if it is qualitatively similar to the dataset collected under the approved QAPP. The 2001 to 2018 dataset has significantly more data points across a greater set of conditions and more subwatersheds, so we expect some variability between the datasets.

Final usability will be determined by Cornell, Canandaigua Lake Watershed Council, and NYSDEC and will be documented in the final modeling report.

4. Data Verification Summary

The Secondary Data Evaluation for Modeling Matrix Template evaluates each of the categories below that reflect the level of data verification (USACE, 2003).

1. Overall Quality of and Level of Detail in Report(s)
- Manuscripts, published reports, agency name, researcher or academic institution
- Public or private
2. Formal Documentation of Procedures
- Standard operating procedures, QAPPs, etc.
- Equipment used, including probe type or technique
- Laboratory method documented
- Calibration records

3. Analytical Methods Used and Detection Limits Achieved (https://www.epa.gov/cwamethods).

5. Data Validation Summary
The Secondary Data Evaluation for Modeling Matrix Template evaluates each of the categories below that reflect the level of data validation (USACE, 2003).

1. Field Calibration Records/Availability
2. Data Review, Validation, and Quality Assurance
3. Assessment of Data Quality Indicators

The assessment factors as presented above are intended to apply to individual parameters. This is considered a "weight-of-evidence" approach which will consider all relevant information in an integrative assessment which will be used to determine final data usability.

Cornell and CLWC, in consultation with NYSDEC, will apply careful judgment when evaluating secondary data for quality and relevance in the context of model development and testing. The use of data with significant uncertainty may have to be weighed against the cost of using default assumptions or committing additional resources to generating new information.

Additional secondary data evaluation criteria

| | |
|---|---|
| Soundness | The extent to which the scientific and technical procedures, measures, methods or models employed to generate the information are reasonable for, and consistent with, the intended application. |
| Applicability and Utility | The extent to which the information is relevant for the intended use. |
| Clarity and Completeness | The degree of clarity and completeness with which the data, assumptions, methods, quality assurance, sponsoring organizations and analyses employed to generate the information are documented. |
| Uncertainty and Variability | The extent to which the variability and uncertainty (quantitative and qualitative) in the information or in the procedures, measures, methods or models are evaluated and characterized. |

| | |
|---|---|
| Evaluation and Review | The extent of independent verification, validation and peer review of the information or of the procedures, measures, methods or models. |
| Traceability | The ability to verify the history, location, or application of an item by means of documented recorded identification |
| Bias | The action of supporting or opposing a particular conclusion in an unfair way, because of allowing personal opinion to influence judgment |

**Data Acquisition Requirements (Non-Direct Measurements):**

See Amendment Box under Section 1.6.

## 2.2 Data Management

Data management will be completed by Cornell's Soil and Water Lab. The modelers will record the original source of input files and any alterations completed to these input files for use in the model. All input data will be checked to ensure the units are compatible and for consistency in how the date is determined on temporal data (e.g. corrections if rainfall is recorded for the previous 24 hours).

Data Management and Hardware/Software Configuration

- Data Management: Data pre- and post-processing will be performed within the Matlab and R scripting languages to minimize manual data entry error.
- Hardware/Software Configuration: The following is a list of the software to be used on this project:
    - Matlab R2014a
    - R Scripting Language
    - RStudio
    - Microsoft Excel
    - Microsoft Word
    - Notepad++
    - Soil and Water Assessment Tool (SWAT) v2012
    - SWAT-CUP
- All data processed in this software will be converted to an excel or text file, so it can be reviewed without the need of specialized software beyond Microsoft Office or GIS.

Hardware/Software Assessments: No code testing will be performed. All software to be used is developed, controlled, and maintained by external organizations.

Hardware/Software Configuration Tests: No code testing will be performed. All software to be used is developed, controlled, and maintained by external organizations.

Records of hard copy data will be maintained by CLWC staff. Electronic data will be stored on a secured computer accessible to CLWC staff only. Electronic backups of the data will be maintained. The data will be formatted into the appropriate input files for analysis and modeling. The original data, as well as the input files and QA/QC graphs, will be maintained by CLWC in hardcopy and electronic format to document the data management process. All data will be maintained for at least 5 years beyond completion of the project. Kevin Olvany will be responsible for overall data management as discussed in Section 1.4 and Kim McGarry will be providing on-going assistance.

**Data Management:** No changes.

# 3.0 ASSESSMENT AND OVERSIGHT

## 3.1 Assessments/Oversight and Response Actions

All modeling and pre- and post-processing will be completed by Mahnaz Sepehrmanesh of Cornell University. Project oversight will be provided by Dr. Todd Walter (Cornell University). Modeling progress will be documented weekly in a short email from Cornell University to the Project Manager. A more detailed review of the status of the model will be conducted monthly between Cornell and the Project Manager.

Model performance assessments will be made frequently by Cornell during model development. Model input data will be graphed and reviewed to ensure the data falls within expected ranges/patterns and is formatted appropriately for the model. Model output will be compared to observed and proxy data and will be reviewed to ensure it makes sense and is consistent with historic data. Periodic review of model performance criteria will be conducted, including the Nash-Suttcliffe Efficiency. If model performance falls below the stated criteria, Cornell and the Canandaigua Lake Watershed Council will work with the NYS DEC to select the best course of corrective action.

The NYS DEC will be periodically updated on the modeling progress. Peer review of the model will be conducted by Tony Prestigiacomo of NYS DEC to ensure that the model is technically adequate, properly documented and meets established quality requirements through the review of assumptions, calculations, extrapolations, methodology, and acceptance criteria.

**Assessments/Oversight and Response Actions:** Modeling progress was provided by Cornell to the Project Manager through regular emails and virtual meetings. The frequency of emails and meetings was determined by progress made on the model. Given that each calibration took 2 weeks to run on the computer, emails and meetings were completed as appropriate.

# 4.0 MODEL APPLICATION

This modeling endeavor is unique and likely to be increasingly common. Specifically, there are very limited tributary discharge data and these data are critical to calibrating watershed models. We are proposing this approach that provides for daily watershed discharge based on relatively common precipitation, lake level, water purveyor and pan evaporation data (Lake Mass Balance Model approved by DEC as part of the Water Supply Permit). Here we use the inferred data to setup, calibrate and validate SWAT.

Our approach is in contrast to other models that often calibrate to a single long-term dataset from a USGS gage. Modeling a large watershed is more complex and will inherently have more error. However, our novel approach will allow us to capture the basic signature and peaks of flow, TSS and nutrients within tributaries without the need to wait years to collect additional stream flow data. This approach could be applied to other watersheds throughout the region that lack long-term flow data from multiple tributaries but do have long-term data on other hydrologic parameters such as lake level.

We will set up and calibrate stream flow and water quality parameters simultaneously so that the parameters that effect both flow and water quality do not overly emphasize a good fit for one at the expense of another. In addition, our water quality data is at the sub-basin level, so running these simultaneously helps ensure we are not overly generalizing flow parameters and that we are capturing sub-basin processes.

## 4.1 Model Setup and Initialization

This project will model the entire Canandaigua Lake watershed using the SWAT 2012 version 10.21 model. Model setup is outlined in Section 1.6, including model input data sources, slope classifications, and numbers of sub-basins and HRUs. For water quality parameters, we will utilize manure and fertilizer management practices established as part of the Cayuga Lake TMDL processes (e.g., Knighton et al. 2017, Pluer et al. 2019), along with rates utilized in the other Finger Lakes SWAT models and local knowledge, for input into the SWAT model. We will utilize the default settings from SWAT for other land use inputs.

For model setup, we will run the flow and water quality parameters on the CLWC data from 2000 to 2008 to determine the parameter range. We will use the discharge from the Mass Balance Model from 2000 to 2008. The year 2000 will act as the model warm up period, and the 2001 to 2008 data will be the model setup period. The Canandaigua Lake Watershed Council has monitored 17 major tributaries, which account for over 70% of the watershed area, for water quality during storm and baseflow events. We will run the model setup using 70% of the data (from 2001 to 2007) from the CLWC monitoring dataset to reduce the initial uncertainty of SWAT parameters and identify behavioral parameter values that lead to plausible model simulations (i.e. rule out ranges of SWAT parameters that perform very poorly with respect to the CLWC data). Because SWAT needs nutrient data in terms of loads, we will convert the nutrient concentrations to loads by normalizing the inflows from the lake mass balance model for sub-basin area.

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| **Model Setup and Initialization:** See Amendment Box under Section 1.6. |

## 4.2 Model Parameterization (Calibration)

We will run the model calibration for the water quality parameters using the 2019 DEC data and the 2020 CLWC data. The parameters will be constrained by the parameter ranges from the model setup. This calibration run will provide a parameter range with the fully approved data. Because SWAT needs nutrient data in terms of loads, we will convert the nutrient concentrations to loads by normalizing the inflows from the lake mass balance model for sub-basin area. If the results are not satisfactory after this calibration, we will run another calibration, constraining the parameter ranges using the average of the parameter ranges from the set up and calibration runs, and utilizing the entire dataset in the calibration (2001 to 2007 CLWC, 2019 DEC and 2020 CLWC data).

SWAT will be calibrated using SWAT-CUP and will generally follow the guidance provided by Abbaspour et al., 2004, 2005, and 2007. This is a standard approach to SWAT calibration. It includes a sensitivity analysis. Ideally, we would like to achieve a Nash-Sutcliffe Efficiency (NSE) greater than 0.36, a threshold commonly agreed to indicate satisfactory calibration/validation at the daily timestep for flow (e.g., Tang et al. 2012). A paired daily time series will be graphed of the SWAT model output and the Mass Balance Model to visually inspect model performance. For pollutants, our target NSE values relative to our flow NSE values are: TSS NSE = 0.71 Flow NSE, TP NSE = 0.70 Flow NSE, and N = 0.60 Flow NSE. Using our flow NSE = 0.36, the corresponding pollutant NSE values would be: TSS NSE = 0.26, TP NSE = 0.25, and N NSE = 0.22.

We will also compare calibrated parameters to those that were used on Cayuga and Owasco Lakes for TMDL and 9E plans, respectively. Having modeled several watersheds, we have found that the model parameters have not varied much regionally, so we anticipate Canandaigua Lake's watershed parameters should be reasonably similar. While we have no specific thresholds beyond the NSE, these other approaches to validation are important to report given this novel situation (having limited direct discharge measurements).

**See Attachment 2 for more details**

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| **Model Parameterization (Calibration):** See Amendment Boxes under Sections 1.6 and 1.7. |

## 4.3 Model Corroboration (Validation and Simulation)

Model Validation

To validate the model, we will assess the model performance for discharge during an independent 10-year time period using the parameters from the calibration. The Lake Mass Balance Model from 2009 to 2020 will act as the primary validation data. This dataset has a much longer time period than any measured stream discharge, which allows us to capture more year to year variability during the validation process. The model validation performance assessment will focus on achieving satisfactory NSE values. Model output and the Lake Mass Balance Model will be graphed together on a paired daily time series to visually assess model performance. If the NSE is below our threshold, model calibration will be modified based on data availability and the validation process will be repeated with updated model parameters.

Given the unique methodology of calibrating to the Mass Balance Model, we will then run a second validation analysis (a correlation analysis) on the West River sub-basin to ensure the model also works at the sub-basin level. This second analysis will utilize discharge from the USGS West River gage from April 2019 to 2020.

For water quality parameters, we will validate the model to the remaining 30% of CLWC data that was not used in calibration and the DEC 2020 data. Because SWAT needs nutrient data in terms of loads, we will convert the nutrient concentrations to loads by normalizing the inflows from the lake mass balance model for sub-basin area.

We will generally compare our results to the thresholds of model acceptance presented in SWAT-CUP manual.

Model Scenarios

The SWAT model will also be used to assess potential pollutant load reductions from a variety of best management practice scenarios. The model output from 2009 to 2019 will act as the existing conditions. Then, best management practice scenarios will be applied to the watershed and the model run using the same parameters. The percent reductions will be calculated to compare the best management practice scenario to existing conditions.

**See Attachment 3 for more details**

**Model Corroboration (Validation and Simulation):** The SWAT model was used to assess potential pollutant load reductions from a variety of best management practice scenarios. We used model output from the entire 21-year record (2000-2020), rather than the period between 2009 to 2019, to act as a baseline for these scenarios.

## 4.4 Reconciliation with User Requirements

As previous stated, the objectives of this modeling project are to 1) assess relative pollutant loading to Canandaigua Lake from subwatersheds to highlight and prioritize areas for management, 2) gain an understanding of the scope and scale of best management practices required to reduce nutrient and sediment loading to the lake, and 3) meet the criteria for a 9 Element Plan. Our data quality objectives for the model reflect these model uses. Regardless, all models have limitations, and these will be noted when using model results.

If any model performance analysis is outside of our acceptable range, we will check for errors in model setup parameters and recalibrate the model. We have multiple sources of input data available for topography and land cover, so we can try to recalibrate with the alternative input data source to see if model performance improves. Furthermore, the SWAT model allows the user to define the number of sub-basins and HRUs, with the benefit of balancing computing requirements with the resolution for model processing. We can also try changing the number of sub-basins and HRUs and then recalibrating to determine if this improves model performance.

If the model fails to perform adequately, after attempts at recalibration, the best results will be presented to the Project Manager. Any deviation from the expected model performance criteria will be documented in the final report.

**Reconciliation with User Requirements:** No changes.

## 4.5 Reports to Management

Cornell University will provide updates on the modeling process and results to the Canandaigua Lake Watershed Council through monthly meetings. As the modeling process proceeds, we will conduct quarterly meeting with NYSDEC to review progress, discuss current or anticipated issues. During the NYSDEC guided simulation phase, we anticipate including NYSDEC in our monthly meetings.

Communications will include the sharing of graphical output via emails and phone conferences. The Project Manager will be responsible for organizing reporting to NYSDEC. The final report requires review and approval by NYSDEC before any release, publication (electronic or hardcopy) or public presentation concerning modeling results. A final report will be completed at the end of the project, as specified in Section 5.0.

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| **Reports to Management:** Meetings were conducted at periodic intervals as needed. |

# 5.0 REPORTS

**Completed and submitted modeling reports must include each of the following:**

1. *Introduction and Background*
2. *Purpose of Modeling/Modeling Objectives*
    a. *Scope and Approach for Each Model Used (including):*
    b. *Physical Setting (and Hydrology, if applicable)*
3. *Observational Data Used to Support Modeling*
    a. *Quality of Acquired Data (and references to data quality reports)*
    b. *Achievement in Meeting Data Acceptance Criteria*
    c. *References to Monitoring Data*
    d. *Discussion on Excluded Data and Basis for Exclusion*
    e. *Description of the Model (including):*
4. *Documentation of Candidate Model Assessments*
    a. *Model Configuration (discusses how model was applied, including):*
        i. *Spatial and Temporal Resolution*
        ii. *Nature of Grid, Network Design or Sub-watershed Delineation*
        iii. *Application of Sub-models (if applicable)*
        iv. *Model Inflows Loads and Forcing Functions*
        v. *Key Assumptions (and associated limitations, if any)*
        vi. *Changes and Verification of Changes Made in Code*
    b. *Model Parameterization (Calibration) and Corroboration (Validation)*
        i. *Objectives, Activities and Methods*
        ii. *Parameter Values and Sources*
        iii. *Rational for Parameter Values Estimated in the Absence of Data*
        iv. *Calibration Variables and Targets*
        v. *Measures of Calibration Performance*
        vi. *Calibration Input, Output and Results Analysis*
        vii. *Model Validation Results*
    c. *Model Use Scenario Analysis and Results (should relate to purpose)*
        i. *Output of Model Runs and Interpretation*
        ii. *Summary of Assessments and Response Actions, if any*
        iii. *Soundness of the Calibration, Validation and Simulations*
        iv. *Review of Initial Assumptions and Model Suitability Evaluation*
    d. *Performance Against the Performance Criteria Including:*
        i. *Model Parameterization (Calibration) and Corroboration (Validation)*
        ii. *Model Sensitivity and Uncertainty Analyses*

5. *Pre- and Post-Processing Software Development*
6. *Maps, Photographs and Drawings*
7. *Deviations from the QAPP Including a List of Non-Applicable Reporting Elements with Explanations*
8. *Conclusions, Recommendations, References and Attachments*

| **Reports:** No changes. |
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## 6.0 REFERENCES

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## ATTACHMENT A - EPA Council for Regulatory and Environmental Modeling (CREM) Guidelines for Model Development

Note: ***Detailed guidance on model development, evaluation and application may be found in the EPA Council for Regulatory and Environmental Modeling (CREM) document at the following address:*** http://www.epa.gov/crem/library/cred_guidance_0309.pdf

**Summary of Recommendations for Model Development**

►Regulatory models should be continually evaluated as long as they are used.
►Communication between model developers and model users is crucial during model development.
►Each element of the conceptual model should be clearly described (in words, functional expressions, diagrams, and graphs, as necessary), and the science behind each element should be clearly documented.
►When possible, simple competing conceptual models/hypotheses should be tested.
►Sensitivity analysis should be used early and often.
►The optimal level of model complexity should be determined by making appropriate tradeoffs among competing objectives.
►Where possible, model parameters should be characterized using direct measurements of sample populations.
►All input data should meet data quality acceptance criteria in the QA project plan for modeling.

**Introduction**

Model development begins after problem identification i.e., after identification that an environmental problem needs to be addressed and after determining that models may provide useful input for the decision making needed to address the problem. In this guidance, model development comprises the steps involved in (1) confirming whether a model is, in fact, a useful tool to address the problem; what type of model would be most useful; and whether an existing model can be used for this purpose; as well as (2) developing an appropriate model if one does not already exist. Model development sets the stage for model evaluation, an ongoing process in which evaluates the appropriateness of the existing or new model to help address the environmental problem.

Model development can be viewed as a process with three main steps: (a) specify the environmental problem (or set of issues) the model is intended to address and develop the conceptual model, (b) evaluate or develop the model framework (develop the mathematical model), and (c) parameterize the model to develop the application tool. Model development is a collaborative effort involving model developers, intended users, and decision makers (the "project team"). The perspective and skills of each group are important to develop a model that will provide an appropriate, credible, and defensible basis for addressing the environmental issue of concern.

A "graded approach" should be used throughout the model development process. This involves repeated examination of the scope, rigor, and complexity of the modeling analysis in light of the intended use of results, degree of confidence needed in the results and resource constraints.

## ATTACHMENT B – QAPP Guidelines for Use of Models for Comparative Purposes

Occasionally, comparative modeling is used, for example, to evaluate potential water flow and water quality benefits from combinations of storm water management practices and designs that have yet to be implemented. A cost benefit analysis of varying designs and design combinations may be the basis for this type of modeling. In these types of instances, the following should be addressed in the quality assurance project plan (QAPP) and included in a report.

- Definition of the Base Line Conditions - the specific conditions, parameters and values that define the baseline condition.
- Criteria for Comparisons - the terms for comparing the model simulation results to the base line condition. For example, the terms may be found in quantities or percentages of runoff, infiltration or storm water contaminant loads.
- Identify Significant Change from Baseline - the application of statistical tools and criteria used to determine if there are significant differences between the baseline condition and model simulation results.
- Identify Simulation Scenarios from Sensitivity Analysis - how the simulation scenarios take into account what is understood from the model sensitivity analysis.
- Corroboration of Model Outputs - use of literature searches, calculations and, for example, the growing number of storm water performance databases to "ground truth" the projected water flow and/or water quality benefits from storm water management designs. Some examples include the following:

1. EPA Urban Best Management Practices Performance Tool http://cfpub.epa.gov/npdes/stormwater/urbanbmp/bmpeffectiveness.cfm
2. University of New Hampshire Stormwater Center http://www.unh.edu/erg/cstev/pubs_specs_info.htm
3. University of Massachusetts Stormwater Technologies Clearinghouse http://www.mastep.net/
4. International Stormwater Database http://www.bmpdatabase.org/
5. National Pollutant Removal Performance Database, September 2007 http://www.cwp.org/Downloads/bmpwriteup_092007_v3.pdf
6. Center for Watershed Protection http://www.cwp.org/PublicationStore/special.htm#pollut2
7. Boston Metropolitan Area Planning Council - Massachusetts Low Impact Development Tool Kit http://www.mapc.org/regional_planning/LID/LID_Links_References.html#national
8. EPA Low Impact Development Literature Review http://www.epa.gov/owow/nps/lid/lid.pdf and http://newmoa.org/prevention/webconferences/stormwaterweb/stormwaterresources.pdf

## ATTACHMENT C - Useful Project Plan Guidelines for Model Evaluation and Documentation

The following list provides additional useful project plan specifications, as appropriate, for model evaluation and documenting the results of model evaluation as conducted during model development and application (EPA 2009, NRC 2007):

**Peer review**

Document any critical review of a model or its application conducted by qualified individuals who are independent of those who performed the work, but who collectively have at least equivalent technical expertise to those who performed the original work. Peer review attempts to ensure that the model is technically adequate, competently performed, properly documented, and satisfies established quality requirements through the review of assumptions, calculations, extrapolations, alternate interpretations, methodology, acceptance criteria, and/or conclusions pertaining from a model or its application (modified from EPA 2006a).

To be most effective and maximize its value, external peer review should begin as early in the model *development* phase as possible (EPA 2006b). Because peer review involves significant time and resources, these allocations must be incorporated into components of the project planning and any related contracts. Peer review in the early stages of model development can help evaluate the conceptual basis of models and potentially save time by redirecting misguided initiatives, identifying alternative approaches, or providing strong technical support for a potentially controversial position (SAB 1993, EPA 1993). Peer review in the later stages of model development is useful as an independent external review of model code (i.e., model verification). External peer review of the *applicability* of a model to a particular set of conditions should be considered well in advance of any decision making, as it helps avoid inappropriate applications of a model for specific regulatory purposes (EPA 1993).

**Test cases**
Provide for basic model runs where an analytical solution is available or an empirical solution is known with a high degree of confidence to ensure that algorithms and computational processes are implemented correctly.

**Corroboration of model results with observations.**
Include comparison of model results with data collected in the field or laboratory to assess the model's accuracy and improve its performance.

**Benchmarking against other models.**
Include comparison of model results with other similar models.

**Sensitivity and uncertainty analysis.**
Conduct investigation of the parameters or processes that drive model results, as well as the effects of lack of knowledge and other potential sources of error in the model.

**Model resolution capabilities.**
Identify the level of disaggregation of processes and results in the model compared to the resolution needs from the problem statement or model application. The resolution includes the level of spatial, temporal, demographic, or other types of disaggregation.

## ATTACHMENT D. Project/Task Description and Schedule

**For completion of Section 1.6. Project/Task Description and Schedule**

Table is included in Section 1.6

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|---|
| **Project/Task Description and Schedule:** See Amendment Box under Sections 1.6. |

## ATTACHMENT E. Documentation of Watershed Model Flow and Chemistry Calibration

**For completion of Section 4.2. Model Parameterization (Calibration-Hydrology)**

| **Category** | **Description** |
|---|---|
| Gaging stations | 2000-2008 Lake Mass Balance Model data, which was developed by Watershed Council and approved by DEC as part of a Water Supply Permit Application, will be used as the measured data for modelling purposes. |
| Calibration locations | Lake outlet |
| Calibration timeframe | 2000-2008 |
| Number of flow data points | 9 years of daily data (2000-2008) from water balance document will be used as the flow at the lake outlet |
| Flow Calibration tolerance | ● Nash Sutcliffe Model Efficiency (NSE) > 0.36 for overall flow, which is used as a threshold for satisfactory in peer-reviewed literature<br>● |
| Flow Calibration documentation | ● Paired daily time series of observed versus predicted flow data<br>● NSE value |

**For completion of Section 4.2. Model Parameterization (Calibration-Chemistry)**

| **Category** | **Description** |
|---|---|
| Chemistry parameters | ● Total phosphorus<br>● Total suspended solids TSS<br>● NO3 yield |
| Number of points for initial setup | ● 17 major tributaries monitored by CLWC during storm events for total phosphorus, TSS and nitrate/nitrite – will utilize 70% of this dataset<br><br>If additional points are needed, data from segment analyses may be utilized:<br>● Deep Run and Fall Brook – Samples collected from 2016 -2018 during 5 storm events. Approximately 10 segments per stream were sampled. All data was analyzed at a NYSDOH ELAP certified lab, was collected by CLWC staff and was covered by FLLOWPA funding QAPP.<br>● Sucker Brook - Sampled at 23 locations from Sept. 2008 – July 2010 (N=7 sampling events). Analytes were TP, TKN, NOx, TSS.<br>● Eelpot Creek - Sampled at 11 locations from Sept. 2006 – Feb. 2009 (N=7 sampling events). Analytes were TP, NOx, TSS. |
| Number of points for calibration | ● DEC Rapid Assessment Program data from 2019<br>● 2020 CLWC monitoring data from 7 streams |
| Chemistry Calibration tolerance | ● TSS NSE = 0.26<br>● TP NSE = 0.25<br>● N NSE = 0.22 |
| Chemistry Calibration documentation | ● Paired daily time series of chemistry observed and modeled<br>● NSE value |

**Documentation of Watershed Model Flow and Chemistry Calibration:** See Amendment Boxes under Sections 1.6 and 1.7.

## ATTACHMENT F. Documentation of Watershed Model Flow and Chemistry Validation

**For completion of Section 4.3. Model Collaboration (Validation and Simulation)**

| **Category** | **Description** |
|---|---|
| Flow Validation | • 10 years of daily data (2009-2020) from water balance document will be used as the flow at the lake outlet<br>• Discharge from USGS stream gage on the West River in the Town of Middlesex installed in 2019 |
| Flow Validation Documentation | • Paired daily time series of observed versus predicted flow data<br>• NSE value |

| | |
|---|---|
| • Chemistry Validation | • 17 major tributaries monitored by CLWC during storm events for total phosphorus, TSS and nitrate/nitrite – will utilize remaining 30% of this dataset that was not used in initial calibration<br>• 2020 DEC Rapid Assessment Survey |
| Chemistry Validation documentation | • Paired daily time series of chemistry observed and modeled |

**Documentation of Watershed Model Flow and Chemistry Validation:** See Amendment Boxes under Sections 1.6 and 1.7.

**APPENDIX C - Part 2**

# Data Usability Assessment Report for Canandaigua Lake Watershed SWAT Model Datasets

## 04/03/2023

Canandaigua Lake Watershed Council

Prepared by:



| | |
|---|---|
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**Abstract:**

This document provides a summary of environmental data collected, a review of the quality objectives (DQO) and indicators (DQI), and evaluations required to assess the usability of data for the **Canandaigua Lake Watershed Soil and Water Assessment Tool (SWAT)** development. Data for model development was used according to the Amended Quality Assurance Project Plan Canandaigua Lake Watershed SWAT Model. This DUAR was completed on the 2001-2018 pre-DEC-QAPP dataset used for model calibration and validation.

Note: The date above indicates the date this DUAR was finalized as part of the 9E plan. The data review and acceptance for use in 9E watershed model development was completed in 2021.

# 1. PROJECT MANAGEMENT

## 1.1. Approval Sheet

Managers and Participants: The undersigned parties certify that the Data Usability Assessment Report (DUAR) presented herein accurately represents their planning and execution efforts with regard to the aforementioned completed.

Kevin Olvany sign here | 6/21/23

**Project Manager** | **Date**
**Kevin Olvany, Canandaigua Lake Watershed Council**

*I certify that I have personally examined and am familiar with the environmental information being submitted. Based on my inquiry of those persons immediately responsible for the sample collection, handling and data management of the environmental information being submitted, I believe the information to be true, accurate and complete.*

sign here | 7/25/2023

**Technical Advisor, Anthony Prestigiacomo, Division of Water, Finger Lakes Watershed Hub, NYSDEC** | **Date**

*The Technical Advisor has reviewed the DUAR and certifies that the DUAR has been completed using the proper format and required contents. The Technical Advisor's certification does not guarantee the overall quality of the project described by the DUAR.*

sign here

**Lindsey DeLuna, AQAO** | **Date**
**NYS DEC Division of Water**

## 1.2. Table of Contents

## 1.3. Data Usability Assessment Summary

The goal of this data usability assessment is to define the procedures used to collect and compile environmental data from a completed project. This DUAR summarizes the pertinent information from CLWC's 2001-2018 pre-DEC-QAPP data collection program to demonstrate acceptability for use. The data from that program was used in the calibration and validation of the SWAT model used in the development of Canandaigua Lake's 9E plan. The results from data **verification** of the field sampling and analytical procedures with the results of the data **validation** are provided as a summary. Additionally, a comparison of the 2001-2018 pre-DEC-QAPP data with DEC-approved-QAPP data is provided as additional support in the pre-DEC-QAPP data's use in 9E model development.

The Canandaigua Lake Watershed Council has an extensive tributary water quality dataset that spans many years (2001-present), accounts for a significant portion of the watershed's drainage area (18 locations), and represents a variety of land cover and weather conditions (35 event-based samples pre-DEC-QAPP, 12 monthly baseline samples in 2007/08). A DEC-Approved QAPP was developed in 2019 for CLWC monitoring. The 2001-2018 pre-DEC-QAPP data was collected in the same mapped locations, by the same CLWC personnel, and using the same methodology as outlined in the 2019 QAPP. All of the water samples were analyzed at an ELAP-certified laboratory. All pre-QAPP data was reviewed annually by the Watershed Program Manager for usability in watershed analysis and management by CLWC. This DUAR is a compilation and review of all pre-QAPP data and data quality for use in the 9E SWAT model project.

The 2001-2018 pre-DEC-QAPP dataset is of sufficient quality for use in the SWAT model. To further support data usability, comparative analyses between the 2001-2018 pre-DEC-QAPP data and the DEC-Approved-QAPP data showed the pre-DEC-QAPP dataset was comparable and representative of the DEC-Approved-QAPP dataset.

## 1.4. Detail Summary of CLWC's 2001-2018 pre-DEC-QAPP Dataset

**Table 1.** Summary of pre-DEC-QAPP dataset

| Section | Description of CLWC's 2001-2018 pre-DEC-QAPP Data |
|---|---|
| A4. Project/Task Org. | Data collected and reviewed by the Canandaigua Lake Watershed Council<br>Kevin Olvany, Watershed Program Manager |
| A5. Problem Definition/ Background | Canandaigua Lake is a drinking water source for 70,000 people and is used by thousands of people each year for recreation. To protect these uses, we must understand the sources of pollution to the lake from the watershed. The Canandaigua Lake Watershed Council has been monitoring 17 major tributaries that drain more than 70% of the watershed for almost 20 years. Monitoring focuses on nutrient and sediment pollution during storm and melt events, but has also analyzed baseflow conditions. The data from this long-term monitoring program is used to identify subwatersheds with water quality problems, prioritize areas for further monitoring and research, select areas for water quality improvement projects, and to calibrate and validate the watershed SWAT model. |
| A6. Project/Task Description | This project collected nutrient and sediment water quality data for the Canandaigua Lake watershed. The Canandaigua Lake Watershed Council has been monitoring 17 |

| Section | Description of CLWC's 2001-2018 pre-DEC-QAPP Data |
|---|---|
| | tributaries (See Table 2 for locations) to the lake for the past 20 years, which account for more than 70% of the drainage area. The focus for sampling has been on larger, watershed-wide storm events, but sampling also took place during baseflow conditions and during very high intensity, isolated events. To further understand nutrient sources, we have conducted segment analyses in subwatersheds that have been identified by monitoring data to have higher pollution risks. |
| A7. Quality Objectives and Criteria | All samples were analyzed by Life Science Laboratories, which is ELAP-certified (NYS DOH ELAP 10248).<br><br>See Table 3 for the 2001-2018 pre-DEC-QAPP data quality objectives |
| A8. Special Training/ Certification | None |
| A9. Documents/Records | Watershed Program staff maintains paper copies of all ELAP-certified laboratory results. Results were transcribed into an excel spreadsheet that contains all of the data from 2001 to present and is stored on a password-protected computer. Data was reviewed to ensure it met data usability standards. Paper and electronic versions of reports summarizing the data are stored at the Canandaigua Lake Watershed Council's office and password-protected computer. |
| B1. Sampling Process Design (Experimental Design) | The seventeen long-term monitoring sites were selected to represent a range of conditions, including subwatershed area and land cover, and are geographically distributed throughout the entire watershed. Samples were collected as close to the outlet into the lake as logistically feasible to reflect the pollutant concentrations entering the lake, though in some cases samples were collected at the outlet into a larger stream. An additional location was added in 2020 at the USGS gage on West River. |
| B2. Sampling Methods | Grab samples were collected by Watershed Council staff and tested for phosphorus, nitrate/nitrite, and total suspended solids. Sampling consisted of submerging an unpreserved pre-coded 500ml or 1000 ml bottle into a typical flow pattern of the stream and moving it up and down within the water column in order to obtain a representative sample. The first bottle was then poured into a second pre-coded 500ml bottle with $H_2SO_4$ (sulfuric acid - preservative for the phosphorus and nitrate/nitrite analysis). The first bottle was then re-submerged into the water column following the same methodology and the resulting sample was analyzed for total suspended solids (TSS). |
| B3. Sample Handling/ Custody Procedures | After sample collection, sample bottles were stored in a cooler on ice or in a refrigerator until received by the ELAP-certified laboratory. A chain-of-custody accompanied the samples and documented sample collection date and location. |
| B4. Analytical Methods | Life Science Laboratories, Inc is a certified (ELAP #10248) testing facility and follows the Environmental Protection Agency's analytical standard methods which are available for all data on COCs and lab reports to CLWC. LOD and LOQ are known and meet the needs of the sampling program. |
| B5. Quality Control | See Table 3 for quality objectives. All samples were analyzed at an ELAP certified lab using standard methods. The Watershed Program Manager either collected samples or was in the field directly overseeing all sample collection. |
| B6. Instrument/Equipm | None |

| Section | Description of CLWC's 2001-2018 pre-DEC-QAPP Data |
|---|---|
| ent Testing, Inspection and Maintenance | |
| B7. Instrument/Equipment Calibration and Frequency | None |
| B8. Inspection/Acceptance for Supplies and Consumables | Sampling bottles were provided by Life Science Laboratories and were inspected by the Watershed Program staff prior to use. |
| B9. Non-Direct Measurements (I.e., Secondary Data) | None |
| B10. Data Management | Watershed Program staff was responsible for entering all field information into Excel spreadsheets. The Project Manager received paper and/or electronic data packets from the analytical laboratory and reviewed for completeness and accuracy. Hard copies of field forms or lab results are stored in a secure location in the Project Manager's office. Electronic copies of data are stored on the Project Manager's password protected work computer. |
| C1. Assessment and Response Actions | Contract laboratory staff notified the Project Manager of any unanticipated problems that arose during this project and any corrective actions taken were documented. |
| C2. Reports to Management | The 2009 Long Term Water Quality Report: Health of Canandaigua Lake and Its Tributary Streams (https://www.canandaigualake.org/_files/ugd/a5c0cd_055cc8bbc2d1404db6611203d86438d9.pdf) and 2014 Comprehensive Update to the Canandaigua Lake Watershed Management Plan (https://www.canandaigualake.org/_files/ugd/a5c0cd_6aca7062d8464848bb9d9c0df23edca6.pdf) summarize the results from this project. |

**Table 2. Long-term monitoring locations**

| Site Code | Sampling Location | GPS Coordinates | |
|---|---|---|---|
| | | North | West |
| T-1 | Sucker Brook | 42.881006 | -77.280876 |
| T-2 | Tichenor Gully | 42.818379 | -77.287362 |
| T-3 | Menteth Gully | 42.798336 | -77.302265 |
| T-4 | Barnes Gully | 42.782248 | -77.315387 |
| T-5 | Seneca Point Gully | 42.743738 | -77.339820 |
| T-27A | South Bristol Direct Drainage - Cook's Point | 42.705432 | -77.360126 |
| T-12 | Lower Naples Creek - Rt 245 | 42.625921 | -77.390029 |
| T-8 | Eelpot Creek | 42.602848 | -77.421613 |
| T-9 | Reservoir Creek | 42.605174 | -77.412789 |
| T-10 | Tannery Creek | 42.609208 | -77.404397 |
| T-7 | Grimes Glen | 42.610266 | -77.405138 |
| T-13 | Lower West River - Sunnyside | 42.656770 | -77.330804 |
| T-14a | West River at USGS gage | 42.70467 | -77.27584 |
| T-17 | Vine Valley Creek | 42.724520 | -77.327895 |
| T-18 | Fisher Gully | 42.773647 | -77.295918 |
| T-19 | Gage Gully | 42.797007 | -77.270414 |
| T-20 | Deep Run | 42.821091 | -77.259116 |
| T-21 | Fall Brook | 42.870579 | -77.251166 |

**Table 3:** Data Quality Objectives and Assessments

| Data Quality Objective (DQOs) | Description | Assessment (calculation) | Acceptability Criteria |
|---|---|---|---|
| *Precision* | the degree in which two measurements agree | | Not applicable |
| *Accuracy/bias* | the degree of agreement between a sample and a true value or an accepted reference | 1. Matrix spikes (MS)<br>2. Laboratory control samples (LCS) | Reviewed lab results and discussed flags with lab manager if needed |
| *Representativeness* | degree to which samples accurately and precisely represent environmental conditions | 1. Site selection criteria used matches project goals.<br>2. Sample collection method representative of stream conditions – collected mid-stream in area of greatest flow. | Checked to see samples made sense with field conditions |
| *Completeness* | the number of valid measurements taken from the number of total measurements taken in the entire project | verified from data sampling plan, data deliverables and completed COC | Lab results checked against field observations and conditions |
| *Comparability* | confidence with which one set of data can be compared to another | comparison of two data sets | Documented sampling locations, personnel, and collection methods, standard analytical methods, holding times, consistent detection limits, common units and consistent rules for reporting |
| *Detection/ Quantification* | Levels of Detection (LOD) and quantification (LOQ) for a specific method and matrix | For methods with no published detection limit, Laboratory calculated LOD/LOQ are used. | LOD (Level of Detection)– for a specific method and matrix, minimum concentration an analyte can be determined to be significantly different from a blank. LOQ (Level of Quantification)– concentration level above which values are associated with a high degree of confidence. |

# Section 2. DATA REVIEW AND EVALUATION

Section 2 is a summary of the procedures used to review and evaluate the data generated from the project.

## 2.1. Data Review, Verification and Validation

**Data Verification** is a process in which different types of data are checked for accuracy and inconsistencies after data migration is done. It is the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements. It helps to determine whether data was accurately translated when data is transferred from one source to another, is complete, and supports processes in the new system.

**Data Validation** is an analyte- and sample-specific process that extends the evaluation of data beyond method, procedural, or contractual compliance (i.e., data verification) to determine the analytical quality of a specific data set. Data validation means checking the accuracy and quality of source data before using, importing or otherwise processing data.

## 2.2. Verification and Validation Methods

### *2.2.1. Data Verification*

Use the following steps to verify the field and laboratory data once all is compiled. For reference to expected visits, number of samples, etc., refer to the appropriate Quality Assurance Project Plan. Verification reports are modified from USEPA (2002).

Table 4. Verification Process

| Verification Process | Complete | Notes/Comments |
|---|---|---|
| **Field Data** | | |
| Are all field visits recorded with sites, dates, and analyst properly identified? | ☒ | |
| Are all photos and other data properly linked to field visit records? | ☐ | Not applicable |
| Are field visits properly linked to field data from instrumentation (example, multi-parameter probes)? | ☐ | Not applicable |
| Are field measurements be linked to a recorded calibration record or quality control check? | ☐ | Not applicable |
| Are all field visits, environmental observations, and instrument data accounted for? | ☒ | |
| Are the field data file finalized with appropriate notes/qualifications? | ☐ | Not applicable |

| Verification Process | Complete | Notes/Comments |
|---|---|---|
| **Analytical Data** | | |
| Are sample collections cross-linked to field site visits by site, date, and sampler? | ☒ | |
| Did the laboratory provide all expected data in laboratory reports (with lab quality control samples and data flags)? | ☒ | |

The 2001-2018 pre-DEC-QAPP dataset was verified.

### *2.2.2. Data Validation*

Use the following steps to validate the field and laboratory data once the verification process is completed. Validation reports are modified from USEPA (2002).

Table 5. Validation Process

| Validation Process | Complete | Notes/Comments |
|---|---|---|
| **Field Data** | | |
| Are data files consistent with expectations (field records)? | ☐ | Not applicable |
| Are all field probe calibrations and any/or quality control checks within specifications? | ☐ | Not applicable |
| **Analytical Data** | | |
| Are all planning documents and data to be validated properly assembled? | ☒ | |
| Have summaries of data verification to determine method, procedural, and contractual required QC compliance/non-compliance been reviewed? | ☒ | |
| Have the verified, reported sample results for the data set as a whole, including laboratory qualifiers, been reviewed? | ☒ | |
| Have the data and QC (field and laboratory) deficiencies been summarized? | ☒ | |
| Prepare analytical data validation report (Section D3-D4 below) | ☒ | |

The 2001-2018 pre-DEC-QAPP dataset was validated.

## 2.3. Evaluation of Data Quality Indicators and Objectives for Analytical Data

Watershed Council staff performed data (at least annually) reviews on the pre-DEC-QAPP data. If there were any laboratory flags, the Watershed Program Manager communicated with the laboratory manager to determine if the flag would impact the usability of the data. If Watershed Council staff found any discrepancies between sample results and expected value ranges based on observed field conditions, the Watershed Program Manager asked the laboratory to run the analysis a second time on the same sample. All data included in the 2001-2018 pre-DEC-QAPP dataset was validated based on Watershed Council staff review and communication with the laboratory.

To further highlight the usability of the pre-DEC-QAPP dataset, the three following analyses were completed on the pre-DEC-QAPP and most recent data collected under QAPPs:

- Equipment Blank and Field Duplicates of Samples Collected with the Same Methodology
- Baseflow Water Quality Data Comparison
- Storm Event Visual Comparisons

### Equipment Blank and Field Duplicates of Samples Collected with the Same Methodology

The 2001-2018 pre-DEC-QAPP dataset did not include field blanks and sample duplicates. However, the 2001-2018 pre-DEC-QAPP samples were collected using the same methodology and by the same personnel as the samples collected in 2020. Therefore, equipment blanks and duplicates collected in 2020 provide an indication of pre-DEC-QAPP sample methodology performance for the CLWC monitoring program. The equipment blanks for total phosphorus, nitrate/nitrite and total suspended solids were all below the detection limit for the respective parameter in 2020 (Table 6). Therefore, the sampling methodology was not introducing any contaminants into the samples, meeting the criteria for accuracy/bias. The water quality samples and associated duplicates all had a relative percent difference less than 20% in 2020, indicating that the samples met the quality criteria for precision and representativeness (Table 7).

Equipment blanks and duplicates collected by CLWC in 2020 under an approved QAPP met quality criteria, providing confidence that the pre-DEC-QAPP dataset would have similar quality to that of the 2020 dataset.

Table 6. CLWC equipment blanks and associated water quality samples

| DEC Code (yyyymmdd_Fcccc_sssss-WS) | Date | Stream | Total P (mg/L) | Nitrate/Nitrite as N by Calc (mg/L) | Total Suspended Soils (mg/L) |
|---|---|---|---|---|---|
| LOQ Reporting Limit | | | 0.002 | 0.05 mg/l for nitrate and nitrite | <4 |

| | | | | | |
|---|---|---|---|---|---|
| 20200423_FONTA_0T14A_EB | 4/23/2020 | T14A EB | <0.002 | <0.1 | <4[1] |
| 20200408_FONTA_0T14A_EB | 4/8/2020 | EB | <0.002 | <0.1 | <4 |
| 20200426_FONTA_0T14A_EB | 4/26/2020 | T14A EB | <0.002 | <0.1 | <4 |
| 20200501_FONTA_0T14A_EB | 5/1/2020 | T14A EB | <0.002 | <0.1[2] | <4 |

1 - Note with TSS: This sample analysis did not meet the method required minimum residual weight for the sample volume provided. An insufficient sample volume was provided by the client. Therefore, this result should be considered to be an estimate.
2 - Note with Nitrogen: This sample was received at LSL after the analytical holding time had expired.

Table 7. CLWC water quality samples and associate duplicates

| DEC Code (yyyymmdd_Fcccc_ sssss-WS) | Date | Stream | Total P (mg/L) | | | Nitrate/Nitrite (mg/L) | | | Total Suspended Soils (mg/L) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample | Dup | RPD | Sample | Dup | RPD | Sample | Dup | RPD |
| 20200423_FONTA_ 00T12_WS | 4/23/2020 | T12 | 0.0047 | 0.0043 | 8.89 | 0.58 | 0.58 | 0.00 | <4 | <4 | Na[2] |
| 20200408_FONTA_ 000T3_WS | 4/8/2020 | T3 | 0.012 | 0.01 | 18.18 | 0.34 | 0.34 | 0.00 | <4 | <4 | Na |
| 20200426_FONTA_ 00T12_WS | 4/26/2020 | T12 | 0.019 | 0.018 | 5.41 | 0.51 | 0.51 | 0.00 | 11 | 12 | -8.70 |
| 20200501_FONTA_ 000T3_WS | 5/1/2020 | T3 | 0.053 | 0.053 | 0.00 | 0.43[1] | 0.43[1] | 0.00 | 22 | 21 | 4.65 |

1 - This sample was received at LSL after the analytical holding time had expired.

2 – Na – samples were < LOD.

**Baseflow Water Quality Data Comparison**

A comparison of water quality data during baseflow conditions is important, as it removes the inherent variability of rainfall distribution in the watershed, timing of sample collection, etc, that can impact storm and melt event sample concentrations. Baseflow was determined by lack of substantial rain for the previous 24 hours and a field assessment of the streams and watershed confirming there was no discernible runoff. A set of baseflow samples was collected by CLWC in 2007 and 2008 as part of the pre-DEC-QAPP dataset. Baseflow water quality samples were collected by CLWC and DEC in 2019 and 2020 that contained field QC samples as outlined in those program respective, DEC-approved QAPPs (Table 8).

The streams selected for monitoring and this analysis are representative of conditions within the Canandaigua Lake watershed. Subwatersheds contained a variety of predominant land cover types and were geographically distributed throughout the watershed. Furthermore, a cluster analyses was conducted to group subwatersheds that behave similarly. These streams represent at least one stream from each cluster. The streams analyzed in the baseflow analysis include:

- Sucker Brook
- Menteth Gully

- Reservoir Creek
- Naples Creek
- Deep Run
- Fall Brook

Table 8. Dates of baseflow sample collection.

| Pre-DEC-QAPP Dataset | DEC-Approved-QAPP Datasets | |
|---|---|---|
| | CLWC Data | NYSDEC Data |
| 2/26/2007 | 4/8/2020 | 7/15/2019 |
| 4/9/2007 | 4/23/2020 | 8/12/2019 |
| 5/3/2007 | 4/26/2020 | 9/17/2019 |
| 5/21/2007 | | 10/10/2019 |
| 6/8/2007 | | 6/1/2020 |
| 7/23/2007 | | 6/30/2020 |
| 8/30/2007 | | 8/12/2020 |
| 9/12/2007 | | 9/16/2020 |
| 10/10/2007 | | |
| 11/20/2007 | | |
| 1/5/2008 | | |
| 1/28/2008 | | |

Baseflow water quality data was comparable between the 2007-08 Pre-DEC-QAPP dataset and the 2019-20 DEC-Approved-QAPP datasets (Table 9). The relative difference between the medians for the two baseflow datasets was small, especially when compared to the range of concentrations experienced on these streams during runoff events. The DEC-Approved-QAPP data was collected from April through October, while the Pre-DEC-QAPP baseflow data was collected throughout the entire year. Even during baseflow conditions, natural variability can cause small differences in concentrations. Overall, the difference between the median baseflow concentrations from the Pre-DEC-QAPP and DEC-Approved-QAPP datasets is relatively small and within expected ranges. Furthermore, a comparison from 1997-99 baseflow phosphorus to the 2007-08 shows that baseflow conditions were stable over a long timeframe (Figure 1 – Source: 2014 Comprehensive Update to the Canandaigua Lake Watershed Management Plan).

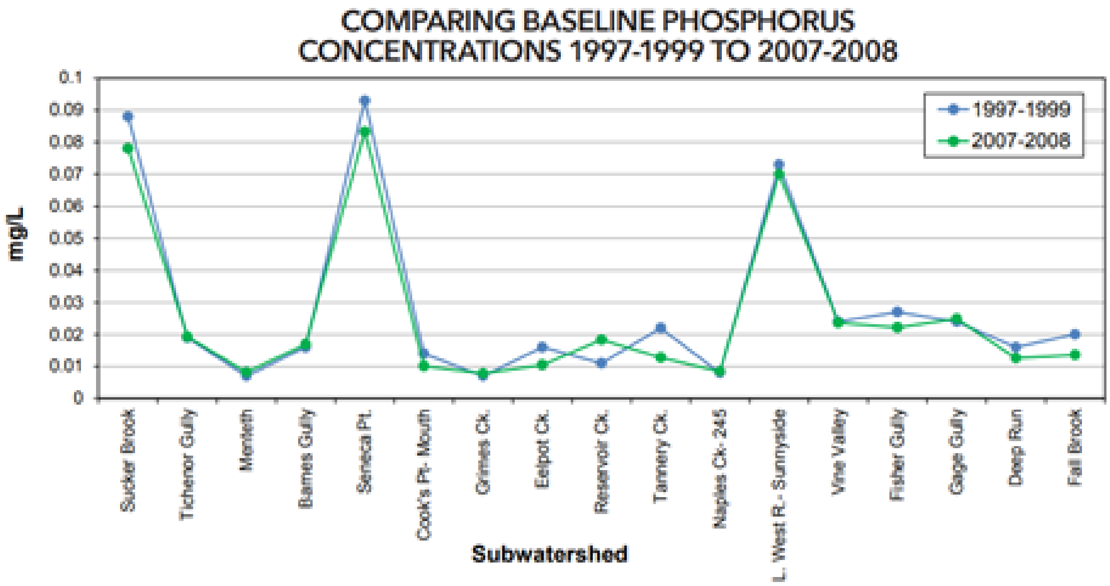



Figure 1. Baseflow comparison for pre-DEC-QAPP phosphorus dataset to an older baseflow dataset.

A Mann-Whitney U Test was conducted on baseflow (non-storm event flow) data to compare the site-specific medians of the CLWC 2007-08 Pre-DEC-QAPP dataset and the 2019-20 DEC-Approved-QAPP data. The median baseflow concentrations were not statistically different between the CLWC 2007-2008 Pre-DEC-QAPP data as compared to the 2019-20 DEC-Approved QAPP data when the p-value was greater than 0.05. For nitrate/nitrite and total phosphorus, five of the six locations were not statistically different between the two datasets (Table 9). For total suspended solids, three of the six locations were similar. However, the statistical analysis on TSS is problematic due to the high number of non-detectable concentrations during baseflow. Therefore, baseflow water quality is statistically similar between the two datasets and the comparability of the datasets further supports the quality of the 2001-2018 pre-DEC-QAPP data and its usability in the SWAT model.

Table 9. Results of the Mann Whitney U Test for baseflow samples comparing the CLWC 2007 to 2008 data (Pre-DEC-QAPP) with the CLWC and DEC data from 2019 and 2020 (DEC-Approved-QAPPs)

| **Nitrite/Nitrate (mg/L)** | | | | | |
|---|---|---|---|---|---|
| Location | CLWC Pre-DEC-QAPP Dataset | | DEC-Approved-QAPP Datasets | | |
| | Median | N | Median | N | P_Value |
| Sucker Brook | 0.51 | 12 | 0.41 | 11 | 0.57 |
| Menteth Gully | 0.51 | 12 | 0.41 | 3 | 0.28 |
| Reservoir Creek | 0.52 | 12 | 0.62 | 3 | 0.89 |

| | | | | | |
|---|---|---|---|---|---|
| Naples Creek | 0.73 | 12 | 0.64 | 11 | 0.65 |
| Deep Run | 1.20 | 8 | 1.60 | 3 | 0.63 |
| Fall Brook | 1.55 | 8 | 0.42 | 9 | 0.01 |
| | | | | | |
| **Total P (mg/L)** | | | | | |
| Location | | | | | P_Values |
| Sucker Brook | 0.054 | 12 | 0.080 | 11 | 1.00 |
| Menteth Gully | 0.009 | 12 | 0.004 | 3 | 0.61 |
| Reservoir Creek | 0.012 | 12 | 0.014 | 3 | 0.56 |
| Naples Creek | 0.005 | 12 | 0.013 | 11 | 0.04 |
| Deep Run | 0.013 | 8 | 0.020 | 3 | 0.41 |
| Fall Brook | 0.015 | 8 | 0.025 | 9 | 0.10 |
| | | | | | |
| **TSS (mg/L)** | | | | | |
| Location | | | | | P_Value |
| Sucker Brook | 2.00 | 12 | 3.80 | 11 | 0.34 |
| Menteth Gully | 2.00 | 12 | 2.00 | 3 | 0.74 |
| Reservoir Creek | 2.00 | 12 | 7.00 | 3 | 0.12 |
| Naples Creek | 2.00 | 12 | 5.20 | 11 | 0.00 |
| Deep Run | 2.00 | 8 | 5.30 | 3 | 0.02 |
| Fall Brook | 2.00 | 8 | 6.30 | 9 | 0.01 |

**Storm Event Visual Comparisons**

Due to the inherent variability found during storm event sampling, the storm/melt event datasets were evaluated through a qualitative, visual assessment of concentration verses flow for total phosphorus, nitrate/nitrite, and total suspended solids. We compared the pre-DEC-QAPP dataset with the DEC-Approved-QAPP datasets (2020 CLWC and 2019-2020 DEC) by plotting concentrations versus overall model simulated flow. Figures 1, 2 and 3 show that the concentrations from the pre-DEC-QAPP data were of a similar range to the DEC-Approved-QAPP data at all levels of sampled flow. The visual assessment further shows the comparability of the datasets and supports the use of the pre-DEC-QAPP data in the SWAT model.

Figure 1. Tributary total phosphorus versus simulated flow

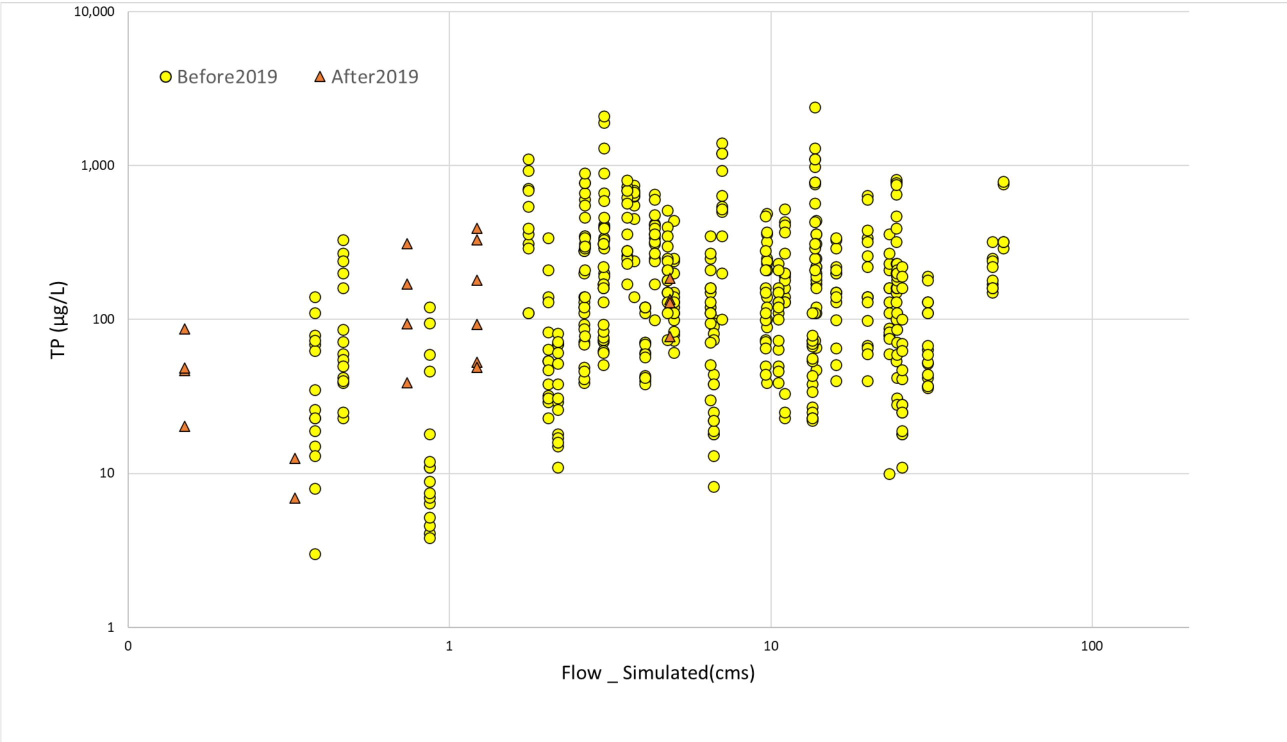



Figure 2. Tributary nitrate/nitrite versus simulated flow

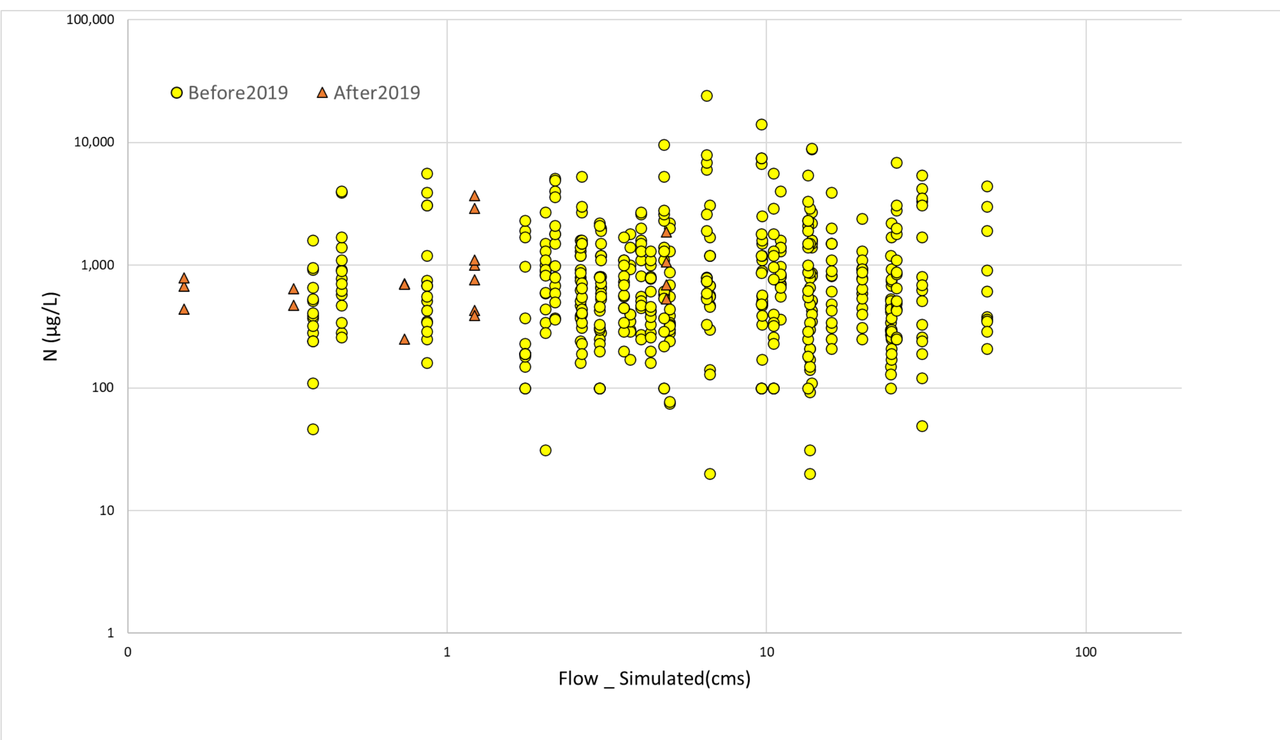
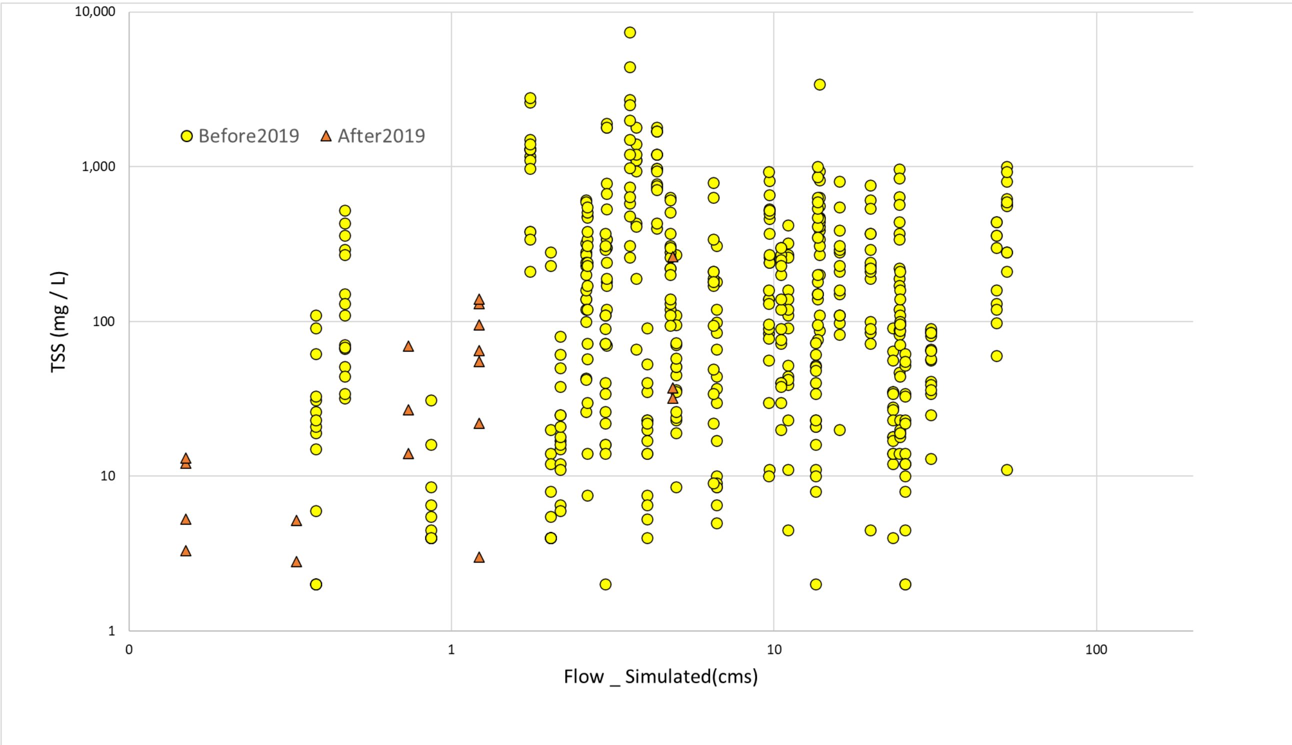


Figure 3. Tributary total suspended solids versus simulated flow




## *2.4. Evaluating Data in Terms of User Needs*

Based on the data verification and validation outlined in this DUAR, equipment blanks and duplicates from the same methodology, a statistical comparison of baseflow water quality samples, and a visual assessment of storm/event water quality samples, the CLWC 2001-2018 pre-DEC-QAPP dataset is of sufficient quality for calibrating and validating the Canandaigua Lake SWAT Model. This dataset is essential to the Canandaigua SWAT model, providing a significant number of calibration and validation data points that cover a wide breadth of watershed and weather conditions. Without use of the CLWC pre-DEC-QAPP dataset, the model would be based on a limited amount of water quality data that does not encompass the breadth of weather conditions, increasing model uncertainty and likely lowering model performance. Use of this dataset facilitated a more robust SWAT model, which far outweighs any uncertainty associated with the dataset.

# Canandaigua Lake SWAT Model Report

Prepared for: Canandaigua Lake Watershed Council

Prepared By: Cornell University Department of Biological & Environmental Engineering

April 2023

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# 1. Introduction

## 1.1. Background

For decades, municipalities within the Canandaigua Lake watershed, including those drawing their public water supply from the lake, have collaborated on effective lake and watershed management actions. These actions are guided by the Canandaigua Lake Watershed Management Plan, which was formally adopted in 2001 and updated in 2014. This 2023 Nine Element Plan supplements the 2014 Watershed Plan with a focused quantitative analysis of phosphorus, a key pollutant affecting water quality. The Nine Element Plan for Enhanced Phosphorus Management (Canandaigua 9E Plan) analyzes watershed sources of phosphorus and defines specific targets, actions, and locations for reducing inputs to Canandaigua Lake. Mathematical modeling of complex watersheds enabled the community to undertake this more quantitative approach to watershed management.

This Appendix details the mathematical modeling completed for the Canandaigua 9E Plan. Mathematical models facilitate knowledge-based watershed management decisions for protecting water quality, an integral component of a 9E Plan. Mathematical modeling supports a quantitative evaluation of several of the defined elements within the 9E framework:

- Identifying and estimating quantifiable sources of pollution in the watershed (Element A)
- Identifying a water quality target or goal and the necessary pollutant reductions required to achieve that goal (Element B)
- Identifying and evaluating best management practices that will achieve reductions needed to meet water quality goals and targets (Element C)
- Identifying criteria that will be used to assess water quality improvements as the plan is implemented (Element H)

This report summarizes development of the watershed model Soil and Water Assessment Tool (SWAT; version 2012 rev 365, Arnold et al.) to quantify phosphorus loading from the landscape to Canandaigua Lake. Cornell University Professors Dr. Scott Steinschneider and Dr. M. Todd Walter and doctoral student Mahnaz Sepehrmanesh of the Department of Biological and Environmental Engineering (BEE) customized the SWAT model to reflect conditions specific to the Canandaigua Lake watershed. The Cornell BEE team was responsible for model calibration and validation, analysis of model projections, and synthesis of results.

At the onset of the watershed modeling program, the modeling team submitted a Quality Assurance Project Plan (QAPP) for review and approval by the New York State Department of Environmental Conservation (NYSDEC). Several data-related issues arose during subsequent model development that required the modeling team to deviate from certain elements of the approved QAPP; rationale for these deviations is discussed in this document. An amended QAPP documenting all changes from the original plan was submitted for NYSDEC review. NYSDEC approved the amended QAPP in 2021 (the final approved modeling QAPP is included as Appendix C to the Canandaigua 9E Plan).

### 1.2 Modeling Objectives

The overall objective of developing a mathematical model of the Canandaigua Lake watershed is to provide information on the phosphorus flux from the landscape as a function of both environmental conditions (e.g., hydrology, meteorology, soils, slopes, land cover) and human factors such as management practices. Once the baseline (current) conditions are quantified and verified, the model can be applied to inform watershed managers on the types, extent, and locations of best management practices needed to reduce phosphorus load from the landscape.

The Canandaigua Lake Watershed SWAT model was developed using site-specific data and information. A robust water quality monitoring effort has been in place for decades by the Canandaigua Lake Watershed Council. Incorporating this extensive dataset into a mathematical modeling framework enables watershed managers to characterize phosphorus loading over a longer time and at a finer geographic resolution. The SWAT model identifies specific subwatersheds that contribute relatively large phosphorus loads to the lake; this information can help prioritize areas for management. Findings of the SWAT model inform the recommendations of the Canandaigua 9E Plan.

### 1.3 Canandaigua Lake Watershed Overview

The Canandaigua Lake covers approximately 109,700 acres (174 square miles) of Central New York's Finger Lakes region and is drained by a network of hundreds of streams and gullies that flow into the Lake (*refer to Figure 2 in the 2023 Nine Element Plan*). The tributary stream network totals more than 350 miles. Land cover is classified as 44.5% forested, 10.9% successional/old field, 28.2% active agriculture (cultivated fields and hay/pasture), 11% developed areas, and 5.4% wetlands.

The watershed is home to approximately 42,000 people within 12 municipalities. Canandaigua Lake is a source of drinking water to some 70,000 customers. Long-term water quality monitoring documents that Canandaigua Lake has excellent water quality that supports multiple uses; these uses include as a source of drinking water with minimal treatment, recreation in and on the water, aquatic habitat, and as an aesthetic resource. Residents and visitors enjoy boating, swimming, fishing, canoeing, kayaking, sailing, and sightseeing. The lake is a primary attraction, drawing people to work, live, and visit the area, providing a foundation for the local economy, and bolstering quality of life.

## 2. Modeling Software and Approach

The modeling software used for this project (SWAT 2012) was developed, maintained, and version controlled by Texas A&M University. The model has been in use since 2012, applied at numerous sites, and has a large user base. The SWAT model is a reliable tool for application to the Nine Element planning process and has been used across multiple Finger Lakes and other

New York lakes and rivers. As part of the model development and calibration process, the Cornell BEE team completed quality control reviews of the model predictions; however, quality control checks were not performed on the modeling software itself.

The modeling team made no changes or modifications to the code (SWAT 2012 Rev. 635). The routine SWATCUP 2019 was used for the calibration/validation process.

# 3. Model Setup, Calibration, and Validation

As with any modeling tool, overall precision and accuracy of the SWAT projections depend on availability, quantity, and quality of input and calibration data. The modeling framework must capture as many unique factors affecting sources and transport of phosphorus and other substances into the lake as necessary to accurately represent the system. The project team developed a SWAT model of the Canandaigua Lake watershed using specific data and information characterizing both the natural and developed land. Monitoring data from multiple streams in the Lake's subwatersheds representing a mix of land use and land cover conditions was an important input. These data sets originated from multiple sources, as summarized in this section. Note that the spatial, weather, land management, and land cover data utilized in the SWAT model were collected by other agencies/organizations or encompassed under a separate QAPP.

## 3.1 Model Setup

### 3.1.1 Watershed Land Cover, Topography, and Soils

The first step in constructing a SWAT model for a specific watershed is to compile the required data layers in GIS:

- Digital elevation model to define topography
- Soil type and hydrologic class and geology
- Land cover
- Land use
- Meteorological conditions

The Cornell modeling team used land cover and topography data for the Canandaigua Lake watershed that are collected and archived by state and federal agencies. The 30 m National Elevation Dataset (NED) digital elevation model was used to define the watershed, sub-watersheds, and land surface elevations (USGS, 2018). Land use information was sourced from the National Land Cover Database (Fry et al., 2011). Soils data originated from the USDA STATSGO dataset (note, these data are pre-loaded in SWAT).

Weather data – specifically, air temperature and precipitation - are required inputs to the SWAT model. The Cornell BEE modeling team consulted with colleagues at the Northeast Regional Climate Center to compile and analyze data from four nearby official weather stations (Canandaigua 3S, Hemlock, Penn Yan, and Dansville). Minimum and maximum air temperature and precipitation data represent averages of the same four stations. Solar radiation, windspeed, and relative humidity are calculated internally in SWAT. Data sources are summarized in **Table 1**.

Table 1. Sources of Input Data, SWAT Model Setup

| Type of Input Data | Data used in model | Source |
|---|---|---|
| Land surface elevation | Digital Elevation Model (DEM) -2018 | US Geological Survey (USGS) https://www.sciencebase.gov/catalog/item/619f2687d34eb622f696c1f5 |
| Land cover | National Land Cover Database (NLDC) 2016 | Federal Multi-Resolution Land Cover Consortium https://www.mrlc.gov/data?f%5B0%5D=category%3ALand%20Cover&f%5B1%5D=year%3A2016 |
| Soil type | STATSGO - Preloaded into SWAT model | |
| Slope | Extracted from DEM data, model uses 5 slope classes: 0-2%, 2-5%, 5-10%,10-20%, and greater than 20% | USGS |
| Air temperature (min and max) and Precipitation | Data from 4 Stations - Canandaigua 3S, Hemlock, Geneva Field Station, and Dansville- extracted from Northeast Regional Climate Center | https://www.nrcc.cornell.edu/ |
| Fertilizer and Dairy Manure Application Rates | Generalized assumptions for the Finger Lakes Region utilized in other SWAT models (baseline Owasco Lake Watershed 9E Plan, 2022) updated with information provided local agricultural agencies and partners | Canandaigua Lake Watershed Council |

### 3.1.2 Hydrology

The lack of a long-term stream gauging station within the Canandaigua Lake watershed posed a challenge to the SWAT modeling effort. Transport of phosphorus, nitrogen, and sediment from the landscape occurs primarily during precipitation and snowmelt events. Modeling transport of pollutants downstream to Canandaigua Lake requires knowledge of streamflow that reflects conditions in the watershed. Once developed and tested, the model can be used in a predictive manner to explore issues such as potential changes in load resulting from changing frequency, intensity, and magnitude of precipitation. In 2019, a USGS gauge was installed on the West River in the Town of Middlesex.

Fortunately, the modeling team was able to use a Lake Mass Balance Model of Canandaigua Lake developed to support a NYSDEC Water Supply Permit application (Permit ID 8-3202-00016/00003-2011). The Lake Mass Balance Model was developed using data from 2000-2009. The model is essentially a water balance for the lake, tracking water inflows and direct precipitation onto the lake surface, outflows and evaporation, and changes in water level. The flow of water leaving through the Lake outlet and feeder canal are gauged and daily water supply withdrawals are reported. Canandaigua Lake daily water surface elevation (lake level) is also gauged. Evaporative losses were estimated from the Northeast Climate Center. Precipitation data were utilized from four nearby official weather stations in collaboration with the Northeast Regional Climate Center. The Cornell SWAT modeling team updated the Mass Balance Model with data through 2019 to complete model setup, calibration, and validation as discussed below.

### 3.1.3 Subwatersheds and Hydrologic Response Units (HRUs)

The Canandaigua Lake watershed is comprised of five HUC12 sub-watersheds: Naples Creek, Bristol Springs, West River, Deep Run, and Sucker Brook. The delineation of subbasins in the SWAT model, using the inputs discussed in Section 3.1.1, resulted in 128 individual sub-watersheds that are generally comparable to the HUC12 scale. A few smaller subbasins were generated in SWAT due to the addition of outlet points at water quality monitoring locations along the stream network. Each sub-watershed was then further subdivided within SWAT into hydrologic response units (HRUs) consisting of areas with generally homogeneous slope, land cover, and soil characteristics. A total of 2968 HRUs were created within the watershed. This model set up supported water quality output at each monitoring location while still being computationally feasible to run. The SWAT model simulates flow and concentrations of water quality parameters at a daily time-step.

### 3.1.4 Water Quality Data

The Canandaigua Lake Watershed Council (CLWC) has monitored base flow and storm events on 17 major tributaries for nutrients and suspended sediment for the past 20 years, as displayed in **Figure 1.** The modeling team utilized the CLWC tributary monitoring dataset along with the NYSDEC Rapid Assessment Survey from 2019 and 2020 to calibrate and validate the SWAT model. The CLWC monitoring data collected under 2020 protocols were approved in the Model QAPP (Appendix B). Note that water quality data collected at one of the 17 locations, Fisher Gully, was not utilized in the model. It was not computationally feasible to include an outlet at this site to extract the simulations.

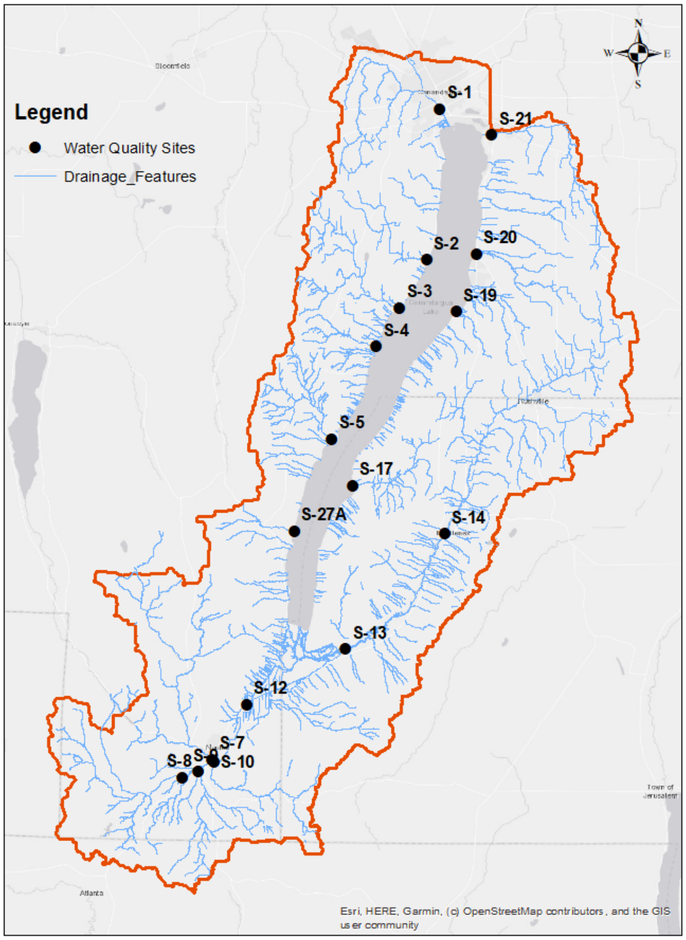


Figure 1. Location of Canandaigua Watershed Council water quality monitoring sites

### 3.1.5 Land Management Practices

Application rates and schedule for adding inorganic fertilizer and dairy manure to agricultural lands were consistent with practices across the Finger Lakes region. The values were reviewed and updated with information from the CLWC staff and other local agricultural experts. Assumptions used in the model set up regarding fertilization rates (inorganic and manure) applications to cultivated lands and hay/pasture are summarized in **Table 2.**

Table 2. Modeled Management Practices for Application of Manure and Fertilizers.

The model uses Elemental P. Phosphorus fertilizer is documented as $P_2O_5$. In order to calculate the conversion of Elemental P to $P_2O_5$, multiply Elemental P by 2.29 to convert to $P_2O_5$. 90 lbs of elemental P equals 206 lbs of $P_2O_5$ fertilizer.

| | Percentage of Watershed Agricultural Lands | Annual Schedule | Elemental P applied (lb/acre per year) | Elemental N applied (lb/acre per year) |
|---|---|---|---|---|
| High rates of manure and fertilizer application | 8% of cultivated land | Twice a year fertilizer application (May and June) and monthly manure application | 90 | 350 |
| Moderate rates of manure and fertilizer application | 34% of cultivated land | Twice a year fertilizer and manure application (May and June) | 25 | 175 |
| Low rates of manure and fertilizer application | 58% of cultivated land and 25% of hay/pastureland | Twice a year fertilizer application (May and June) | 20 | 100 |

#### 3.1.6 Point Sources

As described in the 2023 Canandaigua 9E Plan, phosphorus load from each wastewater treatment facility was set at its permitted value (that is, facilities were assumed to operate at their permitted discharge and permitted effluent phosphorus concentration).

### 3.2 Model Calibration

#### 3.2.1 Approach

The model calibration process consists of adjusting model input parameters such that the model reproduces trends in the observed data. Water quality analytes (phosphorus, nitrogen, and total suspended solids) were measured at the subbasin level (17 sites) but stream discharge was only measured at one site (USGS gage). Data from the USGS gauge site were used for model validation and thus not included in the calibration. Consequently, the Canandaigua SWAT model was calibrated for all observations (discharge and water quality) at the same time. Calibrating the model for discharge and water quality analytes at the same time helped ensure that the SWAT model could adequately simulate conditions at the subbasin level. The water quality data set was used to evaluate simulated conditions at the subwatershed level. The risk of calibrating sequentially (first for hydrology, then for water quality) would be selection of flow parameters that potentially only mimic flow at the basin level, thus losing information for the subbasins. Final calibration parameter values were derived through iterative runs of the model while implementing small model parameter changes based on a combination of graphical and statistical evaluations of the model's agreement with the available monitoring data. The optimal calibration parameters were selected after analysis of 2,000 simulations. The best simulation was selected considering not only the average NSE values for all sites and all parameters, but also the number of sites/parameters that produce positive NSE values. A total of 64 parameters were adjusted in the SWAT model to optimize the match of simulated and observed measurements (**Table 3**).

Table 3. SWAT Parameter List: Calibration Range and Fitted Values

| Parameter | Description | Parameter Value | |
|---|---|---|---|
| | | Range | Fitted Value |
| **SNO50COV** | Snow water equivalent that corresponds to 50% snow cover | 0.01 - 0.85 | 0.10 |
| **SNOCOVMX** | Minimum snow water content that corresponds to 100% snow cover | 0 - 500 | 120.13 |
| **SFTMP** | Snowfall temperature | -5 - +5 | 4.15 |
| **SMFMX** | Maximum melt rate for snow during year | 1.4 – 6.9 | 6.01 |
| **TIMP** | Snow pack temperature lag factor | 0.01 - 1 | 0.98 |
| **SMTMP** | Snow melt base temperature | -5 - +5 | 2.50 |
| **SURLAG** | Surface runoff lag time | 0.05 - 24 | 19.41 |
| **ALPHA_BF** | Baseflow alpha factor | 0.1 - 1 | 0.94 |
| **SMFMN** | Minimum melt rate for snow during the year | 1.4 -6.9 | 1.92 |
| **CN2** | SCS runoff curve number | -10 - +10 | 1.28 |
| **GWQMN** | Threshold depth of water in the shallow aquifer required for return flow to occur | 5- 5000 | 515.74 |
| **OV_N** | Manning's "n" value for overland flow | -0.07 - +0.07 | 0.06 |
| **CH_N2** | Manning's "n" value for the main channel | -0.1 - +0.1 | 0.04 |
| **GW_REVAP** | Groundwater "revap" coefficient | 0.02 – 0.2 | 0.07 |
| **REVAPMN** | Threshold depth of water in the shallow aquifer for "revap" to occur | 0 - 500 | 14.13 |
| **CNCOEF** | Plant ET curve number coefficient | 0.5 - 2 | 0.75 |
| **CH_K1** | Effective hydraulic conductivity in tributary channel alluvium | 0 - 300 | 10.58 |
| **FFCB** | Initial soil water storage expressed as a fraction of field capacity water content | 0 - 1 | 0.24 |
| **GW_DELAY** | Groundwater delay | 0 - 500 | 354.38 |
| **CH_K2** | Effective hydraulic conductivity in main channel alluvium | 1 - 500 | 280.81 |
| **ALPHA_BNK** | Baseflow alpha factor for bank storage | 0 - 1 | 0.43 |

| Parameter | Description | Parameter Value | |
|---|---|---|---|
| | | Range | Fitted Value |
| **PRF_BSN** | Peak rate adjustment factor for sediment routing in the main channel | 0 - 4 | 1.87 |
| **SPEXP** | Exponent parameter for calculating sediment re-entrained in channel sediment routing | 1 - 2 | 1.44 |
| **SPCON** | Linear parameter for calculating maximum amount of sediment that can be re-entrained during channel sediment routing | 0.0001 – 0.01 | 0.002 |
| **CH_COV2** | Channel cover factor | 0.008 – 1 | 0.15 |
| **EVRCH** | Reach evaporation adjustment factor | 0.5 - 1 | 0.99 |
| **CH_COV1** | Channel erodibility factor | 0.008 -1 | 0.67 |
| **ADJ_PKR** | Peak rate adjustment factor for sediment routing in the subbasin | 0 - 4 | 3.32 |
| **SLSUBBSN** | Average slope length | -0.9 - +9 | 4.09 |
| **HRU_SLP** | Average slope steepness | -0.98 - +99 | 98.38 |
| **USLE_P** | USLE equation support parameter | 0 - 1 | 0.93 |
| **CH_N1** | Manning's "n" value for the tributary channels | 0.016- 0.15 | 0.08 |
| **CH_S2** | Average slope of main channel | -0.999 - +999 | 382.25 |
| **EPCO** | Plant uptake compensation factor | 0.01 - 1 | 0.25 |
| **ESCO** | Soil evaporation compensation factor | 0.01 - 1 | 0.71 |
| **CH_ERODMO()** | Channel erodibility factor | 0.001 – 0.6 | 0.42 |
| **USLE_K()** | USLE equation soil erodibility (K) factor | -0.8 - +4 | 3.96 |
| **SOL_AWC()** | Available water capacity of the soil layer | -0.05 - +0.05 | 0.03 |
| **SOL_K()** | Saturated hydraulic conductivity | -10 - +10 | -4.31 |
| **SOL_BD()** | Moist bulk density | -0.4 - +0.4 | 0.15 |
| **SOL_ALB()** | Moist soil albedo | -0.05 - +0.05 | -0.05 |
| **CANMX_AGRR** | Maximum canopy storage for agricultural land | 1 - 100 | 38.64 |
| **CANMX_FRST** | Maximum canopy storage for forest land | 1 - 100 | 19.93 |
| **CANMX_PAST** | Maximum canopy storage for pastureland | 1 - 100 | 74.48 |
| **CMN** | Rate factor for humus mineralization of active organic nitrogen | 0.001- 0.0035 | 0.002 |
| **RSDCO** | Residue decomposition coefficient | 0.02 – 0.1 | 0.09 |
| **FILTERW** | Width of edge-of field filter strip | 0 - 100 | 26.38 |
| **RCN** | Concentration of nitrogen in rainfall | 0 - 15 | 13.46 |
| **RCN_SUB_BSN** | Concentration of nitrate in precipitation | 0 -2 | 0.58 |
| **N_UPDIS** | Nitrogen uptake distribution parameter | 0 - 100 | 32.08 |
| **CDN** | Denitrification exponential rate coefficient | 0 - 3 | 0.56 |
| **SDNCO** | Denitrification threshold water content | 0 - 1 | 0.22 |
| **ERORGN** | Organic N enrichment ratio | 0 - 5 | 2.20 |

| Parameter | Description | Parameter Value Range | Fitted Value |
|---|---|---|---|
| **NPERCO** | Nitrogen percolation coefficient | 0.01 – 0.21 | 0.21 |
| **ERORGP** | Organic P enrichment ratio | 0 - 5 | 1.49 |
| **BC4_BSN** | Rate constant for decay of organic phosphorus to dissolved phosphorus | 0.01- 0.7 | 0.58 |
| **SOL_NO3()** | Initial NO3 concentration in the soil layer | 0 - 100 | 53.78 |
| **BIOMIX** | Biological mixing efficiency | 0 - 1 | 0.22 |
| **P_UPDIS** | Phosphorus uptake distribution parameter | 0 - 100 | 77.58 |
| **PPERCO** | Phosphorus percolation coefficient | 10 – 17.5 | 15.87 |
| **PPERCO_SUB()** | Phosphorus percolation coefficient | 10 – 17.5 | 15.13 |
| **PHOSKD** | Phosphorus soil partitioning coefficient | 100 - 200 | 173.27 |
| **PSP** | Phosphorus sorption coefficient | 0.01 – 0.7 | 0.35 |

### 3.2.2 Calibration Targets

As defined in the approved Modeling QAPP, the target was a Nash-Sutcliffe Efficiency (NSE) above 0.36 for discharge; above 0.25 for Total Phosphorus (TP); above 0.22 for Nitrogen (N); and above 0.26 for Total Suspended Solids (TSS).

### 3.2.3 Calibration Data Sets

The water quality and hydrologic data used during calibration of the Canandaigua SWAT model is summarized in **Table 4**.

Table 4. Datasets used for SWAT model calibration

| Category | Description |
|---|---|
| **Hydrology** | |
| Gauging stations | 2000-2008 Lake Mass Balance Model simulated data, developed by Watershed Council and approved by DEC as part of a Water Supply Permit Application, was used as observed data for modeling purposes. |
| Calibration locations | Canandaigua Lake outlet |
| Calibration timeframe | 2000-2008 |
| Number of flow data points | 9 years of simulated daily discharge at lake outlet (2000-2008)<br><br>The 2000-2001 data were used as the model warm up period. |

| Category | Description |
|---|---|
| Flow Calibration tolerance | Nash Sutcliffe Model Efficiency (NSE) > 0.36 |
| Flow Calibration documentation | Daily time series of simulated data (Mass Balance Model) paired with daily SWAT model simulations; calculated NSE |
| **Water Quality Parameters (TP. TN, TSS)** | |
| Number of points for initial setup | 16 major tributaries monitored by CLWC during storm events for total phosphorus, TSS, and nitrate/nitrite – used 70% of this dataset for calibration |
| Number of points for calibration | DEC Rapid Assessment Program data at four sampling locations from 2019<br><br>DEC-approved 2020 CLWC monitoring data from 7 streams |
| Chemistry Calibration targets | TP NSE = 0.25<br><br>N NSE = 0.22<br><br>TSS NSE = 0.26 |
| Chemistry Calibration documentation | Paired daily time series of chemistry observed and modeled – calculated NSE value |

### 3.2.4 Calibration Results

Results of the SWAT model calibration with respect to streamflow (discharge at the Lake Outlet) for daily and monthly data are summarized in **Table 5**. Note that the SWAT model exhibits a higher NSE when calibrated to monthly, rather than daily observations. **Figure 2** displays the monthly flow measurements (in blue) to the SWAT model projections (in red). The model can simulate monthly fluctuations, though it does not capture the peak values in all cases.

Table 5. Results of Hydrologic Calibration, Canandaigua SWAT Model

| Site | Calibration Dataset | Averaging Period and Number of Observations | NSE |
|---|---|---|---|
| Lake Outlet | 9 years 2001-2008 | Daily<br><br>(2922 days) | 0.16 |

| | | |
|---|---|---|
| 2000-2001 data used as the warm-up period) | Monthly<br><br>(96 months) | 0.43 |

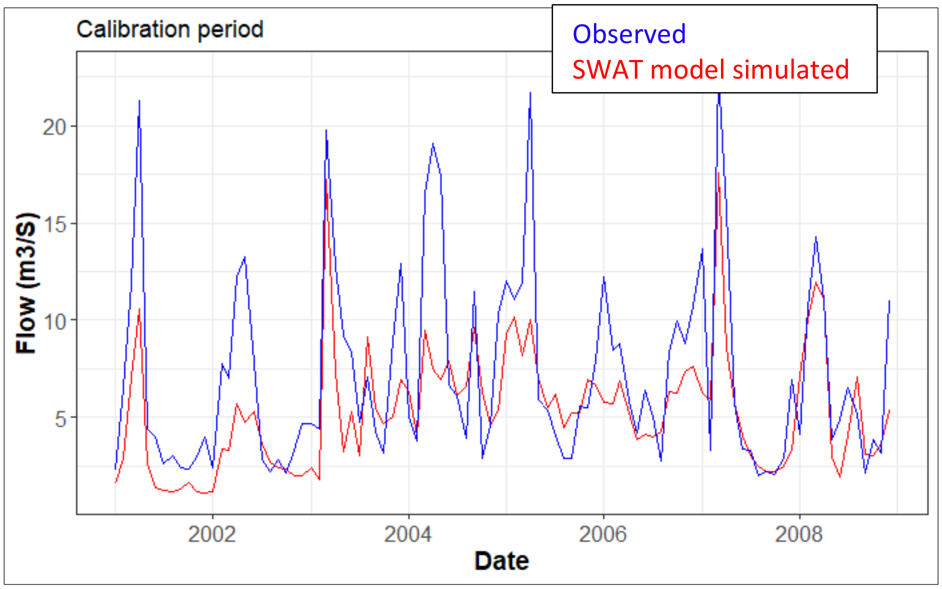


Figure 2. Measured monthly discharge at Lake outlet compared to SWAT model simulations during calibration period

Results of the water quality calibrations are presented in **Table 6** (Total Phosphorus, TP), **Table 7** (Nitrogen), and **Table 8** (Total Suspended Solids, TSS). Monitoring sites with NSE values above the target threshold are presented first and highlighted yellow. For TP (target 0.25), 11 of the 17 sites exhibited positive NSE values. For N (target 0.22), 12 sites were in the positive range. The lowest value is calculated for the TSS data set with only five of 17 sites exhibiting an NSE above zero.

Table 6. Results of Total Phosphorus Calibration, Canandaigua SWAT Model

| Tributary Name | NSE | PBIAS |
|---|---|---|
| Grimes Glen | 0.65 | -56.5 |
| Vine Valley Creek | 0.46 | -37.8 |
| Tannery Creek | 0.43 | -66.2 |
| Lower Naples Creek - Rt 245 | 0.42 | -68 |
| Reservoir Creek | 0.32 | -59.3 |
| Eelpot Creek | 0.21 | -69.7 |
| Menteth Gully | 0.20 | -51.6 |
| Sucker Brook | 0.12 | 8.4 |
| Barnes Gully | 0.12 | -76.9 |

| | | |
|---|---|---|
| South Bristol Direct Drainage - Cook's Point | 0.10 | -89.1 |
| Seneca Point Gully | 0.07 | -82.6 |
| Tichenor Gully | -0.09 | 14.5 |
| Fall Brook | -0.13 | 4 |
| Gage Gully | -1.30 | 50.8 |
| Deep Run | -2.34 | 65.9 |
| USGS | -2.37 | 127 |
| Lower West River - Sunnyside | -3.40 | 32.3 |

Table 7. Results of Nitrogen Calibration, Canandaigua SWAT Model

| Tributary Name | NSE | PBIAS |
|---|---|---|
| Seneca Point Gully | 0.94 | -28.7 |
| Barnes Gully | 0.91 | 3.9 |
| Menteth Gully | 0.91 | -15.9 |
| Lower Naples Creek - Rt 245 | 0.91 | -33 |
| South Bristol Direct Drainage - Cook's Point | 0.76 | 30.7 |
| Reservoir Creek | 0.75 | -46.1 |
| Grimes Glen | 0.71 | -20.8 |
| Tichenor Gully | 0.60 | -46.8 |
| Eelpot Creek | 0.58 | -66.8 |
| Sucker Brook | 0.27 | -69.6 |
| Vine Valley Creek | 0.23 | -72.1 |
| Fall Brook | 0.06 | -82.3 |
| Gage Gully | -0.04 | -86 |
| USGS | -0.05 | -78.4 |
| Deep Run | -0.05 | -85.7 |
| Lower West River - Sunnyside | -0.16 | -61.7 |
| Tannery Creek | -5.42 | 79.7 |

Table 8. Results of Total Suspended Solids Calibration, Canandaigua SWAT Model

| Tributary Name | NSE | PBIAS |
|---|---|---|
| Fall Brook | 0.40 | -10.3 |
| Sucker Brook | 0.15 | -72.8 |
| Tichenor Gully | 0.11 | -79.4 |
| Grimes Glen | 0.03 | -92.2 |
| Menteth Gully | 0.01 | -91.2 |
| Gage Gully | -0.01 | -66.2 |
| Seneca Point Gully | -0.03 | -97 |
| Barnes Gully | -0.03 | -99.3 |

| | | |
|---|---|---|
| Vine Valley Creek | -0.04 | -81.2 |
| South Bristol Direct Drainage - Cook's Point | -0.05 | -99.8 |
| Eelpot Creek | -0.08 | -91.7 |
| Reservoir Creek | -0.10 | -96 |
| Lower Naples Creek - Rt 245 | -0.10 | -94.6 |
| Tannery Creek | -0.15 | -98.6 |
| Deep Run | -0.23 | 12.6 |
| Lower West River - Sunnyside | -0.42 | 0.9 |
| USGS | -5.93 | 156.2 |

The final analysis of the SWAT model calibration examined aggregated results by sites for the three water chemistry parameters. These data are summarized in **Table 9**. Note that the NSE values for combined water quality data from all sites for each water quality variables are above the QAPP threshold for Total Phosphorus (TP) and Nitrogen (N) but not for Total Suspended Solids (TSS). The target NSE for TP is 0.25; the NSE for all sites combined is 0.33. The target NSE for N is 0.22; the NSE value for all sites combined is 0.5. The NSE for TSS from all sites combined is only 0.01, which falls well below target. However, the NSE for TSS is above zero, indicating that the model captures the central tendency of the TSS observations.

Table 9. Results of Water Quality Calibration from Pooled Data, Canandaigua SWAT Model

| VARIABLE | NSE |
|---|---|
| TOTAL PHOSPHORUS | 0.33 |
| NITROGEN | 0.5 |
| TOTAL SUSPENDED SOLIDS | 0.01 |

The following three figures compare SWAT model simulations of tributary loads of TP, N, and TSS from all sites to the calculated individual mass loads from paired values of measured concentrations and simulated discharge. Total P load calibration using data from all monitoring sites is displayed in **Figure 3**. Nitrogen load calibration using data from all monitoring sites is displayed in **Figure 4** and the calibration of Total Suspended Solids load using data from all monitoring sites is displayed in **Figure 5**.

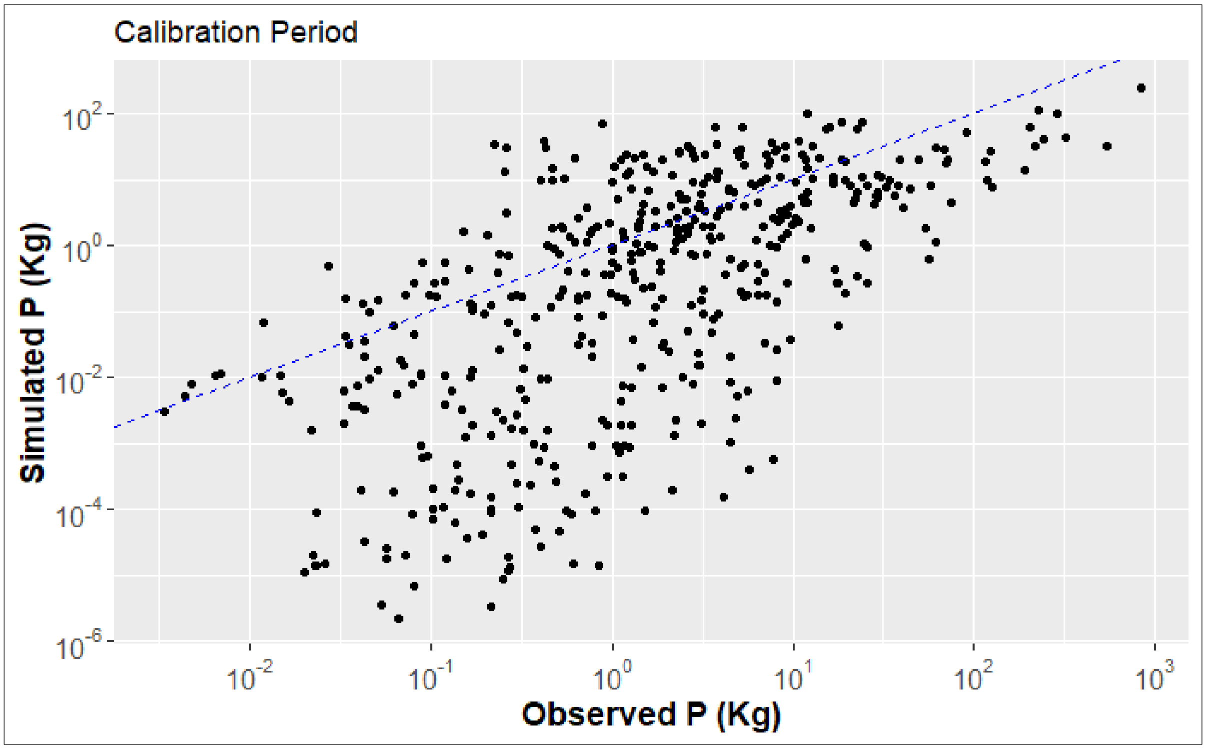


Figure 3. Total Phosphorus calibration, Canandaigua SWAT model

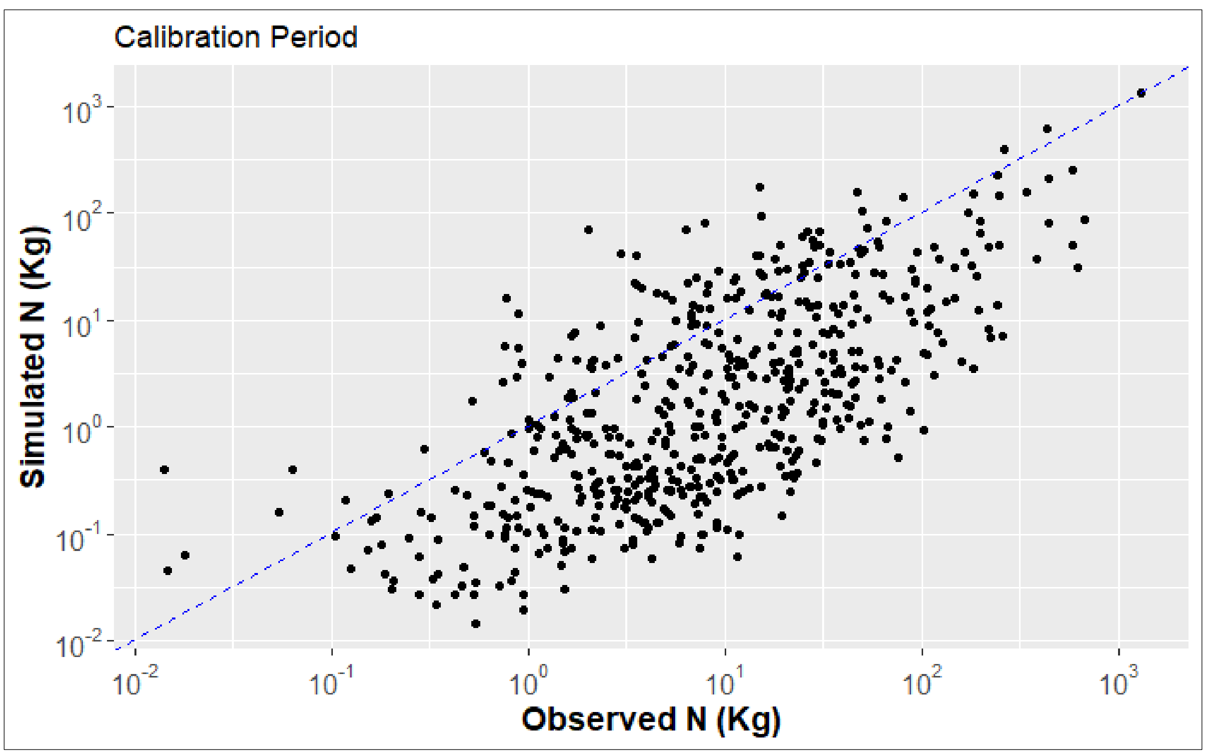


Figure 4. Nitrogen calibration, Canandaigua SWAT model

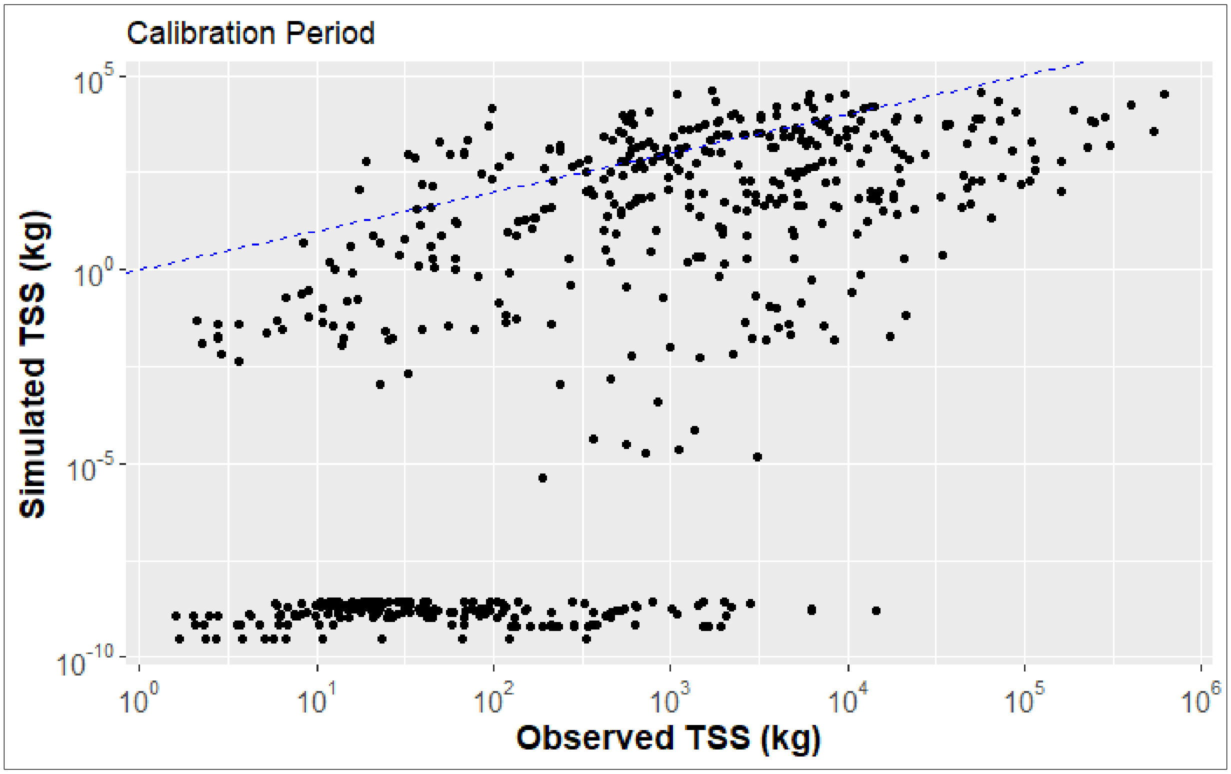


Figure 5. Total Suspended Solids calibration, Canandaigua SWAT model

## 3.3 Model Validation

### 3.3.1 Approach

The model validation process includes comparison of model predictions to data collected during a time interval or at watershed locations that were not included in calibration. SWAT model parameters established during calibration remain unchanged during the validation process. Successful validation, established by a favorable comparison between model predictions and monitoring data, provides confidence in model predictions, and its application to assess various watershed management scenarios. As summarized in **Table 10**, discrete portions of the hydrologic record and the long-term monitoring data set were used for validation.

Table 10. Datasets used for SWAT model validation

| Category | Datasets |
| --- | --- |
| **Hydrology (discharge)**<br><br>***Note: Both daily and monthly averaged flow measurements*** | 11 years of daily discharge through the Outlet (2009-2019)- 4017 days (132 months) |
| | Measured discharge at the USGS stream gauge on West River, Sept. 2019 - December 2020- 16 months |

| | |
|---|---|
| ***were assessed during model validation*** | |
| **Water quality parameter load**<br><br>**(Total P, N, TSS)** | Subset (30%) of long-term storm event monitoring data from 16 tributary streams for concentration; paired with modeled discharge<br><br>2020 NYSDEC Rapid Assessment Survey at four locations within the watershed |

### 3.3.2 Validation Results: Hydrology

The agreement between SWAT model predictions of discharge and measured/simulated discharge was improved when using monthly average values compared to daily values, as summarized in **Table 11.** Using the monthly averaged discharges brought the NSE within targets specified in the modeling QAPP. As shown in **Figure 6** (Outlet) and **Figure 7** (West River), the SWAT model captures the overall patterns of watershed hydrology and West River streamflow.

Table 11. SWAT Model Validation- Hydrology

| SITE | NSE | NUMBER OF OBSERVATIONS |
|---|---|---|
| **OUTLET** | 0.19 | Daily- 4017 days |
| | 0.39 | Monthly- 132 months |
| **USGS GAGE** | 0.26 | Daily- 638 days |
| | 0.67 | Monthly- 16 months |

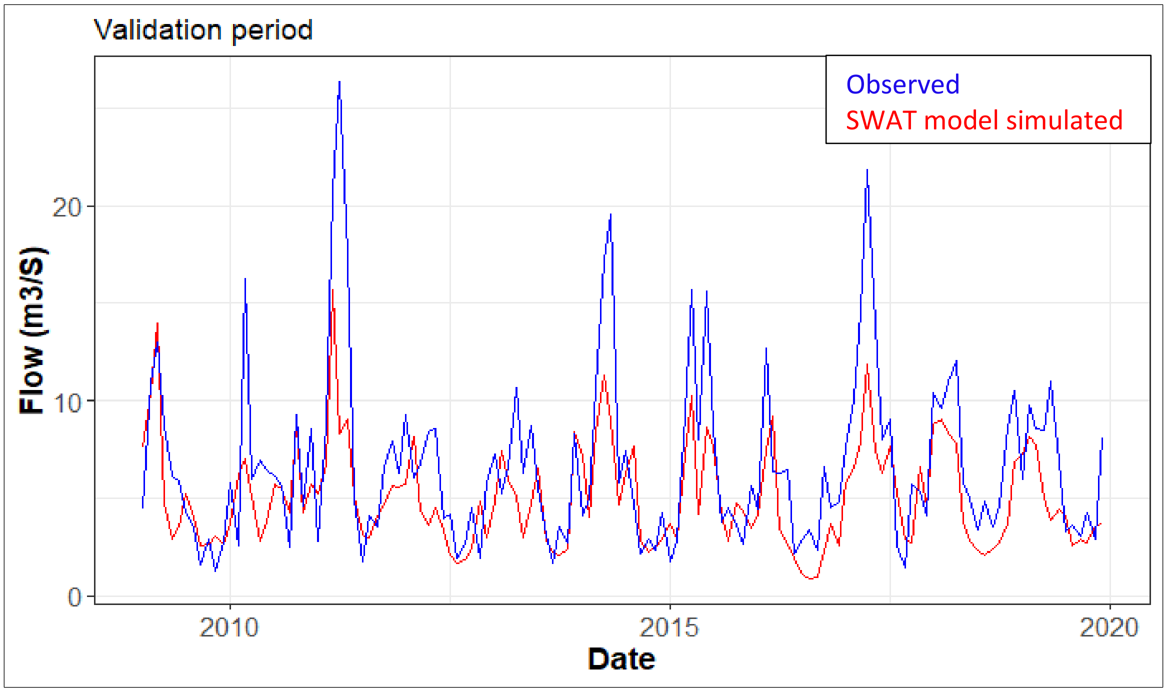


Figure 6. Hydrology Validation, Canandaigua Lake Outlet

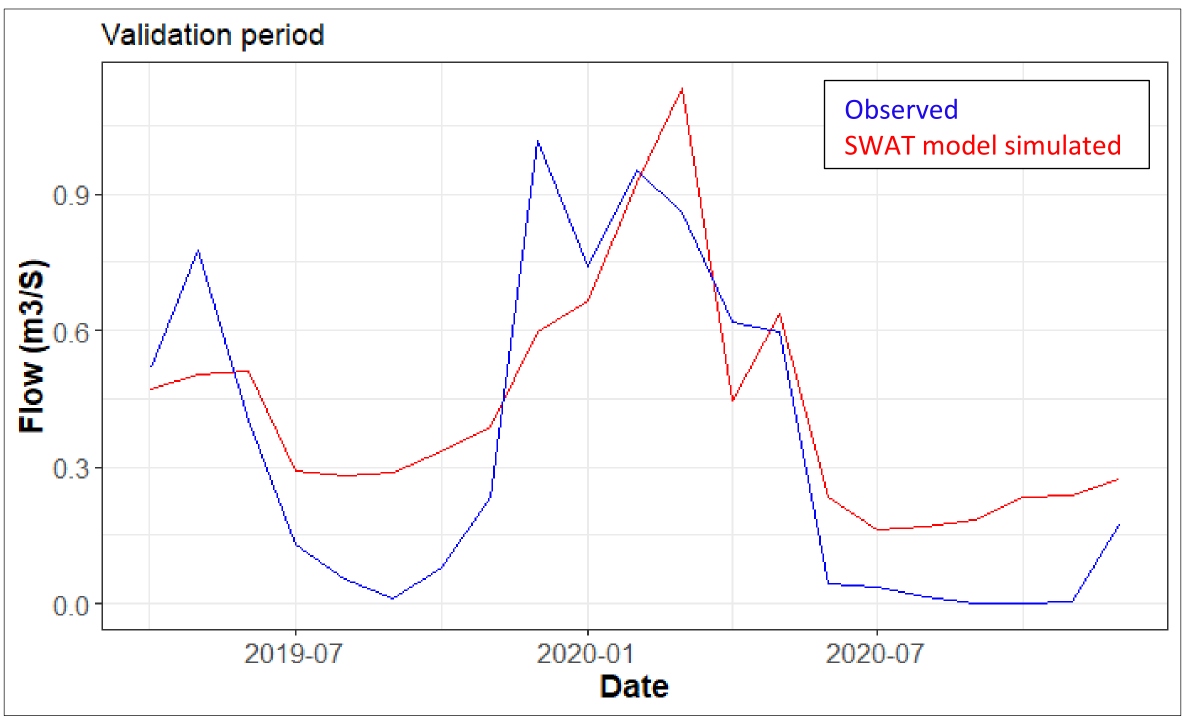


Figure 7. Hydrology Validation, West River USGS Gauge

### 3.3.3: Validation Results: Water Quality

Results of the Canandaigua Lake SWAT model validation for water quality parameters are presented in **Table 12** (Total Phosphorus, TP), **Table 13** (Nitrogen), and **Table 14** (Total Suspended Solids, TSS). Monitoring sites with NSE values above the target threshold are presented first and highlighted yellow. For TP (target 0.25), 11 of the 17 sites exhibited positive NSE values. For N (target 0.22), 11 sites were in the positive range. The lowest value is calculated for the TSS data set with only two of 17 sites exhibiting an NSE above zero.

Table 12. Results of Total Phosphorus Validation, Canandaigua SWAT Model

| Tributary Name | NSE | PBIAS |
|---|---|---|
| Seneca Point Gully | 0.90 | 0.5 |
| Lower Naples Creek - Rt 245 | 0.80 | -12 |
| Tichenor Gully | 0.70 | 16.3 |
| Vine Valley Creek | 0.69 | -18.4 |
| Sucker Brook | 0.67 | 29.6 |
| South Bristol Direct Drainage - Cook's Point | 0.56 | -28.5 |
| Menteth Gully | 0.43 | -18 |
| Eelpot Creek | 0.37 | -5.3 |
| Grimes Glen | 0.24 | -54.8 |
| Fall Brook | 0.02 | -14.1 |
| Tannery Creek | 0.01 | 90.9 |
| Reservoir Creek | -0.47 | 79.8 |
| Deep Run | -2.78 | 24.9 |
| Gage Gully | -3.57 | 91.6 |
| Lower West River - Sunnyside | -11.12 | 127.6 |
| Barnes Gully | -13.09 | 204.8 |
| USGS | -13.13 | -75.9 |

Table 13. Results of Nitrogen Validation, Canandaigua SWAT Model

| Tributary Name | NSE | PBIAS |
|---|---|---|
| Reservoir Creek | 0.82 | -4.7 |
| Vine Valley Creek | 0.69 | -50.1 |
| Eelpot Creek | 0.66 | -23 |
| Lower West River - Sunnyside | 0.60 | -39.7 |
| Sucker Brook | 0.58 | -42.9 |
| Lower Naples Creek - Rt 245 | 0.26 | 25 |
| Deep Run | 0.24 | -72.8 |
| Fall Brook | 0.13 | -64.8 |

| | | |
|---|---|---|
| Tichenor Gully | 0.08 | -16.3 |
| Gage Gully | 0.07 | -82.3 |
| Seneca Point Gully | -0.04 | 37.3 |
| Menteth Gully | -0.53 | 53.1 |
| USGS | -1.35 | 109.7 |
| Grimes Glen | -3.36 | 111.3 |
| South Bristol Direct Drainage - Cook's Point | -5.11 | 186.2 |
| Barnes Gully | -15.27 | 294.4 |
| Tannery Creek | -27.21 | 371.7 |

Table 14. Results of Total Suspended Solids Validation, Canandaigua SWAT Model.

| Tributary Name | NSE | PBIAS |
|---|---|---|
| Fall Brook | 0.35 | -29.4 |
| Gage Gully | 0.25 | -68.5 |
| Deep Run | 0.05 | -66.8 |
| Tichenor Gully | 0.00 | -88.1 |
| Sucker Brook | 0.00 | -81.6 |
| Lower Naples Creek - Rt 245 | -0.12 | -93.2 |
| Vine Valley Creek | -0.16 | -88.6 |
| Seneca Point Gully | -0.17 | -92.4 |
| Lower West River - Sunnyside | -0.17 | -45.1 |
| Reservoir Creek | -0.18 | -91 |
| Menteth Gully | -0.20 | -92.7 |
| Tannery Creek | -0.21 | -96.3 |
| Eelpot Creek | -0.25 | -95.7 |
| Grimes Glen | -0.29 | -89.6 |
| South Bristol Direct Drainage - Cook's Point | -0.30 | -99.4 |
| Barnes Gully | -0.40 | -97.7 |
| USGS | -3.60 | -99.1 |

The final analysis of the SWAT model validation aggregated the sites for the three water quality parameters. The results (**Table 15**) demonstrate satisfactory performance for Total Phosphorus, and Nitrogen, but not for Total Suspended Solids. Although the NSE for TSS is very low, it remains above zero, signifying that the model captures the central tendency of the TSS measurements.

Table 15. Summary performance of SWAT model validation, pooled water quality data

| VARIABLE | NSE | NUMBER OF OBSERVATIONS |
|---|---|---|
| Total Phosphorus | 0.44 | 183 |
| Nitrogen | 0.5 | 171 |
| **TOTAL SUSPENDED SOLIDS** | **0.01** | **185** |

The next three figures compare SWAT model simulations of tributary loads of TP, N, and TSS from all sites to the calculated individual mass loads from paired values of measured concentrations and simulated discharge. Total P load validation using data from all monitoring sites is displayed in **Figure 8**. Nitrogen load validation using data from all monitoring sites is displayed in **Figure 9** and the validation of Total Suspended Solids load using data from all monitoring sites is displayed in **Figure 10.**

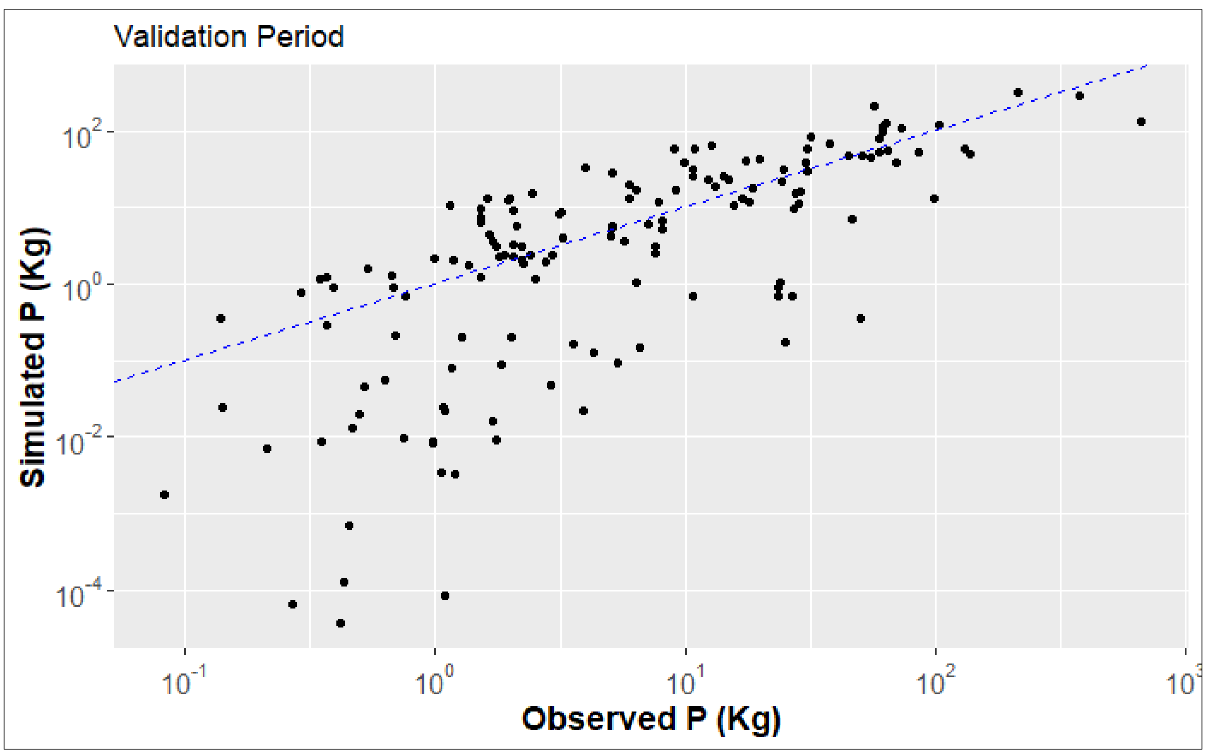


Figure 8. Total Phosphorus Validation, Canandaigua SWAT Model

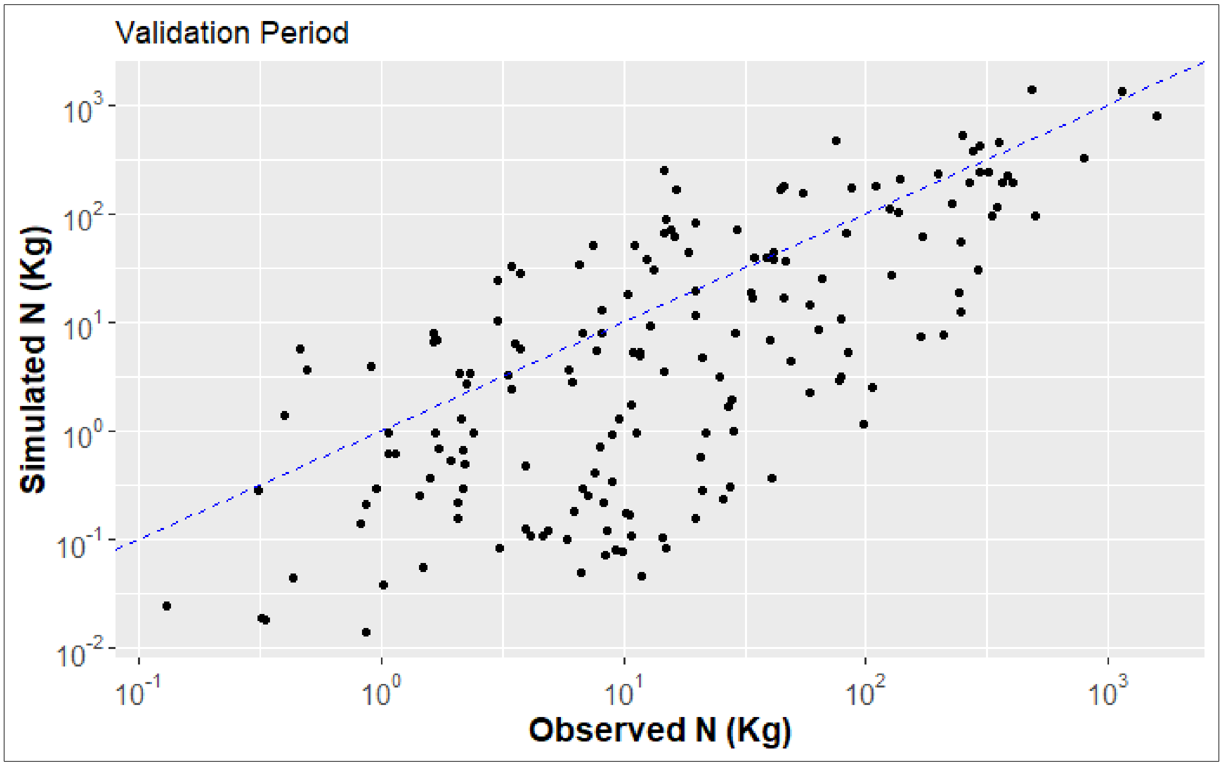


Figure 9. Nitrogen Validation, Canandaigua SWAT model

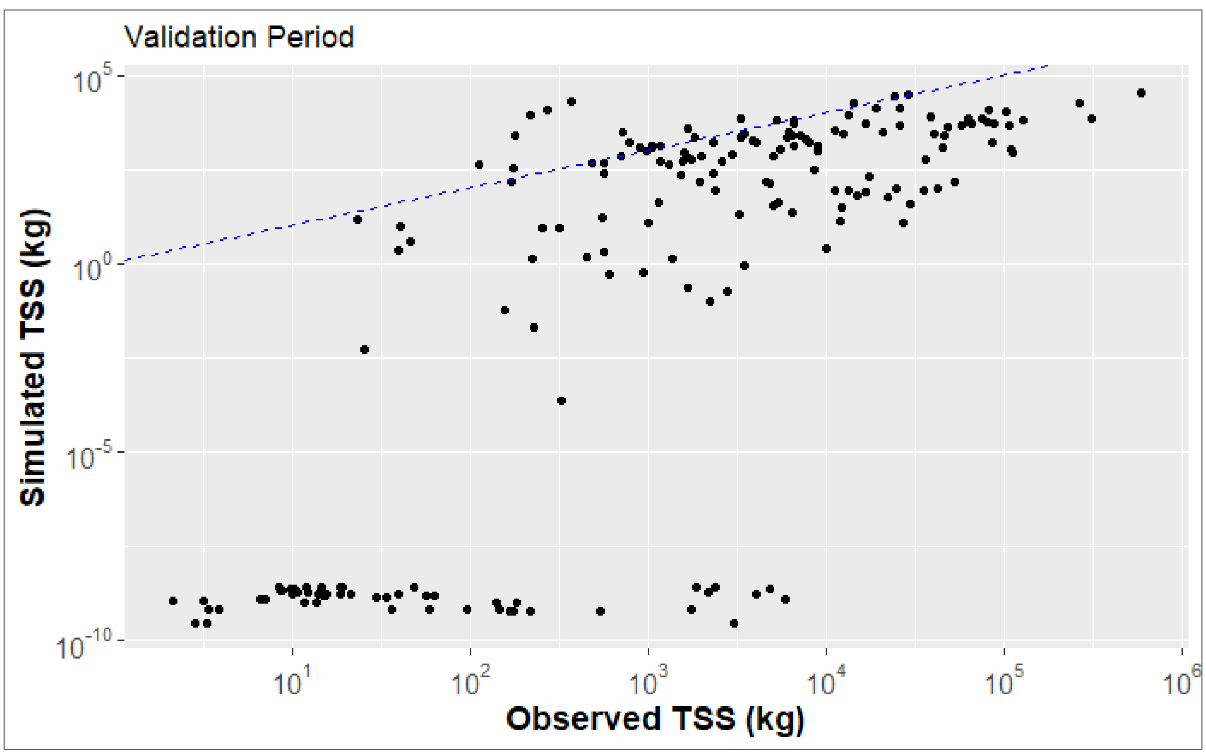


Figure 10. Total Suspended Solids Validation, Canandaigua SWAT model

The accurate simulation of peak flow is crucial for TSS sensitivity, but due to the limited flow data available for the model, expecting a high level of confidence in peak flow simulation is impractical. Consequently, high precision in TSS simulation (high NSE) cannot be expected. Furthermore, water quality samples were collected as a grab sample (as approved in their respective QAPPs), representing a single snapshot in the storm hydrograph. Given its sensitivity to flow, the TSS NSE may also be impacted by the timing of water quality sample in the hydrograph as compared to the model's daily predicted flow. Finally, TSS concentrations during low flow were often below the lab's detection limit, which may additionally impact the comparison between observed and modeled TSS loading.

SWAT estimates total phosphorus (TP) loads by considering the phosphorus load attached to sediment flowing into streams and the amount of soluble phosphorus, making the TP load less sensitive to peak flow. This approach can explain the higher NSE values observed for TP calibration and validation. Similarly, nitrate and TN in SWAT are simulated by transporting them with surface runoff, lateral flow, or percolation, explaining their independence from peak flow and the good NSE values obtained during calibration and validation.

# 4. SWAT Model Application: Current Conditions

### 4.1 Current Conditions: Watershed Wide

Once calibrated and validated, the Canandaigua Lake SWAT model was applied to estimate the current nonpoint phosphorus and nitrogen load from the landscape as a function of land cover (**Table 16**). The watershed area in this table excludes lake surface area. The estimated phosphorus contribution from domestic sewage (both on-site septic systems and effluent from wastewater treatment plants) is tabulated as well. Overall, landscape sources dominate the annual phosphorus load to Canandaigua Lake (**Figure 11**). Cultivated lands contribute the most phosphorus (48%) and hay fields are estimated to contribute an additional 16%. For nitrogen, less than half of the estimated nitrogen load (39%) is estimated to originate from the agricultural landscape, as shown in **Figure 12**. Note that wastewater contributions to nitrogen load is not included in the estimates.

Table 16. Current Conditions: Landscape nonpoint sources and wastewater sources of TP and N to Canandaigua Lake

| Land Cover | Acres \| % of Total Watershed | Unit TP Load (lb/acre) | Annual TP Load (lbs.) \| Percent of Total Load | Annual N Load (lb/acre) | Annual N Load (lbs.) \| Percent of Total Load |
|---|---|---|---|---|---|
| **Developed** | 10,211 \| 8% | 0.39 | 4,003 \| 9% | 1.85 | 18,896 \| 14% |
| **Cultivated Fields** | 23,840 \| 20% | 0.92 | 21,899 \| 48% | 1.66 | 39,534 \| 29% |

| | | | | | |
|---|---|---|---|---|---|
| **Hay/Pasture** | 15,984 \|13% | 0.46 | 7,364 \| 16% | 1.49 | 23,858 \| 18% |
| **Forested** | 59,111 \| 49% | 0.13 | 7,901 \|17% | 0.89 | 52,487 \| 39% |
| **Total Landscape Nonpoint Source** | 109,146 | --- | 41,167 \| 90% | --- | 134,775 |
| **Wastewater treatment plant effluent** | --- | --- | 1,676 \| 4% | --- | --- |
| **On-site wastewater** | --- | | 3,000 \| 6% | -- | Not quantified |
| **Total estimated Nutrient Load, point and nonpoint** | --- | --- | **45,843** | --- | **134,775** |

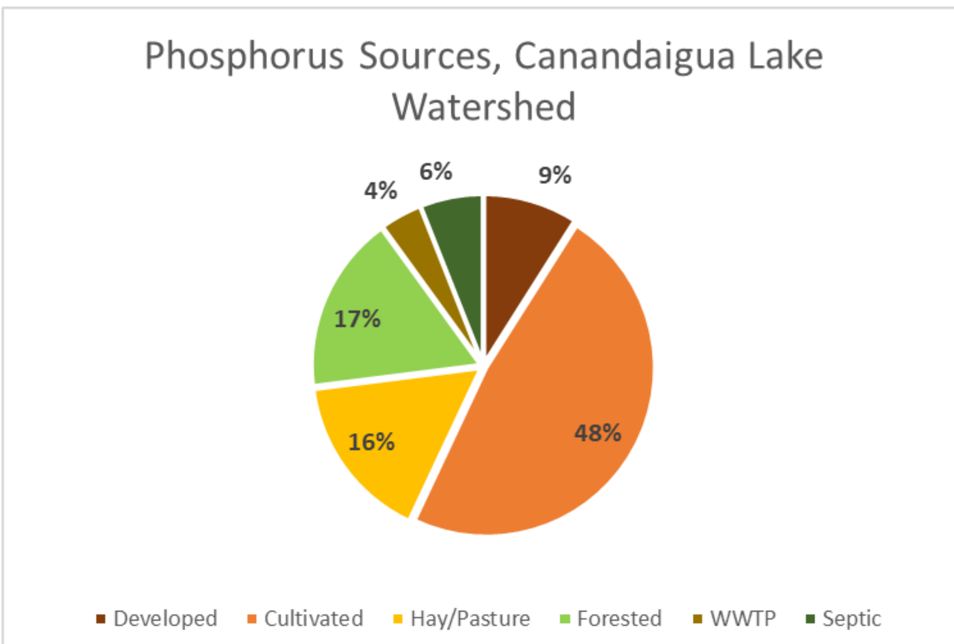


Figure 11. Relative contributions of phosphorus, watershed-wide

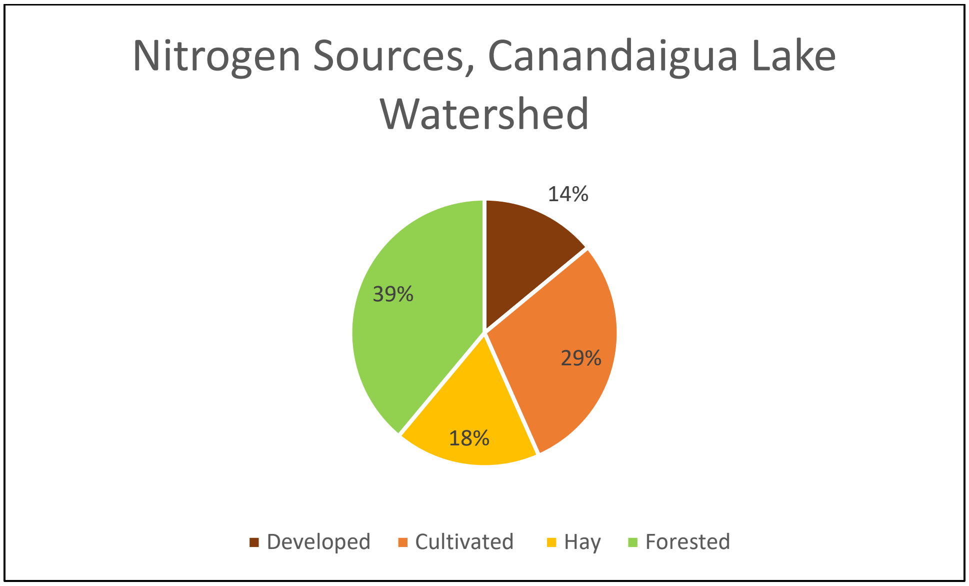


Figure 12. Relative contributions of nitrogen, watershed-wide

## 4.2 Current Conditions: Subbasin Export of Phosphorus and Nitrogen

Annual loads from each of the subbasins were calculated using the HRU results generated by the SWAT model. The results for phosphorus are presented as both annual load (pounds per year) in **Figure 13** as well as unit load (pounds per acre per year) in **Figure 14**. Similar calculations for Nitrogen contribution by subbasin are displayed in **Figure 15** (pounds per year) and **Figure 16** (ponds per acre per year). The four maps use a color scheme where red indicates subbasins with the highest nutrient loads, and green represents those with the lowest contribution. In Figures 13 and 15, the subbasins with the highest loads may have larger areas or higher loads per area, while Figures 14 and 16 account for the area effect and highlight the subbasins that contribute the highest loads per unit area.

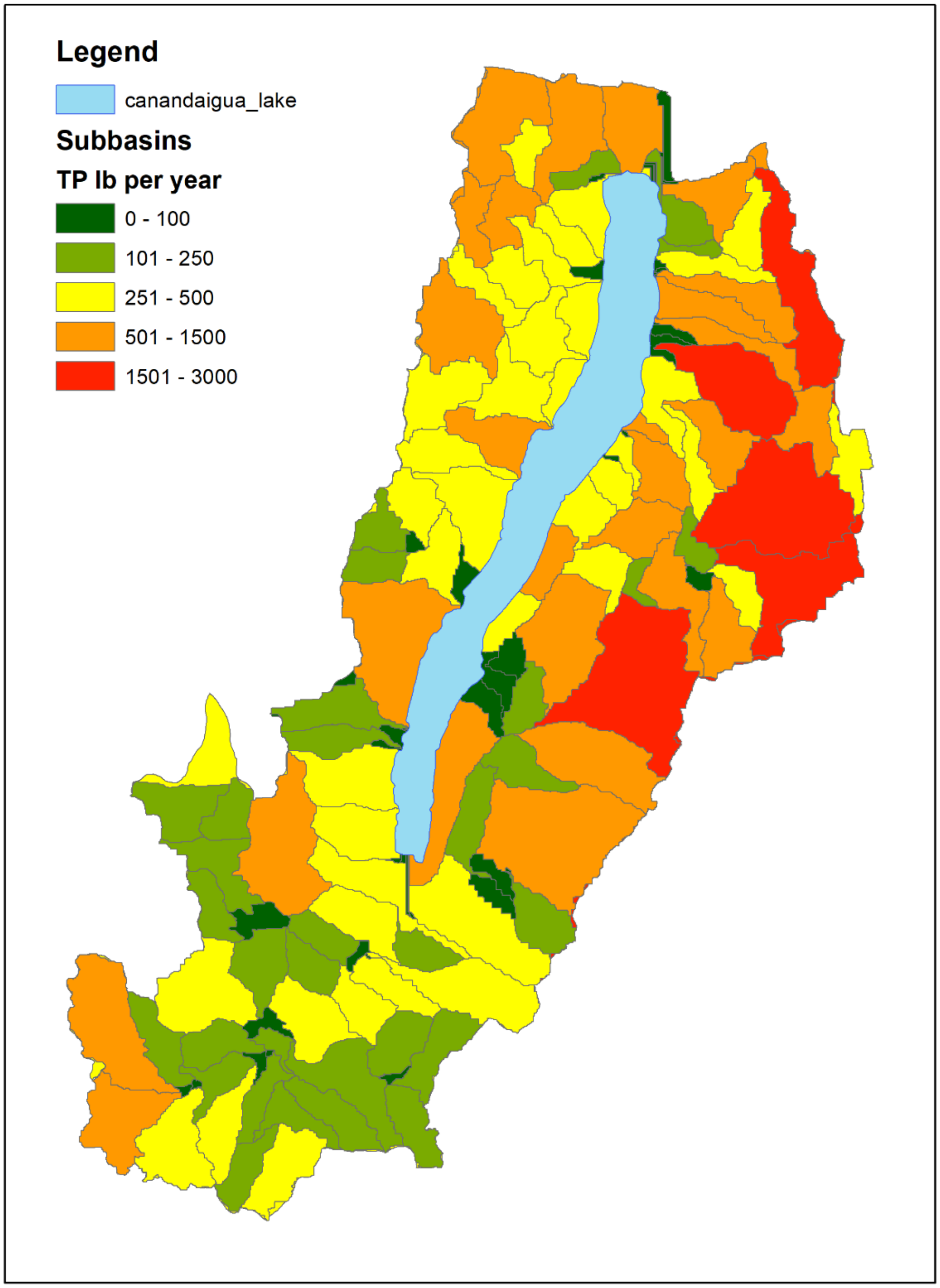


Figure 13. Total phosphorus export by subbasin, pounds per year

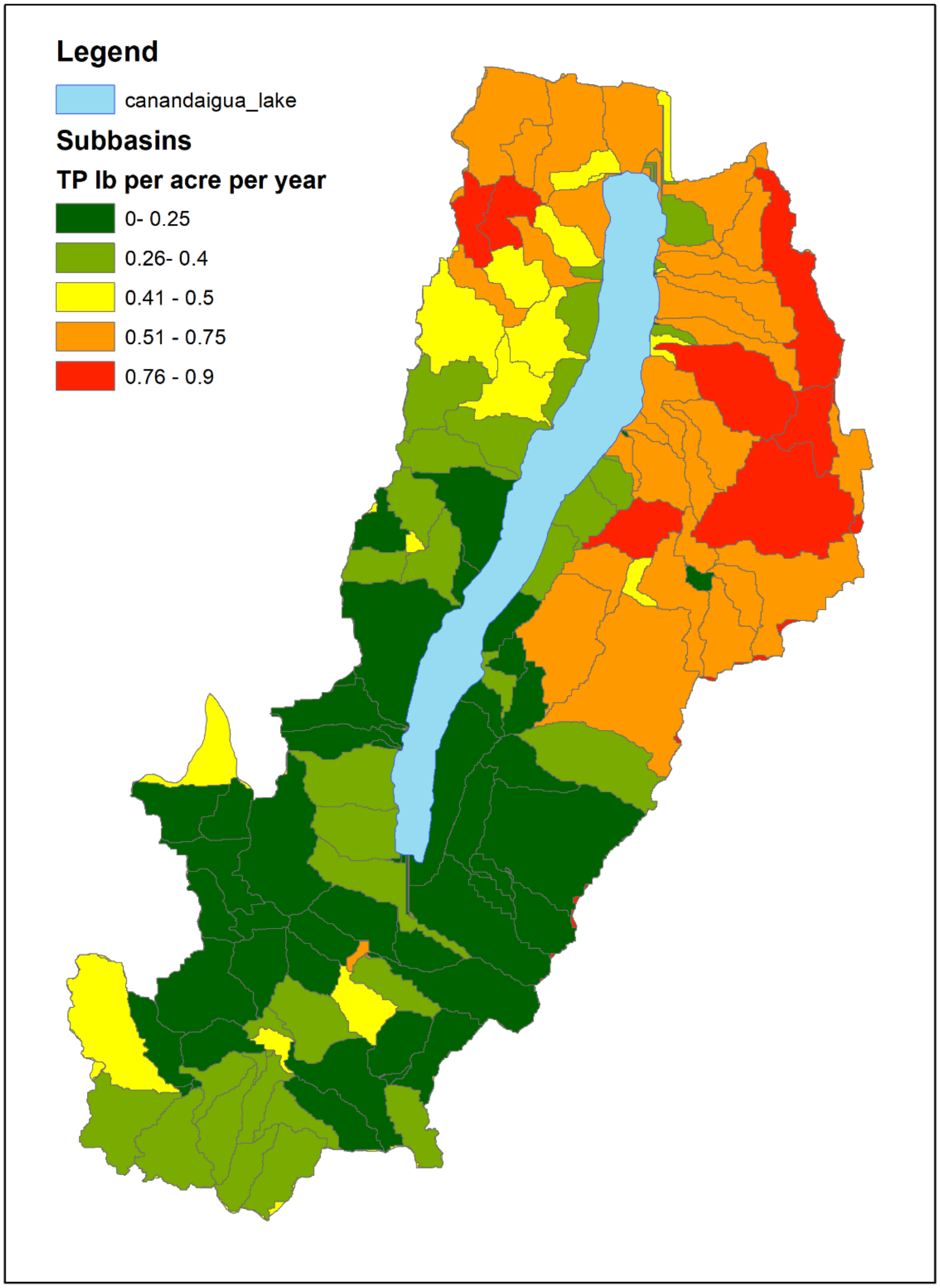


Figure 14. Unit phosphorus export by subbasin, pounds per acre per year

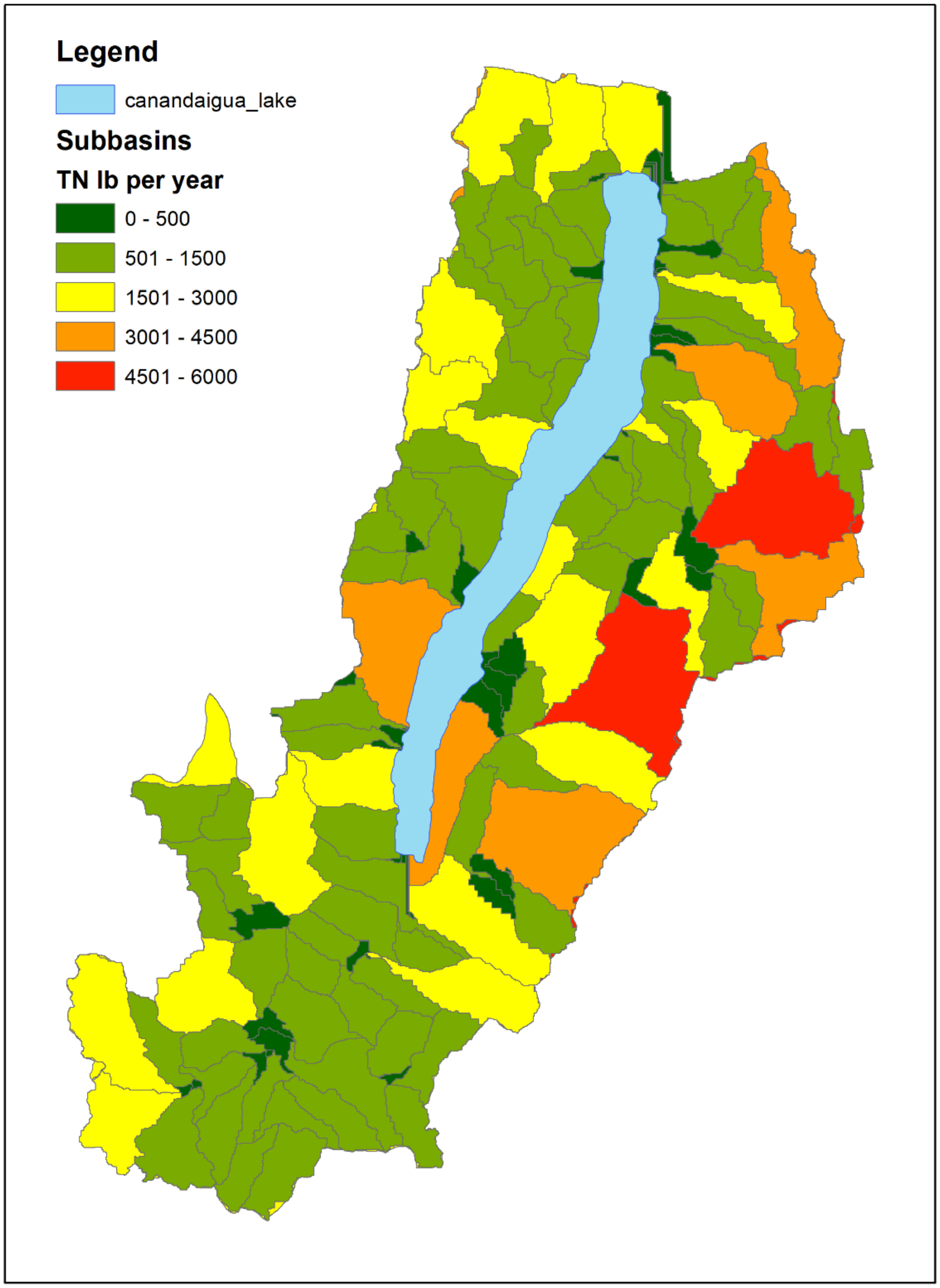


Figure 15. Total Nitrogen export by subbasin, pounds per year

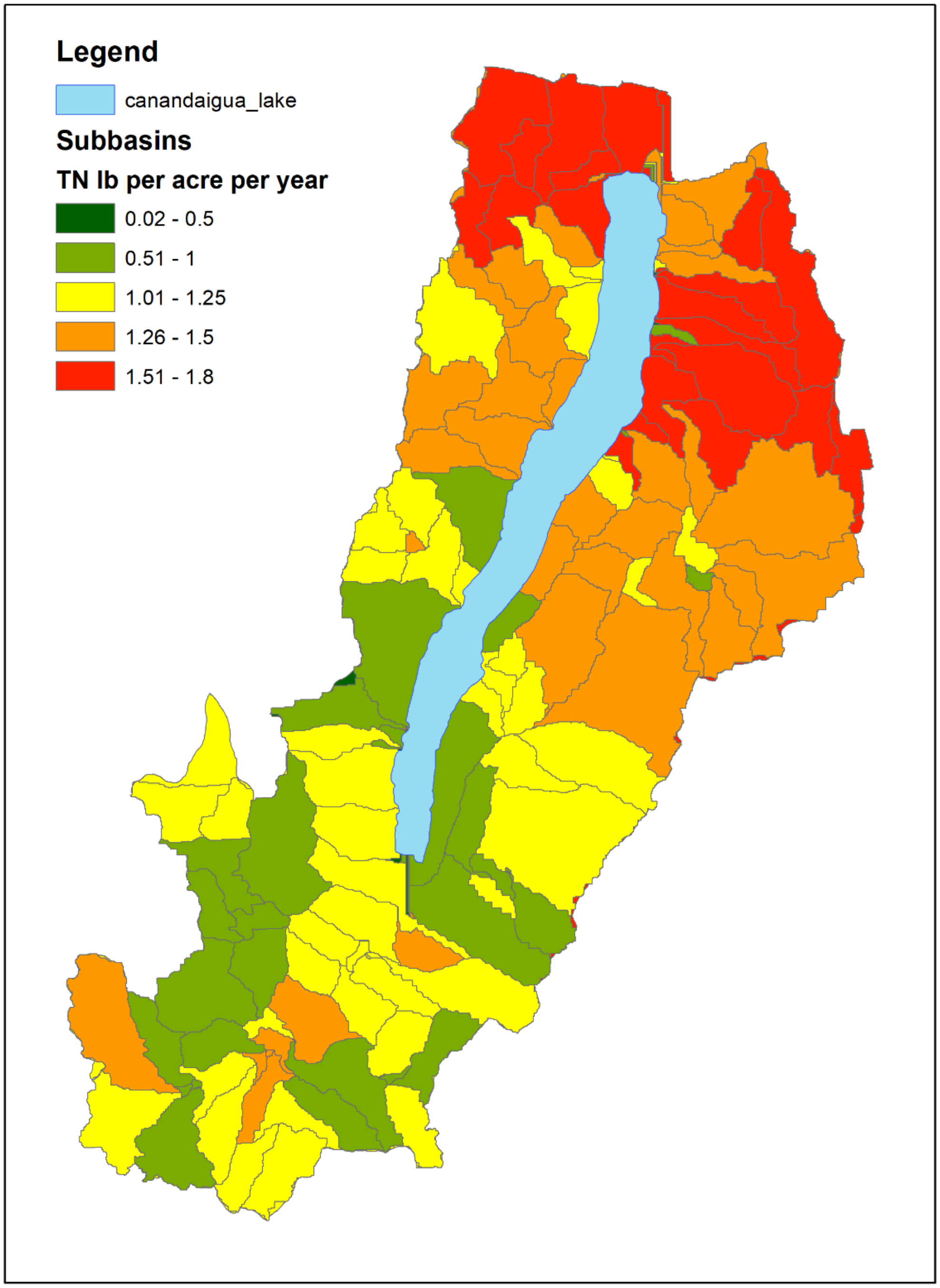


Figure 16. Unit Nitrogen export by subbasin, pounds per acre per year

## 4.3 Current Conditions: HUC12 Scale Loading Estimates

Five major subwatersheds (HUC12) flow into Canandaigua Lake: Naples Creek, Bristol Springs, West River, Deep Run, and Sucker Brook. Land cover varies among these subwatersheds **(Table 17** and **Figure 17**). Naples Creek and Bristol Springs are primarily forested; West River and Deep Run have extensive agricultural lands. Land cover in the Sucker Brook subwatershed includes both agricultural and developed areas. . The following tables and figures provide useful information for identifying specific areas that are likely to experience greater improvements from BMP implementation.

Table 17. Land Cover Breakdown by HUC 12 Subwatersheds

| | **Land Cover Classification** | | | | | |
|---|---|---|---|---|---|---|
| | Cultivated Lands<br>Acres \| % | Pasture and Hay<br>Acres \| % | Forested<br>Acres \| % | Developed<br>Acres \| % | Water<br>Acres \| % | Total Area |
| **Naples Creek** | 2,800<br>8.88% | 2,539<br>8.05% | 24,428<br>77.43% | 1,716<br>5.44% | 64<br>0.20% | 31,547 |
| **West River** | 8,555<br>30.17% | 4,004<br>14.12% | 13,970<br>49.26% | 1,676<br>5.91% | 155<br>0.55% | 28,359 |
| **Bristol Springs** | 989<br>6.81% | 1,607<br>11.05% | 8,529<br>58.66% | 832<br>5.72% | 2,582<br>17.76% | 14,540 |
| **Deep Run** | 5,259<br>20.60% | 5,079<br>19.90% | 9,109<br>35.69% | 1,696<br>6.64% | 4,383<br>17.17% | 25,526 |
| **Sucker Brook** | 6,244<br>28.74% | 2,761<br>12.71% | 4,732<br>21.78% | 4,298<br>19.78% | 3,688<br>16.98% | 21,723 |
| **Total** | 23,847 | 15,990 | 60,768 | 10,217 | 10,873 | 121,695 |

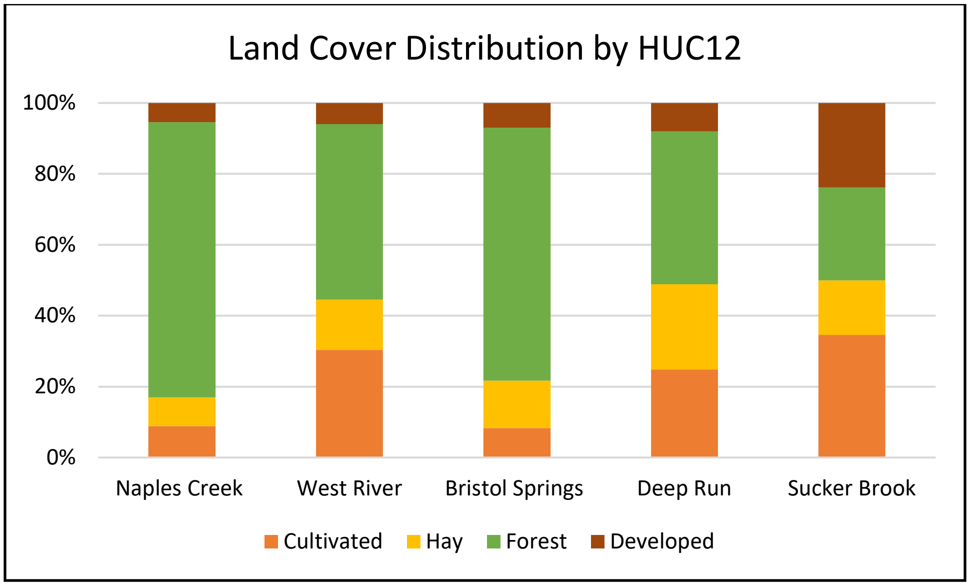


Figure 17. Land Cover by HUC12 (water area excluded)

# 5. SWAT Model Application: Management Scenarios

The Canandaigua Lake SWAT model was run to estimate phosphorus and nitrogen loads from the five HUC12 subwatersheds under current conditions. These baseline loads were compared with projected loads from changing conditions, including changes in land practices and climate. Scenarios were developed in consultation with the stakeholder community.

## 5.1 Reduced Fertilizer Applications to Agricultural Lands

The first scenario simulates the potential reduction in phosphorus and nitrogen loads from the five HUC12 subwatersheds achieved by reducing fertilizer application (**Table 18**). Two simulations were run: the first demonstrating the impact of a 10% reduction and the second demonstrating the impact of a 20% reduction.

Table 18. Management Scenario: Reduce Fertilizer Application to Agricultural Lands

| HUC12 | Baseline Conditions | | Scenario: Reduce Fertilizer Application to Agricultural Lands by 10% | | Scenario: Reduce Fertilizer Application to Agricultural Lands by 20% | |
|---|---|---|---|---|---|---|
| | Total P (lbs./year) | Total N (lbs./year) | Total P (lbs./year) | Total N (lbs./year) | Total P (lbs./year) | Total N (lbs./year) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Naples Creek | 8,480 | 33,553 | 8,139<br>-4.01% | 33,521<br>-0.09% | 8,024<br>-5.37% | 33,395<br>-0.47% |
| West River | 13,595 | 35,045 | 12,659<br>-6.89% | 34,965<br>-0.23% | 12,273<br>-9.72% | 34,594<br>-1.29% |
| Bristol Springs | 3,371 | 12,987 | 3,253<br>-3.50% | 13,000<br>0.10% | 3,199<br>-5.11% | 12,927<br>-0.46% |
| Deep Run | 9,780 | 26,538 | 9,289<br>-5.02% | 26,413<br>-0.47% | 8,954<br>-8.45% | 26,247<br>-1.10% |
| Sucker Brook | 10,617 | 26,652 | 10,010<br>-5.72% | 26,554<br>-0.36% | 9,695<br>-8.68% | 26,371<br>-1.05% |
| Total | 45,843 | 134,775 | 43,351 | 134,455 | 42,146 | 133,534 |
| Percent Change | --- | --- | -5.44% | -0.24% | -8.07% | -0.92% |

## 5.2 Expanded Use of Cover Crops

Cover crops are an effective means to reduce loss of nutrients and sediment from the landscape. The practice has become well-accepted in the Finger Lakes region and its adoption has been encouraged in recent years by expanded access to funding and support for implementation. The Canandaigua SWAT model was applied to simulate the impact of continued expansion of this practice on phosphorus and nitrogen export. Four scenarios were run: two crops (winter wheat and winter rye) and two assumptions regarding adoption (42% of cultivated lands and 100% of cultivated lands). Note that the 42% scenario encompasses cultivated areas that are classified as receiving high and medium application rates of manure and fertilizers. Results are summarized in **Table 19**.

Table 19. Management Scenario: Expanded Cover Crops

| ***HUC12*** | **Baseline Condition, (lbs./yr.)** | | **Winter Rye, 42% Adoption (lbs./yr.)** | | **Winter Rye, 100% Adoption (lbs./yr.)** | | **Winter Wheat, 42% Adoption (lbs./yr.)** | | **Winter Wheat, 100% Adoption (lbs./yr.)** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total P | Total N | Total P | Total N | Total P | Total N | Total P | Total N | Total P | Total N |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Naples Creek* | 8,480 | 33,553 | 7,837<br>-7.58% | 33,257<br>-0.88% | 7,405<br>-12.67% | 33,110<br>-1.32% | 7,875<br>-7.13% | 33,239<br>-0.94% | 7,357<br>-13.24% | 33,148<br>-1.21% |
| *West River* | 13,595 | 35,045 | 11,644<br>-14.35% | 34,306<br>-2.11% | 10,085<br>-25.82% | 34,087<br>-2.73% | 11,684<br>-14.1% | 34,325<br>-2.06% | 10,073<br>-25.91% | 34,161<br>-2.52% |
| *Bristol Springs* | 3,371 | 12,987 | 3,166<br>-6.08% | 12,884<br>-0.79% | 3,015<br>-10.55% | 12,843<br>-1.11% | 3,167<br>-6.05% | 12,891<br>-0.74% | 2,959<br>-12.21% | 12,874<br>-0.87% |
| *Deep Run* | 9,780 | 26,538 | 8,703<br>-11.02% | 26,047<br>-1.85% | 7,926<br>-18.96% | 25,838<br>-2.64% | 8,804<br>-9.98% | 26,029<br>-1.92% | 7,848<br>-19.76% | 25,910<br>-2.37% |
| *Sucker Brook* | 10,617 | 26,652 | 9,428<br>-11.2% | 26,066<br>-2.2% | 8,351<br>-21.34% | 25,879<br>-2.9% | 9,321<br>-12.2% | 26,151<br>-1.88% | 8,262<br>-22.18% | 25,961<br>-2.59% |
| ***Total*** | **45,843** | **134,775** | **40,778** | **132,561** | **36,782** | **131,757** | **40,850** | **132,635** | **36,499** | **132,054** |
| *Percent Change* | --- | --- | -11.05% | -1.64% | -19.77% | -2.24% | -10.89% | -1.59% | -20.38% | -2.02% |

## 5.3 Climate Change

Regional climate models, coupled with recent data, indicate that the Finger Lakes region will experience increasing amounts of rainfall, increased frequency of intense events, and longer periods of drought conditions[1]. This variability in precipitation will alter the transport of P, N, TSS from the watershed into the lake. The SWAT modeling team ran two scenarios to evaluate the projected change in phosphorus and nitrogen load, as summarized in **Table 20**.

The first scenario evaluated the potential impact of an overall 15% increase in precipitation. This increased precipitation is projected to increase TP load by 8% and N load by 5%; the most significant increases are projected for the Naples Creek and Bristol Springs subwatersheds. The second scenario increased precipitation by 15% but only during events with 5 cm/day or greater rainfall. While the same two subwatersheds would be most affected, the overall increased nutrient export is projected to be slightly lower.

[1] Climate related projections for New York are available at NYSERDA https://www.nyserda.ny.gov/climaid NYSDEC https://www.dec.ny.gov/energy/94702.html#Predictions

Table 200. Projected Impact of Increased Precipitation on Nutrient Export

| HUC12 | Baseline Conditions | | 15% Increase in Annual Precipitation | | 15% Increase During Precipitation Events > 5 cm/day | |
|---|---|---|---|---|---|---|
| | Total P (lbs./year) | Total N (lbs./year) | Total P (lbs./year) | Total N (lbs./year) | Total P (lbs./year) | Total N (lbs./year) |
| **Naples Creek** | 8,480 | 33,553 | 9,110 | 36,932 | 9,046 | 36,452 |
| **(Percent Increase)** | | | 7.44% | 10.07% | 6.68% | 8.64% |
| **West River** | 13,595 | 35,045 | 14,185 | 38,093 | 14,141 | 37,595 |
| **(Percent Increase)** | | | 4.34% | 8.70% | 4.01% | 7.28% |
| **Bristol Springs** | 3,371 | 12,987 | 3,610 | 14,464 | 3,582 | 14,244 |
| **(Percent Increase)** | | | 7.09% | 11.37% | 6.26% | 9.68% |
| **Deep Run** | 9,780 | 26,538 | 10,164 | 28,521 | 10,140 | 28,210 |
| **(Percent Increase)** | | | 3.92% | 7.47% | 3.68% | 6.30% |
| **Sucker Brook** | 10,617 | 26,652 | 11,089 | 28,086 | 11,067 | 27,772 |
| **(Percent Increase)** | | | 4.44% | 5.38% | 4.24% | 4.20% |
| **Total** | 45,843 | 134,775 | 48,158 | 146,096 | 47,975 | 144,274 |
| **Percent Increase from Baseline** | | | 5.05% | 8.4% | 4.65% | 7.05% |

## 5.4 Summary of Projections

Overall, expanded use of winter cover crops is projected to have the most benefit for reducing export of phosphorus and nitrogen from the Canandaigua Lake watershed. Even if this management practice is implemented on only cultivated lands that receive medium to large annual applications of manures and/or fertilizers, it can result in an overall decrease in phosphorus load on the order of 11%. With no changes to current management practices, due to projected increased in rain fall and climate change, total phosphorus load is projected to increase by approximately 5%.

The SWAT model projections in Section 5 have been summarized by the HUC12 subwatersheds. The watershed-wide reduction in nutrient export of the scenarios is summarized in **Table 21**.

Expanded use of winter cover crops appears to offer the greatest potential for reducing phosphorus load to Canandaigua Lake, particularly when accompanied by other nutrient management planning measures.

Table 21. Summary of SWAT Model Projections

| Scenario | Total P (Percent change) | Nitrogen (Percent change) |
|---|---|---|
| Reduce Fertilizer Application by 10% to Agricultural Lands (Nutrient Management Plans) | -5.44% | -0.24% |
| Reduce Fertilizer Application by 20% to Agricultural Lands (Nutrient Management Plans) | -8.07% | -0.92% |
| Use of Winter Cover Crop (Rye) on 42% of Agricultural Lands | -11.05% | -1.64% |
| Use of Winter Cover Crop (Rye) on 100% of Agricultural Lands | -19.77% | -2.24% |
| Use of Winter Cover Crop (Wheat) on 42% of Agricultural Lands | -10.89% | -1.59% |
| Use of Winter Cover Crop (Wheat) on 100% of Agricultural Lands | -20.38% | -2.02% |
| Reduce Fertilizer Application by 20% on Developed (Urban) Lands | -0.80% | -0.80% |
| Increase Precipitation by 15% | +5.05% | +8.40% |
| Increase Days with Precipitation > 5 cm/day by 15% | +4.65% | +7.05% |

## 6. Supporting References


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