April 2022

Seneca-Keuka Watershed Nine Element Plan for Phosphorus

Prepared for: Seneca Watershed Intermunicipal Organization
Keuka Watershed Improvement Cooperative
Seneca Lake Pure Waters Association
Keuka Lake Association

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This plan was prepared with funding provided by the New York State Department of State under Title 11 of the Environmental Protection Fund.

DRAFT

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ABBREVIATIONS

9E	Nine Element Plan
AEM	Agricultural Environmental Management
AIS	Aquatic Invasive Species
BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operation
CAST	Chesapeake Assessment Scenario Tool
CCE	Cornell Cooperative Extension
CSLAP	Citizens Statewide Lake Assessment Program
CSI	Community Science Institute
CWCS	Comprehensive Wildlife Conservation Strategy
DOW	Division of Water
ELAP	Environmental Laboratory Accreditation Program
EQIP	Environmental Quality Incentives Program
FLI	Finger Lakes Institute
FL-PRISM	Finger Lakes Partnership for Regional Invasive Species Management
FOIL	Freedom of Information Law
GIS	Geographic Information Systems
HAB	Harmful Algal Bloom
HRU	Hydrologic Response Unit
HUC	Hydrologic Unit Code
KLA	Keuka Lake Association
KLOC	Keuka Lake Outlet Compact
KWIC	Keuka Watershed Improvement Cooperative
MS4	Municipal Separate Storm Sewer Systems
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NRCS	National Resource Conservation Survey
NYSAGM	New York State Department of Agriculture and Markets
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOS	New York State Department of State
NYSFOLA	New York State Federation of Lake Associations
NWI	National Wetlands Inventory
PEERS	Professional External Evaluations of Rivers and Streams
PFA	Perfluoroalkoxy Alkane
POTW	Publicly Owned Treatment Works

PUD	Planned Unit Development
Pure Waters	Seneca Lake Pure Waters Association
QAPP	Quality Assurance Project Plan
RIBS	Rotating Integrated Basin Studies
SPDES	State Pollutant Discharge Elimination System
SRP	Soluble Reactive Phosphorus
SWAP	State Wildlife Action Plan
SWAT	Soil & Water Assessment Tool
SWCD	Soil and Water Conservation District
SWIO	Seneca Watershed Intermunicipal Organization
TAC	Technical Advisory Committee
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TS	Trout Spawning
TSS	Total Suspended Solids
UFI	Upstate Freshwater Institute
USACE	United States Army Corp of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WAVE	Water Assessments by Volunteer Evaluators
WI/PWL	Waterbody Inventory/Priority Waterbodies List
WWTP	Wastewater Treatment Plant

1 Introduction

Keuka Lake and Seneca Lake form the Seneca-Keuka watershed; together these two lakes contain more than half of the water within the eleven New York Finger Lakes. The Seneca Lake watershed is part of the Seneca-Oswego-Oneida basin, which drains a total of 5,100 square miles. This large catchment area directs water from upland areas into streams and rivers that flow into the Finger Lakes and continue north to Lake Ontario through low-gradient rivers. The Seneca-Keuka watershed is located within Central New York, encompassing parts of Schuyler, Yates, Seneca, Chemung, Steuben, and Ontario counties. This watershed is a uniquely beautiful landscape, appreciated for its topography, water resources, mosaic of farmlands, vineyards, and forests, and picturesque rural landscape.

The watershed community has demonstrated strong support for watershed planning and management, with effective partnerships taken place since the 1990s. This Nine Element Plan (9E Plan) builds on relationships and collaborations established through previous watershed planning processes, including *Setting a Course for Seneca Lake,* the *State of the Seneca Lake Watershed* (1999), the *Seneca Lake Watershed Management Plan* (2012), the *Keuka Lake Watershed Protection Plan* (1996), and the *Keuka Lake Watershed Land Use Planning Guide* (2009). The 9E planning process is structured to engage the watershed community, including residents and leaders of municipalities, representatives of water resources management agencies, and non-governmental organizations. The process to develop a 9E Plan involves identifying factors affecting water quality and defining effective strategies to restore and protect resources for future generations.

The 9E planning process differs from prior watershed planning efforts in its focus on adaptive management and use of quantitative tools to identify priority areas for action. Priority areas encompass both geographical regions (subwatersheds) and potential sources of phosphorus affecting water quality. In multiple New York State Department of Environmental Conservation (NYSDEC) documents including priority waterbody lists and lake assessment program reports, phosphorus is considered the primary substance affecting water quality and the usability of the resource for both aquatic habitat and human uses. Due to this, phosphorus is the principal – though not sole – focuses of this plan.

1.1 Watershed Profile and History

The watershed area encompassed within this 9E Plan includes portions of six counties and extends over approximately 712 square miles as measured from the Seneca Lake – Seneca Cayuga Canal confluence in (**Figure 1**). While the region ultimately drains north to Lake Ontario, water also flows from west to east as the Keuka Lake Outlet enters Seneca Lake at the Village of Dresden on the western shoreline of Seneca Lake.

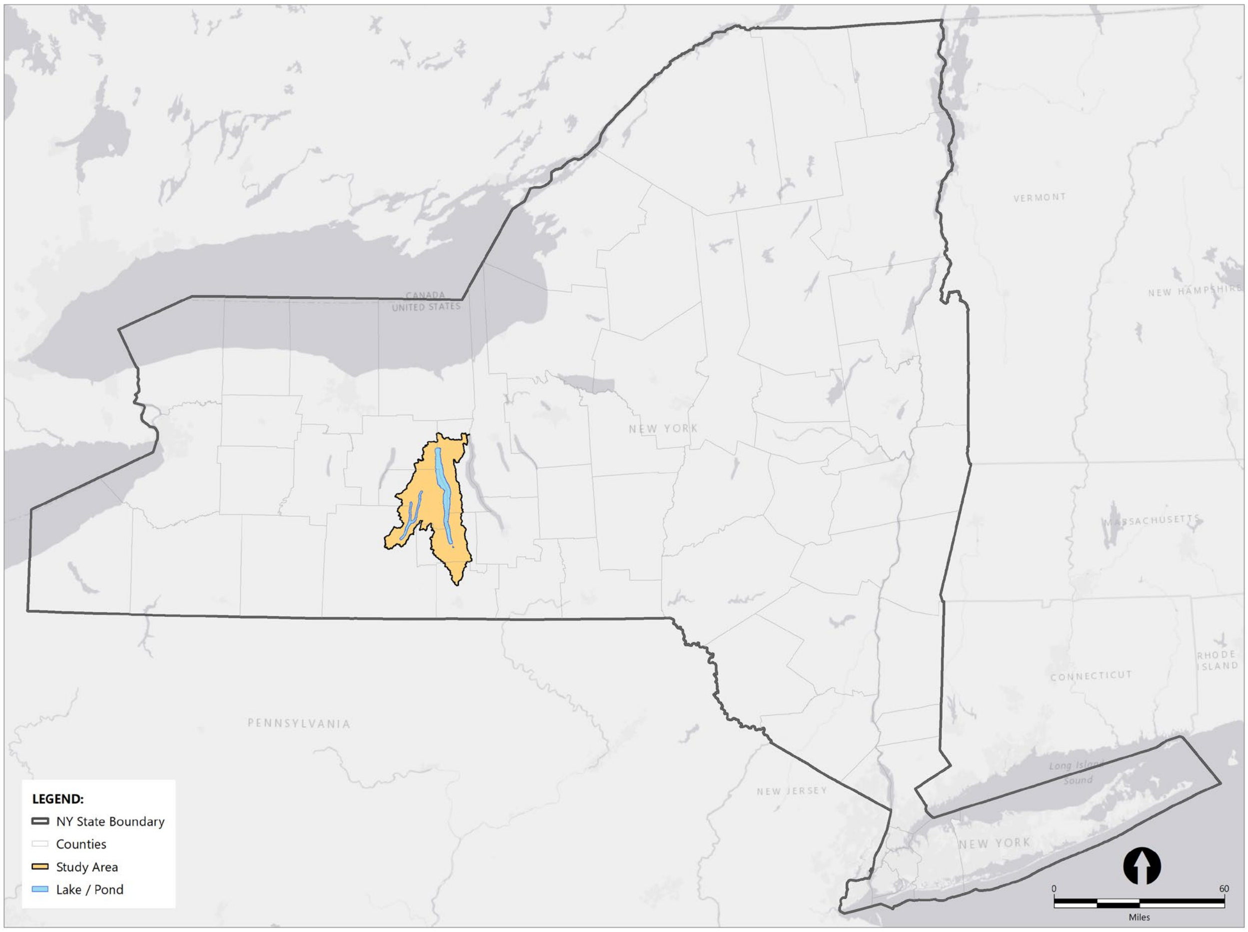

Figure 1: Location Map of the Seneca-Keuka Watershed Within New York State

Note: This location map includes lands surrounding the Seneca Lake Outlet to Cayuga Lake; the Cayuga - Seneca Canal. These small subwatersheds of Silver Creek and Sucker Brook are not included as part of the Seneca-Keuka Watershed 9E Plan for Phosphorus analysis but were analyzed as part of the model setup and calibration.

Geomorphology and hydrology of the Finger Lakes is the consequence of glacial activity over millennia. During the Pleistocene glaciation, ice sheets over two miles high flowed southward gouging deep trenches and deepening pre-glacial river valleys. As the glaciers eventually melted, topographic changes and deposition of materials carved from the landscape by the massive ice sheets altered water flow; the Finger Lakes now drain north into the Great Lakes system. The southern ends of the lakes are defined by high walls cut by steep gorges, with gentle rolling hills and valleys surrounding the lake.

Much of the land in the watershed was covered by forest until the late 1700s when settlers began clearing the land for agricultural and lumbering purposes, the first prominent industries of the watershed. In the 1830s, the Crooked Lake Canal, connecting Keuka and Seneca Lakes, spurred economic growth in the region, allowing the transport of agricultural goods. In the 1830s, the first vineyards were planted, sparking the beginning of a prominent industry in the watershed made possible by the soils, geology, and climate of the area. The advent of the Erie Canal/Barge Canal system further encouraged agricultural production in the watershed by opening new avenues for trade and distribution. Presently, the watershed of Seneca and Keuka Lakes is characterized by its rural landscape, open views to the lakes, and mosaic of farmlands, vineyards, and settlements.

1.2 Issues Impacting the Watershed

Seneca and Keuka Lakes are highly valued water resources that support multiple uses. In New York, all surface waters are classified by "best use" based on stream flow, water quality, habitat, land use and other considerations. Seneca Lake is classified into four separate regulatory segments based on significant variation in morphometry and habitat (**Table 1**).

Table 1: Regulatory Classification of Seneca Lake Segments

Segment	Description	Regulatory Classification	Designated Best Use
Main Lake Middle	Approximately 40,290 acres	AA (TS)	Class AA: Potable water supply, primary and secondary contact recreation, and fishing. The waters shall be suitable for fish, shellfish, and wildlife propagation and survival. TS: Trout spawning
Main Lake North	Approximately 2,560 acres	B(T)	Class B: Primary and secondary contact recreation, and fishing. The waters shall be suitable for fish, shellfish, and wildlife propagation and survival. T: Trout waters
Adjacent to Keuka Lake Outlet	Portion of Seneca Lake within a one-mile radius of inflow from Keuka (Village of Dresden)	B(T)	Primary and secondary contact recreation, and fishing. The waters shall be suitable for fish, shellfish, and wildlife propagation and survival. T: Trout waters
Main Lake South	Approximately 238 acres	B(T)	Primary and secondary contact recreation, and fishing. The waters shall be suitable for fish, shellfish, and wildlife propagation and survival. T: Trout waters

The most recent waterbody segment assessment fact sheet (dated December 7, 2021) issued by NYSDEC lists the main lake (middle) segment of Seneca Lake as "Stressed" for its designated best uses for fishing, primary and secondary contact recreation, and as a water supply source. This designation was assigned to Seneca Lake based on pH data from 2012 (fishing, and recreation), magnesium, pH, and sulfate data from 2012 (water supply). Note that all the assessments in the updated fact sheet are categorized as "unconfirmed."

Use attainment status of the main lake north segment was reported in December 2021 as well; this segment of Seneca Lake is noted as fully supporting its designated best uses for primary and secondary water contact recreation. Fishing was not assessed. The status of the main lake south segment has not been updated since 2016. This prior assessment considered recreational use of the lake's southern segment as threatened by harmful algal blooms (HABs) and pathogens.

Keuka Lake has water quality and habitat conditions that support a reproductive salmonid fishery, as signified by its TS (Trout Spawning) designation. Like the main middle segment of Seneca Lake, Keuka Lake is designated as a Class AA(TS) water body, though it is not segmented due more homogenous characteristics. The lake's best uses are potable water supply, primary and secondary water contact recreation, and aquatic life protection (**Table 2**).

Table 2: Regulatory Classification of Keuka Lake

Segment	Description	Regulatory Classification	Designated Best Use
Entire Lake	Approximately 11,678 acres	AA (TS)	Class AA: Potable water supply, primary and secondary contact recreation, and fishing. The waters shall be suitable for fish, shellfish, and wildlife propagation and survival. TS: Trout spawning

The most recent waterbody segment assessment fact sheet (dated December 7, 2021) issued by NYSDEC lists Keuka Lake as "Stressed" for use as a water supply source, and notes that this assessment is unconfirmed. Pollutants cited include ammonia, chloride, and nitrate + nitrate- Nitrogen. Data are from the 2017 Citizens Statewide Lake Assessment Program (CSLAP) report. However, primary and secondary recreation in and on Keuka Lake are assessed as fully supported.

Since 2017, both Seneca and Keuka Lakes have experienced algal blooms and documented multiple occurrences of cyanobacterial blooms, referred to as HABs. HABs pose a threat to public health and can impair both recreational access and potable water use. Although a scientific consensus on the cause(s) of HABs has not been determined yet, it is clear that warming waters, periods of low winds, and phosphorus availability affect the risk of cyanobacterial blooms. The presence of *Dreissena polymorpha* and *Dreissena rostriformis* (zebra and quagga mussels, respectively) are implicated as well. These invasive species alter the phosphorus exchange at the sediment water interface and effectively increase the biological availability of phosphorus to support the growth of algae and cyanobacteria.

1.3 Existing Plans and Initiatives

- Water Resources Planning and Related Documents:
  - Seneca Lake Watershed Management Plan (2012)
  - Keuka Lake Looking Ahead: A Community Listens to the Lake (1996)
  - Keuka Lake Watershed Viewshed Identification and Prioritization (2015)
  - Setting a Course for Seneca Lake – The State of the Seneca Lake Watershed (1999)
  - Keuka Lake Watershed Farmland & Agricultural Protection Plan (2014)
  - Advancing Resiliency through Housing Assistance in the Genesee-Finger Lakes Region (Current)
  - Genesee-Finger Lakes Impervious Surface Scan (2011)
  - Genesee-Finger Lakes Road Deicing & Storage Inventory (2004)

  - » Green Infrastructure and Low Impact Development Evaluation and Implementation Plan (2011)
  - » Green Infrastructure for Historic Districts (2013)
  - » Finger Lakes Regional Sustainability Plan (2013)
  - » Genesee-Finger Lakes Regional Blueway Trails Analysis (2010)
  - » Genesee-Finger Lakes Regional Inventory of Culturally Significant Areas (2011)
  - » Planning for Transportation and Climate Change: Model Ordinances, Incentives, and Other Resources (2014)
  - » Regional Development Analysis (Build-Out) (2004)
  - » Cleaner Greener Southern Tier, Regional Sustainability Plan (2013)

- Water Quality Documents and Studies:
  - » Annual CSLAP reports for Seneca and Keuka Lakes
  - » Reports by Professor John Halfman, colleagues from the Finger Lakes Institute, and students from Hobart William Smith Colleges (http://people.hws.edu/halfman/#Publications)
  - » Water Quality and Pollution Sources to the Keuka Outlet (2003-2005)
  - » Water Quality of the Eight Eastern Finger Lakes, New York: 2005-2016
  - » Water Quality of Seneca Lake, New York: A 2007 Update
  - » Water Quality of Seneca Lake, New York: A 2011 Update
  - » A 2014 Update on the Chloride Hydrogeochemistry in Seneca Lake, NY
  - » Decade-Scale Water Quality Variability in the Eastern Finger Lakes, New York (2017)
  - » 2018 Finger Lakes Water Quality Report (DEC)
  - » The Impact of the Zebra Mussel on the Limnology, Geochemistry, and Sedimentology of Seneca Lake, NY (1999)
  - » Nonpoint Source Pollutant Management Program, Annual Reports
  - » Case Studies of Individual and Clustered (Decentralized) Wastewater Management Programs – State and Community Management Approaches (2012)

1.4 9E Plan Development Process

The 9E Plan includes review and analysis of recent data, regulatory developments, planning documents, and lake and watershed initiatives. The objective of the Seneca-Keuka Watershed 9E Plan for Phosphorus is to identify specific actions to reduce phosphorus loading to the lakes and minimize the risk of cyanobacterial blooms and other threats to ecosystem services.

9E Plans are among the NYSDEC approaches to Clean Water Planning across the state. The plans' format and content are consistent with the United States Environmental Protection Agency (USEPA) framework for watershed planning; they embrace a watershed approach and recommend specific actions in an adaptive management framework. The 9E framework identifies sources and magnitude of pollutants, determines water quality goals or targets, defines pollution reductions needed to meet the goals, and describes the actions or best management practices (BMPs) needed to achieve the reductions that will improve water quality. The Nine Elements of the plan and their location within this document are listed in **Table 3**.

Table 3: Nine Elements Overview

Nine Element Criteria	NYSDEC/USEPA Definition	Location In Document
a	Identify the causes and sources of pollution that need to be controlled	3
b	Identify water quality target or goal and pollutant reductions needed to achieve goal	3.5, 4.2, 5
c	Identify the best management practices (BMPs) that will help to achieve reductions needed to meet water quality goal/target	4.3, 5
d	Describe the financial and technical assistance needed to implement BMPs identified in element *c*	5
e	Describe the outreach to stakeholders and how their input was incorporated and the role of stakeholders to implement the plan	1.5
f	Estimate a schedule to implement BMPs identified in plan	5
g	Describe the milestones and estimated time frames for the implementation of BMPs	5
h	Identify the criteria that will be used to assess water quality improvement as the plan is implemented	5.4
i	Describe the monitoring plan that will collect water quality data need to measure water quality improvement (criteria identified in element *h*)	5.4.2

1.4.1 Agencies and Organizations

The Town of Geneva is the project's lead agency and is responsible for coordination with the New York State Department of State (NYSDOS), other state, regional, and local entities, and consultants. A local Project Team was assembled to execute this project and consists of representatives from Seneca Watershed Intermunicipal Organization (SWIO), Keuka Watershed Improvement Cooperative (KWIC), Seneca Lake Pure Waters Association (Pure Waters), Keuka Lake Association (KLA), Finger Lakes Institute at Hobart and William Smith Colleges (FLI), Yates County Soil and Water Conservation District (SWCD), Ontario County Planning Department, and project consultants EcoLogic LLC, Anchor QEA and Cornell University.

The NYSDOS provided matching funds for this watershed revitalization plan through a Local Waterfront Revitalization Program grant. NYSDOS reviewed/approved project deliverables and provided guidance to the Project Team. In addition, NYSDEC reviewed the 9E Plan to ensure that it includes the required elements.

EcoLogic LLC is the prime consultant to the Town of Geneva and was responsible for project execution and creation of project deliverables. Anchor QEA joined the EcoLogic project team to develop the watershed model using the Soil and Water Assessment Tool (SWAT). The engineers and scientists from Anchor QEA also developed a mass-balance model of Keuka Lake to link phosphorus inputs to primary productivity metrics. The two firms have collaborated on all elements of this assignment. A separate contract was awarded to engage Cornell University Professor George Frantz on an analysis of local laws and development trends that directly or tangentially affect water quality conditions.

1.4.2 Project Oversight

Town of Geneva Supervisor and SWIO Chair Mark Venuti oversaw development of the Seneca-Keuka Watershed 9E Plan for Phosphorus. The project was managed by Ian Smith, Seneca Watershed Steward affiliated with FLI and SWIO. An Executive Committee was formed to facilitate communication among the many partners in the large watershed. Members of the Executive Committee included:

- Betsy Landre (Ontario County Planning Department)
- Colby Petersen (Yates County SWCD and Keuka Lake Manager)
- Dan Corbett (Pure Waters)
- Kate Hogle (NYSDOS)
- Lisa Cleckner (FLI)
- Mark Morris (KLA)
- Mark Venuti (Town of Geneva and SWIO)
- Steve Butchko (Town of Wayne and KWIC)

A Technical Advisory Committee (TAC) was convened to review existing data, identify data and information gaps, and coordinate monitoring efforts in support of the watershed modeling tasks. An important role of the TAC was to prepare and review Quality Assurance Project Plans (QAPPs) for both monitoring and modeling. The TAC met periodically over the three-year project effort. Members of the TAC included:

- Anthony Prestigiacomo (NYSDEC, Finger Lakes Water Hub)
- Colby Petersen (Yates County SWCD, Keuka Lake Manager)
- Ian Smith (Seneca Lake Steward, FLI)
- Jim Rhea (Anchor QEA)
- Lewis McCaffrey (NYSDEC, Finger Lakes Water Hub)
- Liz Moran (EcoLogic)
- Michelle McGinnis (EcoLogic)
- Mike Werth (Anchor QEA)

A Project Advisory Committee (PAC) was convened and met at key milestones during development of the 9E Plan to discuss vision and goals, receive updates on the water quality modeling efforts, and provide valuable input on recommendations. The PAC included local leaders, representatives of resource management agencies within the watershed, and faculty and staff from area colleges.

1.4.3 Quality Assurance Project Plans (QAPP)

New York State-funded projects that involve collection of environmental data and/or use modeling require development and formal approval of a QAPP. Two QAPPs were required for this project. Project Manager Ian Smith prepared the QAPP that guided tributary monitoring efforts; this document describes locations, parameters, frequency, analytical methods, data screening criteria, and data management (**Appendix A**). Michael Werth and colleagues at Anchor QEA prepared the modeling QAPP to document the models' structures, underlying assumptions, data and information sources, and the process of model validation and calibration (**Appendix B**).

1.4.4 Soil & Water Assessment Tool (SWAT)

A primary task of the 9E Plan is to develop a quantitative model of the Seneca-Keuka watershed capable of predicting transport of dissolved and particulate substances from the landscape to the waterways. Mapping and modeling tools are used to identify specific practices and areas that contribute a disproportionate amount of phosphorus that threaten the receiving water's ability to meet its desired uses. Models used site-specific data and information to reflect local conditions and build confidence in the reasonableness of recommendations for long-term improvement. The team selected the SWAT as the framework to complete the watershed loading analysis. An overview of the SWAT model is provided in this section. Additional details are provided in **Appendix C.**

The SWAT model was selected because it is designed to simulate the movement of both particulate and dissolved phosphorus from the watershed to surface water; these biologically available nutrient inputs affect the proliferation of algae and cyanobacteria. SWAT is applied to quantify and predict the impacts of land management practices on water, sediment, and agricultural chemical yields in large complex watersheds with varying soils, land use, and management conditions. The model has been widely used for Clean Water Plans in New York State, including Cayuga Lake, Owasco Lake, Skaneateles Lake, Canandaigua Lake, and Lake Champlain, among others.

1.4.5 Keuka Lake Mass Balance Model

In addition to the watershed model, Keuka Lake representatives requested the project team to develop a predictive tool linking phosphorus input from the watershed to in-lake concentrations. The Anchor QEA team selected the empirical eutrophication model BATHTUB for application to Keuka Lake. This model estimates steady-state TP concentration of Keuka Lake in response to external loading through an algorithm that includes lake depth, water residence time, dissolved oxygen concentrations, and other factors affecting in-lake deposition rates. The algorithm is based on data from multiple lakes in North America. Recent water quality data for Keuka Lake were used during model set up and testing. Additional detail on the BATHTUB model is included in **Appendix C.**

Note that developing an in-lake water quality model of Seneca Lake was not within the scope of the 9E Plan. Seneca Lake's size, depth, water residence time, and complexity preclude use of a simple empirical model such as BATHTUB for this system. Detailed mapping of Seneca Lake's bottom profile (bathymetry) is an important data gap associated with developing the hydrodynamic framework needed to support a mechanistic water quality model of this complex system.

1.4.6 Management Plan Recommendations

The calibrated SWAT model can support analysis of the relative magnitude and importance of phosphorus sources, both geographically (subwatershed), and by land use and vegetative cover type (developed areas, agricultural lands, forests, etc.). This analysis helps guide the watershed community in defining priority actions for protection and restoration. These priority actions are among the recommendations included in the 9E Plan. It is important to note that many important and potentially effective recommendations cannot be quantified using mathematical modeling tools developed for this project, so general recommendations related to municipal land use guidelines may extend over larger areas of the watershed.

Recommendations for the Seneca-Keuka watershed were identified using multiple sources, including:

- Watershed Management Plans for Seneca and Keuka Lakes
- Input from intermunicipal organizations and citizen coalitions
- Project Advisory Committee
- HABs Action Plans for other Finger Lakes, notably Cayuga Lake (2018)
- Draft phosphorus total maximum daily load (TMDL) for Cayuga Lake (2021)
- Consultations with SWCD staff and other agricultural experts
- Findings from the review of local laws completed by Cornell University Professor George Franz and students (2021)
- Emerging knowledge from FLI and other partners

1.5 Public Participation and Outreach

The public outreach process was designed to:

- Engage watershed stakeholders regarding their vision, goals, priorities, and recommendations
- Provide opportunities to review and comment on draft documents
- Foster effective communication among the project team, project technical advisors, agency representatives, stakeholders, and the public

The Seneca-Keuka Watershed 9E Executive Committee implemented the NYSDOS-approved *Community Outreach Plan* with Project Manager Ian Smith as the leader. The Project Advisory Committee provided input on draft work products, including vision, recommendations, priorities, and participated in public meetings. Three public outreach sessions were held to update the public on the 9E Plan's progress. A fourth public outreach session was held to present this document. Based on feedback from the Project

Advisory Committee and the public, a unified vision statement and set of narrative goals for the Seneca-Keuka Watershed 9E Plan for Phosphorus were developed to guide future implementation and prioritization.

1.5.1 Project Vision

A major goal of the 9E Plan is to preserve and improve water quality, while also fostering progress toward achieving the community's vision for the future of the Seneca-Keuka watershed. This 9E Plan provides direction and purpose to the selection of BMPs and associated implementation strategies. The 9E Plan is not only a reflection of water quality and environmental issues, but also considers cultural, social, and economic factors:

- Biological and chemical deteriorations in water quality have led to the proliferation of HABs, aquatic invasive species (AIS) proliferation, and shifts in aquatic community composition. Deterioration in water quality threatens human health and safety for those using affected waterbodies as a drinking water source, as well as diminishing their recreational value. These issues threaten the desirability of the area for current and future residents and visitors, while directly impacting property values, tax rolls and business revenue.

- Regional changes in climate are affecting precipitation patterns, including increased frequency of intense storm events. At the same time, changes in land cover and land management practices have reduced the landscape's infiltration capacity. The net result is a higher risk of overland flows and elevated stream velocity and discharge. This has resulted in increased frequency and severity of flooding, which poses significant threats to public safety, as well as both private and public infrastructure.

- The Seneca-Keuka watershed is one of the most agriculturally productive regions in New York and, as a result, agriculture is foundational to the local economy and culture. This sector – once dominated by small-scale dairy farms – has diversified to include large, concentrated animal feeding operations (CAFOs), grazing operations, crop farming, and viticulture. This diversification has resulted in secondary economic benefits and cultural shifts of great value.

The Seneca-Keuka watershed is valued for its rural character and composition. In addition to the two lakes, there are diverse landscapes of forests, farms, glens, and wetlands providing unique vistas and contributing to a sense of place. The landscape diversity supports numerous uses by residents and visitors alike, which contribute to economic and cultural diversification of the region. Based on these considerations, the recommendations of the 9E Plan are intended to support the following vision of a desired future:

"The Seneca-Keuka Watershed 9E Plan for Phosphorus will lead to improvements in water quality that will restore natural ecosystems and protect human health, thereby maximizing the economic, social, and cultural

value of these threatened resources. The means for achieving this will ensure preservation and enhancement of the agricultural vitality of the region as well as other highly valued natural resources that together define the character of the landscape and community."

1.5.2 Project Goals

The implementation strategies and the associated BMPs proposed in this document are informed by current water quality conditions and future target conditions. However, developing numeric thresholds for phosphorus is complex, as the element is naturally occurring and required to support life. Phosphorus concentrations in lakes and streams are a net result of multiple factors, including baseline physical, chemical, and biological conditions of the lake and watershed. These features of the environmental setting are affected by human activities such as land management and waste disposal. In addition, there is no set threshold over which phosphorus causes impairments; excessive phosphorus concentrations can cause conditions that adversely affect aquatic habitat, recreational suitability, or the level of treatment required for use as a potable supply.

Due to these factors, New York State has promulgated a narrative ambient water quality standard for phosphorus "*none in amounts that result in the growths of algae, weeds and slimes that will impair the waters for their best usage."* In addition, the state has adopted a phosphorus guidance value (summer average total phosphorus 20 ug/L, upper waters) designed to protect recreational uses.

- *Goal: All waterbodies will meet their designated use criteria.*

The major delivery pathway for phosphorus to large waterbodies in the Seneca-Keuka watershed is via upstream surface water discharges. When an upstream waterbody has less stringent water quality standards than those of the receiving downstream waterbody, the upstream waterbody – even when achieving its designated use – can contribute to the impairment of the downstream waterway.

- *Goal: Upstream waterbodies must meet or exceed the water quality standards of downstream waterbodies at the point of confluence.*

Excessive amounts of phosphorus is strongly implicated as a primary driver of HABs. However, with blooms reported on oligotrophic, mesotrophic, and eutrophic lakes, significant uncertainty remains around the threshold conditions that trigger cyanobacterial blooms. There is consensus that higher concentrations of biologically available phosphorus and warmer waters increase the risk of blooms.

- *Goal: Given the uncertainty in conditions leading to HAB proliferation, phosphorus export from the subwatersheds should be reduced to the greatest extent possible by retaining particulate and dissolved phosphorus on the landscape and minimizing its transport downstream.*

Changes in rainfall patterns in recent decades, coupled with long-term climate model projections, suggest that the watershed will continue to experience more intense storm events (defined as more than one inch of rainfall per hour); these intense storms already pose significant risks. The risk of flooding and downstream transport of phosphorus from the landscape is expected to rise.

- *Goal: BMP selection, design, and implementation will consider changes in rainfall patterns projected over the next several decades to address existing runoff issues and minimize expected increases in flooding and pollutant transport.*

The link between poorly managed agricultural lands and degraded water quality is well established. This has often made the farming community an easy target when promoting environmental remediation. However, the diffuse and omnipresent nature of phosphorus, sediment, and precipitation means all lands are potential contributors to reduced water quality. Furthermore, preservation and support of a sustainable agricultural economy is of critical importance to the Seneca-Keuka watershed community.

- *Goal: The commitment to reduce phosphorus transport to the waterways must be shared and not overly burdensome to any sector of the community.*

As noted above, the watershed's natural resources – forests, wetlands, fields, and waterways- provide direct and indirect economic and cultural value. These landscape features can provide significant ecological and flood mitigation benefits as well. Protection, enhancement, and expansion of the watershed's natural resources can result in broad benefits across multiple sectors.

- *Goal: Protect, restore, and expand the mosaic of natural resources that improve water quality while simultaneously reducing the risk of harm to the built environment and local economy.*

Our collective financial resources to tackle these challenges across the large watershed are limited. Consequently, BMP selection and implementation must consider costs to maximize the return on investment.

- *Goal: BMP selection and implementation will minimize the per-unit cost – e.g. dollars per pound – of reductions in phosphorus loads.*

Though the principal focus of this plan and its associated model is phosphorus loading, additional water quality stressors are known or hypothesized to negatively affect water quality. The presence of invasive species, particularly dreissenid mussels, has been identified as an additional driver of HABs. Proliferation of invasive species is often exacerbated by excessive phosphorus. Plastics, organic contaminants, and other compounds have also been detected in various areas of the watershed.

- *Goal: Prevent the introduction of new invasive species and control – or eradicate if possible –those populations already established. Additional water quality concerns will be addressed and mitigated when feasible.*

2 Watershed Characterization

Water quality is linked to conditions throughout the watershed, including its landscape (geography, soils, hydrology, habitat, and climate), land use (settlement patterns, impervious surfaces, industry and agriculture centers, and waste management practices), and conditions that alter the natural state of the land. This characterization of the environmental conditions and human activities that affect the Seneca-Keuka watershed will provide a basis for recommending long-term protection and restoration strategies for the watershed.

2.1 Physical and Natural Features

A watershed is land that drains its water to a single waterbody, such as a wetland, river, lake, coastal embayment, or ocean. The Seneca-Keuka watershed encompasses approximately 712 square miles of Central New York as measured from the Seneca Lake – Seneca Cayuga Canal confluence and includes 1,315 miles of streams that eventually flow into Seneca Lake. The watershed encompasses 20 subwatersheds (HUC12s) (**Figure 2, Table 4**).

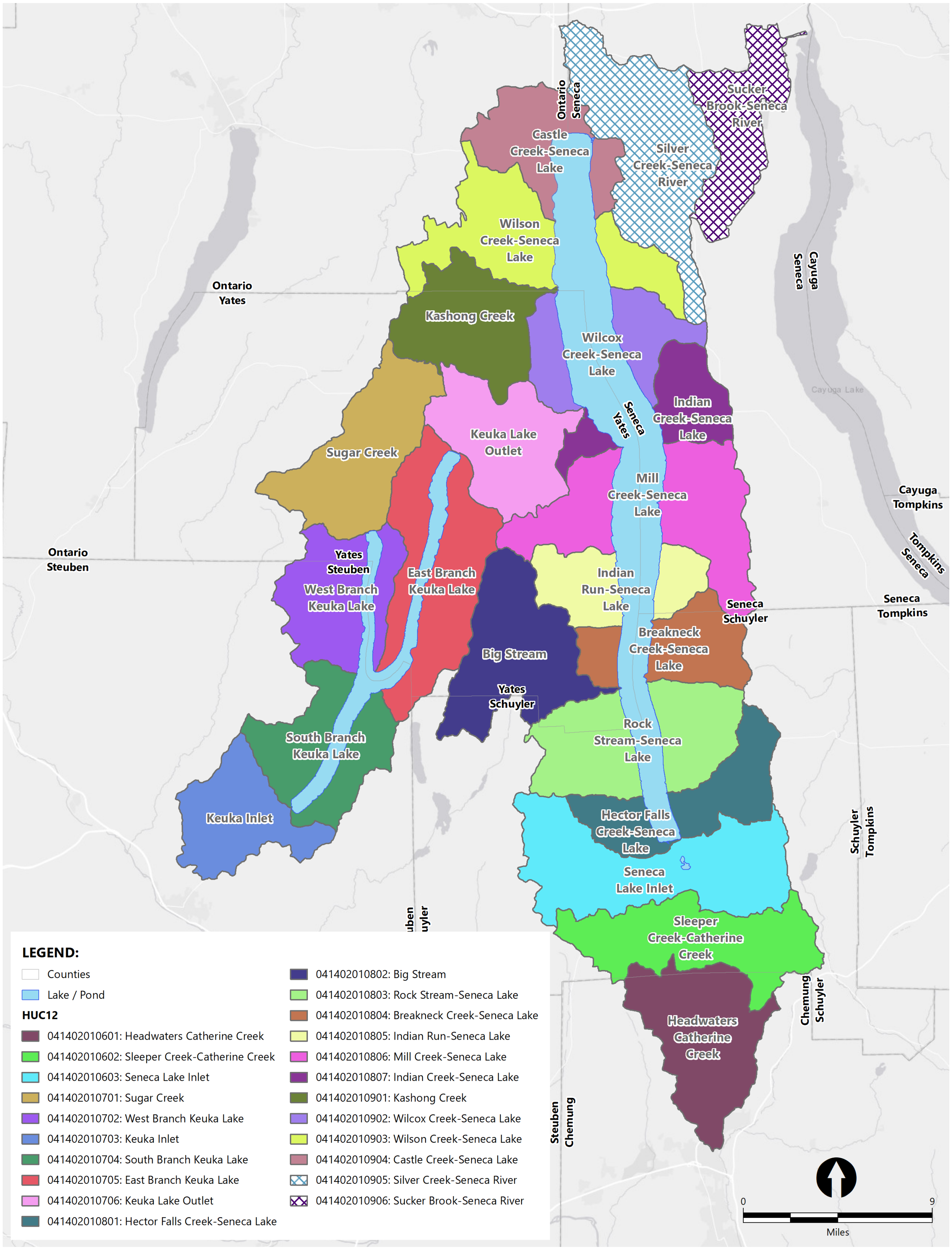

Figure 2: Map of the HUC12 Delineations

Table 4: HUC12 Areal Composition in Seneca-Keuka Watershed

HUC12	Name of HUC12 Watershed	Area (mi² / km²)
041402010601	Headwaters Catherine Creek	36.1 / 93.6
041402010602	Sleeper Creek-Catherine Creek	37.0 / 95.8
041402010603	Seneca Lake Inlet*	48.5 / 125.5
041402010701	Sugar Creek	36.4 / 94.3
041402010702	West Branch Keuka Lake	31.8 / 82.4
041402010703	Keuka Inlet*	25.3 / 65.5
041402010704	South Branch Keuka Lake	34.4 / 89.1
041402010705	East Branch Keuka Lake	48.4 / 125.3
041402010706	Keuka Lake Outlet	31.8 / 82.3
041402010801	Hector Falls Creek-Seneca Lake	28.4 / 73.5
041402010802	Big Stream	37.1 / 96.0
041402010803	Rock Stream-Seneca Lake	45.6 / 118.0
041402010804	Breakneck Creek-Seneca Lake	25.8 / 66.9
041402010805	Indian Run-Seneca Lake	26.0 / 67.8
041402010806	Mill Creek-Seneca Lake	53.4 / 138.2
041402010807	Indian Creek-Seneca Lake	23.2 / 60.2
041402010901	Kashong Creek	30.8 / 79.7
041402010902	Wilcox Creek-Seneca Lake	36.7 / 95.0
041402010903	Wilson Creek-Seneca Lake	44.5 / 115.2
041402010904	Castle Creek-Seneca Lake	30.8 / 79.8
041402010905 and 041402010906	Silver Creek and Sucker Brook- Seneca River *Note: These two HUC12 subwatersheds flow into the Seneca Lake outlet and were not included in SWAT model or the 9E Plan*	48.2 / 124.8 (Silver Creek) 25.8 / 66.7 (Sucker Brook)
Entire Seneca-Keuka Watershed	***Excluding Silver Creek and Sucker Brook***	**712.0 / 1,844.1**

Source: 2011 CDL-NLCD Hybrid Land Cover dataset.
*Note: United States Geological Survey (USGS) HUC names these subwatersheds as Seneca Lake Inlet and Keuka Lake Inlet, but they are commonly referred to as Catherine Creek and Cold Brook subwatersheds, respectively.

2.1.1 Water Use

The NYSDEC Water Quality Standards Program classifies surface waters for their best use, including water supply. Class A and AA waters are waterbodies classified as suitable for drinking and culinary purposes, as well as primary and secondary contact recreation and fishing. The best usages of Class B waters are primary and secondary contact recreation and fishing. Class C waters are best used for fishing. Water quality of Class C waters should be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes. The best use of Class D waters is fishing, although natural conditions such as intermittent flow may restrict this use. The designation (T) indicate that water quality conditions are suitable for trout; the designation (TS) indicates that water quality and habitat support trout spawning. Certain more stringent water quality standards are in place for waters with this designation. Surface waters within the Seneca-Keuka watershed are listed in **Table 5** with their respective classifications and standards.

Table 5: Waterbody Descriptions and Standards in the Seneca-Keuka Watershed

Name	Description	Classification and (Standards)
Kendig Creek	Enters Seneca River from south at a point located 0.1 mile south of N.Y. Route 5 and 0.5 mile northwest of intersection of South River Road and Knight Road.	C
Tribs. Of Kendig Creek	This includes all tribs of Kendig Creek	C
Tribs. of Seneca River	Enter Seneca River from a point 2.0 miles east of Ontario-Seneca county line and 0.7 mile southwest of Packwood Corners to Seneca Lake.	C
Subtrib. of Seneca River	Pond of trib. 1.	C
Seneca Lake	That portion of Seneca Lake from most northerly point on north shoreline of lake south 2.4 miles to an imaginary east-west line across lake passing through Pastime Park with west end 0.2 miles south of south City of Geneva line.	B(T)
Seneca Lake	That portion of Seneca Lake within a 1-mile radius of mouth of Keuka Lake Outlet coming into Seneca Lake from west in Village of Dresden, 0.7 mile northwest of Perry Point.	B(T)
Seneca Lake	That portion of Seneca Lake beginning at imaginary east-west line passing through Pastime Park and extending southerly for approximately 32 miles to an imaginary line passing through mouth of Quarter Mile Creek (trib. 61) on west side of lake 0.2 mile south of north line of Village of Watkins Glen and through mouth of trib. 58 on east side of lake 0.2 mile north of north line of Village of Watkins Glen. The portion within a 1-mile radius of Keuka Lake Outlet is excluded.	AA(TS)
Seneca Lake	That portion of Seneca Lake southerly of imaginary line across lake passing through mouth of Quarter Mile Creek and mouth of trib. 58 to south shore of lake.	B(T)
Tribs. of Seneca Lake	Enter Seneca Lake along east shore from a point 0.1 mile south of where Seneca River enters lake and N.Y. Route 96A crosses Seneca River to a point 0.3 mile north of Yale Farm Road and 0.7 mile south of Sunset Bay.	C
Reeder Creek	Enters Seneca Lake from east at a point 0.3 mile southeast of intersection of East Lake Road and Yale Farm Road and extending 2.0 miles upstream to a point which is located 0.4 mile east of intersection of Route 96A and Yale Farm Road.	C(T)
Reeder Creek	From a point 2.0 miles upstream from mouth to source.	C
Tribs. of Seneca Lake	Enter Seneca Lake along east shore from a point 0.9 mile south of Yale Farm Road, 3.2 miles southwest of MacDougall, to a point 2.4 miles south of Seneca-Schuyler County line, 0.4 mile north of Peach Orchard Point. Trib. 9 portion upstream from above Rt. 96A to source. Trib. 14 upstream from above trib. 2 to source. Trib. 15 upstream from above 1st road crossing within N.Y.S. Willard Psychiatric Center property, including tribs. and P 371, to source. Trib. 20 from above falls upstream to source. Trib. 21 from above falls upstream to source, also known as "16 Falls Creek". Trib. 23 upstream from above falls to source. Trib. 28 upstream from above falls, including tribs., to source. Trib. 38 upstream from above falls, including tribs., to source. Trib. 40 upstream from above falls to source.	C

Name	Description	Classification and (Standards)
Tribs. of Seneca Lake	From trib. 9 (Kendaia Creek) which enters Seneca Lake on east shore in the Town of Romulus south to trib. 40, which enters just below Valois Point. Trib. 9 from mouth upstream 1.5 miles to N.Y. Rt. 96A. Trib. 14 from mouth upstream to trib. 2. Trib. 15 from mouth to first road crossing within N.Y.S. Willard Psychiatric Center. Trib. 20 from mouth upstream to falls. Trib. 21 from mouth upstream to falls (16 Falls Creek). Trib. 23 from mouth upstream to falls. Trib. 28 from mouth to falls 1.3 miles upstream. Trib. 38 from mouth upstream 800 ft. to falls. Trib. 40 from mouth upstream 500 ft. to falls.	C (TS)
Sawmill Creek	Enters Seneca Lake from east at Peach Orchard Point 0.6 mile south of trib. 43. Mouth to falls 0.3 mile upstream.	C(TS)
Sawmill Creek	From falls 0.3 mile upstream from mouth to source.	C
Tribs. of Sawmill Creek	Enter Sawmill Creek from a point 1.7 miles upstream from mouth and 0.1 mile north of Hector Road to a point 3.9 miles upstream from mouth and 0.8-mile northeast of Logan.	C
Tribs. of Seneca Lake	Enter Seneca Lake along east shore from McGrath Point 0.4 mile south of Peach Orchard Point southerly to 0.4 mile north of Glen Eldridge Point 1.1 miles northwest of Village of Burdett. Trib. 45 portion from above falls to source.	C
Bull Horn Creek	From mouth upstream 650 ft. to falls.	C(TS)
Trib. of Seneca Lake	Enters Seneca Lake from east at Glen Eldridge Point 0.9 mile northwest of northwest corner of Village of Burdett. From mouth to first impassable falls located 0.1 mile upstream of mouth.	C(TS)
Trib. of Seneca Lake	From first impassable falls to N.Y. Route 414 bridge located 0.2 mile upstream of mouth.	C
Tribs. of Seneca Lake	From N.Y. Route 414 bridge to source.	C
Hector Falls Creek	Enters Seneca Lake from east at Hector Falls Point 0.5 mile south of Glenn Eldridge Point and 0.7 mile west of Village of Burdett. From mouth to first falls impassable by fish, approx. 300 feet upstream of mouth.	C
Hector Falls Creek	From first falls impassable by fish to N.Y. Route 227 bridge in center of Village of Burdett.	C(TS)
Trib. of Hector Falls Creek	Unnamed pond.	C
Hector Falls Creek	From N.Y. Route 227 bridge in Village of Burdett to trib. 6a.	C(TS)
Hector Falls Creek	From above trib. 6a upstream to source.	C(T)
Tribs. of Hector Falls Creek	Enter Hector Falls Creek from a point 1.8 miles upstream from Route 227 bridge at Village of Burdett and 0.4 mile northwest of Bennettsburg to trib. 3a,1.0 mile upstream and 0.6 mile northwest of Bennettsburg.	C
Trib. of Hector Falls Creek	Enters Hector Falls Creek from south 0.1 mile upstream from trib. 3a, 0.6 mile northeast of Bennetsburg. From mouth to source.	C(TS)
Tribs. of trib. 4 of Hector Falls Creek	Enter stream from a point 1.2 miles upstream from mouth and 1.0 mile southeast of Bennettsburg to a point 1.1 miles upstream and 0.7 mile west of Newtown Road.	C

Name	Description	Classification and (Standards)
Tribs. of Hector Falls Creek	Enter Hector Falls Creek from a point 1.1 miles west of Newtown Road and 0.3 mile north of N.Y. Route 227 to a point 0.8 mile west of Newtown Road and just north of N.Y. Route 227.	C
Trib. of Hector Falls Creek	Enters Hector Falls Creek from west 0.5 mile south of Reynoldsville and 0.2 mile east of N.Y. Route 227.	C(T)
Trib. of trib. 8 of Hector Falls Creek	Enters trib. 8 of Hector Falls Creek from south 0.3 mile upstream from mouth, 0.1 mile west of N.Y. Route 227.	C
Tribs. of Hector Falls Creek	Enter Hector Falls Creek from north and west 0.3 mile south and 0.5 mile southwest of Reynoldsville and 0.2 mile east and 0.1 mile west of N.Y. Route 227, respectively.	C
Tribs. of Seneca Lake	Enter Seneca Lake from east at a point 0.7 mile southeast of Hector Falls Point and 0.1 mile west of N.Y. Route 414 to a point just south at north line and just west of east line of Village of Watkins Glen.	C
Seneca Lake Inlet (name changes to Catherine Creek at trib. 6)	Enters Seneca Lake from south 0.2 mile south of north line and 0.1 mile west of east line of Village of Watkins Glen. From mouth to confluence with Barge Canal.	C(T)
Seneca Lake Inlet	From confluence with Barge Canal to trib. 6, 1.9 miles upstream.	C(TS)
Catherine Creek (upstream end of Seneca Lake Inlet)	From trib. 6 to a point 1.0 mile upstream from trib. 28, 0.6 mile south of Veteran-Horseheads town line and 0.8 mile east of N.Y. Route 14.	C(TS)
Catherine Creek	From a point 1.0 mile upstream from trib. 28 to source.	C
Trib. of Seneca Lake Inlet	Enters Seneca Lake Inlet from east at a point 1.1 miles upstream from mouth, 0.3 mile west of east line of Village of Watkins Glen.	C
Diversion channel	From above trib. 3b to Barge Canal (previously unclassified).	C(TS)
Johns Creek	Enters Seneca Lake Inlet from east 1.3 miles upstream from trib. 1, 0.6 mile east of N.Y. Route 14 in Village of Montour Falls. From mouth 1.2 miles upstream to outlet of P 373a which is Village of Montour Falls water supply reservoir 1.7 miles south of Hector-Montour town line and 0.5 mile east of Skyline Drive.	C
Johns Creek	From and including P 373a to source.	A
Trib. of Johns Creek	Enters Johns Creek from east 0.8 mile upstream from mouth and 0.5 mile north of N.Y. Route 224.	C
Tribs. of Johns Creek	Enter Johns Creek from east and north from a point 0.5 mile south and 1.1 miles west of north and east Montour Town lines to a point 0.1 mile south and 0.9 mile west of said town lines.	A
Tribs. of Seneca Lake Inlet	Enter Seneca Lake Inlet from east in Village of Montour Falls, 0.1 mile north and just south of N.Y. Route 224 and 0.2 mile west of Skyline Drive. Trib. 3c portion from above falls to source.	C
Trib. of Seneca Lake Inlet	From mouth upstream to falls.	C(TS)
Catlin Mill Creek	Enters Seneca Lake Inlet from east in Village of Montour Falls 0.3 mile south of N.Y. Route 224 and 0.3 mile east of N.Y. Route 14. From mouth to source.	C(TS)

Name	Description	Classification and (Standards)
Cranberry Creek	Enters Catlin Mill Creek from north in Village of Odessa, 0.2 mile south and 0.2 mile west of north and east village lines, respectively. From mouth upstream to below trib. c.	C(T)
Cranberry Creek	From trib. c upstream to source.	C(TS)
Tribs. of Cranberry Creek	Enter Cranberry Creek from a point 0.7 mile upstream from its mouth and 0.7 mile east of Upper Foots Hill Road to a point 1.9 miles upstream from its mouth and 0.6 mile east of Upper Foots Hill Road.	C
Tribs. of Catlin Mill Creek	Enter Catlin Mill Creek from a point 0.2 mile south and 0.1 mile west of north and east lines of Village of Odessa to a point 0.6 mile south of Victor-Catherine town line and 0.2 mile west of Steam Mill Road.	C
Trib. of Catlin Mill Creek	Entire trib. 7.	C(TS)
Trib. of Seneca Lake Inlet	Enters Seneca Lake Inlet from east 0.5 mile north of south line and 0.4 mile west of east line of Village of Montour Falls.	C
Trib. of Seneca Lake Inlet	Enters Seneca Lake Inlet from east 0.1 mile north of south and 0.5 mile west of east lines of Village of Montour Falls. From mouth 1.0 mile upstream to a point 0.5 mile southeast of southeast corner of Village of Montour Falls.	C(T)
Tribs. of Seneca Lake Inlet	From a point 1.0 mile upstream from mouth to source.	C
Trib. of Catherine Creek (name changed from Seneca Lake Inlet)	Enters Catherine Creek from east on south line of Village of Montour Falls 0.5 mile east of southeast corner of village. From above trib. 1 upstream to source.	C
Tribs. of Catherine Creek	From mouth upstream to trib. 1.	C(TS)
Trib. of Catherine Creek	Enters Catherine Creek from east at a point 0.3 mile south of south line of Village of Montour Falls and 0.1 mile west of N.Y. Route 14. Mouth to a point 0.8 mile upstream at Wigwam Road bridge.	C(TS)
Trib. of Catherine Creek	From Wigwam Road bridge to source.	C
Tribs. of trib. 9 of Catherine Creek	Enter trib. 9 from a point 0.1 mile upstream from mouth and 0.4 mile south of south line of Village of Montour Falls to a point 1.8 miles north of Schuyler-Chemung County line and 1.2 miles west of Montour-Catherine town line.	C
Tribs. of Catherine Creek	Enter Catherine Creek from a point 1.0 mile south of the south line of Montour Falls Village and 0.4 mile west of the Dix-Montour town line to a point 0.6 mile south of Merka Road and 0.4 mile west of Veteran Hill Road.	C
Tribs. of Catherine Creek	Trib. 10a, from mouth to 1.0 mile upstream; Trib. 12, from mouth to first falls impassable by fish (0.1 mile); trib. 15, mouth to first falls impassable by fish (1.0 mile); trib. 15-1, mouth to first falls impassable by fish (0.2 mile); trib. 18a, mouth to first falls impassable by fish (0.1 mile); trib. 24, from mouth upstream 0.5 mile; trib. 26, from mouth to 0.4 mile upstream of trib. 2.	C(TS)

Name	Description	Classification and (Standards)
Tribs of Catherine Creek	Trib. 10a, from 1.0 mile upstream of mouth to source; trib. 12, from first falls impassable by fish to source; trib. 15, from first falls impassable by fish to source; trib. 15-1, from first falls impassable by fish to source; trib. 18a, from first falls impassable by fish to source; trib. 24, from 0.5 mile upstream of mouth to source; trib. 26, from 0.4 mile upstream of trib. 2 to source.	C
Johnson Hollow Creek and tribs.	Enters Catherine Creek immediately and south of Burch Hill Road.	B
Trib. of Catherine Creek	From mouth upstream to below trib. 1.	C(TS)
Glen Creek (trib. of Seneca Lake)	Enters Seneca Lake from south at a point 0.3 mile south of north line and 0.5 mile west of east line of Village of Watkins Glen. From mouth to trib. 1.	C
Glen Creek	From trib. to 1 N.Y. Route 14 bridge in Village of Watkins Glen.	C(TS)
Glen Creek	From N.Y. Route 14 bridge at Village of Watkins Glen to first falls impassable by fish (0.15 mile).	B(TS)
Glen Creek and VanZandt Hollow	From first falls impassable by fish to source, including P 378a, P 378b and trib. 3.	B
Old Barge Canal Channel	Enters Glen Creek from south 0.3 mile upstream from mouth and 0.4 mile west of east line of Village of Watkins Glen to confluence of Seneca Lake Inlet and Catherine Creek 0.1 mile north of south line and 0.5 mile west of east line at Village of Montour Falls.	C(T)
Trib. of Old Barge Canal Channel	Enters Old Barge Canal Channel from west in Village of Montour Falls, 2.0 miles upstream from mouth and 0.2 mile east of N.Y. Route 14. From mouth to first falls impassable by fish (0.15 mile).	C(TS)
Trib. of Old Barge Canal Channel	From first falls impassable by fish to source.	C
Shequaga Creek	Enters Old Barge Canal Channel from south in Village of Montour Falls 2.2 miles upstream from mouth just south of N.Y. Route 14 crossing. Mouth to 0.7 mile upstream at Village of Montour Falls west line.	C(T)
Shequaga Creek	From Village of Montour Falls west line to trib. 5.	C(TS)
Shequaga Creek	From trib. 5 to source (unnamed). Trib. 5 also named Shequaga Creek.	C
Tribs. of Shequaga Creek	Enter Shequaga Creek from a point 0.5 mile upstream from mouth in Village of Montour Falls and 0.2 mile east of Dix-Montour town line to a point 0.7 mile north of Schuyler-Chemung County line and 0.5 mile southwest of Moreland.	C
Trib. of Shequaga Creek	From mouth to 4.2 miles upstream of mouth.	C(TS)
Trib. of Shequaga Creek	From 4.2 miles upstream of mouth to source.	C
Trib. of Old Barge Canal Channel	Enters Old Barge Canal Channel in Village of Montour Falls 0.6 mile north of its south line and 0.2 mile west of N.Y. Route 14.	C

Name	Description	Classification and (Standards)
Trib. of Glen Creek and VanZandt Hollow	Enter Glen Creek and VanZandt Hollow from a point on Glen Creek in Watkins Glen State Park 2.3 miles upstream from west line of Village of Watkins Glen and 0.1 mile north of N.Y. Route 329 to a point on VanZandt Hollow 0.9 mile west of Reading-Tyrone town line and 0.6 mile north of Mud Lake Road.	C
Tribs. of Seneca Lake	Enter Seneca Lake from west from a point in Village of Watkins Glen 0.2 mile south of north village line to Perry Point 0.3 mile south of Romulus-Ovid town line. Pond P 378c is unnamed.	C
Tribs. of Seneca Lake	Trib. 93, from mouth to first falls impassable by fish (0.15 mile). Trib. 104, from mouth to first falls impassable by fish (1.0 mile), trib. 104-1a from mouth to first falls impassable by fish (200 feet). Trib. 91 from mouth upstream to falls. Trib. 103 from mouth upstream to falls.	C(TS)
Tribs. of Seneca Lake	Trib. 104 and trib. 1a, from first falls impassable by fish to source. Trib. 91 from above falls upstream to source, including all tribs. Trib. 103 from above falls upstream to source, including all tribs. Pond P 378d is unnamed, and stocked with brown, brook trout.	C
Big Stream	Trib. 93 from falls (0.15 mile) to Rt. 14A.	D
Big Stream	From Route 14A at Dundee upstream for about 1.0 mile to Pre-emption Road.	B
Big Stream	From Pre-emption Road to 1.0 mile above trib. 11.	C
Big Stream	From 1.0 mile above trib. 11 to trib. 16.	C(TS)
Big Stream	From above trib. 16 to source. Includes all tribs.	C
Keuka Lake Outlet	Enters Seneca Lake from west in Village of Dresden on Seneca-Yates County line 0.8 mile northwest of Perry Point. From mouth 0.6 mile upstream to N.Y.C. Railroad bridge within Village of Dresden.	C(T)
Keuka Lake Outlet	From a point 0.6 mile upstream from mouth in Village of Dresden to trib. 10.	C(T)
Keuka Lake Outlet	From trib. 10 to source at Keuka Lake south of Village of Penn Yan 0.2 mile west of East Lake Road and 0.5 mile south of West Lake Road.	C
Tribs. of Keuka Lake Outlet	Enter Keuka Lake Outlet from a point 0.1 mile upstream from mouth in Village of Dresden to a point 0.3 mile downstream from Keuka Lake just east of the westline of Village of Penn Yan.	D
Keuka Lake	Begins at source of Keuka Lake Outlet south of Village of Penn Yan and extends southerly 18 miles to Village of Hammondsport.	AA(TS)
Tribs of Keuka Lake	Enter Keuka Lake from east beginning at a point 0.6 mile south of Keuka Lake Outlet 0.1 mile west of East Lake Road to a point 11 miles south on Keuka Lake 1.0 mile northwest of junction of Yates, Schuyler and Steuben county lines and 0.5 mile west of Steuben-Yates county line where trib. 25c enters Lake.	D
Tribs. of Keuka Lake	Enter Keuka Lake from east from a point 0.1 mile southwest of trib. 26 (remnants of Power Flume) southwesterly 6.0 miles to Willow Point 1.0 mile east of Village of Hammondsport.	C

Source: 6 CRR-NY 898.4.

Note: This table is reflective of official name, description, and designation for unique stream segments as determined by NYSDEC and may not reflect local naming conventions or landmarks.

Keuka Lake and most of the main body of Seneca Lake are class AA waterbodies according to the New York Codes, Rules, and Regulations (6 NYCRR 898.4), indicating that their designated best use is for water supply with minimal treatment. Many municipal water purveyors rely on Keuka or Seneca Lake for their water supply, as summarized in **Table 6.**

Table 6: Municipalities Using Keuka Lake or Seneca Lake for Public Water Supply

Lake Used	Water Purveyor	County	Public Water Supply Source
Keuka	Village of Hammondsport	Steuben	Surface
	Village of Penn Yan	Yates	Surface
Seneca	City of Geneva	Ontario	Surface
	Village of Watkins Glen	Schuyler	Surface
	Village of Waterloo	Seneca	Surface
	Village of Ovid	Seneca	Surface

Sources: KLA (Keuka Lake Association - Water Testing and Treatment) and Seneca Lake Watershed Management Plan (2012)

2.1.2 Hydrology

2.1.2.1 Surface Waters

Surface water encompasses streams, rivers, lakes, and wetlands. The Seneca-Keuka watershed contains 85.8 square miles of open water within Seneca and Keuka Lakes, as well as 1,315 miles of streams and rivers.

Seneca Lake has a surface area of approximately 66.3 square miles. Major inflows include the Keuka Outlet located at the central western shore, and Catherine Creek, located at the southern end of Seneca Lake. The primary outflow of Seneca Lake is the Seneca River/Cayuga-Seneca Canal. Other physical characteristics are summarized in **Table 7.** Seneca Lake is characterized as a meso-, mesoligotrophic lake, or between unproductive and moderately productive (CSLAP 2018). Hypolimnetic waters of the lake remain well oxygenated throughout the growing season.

Keuka Lake has a surface area of approximately 18.1 square miles. Keuka Lake is fed primarily by Cold Brook (Keuka Inlet), Sugar Creek, Glen Brook, and Wagener Glen Creek, water flows from the lake through the Keuka Lake Outlet. The Keuka Lake Outlet originates within the Village of Penn Yan and flows into Seneca Lake at the Village of Dresden, located in the middle of the western shoreline. Keuka Lake is classified as mesoligotrophic, signifying a lake of low to moderate productivity (CSLAP 2019).

Table 7: Physical Characteristics of Seneca and Keuka Lakes

Characteristic	Seneca Lake		Keuka Lake	
	English Unit	Metric Unit	English Unit	Metric Unit
Lake Surface Area [a]	43,343 acres 67.7 mi^2	172 km^2	11,584 acres 18.1 mi^2	47 km^2
Max. Lake Length / Shore Length [b]	38 mi/75 mi	61 km/121 km	20 mi/60 mi	32 km/97 km
Watershed Area (Total)[a]	(includes Keuka) 712 mi^2	(includes Keuka) 1,843 km^2	112,825 acres 176 square miles	455 km^2
Ratio of Watershed/Lake Surface Area	6.7	--	8.6	--
Lake Volume [b]	58.5 * 10^6 gallons	15,540 * 10^6 m^3	5.4 * 10^6 gallons	1,434 * 10^6 m^3
Mean Depth [b]	291 ft	89 m	101 ft	31 m
Max Depth [b]	618 ft	198 m	183 ft	55.8 m
Depth of Thermocline [b]	60-125 ft	18-38 m	30-35 ft	9-11 m
Estimated Water Residence Time [c]	18-23 years	--	6-8 years	--

Sources: a. NHDPlus2 Water Boundary Dataset (2015); b. NYSDEC, https://www.dec.ny.gov/outdoor/; c. Water Quality Study of the Finger Lakes (NYSDEC 2017).

Surface water levels are directly linked to natural processes such as precipitation, evaporation, evapotranspiration, infiltration, and runoff. Active United States Geological Survey (USGS) gage sites exist at the Keuka Outlet, Catherine Creek, and Sugar Creek (**Figure 3, Table 8**). Gage sites record daily discharge and peak streamflow data.

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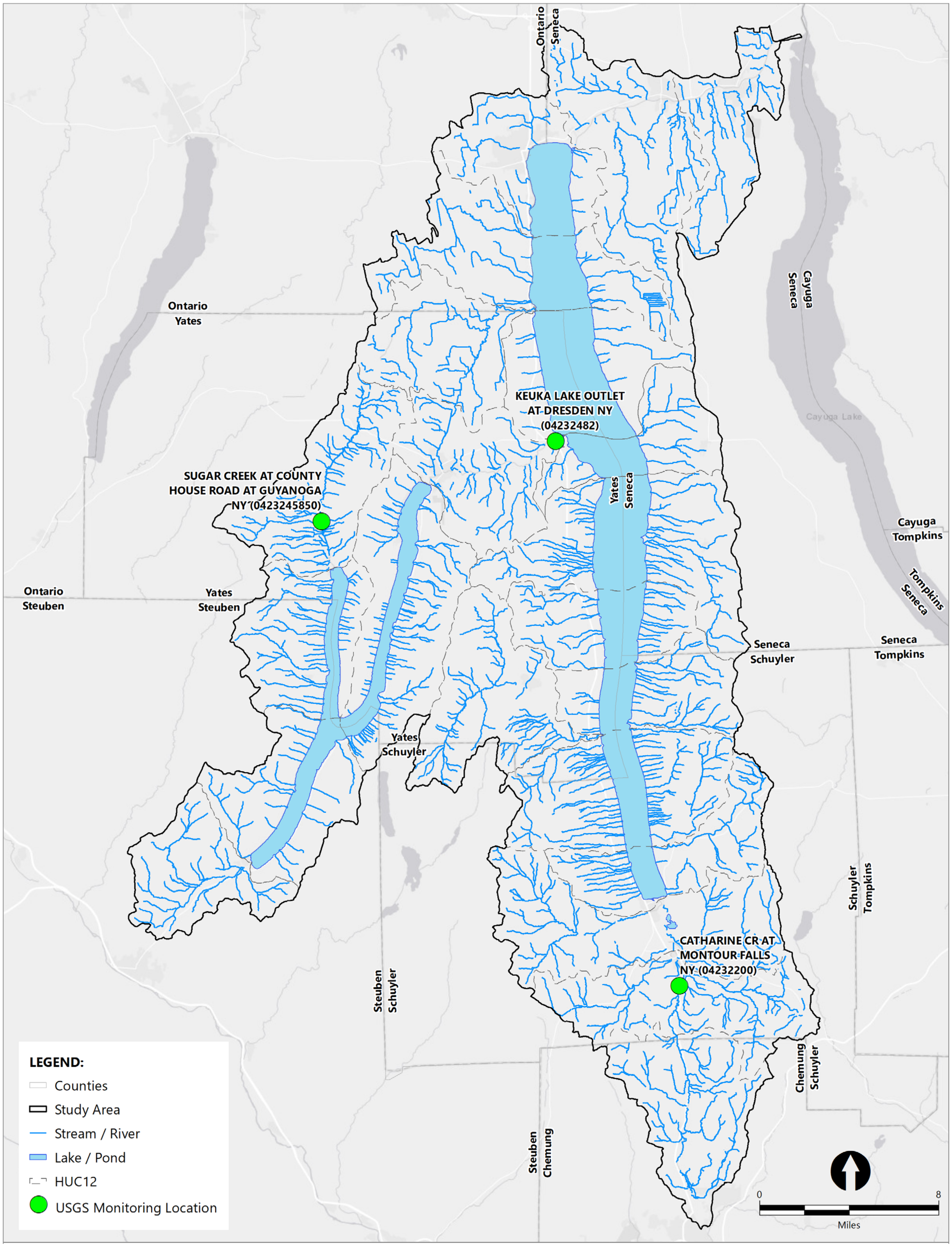

Figure 3: Active USGS Gage Sites in the Seneca-Keuka Watershed

Table 8: USGS Gage Sites in the Seneca-Keuka Watershed

Name	USGS Site Identifier	Latitude, Longitude	Drainage Area (Square miles)	Datum of Gage	Active Years
Catherine Creek at Montour Falls	04232200	42°19'41.8", 76°50'38.1"	41.1	473.40 ft above NAVD88	Aug 1975-Present
Keuka Lake Outlet at Dresden	04232481	42°40'49", 76°57'14"	207	444.85 ft above NAVD88	April 1965-Present
Sugar Creek at County House Rd at Guyanoga	0423245850	42°37'39.7", 77°09'32.1"	24.4	760 ft above NAVD88	April 2019-Present

Sources: USGS National Water Information System and USGS New York Water Science Center

During times of intense and extended rainfall, Seneca Lake levels rise by one foot for every inch of rainfall over a one- or two-day period. Seneca Lake can take a week or more to drain into the Seneca-Cayuga Canal because the lake level can only be lowered at a rate of inches per day. This issue is not unique to Seneca Lake, rapid changes in lake level from intense rain and snowmelt events occur at lakeshore areas across the Finger Lakes. The United States Army Corps of Engineers (USACE) has developed Rule Curves to guide lake level management across the Finger Lakes and reduce the risk of localized flooding for all the interconnected waterways.

Management of Keuka Lake levels is under the purview of the Keuka Lake Outlet Compact (KLOC). The levels are controlled by a series of six gates located at the Main Street Bridge in Penn Yan. KLOC aims to keep the lake level between 714.2 and 713.7 feet above sea level in the summer months and between 712.5 and 712.0 in the winter months. For Seneca Lake, Gravity Renewables owns and operates a hydroelectric power plant located along the Seneca-Cayuga Canal in Seneca Falls. Like the gates in Penn Yan, the hydroelectric plant is used to maintain a target water level for Seneca Lake; 446.3 to 445.7 feet above sea level in the summer and 445.3 to 444.7 feet in winter. Gravity Renewables must comply with requirements set forth by both the Federal Energy Regulatory Commission and the New York State Canal Corporation.

2.1.2.2 Groundwater

Groundwater is hypothesized to seep directly into Seneca Lake along the lake floor. Groundwater is the water held underground in the soil or in pores and crevices in rock. New York State has mapped and identified aquifers throughout the Seneca-Keuka watershed. Large aquifers exist at the northern and southern ends of Seneca Lake, with some smaller aquifers dotting the middle of Yates and Seneca Counties. Large aquifers also exist at the southern and northwestern ends of Keuka Lake.

2.1.3 Climate

The Finger Lakes climatic region is characterized by cold, snowy winters and warm, dry summers, although major flooding events may occur at any time (**Table 9**). Average precipitation for the watershed is 35.5 inches per year. The driest period in the year is between December and March. Snowmelt typically occurs in late March to early April, although recently, there are more frequent snowmelt events throughout the winter season due to increasing temperatures and rainfall.

Table 9: Climate Data

Climate Monitoring Station Station ID (Latitude, Longitude)	Elevation (ft (m))	Average Daily Mean Temperature (°F)		Average Total Precipitation (inches)		
		Winter	Summer	Annual	Winter	Summer
Within Watershed						
Penn Yan Airport, NY USW00054778 (42.6425°, -77.05639°)	902.9 (275.2)	27.2	68.9	32.2	5.1	10.0
Geneva Research Farm USC00303184 (42.8766°, -77.0307°)	717.8 (218.8)	26	68.5	33.5	5.4	10.2
Outside Watershed but in Close Proximity						
Aurora Research Farm, NY USC00300331 (42.7338°, -76.6591°)	830 (253)	27	69.3	36.2	6.1	10.4
Cornell University, Ithaca NY USC00304174 (42.4491°, -76.4491°)	960 (292.6)	25.8	67	37.3	6.5	11.5
Mecklenburg 4 SW, NY USC00305233 (42.4422°, -76.7586°)	1,510 (460.2)	24.8	65.3	37.4	6.4	11.7

Source: Annual/Seasonal Normals, 2010, NOAA Climatic Data

2.1.4 Geology and Topography

The area occupied by Seneca and Keuka Lakes was once part of a vast inland sea during the Paleozoic period, 220-600 million years ago. Sedimentary rocks were formed as water evaporated, salts precipitated, and sediments were deposited and compressed at a depth of 8,000 feet, making what is today's sandstones and shales of the Hamilton, Genesee, Sonyea, Java, and West Falls formations in the southern area of the basin, and the Tully and Onondaga limestones further north. The present-day lake basins, gorges, and other geomorphological features are the result of a cycle of glacial advancement and retreat over millennia.

The Seneca-Keuka watershed topography illustrates the impacts of glacial carving over the past two million years. As displayed in **Figure 4,** the lakes are surrounded by steeply sloped valleys to the south; the landscape gradually reduces in slope and elevation to the north and is characterized by rolling hills and flat plains. For Seneca Lake, the steepest slopes are found in Schuyler County, located at the southwestern region of the watershed. The Keuka Lake watershed also exhibits its steepest slopes in the southwestern region which is in Steuben County.

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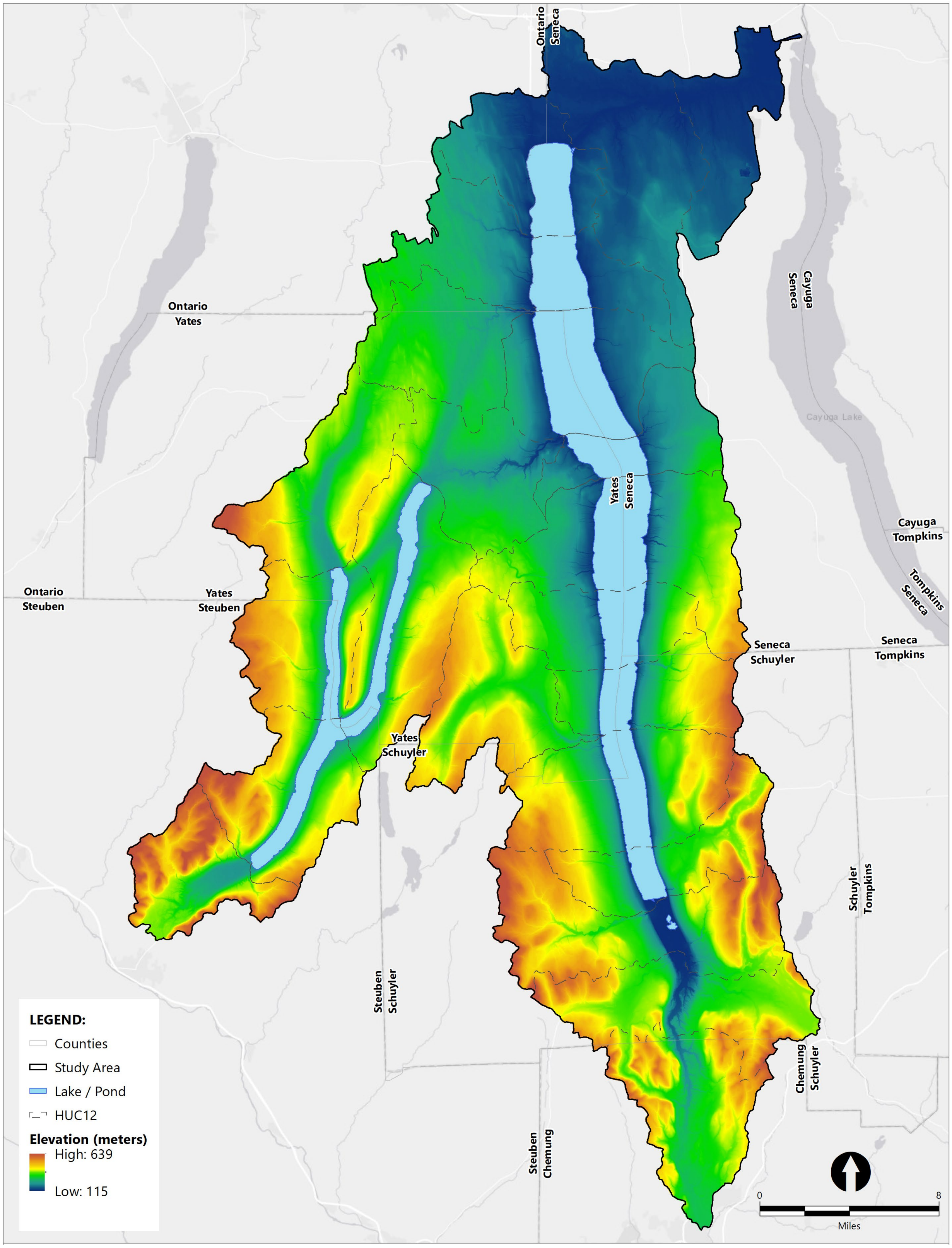

Figure 4: Elevation and Topography Map

2.1.5 Soils

Glacial till and sand and gravel deposits were left behind after the most recent glacial ice retreat event approximately 9,000-10,000 years ago. The largest sand and gravel deposits are located at the southern end of the lakes. In the successive 10,000 years, these deposits have been covered by and mixed with other material deposited by wind and water, and by humus derived from forest that covered the area.

The northern portion of the watershed contains moderately coarse-textured soil with calcareous substrata that provides buffering capacity and makes the soils more suitable for agriculture, commonly classified as Howard, Langford, Valosia and Honeoye-Lima soils (Natural Resource Conservation Service (NRCS) Web Soil Survey). In the south, more acidic, poor to moderately drained soils ae mapped, such as Volusia and Mardin-Lordstown. Volusia Channery silty loam soils at 0-3% and 8-15% slope are the most commonly occurring soils within the watershed. These soils have a low susceptibility to erosion. Highly erodible soils are present in some areas of the watershed.

The NRCS classifies soils into four hydrologic soil groups (A, B, C, D) based on the soil's runoff potential. Runoff potential generally increases from Group A to D.

- **A Soils**: typically sand, loamy land, or sandy loam soils with high infiltration rates
- **B Soils**: usually silt loam or loam soils with a moderate infiltration rate when thoroughly wetted with a fine to moderately coarse texture
- **C Soils**: have a low infiltration rate and a moderately fine to fine structure, typical of sandy clay loams
- **D Soils:** typically clay loam, silty clay loam, sandy clay, silty clay, or clay having a high runoff potential and very low infiltration rates due to its high swelling potential

Type A soils are dominant adjacent to Seneca Lake in the northern end; the northwestern region is characterized by Type B soils. The southern end of the watershed exhibits slower infiltrating soils, primarily Type B and C. This geographical diversity indicates that the southern regions of the watershed are more vulnerable to runoff issues (they exhibit less hydrologic resilience to extreme precipitation events) due to lower infiltration rates and steeper slopes.

2.2 Biological Trends

2.2.1 Ecoregions

The USEPA Level III and IV Ecoregions within the watershed are the Ontario Lowlands and the Finger Lakes Uplands and Gorges (Bryce et al. 2010). The Ontario Lowlands ecoregion, encompassing the northern half of Seneca Lake, is characterized by a more temperate climate relative to surrounding regions of New York State due to the buffering capacity of Lake Ontario and surrounding Finger Lakes. The Finger Lakes Uplands and Gorges is a transitional ecoregion positioned in the southern portion of the watershed. It is characterized by many waterfalls entering the lake basins from hanging valleys created by glaciers on former tributary streams. The region is significantly impacted by the abundance of large lakes, contributing to clouds in November and December, frequent fog in winter, and heavy snowfall. Oak forests dominate drier soils with beech, sugar maple, hemlock, and basswood growing in soils with higher moisture content. Black ash, silver maple, and elm occur in swamps, river floodplains and in the glacial troughs at the ends of the Finger Lakes.

2.2.2 Rare, Threatened, and Endangered Species

The New York Natural Heritage Program aims to conserve biodiversity by providing comprehensive information and scientific expertise on rare species and natural ecosystems. **Table 10** lists rare, threatened, and endangered species in the Seneca-Keuka watershed.

Table 10: Rare, Threatened and Endangered Species in the Seneca-Keuka Watershed

Common Name	Scientific Name	Sub-Group	State Protection Status	Year Last Documented
Animal: Amphibians				
Longtail Salamander	*Eurycea longicauda*	Salamanders	Special Concern	2017
Animal: Dragonflies and Damselflies				
Comet Darner	*Anax longipes*	Dragonflies		2012
Gray Petaltail	*Tachopteryx thoreyi*	Dragonflies	Special Concern	2012
Spatterdock Darner	*Rhionaeschna mutata*	Dragonflies		2005
Tiger Spiketail	*Cordulegaster erronea*	Dragonflies		1999
Plant: Flowering Plant				
Blue-hearts	*Buchnera americana*	Other Flowering Plants	Endangered	1832
Clustered Sedge	*Carex cumulata*	Sedges	Threatened	1956
Cypress-knee Sedge	*Carex decomposita*	Sedges	Endangered	
False Hop Sedge	*Carex lupuliformis*	Sedges	Threatened	
Handsome Sedge	*Carex formosa*	Sedges	Threatened	
Kentucky Coffee Tree	*Gymnocladus dioicus*	Other Flowering Plants	Endangered	1992
Leedy's Roseroot	*Rhodiola integrifolia ssp. leedyi*	Other Flowering Plants	Endangered	2017
Leiberg's Panic Grass	*Dichanthelium leibergii*	Grasses	Endangered	1832
Mare's Tail	*Hippuris vulgaris*	Other Flowering Plants	Endangered	1838
Mead's Sedge	*Carex meadii*	Sedges	Endangered	
Northern Tansy-mustard	*Descurainia pinnata ssp. brachycarpa*	Other Flowering Plants	Endangered	1875
Northern Wild Comfrey	*Andersonglossum boreale*	Other Flowering Plants	Endangered	1918
Porter's Reed Grass	*Calamagrostis porteri ssp. porteri*	Grasses	Endangered	1949
Prairie Wedge Grass	*Sphenopholis obtusata*	Grasses	Endangered	
Reflexed Sedge	*Carex retroflexa*	Sedges	Threatened	1949
Rock Whitlow Grass	*Draba arabisans*	Other Flowering Plants	Threatened	2005

Common Name	Scientific Name	Sub-Group	State Protection Status	Year Last Documented
Slender Pondweed	*Stuckenia filiformis*	Other Flowering Plants	Endangered	1943
Spreading Globeflower	*Trollius laxus*	Other Flowering Plants	Rare	1931
Straight-leaved Pondweed	*Potamogeton strictifolius*	Other Flowering Plants	Endangered	1980
Twinleaf	*Jeffersonia diphylla*	Other Flowering Plants	Threatened	2009
Wild Onion	*Allium cernuum*	Other Flowering Plants	Threatened	2001
Plant: Ferns and Fern Allies				
Marsh Horsetail	*Equisetum palustre*	Horsetails	Threatened	2005
Natural Community: Uplands				
Calcareous Shoreline Outcrop	Calcareous shoreline outcrop	Open Uplands		2002
Hemlock-Northern Hardwood Forest	Hemlock-northern hardwood forest	Forested Uplands		2002
Shale Cliff and Talus Community	Shale cliff and talus community	Open Uplands		2002
Natural Community: Freshwater Nontidal Wetlands				
Floodplain Forest	Floodplain forest	Forested Mineral Soil Wetlands		1996
Highbush Blueberry Bog Thicket	Highbush blueberry bog thicket	Open Peatlands		2005
Perched Swamp White Oak Swamp	Perched swamp white oak swamp	Forested Mineral Soil Wetlands		1988
Silver Maple-Ash Swamp	Silver maple-ash swamp	Forested Mineral Soil Wetlands		1996
Vernal Pool	Vernal pool	Forested Mineral Soil Wetlands		2006

Source: New York Nature Explorer, New York Natural Heritage Program, NYSDEC (2019)

2.2.3 Fisheries

Both Seneca and Keuka Lakes are warm monomictic lakes, meaning they have one period of mixing or turnover each year and one period of thermal stratification. The lakes exhibit thermal stratification during the summer, allowing for a deep, cold, and well oxygenated deep-water layer (termed the hypolimnion) during the summer. The lakes are typically isothermal (uniform temperature throughout the water column) during the winter. Shallower regions of the lakes will freeze over during the winter, but complete ice cover is extremely rare.

Traditionally, lake trout, smallmouth bass, and yellow perch have been the keystone species of the Seneca and Keuka Lakes' fish community. Forage species include alewives, rainbow smelt, sculpin, and freshwater shrimp. The lakes are stocked annually with hatchery-reared lake trout, brown trout, and landlocked salmon. The brown trout population is maintained almost entirely by annual stockings of 43,000 fingerlings and 21,600 yearlings. The rainbow trout fishery is sustained primarily by natural reproduction, with spawning and nursery areas located in Cold Brook, Sugar Creek, and Catherine Creek and its tributaries. Parasitic sea lamprey control is maintained by NYSDEC application of a highly selective chemical lampricide, TFM, to targeted sea lamprey nursery areas in Catherine Creek and Keuka Lake Outlet at three-year intervals.

Seneca and Keuka Lakes participate in the NYSDEC Finger Lakes Angler Diary Program. Anglers record their fishing trip and catch information in provided diaries and provide the data to NYSDEC biologists to help guide management efforts on the Finger Lakes. The data are used to determine growth rates, stocked fish recruitment, angler effort, angler success rates, and percentage of wild or stocked harvest rates.

NYSDEC completed an angler survey of Seneca Lake in 2018 and gathered data from a total of 353 trips by 34 participating volunteers. Although overall catch was down relative to previous years, species composition continued to exhibit a healthy salmonid community. The catch included lake trout (71%), Atlantic salmon (17%), rainbow trout (7%), and brown trout (5%). The lower catch rate was attributed to the effects of sea lamprey predation (Hammers, 2018a). The scheduled lampricide treatments had not occurred for several years leading up to the 2018 angler survey due to severe weather conditions. In addition, low stream levels in 2015 reduced the effectiveness of lampricide treatment. However, successful treatments in Catherine Creek and Keuka Outlet should have noticeable effects on adult trout and salmon populations in future years. Abundance of forage fish, fluctuations in natural recruitment, and changes to stocking can also impact angler catch rates.

NYSDEC fisheries managers have implemented management actions to address concerns over the decline in forage fish, notably the alewife, in Keuka Lake. The decrease in forage fish was likely caused by the scarcity of forage, causing an increase in predation. A primary management effort in 2018 eliminated annual stocking of brown trout and Atlantic salmon. The NYSDEC is also attempting to reestablish a population of the cisco, a native forage fish, and plans to stock 80,000 ciscoes over the next several years (Hammers, 2018b). Cisco are well adapted to low nutrient conditions that characterize Seneca and Keuka Lakes and are expected to do well as the alewife and smelt populations continue to decline.

There are many common invertebrates in Seneca and Keuka Lake, including freshwater mussels (eastern lampmussel (*Lampsilis radiata*), pocketbook (*L. ovata*), pink heelsplitter (*Potamilus alatus*), floaters (*Pyganodon cataracta, P. grandis*), and mud amnicola (*Amnicola limosa*)). A characteristic crustacean of the hypolimnion is *Senecella calanoides*, which was named after Seneca Lake. Characteristic plankton include *Fragilaria* spp. and *Anabaena* spp. in the summer; *Melosira* spp. and *Cryptomonas ovata* in winter; and zooplankton include *Daphnia* spp., and *Diaptomus* spp. in summer; *Limnocalanus macrurus* and *Cyclops bicuspidatus* in winter. Typical aquatic macrophytes include pondweeds (*Potamogeton gramineus*, *P. richardsonii, P. pectinatus*), horned pondweed (*Zannichellia palustris*), naiad (*Najas flexilis*), waterweed (*Elodea canadensis*), tapegrass or wild celery (*Vallisneria americana*), and coontail (*Ceratophyllum demersum*) (Ecological Communities of NYS, 2nd Edition, NY Natural Heritage Program, NYSDEC, 2014).

2.2.4 Invasive Species

Invertebrate species of particular concern are zebra (*Dreissena polymorpha*) and quagga (*Dreissena polymorhpa*) mussels. These AIS established themselves within both Seneca and Keuka Lakes by the early 2000s and, at least within Seneca Lake, are estimated to make up 80-95% of the living mussel population. They are capable of filtering up to two liters of water per day per adult, which in turn can dramatically increase water clarity and significantly reduce lake productivity. These changes have negatively impacted fisheries composition and health while potentially contributing to the proliferation of HABs in recent years as well. Furthermore, recent research suggests their presence are preventing phosphorus from being buried in lake bed sediment which could have dramatic impacts on future management actions (Li, 2021).

AIS plants reported in Seneca Lake include Eurasian watermilfoil, water chestnut, and curly leafed pondweed. In addition, mud Bithynia, scud, bloody-red shrimp, and rudd have also been documented as present. In addition to these species, Keuka Lake has reported the presence of starry stonewort, Chinese mystery snail, and Asian clam. Detection of hydrilla in Cayuga Lake in 2017 has raised great concern across the Finger Lakes. These non-native species have no predators, resulting in high growth rates and a competitive advantage over native species. The cumulative impacts of AIS populations are believed to be a dominate driver in the overall reduction in forage fish species. The large number of access points and proximity to other infested lakes also increases vulnerability to new AIS introductions.

The FLI/FL-PRISM Watercraft Steward Program has been assisting and educating the Finger Lakes boating community since May 2012. Stewards within this program are stationed at various boat launches throughout the Finger Lakes, tasked with assisting watercraft users in inspecting and identifying AIS. In addition to the inspection, stewards educate the community on the threats that AIS pose to waterways, as well as encouraging proper boat maintenance with the "Clean, Drain, Dry" procedure. During the 2021 season, 41,195 inspections were conducted, and 82,706 community members were reached. This program continues to be a key program in outreach, monitoring, and preventing AIS from spreading.

2.3 Land Use and Community Characteristics

2.3.1 Land Use and Land Cover

Both land cover and land use can impact water quality in a watershed. Land cover can function as a buffer against environmental impacts; for example, wetlands provide a buffer against flooding, woodlands buffer waterbodies from runoff, and vegetation can stabilize steep slopes prone to erosion. Land use information helps determine which types of pollutants may be present and how much could potentially be released.

As demonstrated in **Figure 5** and **Table 11**, forest and agriculture are the major land cover classes within the watershed, encompassing 31% and 42% of the total area, respectively. 6% of the watershed area is classified as urban (which includes different density classes). Urban areas typically contribute the most impervious surfaces to the watershed, which affect both the physical and biological integrity of surface waters. Streams draining watersheds with over 10% impervious cover exhibit decreased channel stability and benthic macroinvertebrate diversity (Schueler et al. 2009). Urban development of the Seneca-Keuka watershed is concentrated within the City of Geneva and Villages of Burdett, Dundee, Dresden, Hammondsport, Horseheads, Lodi, Millport, Montour Falls, Odessa, Ovid, Penn Yan, and Watkins Glen. The land use designation also includes approximately 2,095 miles of private and public roads that extend throughout the watershed.

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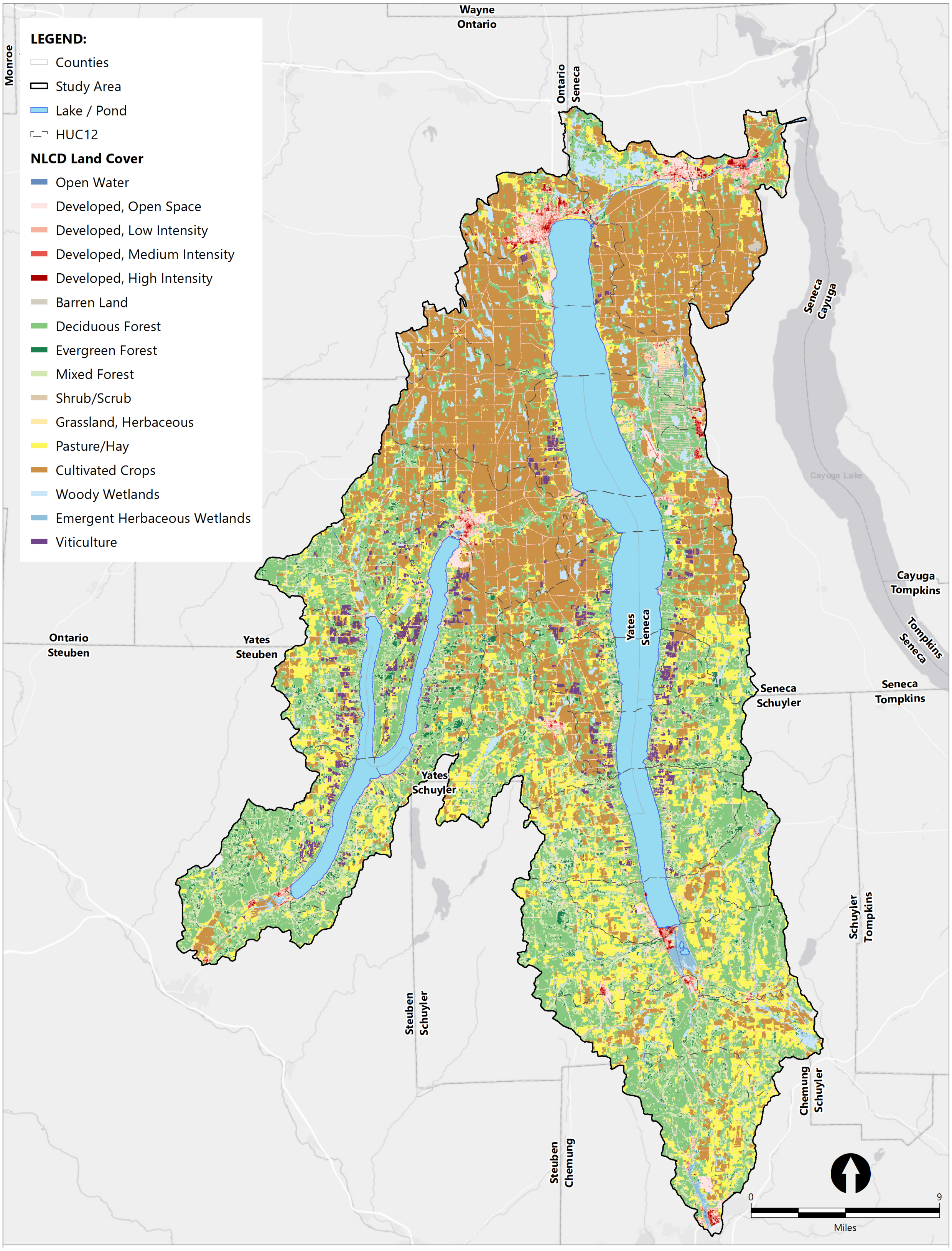

Figure 5: Map of Land Use and Land Cover

Table 11: Land Cover Composition by HUC12 Subwatersheds to Seneca and Keuka Lakes

HUC12	Forest		Scrubland		Wetlands		Developed Areas		Agriculture	
Subwatershed	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Headwaters Catherine Creek (041402010601)	12,807	55.4%	446	1.9%	875	3.8%	1,877	8.1%	7,009	30.3%
Sleeper Creek- Catherine Creek (041402010602)	10,762	45.4%	828	3.5%	1,239	5.2%	1,289	5.4%	9,478	40.0%
Seneca Lake Inlet (041402010603)	15,564	50.2%	2,717	8.8%	1,507	4.9%	1,501	4.8%	9,443	30.5%
Sugar Creek (041402010701)	9,738	41.8%	902	3.9%	906	3.9%	972	4.2%	10,708	45.9%
West Branch Keuka Lake (041402010702)	7,741	38.0%	913	4.5%	270	1.3%	903	4.4%	7,767	38.1%
Keuka Inlet/Cold Brook (041402010703)	10,461	64.7%	1,302	8.0%	355	2.2%	644	4.0%	3,316	20.5%
South Branch Keuka Lake (041402010704)	9,374	42.6%	1,531	7.0%	116	0.5%	993	4.5%	6,070	27.6%
East Branch Keuka Lake (041402010705)	10,504	33.9%	1,813	5.9%	405	1.3%	2,252	7.3%	10,853	35.0%
Keuka Lake Outlet (041402010706)	2,295	11.3%	240	1.2%	479	2.4%	1,831	9.0%	10,708	75.8%
Hector Falls Creek-Seneca Lake (041402010801)	7,531	41.5%	1,042	5.7%	547	3.0%	1,142	6.3%	3,316	33.0%
Big Stream (041402010802)	7,766	32.7%	1,545	6.5%	765	3.2%	1,214	5.1%	6,070	52.2%
Rock Stream-Seneca Lake (041402010803)	11,402	39.1%	2,142	7.3%	571	2.0%	1,050	3.6%	10,853	32.5%
Breakneck Creek-Seneca Lake (041402010804)	5,615	34.0%	1,003	6.1%	178	1.1%	792	4.8%	6,259	37.9%

HUC12	Forest		Scrubland		Wetlands		Developed Areas		Agriculture	
Subwatershed	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Indian Run-Seneca Lake (041402010805)	3,846	23.0%	744	4.4%	329	2.0%	815	4.9%	7,085	42.3%
Mill Creek-Seneca Lake (041402010806)	6,273	18.4%	1,219	3.6%	640	1.9%	1,446	4.2%	17,126	50.2%
Indian Creek-Seneca Lake (041402010807)	2,200	14.8%	1,038	7.0%	513	3.4%	1,429	9.6%	6,068	40.8%
Kashong Creek (041402010901)	1,852	9.4%	91	0.5%	1,166	5.9%	812	4.1%	15,761	80.1%
Wilcox Creek-Seneca Lake (041402010902)	2,001	8.5%	2,321	9.9%	410	1.7%	1,927	8.2%	6,243	26.6%
Wilson Creek-Seneca Lake (041402010903)	2,254	7.9%	1,161	4.1%	1,661	5.8%	1,563	5.5%	16,568	58.2%
Castle Creek-Seneca Lake (041402010904)	1,680	8.5%	137	0.7%	670	3.4%	3,695	18.7%	8,597	43.6%
Watershed Totals	**141,666**	**37%**	**23,135**	**6%**	**13,602**	**4%**	**28,147**	**7%**	**179,298**	**46%**

Source: 2011 CDL-NLCD Hybrid Land Cover dataset

Note: Open water land cover type excluded.

Agriculture is a leading industry and dominant land use in the Seneca-Keuka watershed. Inceptisols mixed with agriculturally productive alfisols developed from limestone-derived glacial till make this area prime farming land. Farms generally become larger and more intensively cultivated in the north where alfisols are more prominent. Corn, soybeans, and forage are the primary crops farmed in the watershed. **Table 12** lists information from the Agriculture Census of 2017 by County. Note that county level agricultural census data presented in **Table 12** do not correspond to the Seneca-Keuka watershed boundaries.

Dairy production is a major agricultural land use in the watershed, as evident by the number of cattle and calves tabulated in the New York State Census of Agriculture. The productive soils, gentle topography, and abundance of water contribute to a thriving agricultural economy that has been a mainstay of the region since the first European settlers arrived. Approximately 80% of cattle are classified as dairy animals across the six counties.

There are many wineries within the Seneca-Keuka watershed and over 8,000 acres designated as vineyards as of 2016; both vineyards and wineries continue to increase in this region. The steep slopes create a natural barrier that allows cold air to sink away from hillside vines. The lake waters buffer air temperatures in spring and fall, effectively lengthening the grape growing season. The micro-climates and steep slopes of the lake valleys provide favorable conditions for growing grapes. Native New York, European, and hybrid grape varieties are grown in the area. Wine production in the area dates to the 1820s (NYSDEC, NY Comprehensive Wildlife Conservation Strategy (CWCS) Plan, 2005; NYSDEC, State Wildlife Action Plan (SWAP), 2015).

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Table 12: New York State Census of Agriculture, 2017

	County					
	Seneca	Yates	Schuyler	Chemung	Steuben	Ontario
Farm Inventory						
Number of Farms	516	867	408	398	1,542	833
Land in Farms (acres)	118,545	144,922	78,805	66,904	397,157	200,089
Average Farm size (acres)	230	133	193	168	258	240
Land Use Practices (% of Farms)						
No Till	16	10	8	12	8	12
Reduced Till	20	18	12	8	12	19
Intensive Till	34	51	21	27	28	36
Cover Crop	22	39	15	11	13	23
Farmed Organically	8	12	6	0	4	6
Top Crops (Acres)						
Corn for Grain	26,593	11,226	3,693	5,298	31,757	28,349
Soybeans for Beans	23,537	5,935	2,476	1,221	6,055	24,055
Forage (Hay/Haylage)	19,532	25,874	24,379	17,146	117,259	40,124
Wheat for Grain	5,882		1,177			12,996
Corn for Silage/Green chop	4,564	5,935	4,768	1,440	23,343	22,251
Grapes		5,987				
Oats for Grain				500	6,899	
Livestock Inventory						
Broiler chickens (meat)	ND	1,371	338	ND	1,034	643
Cattle and Calves	25,514	30,953	14,888	6,384	75,923	60,681
Beef Cows	2,215	1,495	1,612	1,488	8,990	1,724
Dairy Cows	7,522	12,721	6,861	1,888	22,539	26,843
Goats	168	376	418	332	1,506	367
Hogs and Pigs	7,938	204	925	146	ND	ND
Horses and Ponies	1,335	943	454	683	2,152	1,239
Layer chickens (eggs)	68,095	82,637	15,219	1,114	ND	40,723
Sheep and Lambs	3,471	1,785	3,147	992	3,314	1,453
Turkeys	1,259	137	ND	246	213	116

Much of the native forested landscape was converted to support agricultural production and urban development. Most lands remaining in forest cover are held privately, although a significant acreage is held in public trust; NYSDEC and the United States Forest Service are the major land managers (**Table 13**). Timber harvesting remains a significant industry in the watershed, particularly in the southern half. Limited acres of forest are under some form of permanent conservation protection such as that afforded through conservation easements or status as a designated wilderness area (**Figure 6**).

Table 13: Major Wholly or Partially Forested Public Lands within the Seneca-Keuka Watershed

Unit Name	Manager Name	Designation Type	Location (County)	Area (Acres)
Catherine Creek Wildlife Management Area	NYSDEC	State Conservation Area	Schuyler	634
Cold Brook Wildlife Management Area	NYSDEC	State Conservation Area	Steuben	116
Coon Hollow State Forest	NYSDEC	State Resource Management Area	Schuyler Steuben	2,485
Italy Hill State Forest	NYSDEC	State Resource Management Area	Yates	1,905
Pigtail Hollow State Forest	NYSDEC	State Resource Management Area	Steuben	995
Sugar Hill State Forest	NYSDEC	State Wilderness	Schuyler	9,099
Texas Hollow State Forest	NYSDEC	State Resource Management Area	Schuyler	932
Urbana State Forest	NYSDEC	State Resource Management Area	Steuben	2,706
Willard Wildlife Management Area	NYSDEC	State Conservation Area	Seneca	154
Keuka Lake State Park	NYS Office of Park, Recreation & Historic Preservation	State Park	Yates	645
Mark Twain State Park	NYS Office of Park, Recreation & Historic Preservation	State Park	Chemung	466
Sampson State Park	NYS Office of Park, Recreation & Historic Preservation	State Park	Seneca	2,039
Seneca Lake State Park	NYS Office of Park, Recreation & Historic Preservation	State Park	Seneca	155
Watkins Glen State Park	NYS Office of Park, Recreation & Historic Preservation	State Park	Schuyler	804
Finger Lakes National Forest	US Forest Service	National Forest	Schuyler Seneca	16,352

Source: USGS Gap Analysis Project. 2018. Protected Areas Database of the United States

Note: Unit area may include lands outside of the watershed boundary.

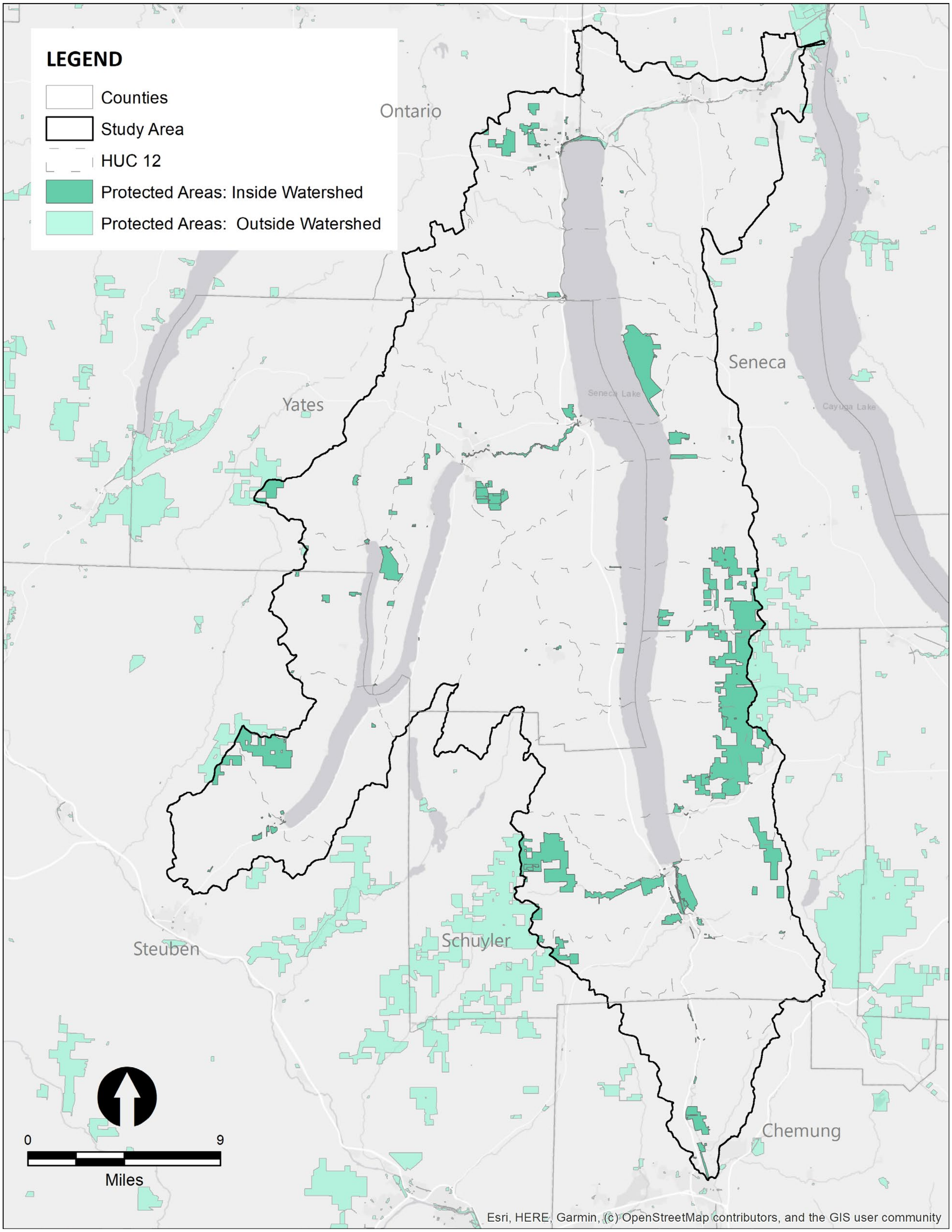

Figure 6: Lands Conferred with Some Level of Conservation Protection Status

Like forested lands, wetlands currently represent a significantly smaller land cover type than in the past; many wetlands were drained and/or filled to support agricultural and urban development. Remaining wetlands are of significant value as they absorb, store, slow down, and filter water, thereby minimizing flooding, stabilizing water flow and sequestering pollutants. Currently emergent herbaceous and woody wetland acreage total 2,491 and 11,654, respectively (**Figure 7**). The New York State Freshwater Wetlands Act of 1975 offers preservation and protection to wetlands of 12.5 acres (5 hectares) or larger and includes a 100-foot buffer area surrounding each wetland. Similarly, the USACE also provides a level of protection to wetlands identified in the National Wetlands Inventory (NWI), irrespective of size, under section 404 of the Clean Water Act.

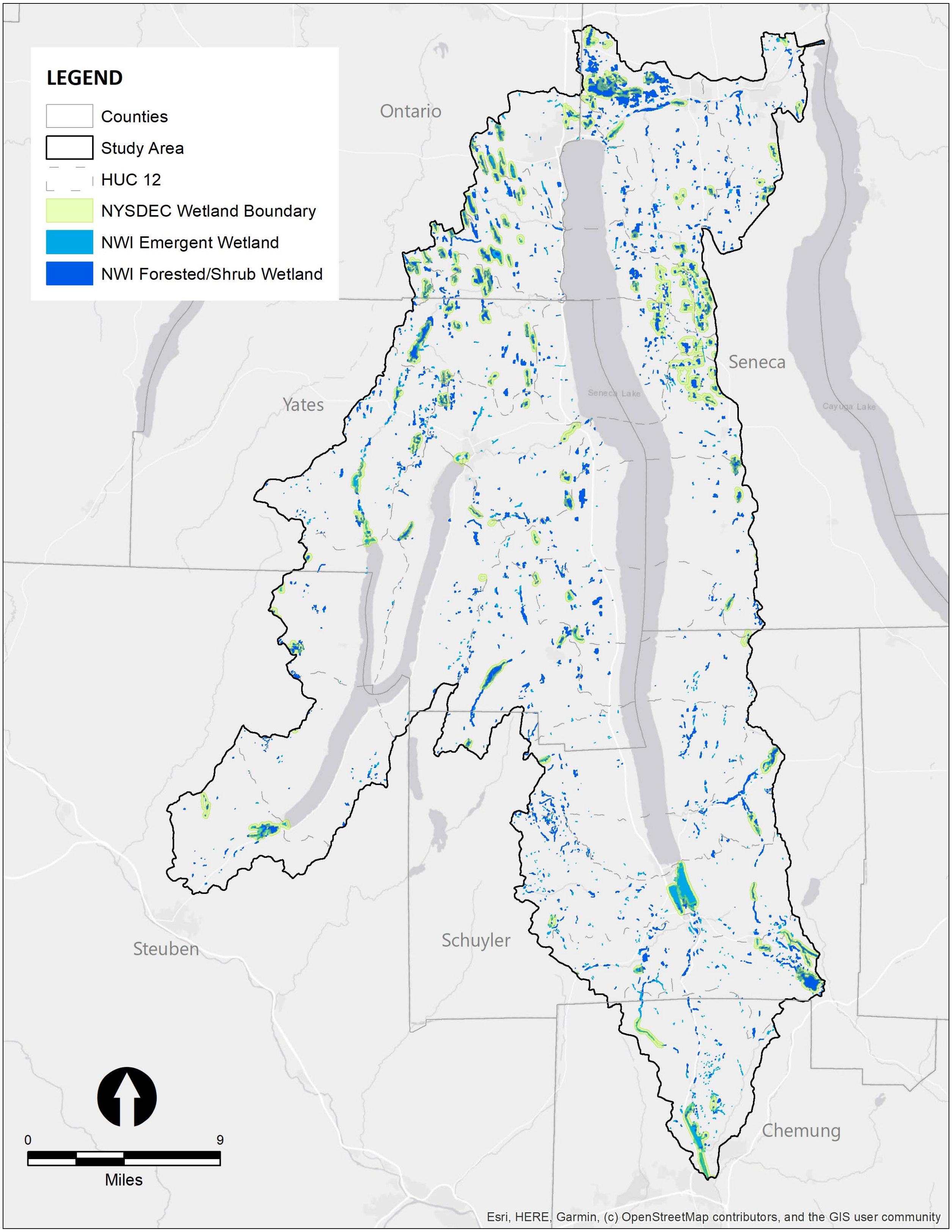

Figure 7: State and Federally Designated Wetlands within the Seneca-Keuka Watershed

2.3.2 Municipalities and Population

Overall, the population has remained relatively stable within the watershed since 1970. The areas experiencing increases in population are located within the western and northeastern portions of the watershed, which are mostly suburban. There are 36 towns, 12 villages, and one city with land area in the Seneca-Keuka watershed as listed in **Table 14**, along with their estimated population.

Table 14: Populations of Municipalities within the Seneca-Keuka Watershed

Name	Population (2020 Estimate)	County
Barrington Town	1,649	Yates
Bath Town	11,818	Steuben
Benton Town	2,727	Yates
Burdett Village	311	Schuyler
Catherine Town	1,650	Schuyler
Catlin Town	2,424	Chemung
Cayuta Town	508	Schuyler
Dix Town	3,856	Schuyler
Dresden Village	279	Yates
Dundee Village	1,608	Yates
Fayette Town	3,767	Seneca
Geneva City	12,639	Ontario
Geneva Town	3,348	Ontario
Gorham Town	4,226	Ontario
Hammondsport Village	617	Steuben
Hector Town	4,884	Schuyler
Horseheads Town	18,600	Chemung
Horseheads Village	6,244	Chemung
Italy Town	1,144	Yates
Jerusalem Town	4,469	Yates
Lodi Town	1,502	Seneca
Lodi Village	287	Seneca
Millport Village	285	Chemung
Milo Town	6,841	Yates
Montour Falls Village	1,592	Schuyler
Montour Town	2,183	Schuyler
Odessa Village	546	Schuyler
Orange Town	1,396	Schuyler
Ovid Town	2,270	Seneca
Ovid Village	599	Seneca
Penn Yan Village	4,948	Yates
Phelps Town	6,790	Ontario
Potter Town	1,812	Yates

Name	Population (2020 Estimate)	County
Pulteney Town	1,252	Steuben
Reading Town	1,641	Schuyler
Romulus Town	4,169	Seneca
Seneca Town	2,668	Ontario
Starkey Town	3,473	Yates
Torrey Town	1,212	Yates
Tyrone Town	1,587	Schuyler
Urbana Town	2,201	Steuben
Varick Town	1,791	Seneca
Veteran Town	3,119	Chemung
Waterloo Town	7,305	Seneca
Watkins Glen Village	1,851	Schuyler
Wayne Town	983	Steuben
Wheeler Town	1,235	Steuben

Source: United States Census Bureau 2020 Estimates (City and Town Population Totals: 2010-2020 (census.gov))
Date accessed: 30 November 2021.

2.3.3 Local Laws

In New York State, land use policy and regulations are primarily the responsibility of local government. Municipal decisions regarding how the landscape is developed will ultimately affect the quality and quantity of lakes and streams. Decisions related to density, impervious surfaces, open space protection, setbacks from waterways, aquifer protection, farmland protection, wastewater management, designation of critical environmental areas and a host of other factors influence the transport of water and substances into Seneca and Keuka Lakes.

Cornell University Professor George Frantz and graduate students in his class on land use, environmental planning and urban design analyzed regional demographic and development trends within the watershed and reviewed municipal land use regulations from the perspective of water resource management. A summary of their 2021 report is included in this section of the 9E Plan; the complete report is included as **Appendix D (Seneca-Keuka Watershed Land Use Regulations and Local Law Assessment)**. Recommendations for additions or revisions to local municipal land use regulations and procedures are included in **Section 5**.

2.3.3.1 Regional Trends

The Seneca-Keuka watershed has a population of 64,600 with 51% residing in city/village areas and 49% in rural areas. From 1980-2010, the region experienced a population increase growth of 1.1%, with most growth attributed to the Mennonite and Amish communities, the prison population at Five Points Correctional facility, and new arrivals from the cities of Ithaca, Elmira, and Corning. Most new development is in the form of single-family homes, with a significant increase in lakefront homes as well as commercial development along the waterfront of Keuka Lake in Penn Yan, Hector, and Benton. The wine industry expanded in the Towns of Hector, Benton, Pulteney, and Starkey. Approximately 180 new farmsteads were added across the watershed; this growth reflects the favorable conditions of climate, soils, and water availability for this important economic driver and ecosystem service.

2.3.3.2 Regional Assessment of Land Use Plans and Regulations

New York is a "home rule" state, meaning that primary authority for guiding community planning and land development is vested in cities, towns, and villages. While this provides local municipalities with the power to define how their community grows, it can also complicate watershed management efforts, particularly related to nonpoint sources of pollution. Differences among local laws can result in inconsistent water resources-related protections within a watershed.

There are several relevant local planning and zoning tools with significant potential to affect lands and waters. Comprehensive plans are strategic documents that define a community's goals and vision for the future and can provide a regulatory basis for modifications to zoning and subdivision laws. Based on the Cornell team's analysis, a minority of watershed municipalities have a comprehensive plan that is up to date according to standard practice (developed within the past 5-10 years). More than half of the municipalities have a comprehensive plan more than 10 years old and many of the smaller more rural watershed municipalities lack a comprehensive plan. 17% of watershed municipalities do not have a comprehensive plan (**Figure 8**). Most municipalities with comprehensive plans have adopted zoning. Of the watershed municipalities, approximately 23% have no zoning regulations currently.

Several relevant local planning and zoning tools hold significant potential to mitigate potential adverse impacts of land development or disturbance. The 2021 Seneca-Keuka Watershed Land Use Regulations and Local Law Assessment provides a breakdown by watershed municipality of these planning tools and regulations that affect water resource protection (**Appendix D**). This analysis describes recommended actions for each municipality to enhance their ability to protect the lands and waters.

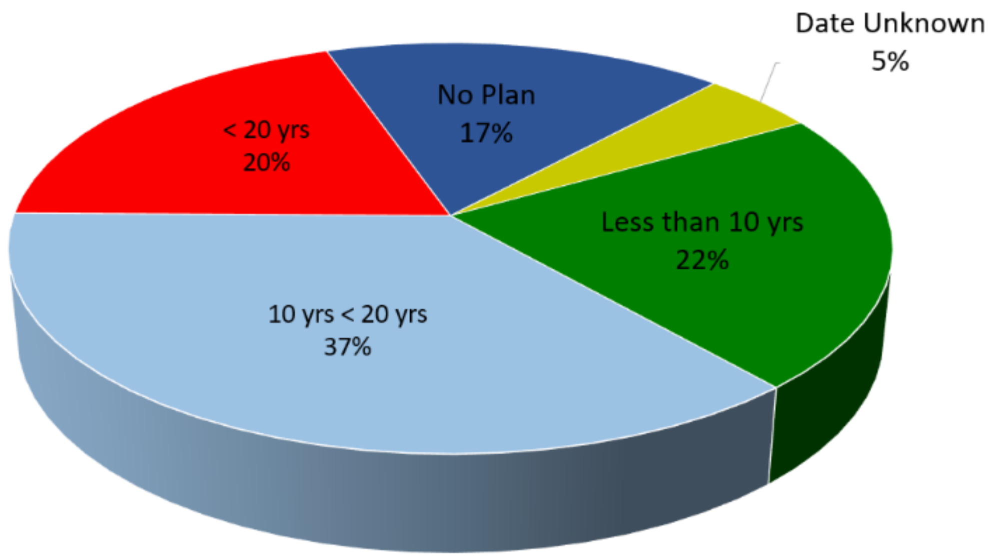

Figure 8: Date of Comprehensive Plan for Watershed Municipalities
Source: Seneca-Keuka Watershed Land Use Regulations and Local Laws Assessment

The **Seneca-Keuka Watershed Land Use Regulations and Local Law Assessment** identified ten land use regulations that affect water quality and assessed the implementation of the regulations within each municipality (**Table 15**). Some highlights of the assessment are:

- 83% of municipalities in the watershed have adopted a zoning ordinance or zoning law
- 80% of municipalities have adopted site plan review regulations
- 78% of municipalities have adopted subdivision regulations, and 25% permit the cluster (conservation) subdivision design approach
- 59% have adopted the planned unit development (PUD) zoning tool. 54% of municipalities have adopted erosion and sedimentation control laws
- 61% have a watershed inspector either at the municipal level or the county level
- 63% have adopted a wastewater management code
- Of the 21 municipalities with lake frontage, 10 (48%) have dock and moorings law
- 80% have adopted a flood damage prevention law

Table 15: Status of Land Use Regulations by Municipality

Municipality	County	Comprehensive Plan (year adopted)	Zoning Regulations (year adopted/updated)	Site Plan Review Law	Planned Unit Development	Subdivision Law	Cluster Development/ Subdivision	Erosion/Sedimentation Control Law	Watershed Inspector	Wastewater Management Code	Docks & Moorings Law	Flood Damage Prevention Law	Landmark Preservation law
Barrington Town	Yates	2007	2012	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No
Benton Town	Yates	2012	1992	Yes	No	Yes	Yes	Yes	Yes	Yes	No	1989	No
Burdett Village	Schuyler	Yes	No	No	No	No	No	No	Yes*	Yes*	No	No	No
Catharine Town	Schuyler	2006	2016	Yes	Yes	Yes	Yes	Yes	Yes*	Yes*	No	1997	No
Catlin Town	Chemung	No	1999	Yes	No	Yes	Yes	Yes	No	No	No	1987	No
Dix Town	Schuyler	2001	2016	Yes	Yes	Yes	Yes	No	Yes*	No	No	No	No
Dresden Village	Yates	2004	2008	Yes	No	Yes	Yes	No	Yes*	Yes	No	2008	No
Dundee Village	Yates	1969	1975	Yes	Yes	Yes	Yes	No	Yes*	No	No	Yes	Yes
Fayette Town	Seneca	2006	2008	Yes	No	Yes	No	No	No	No	No	Yes	No
Geneva City	Ontario	2016	1968	Yes	Yes	Yes	Yes	No	No	No	No	1987	No
Geneva Town	Ontario	2015	2018	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No
Hammondsport Village	Steuben	1990	2001	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	1987	Yes
Hector Town	Schuyler	2001	2020	No	No	No	No	No	Yes*	Yes*	No	1987	No
Horseheads Town	Chemung	1971	1982	Yes	Yes	Yes	No	Yes	No	No	Yes	1996	No
Horseheads Village	Chemung	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	1996	No
Jerusalem Town	Yates	2006	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	2009	No
Lodi Town	Seneca	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No
Lodi Village	Seneca	2010	2007	No	No	No	No	No	No	No	No	Yes	No
Millport Village	Chemung	No	2005	No	No	No	Yes	Yes	No	No	No	1999	No
Milo Town	Yates	2013	2021	Yes	Yes	Yes	Yes	Yes	Yes*	Yes	Yes	1997	No
Montour Falls Village	Schuyler	2007	2010	Yes	No	Yes	Yes	Yes	Yes*	Yes*	No	1993	No
Montour Town	Schuyler	2007	2008	Yes	No	Yes	Yes	Yes	Yes*	Yes*	No	Yes	No
Odessa Village	Schuyler	No	2005	Yes	No	Yes	Yes	Yes	Yes*	Yes*	No	No	No
Orange Town	Schuyler	2012	No	Yes	No	No	No	No	Yes*	Yes*	No	No	No
Ovid Town	Seneca	2019	No	No	No	No	No	No	No	No	No	Yes	No
Ovid Village	Seneca	No	No	No	No	No	No	No	No	No	No	No	No
Penn Yan Village	Yates	2017	2004	Yes	Yes	Yes	Yes	No	Yes*	Yes	Yes	1987	Yes
Potter Town	Yates	1979	2010			Yes			Yes*		No	Yes	No
Pulteney Town	Steuben	Yes	2015	Yes	No	Yes	Yes	Yes	Yes*	Yes	Yes	Yes	No
Reading Town	Schuyler	1993	2018	Yes	No	No	No	No	Yes*	Yes*	No	No	No
Romulus Town	Seneca	2001	2020	Yes	No	Yes	Yes	Yes	No	No	No	Yes	No
Seneca Town	Ontario	2013	2008	Yes	No	Yes	Yes	No	No	Yes	No	Yes	No
Starkey Town	Yates	2014	2015	Yes	Yes	Yes	No	No	Yes*	No	No	Yes	No
Torrey Town	Yates	2008	2011	Yes	Yes	Yes	Yes	No	Yes*	Yes	No	2010	No
Tyrone Town	Schuyler	2008	No	No	No	Yes	Yes	Yes	Yes*	Yes*	No	No	No
Urbana Town	Steuben	1990	1988	Yes	No	Yes	No	Yes	Yes	Yes	Yes	1987	No
Varick Town	Seneca	2006	2019	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No
Veteran Town	Chemung	2004	2019	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No
Waterloo Town	Seneca	2000	2011	Yes	Yes	Yes	No	No	No	No	No	Yes	No
Watkins Glen Village	Schuyler	1993	2012	Yes	No	No	No	Yes	Yes*	Yes*	No	1987	No
Wayne Town	Steuben	2010	2018	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
* In Schuyler County and Yates County, watershed inspectors/inspection services are provided by the county.													

The map in **Figure 9** shows each municipality in the watershed, color-ranked according to the number of water quality regulations they have adopted. The assessment of water quality related local regulations in the Seneca-Keuka watershed region focuses primarily on five planning tools:

- Erosion/Sedimentation Control Law
- Watershed Inspection
- Wastewater Management Code
- Docks and Moorings Law[1]
- Flood Damage Prevention Law

The map highlights the finding that municipalities within the Keuka Lake sub-watershed have a high rate of adoption of protective measures, and that the regulations are consistent across the region. This is likely the result of strong collaboration facilitated by the KWIC, and the KLA Citizens' Advocacy Group. The success of these communities in building local support for these effective planning tools illustrate the potential to expand these efforts across the entire watershed. Moreover, there is great opportunity for creative, intermunicipal solutions for this multifaceted issue.

The **Seneca-Keuka Watershed Land Use Regulations and Local Law Assessment (Appendix D)** provides a breakdown of land use regulations related to water resource protection by municipality. The section lists adopted regulations and recommended actions for each municipality to enhance protection of water resources.

[1] Note that not all municipalities have lake shorelines; since the map includes an evaluation of docking and mooring regulations these municipalities are depicted on the map (Figure 9) with lower scores than those that do.

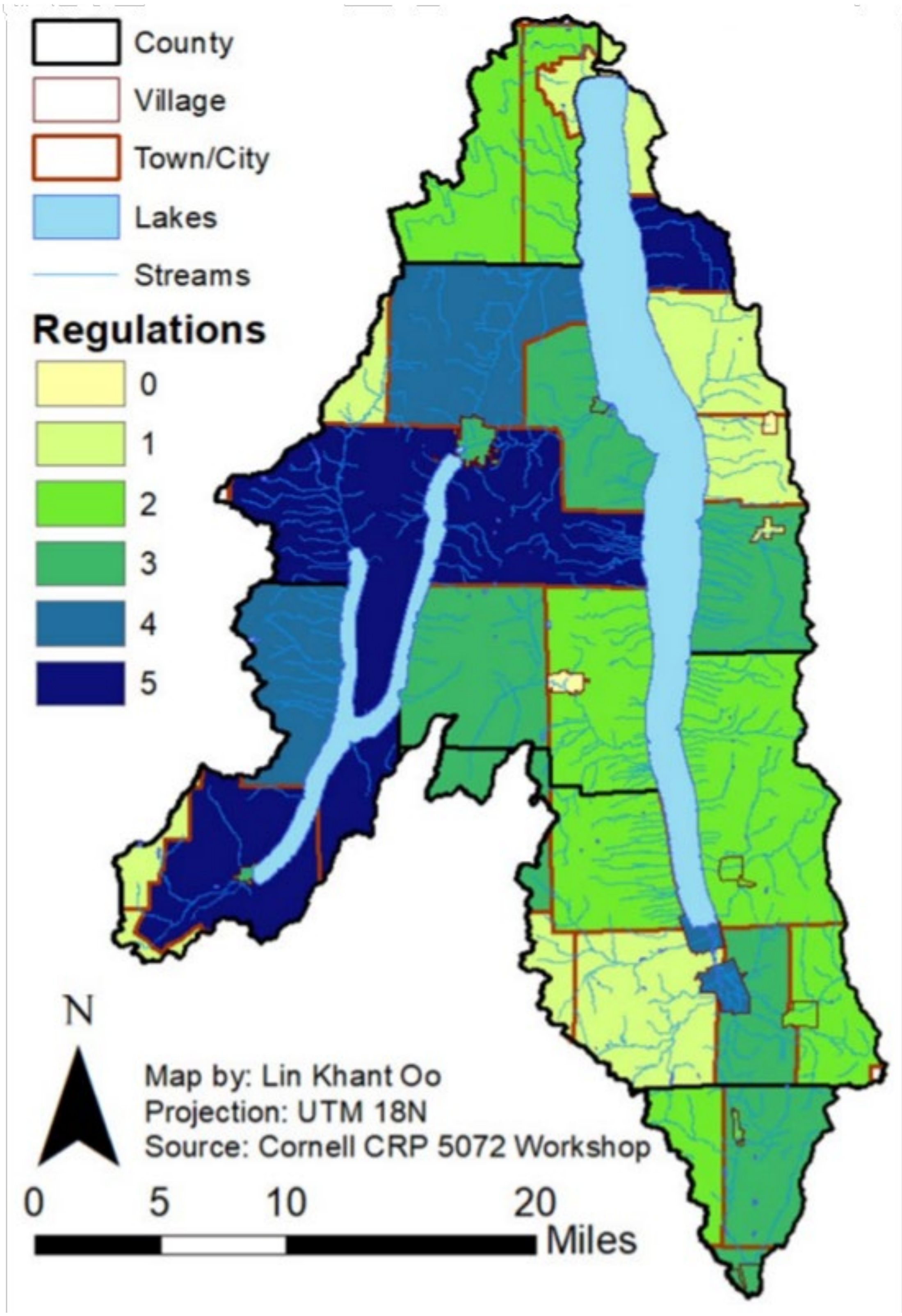

Figure 9: Water Quality Regulation Adoption for Watershed Municipalities
Source: Seneca-Keuka Watershed Land Use Regulations and Local Laws Assessment

2.4 Water Quality Monitoring Efforts

2.4.1 Lake Monitoring

Both Seneca and Keuka Lake participate in Citizens Statewide Lake Assessment Program (CSLAP), a volunteer lake monitoring program run by NYSDEC and the New York State Federation of Lake Associations (NYSFOLA). Trained volunteers monitor water quality conditions and collect samples for chemical analyses from surface and deep waters in the lakes. The CSLAP program conducts biweekly monitoring from June through September. Monitored parameters include water temperature, water clarity, specific conductance, pH, color, TP, nitrogen, dissolved oxygen, chlorophyll-a, calcium, and chloride. This program also samples algal blooms to determine the potential presence of cyanobacteria and toxins. Water samples are sent to an Environmental Laboratory Accreditation Program (ELAP) certified laboratory (currently Upstate Freshwater Institute (UFI)) in Syracuse, New York for analyses. Seneca Lake has participated in the program from 1991-1996 and 2017 to present. Keuka Lake has participated in CSLAP since 2017.

2.4.2 Stream/Contributing Waters Monitoring

Pure Waters established a stream monitoring program in 2015. Trained volunteers collect water samples several times each year with the goal of characterizing water quality and identifying sources of pollutants. Samples are submitted to the Community Science Institute (CSI), an ELAP-certified laboratory located in Ithaca, New York, for analysis. Since 2020, the stream monitoring program has focused sample collection during high flow conditions. Pure Waters also participates in lake level and HABs monitoring.

The KLA established a lake monitoring program in 1992; this program was incorporated into CSLAP in 2017 and now uses standard protocols and an ELAP-certified laboratory for analysis. Trained volunteers monitor three lake sites and conduct shoreline HAB surveillance. A collaborative stream monitoring program of Cornell Cooperative Extension (CCE) and Yates County SWCD is underway; this program is designed to collect water samples at eight tributaries in the Keuka Lake watershed.

In addition, volunteers from the KLA participate in two NYSDEC programs intended to expand stream data and information collection across the state: Professional External Evaluations of Rivers and Streams (PEERS) and Water Assessments by Volunteer Evaluators (WAVE). The PEERS program is a citizen-based water quality assessment focused on water quality sampling. WAVE uses trained citizen scientists to collect benthic macroinvertebrates from wadeable streams. Macroinvertebrates are excellent indicators of long-term water quality conditions, since individual species exhibit a range of tolerance to pollution. Sampling of the benthic community occurs between July 1st and September 30th. If a stream assessment documents six or more pollution-sensitive organisms, the stream is considered to have 'no known impacts. If a stream has more than four pollution-tolerant organisms, it is categorized as 'possibly impaired'. Results of WAVE are used to flag sites that may require additional investigations by professional staff.

Both PEERS and WAVE findings augment the professional monitoring conducted on a five-year rotation cycle by the NYSDEC Stream Biomonitoring Unit in support of the New York State Waterbody Inventory and Rotating Integrated Basin Studies (RIBS). The citizen monitoring programs expand NYSDEC's capacity to evaluate the state's surface water conditions and help flag areas of concern that may be impacted by non-point source discharges. WAVE collaborates with the Finger Lakes Partnership for Regional Invasive Species Management (FL-PRISM) program to coordinate efforts to manage aquatic and terrestrial invasive species.

Sampling locations in the Seneca-Keuka watershed are summarized in **Table 16** and described in the following section. Note that Pure Waters and KLA data are available online at communityscience.org/.

Table 16: Sampling Sites of Contributing Waters to Seneca and Keuka Lakes

Watershed	Sampling Site Name	Latitude	Longitude	Site Type	Sampling Program
Big Stream	Crystal Springs @ Crystal Springs Road	42.4885	-77.0478	Synoptic	Pure Waters
Big Stream	Chubb Creek @ 14A	42.5277	-77.0021	Synoptic	Pure Waters
Big Stream	Big Stream @ Dundee-Glenora Rd	42.5091	-76.9628	Synoptic	Pure Waters
Big Stream	Big Stream Mouth @ Glenora Point	42.49	-76.9143	Synoptic	Pure Waters
Big Stream	Upstream Dundee Wastewater Plant	42.5178	-76.9744	Synoptic	Pure Waters
Big Stream	Dundee WWTP Discharge	42.5167	-76.9703	Synoptic	Pure Waters
Big Stream	Dundee WWTP Pond Outfall	42.5169	-76.9721	Synoptic	Pure Waters
Catherine Creek	Catherine Creek @ Genesee St	42.3283	-76.8441	Red Flag	Pure Waters
Catherine Creek	Catherine Creek @ Huck Finn Rd	42.2129	-76.8457	Investigative	Pure Waters
Catherine Creek	Logan Creek (Tug Hollow) - upstream of CR5 Bridge	42.4236	-76.8528	Biological	Pure Waters
Catherine Creek	Catherine Creek in Millport	42.2736	-76.8387	Synoptic	Pure Waters
Catherine Creek	Havana Glen Mouth	42.3362	-76.8368	Synoptic	Pure Waters
Catherine Creek	Catherine Creek @ Seneca Lake	42.3818	-76.8602	Synoptic	Pure Waters
Catherine Creek	Upstream of Montour Falls WWTP	42.3509	-76.8498	Synoptic	Pure Waters
Catherine Creek	Downstream of Montour Falls WWTP	42.3538	-76.8529	Synoptic	Pure Waters
Catherine Creek	Catherine Creek @ Genesee St.	42.3283	-76.844	Synoptic	Pure Waters
Catherine Creek	*Catherine Creek @ Smith Rd*	*42.2319*	*-76.8422*	*Synoptic*	*Chemung SWCD*

Watershed	Sampling Site Name	Latitude	Longitude	Site Type	Sampling Program
Catherine Creek	*Catherine Creek Upper*	*42.2951*	*-76.8475*	*Synoptic*	*Chemung SWCD*
Keuka Outlet	Keuka Outlet Tributary @ Ridge Rd.	42.6669	-76.9947	Synoptic	Pure Waters
Keuka Outlet	Charles St. Bridge	42.6805	-76.9538	Synoptic	Pure Waters
Keuka Outlet	Keuka Lake Boat Launch	42.6574	-77.0589	Synoptic	Pure Waters
Keuka Outlet	Fox's Mill Rd.	42.6596	-77.0371	Synoptic	Pure Waters
Keuka Outlet	Keuka Outlet Birkett Mills	42.66	-77.052	Synoptic	Pure Waters
Keuka Outlet	Penn Yan Wastewater Treatment Plant	42.658	-77.0347	Synoptic	Pure Waters
Keuka Outlet	Keuka Outlet Ash Upstream	42.677	-76.963	Investigative	Pure Waters
Keuka Outlet	Keuka Outlet Ash Downstream	42.679	-76.962	Investigative	Pure Waters
Keuka Outlet	Keuka Outlet @ Indian Pines Park	42.6519	-77.0647	Synoptic	Pure Waters
Keuka Outlet	Keuka Outlet @ Jacob Creek	42.6831	-77.0514	Synoptic	Pure Waters
Kashong Creek	Bridge at Thistle Street	42.7551	-77.0311	Synoptic	Pure Waters
Kashong Creek	Bridge at Bellona	42.7578	-77.0151	Synoptic	Pure Waters
Kashong Creek	Bridge at Route 14	42.7651	-76.9765	Synoptic	Pure Waters
Reeder Creek	Reeder Creek @ Rt. 96 A	42.7895	-76.8983	Synoptic	Pure Waters
Reeder Creek	Reeder Creek @ Access Road	42.7882	-76.8867	Synoptic	Pure Waters
Reeder Creek	Reeder Creek @ N. Patrol Rd	42.7867	-76.8868	Synoptic	Pure Waters
Reeder Creek	Reeder Creek Mouth	42.786	-76.928	Synoptic	Pure Waters
Reeder Creek	Kendig Creek @ Secor Rd.	42.7869	-76.8562	Investigative	Pure Waters
Shequaga Creek	Shequaga Creek @ Johnson Hollow	42.3177	-76.8972	Investigative	Pure Waters
Shequaga Creek	Shequaga Creek @ Russell Rd	42.315	-76.9284	Investigative	Pure Waters
Shequaga Creek	Shequaga Creek @ Cooley Road	42.3095	-76.9495	Investigative	Pure Waters
Shequaga Creek	Shequaga Creek at Cronk Rd	42.3286	-76.8849	Red Flag	Pure Waters
Shequaga Creek	Shequaga Creek in Montour Falls	42.3468	-76.8514	Red Flag	Pure Waters
Glen Eldridge Creek	Glen Eldridge Creek Mouth	42.4257	-76.8692	Synoptic	Pure Waters

Watershed	Sampling Site Name	Latitude	Longitude	Site Type	Sampling Program
Keuka Lake	Central Shallow	42.4925	-77.1503	Synoptic	KLA
Keuka Lake	Central Deep	42.4925	-77.1503	Synoptic	KLA
Keuka Lake	East Branch Shallow	42.5491	-77.1024	Synoptic	KLA
Keuka Lake	East Branch Deep	42.5491	-77.1024	Synoptic	KLA
Keuka Lake	West Branch Shallow	42.5594	-77.1458	Synoptic	KLA
Keuka Lake	West Branch Deep	42.5594	-77.1458	Synoptic	KLA
Keuka Lake	South Shallow	42.4188	-77.1985	Synoptic	KLA
Keuka Lake	South Deep	42.4188	-77.1985	Synoptic	KLA
Keuka Lake	Eggleston Pt	42.5488	-77.0986	Synoptic	KLA
Keuka Lake	Willow Grove	42.6117	-77.0761	Synoptic	KLA
Keuka Lake	Stone Pt, Pulteney	42.5314	-77.15	Synoptic	KLA
Keuka Lake	Hammondport Beach	42.4098	-77.2175	Synoptic	KLA
Keuka Lake	Central thermocline depth	42.4925	-77.1503	Synoptic	KLA
Keuka Lake	East thermocline depth	42.5491	-77.1024	Synoptic	KLA
Keuka Lake	West thermocline depth	42.5594	-77.1458	Synoptic	KLA
Keuka Lake	South thermocline depth	42.4188	-77.1985	Synoptic	KLA
Cold Brook	Cold Brook at middle	42.39539	-77.2554	Synoptic	KLA PEERS
Cold Brook	Cold Brook at mouth	42.40482	-77.2196	Synoptic	KLA PEERS
Cold Brook	Cold Brook headwaters	42.37755	-77.2783	Synoptic	KLA PEERS
Eggleston Glen	Eggleston Glen at mouth	42.51398	-77.1039	Synoptic	KLA PEERS
Sugar Creek	Sugar Creek at middle	42.62293	-77.158	Synoptic	KLA PEERS
Sugar Creek	Sugar Creek at mouth	42.60197	-77.151	Synoptic	KLA PEERS
Sugar Creek	Sugar Creek headwaters	42.6868	-77.1271	Synoptic	KLA PEERS
Wagener Glen	Wagener Glen at mouth	42.53081	-77.1529	Synoptic	KLA PEERS

Source: Community Science Institute, Seneca Lake Watershed Monitoring Region (Community Science Institute Database)

2.4.2.1 Monitored Surface Water Inflows to Seneca Lake

Keuka Outlet is the largest tributary to Seneca Lake and is the sole outlet of Keuka Lake, which exhibits consistently good water quality. The tributary flows east from Penn Yan to Dresden, on the central western shore of Seneca Lake. Six control gates located at the Main Street Bridge in Penn Yan regulate flow and water levels in the Keuka Lake Outlet. Agriculture (79%) and forested land (16%) comprise the major land cover within the direct drainage area to outlet, excluding Keuka Lake. Water quality sampling of the Keuka Outlet has been conducted since 2015; the monitoring program has expanded from four sites to ten. Keuka Outlet is a Class C fishing stream. The stream receives discharge from the Penn Yan wastewater treatment plant (WWTP) regulated by a NYSDEC State Pollutant Discharge Elimination System (SPDES) permit, however, that permit does not specify nutrient or bacteria limits for the treated effluent. Additional testing was conducted for metal contamination from the Lockwood Landfill, near Dresden, which was an ash disposal site for the Greenridge coal-fired power plant. In addition, a dredging project conducted under NYSDEC oversight is underway to remediate residual waste from a former manufactured gas plant. In 2018, Pure Waters sampling revealed that 61% of samples failed to meet guidelines for *E. coli* levels. *E. coli* levels increased moving downstream from Keuka Lake to Seneca Lake, eventually approaching the 235 colonies/100 mL single sample limit for water contact recreation. This could be due to agricultural runoff or inputs from the Penn Yan Wastewater Treatment Plant. During the one high flow event captured in 2018, TP levels increased significantly, demonstrating how high flow events combined with high nutrient concentrations can substantially increase load to Seneca Lake. TSS concentrations, sampled during wet weather events, are extremely high at all locations, indicating the critical impact of stormwater on erosion and transport of soil from the landscape to the waterways.

Catherine Creek, located at the southern end of Seneca Lake, originates in Horseheads, and flows north. It is the longest tributary flowing into Seneca Lake; the watershed lands are primarily agricultural (49%) and forests (45%). Catherine Creek is a Class C waterbody and formerly received treated effluent from the Montour Falls WWTP. Similarly, the Watkins Glen WWTP discharged treated effluent into Seneca Lake near the confluence with Catherine Creek. A project to upgrade and consolidate these two WWTPs into a new facility with advanced treatment capabilities, including phosphorus removal, was completed and online in 2021. Effluent is discharged into Catherine Creek approximately 4,000 feet upstream from the Seneca Lake – Catherine Creek confluence. Sampling of Catherine Creek is conducted at nine sites as of 2019. Sites directly upstream and downstream of the Montour Falls WWTP enable assessment of the effect of that point source. TP concentrations were elevated during wet weather at the Millport and Havana Glenn Mouth stations, averaging three times higher than conditions during baseflow. *E. coli* levels increased during storm events. During baseflow conditions, TSS concentrations were generally less than 10 mg/L, except for the site directly downstream of the Montour Falls WWTP outfall. During wet weather, TSS concentrations were significantly elevated at all sites, demonstrating the impact of storm events on loading.

Kashong Creek enters Seneca Lake at its western shore approximately seven miles south of Geneva. The watershed land cover is approximately 83% agriculture and 15% forested. Residential land cover is low. Kashong Creek has been monitored at three locations since fall 2016, consequently, fewer samples have been collected for this stream relative to others. Kashong Creek exhibits high variability in annual hydrology; high flows are typical in spring, but it is not uncommon for the streambed to be completely dry by late summer. The creek is designated a Class C stream and was listed on the states 2007 Waterbody Inventory/Priority Waterbodies List (WI/PWL) as possibly affected (needing verification) by silt/sediment and nutrients. Note that the draft 2020-2022 Priority Waterbodies list released on December 28th, 2021, proposes delisting all water segments previously noted as impaired for silt/sediment. Bacteria, TP, and TSS concentrations are elevated during wet weather at all three sampling locations.

Big Stream is designated a Class D stream from the falls, west to Rt. 14A, and Class C for the remainder of its length. Effluent from the Dundee WWTP flows into this stream, either directly or through a holding pond. The Dundee WWTP SPDES permit was updated in October 2020, which places limits on nutrients and bacteria. Further information on the SPDES permit can be found at

Permit.IndSPDES.NY0025445.2021-09-25.Modification_x.pdf. Requirements to control these pollutants required upgrades to the plant, which are underway. Big Stream drains 74% agricultural and 15% forested lands. It passes through the village of Dundee and enters Seneca Lake at Glenora Point on its western shore. Pure Waters has monitored this stream from its origin to its mouth on Seneca Lake since 2014, typically sampling four to five times each year at seven sites. The stream has also been included in the WAVE program. Sampling results demonstrate elevated phosphorus concentrations at downstream locations compared with upstream locations during low flow conditions. This finding is consistent with the influence of a point source such as the WWTP discharge to this segment (Pure Waters, 2018). High phosphorus concentrations evident during storm events likely are the result of agricultural runoff and may also reflect the impact of sanitary sewer overflows. *E. coli* concentrations are elevated under average flow conditions, and extremely high in the vicinity of the Dundee WWTP outfall. High flow conditions increase *E. coli* levels by two orders of magnitude compared to base flow conditions, likely due to runoff from agricultural operations. Spikes in TSS concentrations were observed during wet weather events indicating significant erosion and sediment reaching the waterways.

Reeder Creek flows north then west, entering Seneca Lake at its northeastern shore. The watershed consists of 60% forested and 31% agricultural lands, with a wetland area at its source. It originates at the former Seneca Army Depot, a historically contaminated site where munitions were detonated or burned. The Depot is the focus of an ongoing environmental remediation and cleanup effort. It is a Class C stream that receives effluent from the Five Points Correction Facility and Hillside Children's Center wastewater treatment facilities. Sampling is severely limited by the lack of accessibility to the Depot area, and therefore three sites are frequently sampled with a fourth location dependent on access. Reeder Creek was sampled as a WAVE site in 2015 and was assessed as "possibly impaired". It was added to Part A of the NYSDEC 2016 303(d) List due to its elevated phosphorus concentration. Suspected sources cited by the WI/PWL (2016) include municipal discharges and disposal of munitions and other activities at the Seneca Army Depot. Pure Waters has sampled Reeder Creek since 2014. Average baseflow TP concentrations are highest at North Patrol Rd (880 ppb) and lowest at the confluence with Seneca Lake at Lake Rd (200 ppb). Seneca Army Depot disposal sites were located very close to the creek and potential phosphorus contamination was not considered at the time. Some experts suspect that groundwater is contaminated due to burning of old ammunition from the Seneca Army Depot. In some cases, wet weather samples have had decreased concentrations of TP. This indicates that baseflow TP concentrations are elevated and are diluted during storm events, which is typical of streams affected by point source discharges. This differs from streams where nonpoint sources from watershed runoff are significant sources of annual phosphorus loading. Apart from phosphorus, water quality declines during high flow conditions, experiencing elevated levels of bacteria, nitrogen, and TSS. In addition to wastewater discharges, there are likely other multiple sources of *E. coli* in the watershed.

The mouth of **Glen Eldridge** is located on the east shore at the southern end of Seneca Lake. It is representative of a small, pristine stream draining 20 square miles. The stream drains about 80% forest lands and 20% agricultural lands.

2.4.2.2 *Monitored Surface Water Inflows to Keuka Lake*

Eggleston Glen. Eggleston Glen flows into Keuka Lake in the Town of Barrington along the lake's eastern shore. The stream originates just west of the Old Bath Road and north of Knapp Road. A secondary tributary originates further south and west near the Keuka Vista Road. The stream includes two sets of waterfalls "Little Falls", which flows over a 69-foot elevation change and "Big Falls" which flows over a 110-foot elevation change. Land cover in the Eggleston Glen subwatershed is a mix of forest (52%) and agricultural lands (34%).

Sugar Creek. Sugar Creek drains 36 square miles north of the western arm of Keuka Lake primarily in the Town of Jerusalem. Vineyards are a common land cover close to the mouth at Keuka Lake. The Sugar Creek watershed is classified as 44% agriculture, 42% forest and grassland, and 4% developed.

Wagener Glen. Wagener Glen is a tributary to Keuka Lake in the Town of Pulteney on the western shore of Keuka Lake. It drains a mix of forest and agricultural lands, with a high concentration of vineyards.

2.4.3 Flow Data

Watershed models must be capable of predicting how the stream network responds to meteorological conditions. Modelers rely on discharge data recorded on gauged streams to calibrate and test that the hydrology model adequately reflects local conditions. There are four USGS gauge stations within the watershed that have tracked continuous flow over various periods of time (**Table 17**). FLI installed continuous flow monitors in several streams in 2019.

Table 17: Hydrologic Gauging Stations

Station Name	Operator / Station ID	Latitude	Longitude
Keuka Lake Outlet at Dresden	USGS-04232482	42.68028	-76.95388
Catherine Creek at Montour Falls	USGS-04232200	42.32833	-76.84389
Sugar Creek at Guyanoga	USGS-0423245850	42.62769	-77.15892
Watkins Glen (Inactive as of Sept. 2013)	USGS04232400	42.3833	-76.8681
Big Stream at Mouth	FLI	42.4900	-76.9143
Castle Creek at Main Street	FLI	42.8696	-76.9796
Cold Brook (Keuka Inlet) at Pleasant Valley Road	FLI	42.5308	-77.2196
Kashong Creek at Route 14 Bridge	FLI	42.7651	-76.9765
Reeder Creek at Mouth	FLI	42.7860	-76.9280
Wagener Glen at Mouth	FLI	42.5308	-77.2196

Tributary water quality data are more valuable to resource managers when stream flow (discharge) is measured at the same time. Paired concentration and flow data enable calculation of load. Samples collected across a range of hydrologic conditions are of great value to watershed modelers, as most transport occurs during high flow conditions. As displayed in **Figure 10,** only a limited number of locations in the Seneca-Keuka watershed have these paired observations. Most of the non-USGS collected discharge data collected prior to 2020 originates from monitoring conducted by John Halfman and the FLI. This data was categorized as B level data, suitable for use for general understanding and model set-up, but not incorporated for use in model calibration.

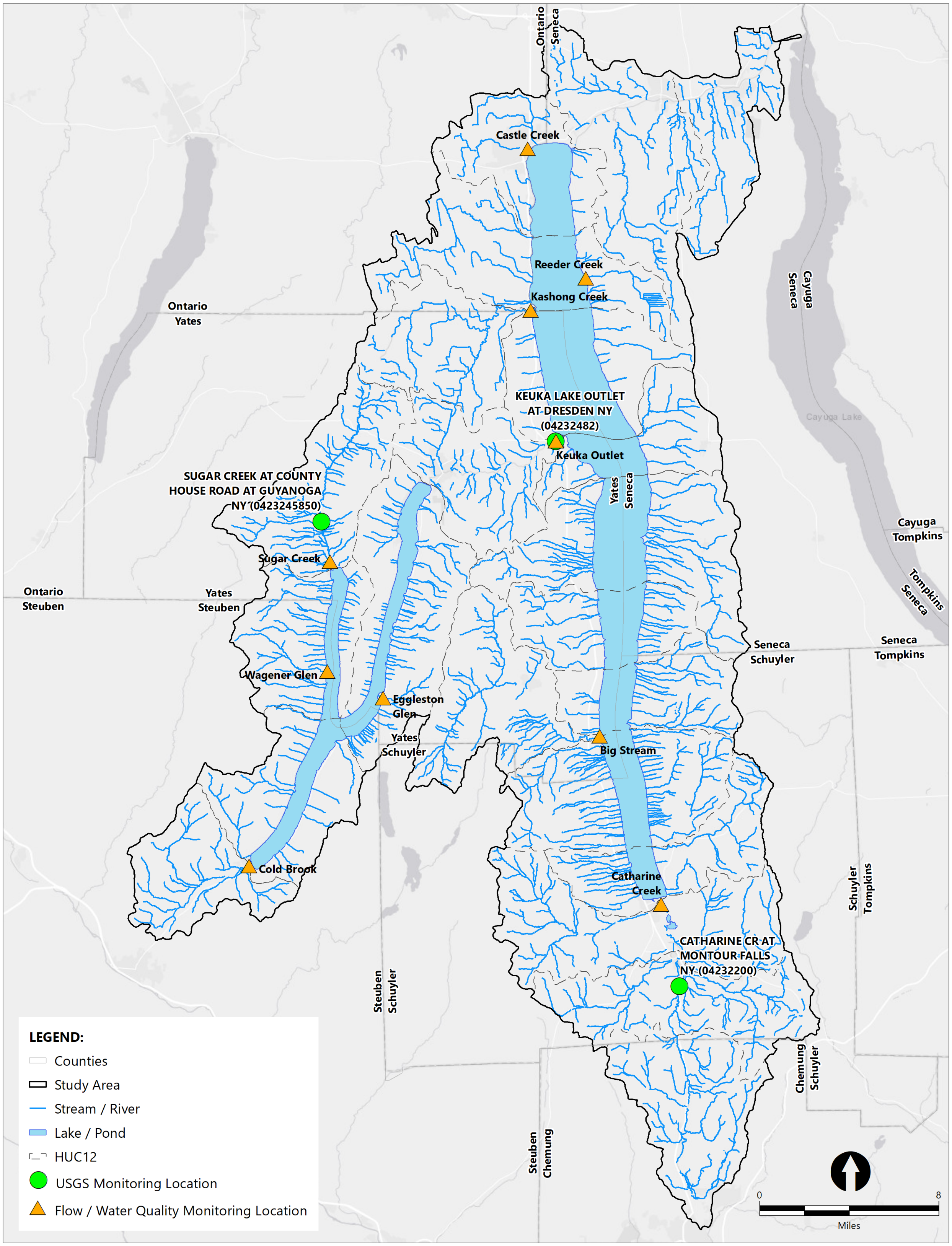

Figure 10: Monitoring Locations in the Seneca-Keuka Watershed

2.5 Current Water Quality Conditions

2.5.1 Lake Trophic Status

Lakes are often classified according to their trophic state and assigned a term describing their position on a continuum of primary productivity. Highly productive lakes exhibit elevated concentrations of phosphorus and phytoplankton and low water clarity. These lakes are termed "eutrophic" from the Greek word meaning well-fed. At the other end of the trophic continuum are lakes of low productivity; "oligotrophic" (poorly fed) lakes have low concentrations of phosphorus and phytoplankton and exhibit high water clarity. The designation "mesotrophic" refers to lakes that fall somewhere in between. Lake managers use several trophic state indicator parameters to track productivity (**Table 18**). Key trophic state indicator parameters include:

- **Total Phosphorus (TP).** Phosphorus is the limiting nutrient for growth of phytoplankton (defined as microscopic algae and cyanobacteria) that form the base of the lake's food web. Therefore, phosphorus availability is a key determinant of trophic state for most lakes at this latitude including the Finger Lakes.

- **Chlorophyll-a.** Chlorophyll-a is a photosynthetic pigment present in phytoplankton. It's concentration in lake water samples is an excellent surrogate for phytoplankton density.

- Water clarity, as measured by **Secchi disk transparency**. Secchi disks are 20 cm diameter flat disks with alternating quadrats of black and white. The disk is lowered through the water column (from a boat or dock) until it is no longer visible, and the depth is recorded. This simple metric is widely used for its ease and comparability.

- **Dissolved oxygen** content of the deep waters is sometimes included as a fourth trophic state parameter related to primary productivity. In lakes deep enough to undergo thermal stratification (as are both Keuka and Seneca), oxygen can be depleted in the deep waters as phytoplankton settles from the upper sunlit layer and is decomposed in the depths. Microorganisms use oxygen dissolved in the lake water as they decompose organic material. The rate and magnitude of oxygen depletion is an indication of relative supply and demand. With low primary productivity (less phytoplankton) oxygen depletion is minimal.

Table 18: Trophic State Indicator Parameters

Parameter	Trophic State		
	Oligotrophic	**Mesotrophic**	**Eutrophic**
Total Phosphorus (TP)	< 10 µg/l	10-20 µg/l	> 20 µg/l
Chlorophyll-a	< 2 µg/l	2-8 µg/l	> 8 µg/l
Secchi Disk Transparency	> 5 meters	2-5 meters	< 2 meters
Dissolved Oxygen in Lower Waters (Percent Saturation)	80 - 100	10-80	<10

Source: Chapter 4 of *Diet for a Small Lake: The Expanded Guide to New York State Lake and Watershed Management* (https://www.dec.ny.gov/docs/water_pdf/dietlakech4.pdf)

Both Seneca and Keuka Lakes are at the lower end of the trophic continuum as displayed in **Figure 11,** which depicts trophic state indicator parameters in the lake waters over a 17-year period. While there is variability between years, Seneca Lake consistently exhibits high water clarity (summer average Secchi disk transparency generally greater than 5 m), low nutrient levels (summer average TP less than 10 ug/L), and low to intermediate algal abundance (summer average chlorophyll-a generally less than 5 ug/L). Dissolved oxygen concentrations show no evidence of depletion during the summer stratification period. However, recent data indicate increasing productivity. The lake is currently considered as a mesotrophic system (moderately productive).

Recent data for Keuka Lake suggest that it is oligo-mesotrophic (low to moderately productive) based on the lake's high water clarity (summer average Secchi disk transparency generally greater than 5 m), low nutrient levels (summer average TP less than 10 ug/L), and low to intermediate algal abundance (summer average chlorophyll-a generally less than 5 ug/L). Dissolved oxygen concentrations show no evidence of depletion. Data plotted in **Figure 12** suggest that Keuka Lake may be trending toward lower productivity; this trend is consistent with the fisheries discussion in **Section 2.2.3.**

In summary, both Seneca and Keuka Lakes currently exhibit excellent water quality conditions and overall low to moderate levels of primary productivity, as evident from the ambient concentrations of phosphorus and chlorophyll-a, and high water clarity. Conditions vary from year to year. This variability likely reflects differences in weather and timing of sample collection. However, there are indications of long-term trends in the lakes' trophic conditions. According to the 2018 NYSDEC Finger Lakes Water Quality Report, Keuka Lake's water quality has improved continually since the 1970s based on chlorophyll-a measurements taken since the 1970s. The same report concludes that Seneca Lake's water quality (as indexed by chlorophyll-a concentrations) has improved since the 1970s, but a trend toward declining water quality began in the 1990s and early 2000s (NYSDEC 2019).

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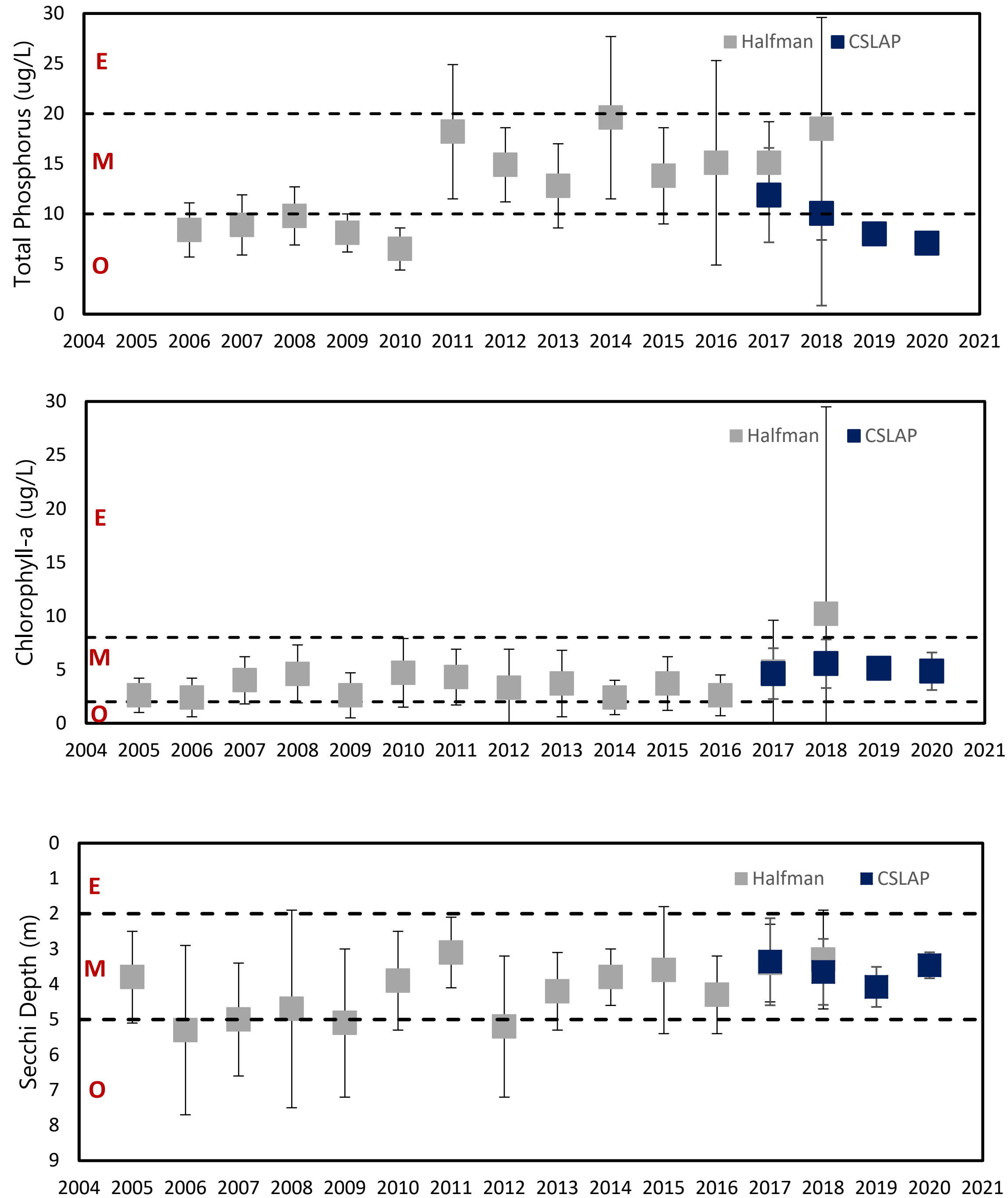
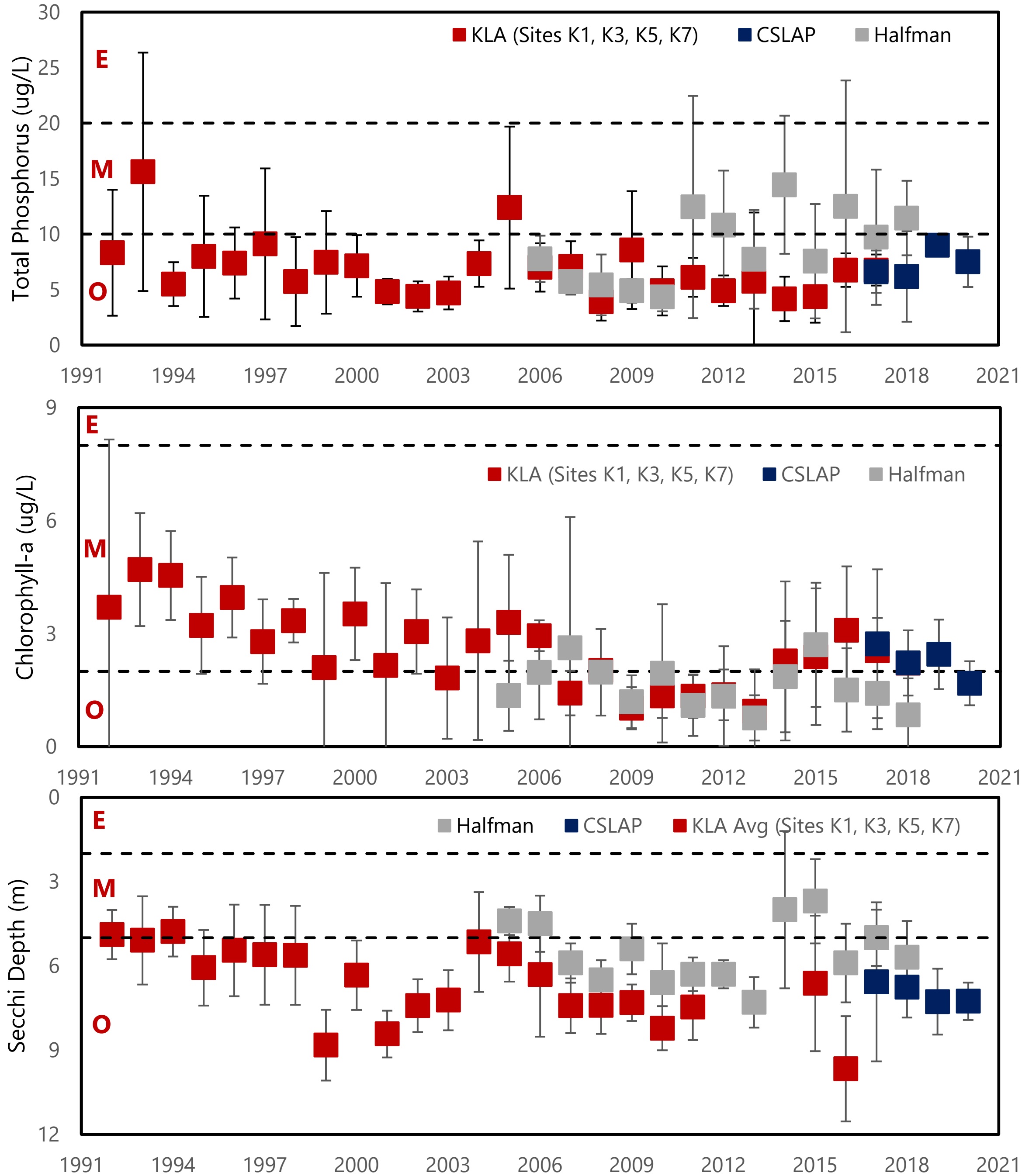
Figure 11: Trends in Seneca Lake Trophic Status



Notes: Summer average (**a**) total phosphorus, (**b**) chlorophyll-a, and (**c**) Secchi disk transparency in Seneca Lake. E, M, and O indicate eutrophic, mesotrophic, and oligotrophic ranges as defined by NYS Trophic State Criteria. Error bars represent standard deviation.

Figure 12: Trends in Keuka Lake Trophic Status



Notes: Summer average (**a**) total phosphorus, (**b**) chlorophyll-a, and (**c**) Secchi disk transparency in Keuka Lake. E, M, and O indicate eutrophic, mesotrophic, and oligotrophic ranges as defined by NYS Trophic State Criteria. Error bars represent standard deviation.

2.5.2 Waterbody Inventory/Priority Waterbodies List

Under the Federal Clean Water Act, the NYSDEC is required to provide periodic assessments of water resources throughout the state, including their ability to support designated uses (e.g., aquatic life protection, public water supply, contact recreation). Data and information from NYSDEC monitoring and other programs are used to evaluate surface water status. The inventory of this water quality information is referred to as the Waterbody Inventory/Priority Waterbodies List (WI/PWL) and used to identify and resolve water quality issues, pollutants of concern, and contributing point and nonpoint sources.

Data included in the 2016 WI/PWL for the Seneca Keuka watershed are summarized in **Table 19**. There are 32 listed waterbodies within the Seneca-Keuka watershed, and 18 designated as unassessed. Although Seneca Lake (middle and south) and Keuka Lake are categorized as threatened, they are listed to emphasize the need for protection. These waterbodies are highly valued resources due to their Class AA(TS) drinking water supply designation, so categorization reflect resource value rather than specific identified threats. As discussed earlier in **Table 6**, six municipalities rely on Keuka and Seneca Lake for drinking water.

Table 1919: WI/PWL, 2016

Waterbody Name	Date Revised	Category	Impacted Designated Use	Cause/ Pollutant	Source	Notes
Seneca River, Upper, Main Stem (0705-0023)	12/7/21	Needs Verification (IR 3)	Fishing	pH,	Agriculture	Village of Waterloo water supply intake at the western edge.
Cleef Lake (0705-0072)	12/7/21	Needs Verification (IR 3)	Fishing	pH	Unknown	
Seneca River, Upper, Main Stem (0705-0044)	12/7/21	Needs Verification (IR 3)	Fishing, Primary and Secondary Contact Recreation, Source of Water Supply	pH, HABs	Unknown	
Minor Tribs to Upper Seneca River (0705-0046)	-	Unassessed				
Sucker Brook and tribs (0705-0047)	-	Unassessed				
Silver Creek and tribs (0705-0048)	-	Unassessed				
Gem Lake (0705-0049)	-	Unassessed				
Kendig Creek and tribs (0705-0024)	12/7/21	Needs Verification (IR 3)	Fishing	Dissolved Oxygen, pH	Unknown	
Seneca Lake, Main Lake, North (0705-0026)	12/7/21	Needs Verification (IR 3)	Fishing, Primary and Secondary Contact Recreation	Ammonia, Phosphorus	Unknown	
Minor Tribs to Seneca Lake, Eastern (0705-0073)	-	Unassessed				
Reeder Creek and tribs (075-0074)	12/7/21	Impaired (IR 5)	Fishing, Secondary Contact Recreation	Dissolved Oxygen, pH, Phosphorus, HABs	Municipal discharges, landfill/land disposal (Seneca Army Depot)	Seneca Army Depot now closed.

Waterbody Name	Date Revised	Category	Impacted Designated Use	Cause/ Pollutant	Source	Notes
Minor Tribs to Seneca Lake, Northwest (0705-0073)	-	Unassessed				
Kashong Creek and tribs (075-0017)	8/15/07	Needs Verification (IR 3)	Aquatic life	Nutrients	Agriculture, roadbank erosion, streambank erosion	Focus of a 208 study (1978) found significant impacts from soil erosion, implemented streambank stabilization and agricultural BMPs.
Wilson/Burrell Creek and tribs (0705-0096)	-	Unassessed				
Seneca Lake, Main Lake, Middle (0705-0021)	12/7/21	Needs Verification (IR 3)	Fishing, Primary and Secondary Contact Recreation, Source of Water Supply	Magnesium , pH, Sulfate, HABs, pathogens	Mining, Unknown	Serves as water supply for the City of Geneva, Village of Waterloo, and Village of Ovid. SWAP assessment found elevated susceptibility to contamination for this source of drinking water, elevated potential for phosphorus, DBP pre-cursors, and pesticides, contamination based on land use and activities in the watershed. Included on PWL as threatened due to its highly valued resource due to its designation of a Class AA(TS) drinking water supply (needs to be protected, not necessarily threatened).
Seneca Lake, Main Lake, South (0705-0014)	5/18/16	Threatened	Public bathing	Pathogens, Harmful algal blooms, low D.O.	Municipal discharges (Watkins Glen WWTP), Unknown	Watkins Glen WWTP has a history of SPDES permit violations dating back to 2007 for settleable solids, fecal and total coliform, and total residual chlorine. WWTP currently located between a public access beach and a drinking water intake.
Indian Creek and tribs (0705-0075)	12/7/21	Needs Verification (IR 3)	Fishing	Dissolved Oxygen, pH	Unknown	

Waterbody Name	Date Revised	Category	Impacted Designated Use	Cause/ Pollutant	Source	Notes
Mill Creek and tribs (0705-0076)	8/15/07	No Known Impacts				
Saw Mill Creek and tribs (0705-0077)	12/7/21	Needs Verification (IR 3)	Fishing	pH	Unknown	
Hector Falls Creek and tribs (0705-0007)	8/15/07	No Known Impact				
Minor tribs to Seneca Lake, Southwest (0705-0085)	-	Unassessed				
Rock Stream and tribs (0705-0086)	8/15/07	No Known Impacts				
Big Stream, Lower, and tribs (0705-0087)	5/21/07	No Known Impacts				
Big Stream, Upper, and tribs (0705-0088)	-	Unassessed				
Plum Point Creek and tribs (0705-0089)	-	Unassessed				
Keuka Lake Outlet and tribs (0705-0020)	12/7/21	Needs Verification (IR 3)	Fishing	pH	Unknown	Sea lamprey nursery area that receives DEC treatment at 3 year intervals with selective lampricide, TFM.
Keuka Lake (0705-0003)	12/7/21	Needs Verification (IR 3)	Primary and Secondary Contact Recreation, Source of Water Supply	Phosphorus, Ammonia, Chloride, Nitrate, and Nitrite	Agriculture, Unknown	Threat reflects the class AA(TS) designation of the lake and its resource value, rather than specifically identified threats.
Minor tribs to Keuka Lake, Eastern (0705-0090)	-	Unassessed				
Keuka Lake Inlet/Cold Brook, and tribs (0705-0091)	12/7/21	Needs Verification (IR 3)	Fishing	Dissolved Oxygen	Unknown	

Waterbody Name	Date Revised	Category	Impacted Designated Use	Cause/ Pollutant	Source	Notes
Minor tribs to Keuka Lake, Western (0705-0092)	12/7/21	Needs Verification (IR 3)	Fishing	pH	Unknown	
Sugar Creek, Lower, and tribs (0705-0018)	8/15/07	No Known Impacts				
Sugar Creek, Upper, and tribs (0705-0093)	-	Unassessed				
Minor tribs to Keuka Lake, Northern (0705-0094)	-	Unassessed				
Seneca Lake Inlet and minor tribs (0705-0078)	-	Unassessed				
Catherine Creek and tribs (0705-0011)	8/15/07	No Known Impacts				Important mating area for rainbow trout fishery. Sea lamprey nursery area, DEC control program involves applications of selective lampricide, TFM, at three year intervals.
Johns Creek, Upper, and tribs (0705-0079)	-	Unassessed				
Catlin Mills Creek and tribs (0705-0080)	-	Unassessed				
Mitchell Hollow Creek and tribs (0705-0081)	-	Unassessed				
Glen Creek and minor tribs (0705-0081)	12/7/21	Needs Verification (IR 3)	Fishing, Primary and Secondary Contact Recreation	Dissolved Oxygen, pH	Unknown	
Old Barge Canal and minor tribs (0705-0083)	-	Unassessed				
Shequaga Creek and tribs (0705-0084)	-	Unassessed				

Source: NYSDECInfo Locator (DECinfo Locator (ny.gov))

Note: Waterbodies with revisions dated in 2021 contain information from revised NYSDEC fact sheets that are awaiting verification.

3 Waterbody Impairments and Sources of Phosphorus

3.1 Known Impairments

Seneca Lake and Keuka Lake were included on the 2016 NYSDEC/Division of Water (DOW) Priority Waterbodies List as threatened waterbodies due to their resource value as a potable water source and the need to provide additional protection, rather than any specifically identified threats. Swimming is evaluated as threatened by occasional growths of aquatic plants and algal blooms that can discourage swimming and other recreational uses. Although all uses are currently supported in the lakes, these threats should continue to be monitored.

3.2 Stressors and Impacts on Waterbody

In recent years, Seneca Lake has experienced an increase in algal blooms and HABs. HABs threaten and impair recreational access and potable water use. Although the scientific consensus on the cause(s) of HABs is not yet clear, it is known that nutrient dynamics and phosphorus pollution plays a role in HABs viability and proliferation. Excessive phosphorus, as well as other factors such as climate change, are suspected drivers of cyanobacterial blooms.

In 2021, there were 72 HAB reports in Seneca Lake, and 12 HAB reports in Keuka Lake. There have been confirmed HABs with high toxins in Seneca Lake since 2015, and Keuka Lake since 2017. Shoreline surveillance began in 2018. **Table 20** and **Table 21** display annual summaries of HABs in Seneca and Keuka Lake (respectively) since 2015. These data were compiled from the NYSDEC HABs archive page (Harmful Algal Blooms (HABs) Archive Page - NYS Dept. of Environmental Conservation) and NYSFOLA CSLAP website (CSLAP Report Search – NYSFOLA).

Table 2020: Summary of Reported HABs in Seneca Lake, 2015-2021

Year	Bloom Period (Date Reported, Date Removed)	# Weeks on Notification Page (pre-2019) Number of Reported Blooms (post-2019)
2015	8/21-10/20	9
2016	9/2-10/27	8
2017	9/15-10/20	5
2018	8/24-10/27	9
2019	8/21-10/19	35 reports*
2020	8/22-10/9	16 reports*
2021	8/25-10/19	72 reports*

Source: NYSDEC Harmful Algal Blooms Archive Page and NYSFOLA CSLAP
*Note: In 2019, NYSDEC modified the format of Archived HAB notices.

Table 2121: Summary of Reported HABs in Keuka Lake, 2017-2021

Year	Bloom Period (Date Reported, Date Removed)	# Weeks on Notification Page (pre-2019) Number of Reported Blooms (post-2019)
2017	4/8-10/20	28
2018	8/17-10/27	10
2019	7/3-10/30	24 reports*
2020	7/21-9/19	14 reports*
2021	8/16-11/9	12 reports*

Source: NYSDEC Harmful Algal Blooms Archive Page and NYSFOLA CSLAP

*Note: In 2019, NYSDEC modified the format of Archived HAB notices.

3.3 Potential Sources of Phosphorus

The significant sources of phosphorus and other pollutants loading to Seneca and Keuka Lakes are nonpoint source phosphorus inputs from the contributing watershed (agricultural lands, forest, streambank erosion and ditches), point sources from regulated facilities, and input from onsite wastewater disposal systems (septic systems).

3.3.1 Point Sources

Table 22 lists the 81 point sources within the watershed. CAFOs, publicly owned treatment works (POTWs), and municipal separate storm sewer systems (MS4s) are distinguished by color. Red refers to CAFOs, blue refers to POTWs, and green refers to MS4s. Locations of the regulated point sources within the Seneca-Keuka watershed are displayed in **Figure 13.** Point sources require a SPDES permit if they have a disposal system, outlet, or discharge pipe that discharge wastewater into surface or ground waters. Point sources with SPDES permits are listed in **Table 23,** which can also be found at DECinfo Locator (ny.gov).

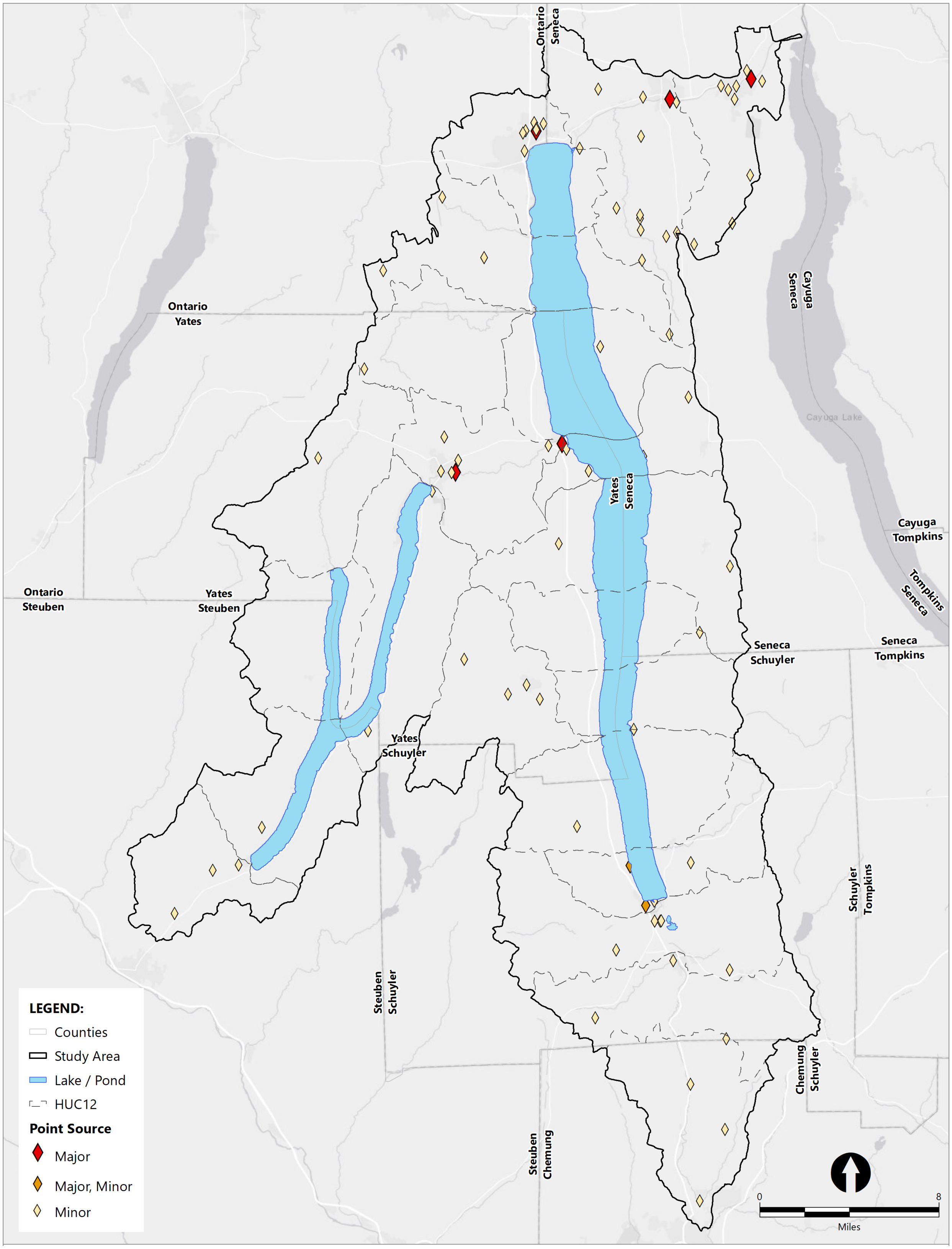


Figure 13: Point Sources in the Seneca-Keuka Watershed Study Area

Table 22: Point Sources in the Seneca-Keuka Watershed

Subwatershed (HUC12)	Name	SPDES ID	Location	Latitude	Longitude
Headwaters Catherine Creek (041402010601)	Pepsi Bottling Group Inc	NYR00D528 NYR00F358	Horseheads	42.190258	-76.8258
	Millport MS4 Storm Sewers	NYR20A029	Millport	42.265663	-76.8343
	Veteran MS4 Storm Sewers	NYR20A082	Millport	42.236434	-76.8042
Sleeper Creek-Catherine Creek (041402010602)	Wonderview Farm	NYA000503	Montour Falls	42.29506	-76.8032
	Rhodes Dairy Farm	NYA000512	Beaver Dams	42.30845	-76.9175
Seneca Lake Inlet (041402010603)	Westervelts Little Piggy Hill Farm	NYA000214	Watkins Glen	42.352206	-76.8994
	Frog Hollow Marina	NYR00F292	Watkins Glen	42.371284	-76.8602
	Wixson Sand and Gravel, LLC	NYR00F890	Montour Falls	42.339635	-76.8003
	Central Asphalt	NYR00A528 NYD980755201	Watkins Glen	42.371	-76.861
	First Student Inc	NYR00E559	Watkins Glen	42.370923	-76.866
	Montour Falls (V) STP	NY0021865	Montour Falls	42.34553	-76.8496
	Watkins Glen (V) STP	NY0020524 NYL020524	Watkins Glen	42.38112	-76.8738
Sugar Creek (041402010701)	David K. Vaughan & Sons	NYA000364 NYAE00364	Penn Yan	42.72668	-77.1219
	B&B Recycling	NYR00C248	Penn Yan	42.67	-77.165
Keuka Inlet/Cold Brook (041402010703)	Pleasant Valley Wine Co	NY0001007 NYN008012981	Hammondsport	42.40219	-77.2515
	Bath Fish Hatchery	NY0035424	Bath	42.374167	-77.2845
	Mercury Aircraft Inc	NY0108979 NY0245976 NYD002206639	Hammondsport	42.405679	-77.229
South Branch Keuka Lake (041042010704)	Bully Hill Vineyards Inc	NY0098566 NYD053652038	Hammondsport	42.430209	-77.2088
East Branch Keuka Lake (041402010705)	Morgan Marine	NYR00F005	Penn Yan	42.648	-77.062
	Keuka Hydroelectric Project	NYR10L261	Wayne	42.492972	-77.1169
	Penn Yan Village of Municipal Water Plt	NY0246107, NYR00001, NY6101263	Penn Yan	42.640278	-77.0797
Keuka Lake Outlet (041402010706)	Metal Recovery LLC	NYR00E166	Penn Yan	42.68313	-77.0514
	Milo Bulk Terminal	NYR00G312	Penn Yan	42.653632	-77.027
	Tec3 Olaf A Frederiksen Usarc	NYR00C446	Penn Yan	42.668	-77.039
	Greenidge Station	NY0001325 NYD013508916	Dresden	42.679134	-76.9486
	Lockwood Ash Disposal Site	NY0107069	Dresden	42.677806	-76.9605

Subwatershed (HUC12)	Name	SPDES ID	Location	Latitude	Longitude
	Penn Yan (V) STP	NY0029726	Penn Yan	42.66035	-77.0413
Hector Falls Creek-Seneca Lake (041402010801)	Seneca Valley Farm	NYA00E468	Burdett	42.404944	-76.8514
	Cargill Inc - Watkins Glen Plant	NY0002241 NYD096304647	Watkins Glen	42.383917	-76.8663
	U S Salt - Watkins Glen Refinery	NY0002330 NYR00C453 NYD002246361	Watkins Glen	42.406722	-76.8876
Big Stream (041402010802)	Elam R Hoover Farm	NYA001448	Dundee	42.53943	-77.0331
	Mark L. Hoover	NYA001526 NYAE01526	Dundee	42.51718	-76.9949
	Dundee Wastewater Treatment Plant	NY0025445	Dundee	42.514083	-76.9669
	Dundee (V)	NYL025445	Dundee	42.52331	-76.9785
Rock Stream-Seneca Lake (041402010803)	Jayne's Used Auto Parts	NYR00D871	Reading Center	42.432	-76.934
	Hector WTP (T)	NY0271772	Hector, Town Of	42.494662	-76.8847
Indian Run-Seneca Lake (041402010805)	Cardinal Disposal	NYR00G236	Dundee	42.54448	-76.9496
Mill Creek-Seneca Lake (041402010806)	Just Serendipity	NYA001336	Lodi	42.60031	-76.8009
	Andersen Farms	NYA001349 NYAE01349	Himrod	42.61445	-76.951
	Champion Scrap Metals	NYR00E348	Lodi	42.557632	-76.8274
Indian Creek-Seneca Lake (041402010807)	Hansen Pit	NYR00F931	Torrey, Town Of	42.661611	-76.9252
	Transelco Division of Ferro Corporation	NYR00B866	Penn Yan	42.67554	-76.9446
	Ferro Electronic Materials	NY0002097 NYR00B866 NYD000765024	Penn Yan	42.67554	-76.9446
	Five Points Correctional Facility	NY0246972 NYR000100511	Romulus	42.709558	-76.8378
	Seneca Co SD #1 STP	NY0160407	Willard	42.671167	-76.8773
Wilcox Creek-Seneca Lake (041402010902)	Lakeshore Landing	NYR10J480	Romulus	42.741861	-76.9154
Wilson Creek-Seneca Lake (041402010903)	Heifer Haven Farms	NYA00E136	Stanley	42.83786	-77.0545
	Phalen Farms	NYA00E467	Stanley	42.79028	-77.1059
	Vince Deboover Farm	NYA00C017	Geneva	42.79907	-77.0175
	U S Seneca Army Depot	NY0021296 NY0213820830 NYD213820830	Romulus	42.75	-76.8545
	Seneca County Sewer District #2, Five Points Correctional & Hillside	NY0246972	Romulus	42.709558	-76.8378
	Guardian Industries - Geneva	NYR00C270	Geneva	42.88261	-76.9722

Subwatershed (HUC12)	Name	SPDES ID	Location	Latitude	Longitude
Castle Creek-Seneca Lake (041402010904)	Univar USA Inc	NYR00D837	Geneva	42.881187	-76.9817
	Ups-Geneva	NYR00C009	Geneva	42.8864	-76.9741
	Zotos International Inc	NYR00B106	Geneva	42.885697	-76.9661
Castle Creek-Seneca Lake (041402010904)	WWS Associates Inc, Dba 2trg	NYR00F352	Geneva	42.87965	-76.984
	Marsh Creek WWTP	NY0027049	Geneva	42.880901	-76.9724
	Geneva (C)	NYL027049	Geneva	42.86799	-76.9827

Note: Red colored rows refer to CAFOs, blue refers to POTWs, and green refers to MS4s.

Table 23: SPDES Permits in the Seneca-Keuka Watershed

Name	SPDES ID	Permit Exp. Date	Location	Latitude	Longitude
Bath State Fish Hatchery	NY0035424	4/30/2026	Bath	42.374	-77.284
Buckeye Terminals LLC	NY0001031	2/28/2025	Geneva	42.870	-76.934
Bully Hill Vineyards Inc.	NY0098566	11/30/2031	Hammondsport	42.429	-77.209
Cargill Salt Company	NY0002241	N/A	Watkins Glen	42.384	-76.865
Ferro Electronic Materials – Penn Yan Facility	NY0002097	11/30/2023	Penn Yan	42.675	-76.945
Greenridge Power Generating Station	NY0001325	9/30/2022	Dresden	42.679	-76.948
Hillside Water Resource Recovery Facility	NY0272116	12/31/2024	Romulus	42.787	-76.886
Lockwood Ash Disposal Site	NY0107069	N/A	Dresden	42.676	-76.961
Marsh Creek Wastewater Treatment Plant	NY0027049	N/A	Geneva	42.879	-76.973
Mercury Aircraft, Inc.	NY0108979	3/31/2026	Hammondsport	42.406	-77.230
Penn Yan (V) Water Treatment Plant	NY0246107	6/30/2026	Penn Yan	42.650	-77.079
Pleasant Valley Wine Company	NY0001007	5/31/2023	Hammondsport	42.401	-77.254
Seneca County Sewer District #1 STP	NY0160407	12/31/2024	Willard	42.673	-76.875
Seneca County Sewer District #2 (5 PTS Correctional WRRF)	NY0246972	12/31/2024	Romulus	42.750	-76.851
Seneca Foods Corporation	NY0072257	12/31/2022	Geneva	42.893	-76.985
Town of Gorham Sewage Treatment Plant	NY0160814	10/31/2026	Gorham	42.804	-77.133
Town of Hector Water Treatment Plant	NY0271772	5/31/2022	Hector	42.496	-76.885
U.S. Salt, Watkins Glen New York Facility	NY0002330	N/A	Watkins Glen	42.407	-76.887
Village of Dundee Wastewater Treatment Plant	NY0025445	9/30/2025	Dundee	42.517	-76.970
Village of Odessa Wastewater Treatment Facility	NY0272183	7/7/2031	Odessa	42.335	-76.800
Village of Penn Yan Sewage Treatment Plant	NY0029726	2/29/2024	Penn Yan	42.656	-77.036
Watkins Glen/Montour Falls Regional Wastewater Treatment Facility	NY0271942	10/31/2022	Watkins Glen	42.373	-76.857

Source: DECinfo Locator Map (DECinfo Locator (ny.gov))

3.3.2 Nonpoint Sources

Anchor QEA applied the SWAT model to estimate phosphorus loads from lands within the Seneca-Keuka watershed. Phosphorus loads from various nonpoint source sectors are summarized in **Table 24**. The SWAT model was calibrated and verified using monitoring data collected within the Seneca-Keuka watershed that met NYSDEC quality assurance requirements. Land cover classifications reflect the 2016 National Land Cover Database (NLCD) that was available at the onset of the modeling effort. Note that there is interannual variation in agricultural land cover based on many factors, including crop rotation.

Table 24: Source Sector Loads to Seneca and Keuka Lakes, SWAT Model Estimates

Source	Estimated Total Phosphorus Load (lbs/yr)	Estimated Total Phosphorus (%)
Cultivated Crops	175,000	64%
Hay/Pasture	45,000	17%
Developed Land	13,000	5%
Viticulture	5,000	2%
Forested Lands/Wetlands	31,000	11%
Septic Systems	2,900	1%

The SWAT watershed model does not explicitly simulate sediment erosion from stream beds and banks; it estimates material transport from the landscape to the streams and is calibrated to stream data collected within the Seneca-Keuka watershed. Water quality samples from tributaries to Seneca and Keuka Lakes were collected over a range of hydrologic conditions. Results reflect the net transport of sediment and phosphorus to stream monitoring locations from sheet flow across the landscape, transport through road ditches and tile drainage outlets, as well as erosion of stream beds and banks.

3.4 Evaluation of Scenarios Using SWAT

The calibrated SWAT model was applied to demonstrate the estimated phosphorus load change by three scenarios:

- Scenario 1: Expansion of cover crops (winter wheat) to all agricultural parcels during the non-growing season (fall to mid-April)
- Scenario 2: Increase precipitation by 10% to simulate effects of climate change
- Scenario 3: Expand conservation tillage (including no-tilling, strip-tilling, and ridge-tilling) to all agricultural parcels

The model projections presented in **Tables 25, 26, and 27** provide insights into priority BMP actions and locations with the watershed to reduce phosphorus input to the lakes. Scenarios 1 and 3 are bounding calculation; the simulation assumed that all existing agricultural parcels adopt the proposed BMP. Scenario 2 was modeled to estimate the effects that increased precipitation from climate change may have on runoff and transport of phosphorus from the watershed to the lakes. A map displaying the subwatershed phosphorus loads used in each of the scenarios is included as **Figure 14.**

Meeting the goals set forth in the Agricultural Environmental Management (AEM) Strategic Plan will require continued support to the agricultural community. This support encompasses both financial support to offset the direct costs of BMP implementation and ensuring that Districts and other agricultural support agencies are adequately staffed. The SWAT model projections indicate that expanded adoption of cover crops is one example of an agricultural practice with potential for a significant reduction in annual phosphorus export from the landscape to the surface waters. Keeping vegetative cover on the landscape for longer periods each year not only stabilizes soils and improves infiltration, but also incorporates phosphorus and other nutrients into plant biomass. The net result is reduced phosphorus load and improved hydrologic resiliency (**Table 25, Figure 15**).

More extreme weather events from climate change were simulated in the second scenario by increasing precipitation by 10%. The increase in precipitation resulted in an increase in TP load by approximately 18% across the entire watershed; predictions vary by subwatershed as summarized in **Table 26 .** These differences reflect the differences among the subwatersheds in both underlying environmental conditions (soils, topography, hydrology) and human uses (impervious surfaces and other land uses, management practices). The implication of this scenario is the need for a concerted effort across the watershed to prevent additional increased phosphorus inputs.

The third scenario modeled was expansion in conservation tillage to all agricultural parcels. This bounding scenario modeled the impacts of leaving crop residue from the previous growing season on the field to minimize soil erosion and enhance infiltration, followed by partial clearing before the next growing season. Widespread adoption of conservation tillage was anticipated to result in a net reduction in phosphorus export. However, the SWAT model predicted a net increase of approximately 8% (**Table 27**). This increase is likely due to the base calibration of the SWAT model, which includes surface application of manure and fertilizer. The change to all conservation tillage would reduce the extent to which manure and other fertilizers are incorporated into the soil profile. With more nutrients in the surface layer, the model predicts an increased concentration of phosphorus in runoff from cultivated fields.

However, adoption of conservation tillage would likely be one component of an integrated system of agricultural BMPs. Conservation tillage coupled with measures such as riparian buffers, grassed waterways, WASCOBs, and other measures to intercept and infiltrate runoff before it reaches surface waters can be highly effective. In addition, agricultural producers with adequate storage capacity for manure can adjust land spreading operations to reflect weather predictions. The general modeling framework does not accommodate the benefits of integrated management practices and advancements in decision support tools. The conservation tillage scenario results offer an example of the limits of simplifying assumptions across large watershed areas. Both recommended and actual practices will vary each year in response to crop needs, weather conditions, technical innovations, and many factors.

Table 25: SWAT Model Projection: Estimated Phosphorus Load Change from Expanded Cover Crops

Subwatershed (HUC12) Name	HUC12 Drainage Area (acres)	Base Scenario: Landscape Phosphorus Loading from All Sources (Current Conditions)		Scenario: Cover Crops (Winter Wheat) on All Agricultural Parcels		
		Total Phosphorus (lb/yr)	Total Phosphorus (lb/acre/yr)	Total Phosphorus (lb/yr)	Total Phosphorus (lb/acre/yr)	Percent Change from Base Scenario
Headwaters Catherine Creek	22,862	16,751	0.73	12,129	0.53	-28%
Sleeper Creek-Catherine Creek	23,569	18,992	0.81	14,748	0.63	-22%
Seneca Lake Inlet	30,468	18,424	0.60	16,767	0.55	-9%
Hector Falls Creek-Seneca Lake	19,126	12,495	0.65	10,352	0.54	-17%
Big Stream	23,443	19,713	0.84	15,320	0.65	-22%
Rock Stream-Seneca Lake	29,141	15,684	0.54	12,650	0.43	-19%
Breakneck Creek-Seneca Lake	18,409	9,876	0.54	8,397	0.46	-15%
Indian Run-Seneca Lake	13,640	8,994	0.66	7,013	0.51	-22%
Mill Creek-Seneca Lake	35,262	27,768	0.79	21,774	0.62	-22%
Indian Creek-Seneca Lake	16,432	6,949	0.42	5,443	0.33	-22%
Kashong Creek	19,519	19,706	1.01	14,859	0.76	-25%
Wilcox Creek-Seneca Lake	22,489	6,907	0.31	5,027	0.22	-27%
Reeder Creek Subbasin	3,620	3,931	1.09	3,712	1.03	-6%
Wilson Creek-Seneca Lake	27,676	21,845	0.79	17,870	0.65	-18%
Castle Creek Subbasin	4,077	2,962	0.73	2,579	0.63	-13%
Castle Creek-Seneca Lake	19,521	12,920	0.66	9,456	0.48	-27%
Keuka Inlet	15,825	4,188	0.26	3,012	0.19	-28%
South Branch Keuka Lake	24,009	9,281	0.39	8,355	0.35	-10%
Sugar Creek	22,193	8,352	0.38	5,330	0.24	-36%
West Branch Keuka Lake	20,730	8,918	0.43	7,574	0.37	-15%
East Branch Keuka Lake	29,257	10,607	0.36	8,415	0.29	-21%
Keuka Lake Outlet	20,361	10,617	0.52	7,224	0.35	-32%

Table 26: SWAT Model Projection: Estimated Phosphorus Load Change from Climate Change (10% Precipitation Increase)

Subwatershed (HUC12) Name	HUC12 Drainage Area (acres)	Base Scenario: Landscape Phosphorus Loading from All Sources (Current Conditions)		Scenario: Precipitation Increased by 10%		
		Total Phosphorus (lb/yr)	Total Phosphorus (lb/acre/yr)	Total Phosphorus (lb/yr)	Total Phosphorus (lb/acre/yr)	Percent Change from Base Scenario
Headwaters Catherine Creek	22,862	16,751	0.73	19,206	0.84	15%
Sleeper Creek-Catherine Creek	23,569	18,992	0.81	22,250	0.94	17%
Seneca Lake Inlet	30,468	18,424	0.60	21,342	0.70	16%
Hector Falls Creek-Seneca Lake	19,126	12,495	0.65	14,522	0.76	16%
Big Stream	23,443	19,713	0.84	22,761	0.97	15%
Rock Stream-Seneca Lake	29,141	15,684	0.54	18,101	0.62	15%
Breakneck Creek-Seneca Lake	18,409	9,876	0.54	11,627	0.63	18%
Indian Run-Seneca Lake	13,640	8,994	0.66	10,426	0.76	16%
Mill Creek-Seneca Lake	35,262	27,768	0.79	33,074	0.94	19%
Indian Creek-Seneca Lake	16,432	6,949	0.42	8,810	0.54	27%
Kashong Creek	19,519	19,706	1.01	24,853	1.27	26%
Wilcox Creek-Seneca Lake	22,489	6,907	0.31	8,539	0.38	24%
Reeder Creek Subbasin	3,620	3,931	1.09	4,293	1.19	9%
Wilson Creek-Seneca Lake	27,676	21,845	0.79	27,106	0.98	24%
Castle Creek Subbasin	4,077	2,962	0.73	3,714	0.91	25%
Castle Creek-Seneca Lake	19,521	12,920	0.66	15,901	0.81	23%
Keuka Inlet	15,825	4,188	0.26	4,969	0.31	19%
South Branch Keuka Lake	24,009	9,281	0.39	10,311	0.43	11%
Sugar Creek	22,193	8,352	0.38	9,818	0.44	18%
West Branch Keuka Lake	20,730	8,918	0.43	9,994	0.48	12%
East Branch Keuka Lake	29,257	10,607	0.36	11,996	0.41	13%
Keuka Lake Outlet	20,361	10,617	0.52	12,005	0.59	13%

Table 27: SWAT Model Projection: Estimated Phosphorus Load Change from Expanded Conservation Tillage

Subwatershed (HUC12) Name	HUC12 Drainage Area (acres)	Base Scenario: Landscape Phosphorus Loading from All Sources (Current Conditions)		Scenario: Conservation Tillage on All Agricultural Parcels		
		Total Phosphorus (lb/yr)	Total Phosphorus (lb/acre/yr)	Total Phosphorus (lb/yr)	Total Phosphorus (lb/acre/yr)	Percent Change from Base Scenario
Headwaters Catherine Creek	22,862	16,751	0.73	17,036	0.75	2%
Sleeper Creek-Catherine Creek	23,569	18,992	0.81	19,542	0.83	3%
Seneca Lake Inlet	30,468	18,424	0.60	18,412	0.60	0%
Hector Falls Creek-Seneca Lake	19,126	12,495	0.65	12,755	0.67	2%
Big Stream	23,443	19,713	0.84	21,579	0.92	9%
Rock Stream-Seneca Lake	29,141	15,684	0.54	16,245	0.56	4%
Breakneck Creek-Seneca Lake	18,409	9,876	0.54	10,234	0.56	4%
Indian Run-Seneca Lake	13,640	8,994	0.66	9,247	0.68	3%
Mill Creek-Seneca Lake	35,262	27,768	0.79	31,213	0.89	12%
Indian Creek-Seneca Lake	16,432	6,949	0.42	8,114	0.49	17%
Kashong Creek	19,519	19,706	1.01	23,001	1.18	17%
Wilcox Creek-Seneca Lake	22,489	6,907	0.31	8,187	0.36	19%
Reeder Creek Subbasin	3,620	3,931	1.09	4,072	1.12	4%
Wilson Creek-Seneca Lake	27,676	21,845	0.79	24,799	0.90	14%
Castle Creek Subbasin	4,077	2,962	0.73	3,247	0.80	10%
Castle Creek-Seneca Lake	19,521	12,920	0.66	15,457	0.79	20%
Keuka Inlet	15,825	4,188	0.26	4,309	0.27	3%
South Branch Keuka Lake	24,009	9,281	0.39	9,281	0.39	0%
Sugar Creek	22,193	8,352	0.38	9,612	0.43	15%
West Branch Keuka Lake	20,730	8,918	0.43	9,199	0.44	3%
East Branch Keuka Lake	29,257	10,607	0.36	11,312	0.39	7%
Keuka Lake Outlet	20,361	10,617	0.52	13,597	0.67	28%

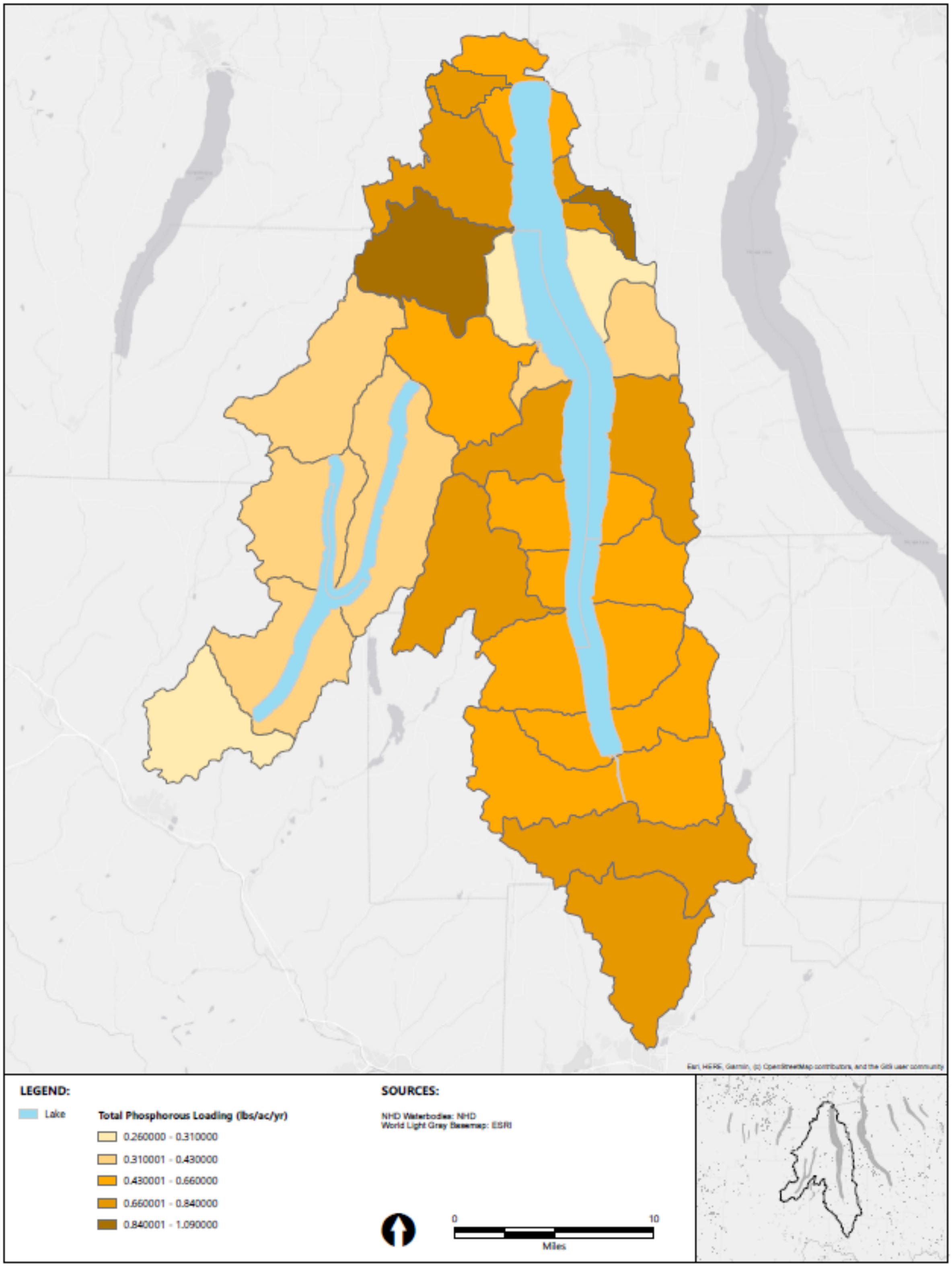


Figure 14: Baseline SWAT Model Projection: Estimated Total Phosphorus Load per Acre by Subwatershed

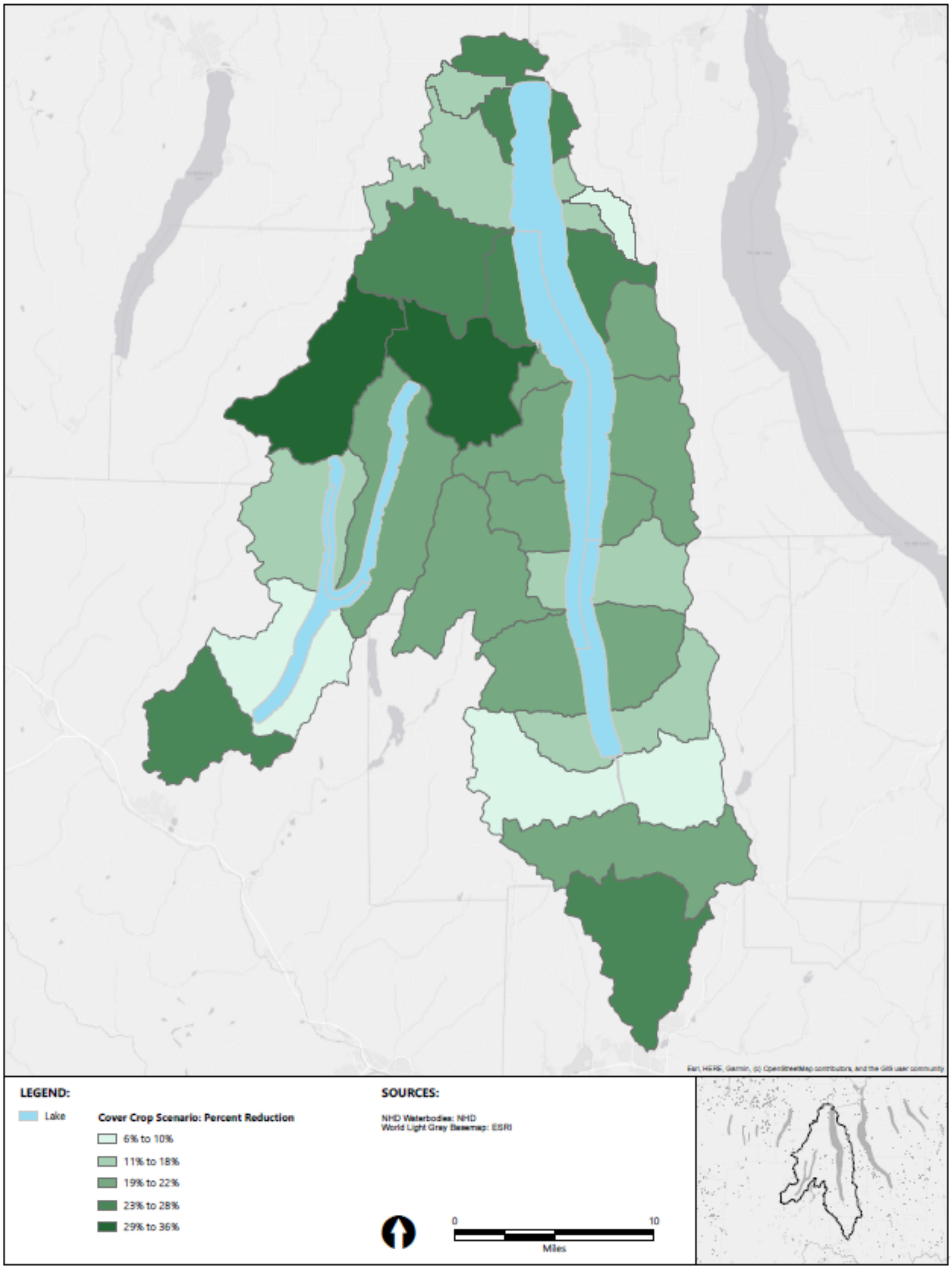


Figure 15: Cover Crops SWAT Model Projection: Estimate Total Phosphorus Load Reduction per Acre by Subwatershed

3.5 Reduction Targets

A component of a 9E Plan is to consider in-lake water quality targets that meet New York State standards and guidelines and support the waterbody's designated "best use". The designated best uses for Seneca and Keuka Lakes includes aquatic life protection, fishing, and recreation in and on the waters. Keuka Lake and the main lake middle section in Seneca Lake are designated as potable water supplies. These designated uses have associated ambient water quality standards or guidance values used to evaluate the extent to which water quality conditions support the designated uses.

Across the Finger Lakes, phosphorus is the nutrient that regulates growth of algae and cyanobacteria. While there is no ambient water quality standard for phosphorus in lakes, NYSDEC considers a summer average TP of 20 ug/L as a guidance value to evaluate whether recreational uses are supported. There is also a narrative phosphorus standard in place to protect against "excessive growth of algae, weeds, and slime".

NYSDEC is in the process of developing nutrient criteria for waterbodies to reduce the risk of water quality degradation from nutrient enrichment. As nutrient criteria development is underway, one option for the Seneca Keuka 9E Plan for Phosphorus is to adopt a water-body specific target that relates phosphorus to chlorophyll-a concentration. For example, the NYSDEC adopted a target in-lake chlorophyll-a concentration of 4 ug/L (summer average) for the Class AA section of Cayuga Lake in their draft 2021 Phosphorus TMDL. This linkage between chlorophyll-a and phosphorus is based on research and analysis completed by NYSDEC staff and other researchers (Callinan et al. 2013).

Keuka Lake and the main lake middle section of Seneca Lake are classified AA waters. In the absence of a statewide nutrient criteria for phosphorus, the selected reduction target is to adopt the most stringent (lowest) chlorophyll-a target of 4 ug/L. This value was selected based on the need to minimize dissolved organic carbon in public water supplies and manage the risk of creating disinfection byproducts.

Reducing phosphorus export from the Seneca Keuka watershed is a key focus of this 9E Plan. Various programs and organizations discussed in **Section 2.4** provide data to quantify the linkage between phosphorus input and lake water quality metrics, including chlorophyll-a.

4 Priority Areas and Restoration Strategies

4.1 Priority Subwatersheds

Because resources are limited, recommended actions are prioritized by subwatershed. The HUC12 subwatersheds were reviewed for their current conditions and vulnerability as well as the potential effectiveness of management intervention. The priority rankings (**Table 28**) reflect the relative magnitude of phosphorus export.

Rankings are based on the phosphorus loads from the subwatershed and current water quality data. Areas that contributed the greatest amount of phosphorus throughout the Seneca-Keuka watershed were identified as the highest priority subwatersheds. Additional detail on project implementation is provided in **Section 5.1**.

The Reeder Creek subbasin was analyzed separately due to its uniqueness relative to the surrounding Wilson-Creek Seneca Lake HUC12 subwatershed and its listing on the 303(d) list as impaired for phosphorus. SWAT model scenario results coupled with characterization information suggest that the Reeder Creek subbasin will not benefit significantly from agricultural improvements nor is this area particularly sensitive to projected increases in precipitation. Point sources from WWTPs comprise most of the phosphorus load and thus improvements to these facilities (currently underway) should remain the highest priority. Additional information suggests phosphorus emanating from the former Seneca Army Depot represents a substantial portion of the remaining load. As the magnitude and location of this source is not fully known, direct remediation of the affected landscape is not practical. Approaches that intercept/divert and treat Reeder Creek as it flows through and emerges from the Depot should be prioritized.

The Kashong Creek, Mill Creek-Seneca Lake, and Wilson Creek-Seneca Lake subwatersheds are dominated by agricultural land cover; 80.1%, 50.2% and 58.2% respectively. Consequently, agricultural BMPs are highest priority. Model scenario results for Kashong and Wilson Creeks suggest agricultural BMPs that address hydrological resiliency (e.g., cover crops, grassed waterways, etc.) should be prioritized over those focusing solely on phosphorus supply as both subwatersheds are very sensitive to project precipitation increases. Hydrologic resiliency projects adjacent to these landscapes such as those applicable to road drainage ditches and headwater streams should be prioritized as well.

Model results for Mill Creek-Seneca Lake were similar to watershed-wide projections and thus provided less clear direction for actions. This makes prioritization more challenging. A comparatively higher proportion of forested lands and more diverse composition of agricultural land use types (viticulture and pasture are comparatively absent from Kashong and Wilson) suggests that a wide array of BMPs are applicable and should be prioritized based primarily on willingness of landowners to implement practices. The lingering impacts of the August 2018 storm in the eastern portion of this subwatershed suggest that restoration of stream function should be prioritized as well.

While still heavily agricultural in composition (40.0%), the Sleeper Creek-Catherine Creek subwatershed contains a higher percent of forested lands (45.4%) than the other prioritized subwatersheds (7.9% to 18.5% forest cover). Model scenario results reveal a higher sensitivity to changes in precipitation than neighboring subwatersheds as well, though lower proportional benefit from cover crops. As such, BMPs that target forest management and preservation should be prioritized; particularly where highly erodible class C and D soils are present. Hydrological resiliency BMPs associated with developed landscapes such as road ditch/culvert improvements and green infrastructure may be disproportionately effective and prioritized in this subwatershed given the steep terrain and hydrologically sensitive location of the villages of Montour Falls and Odessa.

Table 28: Priority Subwatersheds

Subwatershed (HUC12)	Estimated Total Phosphorus Annual Loads (SWAT Model Projections)	Priority
Reeder Creek Subbasin	1.09 lb/acre/yr	Highest
Kashong Creek	1.01 lb/acre/yr	Highest
Big Stream	0.84 lb/acre/yr	High
Sleeper Creek – Catherine Creek	0.81 lb/acre/yr	High
Mill Creek	0.79 lb/acre/yr	High
Wilson Creek – Seneca Lake	0.79 lb/acre/yr	High

4.2 Phosphorus Load Reductions Needed

The projected targets for reductions were informed by current water quality conditions, chlorophyll-a level targets, and the watershed modeling tools that estimate load and identify priority areas and sources. **Table 29** summarizes target phosphorus load reductions by subwatershed. These selected targets consider expanded adoption of BMPs by local governments, the agricultural community, and watershed residents. Streams affected by point sources are assigned a higher percent reduction, while streams with low percentages of agriculture and developed areas are assigned lower targets.

The Seneca-Keuka Watershed Nine Element Plan for Phosphorus is not a regulatory document. These phosphorus reduction targets reflect results of analyses and modeling and extended conversations with the stakeholder community.

Table 29: Target Phosphorus Load Reductions

Subwatershed (HUC12)	Current Phosphorus Load (pounds)	Projected Load Increase from Climate (%)	Target Phosphorus Reduction (%)
Headwaters Catherine Creek	16,751	15%	-20%
Sleeper Creek-Catherine Creek	18,992	17%	-25%
Seneca Lake Inlet	18,424	16%	-20%
Hector Falls Creek-Seneca Lake	12,495	16%	-20%
Big Stream	19,713	15%	-25%

Rock Stream-Seneca Lake	15,684	15%	-20%
Breakneck Creek-Seneca Lake	9,876	18%	-20%
Indian Run-Seneca Lake	8,994	16%	-20%
Mill Creek-Seneca Lake	27,768	19%	-25%
Indian Creek-Seneca Lake	6,949	27%	-30%
Kashong Creek	19,706	26%	-40%
Wilcox Creek-Seneca Lake	6,907	24%	-25%
Reeder Creek Subbasin	3,931	9%	-25%
Wilson Creek-Seneca Lake	21,845	24%	-30%
Castle Creek Subbasin	2,962	25%	-30%
Castle Creek-Seneca Lake	12,920	23%	-25%
Keuka Inlet	4,188	19%	-20%
South Branch Keuka Lake	9,281	11%	-15%
Sugar Creek	8,352	18%	-20%
West Branch Keuka Lake	8,918	12%	-15%
East Branch Keuka Lake	10,607	13%	-15%
Keuka Lake Outlet	10,617	13%	-15%

An important factor to consider is lake residence time. As discussed in **Section 2.1.2.1, Table 7**, Seneca Lake has an estimated residence water time of 18-23 years, and Keuka Lake 6-8 years. Nutrient reductions from recommended BMPs may not be detected in the water column until the lake reaches a new equilibrium in response to the load reduction. Response time is estimated to be up to three times the hydraulic residence time. The decadal time scale for response to changes in load emphasizes the importance of preventing loading increases from factors beyond local control, such as changing weather patterns by aggressive measures to reduce phosphorus load from all sources.

As described in **Section 2.5.1**, both Seneca and Keuka Lakes currently have chlorophyll-a levels less than 5 ug/L. The interannual variability is largely driven by differences in meteorological conditions, especially the total volume, timing, and intensity of rainfall events.

4.3 Proposed Best Management Practices (BMPs)

The goal of the Seneca-Keuka Watershed 9E Plan is to identify and implement strategies that will protect land and water resources into the future and help ensure that the lake supports its designated uses. A collaborative community-driven approach is the mechanism to meet this goal.

An implication of the modeling analysis is the relative effectiveness of reduction in dissolved phosphorus compared with particulate phosphorus. TP incorporates both the total and dissolved fractions. However, the dissolved phosphorus fraction is associated with a much greater biological availability, meaning that it is more potent for supporting growth of cyanobacteria and other phytoplankton. Management practices that address bioavailable phosphorus are considered the most cost-effective strategies to mitigate the risk of eutrophication (Sonzogni et al. 1982).

For agricultural land cover, the ratio of total and dissolved phosphorus in runoff is a complex function of processes related to erosion, desorption and dissolution reactions, plant residue decomposition, and the field's baseline phosphorus index and infiltration capacity (wetness index). These baseline conditions are influenced by soil and fertilizer phosphorus management practices such as tillage and the nutrient and solids content of applied fertilizers. The timing of rainfall events with respect to land application is also a significant determinant. Identifying agricultural practices with the most potential to reduce loss of dissolved phosphorus is an active area of research. Recommendations include phosphorus placement near the seed depth at planting by tillage, injection, or deep banding. Infiltration basins with vegetative cover can capture dissolved phosphorus during the active growing season.

Enhanced dissolved phosphorus removal in runoff from developed areas is another area of active research. A report by the Center for Watershed Protection (Hirschman et al. 2017) describes measures to increase nutrient removal in green infrastructure practices such as bioretention. Strategies include adding media amendments to chemically bind soluble phosphorus, increasing water residence time, and maximizing plant uptake.

As evaluated in Scenario 2: 10% increase in precipitation, increased risk of extreme precipitation events is a primary driver of water quality degradation. High intensity rain events contribute to flood risk, runoff from the landscape, and erosion of streams, gullies, and roadside ditches. These processes deliver phosphorus to Seneca and Keuka Lakes; both soluble and particulate phosphorus have a direct impact on abundance of HABs, phytoplankton, aquatic macrophytes, water clarity, and aquatic habitat.

A challenge for watersheds dominated by nonpoint sources of pollution is the reliance on voluntary measures to modify practices across all land cover types and uses. Some measures rely on local municipalities while others rely on private landowners. State and federal programs offer technical support and access to some cost sharing opportunities to the agricultural sector.

Recommendations from multiple stakeholders are incorporated into the 9E Plan. Key categories are noted below with a brief explanation of their potential contribution to the overall goal of improved hydrologic resiliency and managing the loss of phosphorus, sediment, and other pollutants from the landscape.

- Measures to increase infiltration, and slow velocity and erosive potential of overland flow, and reduce peak flow rates in the stream network. Examples: water and sediment control basins, floodplain restoration, wetland protection, stormwater ponds, road ditch improvements, streambank stabilization and other green infrastructure projects to promote natural hydrology.
- Measures to reduce the risk of sediment transport from disturbed lands. Examples: local laws for sediment and erosion control measures, steep slope ordinances and management, forested or vegetated riparian areas, and planting of winter cover crops.
- Measures to reduce the risk of phosphorus, manure, and other agricultural chemicals reaching the waterways. Examples to consider include supporting producers with technical and financial resources needed to develop nutrient management plans for farms across the Seneca-Keuka

watershed. These plans may include silage leachate management, animal waste storage, barnyard runoff improvements, alarm systems on manure storage infrastructure, and other farm-specific approaches.

- Measures to reduce the risk of phosphorus-enriched wastewater from individual on-site wastewater disposal systems from reaching surface waters.

5 Projects and Implementation Strategy

Many recommended actions within the Seneca-Keuka Watershed 9E Plan for Phosphorus will require funding support for implementation. Consequently, the prioritization, partners, and potential funding sources listed in **Table 30** should be considered as a general guideline. FLI and partner agencies will continue to review available funding opportunities and respond to updated program priorities.

Preventing new sources of phosphorus and other potential pollutants from reaching Seneca and Keuka Lakes is critically important. This finding is reinforced by the climate change SWAT model projection, which underscores the impact increased precipitation has on lake water quality. Measures such as land use regulation and guidelines, education and outreach, and continued surveillance to identify invasive species will affect nutrient and sediment loading to surface waters. Adoption of cover crops, conservation subdivision codes, steep slope ordinances, and impervious surface guidelines are examples of actions that can help reduce adverse impacts of new development. Although the impact of some preventative measures cannot be directly quantified, continued partnerships and community engagement are key to protecting the Seneca-Keuka watershed for future generations.

The project team received input and guidance from many interested parties while creating this 9E Plan. Ideas for projects and initiatives emerged from discussions with (among others) the local SWCDs, SWIO, Pure Waters, KLA, KWIC, Finger Lakes Land Trust and members of the public. A Project Advisory Committee (PAC) was convened and met at key milestones during the 9E Plan development to discuss vision and goals, receive updates on the water quality modeling efforts, and provide valuable input on recommendations. The PAC included local leaders, representatives of resource management agencies, and faculty and staff from area colleges. All the discussions shared a common theme: a strong commitment to protecting the lake and watershed and a desire to direct efforts into cost-effective measures that reflect the best available science.

As previously mentioned, not all recommended actions can be evaluated in a quantitative manner. The watershed modeling tool SWAT is best suited for evaluating BMPs for agricultural watersheds and has been applied to estimate nonpoint source loading for many of the Finger Lakes. Additional monitoring and assessment of water quality changes in response to implemented actions will likely improve the precision and accuracy of the model projections. The SWAT model projections for Seneca and Keuka Lake are based on recent water quality monitoring data collected within this watershed and capture site-specific conditions of soils, topography, hydrology, and current management practices.

Another important tool to identify and screen recommendations that are not directly addressed by the SWAT model is the NYSDEC catalogue of recommended practices for inclusion in watershed management plans https://www.dec.ny.gov/chemical/96777.html. This catalogue, which has been approved by USEPA for consistency with provisions of the Clean Water Act Section 319, encompasses practices for a range of land uses and provides guidance on their costs and effectiveness. Effectiveness and costs of agricultural BMPs are also informed by guidance from the New York State Department of Agriculture and Markets (NYSAGM) and NRCS. In addition to these resources, BMP costs and effectiveness are tracked by agencies and researchers working within the Chesapeake Bay watershed program. The Chesapeake Assessment Scenario Tool (CAST) provides another means to estimate the effectiveness of practices in meeting reduction goals for watershed nonpoint sources.

These multiple guidance documents are also reflected in the summary of recommendations included as **Table 30**. The projected effectiveness and estimated costs reflect experience across a range of systems and highlight the importance of continued monitoring and assessment to capture site specific data for the Seneca-Keuka watershed.

Table 30: Implementation Strategy and Target Reduction Overview

Note: Load reduction efficiencies derived from Chesapeake Assessment Scenario Tool source data (version Phase 6 – 7.0.0). Cost estimate for agricultural BMPs derived from NRCS EQUIP allowable costs (2021). All additional cost estimates derived from input provided by various technical resources.

Category 1: Hydrologic Resilience							
Recommended Action	**Pollutants Addressed**	**Location/ HUC12**	**Estimated Phosphorus Load Reduction (if possible)**	**Lead Organizations & Partners**	**Estimated Cost**	**Potential Funding Sources**	**Priority or Schedule**
Increase stormflow resilience of streams by reconnecting floodplains and/or constructing floodplain wetlands in areas frequently inundated with water	Phosphorus, Nitrogen, Sediment, *E. coli*, Heavy Metals, Oil and Grease	Watershed -wide	Floodplain: Site specific Wetland: 20-40%	Individual municipalities, SWCDs and SWIO/KWIC	$50,000 to $1M+	DEC, DOS, EFC, USEPA, GLC, USDA, Private Conservation Programs, Office of Parks, Recreation & Historic Preservation, DOI	Highest
Implement Green Infrastructure practices to intercept stormwater prior to entering waterways	Phosphorus, Nitrogen, Sediment, *E. coli*, Heavy Metals, Oil and Grease, Organics, Plastics, Salts	Urban and Suburban areas	Dry Detention: 20% Filter & Infiltration Practices: 54-85% Forest Buffer: 50% Vegetated Channel: 10-45% Permeable pavement: 20-80% Wet Ponds: 45%	Municipalities and SWIO/KWIC	$1,000 to $1M+	DEC, DOS, EFC, USEPA, GLC	Highest

Category 1: Hydrologic Resilience							
Recommended Action	**Pollutants Addressed**	**Location/ HUC12**	**Estimated Phosphorus Load Reduction (if possible)**	**Lead Organizations & Partners**	**Estimated Cost**	**Potential Funding Sources**	**Priority or Schedule**
Conserve high value natural resources providing resiliency to precipitation and flooding (steep slope forests, floodplains, wetlands, etc.) through acquisition and/or easements	Phosphorus, Sediment	Watershed -wide	Site Specific Conservation Landscaping Practices: 25%	Municipalities and Land Trusts	$1,000 to $10,000 per acre	DEC, DOS, USEPA, DOI, Private Conservation Programs	Highest
Increase upland retention through implementation of water storage BMPs (retention basins, wetlands, etc.)	Phosphorus, Nitrogen, Sediment	Watershed -wide	Agricultural and Forested Lands: 22-40% Developed Lands: 20-45%	SWCD and SWIO/KWIC	$2,500 to $10,000	DEC, DOS, EFC, USEPA, GLC, USDA, Private Conservation Programs, DOI	High
Plant trees and shrubs on lands with limited or reduced hydrological storage capacity and incorporate climate change impacts regarding species selection	Phosphorus, Sediment, Heavy Metals	Watershed -wide	Site Specific	Individual municipalities, SWCDs and SWIO/KWIC	$5 to $250 per tree	DEC, DOS, EFC, USEPA, GLC, USDA, Private Conservation Programs, Office of Parks, Recreation & Historic Preservation, DOI	High
Reduce flow velocities and promote sedimentation within road ditches through installation of check dams and other facilities	Phosphorus, Sediment	Watershed -wide	Site Specific Open Vegetated Channel: 10-45% Grassed buffer: 40-56%	Individual municipalities and SWCDs	$50 to $1000 per unit	DEC, DOS, DOT, USEPA	High

Category 1: Hydrologic Resilience							
Recommended Action	**Pollutants Addressed**	**Location/ HUC12**	**Estimated Phosphorus Load Reduction (if possible)**	**Lead Organizations & Partners**	**Estimated Cost**	**Potential Funding Sources**	**Priority or Schedule**
Proper sizing and design of culverts and channels to avoid headcuts and provide for aquatic connectivity	Phosphorus, Sediment	Watershed -wide	Site Specific	Individual municipalities and SWCDs	$500 to $10,000 per unit	DEC, DOS, DOT, USEPA	Medium
Improve separation of stormwater from freshwater resources through the establishment and implementation of comprehensive municipal stormwater programs	Phosphorus, Sediment, Heavy Metals, Oil and Grease	Urbanized areas	Variable; dependent on water volume and fraction treated.	Individual Municipalities and SWIO/KWIC	$25,000 to $75,000	DEC, DOS, EFC, USEPA, GLC	Medium
Reduce the occurrence of streambank degradation via installation of stabilization features (log/stone vanes, vegetated areas, etc.)	Phosphorus, Sediment	Watershed -wide; prioritize areas with stable upstream hydrology	Site Specific; CAST Default: 0.068 lbs/linear ft/year	SWCDs and SWIO/KWIC	$50,000 to $500,000+	DEC, DOS, EFC, USEPA, GLC	Medium
Eliminate direct discharges from impervious structures (downspouts, sump-pumps, etc.) into/onto roadways, road ditches, stormwater systems and/or waterways	Phosphorus, Sediment, Heavy Metals, Oil and Grease	Urban and suburban areas	Impervious Disconnection to Ammended Soils: 14.6%	SWIO/KWIC and Pure Waters/KLA	Free to $2500	DEC, USEPA, GLC	Medium
Develop prediction model/tool to better manage releases from Keuka Lake	Phosphorus, Sediment, *E. coli*	Keuka Lake Outlet	Dependent on fraction of TP loading in Keuka Outlet derived from streambank erosion	SWIO/KWIC	$150,000	DEC, DOS, USEPA	Medium

Category 1: Hydrologic Resilience							
Recommended Action	**Pollutants Addressed**	**Location/ HUC12**	**Estimated Phosphorus Load Reduction (if possible)**	**Lead Organizations & Partners**	**Estimated Cost**	**Potential Funding Sources**	**Priority or Schedule**
Proper sizing and design of bridges to avoid headcuts and provide for aquatic connectivity	Phosphorus, Sediment	Watershed -wide	Site Specific	Individual municipalities and SWCDs	$25,000 to $250,000+ per unit	DEC, DOS, DOT, USEPA	Low
Daylight buried streams to reestablish floodplains and biological function	Phosphorus, Sediment, Heavy Metals, Oil and Grease	Urbanized areas	Site Specific	Individual municipalities and SWIO/KWIC	$100,000 to $1M+	DEC, DOS, Empire State Development, USEPA, EFC, Private Conservation Programs	Low
Increase in-stream hydrologic storage and biological function by re-establishing stream meander in artificially channelized areas	Phosphorus, Nitrogen, Sediment, *E. coli*	Artificially channelize d stream reaches	Site Specific; CAST Default: 0.068 lbs/linear ft/year	SWIO/KWIC	$250,000 to $1M+	DEC, USEPA, Private Conservation Programs	Low

Category 2: BMPs on Working Landscapes (Timberlands, Croplands, Grazing Lands, etc.)							
Recommended Action	**Pollutants Addressed**	**Location/HUC12**	**Estimated Phosphorus Load Reduction (if possible)**	**Lead Organizations & Partners**	**Estimated Cost**	**Potential Funding Sources**	**Priority or Schedule**
Acquisition, easements and/or preservation of lands containing or bordering riparian corridors, wetlands and other waterbodies adjacent to agriculture/timberlands	Phosphorus, Nitrogen, Sediment, *E. coli*	Watershed-wide; prioritized by erodibility of soils	Site Specific Forest or Grass Buffer Adjacent Croplands: 30-45%; Pasture: 20%	Municipalities, Land Trusts and SWCDs	$0 -$5,000 per acre	DEC, DOS, USEPA, USDA, DOI, Private Conservation Programs	Highest
Increase participation of non-CAFO agricultural community in AEM program and/or completion of Tier 3 Resource Management Plans	Phosphorus, Nitrogen, Sediment, *E. coli*, Pesticides, Herbicides	Watershed-wide with outreach; prioritized based on lack of existing participation and model scenario 1 and 3 outcomes	Site Specific Manure Incorporation: 12-24% Tillage Management: 2-71% Rotational/Prescribed Grazing: 24%	SWCDs and SWIO/KWIC	$50,000	NYSAGM	Highest
Plant cover crops on croplands that are prone to erosion and nutrient runoff when bare	Phosphorus, Nitrogen, Sediment, *E. coli*	Cropland areas in subwatersheds	Site Specific; Refer to **Table 24**	SWCDs	$50 to $100 per acre	NYSAGM, USEPA, GLC, USDA	Highest
Acquisition/easements and restoration of degraded forested areas adjacent to agriculture/timberlands	Phosphorus, Nitrogen, Sediment, *E. coli*	Watershed-wide	Variable Forest or Grass Buffer Adjacent Croplands: 30-45%; Pasture: 20%	Municipalities, Land Trusts and SWCDs	$5,000 to $10,000 per acre	DEC, DOS, USEPA, USDA, DOI, Private Conservation Programs	High

Category 2: BMPs on Working Landscapes (Timberlands, Croplands, Grazing Lands, etc.)							
Recommended Action	**Pollutants Addressed**	**Location/HUC12**	**Estimated Phosphorus Load Reduction (if possible)**	**Lead Organizations & Partners**	**Estimated Cost**	**Potential Funding Sources**	**Priority or Schedule**
Development and/or adoption of new tile-drainage BMPs	Phosphorus, Nitrogen, Sediment	Agricultural fields employing tile-drainage throughout the watershed	Unknown; existing research indicates 4-99% dependent on media and scale in non-agriculture applications (Penn *et al*, 2017)	Research/Academic Institutions and SWCDs	\$5,000 to \$250,000	NYSAGM, USEPA, USDA, GLC, GLRC	High
Promotion and/or development of market models that provide financial incentives to agricultural and timber producers for implementing conservation practices	Phosphorus, Nitrogen, Sediment, *E. coli*, Pesticides, Herbicides	Watershed-wide	N/A	SWIO/KWIC	\$200,000+	USEPA, USDA, GLC	High
Implement field erosion control systems (e.g. bioswales, grassed waterways, WASCOBs, etc.)	Phosphorus, Nitrogen, Sediment, *E. coli*	Agricultural and silviculture areas in subwatershed	Site Specific; Dependent on extent of field erosion and target design efficiency.	SWCDs	\$2,500 to \$10,000 per acre; or \$5 to \$25 per square foot	NYSAGM, USEPA, GLC, USDA	High
Livestock exclusion systems (e.g. fencing, controlled crossings, etc.) to separate livestock from waterways	Phosphorus, Nitrogen, Sediment, *E. coli*	Grazing areas in subwatersheds	Site Specific; exclusionary fencing increases forested/grassed buffer efficiency by 12-37%	SWCDs	\$2 to \$25 per foot for fence; \$10 to \$50 for stream crossing & access structures	NYSAGM, USEPA, GLC, USDA	Medium

Category 2: BMPs on Working Landscapes (Timberlands, Croplands, Grazing Lands, etc.)							
Recommended Action	**Pollutants Addressed**	**Location/HUC12**	**Estimated Phosphorus Load Reduction (if possible)**	**Lead Organizations & Partners**	**Estimated Cost**	**Potential Funding Sources**	**Priority or Schedule**
On-farm manure storage management structures and equipment	Phosphorus, Nitrogen, *E. coli*	Dairy farms in subwatersheds	Livestock Dependent; Beef: 39% Dairy: 20% Hogs: 39% Poultry: 9% Sheep/Horses/Goats: 3%	SWCDs	$50,000 to $350,000 per unit	NYSAGM, USEPA, GLC, USDA	Medium
Acquisition, easements and/or restoration of herbaceous riparian areas adjacent to agriculture/timberlands	Phosphorus, Nitrogen, Sediment, *E. coli*	Cropland areas in subwatersheds	Site Specific Forest or Grass Buffer Adjacent Croplands: 30-45%; Pasture: 20%	SWCDs	$1,000 to $3,000 per acre	DEC, DOS, USEPA, USDA, DOI, Private Conservation Programs	Medium
Purchase conservation equipment that can be shared across multiple SWCDs and municipalities (e.g. hydroseeders, bark blowers, specialized seeders, etc.)	Phosphorus, Nitrogen, Sediment, *E. coli*, Pesticides, Herbicides	Watershed-wide	Variable	SWCDs	$10,000 to $100,000 per unit	NYSAGM, USDA	Medium
Explore the feasibility of technologies that reduce the mass of animal waste material to be handled such as collaborative anaerobic digesters and implement as practical	Phosphorus, Nitrogen, *E. coli*	Watershed-wide	Variable; potentially 100% of material diverted	Research/Academic Institutions and SWCDs	$200,000+	NYSAGM, USDA, USEPA	Medium

Category 2: BMPs on Working Landscapes (Timberlands, Croplands, Grazing Lands, etc.)							
Recommended Action	**Pollutants Addressed**	**Location/HUC12**	**Estimated Phosphorus Load Reduction (if possible)**	**Lead Organizations & Partners**	**Estimated Cost**	**Potential Funding Sources**	**Priority or Schedule**
Construct agrichemical handling facilities to reduce the potential for chemical runoff	Pesticides, Herbicides	Croplands (especially vineyards)	N/A	SWCDs	$10 to $60 per sq foot	NYSAGM, USDA	Medium
Satellite manure storage structures and spreading sites	Phosphorus, Nitrogen, *E. coli*	Areas with high numbers of small-scale dairy farm operations	Livestock Dependent; Beef: 39% Dairy: 20% Hogs: 39% Poultry: 9% Sheep/Horses/Goats: 3%	SWCDs and SWIO/KWIC	$100,000 to $500,000 per unit	NYSAGM, USEPA, GLC, USDA	Low
Bioreactor structures (e.g. constructed wetlands) at terminus/turnouts of swales	Phosphorus, Nitrogen, Sediment, *E. coli*	Watershed-wide	Site Specific Wetland Creation/Rehabilitation on Agricultural Lands: up to 40%	SWCDs	$2,500 to $7,500 per unit	NYSAGM, USEPA, GLC, USDA, DEC	Low
Stabilization of drainage swales through establishment of vegetation and/or installation of check dams	Phosphorus, Nitrogen, Sediment	Agricultural/Forest fields employing drainage swales throughout the watershed	Site Specific Vegetated Open Channel: 10-45%	SWCDs	$2 to $50 per foot	NYSAGM, USEPA, USDA, GLC	Low
Map and database tile drainage lines to inform BMP prioritization and research	Phosphorus, Nitrogen, Sediment	Watershed-wide	N/A	SWCDs	$80,000	NYSAGM, USDA	Low
Mulch harvested croplands and timber lands to reduce erosion and nutrient runoff	Phosphorus, Nitrogen, Sediment, *E. coli*	Croplands and timber harvest areas	Variable	SWCDs	$80 to $500 per acre	NYSAGM, USEPA, GLC, USDA	Low

Category 3: Wastewater Management							
Recommended Action	**Pollutants Addressed**	**Location/HUC12**	**Estimated Phosphorus Load Reduction (if possible)**	**Lead Organizations & Partners**	**Estimated Cost**	**Potential Funding Sources**	**Priority or Schedule**
Increase the functional capacity, capability, and efficiency of WWTPs	Phosphorus, Nitrogen, *E. coli*, Heavy Metals, Organics	041402010602, 041402010706, 041402010801, 041402010903	Site Specific	Individual Municipalities and SWIO/KWIC	$1M+	DEC, EFC, USDA, USEPA	High
Replace and/or upgrade failing septic systems	Phosphorus, Nitrogen, *E. coli*, Organics	Watershed-wide	Site Specific; maximum of 2,929 lbs/year watershed-wide assuming 25% failure rate	SWCDs, individual municipalities and SWIO/KWIC	$20,000 to $100,000+ per unit	DEC, USEPA	Medium
Develop feasibility studies on installation of sanitary sewer infrastructure and implement where practical	Phosphorus, Nitrogen, *E. coli*, Organics	Higher-density areas currently not served	N/A	Individual municipalities and SWIO/KWIC	$75,000+	DOS, USEPA, USDA, EFC	Medium
Increase adoption of enhanced phosphorus removal technologies designed for personal and public wastewater systems	Phosphorus	Watershed-wide	Up to 99% Removal Efficiency (Penn *et al*, 2017)	SWCDs, individual municipalities and SWIO/KWIC	$20,000+	DEC, USDA	Low
Explore novel opportunities to identify failing systems via non-direct monitoring methods	Phosphorus, Nitrogen, *E. coli*, Organics	Watershed-wide	N/A	Research/Academic Institutions	$5,000 to $50,000	DEC, GLRC, GLC, USEPA	Low

Category 4: Invasive Species Management						
Recommended Action	**Target Species (Terrestrial and Aquatic)**	**Location/HUC12**	**Lead Organizations & Partners**	**Estimated Cost**	**Potential Funding Sources**	**Priority or Schedule**
Support and expand the Boat Launch Stewards program	Aquatic Invasives	Boat launches where currently absent	FL-PRISM and CCE	$10,000 per steward per season (16 weeks)	DEC, USEPA, DOS, Private Conservation Programs	High
Install informational kiosks and signage at boat launches on invasive species spread prevention	Aquatic Invasives	Boat launches where currently absent	FL-PRISM, Office of Park, Recreation & Historic Preservation	$100 to $500	DEC, USEPA, USDA	High
Support invasive species outreach and educational initiatives	All with focus on high priority species (hydrilla, starry stonewort, water chestnut, spotted lanternfly, etc.)	Watershed-wide	FL-PRISM, CCE and Pure Waters/KLA	$5,000+ startup; $2,500+ recurring	DEC, USEPA	High
Conduct research and monitoring to improve early detection and rapid response, including integration of citizen science	Presently absent species (hydrilla, spotted lanternfly, etc.)	Watershed-wide	FL-PRISM and CCE	$50,000+	DEC, USEPA, USDA, USFWS	Medium
Increase state, regional, and local capacity to respond to new or additional invasive species	N/A	Watershed-wide	FL-PRISM, CCE and DEC	$50,000+	USEPA, USDA, USFWS	Medium
Install boat cleaning stations at public boat launches	Aquatic Invasives	Boat launches where currently absent	FL-PRISM, Office of Park, Recreation & Historic Preservation	$250 to $30,000	DEC, USEPA, USDA	Medium
Install boot brush stations at trailheads and other access points	Terrestrial invasives, didymo	Watershed-wide	FL-PRISM, Office of Park, Recreation & Historic Preservation, Land Trusts	$100 to $500 per stations	DEC, USEPA, USDA	Low

Category 4: Invasive Species Management						
Recommended Action	**Target Species (Terrestrial and Aquatic)**	**Location/HUC12**	**Lead Organizations & Partners**	**Estimated Cost**	**Potential Funding Sources**	**Priority or Schedule**
Pre-emptively remove highly vulnerable native species (ash, eastern hemlock, etc.) to preserve ecological function	Trees/Shrubs highly susceptible to invasive pests that cannot be controlled	Watershed-wide	FL-PRISM and SWIO/KWIC	$10,000 to $250,000+	DEC, USEPA, USDA	Low
Develop control/eradication systems to manage or remove established invasive populations	Prioritize the control of established species that dramatically impact ecologic function (zebra mussels, quagga mussels, sea lamprey, etc.)	Watershed-wide	Research/Academic Institutions, DEC, USFWS	$50,000+	DEC, USEPA	Low

Category 5: Local Laws						
Recommended Action	**Pollutant(s) Addressed**	**Location/HUC12**	**Lead Organizations & Partners**	**Estimated Cost**	**Potential Funding Sources**	**Priority or Schedule**
Adopt open space conservation rules to preserve forests, wetlands, and other high value resources during subdivision	Phosphorus, Nitrogen, Sediment, *E. coli*, Heavy Metals, Salts, Organics, Oil & Grease, Plastics	Watershed-wide	SWIO/KWIC, REDCs, Individual Municipalities	$10,000+	DOS	Highest
Develop a universal minimum set of sanitary standards for adoption by municipalities	Phosphorus, Nitrogen, E. coli	Watershed-wide excluding Keuka Lake basin	SWIO	$50,000+	DOS, DEC, USEPA	Highest
Develop watershed rules and regulations in accordance with the goals of NY Public Health Law Section 1100	Potentially any/all	Watershed-wide	SWIO/KWIC	$100,000+	DOS	High
Continue and expand stream inventory programs to identify priority segments for BMP implementation and education/outreach purposes	Phosphorus, Nitrogen, Sediment, *E. coli*, Heavy Metals, Salts, Organics, Oil & Grease, Plastics	Watershed-wide	SWIO/KWIC, SWCDs, Pure Waters, KWIC	$15,000+	DOS, DEC	High
Develop and adopt riparian area and/or floodplain protection rules	Phosphorus, Nitrogen, Sediment, *E. coli*, Salts, Organics	Watershed-wide	SWIO/KWIC, REDCs, Individual Municipalities	$10,000+	DOS	Medium
Implement steep slope ordinances to reduce the probability of erosion	Phosphorus, Sediment	Watershed-wide	SWIO/KWIC, REDCs, Individual Municipalities	$10,000+	DOS	Medium

Category 5: Local Laws						
Recommended Action	**Pollutant(s) Addressed**	**Location/HUC12**	**Lead Organizations & Partners**	**Estimated Cost**	**Potential Funding Sources**	**Priority or Schedule**
Implement stormwater runoff rules for impervious areas to reduce downstream flooding hazards	Phosphorus, Nitrogen, Sediment, Heavy Metals, Salts, Organics, Oil & Grease, Plastics	Moderate to high density developed areas; predominately villages/cities	SWIO/KWIC, REDCs, Individual Municipalities	$10,000+	DOS	Medium
Develop overlays to inform zoning and limit the loss of prime agricultural and forestry lands to development	Phosphorus, Nitrogen, Sediment, *E. coli*	Watershed-wide	SWIO/KWIC, REDCs, Individual Municipalities	$10,000+	DOS, DEC	Low
Limit the proportional amount of impervious surface allowable on a given parcel	Phosphorus, Nitrogen, Sediment, Heavy Metals, Salts, Organics, Oil & Grease, Plastics	Moderate to high density developed areas; predominately villages/cities	SWIO/KWIC, REDCs, Individual Municipalities	$10,000+	DOS	Low

Category 6: Education, Outreach, Economic Development and Additional Pollutants of Concern						
Recommended Action	**Pollutant(s) Addressed**	**Relevant Municipalities/ Location/HUC12**	**Lead Organizations & Partners**	**Estimated Cost**	**Potential Funding Sources**	**Priority or Schedule**
Continually engage watershed stakeholders across all groups and demographics in volunteer engagement opportunities concerning water quality protection and improvement	Potentially any/all	Watershed-wide	SWCDs, SWIO/KWIC, CCEs, SLWPA, KLA	$1,000+	DEC, USEPA, USDA, Private Educational Programs	Highest
Develop educational and outreach programs to engage watershed stakeholder on water quality concerns, improvements, and outcomes	Potentially any/all	Watershed-wide	SWCDs, SWIO/KWIC, CCEs, SLWPA, KLA, academic institutions	$1,000+	DEC, USEPA, USDA, Private Educational Programs	Highest
Develop distributable educational material and content on water quality for circulation to watershed stakeholders and beyond	Potentially any/all	Watershed-wide	SWCDs, SWIO/KWIC, CCEs, SLWPA, KLA, academic institutions	$1,000+	DEC, USEPA, USDA, Private Educational Programs	Highest
Develop management tools to assist with tracking implemented BMPs to identify maintenance issues prior to anticipated end-of-life	Potentially any/all	Watershed-wide	SWCDs and SWIO/KWIC	$25,000+	DOS	Medium
Conduct natural resource inventory analyses to identify high priority areas for conservation and/or restoration	Potentially any/all	Watershed-wide	SWIO/KWIC, REDCs, Individual Municipalities	$10,000+	DOS, DEC	Medium
Integrate water quality protection efforts into AgroTourism marketing programs/projects to maximize the value and appeal of producers/products to consumers	Phosphorus, Nitrogen, Sediment, *E. coli*, Pesticides, Herbicides	No geographical limitation	REDCs and Industry Groups (Farm Bureau, Wine & Grape Foundation, etc.)	$10,000+	Empire State Development, USDA, NYSAGM	Medium

Category 6: Education, Outreach, Economic Development and Additional Pollutants of Concern						
Recommended Action	**Pollutant(s) Addressed**	**Relevant Municipalities/ Location/HUC12**	**Lead Organizations & Partners**	**Estimated Cost**	**Potential Funding Sources**	**Priority or Schedule**
Develop guidance manuals and other resources that can assist private landowners with implementing stormwater reduction projects	Phosphorus, Nitrogen, Sediment, *E. coli*, Heavy Metals, Salts, Organics, Oil & Grease, Plastics	Watershed-wide	SWIO/KWIC and Pure Waters/KLA	$5,000+	DOS	Medium
Prevent the potential for surface water and groundwater contamination by hazardous materials through community collection programs and the promotion/development of process changes	Hazard compounds/materials (battery acid, paint, etc.)	Watershed-wide	SWCDs, SWIO/KWIC and individual Municipalities	$1,000+	DEC, USDA	Medium
Develop in-lake circulation models to improve planning and prioritization	Any/All	Seneca Lake	SWIO and NYSDEC	$350,000	DOS, DEC	Medium
Develop and pilot in-stream and/or in-lake treatment technologies to reduce HABs formation	HABs	Areas of recurring HABs formation	Academic/Research Institutions and DEC	$50,000+	DEC, EPA	Medium
Assess concentrations and significance of contaminates such as pesticides, trace metals and organic pollutants in fish, wildlife, and vulnerable fish-consuming populations	Bioaccumulating pollutants	Watershed-wide	Academic/Research Institutions and DEC	$10,000+	USEPA, USFWS, USDA	Medium
Construct covered salt storage facilities and eliminate open storage	Salts	Watershed-wide; prioritized by absence and road density	SWCDs and Individual Municipalities	$200,000 to $1M+	DEC	Low

Category 6: Education, Outreach, Economic Development and Additional Pollutants of Concern						
Recommended Action	**Pollutant(s) Addressed**	**Relevant Municipalities/ Location/HUC12**	**Lead Organizations & Partners**	**Estimated Cost**	**Potential Funding Sources**	**Priority or Schedule**
Develop and implement comprehensive programs to detect and remove PFAs compounds from public and private water supplies	PFAs	Watershed-wide; prioritize areas based on proximity to Seneca Army Depot	SWIO/KWIC and individual Municipalities	$10,000+	DEC, DOS, EFC, USEPA	Low
Adopt practices and/or acquire equipment that can reduce the use and/or transport of road salt	Salts	Watershed-wide; prioritized by road density	SWCDs and Individual Municipalities	$50,000+	DEC	Low
Implement stormwater BMPs designed to capture and remove plastics from stormwater systems and waterways	Plastics	Urban stormwater outlets	SWCDs, SWIO/KWIC and individual Municipalities	$500-$2500 per site not including maintenance	DEC, DOS, USEPA, USFWS	Low
Identify and restore contaminated lands such as inactive or unpermitted landfills and hazardous material storages, as well as mined lands and petroleum storage facilities	Hazard compounds/materials (battery acid, paint, etc.)	Watershed-wide	SWCDs, Municipalities, SWIO/KWIC	$25,000+	DEC, USEPA	Low
Enhance the economic, social and health benefits of natural resources (trail construction, habitat enhance, etc.) to prevent land use conversion	Directly –None Indirectly – Potentially Any/All	Watershed-wide	REDCs and Land Managers	$50,000 to $250,000+	Empire State Development, DOS, Office of Park, Recreation and Historic Resources, Private Conservation/Recreation Programs	Low

5.1 Implementation Strategy and Prioritization

Inherent resource limitations require prioritization of BMPs. Cost per unit reduction, total potential reductions for a given practice, flexibility in implementation, extent of public support/opposition, likelihood of voluntary adoption, and extent of existing expertise and/or resources to implement a given type of BMP were all considered in prioritization.

For landscape-based projects, BMPs targeting the volume and velocity of surface runoff are generally prioritized over measures targeting the supply and generation of phosphorus. This approach was prioritized over alternative actions due to its applicability across the entire watershed. Focusing on water movement enables flexibility across varying land uses types, co-benefits arising from reductions in risk of adverse downstream impacts, and linkage to changes in precipitation patterns. This approach also reflects the central importance of food production in the Seneca-Keuka watershed- past, present, and future.

BMPs which preserve existing natural resources and landscapes that reduce runoff are arguably the most cost effective as such resources provide benefits without costs. Examples include wetland preservation and protection of steep slope areas susceptible to erosion in the absence of vegetation. Protections can be provided to both these critical areas through acquisition, easements and/or establishment of local laws. The New York State *Open Space Planning Guide* provides additional information regarding the value, prioritization, and means of protection critical areas.

Outside such landscapes, engineered systems and management actions can be employed. Examples include use of green infrastructure systems such as bioswales in developed areas, or use of cover crops and grassed waterways on croplands. Given the composition of the Seneca-Keuka watershed, these types of projects have the greatest potential to reduce phosphorus loads. In general, implementation of BMPs within headwater areas and smaller tributaries should be prioritized over large downstream areas to avoid premature failure of downstream systems in the absence of upland improvements.

Opportunities for significant phosphorus load reductions via reductions in the supply of available phosphorus are limited when viewed from a watershed scale perspective. Typically, such BMPs are more complex and costly as well. However, there are site specific situations where such BMPs are the only and best option, and/or cases where such BMPs may have significant benefits within a HUC12 subwatershed if not necessarily the entire watershed. Examples include the use of manure storage facilities on dairy farms or upgrades to WWTPs.

The prioritization of BMPs summarized in Table 28 was done from a watershed-wide perspective. In most cases, there is no geographical limitation to their implementation beyond the applicability of a given BMP to a site. For example, wetland preservation is only relevant to wetland areas. Some identified BMPs are not specifically tied to a geographical area such as outreach, economic development, and planning projects; although agencies and individuals may choose to target specific areas or populations to maximize their value. However, for those that are, information within the 9E Plan may help agencies and individuals prioritize and strategize at the HUC12 scale.

The climate scenario identifies HUC12s that are most sensitive to increasing precipitation and consequently in greatest need of BMPs to reduce runoff. Similarly, the cover crop scenario can be used to prioritize implementation of this agricultural practice by HUC12, and as a general proxy for the potential benefits of cropland-based practices overall. Information including land use composition, soil erodibility and existing local laws can be used to refine project prioritization for a given subwatershed while additional BMP projects have been identified to assist in further prioritization refinement. Ultimately, site specific guidance is beyond the scope of this plan.

Finally, certain BMPs identified in this document such as those concerning invasive species, road salt, and PFAs are not directly related to phosphorus reduction but are included for completeness due to the absence of an existing Seneca-Keuka watershed management document. Prioritization of such BMPs is based on extent of relationship (if any) to phosphorus loading and associated impacts, significance of concern as expressed by public input, and the effectiveness of a given BMP relative to the alternatives that addresses the same water quality concern.

5.2 Compliance and Enforcement

A Nine Element Plan is not a regulatory document. However, a well-defined and staffed program to monitor progress and ensure compliance with performance standards for BMPs is an essential component of watershed management.   Since many of the recommended actions are voluntary and incentive-based, outreach and education coupled with financial and technical support are key. State and local government also have tools for enforcement of certain regulatory programs, as summarized below.

NYSDEC protects New York's water resources through various regulations, policies, and partnerships. The agency's Division of Water, Bureau of Water Compliance (BWC), with support from the Office of General Council and the Division of Law Enforcement, manages compliance elements of the SPDES Permit Program and enforcement against those discharging to waters of the state without a permit or beyond the authority of their permit.

The applicability of the SPDES program to discharges varies based on the nature and scale of the discharge. Permits are issues to control wastewater discharges from municipal, industrial, commercial and some privately owned residential treatments plants, and to control stormwater discharges from industrial activities, municipal separate storm sewer systems, construction activities and CAFOs.

As a "home-rule" state, authority over land use regulations and development – and by extension compliance and enforcement – lies with local municipalities, although NYSDEC's Protection of Waters and Freshwater Wetlands programs offer some level of landscape protection to those waterbodies. Municipal compliance and enforcement depend on applicable local laws which vary around the watershed. Note that the majority of BMPs identified in *Category 5: Local Laws* would provide the basis for future compliance and enforcement actions.

5.3 Technical and Financial Assistance

This plan relies heavily on voluntary adoption of best management practices on privately owned lands, actions by local government related to land use regulation and infrastructure management, and community partnerships leading conservation and education efforts. Various forms of technical and financial assistance are available to help implement recommendations.

5.3.1 Sources of Technical Assistance

Multiple groups have the technical resources to lead and/or assist with execution of the actions proposed in this document (**Table 31**). Given the land use composition of the watershed – predominately privately owned agricultural and forest lands – soil and water conservation districts are best positioned to execute the majority of practices and thus will be the principal agencies tasked with executing the 9E Plan. Capacity and capability vary across districts, but all have pre-existing relationships with land managers across their respective counties, as well as decades of expertise implementing such projects. This expertise extends to execution of certain municipal based projects as well.

Capacity and capability similarly vary across municipalities with the municipal organizations (e.g., counties, City of Geneva, etc.) capable of executing entire projects independently, while smaller communities may require outside assistance. KWIC and SWIO were created partly in response to this recognition, though watershed-scale coordination was a principal motivation as well. Presently, the capabilities and focus of each organization is quite different but ultimately both parties have the potential to execute projects alongside watershed municipalities as applicable. Individual municipal public works, highway, and planning departments – where established – can also serve as lead and/or partner agencies as resources allow.

Like KWIC and SWIO, Southern Tier Central and Genesee-Finger Lakes Regional Planning Council exist in part to increase the capacity of watershed municipalities. Both organizations offer expertise across a wide range of disciplines that can directly and indirectly contribute to water quality improvement. Two additional regional organizations serving the Seneca-Keuka watershed include FLI and FL-PRISM; the latter of which is based at the former. FLI and FL-PRISM staff capabilities include research, outreach, monitoring, and implementation with FL-PRISM a regional leader in invasive species management.

The Seneca-Keuka watershed is home to multiple academic institutions including Hobart and William Smith Colleges and Keuka College. Cornell University has Cornell Cooperative Extension offices within each county, and the Cornell Experimental Station is in Geneva. While the focus and capacity of these institutions vary, they collectively offer great expertise in research, monitoring, and public engagement. In some cases, these institutions manage a significant amount of land in the watershed and thus may be prime locations for implementation of landscape based BMPs.

Additional organizations well suited to outreach tasks include the two local lake associations: KLA and Pure Waters. Both have existing capacity to engage a significant proportion of watershed stakeholders, with a membership base already sensitive to water quality concerns. This high level of member engagement can be leveraged to assist with citizen science and other volunteer assistance opportunities. Additional non-profit organizations focused on water quality issues include Bluff Point Association, Finger Lakes Museum, Friends of the Outlet, New York Farm Bureau, NYSFOLA, New York Wine and Grape Foundation, and Seneca Lake Guardian.

Finally, although most watershed lands are held privately, there is a significant amount of publicly accessible land held by government entities and non-profit organizations including the Finger Lakes Land Trust, New York State, and the federal Forest Service. These groups have capacity to execute a diverse range of projects, though each must balance the need to distribute resources across a geographical footprint that extends beyond the Seneca-Keuka watershed.

Continued and expanded partnership development amongst all groups is an identified recommended action as it will foster sharing of expertise and increase regional capacity. Similarly, internal capacity building, particularly within the SWCDs, is another important proposed action that can increase the total supply of available technical resources.

Table 31: Contact Information for Technical Resources

Category	Organization	Primary Contact	Address	Email	Phone
Soil and Water Conservation District	Chemung County	Karen Tillotson, District Manager	851 Chemung Street, Horseheads NY 14845	karen@chemungswcd.com	607.739.2009
	Ontario County	Megan Webster, District Manager	480 North Main Street, Canandaigua NY 14424	info@ontswcd.com	585.396.1450
	Schuyler County	Jerry Verrigni, District Manager	2400 Meads Hill Road, Watkins Glen NY 14891	jerryverrigni@hotmail.com	607.535.0878
	Seneca County	Erin Peruzzini, District Manager	2041 US Route 20 Suite #2, Seneca Falls NY 13148	senecacountyswcd@gmail.com	315.568.4366
	Steuben County	Jeff Parker, District Manager	415 W Morris Street, Bath NY 14810	jgparker@stny.rr.com	607.776.7398
	Yates County	Colby Petersen, District Manager	417 Liberty Street Suite 1034, Penn Yan NY 14527	info@ycsoilwater.com	315.536.5188
Intermunicipal Organizations	Keuka Watershed Improvement Cooperative	Colby Petersen, District Manager	417 Liberty Street Suite 1034, Penn Yan NY 14527	info@ycsoilwater.com	315.536.5188
	Seneca Watershed Intermunicipal Organization	Ian Smith, Seneca Watershed Steward	601 South Main Street, Geneva NY 14456	ismith@hws.edu	315.781.4559
County Planning Department	Chemung County	Kevin Meindl, Director	400 East Church Street, Elmira NY 14902	planning@chemungcountyny.gov	607.737.5510
	Ontario County	Thomas Harvey, Director	20 Ontario Street, Canandaigua NY 14424	planning@co.ontario.ny.us	585.396.4455
	Schuyler County	Kristin VanHorn, Director	105 Ninth Street Units 39, Watkins Glen NY 14891	KVanHorn@co.schuyler.ny.us	607.535.8211
	Seneca County	Jill Henry, Director	1 DiPronio Drive, Waterloo NY 13165	jhenry@co.seneca.ny.us	315.539.1838
	Steuben County	Matt Sousa, Director	3 East Pulteney Street, Bath NY 14810	msousa@steubencounty.ny.gov	607.664.2268
	Yates County	Jeff Ayers, Director	417 Liberty Street, Penn Yan NY 14527	jayers@yatescounty.org	315.536.5153

Category	Organization	Primary Contact	Address	Email	Phone
Regional Economic Development Council	Genesee-Finger Lakes Regional Planning Council	Rich Sutherland, Interim Executive Director	50 West Main Street, Rochester NY 14614	info@gflrpc.org	585.454.0190
	Southern Tier Central Regional Planning and Development Board	Chelsea Robertson, Executive Director	8 Denison Parkway East Suite 310, Corning NY 14830	crobertson@ stcplanning.org	607.962.5092
Regional Environmental Organization	FLI at Hobart and William Smith Colleges	Lisa Cleckner, Director	601 South Main Street, Geneva NY 14456	cleckner@hws.edu	315.781.4381
	Finger Lakes Land Trust	Max Heitner, Director of Conservation	202 East Court Street, Ithaca NY 14850	info@fllt.org	607.275.9487
	Finger Lakes Partnership for Regional Invasive Species Management	Hilary Mosher, Program Coordinator	601 South Main Street, Geneva NY 14456	mosher@hws.edu	315.781.4385
Academic Institutions	CCE Chemung County	Michelle Podolec, Executive Director	425 Pennsylvania Avenue, Elmira NY 14904	chemung@cornell.edu	607.734.4453
	CCE Ontario County	Tim Davis, Executive Director	480 North Main Street, Canandaigua NY 14424	ontario@cornell.edu	585.394.3977
	CCE Schuyler County	Nathan Scott, Executive Director	323 Owego Street Unit #5, Montour Falls NY 14865	schuyler@cornell.edu	607.535.7161
	CCE Seneca County	Ave Bauder, Executive Director	Main Street Shop Centre Suite #308, Waterloo NY 13165	seneca@cornell.edu	315.539.9251
	CCE Steuben County	Tess McKinley, Executive Director	20 East Morris Street, Bath NY 14810	steuben@cornell.edu	607.664.2300
	CCE Yates County	Arlene Wilson, Executive Director	417 Liberty Street Suite 1024, Penn Yan NY 14527	yates@cornell.edu	315.536.5123

Category	Organization	Primary Contact	Address	Email	Phone
Academic Institutions	Cornell University Agricultural Experiment Stations	Margaret Smith, Director	630 West North Street, Geneva NY 14456	CornellAES@cornell.edu	607.254.8764
	Hobart and William Smith Colleges	N/A	300 Pulteney Street, Geneva NY 14456	N/A	315.781.3000
	Keuka College	N/A	141 Central Avenue, Keuka Park NY 14478	N/A	315.279.5000
Lake Associations & Additional Not-For-Profits	Finger Lakes Museum	Natalie Payne, Executive Director	3369 Guyanoga Road, Branchport NY 14418	communications@ fingerlakesmuseum.org	315.595.2200
	Friends of the Outlet	Phillip Rahr, President	PO Box 65, Dresden NY 14441	prahr@keukaoutlettrail.or g	N/A
	Keuka Lake Association	Ray Dell, President	142 Main Street, Penn Yan NY 14527	info@keukalakeassoc.org	315.694.7324
	New York Farm Bureau	Steve Ammerman, Director of Communications	159 Wolf Road Suite 300, Albany NY 12205	info@nyfb.org	518.436.8495
	New York State Federation of Lake Associations	Nancy Mueller, Manager	PO Box 84, LaFayette NY 13084	fola@nysfola.org	315.677.9987
	New York Wine and Grape Foundation	Sam Filler, Director	One Keuka Business Park Suite 208, Penn Yan NY 14527	info@newyorkwines.org	315.924.3700
	Seneca Lake Guardian	Joseph Campbell	PO Box 333, Watkins Glen NY 14981	info@senecalakeguardian. org	N/A
	Seneca Lake Pure Waters Association	Kaitlin Fello, Association Director	Technology Farm Drive, Geneva NY 14456	info@senecalake.org	315.945.0888
State and Federal Agencies*	NYSDEC Finger Lakes Watershed Program	Aimee Clinkhammer, Watershed Coordinator	615 Erie Boulevard West, Syracuse NY 13204	FLWP@dec.ny.gov	518.402.8013
	NYSDEC Region 8	Administration	6274 East Avon-Lima Road, Avon NY 14414	region8@dec.ny.gov	585.226.5400

Category	Organization	Primary Contact	Address	Email	Phone
	NYS Office of Parks, Recreation & Historic Preservation, Finger Lakes Region	Fred Bonn, Regional Director	2221 Taughannock Road, Trumansburg NY 14886	Fred.Bonn@parks.ny.gov	607.387.7041
	US Army Corps of Engineers, Buffalo District	Public Affairs Office	1776 Niagara Street, Buffalo NY 14207	Public.Affairs@ lrb01.usace.army.mil	800.833.6390
	US Forest Service, Finger Lakes National Forest	Jodie Vanselow, District Ranger	5218 State Route 414, Hector NY 14841	jodie.vanselow@usda.gov	607.546.4470

*Note: Agencies listed are limited to those located within and/or whose responsibilities focus on the Seneca-Keuka watershed.

5.3.2 Estimates of Financial Assistance Needed

Development of mechanistic lake water quality models was beyond the scope of this project, thus no quantitative target for nutrient levels were formally established. Due to this limitation, there are only estimated costs for implementation of proposed actions. Agencies and organizations identified in the previous section should rely on future assessments of progress towards achieving the narrative goals established during this project to make determinations regarding the need to increase or decrease the pursuit of further financing.

Given the challenge to address predominately nonpoint sources of nutrient and sediment pollution in a heavily agrarian watershed where ensuring sufficient supplies of both are available for maximizing plant growth, a continuous input of financing is anticipated. Projected impacts from external stressors beyond the scope of this project such as climate change are also anticipated to increase long-term financial commitments.

Financial needs may be reduced over time through several mechanisms; all of which are recommended management actions. Development of "In-Lake" models would establish quantitative targets for nutrient levels and by extension set a target endpoint for the total number of BMPs needed thereby avoiding redundancy and overruns. Once target nutrient levels are achieved, funding needs would then be limited to maintenance costs which are typically lower (though fewer financial resources are currently available for maintenance than new construction). The development and procurement of items that increase efficiency ranging from BMP maintenance databases to manure injectors would further reduce costs. Finally, the continued expansion of partnership develop would similar increasing efficiency and reduce long-term financial commitments.

5.3.3 Potential Funding Sources for Proposed Management Actions

It is anticipated that most actions will be funded through various state and federal cost-sharing programs. Additional local and regional financial resources – both private and public – are available as well, though are more limited in size and scope. All such known resources are identified in **Table 32**.

Table 32: Financial Resources to Support Recommendations

Funding Source	Program	Description	Related Seneca-Keuka Watershed Recommendations
STATE			
NYS Dept of Agriculture and Markets (NYSAGM)	Agricultural Nonpoint Source Abatement and Control Program (ANSACP)	Financial assistance program for projects led by SWCDs that involve planning, designing, and implementing priority BMPs. The program also provides cost-share funding to farmers to implement BMPs. For more info visit https://www.nys-soilandwater.org/aem/nonpoint.html.	Agricultural Practices and Management
	Agricultural Environmental Management (AEM) Program	SWCDs engage local partners such Cooperative Extension, NRCS, AEM Certified Planners, Certified Crop Advisors, USDA Technical Service Providers, and agri-businesses to assist farmers in farm planning to reduce runoff and erosion.	Agricultural Practices and Management
	Climate Resiliency Farming (CRF) Program	Assistance to reduce the impact of agriculture on climate change (mitigation) and to increase the resiliency of NYS farms in the face of a changing climate (adaptation).	Agricultural Practices and Management
	Community Resiliency Training Program	Provides community and municipality-based training events to increase resiliency to future flooding and outbreaks of harmful algal blooms in high-risk waterbodies.	Floodplain and Stormwater Management, Pollution Control
	County Agricultural and Farmland Protection Planning Grants	Financial assistance for the development of County Agricultural and Farmland Protection Plans and assist implementation of such plans.	Agricultural Practices and Management, Infrastructure & Development
	Source Water Buffer Program	Funding to support, expand or enhance water quality protection through the purchase of conservation easements on agriculture lands that preserves or establishes buffers for surface or ground waters.	Agricultural Practices and Management, Floodplain and Stormwater Management, Conservation
	Water Quality Improvement Project Program (WQIP)	For projects that reduce runoff, improve water quality, and restore habitat. Eligible applicants include municipalities, municipal corporations, and Soil and Water Conservation Districts	Infrastructure and Development, Pollution Control

Funding Source	Program	Description	Related Seneca-Keuka Watershed Recommendations
NYS Dept of Environmental Conservation (NYSDEC)	Climate Smart Communities (CSC) Grants	Provides 50/50 matching grants to municipalities for eligible climate mitigation and adaptation projects. This includes projects aimed at reducing flood-risk, increasing natural resiliency, extreme-event preparation, relocation or retrofit of critical infrastructure, and improving emergency preparedness.	Floodplain and Stormwater Management, Infrastructure and Development
	Community Forest Conservation Grant Program	Funds municipal land acquisition for community forests to protect habitat, improve air/water quality and provide for recreational opportunities	Floodplain and Stormwater Management, Conservation
	Non-Agricultural Nonpoint Source Planning and Municipal Separate Storm Sewer System (MS4) Mapping Grants	Provides up to 90/10 matching grants to local governments and Soil and Water Conservation Districts to help pay for initial planning of non-agriculture nonpoint source water quality improvement projects and mapping of regulated MS4s.	Floodplain and Stormwater Management
	Invasive Species Grant Program	Designed to support projects that target both aquatic and terrestrial invasive species. The program allows applications for two new categories: Lake Management Planning and Aquatic and Terrestrial Invasive Species Research.	Invasive Species
	Trees for Tribs	Provides schools with free trees to plant on school property.	Floodplain and Stormwater Management
	NYS Conservation Partnership Program	Funds to enable local organizations to strengthen urban, rural, and suburban, land conservation and public outreach programs, build community partnerships and implement BMPs.	Floodplain and Stormwater Management, Conservation
	Water Quality Management Planning Programs: Clean Water Act, Section 604(b) Funding	Funding is available to implement regional comprehensive water quality management planning activities, including tasks to determine the nature, extent and causes of point and nonpoint source water pollution problems, and to develop plans to resolve these problems.	Infrastructure and Development, Water and Wastewater Management, Pollution Control

Funding Source	Program	Description	Related Seneca-Keuka Watershed Recommendations
NYSDEC, OPRHP, Empire State Development Corporation, NYSDOS, NYSAGM	Environmental Protection Fund	Funds capital projects that protect the environment and enhance communities. Eligible projects include conserving farmland, restoring habitat, controlling invasive species, upgrading municipal sewage treatment plants, cleaning up waterfront property and creating public parks, purchasing land for the NYS Forest Preserve, and restoring historic sites.	Invasive Species, Infrastructure and Development
NYSDEC, NY Sea Grant	NY's Great Lakes Basin Small Grants	Support stakeholder-driven efforts to restore and revitalize the state's Great Lakes region and demonstrate successful application of ecosystem-based management.	Floodplain and Stormwater Management, Invasive Species, Pollution Control
NYSDEC / Land Trust Alliance	Forest Conservation Easements for Land Trusts Program	Public-private partnership funding provided to increase the pace of forested land conservation to combat climate changes.	Floodplain and Stormwater Management, Conservation
NYSDEC / NYS Environmental Facilities Corporation (NYSEFC)	Clean Water State Revolving Fund	Provides interest-free or low-interest rate financing for wastewater and water quality improvement projects to municipalities. Eligible projects include construction or restoration of sewers and wastewater treatment facilities, stormwater management, landfill closures, as well as habitat restoration and protection projects.	Water and Wastewater Management, Floodplain and Stormwater Management, Infrastructure and Development
	Wastewater Infrastructure Engineering Planning Grant	Provides grants to municipalities to help pay for the initial planning of eligible Clean Water State Revolving Fund water quality project.	Water and Wastewater Management
NYS Environmental Facilities Corporation (NYSEFC)	Drinking Water State Revolving Fund	Provides market-rate and below market-rate financing for the construction of eligible public water system projects for the protection of public health. Eligible projects include upgrade or replacement infrastructure needed to achieve or maintain compliance with federal or state health standards, and provide the public with safe, affordable drinking water.	Water & Wastewater Management

Funding Source	Program	Description	Related Seneca-Keuka Watershed Recommendations
NYS Environmental Facilities Corporation (NYSEFC)	Clean Water Infrastructure Act (CWIA) Grants	Funds municipalities to perform capital projects to upgrade or repair wastewater treatment plants and to abate combined sewer overflows, including projects to install heightened nutrient treatment systems. *Inter-Municipal Water Infrastructure Grant Program* funds municipalities, municipal corporations, and SWCDs for wastewater plant construction, retrofit of outdated stormwater management facilities, and installation of municipal sanitary sewer infrastructure. *Consolidated Animal Feeding Operation Waste Storage and Transfer Program Grant* funds SWCDs to implement comprehensive nutrient management plans through the completion of agricultural waste storage and transfer systems on larger livestock farms. *CWIA Source Water Protection Land Acquisition Grant Program* funds municipalities, municipal corporations, SWCDs and not-for-profits (land trusts) for land acquisition projects providing source water protection. This program is administered as an important part of the WQIP program.	Water and Wastewater Management, Agricultural Practices and Management, Infrastructure and Development, Pollution Control
	Integrated Solutions Construction Grant Program	Provides funding for projects that incorporate green infrastructure into Clean Water State Revolving Fund (CWSRF) projects that remove stormwater from combined, sanitary, or storm sewers. This funding is available only in conjunction with CWSRF financing.	Floodplain and Stormwater Management, Water and Wastewater Management
	Green Innovation Grant Program (GIGP)	Provides municipalities, state agencies, private entities, as well as SWCDs with funds to install transformative green stormwater infrastructure.	Floodplain and Stormwater Management, Infrastructure and Development

Funding Source	Program	Description	Related Seneca-Keuka Watershed Recommendations
NYS Environmental Facilities Corporation (NYSEFC)	Wastewater Infrastructure Engineering Planning Grant	Available to municipalities with median household income equal to or less than $65,000 according to the United States Census. Priority is usually given to smaller grants to support initial engineering reports and plans for wastewater treatment repairs.	Water and Wastewater Management
	Septic Replacement Fund	Provides participating counties with funds to reimburse a property owner for up to 50% of the costs (up to a max of $10,000) of their eligible septic system project. Eligible projects include replacement of a cesspool with a septic system; installation, replacement or upgrade of a septic system or components; installation of enhance treatment technologies.	Water and Wastewater Management
NYS Environmental Facilities Corporation (NYSEFC) and USFWS	Clean Vessel Assistance Program (CVAP)	A reimbursement grant program that aids marinas in the installation, renovation, and replacement of pump-out stations for the removal and disposal of recreational boater septic waste.	Pollution Control
NYS Dept of State (NYSDOS)	Local Waterfront Revitalization Program (LWRP)	Funded projects match grants to revitalize communities and waterfronts. These projects may include green infrastructure components.	Floodplain and Stormwater Management, Infrastructure and Development, Water Quality Research, Planning and Monitoring
	Brownfield Opportunity Area Program	Provides funding to eligible municipalities and community-based not-for-profit organizations to complete: 1) a Brownfield Opportunity Area (BOA) nomination; 2) pre-development activities within a BOA where a nomination forms the basis for a designation; and 3) Phase II Environmental Site Assessments with a designated BOA.	Floodplain and Stormwater Management, Infrastructure and Development
	Smart Growth Comprehensive Planning Grant Program	Provides funding for eligible villages, towns, cities, counties, reginal planning entities, and not-for-profit organization to advance the preparation of municipal comprehensive plans to establish land use policies which support smart growth and clean energy principles.	Local Laws and Regulations
NYS Dept of Transportation (NYSDOT)	Transportation Alternatives Program	Provides funding for roadway improvements and culvert and bridge replacements, as well as pedestrian and bicycle paths.	Infrastructure and Development

Funding Source	Program	Description	Related Seneca-Keuka Watershed Recommendations
NYS Dept of Transportation (NYSDOT)	Bridge NY Program	Funding available for local governments to rehabilitate and replace bridges and culverts statewide.	Infrastructure and Development
NYS Office of Parks, Recreation and Historic Preservation (NYSOPHRP)	Environmental Protection Fund Municipal Grants Program	Provides funding for acquisition, preservation, planning, development, and improvement of parks, historic properties, and heritage areas. Funding is available through the following grant categories: Park Acquisition, Development and Planning Program; Historic Property Acquisition, Preservation and Planning Program; Heritage Areas System Acquisition, Development and Planning Program.	Infrastructure and Development
NYS Office of Homes and Community Renewal	Community Development Block Grant (CDBG) Program – Small Cities	Funds may be utilized to address construction or renovation of various infrastructure projects such as water, wastewater and solid waste facilities, streets, and flood control projects.	Water and Wastewater Management, Floodplain and Stormwater Management, Infrastructure and Development
New York State Pollution Prevention Institute	Community Grants	Funding to projects that seek to improve the health, environmental quality, and economic vitality of communities across New York State. Designed to support public awareness and understanding that lead to adoption of sustainable practices.	Collaboration, Partnerships, and Outreach
Great Lakes Research Consortium	Small Grants Program	Provides funding dedicated to collaborative research and education on the Great Lakes and Great Lakes basin within New York State.	Water Quality Research
FEDERAL			
Federal Emergency Management Agency (FEMA)	Hazard Mitigation Grant Program	Helps communities implement hazard mitigation measures to protect against life and property damages.	Floodplain & Stormwater Management
US Dept of Agriculture, Farm Service Agency (FSA)	Conservation Reserve Program (CRP)	A voluntary program for agricultural landowners that provides farmers with annual rental payments and cost-share assistance to establish long-term, resource covers on eligible farmland.	Agricultural Practices & Management

Funding Source	Program	Description	Related Seneca-Keuka Watershed Recommendations
US Dept of Agriculture, Farm Service Agency (FSA)	Conservation Reserve Enhancement Program (CREP)	In exchange for removing environmentally sensitive land from production and introducing conservation practices, farmers, ranchers, and agricultural landowners are paid an annual rental rate and incentive payments.	Agricultural Practices & Management
	Farmable Wetlands Program	Voluntary program designed to restore previously farmed wetlands and wetland buffer to improve both vegetation and water flow.	Agricultural Practices & Management, Floodplain & Stormwater Management
US Dept of Agriculture, Natural Resources Conservation Service (USDA-NRCS)	Agricultural Conservation Easement Program (ACEP)	Provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits.	Agricultural Practices & Management, Floodplain & Stormwater Management
	Agricultural Management Assistance (AMA) Program	Provides financial and technical assistance to agricultural producers to voluntarily address issues such as water management, water quality, and erosion control by incorporating conservation into their farming operations.	Agricultural Practices & Management. Pollution Control
	Conservation Stewardship Program (CSP)	Voluntary program that provides financial and technical assistance to implement conservation practices on agricultural and forested lands.	Agricultural Practices & Management, Forestry Management
	Environmental Quality Incentives Program (EQIP)	Voluntary program that provides financial and technical assistance to agricultural producers to plan and implement conservation practices that improve soil, water, plant, animal, air and related natural resources on agricultural land.	Agricultural Practices & Management, Forestry Management
	Conservation Innovation Grants	Provides funding that supports the development of new tools, approaches, practices, and technologies to further natural resource conservation or private lands.	Agricultural Practices & Management, Forestry Management
	Wildlife Habitat Incentive Program (WHIP)	Voluntary program that provides financial and technical assistance to help participants develop fish and wildlife habitat on private agricultural land, non-industrial private forest land, and Indian land.	Invasive Species
US National Oceanic and Atmospheric Administration	Environmental Literacy Grants	Funds to support the education of k-12 students and the public so they are knowledgeable of the ways in which their community can become more resilient to extreme weather events and/or other environmental hazards	Education & Outreach

Funding Source	Program	Description	Related Seneca-Keuka Watershed Recommendations
US Dept of Agriculture, Rural Development	Water & Waste Disposal Loan & Grant Program	Provides funding for clean and reliable drinking water systems, sanitary sewage disposal, sanitary solid waste disposal, and storm water drainage to households and businesses in eligible rural areas.	Water and Wastewater Management
	Community Facilities Direct Loan & Grant Program	Provides funding to develop essential community facilities in rural areas.	Water and Wastewater Management
US Dept of Agriculture, US Forest Service	Citizen Science Competitive Funding Program	Provides funding to support innovative projects that address science and resource management information needs while connecting people to the land and one another.	Water Quality Research, Collaboration, Partnerships, and Outreach
US Environmental Protection Agency (USEPA) and US Forest Service	Great Lakes Restoration Initiative Forest Restoration	Funding to implement green infrastructure projects that improve habitat and other ecosystem function in the Great Lakes are eligible for funding.	Floodplain and Stormwater Management, Infrastructure and Development
	Great Lakes Restoration Initiative Cooperative Weed Management	Funding to detect, prevent, eradicate, and/or control invasive plant species to promote resiliency, watershed stability, and biological diversity.	Invasive Species
US Fish and Wildlife Service (USFWS)	Partners for Fish and Wildlife Program	Assists landowners with technical and financial assistance to help protect, enhance, and restore wildlife habitat on privately owned lands. Activities include restoring wetlands, grasslands, in-stream habitats, stream banks, riparian and floodplain areas.	Floodplain and Stormwater Management, Infrastructure and Development
	National Fish Passage Program	Restore aquatic organism passage at man-made barriers including dams and culverts; priorities include projects restoring habitat to freshwater mussels, brook trout, lake sturgeon, Atlantic salmon, and American eel.	Infrastructure and Development
	North American Wetlands Conservation Act Grants	Funding to support long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitat for the benefit of all wetlands-associated migratory birds	Floodplain and Stormwater Management, Conservation, Invasive Species

Funding Source	Program	Description	Related Seneca-Keuka Watershed Recommendations
US Environmental Protection Agency (USEPA)	Clean Water Act Section 319 Nonpoint Source Management Program	Funding to support a variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects and monitoring to assess the success of specific nonpoint source implementation projects.	Water Quality Research, Planning and Monitoring, Pollution Control; Collaboration, Partnerships and Outreach
	EPA Environmental Education Grants	Supports environmental education projects and promote environmental awareness and stewardship.	Collaboration, Partnerships, and Outreach
	Water Research Grants	Funding to develop and support the science and tools necessary to develop sustainable solutions to 212st century water resource problems.	Water Quality Research
Great Lakes Commission	Sediment and Nutrient Reduction Program	Provides funding to reduce nutrients and sediments from entering the Great Lakes.	Floodplain and Stormwater Management, Agricultural Practices & Management, Forestry Management
LOCAL, REGIONAL & PRIVATE FOUNDATIONS			
Municipalities	Municipal Budgets	Provide labor and equipment from Departments of Highways and/or Public Works to do tasks such as clean debris from streams, culverts, storm drains, etc.	All
Ontario County Water Resources Council	Mini Grants Program	Small grants to support projects addressing one or more water quality priorities.	Floodplain & Stormwater Management, Agricultural Practices & Management, Forestry Management, Invasive Species, Planning, Monitoring, Education & Outreach, and Local Laws
Yates County Planning Department	Natural & Recreational Resources Grant	Funds to support protection and preservation of natural and recreational resources in Yates County.	Floodplain and Stormwater Management, Planning, and Monitoring
Seneca Lake Pure Waters Association	Sediment, Nutrient & Pollution Reduction Program	Funds to support water quality improvement action within the Seneca Lake watershed with a focus on sediment and nutrients.	Floodplain & Stormwater Management, Agricultural Practices & Management, Forestry Management
National Fish and Wildlife Foundation	Five Star and Urban Waters Restoration Grant Program	Provides funding to address water quality issues in priority watersheds, such as erosion due to unstable streambanks, pollution from stormwater runoff and dergraded shorelines caused by development.	Floodplain and Stormwater Management

Funding Source	Program	Description	Related Seneca-Keuka Watershed Recommendations
National Fish and Wildlife Foundation	Sustain Our Great Lakes Program	Funding to support fish, wildlife, habitat and water quality improvement and protection within the Great Lakes Basin	Floodplain and Stormwater Management, Invasive Species
Wildlife Conservation Society	Climate Adaptation Fund	Funding to increase the pace and scale of impact in adaption for wildlife and ecosystems by increasing innovation, accelerating learning, and mainstreaming proven adaptation approaches.	Floodplain and Stormwater Management, Invasive Species
Freshwater Future	Project Grants Program	Provides financial support for activities led by community groups work to promote river, lake, shoreline, wetland, groundwater, and drinking water protection in the Great Lakes basin through grassroots advocacy.	Floodplain and Stormwater Management, Planning, and Monitoring, Education & Outreach, and Local Laws
Great Lakes Basin States	Great Lakes Protection Fund	Provides funding to project that will create and advance the next generation of actions to protect and restore the ecological health of the Great Lakes	All
Appalachian Regional Commission	Area Development Program	Funding provided to support critical infrastructure pertaining to water and wastewater systems and transportation networks anchoring regional economic development.	Water and Wastewater Infrastructure, Stormwater Management
Northern Borders Regional Commission	Economic Infrastructure Grants	Funding provided to support critical infrastructure pertaining to water and wastewater systems and transportation networks anchoring regional economic development.	Water and Wastewater Infrastructure, Stormwater Management

5.4 Evaluation of 9E Plan and Implementation Actions

FLI is the organization tasked with tracking progress toward implementation of the recommended actions and conditions of the Seneca-Keuka watershed. This institutional structure continues to be an effective avenue for collaborative efforts and communication. Adaptive management is a critical feature of the 9E Plan. Continued monitoring of water quality, habitat conditions, and hydrology will inform FLI of emerging issues and the need for additional actions. Monitoring efforts should be guided by a formal QAPP, and all analyses should be performed by an ELAP-certified laboratory.

The lakes and watershed are not static, nor are the modeling tools. FLI will serve as the repository of the SWAT model files and will periodically update the analyses as land cover and management practices change, additional site-specific data become available (including weather, hydrology, and tributary water quality data), and the SWAT model framework evolves. Other planning and monitoring efforts may also include metrics to evaluate progress toward meeting goals designed to ensure the protection and quality of the lakes.

Reviewing and, if warranted, updating the 9E Plan on a ten to twenty year cycle is recommended. This interval is comparable to recommended best practices for community comprehensive plans. Moreover, the lake's water residence time and the importance of annual weather patterns on nonpoint source loading support the need for tracking over a multi-year time frame. FLI may consider other triggering events as they schedule periodic updates. Such events may include changes in regulatory policies, emerging contaminants, revised lake management approaches, new technologies for nutrient inactivation or cyanobacteria, innovated management practices, expanded monitoring data, major changes in land use or land cover, updated modeling tools, and others.

Both quantitative and qualitative metrics will be used to track implementation of the recommended actions, and the extent to which Seneca and Keuka Lakes are supporting their designated uses (discussed in **Section 2.1.1**). Examples of key metrics are listed below.

5.4.1 Evaluation Criteria

- Local SWCDs have an effective system to track projects targeting nutrient and sediment losses from agricultural lands. The number of grant awards, collaborating agricultural producers, and extent of landscape with BMPs are important metrics to monitor the success of voluntary, incentive-based measures.
- In partnership with FLI and FL-PRISM, review data from iMap Invasives and boat launch steward programs tracking invasive species.
- Monitor funding and staffing levels at relevant resource management agencies.
- FLI will continue tracking local initiatives to incorporate water resource protection measures into land use regulations and guidelines.
- Data from CSLAP and other NYSDEC programs to evaluate trophic state indicator parameters and other ambient water quality standards related to aquatic habitat. For example, summer average

chlorophyll-a concentrations at or below 4 ug/L will be considered evidence of successful implementation of the 9E Plan.

- Data from New York State Department of Health (NYSDOH) regarding compliance with primary and secondary contact recreational standards. Metrics such as number of beach closures will be tracked to indicate effectiveness of the 9E Plan.
- Data from water purveyors reporting the number of exceedances of maximum contaminant levels in drinking water supply.
- Stream flow, meteorological data, and tributary water quality data, including calculated external load used to update the SWAT model.
- Results of any upstream and downstream / before and after monitoring programs designed to evaluate effectiveness of installed BMPs. This encompasses road ditch improvement projects, streambank stabilization measures, agricultural BMPs (e.g., Tier 5 AEM efforts), and projects designed to reduce flood risk.
- Data from NYSDEC HABs database to track the count, frequency, intensity, duration, and toxicity of HABs in Seneca and Keuka Lakes.
- Phosphorus load from permitted WWTP and compliance with SPDES permits

5.4.2 Monitoring Plan

Ongoing monitoring programs can be used to assess progress toward the project vision and goals, evaluate effectiveness of implemented management practices, and highlight emerging issues. The 9E Plan embraces an adaptive management approach to continual evaluation and improvement. As discussed, hydrologic resilience to extreme precipitation events is a key driver for managing nonpoint source pollution. Monitoring during high discharge conditions is essential to quantify progress toward increased resilience which underlies most recommendations of this 9E Plan. New data and information can be used to refine the SWAT model for a periodic re-evaluation of priority areas and actions. In addition, a commitment to ongoing monitoring can hold regulated entities accountable. This section identifies monitoring strategies to achieve these objectives and outlines organizational resources currently available.

5.4.2.1 Precipitation

Direct precipitation is a minimal source of contaminant loading to the surface waters, so there are no specific recommendations regarding atmospheric deposition. However, precipitation is a principal driver of watershed hydrology and a major influence on fate and transport of material from the landscape to surface waters. The risk of stormwater runoff increases in response to more frequent and intense rain events. Therefore, accurate characterization of runoff is closely dependent on high quality precipitation data.

The National Oceanic and Atmospheric Administration (NOAA) is an agency within the United States Department of Commerce. NOAA's National Weather Service maintains a series of weather stations to measure and report meteorological data, including precipitation. These data are publicly available via NOAA's online data portal (https://www.weather.gov/wrh/climate) and are subject to quality assurance review prior to publication. Multiple stations are located within or adjacent to the Seneca-Keuka watershed in the communities of Canandaigua, Corning, Elmira, Geneva, Mecklenburg, Penn Yan, Watkins Glen, and Waterloo. The period of record, frequency of collection, measured parameters and data completeness vary among stations. At present, a significant gap in coverage exists along the eastern side of Seneca Lake; establishing an additional station is recommended.

Additional precipitation data are periodically collected by Hobart and William Smith Colleges, Keuka College, CCE, SWCDs, and private individuals and organizations. These data are not screened using the NOAA quality assurance parameters and were not included in the watershed model. However, these data can be used to support education and outreach and preliminary engineering design efforts to improve stormwater management.

5.4.2.2 Stream Hydrology, Chemistry and Morphology

Upstream surface water flow is the dominant means by which phosphorus and most additional contaminants of concern enter Keuka Lake, Seneca Lake, and other downstream waterbodies. Groundwater flow and direct deposition appear to be minimal contributors of sediment and phosphorus to the lakes, with some exceptions. Therefore, accurate measurement of stream discharge volume and contaminate concentrations in response to drivers (e.g., precipitation, land use, slope, and soil) are needed to properly estimate loading rates for contaminates. Furthermore, the volume of surface water itself can be an ecological, economic, and social concern given the impact of its overabundance or absence.

USGS is a scientific agency within the United States Department of Interior. USGS's New York Water Science Center maintains three stream gauging stations within the Seneca-Keuka watershed: Sugar Creek in Branchport, Catharine Creek in Montour Falls, and Keuka Outlet in Dresden (**Section 2.1.2.1, Figure 3**). An additional USGS station is located along the Seneca River in Seneca Falls; this station is located outside of the watershed but measures and reports water surface elevation of Seneca Lake. All USGS data are subject to rigorous quality control processes and are therefore suitable for use in various applications, including the watershed model. Both the Keuka Outlet and Seneca River gauges are influenced by hydrological control structures. As controlled streams, the potential for using these two sites to quantify discharge response to meteorological conditions is limited. USGS streamflow data are available on the National Water Dashboard https://dashboard.waterdata.usgs.gov.

Trained staff from NYSDEC routinely collect watershed data in support of multiple programs. While chemical and biological data are the typical focus of these programs, hydrological data are often collected in conjunction with this information. Such information is often limited to instantaneous discharge and concentration, but more continuous data may be available for certain parameters. In addition to the long-standing statewide programs such as CSLAP, WAVES, and RIBS (described in **Section 2.4.2**) the Finger Lakes Water Quality Hub has been active in supporting enhanced monitoring to develop 9E Plans, including winter sampling of the Finger Lakes, installation of monitoring buoys, investigations of benthic mussels, and many other initiatives that elucidate the state of the ecosystems. All NYSDEC data are subject to state review and approval of a QAPP. Data are not currently publicly accessible via an online portal but are often found in published reports and may be requested though the Freedom of Information Law (FOIL). (https://www.dec.ny.gov/public/373.html).

Additional stream data are collected by volunteers and staff from KWIC, SWIO, KLA, and Pure Waters. Data are currently collected at the outlet of the following streams: Big Stream, Castle Creek, Cold Brook, Kashong Creek, Reeder Creek and Wagener Glen. Additional chemistry data are frequently collected at various points upstream of these locations. The data are subject to the monitoring QAPP developed as part of the Seneca-Keuka Watershed 9E Plan for Phosphorus and can be used in conjunction with the watershed model. Most of these data are not currently available online and can be obtained by request of the relevant organization. Some water quality data are available through the CSI online database http://www.database.communityscience.org/.

Stream monitoring is costly, and the capacity of the watershed organizations to continue the current program is uncertain. One alternative is to commit to one annual synoptic survey of all monitoring locations and rotate among the locations for higher frequency sampling based on budget and labor constraints. Sites selected for the higher frequency monitoring could be based on subwatershed prioritization, or status of implemented BMPs. This design would reduce the number of analytical samples and associated costs.

If an annual synoptic survey is planned, the watershed management team should consider methods to capture comparable flow conditions to enable meaningful comparisons. One option is to target spring conditions with moderate to high flow conditions when export of phosphorus and sediment is highest. To the extent possible, discharge should be monitored throughout the year. Alternative methods to those described in the monitoring QAPP, such as installing ultrasonic sensors, may offer a means of year-round data collection at reasonable cost. Reduction in the suite of chemical analytes could also reduce cost, as the principal focus of the 9E Plan is sediment and phosphorus loading. It is strongly recommended that both dissolved and particulate fractions of phosphorus be analyzed. At present, insufficient data are available to calibrate and apply the SWAT model to simulate soluble reactive phosphorus (SRP) loading across the watershed but being able to do so would improve watershed management decisions.

Finally, inclusion of stream morphology data into existing stream monitoring work is strongly recommended. Stream morphology refers to analysis of the physical shape and structure of the stream channel and bed. These features are dynamic and are influenced by both natural conditions (underlying geology, soils, hydrology, riparian vegetation, etc.) as well as human activities (land cover, impervious surfaces, connections to ditches and tile drains, etc.). Analysis of morphological changes over time could provide useful information and would require a relatively small amount of additional effort. At present, the SWAT model lacks the capability to isolate the portion of sediment loading (and associated phosphorus loading) derived from streambank erosion versus adjacent landscape runoff. This limitation could be partially addressed through morphological data, which in turn could have significant impacts on identifying the most appropriate actions for a given subwatershed.

5.4.2.3 Groundwater Hydrology and Chemistry

Groundwater flow enters Seneca and Keuka Lakes directly and contributes baseflow to tributary streams. Antecedent moisture and ground water saturation have a significant influence on the volume of overland flow that reaches surface waters. In general, groundwater is not considered a significant source of contamination as percolation through the soil profile will filter particulates and may immobilize many dissolved chemicals through chemical or biologically-mediated processes. However, there are two notable exceptions relevant to the Seneca-Keuka watershed. First, failing septic systems near waterbodies and/or drinking water wells pose the risk of microbial and chemical contamination, notably nutrients. Second, is the risk of per/polyfluoroalkoxy alkane substances (PFAs) associated with the former Seneca Army Depot reaching the waterways.

Given the financial and access challenges associated with groundwater monitoring, only limited data are publicly available. USGS monitors water table elevation at several (four as of October 2021) monitoring wells located within the watershed; these data are available via the National Water Dashboard. The Town of Geneva which draws its public water supply groundwater wells, also maintains water table elevation records which are available upon request. Finally, as part of this project, KWIC installed a monitoring well within the Sugar Creek subwatershed. No additional groundwater elevation monitoring is recommended at this time.

Addressing the potential for contamination of groundwater, and ultimately surface water, from failing septic systems is best achieved via septic inspection programs. Regulations regarding requirements for septic inspections vary around the watershed but existing programs provide insight into failure rates which can be coupled with demographic data to estimate potential contaminant loading from septic systems. Where available, data can be obtained from the varying authorities responsible for these programs including county health departments, KWIC, and local municipalities.

Various indirect methods have been developed to detect septic system contamination of surface waters with mixed results. The principal challenge lies with isolating septic system inputs from other contaminant sources. Most methodologies use the presence/absence of anthropogenic compounds such as laundry brighteners or caffeine as indicators of the presence of wastewater plumes in surface water. These results can indicate the presence of a probable wastewater signal, but do not help quantify the relative significance of the source in terms of risk to human health or the environment as compared with other sources. Screening is recommended in areas where inspection programs are not in place, but septic derived contamination is suspected based on soil class, proximity to surface water, and age of the system.

Groundwater contamination via PFAs compounds was identified as an issue of emerging concern due to their carcinogenic impacts and resistance to degradation in the environment, particularly in water. These unique compounds are used to make coatings and products that resist heat, oil, stains, grease, and water. While the geographic distribution of PFAs is limited by proximity to areas of production and/or concentrated use, PFAs were used heavily on the Seneca Army Depot along the eastern shore of Seneca Lake. Investigative monitoring conducted by the USACE has documented PFA contamination of soils located in and around the former Depot. There is growing concern that the area of contamination may expand outward toward private wells and Seneca Lake. Regulations now require public water utilities serving more than 10,000 people to test for certain PFA variants which can provide insight into the need for further action based on results. However, private wells located near the former Depot remain the most threatened. If private citizens express concern and interest, local municipalities should coordinate through SWIO to develop a standardized methodology to assess the extent of PFA contamination in private wells.

5.4.2.4 In-Lake Hydrology and Chemistry

For the purposes of informing watershed management, in-lake data are of more limited utility. This is largely the result of two factors: 1) absence of an in-lake hydrodynamic model (or any model of Seneca Lake); and 2) decadal-scale water residence times for both Seneca and Keuka Lakes. As mentioned in **Section 2.4.1**, Seneca and Keuka Lakes continue to participate in CSLAP. CSLAP data are subject to state quality control standards and were used in development of the Keuka Lake BATHTUB model. The value of the CSLAP data is its comparability across multiple lakes and over time, and its use in long-term trend analysis. With multiple monitoring locations on the large Finger Lakes, CSLAP data can also be used to inform design of a future hydrodynamic modeling effort. However, stream monitoring is a more direct and timely approach to track the effectiveness of watershed actions for reducing nutrient and sediment inputs.

Lake water quality is also routinely monitored by public water purveyors. Public water systems serving over 10,000 individuals are required to report annually on a wide range of water quality parameters. This information is subject to quality control standards and review by NYSDOH. Reports can be obtained by contacting either the regional Department of Health Office or the water utility directly. In many cases, annual reports are made available to residents each spring and archived on the associated municipal website. Continuation of these programs as currently designed will provide an appropriate level of information on in-lake physical and chemical conditions to inform watershed management.

As noted briefly in Section 1.4.5, there are no mechanistic water quality models for the lakes. Lake water quality models can provide a tool for scenario testing (for example, what if phosphorus inputs change by x percent) that can help stakeholders understand the time scale over which changes in watershed inputs could affect lake water quality. An empirical model was developed for Keuka Lake as part of the 9E Plan and helps this evaluation. However, the size and complexity of Seneca Lake precluded this approach. Detailed mapping of Seneca Lake's bottom profile (bathymetry) is an important data gap associated with developing the hydrodynamic framework needed to support a future mechanistic water quality model of this complex system.

5.4.2.5 Aquatic and Terrestrial Biology

Ecosystems are unique in that the overabundance of a certain organism, such as *E. coli*, can be a source of contamination itself, while the overabundance of another organism, such as cyanobacteria, can be a response to the overabundance or absence of other environmental drivers. In some cases, both are true. Each is important from a watershed management perspective given the potential economic, social, and health impacts associated with excessive amounts of certain organisms. Biological monitoring can also be used to assess improvement or decline in overall ecological health. The New York State RIBS program, for example, uses benthic macroinvertebrate community metrics as an assessment of long-term water quality conditions and returns to sentinel monitoring sites every five years. The 9E Plan does not include recommendations to expand these programs.

HABs are one of the most significant environmental challenges facing the Seneca-Keuka watershed. With the current limited understanding of the interplay of factors affecting HABs, there is no direct linkage between watershed loading and the risk of HABs development. It is known that water temperature, biologically available phosphorus concentration are key physical and chemical drivers of HAB development. In addition, biological factors such as the abundance of benthic dreissenid mussels, are implicated in the increasing occurrence of HABs in low nutrient lakes. Efforts to retain phosphorus on the landscape, mitigate temperature increases through vegetation and controls on thermal discharges, and surveillance for invasive species are all important tools for reducing the risk of HABs in the lakes.

Continuation and expansion of HABs surveillance is an important measure for increased public awareness and protection of public health and is highly recommended. Both Pure Waters and KLA have well-established volunteer HABs monitoring programs. Volunteers are trained in how to properly identify blooms and report them using Pure Waters' (https://senecalake.org/Blooms) and/or NYSDEC's New York HAB (https://www.dec.ny.gov/chemical/77118.html) Systems. The NYS HABS site tracks and reports data across the state and is publicly available.

Similarly, while *E. coli* monitoring can protect individuals from exposure, these data are of limited utility for evaluating the need for and effectiveness of BMPs. Pure Waters' stream monitoring program tests for *E. coli* on a limited basis; data are available through the CSI database. Given the high costs associated with *E. coli* monitoring and its low public health utility, it is recommended that such monitoring only be conducted when additional observations suggest contamination within a specific location and the bacteriological data could inform remedial decisions.

Invasive species monitoring, of both terrestrial and aquatic communities, is extremely important to successful watershed management as invasives proliferation can be a cause of or response to ecological degradation. Prevention is almost always more effective and cost-efficient than eradication, and early detection monitoring programs are the best means of prevention. FL-PRISM serves as the principal agency for invasive species issues in the Seneca-Keuka watershed and partners with multiple New York State agencies, including NYSDEC, Office of Parks, Recreation and Historic Preservation, CCE, Lake Associations, and local municipalities. Monitoring programs are in place for detection of highly problematic species such as hydrilla and spotted lanternfly and should be prioritized and expanded based on funding availability and threat. One monitoring program worth special identification and prioritization is the FL-PRISM Watercraft Steward Program, discussed in **Section 2.2.4**. This highly effective program stations trained individuals at public boat launches across the watershed to inspect boats as they enter and exit waterbodies. Monitoring programs for location and treatment of established populations of invasive species are less developed and should be pursued as needed basis such as part of a larger management action project.

5.4.2.6 Landscape

Land cover and land use data are integral to the SWAT model. Much of this information is largely static over decadal time scales, with some exceptions. Additionally, some landscape data can be collected through traditional direct quantitative measurements such as aerial photography while other information must be collected through social science methodologies (e.g., surveys).

The Multi-Resolution Land Characteristics Consortium is a group of federal agencies that coordinate and generate land cover information at a national scale with the NLCD its preeminent product. The NLCD provides data on land cover at a 30 meter resolution with a 16-class legend and is updated on a 10-year cycle. Similarly, USGS and NYSDEC have partnered to develop statewide digital elevation models with 10 meter resolution. While higher resolution data may be available through county and academic sources, the potential for inconsistencies in methodologies across agencies and partial geographical coverage limits the applicability of this information for watershed-scale management. One notable exception is the viticulture land use data which can be obtained in consultation with CCE and Yates County SWCD.

Given that agriculture and silviculture are the dominant land use types in the Seneca-Keuka watershed, accurate characterization of land use management decisions (planting dates, harvest dates, tillage, etc.) is critical to model performance. This information does not need to be collected at a parcel scale but rather should be an average that represents the overall variability. The HUC12 level of reporting is recommended. Going forward, this data can be expected to more variable than in years past as farmers and foresters adapt to a changing climate. More frequent updates would help guide decision making. Updating information on a decadal scale corresponding to NLCD updates is recommended.

One specific land use management practice worth greater exploration is tile drainage. The use of tile drainage is widespread throughout the watershed and can have significant beneficial and/or negative effects on water quality. While the SWAT model has the capacity to simulate these effects, insufficient information regarding the location and extent of tile drainage prevented the use of this feature. Furthermore, the presence/absence of tile drainage can greatly impact the efficacy of various best management practices and thus could impact prioritization at the watershed-scale. For these reasons the monitoring plan recommends locating and mapping tile lines throughout the watershed via satellite imagery and/or surveying. Given the scope of this effort, it will likely be necessary to secure specific support and funds to achieve this.

A final landscape data need concerns information on best management practices themselves. Obviously, any existing or future BMPs will yield positive benefits to the watershed. Having accurate information on the location, design and lifespan of a given BMP can inform the need for additional BMPs within geographical areas of the watersheds and improve the accuracy of the SWAT model over time which in turn would improve assessment of progress towards achieving reduction goals.

6 Conclusions

The Seneca Keuka Lake watershed provides a multitude of ecosystem services that benefit us all, as reflected in the community's vision and goals statement. The lands and waters support food and fiber production, offer beautiful vistas and diverse recreational opportunities, provide habitat for a diverse assemblage of native species, and are a source of clean and abundant drinking water. In addition, the watershed lands and waters support power generation and waste assimilation for development activities. This beautiful region of the New York Finger Lakes has provided a unique sense of place to generations.

Actions are needed to protect and preserve the watershed's ability to support these interrelated ecosystem services. The Seneca Keuka Watershed Nine Element Plan for Phosphorus focuses on a key challenge facing many lakes and watersheds, the need to control phosphorus inputs. This 9E Plan analyzes phosphorus sources and locations, estimates current loadings, and uses a mathematical model to project the consequences of changing conditions. The findings support a series of recommended action designed to reduce phosphorus inputs.

Landscape sources are the primary contributors of phosphorus to Seneca and Keuka Lakes. Therefore, managing these diffuse sources will require ongoing efforts of many parties: individual landowners, local leaders, farmers, foresters, and resource management agencies. Continued collaboration and partnerships are the key to protecting this resource for future generations.

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Appendix A
Quality Assurance Project Plan: Stream Monitoring

QAULITY ASSURANCE PROJECT PLAN:
Stream Monitoring Program in Support of Seneca-Keuka Watershed Nutrient Model

Prepared by:

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February 10, 2020

REVISION RECORD

Revision No.	Date of Revision	Revised By	Description of Change	Effective Date

GROUP A: PROJECT MANAGEMENT ELEMENTS

A1: Title and Approval Sheet

Quality Assurance Project Plan:
Stream Monitoring Program in Support of Seneca-Keuka Watershed Nutrient Model

_________________________ Date: 2-25-20

Ian Smith, Seneca Lake Watershed Steward, Finger Lakes Institute at Hobart and William Smith Colleges

_________________________ Date: 2-25-20

Colby Petersen, Keuka Lake Watershed Coordinator, Yates County Soil and Water Conservation District

_________________________ Date: 2/25/20

Kelly Coughlin, Chair Water Quality Committee, Seneca Lake Pure Waters Association

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A2.3 List of Abbreviations

9E	Nine Element Watershed Plan
BMP	Best Management Practice
COC	Chain of Custody
CSI	Community Science Institute
CSLAP	Citizen Science Lake Assessment Program
EPA	Environmental Protection Agency
FLI	Finger Lakes Institute
HAB	Harmful Algal Bloom
HDPE	High Density Polyethylene
HUC	Hydrological Unit Code
HWS	Hobart and William Smith Colleges
KLA	Keuka Lake Association
KLWC	Keuka Lake Watershed Coordinator
KWIC	Keuka Watershed Improvement Cooperative
NELAP	National Environmental Laboratory Accreditation Program
NH_3	Ammonia
NO_x	Nitrate + Nitrite
NYSDEC	New York State Department of Environmental Conservation
NYSDOS	New York State Department of State
QAPP	Quality Assurance Project Plan
QAQC	Quality Assurance / Quality Control
RPD	Relative Percent Difference
SLPWA	Seneca Lake Pure Waters Association
SLWS	Seneca Lake Watershed Steward
SRP	Soluble Reactive Phosphorus
SWAT	Soil Water Assessment Tool
SWIO	Seneca Watershed Intermunicipal Organization
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
USGS	United States Geological Survey
WQ	Water Quality
YCSWCD	Yates County Soil and Water Conservation District

A3: Distribution List

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A4: Project/Task Organization

Ian Smith: *Seneca Lake Watershed Steward (SLWS), Finger Lakes Institute at Hobart & William Smith Colleges*
Responsibilities: Coordinate and manage collection of hydrological data from Seneca Lake watershed. Perform all hydrological computational analyses. Project QAQC Officer; makes final quality assurance and quality control (QAQC) assessments on usability of all hydrological and chemical data upon entry into database.

Colby Petersen: *Keuka Lake Watershed Coordinator (KLWC), Yates County Soil & Water Conservation District*
Responsibilities: Coordinate and manage collection of hydrological data from Keuka Lake watershed. Validation of accuracy with all hydrological and chemical data records upon entry and QAQC approval.

Kelly Coughlin: *Water Quality Program Manager Seneca Lake Pure Waters Association*
Responsibilities: Coordinate and train SLPWA water quality volunteers. Manage collection of samples from Seneca Lake watershed for analysis and assure compliance with QAPP procedures. Enter analysis results into database upon receipt from analytical laboratory.

Rose Ann Garry: *Quality Assurance Officer, NYSDEC Division of Water Standards and Analytical Support Section*
Responsibilities: Verify that those elements outlined in the *EPA Requirements for Quality Assurance Project Plans (QA/R-5)* document are present and sufficiently addressed within this QAPP.

SLWPA Water Quality Volunteers: *Water Quality Volunteers*, *SLPWA*
Responsibilities: Collect water quality samples and record field metadata. Delivery of water samples to laboratory.

YCSWCD and FLI Water Quality Technicians: *Water Quality Technicians, YCSWCD and FLI*
Responsibilities: Conduct field discharge measurements. Record and download stream stage data.

Lines of responsibility and communication for personnel involved in project implementation are illustrated in Figure 1. Any changes to planning and/or project documents will receive technical and management review by the SLWS and KLWC.

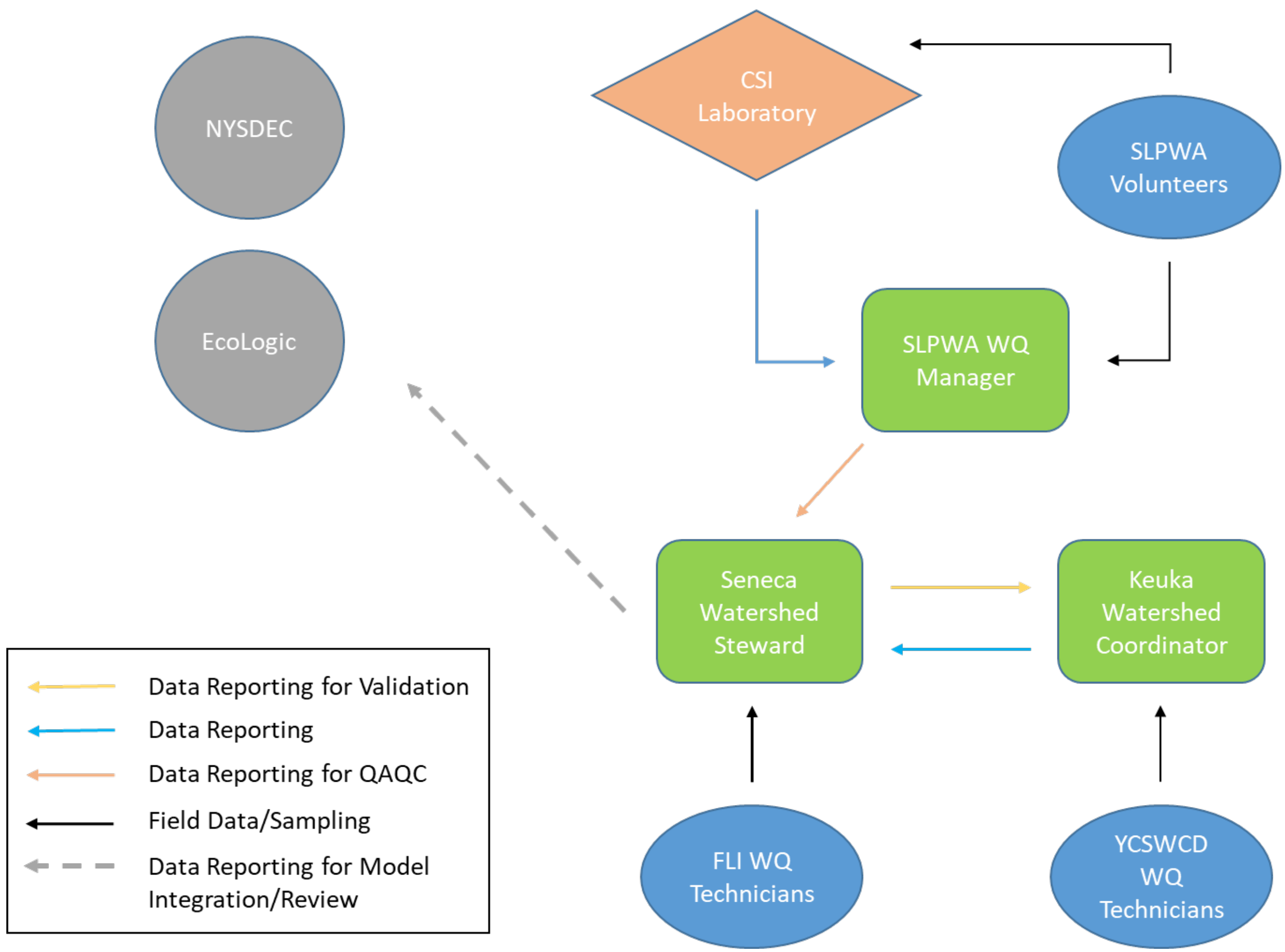

Figure 1. Data management workflow for water monitoring program.

A5: Problem Definition/Background

The 712 square miles Seneca Lake watershed – which includes both Seneca and Keuka Lakes – is located in Finger Lakes region of upstate New York and subwatershed of Lake Ontario and the greater Great Lakes Basin (Figure 1). The Seneca watershed extends from the communities of the Village of Hammondsport and Town of Branchport in the west, to the Village of Horseheads and Town of Fayette in the east, spanning the five counties of Chemung, Ontario, Schuyler, Seneca, Steuben and Yates.

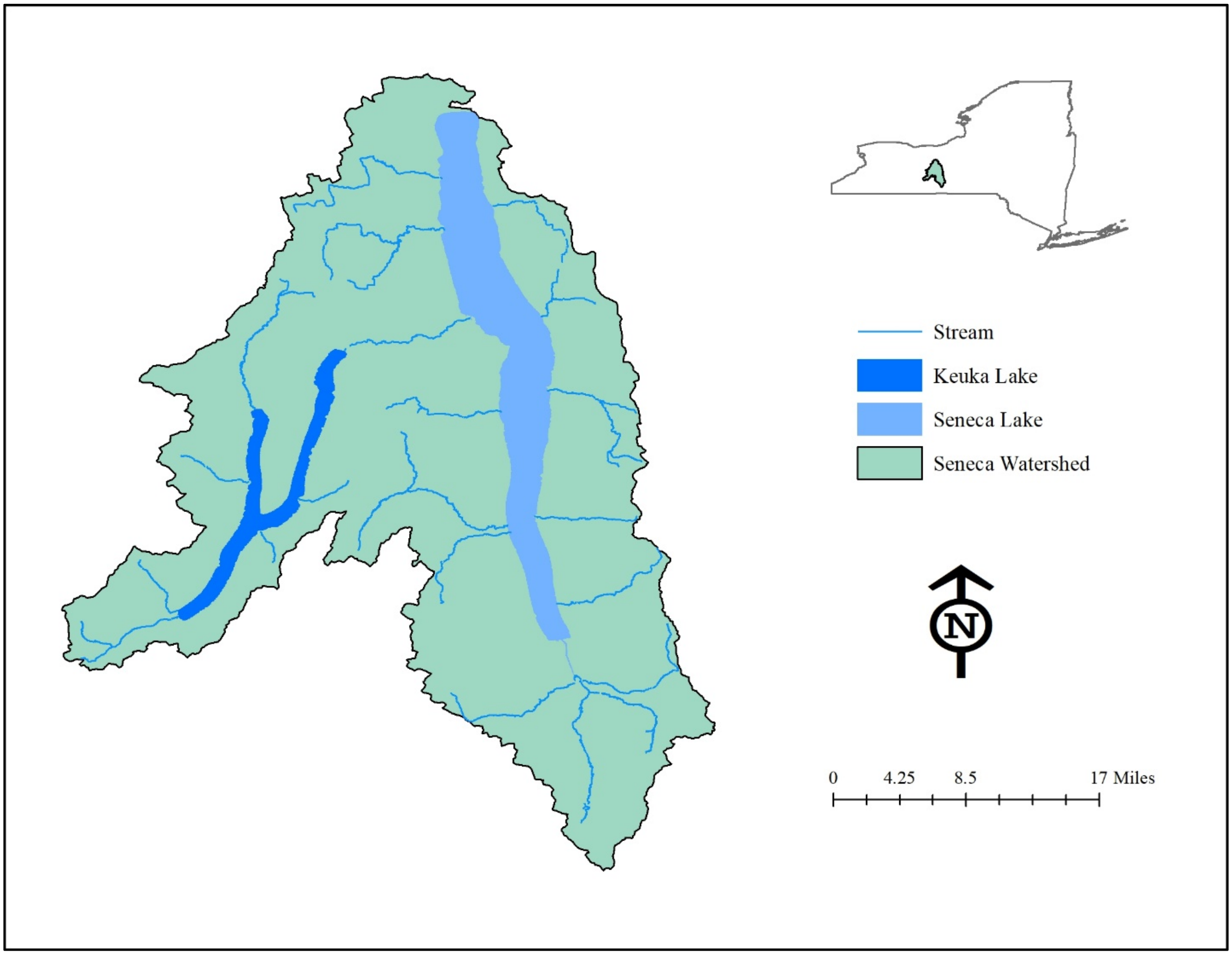

Figure 2. The Seneca Lake watershed and its principal tributaries.

Combined, Keuka and Seneca lakes contain more than half of all surface waters in the Finger Lakes region, and as such are a valuable natural resource to surrounding communities as indicative of the waterbodies inclusion on the 2016 NYSDEC Division of Water's Priority Waterbodies List. Both lakes and a small portion of headwater tributary streams are designated Class A/AA and serve as public waters supplies for several communities including some lakeshore residents who draw directly from the lakes themselves.

The watershed itself is highly valued for its uniquely beautiful lands and rural characteristics. It is at the heart of the burgeoning Finger Lakes agro-tourism industry and contains the vast majority of wineries and vineyards that have made the Finger Lakes regional an international destination. Extensive recreational opportunities such as sailing and fishing, plus numerous publically accessible lands and parks such as Watkins Glen State Park, only add to its social and economic value.

While Reeder Creek – a tributary to Seneca Lake located in the northeastern portion of the watershed – is the only waterway identified as impaired and listed on the New York State 303(d) list, the relatively recent and continuous proliferation of harmful algal blooms (HABs) in both Seneca and Keuka Lake threaten the health and continued use of these resources. Keuka Lake Association (KLA) and Seneca Lake Pure Waters Association (SLPWA) have implemented volunteer based HABs monitoring programs and documents dozens of blooms over the last three years, while NYSDEC's Citizen Science Lake Assessment Program (CSLAP) reports make clear the threats posed by HABs (Figure 2).

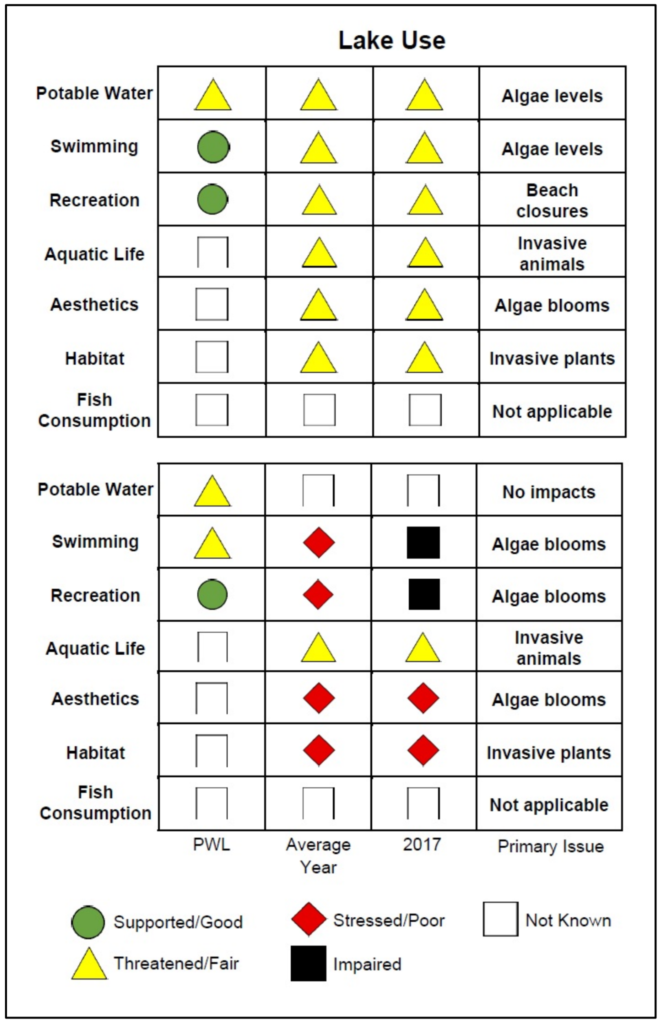

Figure 3. CSLAP water quality report cards for Keuka Lake (top) and Seneca Lake (bottom) north sites in 2017. Source: NYSDEC (2017a, 2017b).

Although a scientific consensus on the cause(s) of HABs is not clear, reductions in watershed nutrient loading is frequently identified as a key management tool for limiting the proliferation of HABs and improving overall water quality. As such, the regional stakeholder groups of KLA, SLPWA, Keuka Watershed Improvement Cooperative (KWIC) and Seneca Watershed Intermunicipal Organization (SWIO) have formed a partnership to pursue completion of a Nine Element watershed management plan (9E) to limit nutrient loading to the lakes. In 2019, the environmental consultant firm EcoLogic, LLC was hired to help lead this effort with additional guidance and support from the NYSDEC Finger Lakes HUB.

The stream monitoring program has been established to provide water quality data of sufficient quality to be used in the nutrient model developed as part of the 9E process, and this QAPP developed to ensure that this objective is meet.

A6: Project/Task Description

A Soil Water Assessment Tool (SWAT) model is being developed as part of 9E planning process to characterize the extent and distribution of nutrient loading across the 1,300 plus miles of streams within the watershed. This model is dependent upon the availability of high quality water chemistry and hydrology data which are currently lacking. As such, this monitoring project is developed to provide key water quality data from the Seneca watershed needed for use in the SWAT model. This QAPP serves as guide for all field monitoring, sample collection and storage, laboratory analysis, and data entry practices associated with said project.

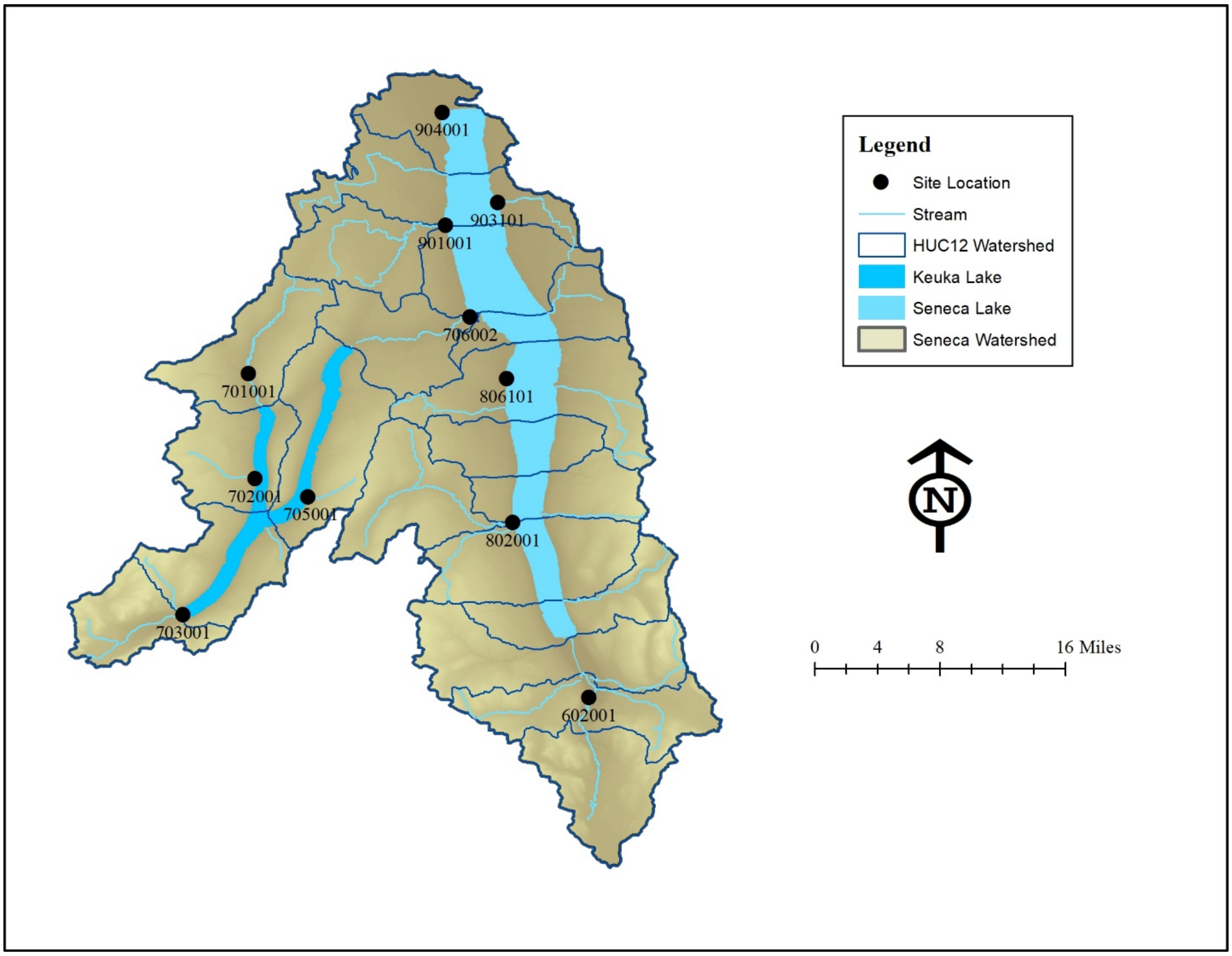

Figure 4. Monitoring site locations for 9E.

The 9E partnership group, EcoLogic and NYSDEC have identified eleven sites for monitoring (Figure 4). Out of these, NYSDEC is responsible for the collection a portion of the water chemistry data at seven and hydrology data at three. In addition, USGS gauging stations are present at three. The remaining water chemistry and hydrology needs are the subject of this QAPP (Table 1).

Table 1. Monitoring sites subject to this QAPP and data gathering framework.

Site Name	HUC12 ID	Site Location (Lat, Long)	Site ID	# Water Chemistry Sampling Events			Responsible Organization for Chemistry	Flow Data C = Continuous I = Instantaneous	Responsible Organization for Flow[1]
				Baseflow	Low-Intensity Stormflow	High-Intensity Stormflow			
Catherine Creek	41402010602	42.32833, -76.84389	602001	4	—	—	SLPWA	—	—
West Branch Keuka Lake	41402010702	42.53081, -77.15289	702001	—	—	—	—	C	KWIC
Keuka Inlet	41402010703	42.40482, -77.21960	703001	—	—	—	—	C	KWIC
Keuka Lake Outlet	41402010706	42.68028, -76.95388	706002	4	2	—	SLPWA	—	—
Big Stream	41402010802	42.49000, -76.91430	802001	4	—	—	SLPWA	C	—
Mill Creek Unnamed Trib	41402010806	42.62330, -76.82008	806101	—	—	—	—	C	SWIO
Kashong Creek	41402010901	42.76510, -76.97650	901001	4	—	—	SLPWA	—	—
Reeder Creek	41402010903	42.78600, -76.92800	903101	4	—	2	SLPWA	C	SWIO
Castle Creek	41402010904	42.86964; -76.97958	904001	4	2	—	SLPWA	C	SWIO

[1] SWIO and KWIC watershed project managements services provided by FLI and YCSWCD staff, respectively.

While this does not necessarily allow for a full watershed-scale analysis, the selected sites are representative of the watershed as a whole. However, the 9E partnership group acknowledges that additional monitoring locations and/or subsequent revisions to this QAPP may be required in the future as organizational responsibilities shift and specific remediation projects proposed in the 9E are pursued.

Water quality chemistry data collection responsibility lies with SLPWA and their volunteers. Samples will be collected under variable flow conditions and at varying frequencies between April 2020 and October 2020. Four baseflow events will be sampled at four (4) to six (6) week intervals, and, at sites 706002, 903101 and 904001, two (2) stormflow events dependent on the availability of appropriate hydrological conditions. For sites 706002 and 904001, a single sample will be collected during each stormflow event; denoted as low-intensity storm sampling. For site 903101, 5-12 samples will be collected at 30 to 60 minute intervals for each event depending on hydrological response of the stream segment being monitored; denoted as high-intensity storm sampling. All samples will be analyzed for total phosphorus (TP), soluble reactive phosphorus (SRP), nitrate and nitrite (NO_x) total Kjeldahl nitrogen (TKN), ammonia (NH_3) and total suspended solids (TSS).

Hydrology data collection responsibility lies with FLI, YCSWCD and their respective technicians. Hydrology data will be collected continuously over the same April through October period at sites 702001, 703001, 806101, 903101, and 904001. Additional sampling information can be found in sections B2 and B3 of this document.

Monitoring data will ultimately be used to setup and calibrate the SWAT model, which in turn will be used to quantify nutrient loading and inform nutrient reduction efforts. Furthermore, continued collection of data can be used in conjunction with the SWAT model to assess success or failure at achieving these reductions.

A7: Data Quality Objectives and Criteria

When developing a monitoring program, sample location, sample frequency, adherence to standard methods, and statistical rigor must be considered to generate viable data. In an ideal scenario, data would be collected on a watershed-wide and continuous basis using standard and statistically robust methods. In reality, spatial, temporal and financial limitations impose constraints on monitoring design. Instead, it must be designed in such a way as to achieve the study objectives – in this case identifying/monitoring pollution sources and future Best Management Practice (BMP) efficacy – while remaining financially achievable and statistically defensible.

Various approaches can be employed when selecting monitoring sites. As the sensitivity of the SWAT model being developed is limited to the Hydrological Unit Code (HUC) 12 scale, the 9E partnership group is specifically concerned with addressing those HUC12 watersheds representative of the greater Seneca watershed as a whole and not currently monitored in whole by NYSDEC or the United States

Geological Survey (USGS). The group also limits the number of total monitoring sites to ensure that it has the capacity to complete all monitoring activities within a single 24-hour period.

Similarly, the group has to limit the frequency of sampling to ensure that personnel time and monetary resources are not depleted but still allow for the generation of statistically relevant data. Because the overall goal is ultimately to improve water quality and reduce nutrient availability, the group intends to collect data over an indefinite period until the target loads reductions identified by the 9E model and watershed plan are meet. As previously mentioned, future BMP projects may require more targeted and frequent sampling to better characterize pollution sources/reductions but are currently not the subject of this program.

Any data generated must be of known and acceptable quality for use in developing the 9E. Significant inaccuracies could lead to poor management decisions and, as such, yield limited improvements in water quality. Assessments of quality for hydrology data is limited to adherence with sampling methodology (see section B4) and compliance with equipment maintenance practices (see section B6). For chemistry data, this project uses the following data quality indicators: precision, accuracy, representativeness, and, when applicable, comparability.

Precision assesses the reproducibility for a given result and is confirmed through the replication of all analytical data at a given location. This will be quantitatively assessed through collection and analysis of a duplicate field sample at a frequency of at least 5% (1 duplicate per 20 samples), and expressed as the relative percent difference (RPD) which is defined as follows:

$$\text{RPD (\%)} = [\,|X_1 - X_2| \div (|X_1 + X_2| \div 2)] \times 100$$

where X_1 is the original sample concentration and X_2 is the duplicate sample concentration. A RPD of ≤15% will be indicative of sufficient precision in field sampling methodology, although exceedances may be permitted when levels are below the laboratory reporting limit with final determination on usability made the QAQC Officer, the Seneca Watershed Steward. The 9E team relies on the in-house Quality Assurance / Quality Control (QAQC) of the Community Science Institute (CSI) in determining the precision of the analytical methods employed and discussed further in section B4. CSI's acceptance criteria for precision is ≤15%. Any RPD in excess of 15% for a given parameter is to be noted on the analytical report issued by CSI.

Accuracy is typically assessed in two ways: through the analysis of a sample containing a known quantity of a given analyte (henceforth referred to as a QC standard); and/or through the addition of a known amount of a given analyte to a random sample and quantitative comparison to that sample without addition (henceforth referred to as a matrix spike). The QC standard assures that the equipment is measuring accurately relative to a non-sample while also tracking sensor drift. The matrix spike(s) assesses whether a sample has high or low bias resulting from some sort of interference.
This project relies on the in-house QAQC of CSI in determining the accuracy of the various laboratory methods employed in analysis as assessed through the inclusion and analysis of a QC standard, matrix spike and matrix spike duplicate for each parameter as appropriate (matrix spikes are not typically

employed in TSS analysis nor required by National Environmental Laboratory Accreditation Program standards) at a minimum frequency of once per every 10 samples. CSI's acceptance criteria for accuracy is ≤15% with exceedances noted in the analytical report issued by CSI.

Representativeness, or the ability of a sample to replicate the environmental conditions at the time of sampling, will be assessed both quantitatively and qualitatively. A blank sample consisting of deionized water will be collected, stored, shipped and analyzed in an identical manner to other collected samples for each sampling event. Laboratory analysis of the blank will allow for quantitative assessment of the extent of bias and error introduced by the sampling methodology. For the blank, any analyte value reported in excess of the detection limit will be an indicator of statistically significant error. Qualitative evaluation of bias and error will be assessed through adherence to all quality control processes implemented by the analytical laboratory (e.g. chain of custody procedures, sample preservation, sample holding times, etc.). Failure to comply could suggest a source for any observed error evident in the blank.

Finally, when possible, the comparability, or the degree to which data across multiple studies agree with one another, will be assessed qualitatively as it is an indication of the replicability of all data. Large disagreements in data for an identical location and time are indicative of failures in QAQC for at least one of the datasets. In such a scenario it is inappropriate to use faulty data in any analysis or decision making unless it can be conclusively determined why the disagreement is present and/or the data can be quantitatively adjusted (e.g. unit disagreement).

Data found to be outside acceptable guidelines for precision, accuracy, representativeness and/or comparability will not be included for use in the SWAT model, though it may be recorded and flagged at the discretion of the QAQC Officer. Field hydrology data found to be unacceptable will be reported by QAQC Officer who will attempt to determine the source of the error. If the error is instrument based, the QAQC Officer will contact the appropriate manufacturer for guidance on repairing or replacing the defective device. If the error is believed to be due to sampling design, the QAQC Officer, in conjunction with the Data Validation Officer will be responsible for re-designing the affected sampling protocols and re-training any field personnel or volunteers. In the event data generated by the contracted laboratory is found to be unacceptable, the QAQC Officer will request a rerun of the sample(s) to confirm the validity of the report.

A8: Special Training/Certification

The SLWPA Water Quality Manager is responsible for providing training to all SLPWA volunteers in matters related to water quality chemistry data/sample collection. The SLWS and KLWC are responsible for providing training to all FLI and YCSWCD Water Quality Technicians, respectively, in matters related to hydrological data collection. Through a combination of educational and professional experience, these individuals have acquired the knowledge and skills necessary to assess the appropriate level of training required to sufficiently meet the quality objectives. In some cases, individuals offering their assistance may already have obtained training/certification through their own in-house processes;

e.g. NYSDEC Finger Lakes HUB personnel. It is the responsibility of the QAQC Officer to determine if such individuals require any further training or certification.

Each individual responsible for the collection of any data/samples is to be trained for those tasks he/she is expected to carry out. This could include equipment operation, maintenance and calibration, proper sampling techniques, storage and transport guidelines, and/or data recording and entry.

At present, the QAQC Officer has concluded that no specific certifications are necessary to carry out the sampling schemes described in this document. However, it is incumbent upon the QAQC Officer to stay apprised of any regulatory changes made by these – or any other relevant – agencies and adjust the training and certification protocols as necessary.

A9: Documents and Records

A hardcopy version of the QAPP will be housed with the Seneca Lake Watershed Steward housed at the Finger Lakes Institute at 601 South Main, Geneva NY 14456. An electronic copy will reside on a google share drive and will be accessible for all personnel. In the event of any revisions, the updated version will replace all physical and electronic copies, though the QAQC Officer may maintain an electronic copy for historical records if deemed necessary. This QAPP is to be updated and revised at a minimum of every 5 years to reflect any changes and will be sent back to NYSDEC for further review and comment.

The partnership group intends to have at least one physical and one electronic record for each data point or report generated, in order to prevent the permanent loss of information. The QAQC Officer is responsible for maintaining all physical and electronic records associated with this work. Physical documentation includes field datasheets, calibration and QC logs, chain of custody forms, laboratory results and project reports. Physical documents will be stored in the QAQC's office and retained for a period of ten years. All electronic data and reports will be stored in perpetuity on the FLI server and compiled using the Microsoft Office suite of programs (Word, Excel, Access, etc) while additional software such as ArcGIS and R may be used in further analysis. The following data will be recorded:

- Site name/location
- Site description
- Date and time
- Personnel
- Field notes
- QAQC information
- Hydrological computations
- Analyte values
- Observed error sources

Data will be used to calibrate the Seneca Lake Watershed 9E SWAT model and by extension inform completion of the 9E Plan. Replication of this program used in conjunction with the SWAT model will allow for tracking and assessment of future restoration efforts, though will require an update of this QAPP. Data may also be used by partnership group members for outreach purposes such as newsletter articles, fundraising and public presentations. Finally, data may be submitted and shared with other watershed organizations and government agencies for the furtherance of watershed research and restoration when requested.

GROUP B: DATA GENERATION AND ACQUISITION ELEMENTS

B1: Sampling Process Design (Experimental Design)

Project sampling design is established with the goal of yielding an understanding of the physical and chemical characteristics of the Seneca watershed when used in conjunction with the SWAT model. Temporal and financial constraints make a comprehensive analysis of the entire watershed impractical. Instead, the sampling design places an emphasis on a group of HUC12 subwatersheds whose characteristics are representative of the greater watershed (Table 2).

Table 2. Percent land cover type by subwatershed. Source: 2011 CDL-NLCD Hybrid Land Cover Dataset.

HUC12 Name	HUC12 #	Forest (%)	Scrubland (%)	Wetland (%)	Urban (%)	Agriculture (%)
Sleeper Creek-Catharine Creek	041402010602	45.4	3.5	5.2	5.4	40.0
Sugar Creek	041402010701	41.8	3.9	3.9	4.2	45.9
W. Branch Keuka Lake	041402010702	38.0	4.5	1.3	4.4	38.1
Keuka Inlet	041402010703	64.7	8.0	2.2	4.0	20.5
E. Branch Keuka Lake	041402010705	33.9	5.9	1.3	7.3	35.0
Keuka Lake Outlet	041402010706	11.3	1.2	2.4	9.0	75.8
Big Stream	041402010802	32.7	6.5	3.2	5.1	52.2
Mill Creek	041402010806	18.4	3.6	1.9	4.2	50.2
Kashong Creek	041402010901	9.4	0.5	5.9	4.1	80.1
Wilson Creek	041402010903	7.9	4.1	5.8	5.5	58.2
Castle Creek	041402010904	8.5	0.7	3.4	18.7	43.6
Seneca Lake Watershed	**NA**	**31.1**	**5.1**	**3.0**	**6.2**	**42.1**

The majority of monitoring sites are established at or near the principal HUC12 outlet with the exceptions of sites 806101 and 903101 which were selected due to the availability of previously collected hydrology data and the uniqueness of the 303(d) listed Reeder Creek (Table 3), respectively. In general, the availability of existing chemistry and/or hydrology data was an additional factor in site selection. Completed or ongoing SLPWA, NYSDEC and USGS monitoring efforts that generated or continue to generate data deemed usable through QAQC assessment by EcoLogic (with input from NYSDEC) are available for all monitoring locations to varying degrees. These existing data, coupled with the data obtained from the monitoring program subject to this QAPP, will improve performance of 9E SWAT model, ensuring that the model achieves its own quality standards.

Table 3. New York State 303(d) listed streams in the Seneca Lake watershed. Source: 2018 NYSDEC

Water Index #	Waterbody Name (WI/PWL ID)	County	Type	Class	Cause/Pollutant	Suspected Source	Year Listed
Ont 66-12-P369-6	Reeder Creek and tribs (0705-0074)	Seneca	River	C	Phosphorus	Unknown	2016

With the exception of site 806101 where existing chemistry data is unavailable, samples are to be collected at all sites under varying flow conditions throughout the sampling period in an effort to capture the variability in loading rates. Due to limitations in equipment and personnel availability, the sampling frequency during stormflow events will vary. A single grab sample will be collected at half the sites (low-stormflow sampling), while 5 to 12 samples will be collected at a rate of 1 per hour at the remaining half (high-stormflow sampling) in an effort to capture the change in loading along the rising and falling limb of the peak discharge curve. However, it may be necessary to lengthen or shorten the high-stormflow sampling interval depending on the rate of response in stream discharge to precipitation events as assessed through analysis of hydrology data. All collected samples are to be analyzed for TP, SRP, NO_x, NH_3, TKN and TSS by CSI.

Hydrology data will be collected continuously at all sites lacking existing hydrological recording equipment; e.g. USGS gauged sties. Stage height will be recorded at one-hour intervals for all sites except 806101 where it the interval will be 20 minutes. Previously collected hydrology data indicates that the stream responds rapidly to precipitation and a shorter interval is needed to capture peak discharge. Stage data will be correlated to field discharge measurements collected under variable flow conditions. A minimum of two discharge transects are to be conducted on any given day and averaged to establish a discharge value at a given stage. Discharge values will be determined at a minimum of five (5) different stage heights to establish a statistical relationship between stage and discharge.

The following metadata will be collected with each field sampling or discharge measurement event,

- Site name/ID, date, time and sampler(s)
- Equipment ID numbers, if used
- Climatic conditions
- Visual assessment of water
- Field notes regarding any abnormal site condition and/or maintenance performed
- Geographical coordinates via GPS device if not previously recorded

In addition, air temperature and water temperature data will be recorded during chemistry sampling events using a standard thermometer. While sampling is scheduled on a roughly monthly basis between April and September, seasonal restrictions may prohibit sampling during prolonged periods of drought. Additional delays may arise from unexpected events inhibiting the scheduled availability of staff or volunteers. In the event a scheduled sampling has to be postponed or is delayed, all volunteers, staff and (if needed) CSI are to be notified and an updated date scheduled. When possible, any updated date is to be within one week of the initial sampling date to avoid excessively long/short periods between samplings. If conditions prohibit sampling within a given month, that sampling is to be abandoned rather than sampling twice within one month.

B2: Sampling Methods

Chemical and physical field sampling is to take place within a stream/discharge segment that, as much as possible, is: 1) free of non-uniformly distributed sediment or debris; 2) upstream from the in-stream path used by the sampler to reach the sampling point; 3) sufficiently downstream of any immediate upstream tributary or discharge; and 4) free of significant physical structures that generate non-uniform hydraulics. Furthermore, all future data collection is to take place approximately along the same transect when possible. The introduction of potential sources of error will be minimized by following these guidelines.

Sampling methods for water chemistry analysis are consistent with EPA standard methods guidelines. Pre-cleaned bottles will be provided by CSI laboratory ahead of a sampling event and stored in a cooler in dust free location to prevent potential contamination. At the time of sampling, all bottles are to be labeled with the following information: sample location/ID, sample date and time (military time), sampler initials, analyte(s), and preservative (if any used).

Two grab samples will be collected per site for each baseflow or low-stormflow sampling event. For high-stormflow sampling at site 903101, 15 to 36 grab samples at 5-12 different points in time will be collected. A sample will be collected from the thalweg at approximately 50% depth facing upstream in a triple rinsed (using approximately 100mL of sample water with each rinse) 1000mL high density polyethylene (HDPE) bottle provided by the laboratory. A 75mL sterile syringe is then filled and rinsed three times using this collected sample. The syringe will be filled and a 0.45µm filter attached. A 75mL HDPE bottle will be triple rinsed using 10-120 mL of filtered sample. The 75mL bottle is then filled with filtered sample – refilling the syringe as needed – for SRP analysis. No head space is to remain in the sample bottle and filtration is to be completed within 15 minutes of initial sample collection. After discarding any remaining sample left in the 1000mL HDPE bottle, the bottle is then refilled leaving no head space within the container for TP, NO_x, NH_3, TKN and TSS analysis.

Stream discharge measurements will be collected by the velocity-area method. A wading rod and either a Hach FH950 Flow Meter or a USGS Type AA flow meter paired with an AquaCalc Pro will be used to take a series of velocity measurements along a transect perpendicular to streamflow. A tape will be placed across a given stream segment and, at intervals that are approximately $1/15^{th}$ to $1/20^{th}$ of the total distance from bank to bank, stage depth will be recorded and a velocity measurement taken at 60% of stage depth across the entire length of the transect (Figure 5). A minimum of 15 measurements are required with no more than 20% of total discharge volume measured at a single location. In some instances flow may be directed through an artificial structure such as a culvert or weir. In this case, a single depth and velocity measurement can be taken at the thalweg assuming laminar flow and sufficient knowledge of the cross-sectional area – e.g. diameter of a culvert or pipe– is known.

Site Name:	**Station**	**Distance (dec.ft)**	**Depth (dec.ft)**	**Velocity (ft/s)**
Site ID:	1		0	0
Personnel:	2			
	3			
	4			
Date:	5			
Time:	6			
Stage:	7			
	8			
	9			
Instrument ID:	10			
QAQC Field Check:	11			
	12			
	13			
Notes/Maintenance:	14			
	15			
	16			
	17			
	18			
	19			
	20		0	0

Figure 5. Field datasheet for discharge measurements.

Continuously collected stage data will be recorded via Onset HOBO® U20L-04 water level logger or Meter Group Hydros 21 mated to an EnviroDIY Mayfly data logger. Equipment is to be installed via manufacture guidelines and USGS gauging standards. Sensors are to be placed within a free flowing and continuously wetted portion of the stream. A sensor will then be affixed to quarter inch rebar driven into the streambed to prevent movement of the sensor. A gauge board is to be affixed to an additional piece of rebar and placed nearby to track and account for sensor drift; stage to be recorded on the field sheet at each discharge measurement event. An additional HOBO ® logger is to be deployed in open air to collect atmospheric pressure data to allow for atmospheric compensation. Stream deployed sensor pressure data will then be converted into stage depth data using the HOBOware® analysis software in conjunction with the built in atmospheric compensation tool.

B3: Sample Handling and Custody

Table 4. Sample storage requirements for parameters of interest. Source: EPA, 1987.

Measurement	Vol. Required (mL)	Container	Lab Preservation	Holding Time
Total Phosphorus	100	HDPE	< 4°C, H_2SO_4 to pH <2	28 days
Soluble Reactive Phosphorous	50	HDPE	< 4°C	48 hours
Nitrate + Nitrite	100	HDPE	< 4°C, H_2SO_4 to pH <2	28 days
Ammonia	100	HDPE	< 4°C, H_2SO_4 to pH <2	28 days
Total Kjeldahl Nitrogen	100	HDPE	< 4°C, H_2SO_4 to pH <2	28 days
Total Suspended Solids	500	HDPE	< 4°C	7 days

Sample labels provided by the contracted laboratory are to be filled out in full to accurately reflect the time of sampling. This information will also be concurrently recorded on the chain of custody (COC) provided by the contracted laboratories (Figure 5). Labels and the COC are to be filled out by the individual collecting the sample and checked for accuracy by another individual. Samples are stored on ice in an insulated cooler while in the field. No field-preservation is required for this project.

Samples submitted to CSI must be accompanied by a fully completed COC that serves as the request form for analysis. All SLPWA Volunteers must make certain that all information requested on the COC is provided and that the information on the COC mirrors that of the sample labels. The SLPWA volunteer(s) responsible to delivery of samples to CSI will sign and date the COC upon relinquishment at which point CSI is responsible for following the sample handling and custody guidelines established by EPA standard methods. Laboratory personnel are responsible for review of the COC for completeness and will not sign off on them unless complete.

The SLPWA Volunteer responsible for delivery of samples should retain a copy of the COC and submit to the SLPWA WQ Manager. The WQ Manager will in turn provide a copy of the COC to the QAQC Officer in conjunction with analytical results for assessment.

Community Science Institute www.communityscience.org **Code:**

NYSDOH-ELAP #11790 EPA Lab Code NY01518

Stream Water Sample Tracking Sheet and Chain of Custody

Location Information

Stream: ______________________________

Sample Location: ______________________ **Sample Location Code:** ________

Location Latitude/ Longitude: ____

Location Type: ☐ Synoptic ☐ Investigative (please fill out coordinates above)

General Information

Sample Collected By: ________________________

Date Sampled: _____________ **Time Sampled:** _____________

The CSI team loves photos of water features and volunteers monitoring! Please send photos to info@communityscience.org

Weather Conditions

Sky: ☐ Clear ☐ Partly Cloudy ☐ Overcast ☐ Rainy | **Rain:** ☐ Light ☐ Moderate ☐ Heavy

Wind: ☐ Calm ☐ Moderate ☐ Windy ☐ Rainy | **Air Temperature:** _____ ° C

Please describe any unusual weather conditions that might impact water quality on the back of this sheet.

Water Conditions

Water Temperature: _____ ° C | **Flow Conditions:** ☐ Baseflow ☐ Moderate ☐ Stormwater

Water Appearance: ☐ Clear ☐ Murky ☐ Muddy ☐ Chocolate Brown

How was the sample collected: ☐ Waded ☐ From Shore ☐ From Bridge

Please describe any unusual field observations that might impact water quality on the back of this sheet.

Sample Storage: ☐ Wet Ice (Preferred) ☐ Blue Ice ☐ Not Cooled

Chain of Custody

	Date	Time	# Cont.	Relinquished By	Accepted By	Remarks
1.						
2.						
3.						

<u>Sample acceptance policy</u>: Sample **must be** identified unambiguously by entering the field code and the date and time of collection directly on the label on the sample bottle. Samples **must be** cooled such that the temperature is 6° C (43° F) **or less** on arrival at the lab; alternatively, the sample must arrive at the lab **on ice**. Wet ice is preferred. Sample containers **must be** intact and undamaged. **No preservative** may be added to the sample. Samples that do not meet acceptance criteria **may be rejected** at the discretion of laboratory personnel.

Lab Use Only **Sample Temperature:** _____ ° C **Sample Accepted:** ☐ Yes ☐ No

283 Langmuir Lab/Box 1044 95 Brown Road Ithaca NY 14850

607 257 6606 info@communityscience.org

Figure 6. Chain of Custody for CSI.

B4: Analytical Methods

The 9E partnership group presently contracts with the National Environmental Laboratory Accreditation Program (NELAP) certified Community Science Institute based in Ithaca, New York. The standard methods used in analysis of samples, their detection limits, and the expected range are presented in Table 5.

Table 5. Analytical method and limits of analysis for parameters of interest.

Parameter	Method	Expected Range	MDL[a]	RL[b]
Total Phosphorus	SM 18 4500-P E, B	10 – 150	1.5	4
Soluble Reactive Phosphorous	SM 18 4500-P E	1 – 150	0.3	1.1
Nitrate + Nitrite	SM 18 4500-NO3 F	0.01 – 2.0	0.01	0.02
Ammonia	SM 18 4500-NH3 D or E	0.01 – 2.0	0.05	0.1
Total Kjeldahl Nitrogen	SM 18 4500-NH3 D or E	0.01 – 1.0	0.05	0.1
Total Suspended Solids	SM 18 2540 D	1 - 250	1	2.5

[a] Method Detection Limit: lowest or minimum level that provides 99% confidence level that the analyte is detected. Any reported result values that are less than the RL are considered estimated values.
[b] Reporting Limit: lowest or minimum level at which the analyte can be quantified.

In order to maintain their New York State and NELAP certification, CSI must undergo an audit which assesses, amongst other things, that staff are adequately trained at performing their assigned responsibilities, QC procedures are in place and corrective actions are effective and traceable. As such, this project relies on CSI's in-house QAQC procedures and expertise to assure the validity of the data reported.

B5: Quality Control

This project relies on CSI's QAQC procedures when assessing the quality of laboratory analytical data. When a reported measurement is outside the limits of the analysis, it will be recorded at the level of the detection limit and flagged as such. In the event that the QAQC Officer suspects the reported measurement is inaccurate, a rerun of the suspect sample(s) and parameter(s) will be requested. If this is not possible, the data will be recorded and flagged, although used in further analysis if all QAQC checks have passed.

To validate all in-house field, filter and storage methods, additional QC samples will be submitted to CSI for analysis. Results of QC samples are to be recorded in the appropriate in water quality dataset under the "QAQC" table.

Immediately prior to the start of sampling, a *field blank* will be collected in an identical manner to that of a standard sample. DI water will be used to triple rinse both the 1000mL and 75mL laboratory provided

HDPE bottles and a sample collected. DI water is to go through the same filtering process used for SRP analysis and rinsing with regards to the 75mL bottle. The *field blank* will be submitted to the lab and any reported value in excess of two times the detection limit will be indicative of error in the sampling and/or handling procedure.

A *field duplicate* will be collected at a rate of 1 per 20 samples with the location(s) to be duplicated selected at random. This sample will be collected, handled, filtered, stored and analyzed in an identical manner to that of the standard sample. Significant deviation between the standard and duplicate sample will be indicative of error and will be quantitatively calculated as the RPD (see section A7). A RPD in excess of 20% will be indicative of significant error.

Quality control of field thermometers will be assessed through periodically comparing field thermometer readings to that of a certified thermometer. Similarly, stage sensor accuracy will be monitored for sensor drift through the recording of the field stage height on the gauge board and analysis of this relationship. Finally, flow meter sensors will be periodically checked through zero flow measurements consisting of placement of the sensor in a stationary container of water; readings +/- 0.01 ft/sec indicative of sensor error.

The QAQC Officer will be responsible for determining the appropriate corrective action upon discovery of a quality control failure. If it is possible to trace the specific source of error, the affected data will be recorded and flagged. In such an instance, changes in the procedure – and subsequently changes in this document – may be called for. If the cause of error is not determinable, then the affected data will be omitted and the entire sampling could be repeated.

B6: Instrument/Equipment Testing, Inspection, and Maintenance

Regular maintenance of instrumentation is necessary to maximize lifespan and reliability. The QAQC Officer will be responsible for testing, inspecting and maintaining all field equipment and assuring proper functionality prior to any field use. Maintenance of all laboratory equipment is subject to CSI's authority and beyond the scope of this QAPP.

At the termination of any inspection or field sampling activity, all equipment is to be examined for damage, cleaned with tap or DI water, and stored according to the manufacturer's guidelines. Given that all equipment eventually fails, the QAQC Officer will be responsible for assuring that replacements are kept in stock for frequently replaceable and susceptible components whenever financially feasible in order to avoid extended delays in project work.

Where applicable, battery life, gaskets, electrical contacts, storage solutions and programming will all be examined. The QAQC Officer will maintain a maintenance log and in the event an issue is found, he/she will make note of the date, the nature of the error, maintenance performed and whether the error was corrected. The QAQC Officer will contact the appropriate manufacturer and arrange to have the affected instrument returned for repair as needed. These instrumentation checks are to be performed on a quarterly basis. Any field sampling personnel are to report failures or anomalies to the appropriate manager as well.

B7: Instrument/Equipment Calibration and Frequency

All equipment used in this project is calibrated by the manufacturer during production and does not require recalibration. Continued accuracy of the calibration is assessed through the quality control procedures previously described. This project relies on the requirements set forth by the state of NY and NELAP in assuring that all laboratory equipment used by CSI is calibrated and operated in a manner consistent with the manufacturers' designs. Furthermore, QAQC results (pass/fail for matrix spikes and QC samples, RPD for field duplicates) will be used as an assessment of continued mechanical performance.

B8: Inspection/Acceptance of Supplies and Consumables

With the exception of those supplies provided by CSI (e.g. sample bottle), the QAQC Officer is responsible for ordering, inspecting, logging, testing and distributing all supplies and consumables. In addition the QAQC Officer will maintain a log noting the date received, manufacturer, lot number, expiration date, and include a certificate of analysis when applicable. Supplies and consumables will only be accepted in original manufacturer packaging.

B9: Non-Direct Measurements

This project does not concern the use of secondary data sources, though the SWAT model itself will rely on additional data sources/projects.

B10: Data Management

Field data are recorded on site on either the discharge datasheet (Figure 5) or CSI COC (Figure 6). Copies of CSI COC are submitted to the SLPWA WQ Manager while discharge field data sheets are submitted to the SLWS. All datasheets are inspected for missing and/or questionable data. Chemical analysis data generated by CSI are sent via email to SLPWA WQ Manager and reported in the CSI database. The SLPWA WQ Manager will then enter the CSI data into the project database and scans of the hardcopies uploaded for data validation. The SLWS is responsible for hydrological data entry and digitization. Hard copies of the original CSI data sheets are kept on file with the SLWPA WQ Manager. Hard copies of hydrology data are kept on file with the SLWS. Hard copies are to be keep for a period of five years. Digital/digitized versions are to be transferred over from the Google Drive to the FLI server at the end of the sampling period and keep in perpetuity.

The project partnership uses a combination of Microsoft ® Word and Excel, Google Drive docs and sheets, and Onset HOBOware software to manage and analyze data. Flow calculations are computed using Excel, while Google Docs and Sheets are used to record data and track reporting. The SLPWA WQ Manager is responsible for entering all field and laboratory chemistry data. Once all data are entered, the QAQC Officer inspects the data for compliance with QAQC requirements to confirm successful sampling and analysis execution. Finally, the KLWC validates that all data entry requirements are complete and accurate. All data entry and error correction activities are recorded in a set of documents prior to and immediately after any data management activity with hard copies retained in the SLWS's office and digital/digitized versions kept in perpetuity on FLI database.

Queries have been setup within Excel to facilitate the analysis of data within Excel and R without risking any alteration to the master dataset. The SLWS is responsible for conducting all data analysis for incorporation into reports that do not fall within the scope of EcoLogic's contract work.

B11: Project Schedule

Table 6. Annual monitoring project schedule/timeline.

TASK	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Field Sampling												
Lab Analysis												
Data Entry												
QAQC (Field)												
QAQC (Lab)												
QAQC (Data)												
Supplies Procurement												
Equipment Maintenance												
Project/Model Integration												

The project schedule is presented in Table 6. In summary, sampling and laboratory analysis will be conducted every month. QAQC of field data is to be done concurrently with sampling. Lab samples will be delivered to CSI within 24 hours and analysis completed within 28 days. Lab and field data will be entered into the database as available, after which QAQC of data entry will be completed every other month. Major equipment maintenance and resupply of consumables will be performed as needed; expected frequency 3-6 months. Finally, generated data will be integrated into the 9E SWAT model upon completion of all field work, analysis and QAQC.

GROUP C: ASSESSMENT AND OVERSIGHT ELEMENTS

C1: Assessment and Response Actions

Regular assessments will be carried out by the SLPWA WQ Manager, SLWS and KLWC with the purpose of verifying conformance with the procedures discussed in this document. The frequency of these assessments will vary depending on the nature of the procedure under evaluation.

Field sampling personnel and volunteers will be assessed onsite during their initial training and first sampling, beyond which point field and laboratory data sheets will be used as a proxy for sampling error detection. Field and laboratory data sheets will be assessed upon receipt and in accordance with the QAQC procedures described in sections A7 and B5. Maintenance, QC and supplies logs will be used to evaluate the reliability of data and identify any equipment based errors. This project will rely on the contracted laboratory's in-house assessment regarding their own performance. Finally, the SLWS and KLWC will evaluate the accuracy of any data entry on a bi-monthly basis and of any data analysis prior to inclusion into any reports.

The SLPWA WQ manager, SLWS and KLWC will have the authority to issue stop work orders for those components for which each assuming management responsibility. The SLWS will be responsible for issuing corrective actions which will vary depending on the nature of the error source. Corrections associated with personnel error will be denoted in the data records and the appropriate manager will re-train the individual(s) in the proper sampling methods or issue changes to the sampling methodology itself if appropriate. Equipment and laboratory based corrections will be noted in the data records as well. Depending on the severity of these errors any associated data may be rejected and an order to redo the entire sampling issued. If the nature of an error(s) requires a change to any of the monitoring procedures described within this QAPP, NYSDEC is to be notified of the error, anticipated corrective action/change, and a revised version of the QAPP sent to NYSDEC upon correction of the error(s). Data management errors and the associated corrective actions are discussed in section B10.

C2: Reports to Management

Reports to management are largely governed by the requirements set forth by the grant(s) funding the project work. The New York State Department of State (NYSDOS) – in conjunction with a matching contribution provided by various local private and public institutions – is providing funds for development of the 9E and associated SWAT model. As such, reports typically consist of semi-annual and close-out reports. These reports will be generated by the SLWS and submitted to the NYSDOS Project Coordinator.

Semi-annual reports will consist of a project narrative covering the current development status of varies components accompanied by a detailed description of work completed. These reports cover a six month period and are due in the months of January and July. Close out reports will be more detailed and cover the entire life of the project. This report will include an executive summary, project location, problem description, project highlights, results, project partners, and budget breakdown.

Additional reports will include laboratory analytical reports generated by the contracted laboratory and QC corrective action reports generated by the QAQC Officer. Laboratory results will be submitted to the SLPWA WQ Manager within 30 days after receipt of samples. QC corrective reports will be generated and dispersed among all project members when an error significant enough to require a change in procedure is necessary. These reports will identify the error, describe why it occurred, and describe the action taken to correct it.

GROUP D: DATA VALIDATION AND USABILITY ELEMENTS

D1: Data Validation and Usability

The following criteria are used to accept, reject or qualify data:

- Field data
  - All field datasheet information is complete and legible
  - Equipment maintenance and QC checks indicate proper operation
  - Laboratory analysis of blanks and duplicates show no indication of improper sampling
  - Sampling procedures and locations correspond to those established in this document

- Laboratory data
  - Sample handling procedures documented on the chain-of-custody are in compliance
  - Blanks and duplicates show no evidence of sampling or analysis error
  - The laboratory reports indicate presence/absence of in-house QAQC failures

- Data Entry and Analysis
  - Recorded values correspond to those on field or laboratory data sheets
  - No errors within flow calculations are evident
  - QAQC and Data Validation has been performed

Any failures to conform to the procedures in this document and the subsequent impacts on any data will be reported in the semi-annual and/or close-out reports.

D2: Verification and Validation Methods

Laboratory data will be validated through successful adherence to the sample handling and storage requirements as tracked with the COC and discussed in section B3, as well as the contracted laboratory's in-house QAQC processes (i.e. duplicates, matrix spikes, etc.). CSI procedures and practices are continuously audited as required by NY State and NELAP certifications.

Field data will be validated through the qualitative and quantitative processes discussed in sections A7, B5 and B7. Calibration and QC checks on blanks, duplicates and secondary standards will be used to confirm or deny the presence of significant error introduced by the sampling methodology. The accuracy of all data recorded in the database and any analysis results integrated into SWAT model or reports will be validated through the processes described in section B10. Entry, QAQC, and error report logs establish a data narrative used to track all aspects of data generation with validation performed.

Every two, all data and QAQC data will be validated for accuracy by the KLWC. This individual with receive all necessary information to ensure an accurate and complete validation of the data management process and all data (Figure 7).

DATA VALIDATION CHECKLIST

Validator:____________________________________

Period of Record:_______________________________

Validation Item	Yes	No	If "No", Error(s) Description
Field data sheets accurate complete?			
Database records of field data are accurate? Flow calculations free of errors?			
Equipment calibration and maintenance logs complete? Calibration and QC checks pass?			
Chain of custody accurate & complete?			
Laboratory reports match database values?			
Laboratory QAQC check failures logged in FOB database?			
Field blanks and duplicates sheets complete? Values within range for QAQC?			
Data entry record complete?			
QAQC check of database and error reporting complete and accurate?			

Sign__________________________________

Date__________________________________

Figure 7. Data validation checklist for completion by KLWC.

D3: Reconciliation with User Requirements

This monitoring project is carried out with the goal of providing information necessary to validate and calibrate the 9E SWAT model. Data must meet the standards set forth in this document to be used in support of decision making as it relates to these goals.

As data is submitted, the QAQC Officer will make a determination on the final usability of all data. This assessment will consider findings from all field and laboratory results, QAQC information, and inherent usability limitations. Justification for use and limitations on use will be discussed amongst all project partnership groups before inclusion into the SWAT or project reports. If at any point the project partnership group feels the monitoring program is failing to meets its goals, the SLWS may alter various parameters of the project including but not limited to sample location, sample frequency, QAQC protocols and analytical parameters of interest. This document will be updated to reflect any changes as appropriate and all pertinent parties made aware.

The NYSDEC may review all data generated and collected as part of this project at its own discretion.

REFERENCES

New York State Department of Environmental Conservation. 2016. *2016 Section 303(d) List of Impaired Waters Requiring a TMDL/Other Strategy*. Technical report prepared United State Department of Environmental Protection. 44 pages.

New York State Department of Environmental Conservation. 2017a. *Keuka Lake, Steuben, Yates Co.: 2017 CSLAP Report Site 1 (N).* Technical Report. 9 Pages.

New York State Department of Environmental Conservation. 2017b. *Seneca Lake, Ontario, Schuyler, Seneca, Yates Co.: 2017 CSLAP Report Site 1 (N).* Technical Report. 9 Pages.

United States Environmental Protection Agency (EPA). 1987. Sample preservation. In *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79-020. U.S.E.P.A., Cincinnati, Ohio, USA. pp.xv-xx.

Appendix B
Quality Assurance Project Plan: Watershed Modeling

August 11, 2020
Seneca-Keuka Watershed Nine Element Plan

Seneca-Keuka Watershed Model Quality Assurance Project Plan

Prepared by
Anchor QEA, LLC
290 Elwood David Road, Suite 340
Liverpool, New York 13088

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ABBREVIATIONS

9EP	Nine Element Plan
BWRM	Bureau of Water Resources Management
CDL	Cropland Data Layer
HAB	harmful algal bloom
NASS	National Agricultural Statistics Service
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOC	New York State Department of State
QA	quality assurance
QAPP	*Quality Assurance Project Plan*
SRP	soluble reactive phosphorus
SWAT	Soil and Water Assessment Tool
SWCD	Soil and Water Conservation District
TAC	Technical Advisory Committee
TP	total phosphorus
TSS	total suspended solids
USDA	U.S. Department of Agriculture

Title and Approval Sheet

Watershed Modeling Project Manager—Anchor QEA, LLC, Michael Werth

	August 11, 2020
Signature	*Approval Date*

Watershed Modeling QA Manager—Anchor QEA, LLC, Jennifer Benaman

	August 11, 2020
Signature	*Approval Date*

Seneca Watershed Steward—Finger Lakes Institute, Ian Smith

	August 20, 2020
Signature	*Approval Date*

Prime Contractor—EcoLogic, LLC, Elizabeth Moran

Signature	*Approval Date*

New York State Department of Environmental Conservation (NYSDEC)—Lauren Townley, Bureau of Water Resources Management (BWRM)

Signature	*Approval Date*

NYSDEC—Anthony Prestigiacomo, Finger Lakes Water Hub

	8/17/2020
Signature	*Approval Date*

NYSDEC—Lewis McCaffrey, Finger Lakes Water Hub

	APPROVED By lpmccaff at 1:40 pm, Aug 17, 2020
Signature	*Approval Date*

NYSDEC—Rose Ann Garry, Quality Assurance Officer, Division of Water Standards and Analytical Support Section

	08/13/2021
Signature	*Approval Date*

Seneca-Keuka Watershed Model Quality Assurance Project Plan Update Log

Prepared by	Date	Revision No.	Summary of Changes
Michael Werth	08/11/2020	0	Original document

1 Distribution List

Table 1
Modeling Quality Assurance Project Plan Distribution List

Name	Title (Relative to Project)	Organization	Contact Information	Document Type
Rose Ann Garry	Quality Assurance Officer	NYSDEC	roseann.garry@dec.ny.gov (518) 402-8159	Hardcopy and Electronic
Ian Smith	Seneca Watershed Steward	Finger Lakes Institute	ismith@hws.edu (315) 781-4559	Electronic
Lauren Townley	Project Manager	NYSDEC BWRM	lauren.townley@dec.ny.gov	Electronic
Anthony Prestigiacomo	Technical Advisor	NYSDEC—Finger Lakes Hub	anthony.prestigiacomo@dec.ny.gov	Electronic
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Liz Moran	Prime Contractor	EcoLogic, LLC	lmoran@ecologicllc.com (315) 655-8305	Electronic
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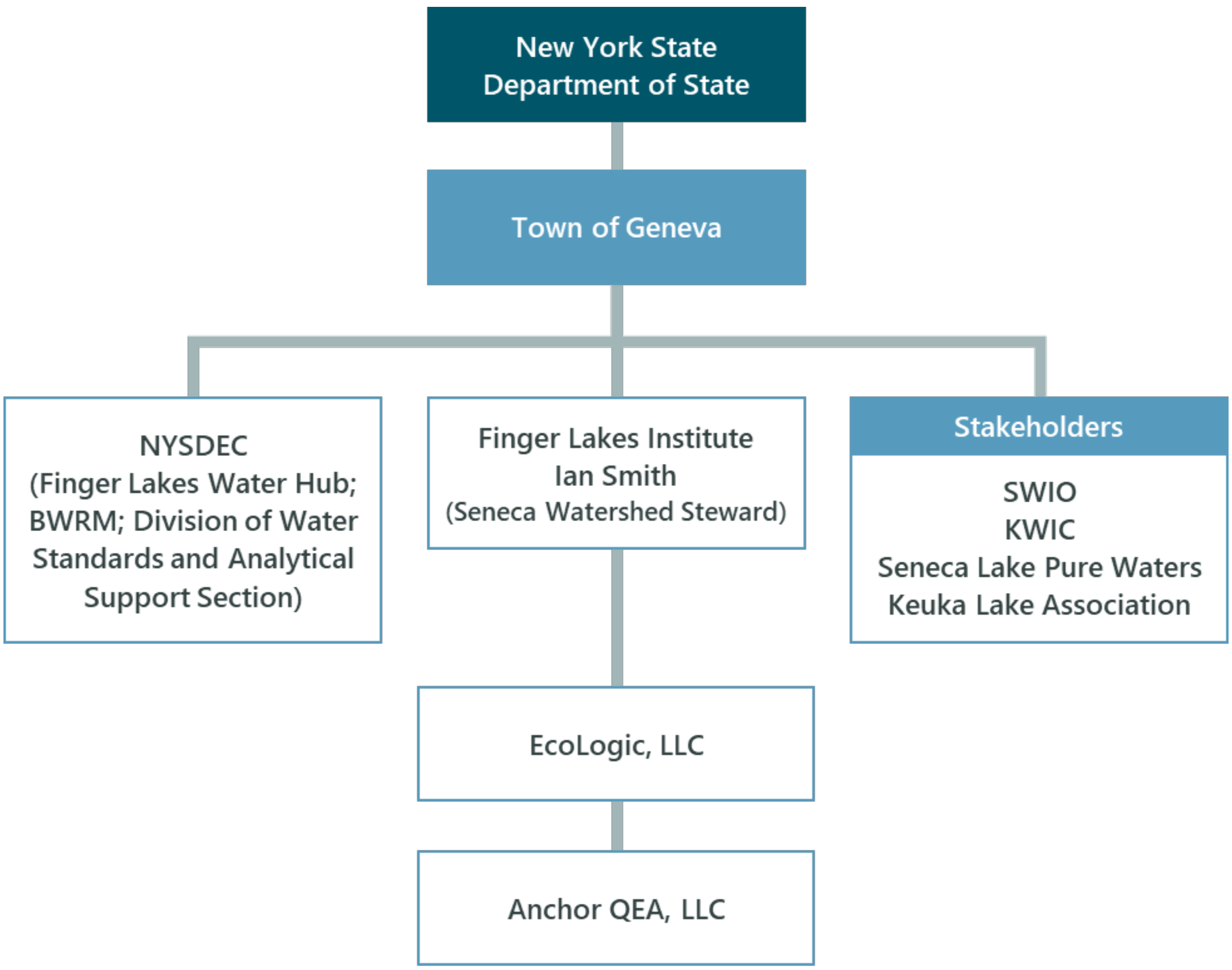
2 Project Organization

Anchor QEA, LLC, through its subcontract agreement with EcoLogic, LLC, is responsible for the development, calibration, and application of the watershed model in support of the Seneca-Keuka Watershed Nine Element Plan (9EP). The organizational chart (Figure 1) shows the various organizations involved in this project.

Figure 1
Project Organizational Chart



BWRM: Bureau of Water Resource Management
KWIC: Keuka Watershed Improvement Cooperative
NYSDEC: New York State Department of Environmental Conservation
SWIO: Seneca Watershed Intermunicipal Organization

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

Anchor QEA, LLC

- Michael Werth: Watershed Modeling Project Manager
  - Oversight of modeling work, including coordination with project partners
  - Prepare, maintain, and update this *Quality Assurance Project Plan* (QAPP)
  - Assist with preparation and review of final modeling report
- Jennifer Benaman: Watershed Modeling QA Manager
  - Oversight of quality assurance (QA)/quality control checks on model inputs, setup, calibration, validation, and application
  - Technical review of final modeling report

Finger Lakes Institute

- Ian Smith: Seneca Watershed Steward
  - Oversight regarding development and implementation of the 9EP for the Seneca-Keuka Watershed
  - Communication with project stakeholders and the public regarding the 9EP and supporting modeling work.

EcoLogic, LLC

- Elizabeth Moran: Prime Contractor
  - Project manager for development of 9EP
  - Oversight of modeling work and integration into 9EP

New York State Department of Environmental Conservation

- Lauren Townley (NYSDEC BWRM): Section Chief
- Anthony Prestigiacomo (NYSDEC – Finger Lakes Hub): Technical Advisor
  - Project oversight and oversight of modeling work
  - Review of this QAPP and final modeling report
- Lewis McCaffrey (NYSDEC – Finger Lakes Hub): Technical Advisor
  - Project oversight and oversight of modeling work
  - Review of this QAPP and final modeling report
- Rose Ann Garry: Quality Assurance Officer
  - 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/quality control issues
  - Review and approve this QAPP to verify that those elements outlined in the U.S. Environmental Protection Agency's Requirements for QA Project Plans (QA/R-5) are successfully discussed

3 Problem Definition/Background

A 9EP is currently being developed for the Seneca-Keuka Lake watershed. The 9EP will recommend specific actions to protect Seneca and Keuka Lakes from cyanobacterial blooms (i.e., harmful algal blooms [HABs]) and other threats to the ecosystem services they provide.

As water resource management issues have become increasingly more complex, the need for sophisticated decision support tools has grown. Quantitative water quality modeling is one of the primary tools necessary to meet this demand. In the framework of a 9EP, water quality models (that have been developed using guidelines for modeling QA addressed in this modeling QAPP) are tools that can support evaluation of several of the defined elements, including the following:

- Identifying and quantifying 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 the best management practices that will be used to achieve reductions needed to meet the water quality goal/target (Element C)
- Identifying the criteria that will be used to assess water quality improvements as the plan is implemented (Element H)

Our project team has selected the Soil and Water Assessment Tool (SWAT 2012[1]) model to simulate runoff and suspended sediment and nutrient loading to Seneca and Keuka Lakes from their respective subwatersheds. SWAT is a river basin-scale model jointly developed by the U.S. Department of Agriculture's Agricultural Research Service and Texas A&M to quantify the impact of land management practices in large, complex watersheds. This model was selected for this project because it is designed to simulate the movement of both particulate and dissolved phosphorus as well as several chemical forms of nitrogen from the watershed to surface water; these biologically available nutrient inputs are implicated in HABs. The SWAT model will be calibrated to current conditions using available streamflow and water quality monitoring data for multiple streams draining subwatersheds that exhibit a mix of land use and land cover conditions.

In addition, a relatively simple in-lake water quality model of Keuka Lake will be developed to evaluate the potential impacts of reduced watershed nutrient loading on lake water quality conditions. This information will help the many stakeholders understand the potential benefits and timeframe associated with watershed nutrient reduction efforts on in-lake water quality and water quality leaving Keuka Lake. Our project team has selected the BATHTUB[2] model to achieve this objective. BATHTUB is an empirical (i.e., data driven, not mechanistic) eutrophication model for lakes and reservoirs that is capable of formulating steady-state water and nutrient mass balances in a

[1] https://swat.tamu.edu/
[2] http://www.wwwalker.net/bathtub/help/bathtubWebMain.html

spatially segmented hydraulic network. This model uses empirical relationships developed and tested previously for reservoir applications to predict eutrophication-related water quality conditions for various nutrients.

Seneca Lake is nearly 40 miles long with a maximum depth of over 600 feet and a hydraulic residence time of approximately 18 years (Hobart and William Smith Colleges et al. 2012). Given the complexity of simulating a lake of this size, an in-lake water quality model of Seneca Lake will not be developed for this project.

4 Project/Task Description and Schedule

Table 2 summarizes the project's major modeling-related tasks/milestones and the anticipated schedule for completion.

Table 2
Modeling-Related Tasks and Schedule

Task Description	Schedule
Begin watershed model development	February 2020
Field data collection in support of modeling	March to October 2020
Public Meeting 1 (describe modeling approach, major inputs, etc.)	July 2020
Complete initial watershed/Keuka in-lake model calibration[1]	October 2020
Finalize watershed/Keuka in-lake model calibration/validation[2]	January 2021
NYSDEC review of final calibration; development of management alternatives	June 2021
Evaluation of management alternatives using calibrated model	August 2021
Public Meeting 2 (present modeling results and initial recommendations)	October 2021
Complete initial draft of 9EP	December 2021

Notes:

1. Initial calibration will be completed using available (pre-2020) hydrology and water quality data.
2. Final calibration/validation will include 2020 hydrology and water quality data. This task includes time for NYSDEC review of calibration approach.

5 Quality Objectives and Criteria for Model Input/Outputs

The overall quality objective for this project is to set up, calibrate, and validate a model of the Seneca-Keuka Lake watershed that can assist in the development of the 9EP. The water quality data that will be used for model setup, calibration, and validation will only be those data deemed sufficient for that purpose based on the results of NYSDEC's Secondary Data Evaluation for Modeling. This evaluation has been conducted initially and sent to NYSDEC for review and will be maintained throughout the project to track the use of secondary data in model setup, calibration, and/or validation of the model. This table will track information relevant to verifying and validating data sources and provide any limitations on data use for the purposes of modeling.

The modeling software to be used for this project (SWAT 2012 and BATHTUB) has been developed, maintained, and version controlled by external individuals or organizations—SWAT is maintained by Texas A&M University, and BATHTUB was developed by Dr. William Walker for the Environmental Laboratory, U.S. Army Corps of Engineers Waterways Experiment Station.

The version of SWAT being used for this project (SWAT 2012) has been in use for many years (since 2012) and has been applied at various sites. SWAT also has a relatively large user community. Likewise, the version of BATHTUB that will be applied to this project (version 6.1) has been in use since 2006 and has been applied at a number of sites to support Total Maximum Daily Load (TMDL) assessments.[3] Both SWAT 2012 and BATHTUB are deemed to be reliable tools for application to the 9EP planning process for Seneca and Keuka Lakes. As part of the model development and calibration process, Anchor QEA will perform quality control reviews of the model predictions; however, quality control checks will not be performed on the modeling software itself.

Preparation of model input files and post-processing and analysis of model outputs will be performed using a combination of Esri's ArcGIS software (including an ArcGIS-based user interface developed by Texas A&M for SWAT 2012) and custom computer code developed in Python.[4] Specifically, custom scripts will be developed in Python to generate input files for the ArcGIS user interface and to assist in developing graphics of model outputs. Use of this kind of software for input/output file management reduces the likelihood of errors associated with manual preparation/processing of files.

6 Special Training Requirements/Certification

The modeling work to be performed by Anchor QEA will be completed and reviewed by staff with watershed and in-lake water quality modeling expertise. Anchor QEA staff assigned to this project have decades of experience developing and applying watershed and water quality models. Dr. James Rhea and Dr. Jennifer Benaman will be providing technical oversight of the project. Dr. Benaman leads the firm's watershed assessment and modeling group and has applied watershed models in general (and SWAT in particular) for a variety of systems across the United States, including the Cannonsville Reservoir in New York State (NYS). Dr. Rhea was the principal investigator for the development and application of the water quality models for Onondaga Lake and the Three Rivers System in Central New York. These models were applied by NYSDEC to develop a TMDL assessment of total phosphorus for Onondaga Lake and to assess the diversion of the Syracuse Metropolitan Wastewater Treatment Plant to the Seneca River. Both water quality models underwent extensive

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[3] The BATHTUB model is no longer actively supported by Dr. Walker.
[4] https://www.python.org/

peer review and were universally accepted by the agencies overseeing the execution of the Amended Consent Judgement between NYS and Onondaga County. Further, the project manager for this project (Michael Werth) and the project scientist (Chantell Owen) both have extensive experience developing and applying watershed models.

7 Measurement and Data Acquisition

7.1 Calibration

Calibration of a model consists of adjusting input parameters so the model accurately reproduces trends in data. The following subsections summarize the anticipated calibration/validation process for this project.

7.1.1 Watershed Model (SWAT)

A three-step, sequential calibration process will be performed for the watershed model: 1) watershed hydrology calibration; 2) sediment load calibration; and 3) nutrient load calibration. Calibration needs to progress in this stepwise manner because watershed hydrology drives constituent loading (both sediments and nutrients), and sediment transport can also impact nutrient loading. For each of these three steps, final calibration parameter values will be 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 site data.

For watershed hydrology, a considerable amount of hydrologic data has been collected throughout the watershed; however, these data are not ideal for calibration of the hydrologic model. Ideally, a relatively longer-term, continuous hydrologic record that captures a range of flow conditions at various locations (preferably daily average flow) is needed for robust hydrologic model calibration. There are only two locations in this watershed with a continuous long-term record of daily average flow (the U.S. Geological Survey gage in the Keuka Lake Outlet at Dresden and in the Seneca River near Seneca Falls); however, the measurements at these locations are affected by control structures, so their utility for model calibration is likely limited. In other words, the fluctuations and water volumes observed at these stations are not always in direct response to precipitation events, making it difficult to use these locations for a traditional hydrologic calibration. However, the data at these stations will be evaluated for establishing a water balance, which could be used to assess overall hydrologic model performance. There are flow data that have been (or will be) collected at other watershed locations, but these data represent a relatively short period of record that may not capture the full range of flow conditions. As such, the watershed hydrology calibration will focus on a combination of visual goodness-of-fit between model predictions and observed data at various locations (i.e., comparison of time-series of model-predicted and observed flows) and statistical comparisons between model predictions and data using metrics such as Nash Sutcliffe Model

Efficiency (Nash and Sutcliffe 1970) and Percent Bias (PBIAS). We will generally compare our results to the thresholds of model acceptance for these metrics presented in Table 3 (Moriasi et al. 2007). Consideration was given to applying more sophisticated statistical methods of model calibration (e.g., methods such as a probabilistic Monte Carlo calibration approach where various distributions of model input parameters are generated), but the site data were deemed insufficient to support this type of approach.

Table 3
General Performance Ratings for Recommended Statistics for a Monthly Time Step

Performance Rating	RSR	NSE	PBIAS (%)		
			Streamflow	Sediment	Nutrients
Very good	0.00 ≤ RSR ≤ 0.50	0.75 < NSE ≤ 1.00	PBIAS ≤ ±10	PBIAS ≤ ±15	PBIAS < ±25
Good	0.50 < RSR ≤ 0.60	0.65 < NSE ≤ 0.75	±10 ≤ PBIAS < ±15	±15 < PBIAS ≤ ±30	±25 ≤ PBIAS < ±40
Satisfactory	0.60 < RSR ≤ 0.70	0.50 < NSE ≤ 0.65	±15 ≤ PBIAS < ±25	±30 < PBIAS ≤ ±55	±40 ≤ PBIAS < ±70
Unsatisfactory	RSR > 0.70	NSE ≤ 0.50	PBIAS ≥ ±25	PBIAS ≥ ±55	PBIAS ≥ ±70

Notes:
Recommended statistics from (Moriasi et al. 2007)
RSR: Root Mean Squared Error (RMSE)-observations standard deviation ratio
NSE: Nash-Sutcliffe coefficient of model efficiency (Nash and Sutcliffe 1970)
PBAIS: percent bias

The general performance ratings shown apply to a typical dataset that would include long-term, continuous measurements with lower levels of uncertainty. Given the limited number of high certainty measurements within the watersheds, the threshold of performance ratings deemed appropriate for this system cannot be established a priori. If model performance is considerably lower than the satisfactory thresholds presented in Table 3, then the accuracy of the input data and model assumptions will be reviewed. The historical data record being used for calibration will also be reviewed to determine if there are any non-representative samples or measurements that may be influencing the calibration. Any model performance issues (and qualification of results if necessary) will be documented in the final report.

The same type of calibration approach described above (i.e., combination of visual goodness-of-fit and statistical model-to-data comparisons) will be used for simulation of sediment and water quality parameters. It should be noted that a broader range of acceptable goodness-of-fit measures exist for water quality than for hydrology because there is typically a much greater amount of uncertainty/variability in water quality grab samples than there is in hydrology measurements (see Table 3).

Based on the available tributary monitoring data for the Seneca-Keuka Lake watershed, the water quality calibration will focus on total suspended solids (TSS), total phosphorus (TP), and soluble-reactive phosphorus (SRP). Total nitrogen will also be simulated with the model, but the model will not be calibrated for this constituent given that phosphorus is generally understood to be the nutrient limiting algal growth in the Finger Lakes (Halfman 2016).

It is anticipated that the watershed model simulation period will be an approximate 10-year period between 2010 and 2020; however, model calibration will focus on the period between 2015 and 2019, which has the largest amount of data deemed suitable for model calibration. Model calibration will also focus on a select subset of sub-basins for which water quality data are available—data from the remaining sub-basins (and new data anticipated to be collected in 2020) will be reserved for validation of the model predictions. Sub-basins anticipated to be used for water quality calibration and validation are summarized in Table 4. The calibrated and validated model will then be applied to simulate the impact of select watershed best management practices on nutrient loadings to the lakes.

Table 4
Model Calibration and Validation Sub-Basins

Watershed	HUC12 Sub-Basin	Use
Keuka	Sugar Creek	Calibration
	East Branch Keuka Lake	Validation
	West Branch Keuka Lake	Validation
	Keuka Inlet	Validation
Seneca	Wilson Creek-Seneca Lake	Calibration
	Big Stream	Calibration & Validation
	Sleeper Creek-Catherine Creek	Calibration
	Headwaters Catherine Creek	Calibration
	Seneca Lake Inlet	Calibration & Validation
	Kashong Creek	Calibration & Validation
	Castle Creek	Validation
	Reeder Creek	Validation
	Keuka Lake Outlet	Calibration & Validation

7.1.2 Keuka In-Lake Model (BATHTUB)

As described in Section 3, a relatively simple in-lake water quality model of Keuka Lake will be developed to evaluate the potential impacts of reduced watershed nutrient loading on Keuka Lake water quality conditions. A primary input to the Keuka in-lake model will be flows and nutrient loads (focusing on TP) discharged from the Keuka Lake watershed—these values will be derived from the calibrated SWAT watershed model. Because water quality monitoring has occurred at various locations throughout Keuka Lake, calibration of the in-lake model will focus on a pooled data set (i.e., the model will be calibrated to average conditions over a specific area or segment, and not necessarily to data collected at a discrete location).[5] The calibration data set will also be selected such that it overlaps with the watershed model calibration period described above (i.e., 2015 to 2019).

The BATHTUB model has an internal procedure to assist with model calibration. This procedure derives least-squares estimates for model calibration factors, calculated from log-transformed observed and predicted concentrations of the nutrients being simulated in each model segment. Primary model calibration factors are the exchange rate between model segments, and nutrient sedimentation (loss) rate. Calibration error targets for the Keuka in-lake model are ±15% mean error for TP on a lake-wide basis.

Regarding the linkage between the SWAT watershed model and the Keuka in-lake model, as noted above, flows and nutrient loads predicted by the calibrated SWAT watershed model for the Keuka Lake portion of the watershed will be input to the in-lake model. The output from the Keuka in-lake model will then be used as an input to the Seneca Lake watershed portion of the SWAT model.

7.2 Non-Direct Measurements (Data Acquisition Requirements)

The following is a summary of non-direct measurements/data sets required to set up the watershed model to simulate nutrient loads within the Seneca-Keuka Lake watershed.

- Digital elevation model data (USGS 2017)
- National Hydrography Dataset (USGS 2019a)
- National Land Cover Database (USGS 2019b)
- Soil Survey Geographic Database (NRCS 2020)
- Viticulture (i.e., grape cultivation) areas (USDA 2019; Yates County SWCD 2020)
- Weather data (NOAA 2019)
- State Pollutant Discharge Elimination System discharge information (EPA 2019)

Viticulture datasets were retrieved from U.S. Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) Cropland Data Layer (CDL) and Yates County Soil and Water Conservation District (SWCD). The CDL is published yearly and derived from satellite imagery with 30-meter spatial resolution and an overall accuracy of approximately 70% for NYS (USDA 2019). Full accuracy evaluations can be found on the USDA NASS website. The spatial dataset of viticulture areas provided by Yates County SWCD is the result of a collaborative effort between Yates County SWCD

[5] The BATHTUB model allows spatial segmentation (i.e., division of the lake into separate water quality segments for the purposes of modeling). The need for such segmentation will be evaluated during model development. For example, segmentation may be warranted if lake water quality data indicate there are significant spatial differences in water quality in different portions of the lake. Data would be averaged within a given segment for the purposes of calibration.

and the Finger Lakes Grape Program through Cornell University and was derived using a combination of satellite imagery and ground-truthing at individual farms.

In addition, all flow and water quality monitoring data needed for model calibration and validation for this project has already been collected or is in the process of being collected by NYSDEC or other stakeholders under a separate approved QAPP.

7.3 Data Management and Hardware/Software Configuration

Pre-processing of input data sets and post-processing of model outputs will be performed using Python scripting language to minimize potential errors associated with manual data entry and/or pre/post-processing. In addition, software (including Microsoft Excel and Esri ArcGIS) will be used to support the modeling being conducted for this project.

8 Assessment and Oversight

8.1 Assessment and Response Actions

The modeling work for this project, including input pre-processing and output post-processing, will be performed by Anchor QEA. Oversight of the modeling work and tracking of modeling progress will be provided by the project Technical Advisory Committee (TAC) consisting of Dr. Liz Moran (EcoLogic), Ian Smith (Finger Lakes Institute), Dr. Lewis McCaffrey (NYSDEC), and Anthony Prestigiacomo (NYSDEC).

8.2 Plans for Science and Product Peer Review

The theoretical basis for SWAT is documented by Neitsch et al. (2009). Documentation of the BATHTUB model, including model theory, can be found on the BATHTUB website (cited in Section 3). Peer review of the modeling work being conducted by Anchor QEA for this project will occur through regular meetings with the project TAC (which the TAC has discussed and agreed will occur approximately bimonthly).

8.3 Reports to Management

Modeling updates will be provided by Anchor QEA during TAC meetings verbally and through the use of PowerPoint presentation(s) as needed. Any decisions and/or action items discussed during TAC meetings will be informally documented and retained in meeting notes.

9 Data Validation and Usability

9.1 Departures from Validation Criteria

None anticipated. Any deviations from established criteria will be documented in the final report.

9.2 Validation Methods

Model results will be accepted based on the calibration methodology discussed above. The data set that will be used for model validation has been screened using NYSDEC's Secondary Data Evaluation for Modeling and is described in Section 7.1.

9.3 Reconciliation with User Requirements

The calibrated SWAT and BATHTUB models should not be used without first having knowledge of the principles of hydrology and water quality and having experience in performing SWAT and BATHTUB model simulations. Experienced Anchor QEA staff who have developed and calibrated these models will apply them to support evaluations of potential watershed management scenarios for the 9EP. That said, the executable model code and model application documentation for both the SWAT and BATHTUB models will be delivered to the Seneca-Keuka 9E Executive Committee (and NYSDEC and/or New York State Department of State [NYSDOS] if requested) to facilitate future applications of the model.[6]

10 Document and Record Control

This QAPP is a controlled document that will be managed by the prime contractor on this project (EcoLogic). Any revisions will be tracked by a revision number assigned to the document. Following approval of any revision to this document, Dr. Liz Moran (EcoLogic) will send the revised QAPP to each person on the distribution list provided in Section 1. Dr. Moran will be responsible for preparation, maintenance, updates, and distribution of this QAPP and has ultimate responsibility for changes to records and documents, whether handwritten or electronic.

Records of written correspondence, internal notes, emails, and communications between the team members and other project members will be kept for a minimum of 5 years. At the completion of this project, project records and documents will be transmitted to Ian Smith (Finger Lakes Institute). Model documentation will include a summary of key model assumptions, model input parameters, land use and management practice assumptions, and GIS layers of model inputs. In addition, the model documentation files will include any relevant model calibration and validation graphics and statistics. A draft outline of the final model report is provided as follows.

[6] Model documentation will be included as an appendix to the Seneca-Keuka 9E Plan and will detail the model development, calibration, validation, and application of the models. The documentation will be sufficient for a practiced watershed and water quality modeling professional to apply the model. The scope of work for the project precludes the development of a detailed user interface or model application guide.

Draft Final Report Outline

- Introduction and Background
- Modeling Objectives
- Modeling Approach (SWAT and BATHTUB)
- Summary of Data Used to Support Modeling
- Model Configuration
  - Subbasin Delineation
  - Input Datasets (land cover, elevation, hydrography, soils, and meteorology)
  - Model Parameterization
- Model Calibration
  - Approach
  - Calibration Variables and Targets
  - Calibration Results
  - Model Performance
- Sensitivity Analysis
- Model Validation
- Model Use Scenarios and Results
- Conclusions and Recommendations
- References
- Appendices

Final reports will be distributed to the NYSDOS and NYSDEC. Any publications in technical or trade journals or oral presentations at external venues (such as technical conferences) resulting from this project will be submitted to the project partners, including NYSDEC, for review and approval.

Records will be retained at the Finger Lakes Institute for a minimum of 5 years following project completion. Electronic data will remain on a secure, password-protected server for at least 5 years after the completion of the project and will be routinely backed up as part of the electronic data security and safety protocols. If the project Executive Committee requests destruction of electronic records after 5 years, files will be deleted from the server.

11 References

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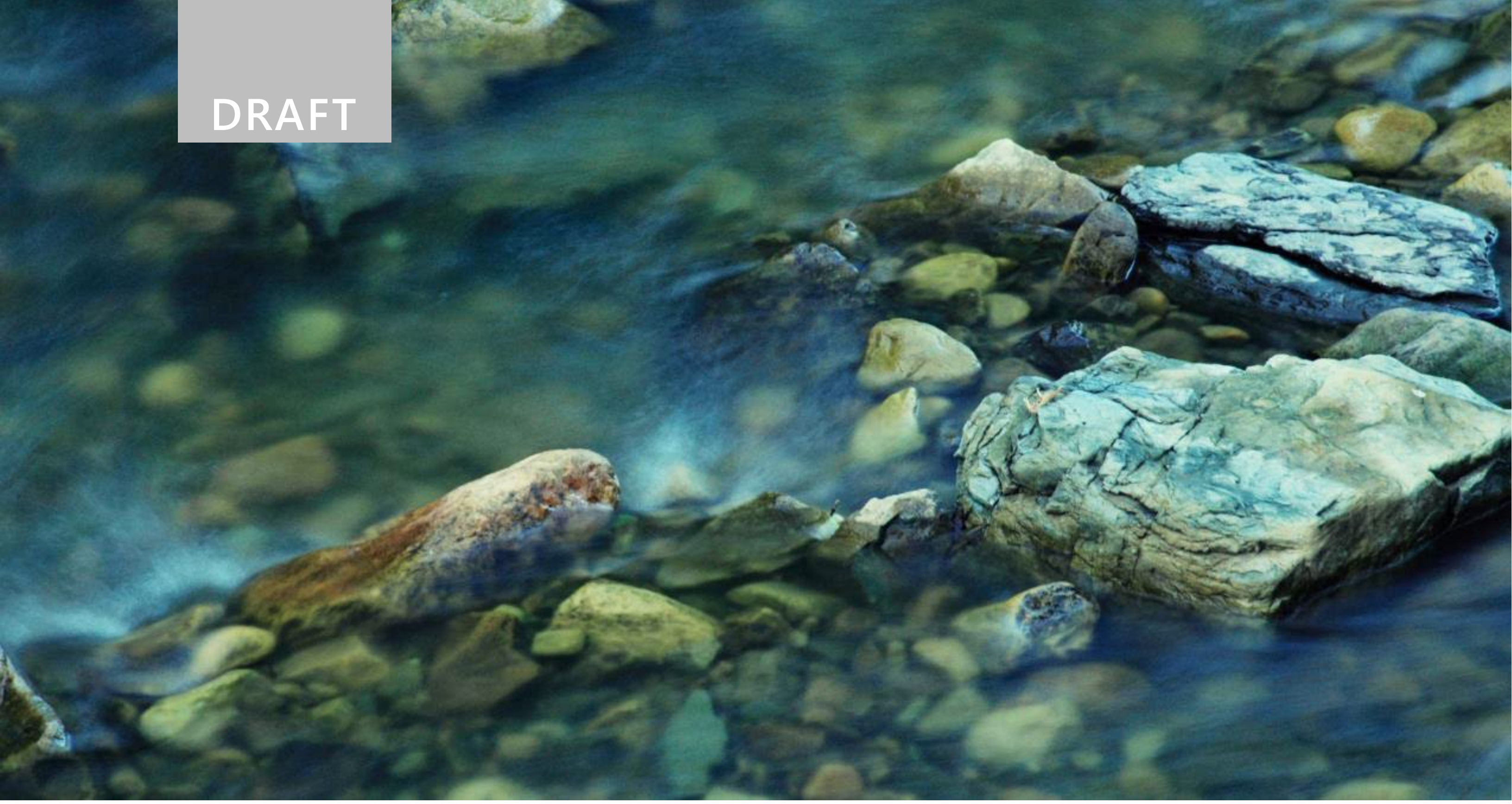
Appendix C
SWAT and BATHTUB Model Report



DRAFT

February 2022
Seneca-Keuka Watershed Nine Element Plan

Seneca-Keuka Watershed Model Report

DRAFT

February 2022
Seneca-Keuka Watershed Nine Element Plan

Seneca-Keuka Watershed Model Report

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Figure A3-12 Annual Total Suspended Solids Load at Calibration Locations
Figure A3-13 Annual Total Phosphorus Load at Calibration Locations
Figure A3-14 Hydrology Validation
Figure A3-15 Annual Total Suspended Solids Load at Validation Locations
Figure A3-16 Annual Total Phosphorus Load at Validation Locations
Figure A4-1 Keuka Lake TP Load Response

ABBREVIATIONS

µg/L	microgram per liter
9E	Nine Element Plan
CDL	Cropland Data Layer
CV	coefficient of variation
DEM	Digital Elevation Model
FLI	Finger Lakes Institute
hm^3/yr	cubic hectometers per year
HRU	Hydrologic Response Unit
HUC	Hydrologic Unit Code
kg	kilogram
km	kilometer
km^2	square kilometer
m	meter
mg/kg	milligram per kilogram
mg/L	milligram per liter
MGD	million gallons per day
MPCA	Minnesota Pollution Control Agency
NHD	National Hydrography Dataset
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NSE	Nash-Sutcliffe coefficient of model efficiency
NYSDEC	New York State Department of Environmental Conservation
PBIAS	percent bias
PET	potential evapotranspiration
QAPP	*Quality Assurance Project Plan*
RSR	Root Mean Square Error
SRP	soluble reactive phosphorus
STP	sewage treatment plant
SWAT	Soil and Water Assessment Tool
TMDL	Total Maximum Daily Load
TP	total phosphorus
TSS	total suspended solids
USACE	U.S. Army Corp of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WWTP	wastewater treatment plant

YCSWCD	Yates County Soil and Water Conservation District

1 Introduction

1.1 Background

The modeling described in this report was performed in support of the 9 Element Plan (9E) prepared for the Seneca-Keuka watershed. Watershed and water quality models facilitate knowledge-based water resource management decisions and are an integral component of the 9E planning process. Indeed, such models support evaluation of several of the defined elements within the 9E, including:

- Identifying and quantifying 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 the best management practices that will be used to achieve reductions needed to meet the water quality goal and target (Element *c*)
- Identifying the criteria that will be used to assess water quality improvements as the plan is implemented (Element *h*)

The Soil and Water Assessment Tool (SWAT 2012[1]) model was selected to simulate runoff and suspended sediment and nutrient loading to Seneca and Keuka Lakes from their respective watersheds. SWAT is a river basin-scale model jointly developed by the U.S. Department of Agriculture's (USDA's) Agricultural Research Service and Texas A&M to quantify the impact of land management practices in large, complex watersheds. This model was selected for this project because it is designed to simulate the movement of both particulate and dissolved phosphorus from the watershed to surface water. The SWAT model was calibrated to current conditions using available streamflow and water quality monitoring data for multiple streams conveying water, solids, and nutrients from a number of sub-watersheds exhibiting a mix of land use and land cover conditions.

In addition, an in-lake water quality model of Keuka Lake was developed to assess the potential impacts of reduced watershed nutrient loading on lake water quality indicators. The BATHTUB[2] model, an empirical (i.e., data driven, not mechanistic) eutrophication model for lakes and reservoirs was selected to assess Keuka Lake response to reductions in watershed loadings. BATHTUB is capable of formulating steady-state water and nutrient mass balances in a spatially segmented hydraulic network. This model uses empirical relationships developed and tested previously for reservoir applications to predict eutrophication-related water quality conditions for various nutrients.

An in-lake water quality model of Seneca Lake was not developed for this project. Seneca Lake is nearly 40-miles-long with a maximum depth of over 600 feet and a hydraulic residence time of

[1] https://swat.tamu.edu/
[2] http://www.wwwalker.net/bathtub/help/bathtubWebMain.html

approximately 18-23 years (NYSDEC, 2019b). The complexity of simulating a lake of this size precludes the use of a simple empirical model such as BATHTUB for this system.

1.2 Modeling Objectives

The primary objective of modeling described herein was to build a quantitative tool to help guide watershed management practices toward the preservation and improvement of Seneca Lake and Keuka Lake water quality. Specifically, the calibrated and validated watershed model enables a quantitative assessment of: 1) the relative contributions of point and non-point sources of nutrients within the watershed under current conditions; and 2) predicted changes in nutrient loadings associated with potential changes in land management practices and/or changes in climatological conditions.

1.3 Seneca-Keuka Watershed Overview

The Seneca-Keuka watershed area extends over approximately 712 square miles, including six counties. While the watershed ultimately drains north to Lake Ontario, water also flows from west to east as Keuka Lake outlet enters Seneca Lake. This watershed encompasses 20 HUC12 sub-watersheds, 5 of which convey water, sediments, and nutrients into Keuka Lake, and the remainder convey water, sediments, and nutrients to Seneca Lake (HUC12 boundaries are shown in Figures A3-1 through A3-6). Two tributary streams (Silver Creek and Sucker Brook) flow into the Cayuga-Seneca canal—because these sub-watersheds are located downstream of Seneca Lake, they were excluded from the watershed model and therefore not part of the Seneca-Keuka watershed loading analysis.

2 Modeling Software and Approach

The modeling software used for this project (SWAT 2012 and BATHTUB) was developed, maintained, and version controlled by others—SWAT is maintained by Texas A&M University, and BATHTUB was developed by Dr. William Walker for the Environmental Laboratory, U.S. Army Corps of Engineers Waterways Experiment Station.

The version of SWAT used for this project (SWAT 2012) has been in use for many years (since 2012), been applied at numerous sites, and has a large user community. Similarly, the version of BATHTUB applied in this project (Version 6.1) has been in use since 2006 and applied to a number of sites to support Total Maximum Daily Load (TMDL) assessments. Both SWAT 2012 and BATHTUB are reliable tools for application to the 9E planning process for Seneca and Keuka Lakes. As part of the model development and calibration process, Anchor QEA performed quality control reviews of the model predictions; however, quality control checks were not performed on the modeling software itself.

A *Seneca-Keuka Watershed Model Quality Assurance Project Plan* (QAPP; Anchor QEA and EcoLogic 2020) was prepared in advance of the modeling work to guide the development, calibration, and validation of the models. The QAPP describes the quality objectives and criteria for model inputs and outputs and was approved by New York State Department of Environmental Conservation (NYSDEC) in August 2020.

3 Watershed Model (SWAT)

3.1 Model Development

A number of external datasets are required to parameterize SWAT to appropriately represent the Keuka and Seneca Lake systems. In addition, flow and water quality monitoring data needed for calibration and validation of SWAT (and the Keuka in-lake model [BATHTUB]) were collected by U.S. Geological Survey (USGS), NYSDEC, or stakeholders. A summary of water quality monitoring efforts conducted in the watershed are described in Section 2.4 of the 9E. This section describes the various datasets that were used to develop the watershed mode and specify the spatial and temporal domain, including delineation of model sub-watersheds.

3.1.1 Input Datasets

3.1.1.1 Topography and Slope

SWAT requires a digital elevation model (DEM) to determine flow direction and slope of the terrain and tributaries and is used to support sub-watershed delineation. The 10-meter (m) DEM (USGS 2017) was applied to the Seneca-Keuka watershed models. This DEM has elevations that range from 115 to 638 m, with the steepest terrain location in the headwater areas (see Figure A3-1). In the SWAT model, the differences in elevation impact the snowmelt processes, and the slope controls the amount of runoff and pollutant transport.

3.1.1.2 Stream Network

The stream network for this watershed was based on the National Hydrography Dataset (NHD; USGS 2019a). This dataset is used to supplement the sub-watershed delineation process and represents the primary path of flow within the watershed (see Figure A3-2). The stream network can be superimposed or "burned in" where the topography is flat, or the DEM does not accurately represent the stream network.

3.1.1.3 Land Use

The high-resolution (30-m) land cover used in the SWAT model was based on the 2016 National Land Cover Database (NLCD; USGS 2019b). Twenty individual land uses were modeled in SWAT, including crops (i.e., general row crops, alfalfa, soybean, corn, hay, winter wheat), pasture, grapes, forest (i.e., deciduous, evergreen, mixed), rangeland, wetlands (i.e., woody and herbaceous), developed land (i.e., high, medium, and low intensity, and open space), and water (see Figure A3-3).

Viticulture (i.e., grape cultivation) is a land use that is relatively extensive in the Seneca-Keuka watershed; however, it is not represented in the NLCD. Therefore, to account for this land use, viticulture datasets obtained from USDA National Agricultural Statistics Service Cropland Data Layer (CDL) and Yates County Soil and Water Conservation District (YCSWCD) were superimposed over the

NLCD to obtain a better representation of vineyards within the watershed. The CDL is published yearly and derived from satellite imagery with 30-m spatial resolution and an overall accuracy of approximately 70% for New York State (USDA 2019). The viticulture areas provided by Yates County YCSWCD were derived using a combination of satellite imagery and ground-truthing at individual vineyards.

3.1.1.4 Land Management Practices

Land management practices (i.e., tillage and fertilization) and growing seasons were specified in the SWAT model for alfalfa, corn, soybeans, hay, grapes, winter wheat, general agriculture, and pasture. Table A3-1 provides additional detail on the tillage and fertilization practices implemented in SWAT for each agricultural land use. This information represents generalized land management practices for the upstate New York region obtained from various sources (YCSWCD 2020; SWAT model developed separately for the Mohawk River watershed; Cornell University) and does not necessarily represent specific practices implemented at individual farms within the watershed.

Table A3-1
Land Management Practices Specified in SWAT for Agricultural Land Uses

Crop	Growing Season		Tillage Practice (Date)	Fertilizer (Date)
	Start Date	Harvest Date(s)		
Alfalfa	5/1	5/29, 6/29, 7/29, 8/29	Field Cultivator (3/22)	Manure (4/14, 5/31, 7/1, 7/31)
Corn	5/21	9/15	Mulch Tiller (5/1) Tandem Disk (5/8)	Urea (4/30) 20-20-0 (5/20)
Soybeans	5/31	10/1	Mulch Tiller (5/17) Tandem Disk (5/24)	20-20-0 (5/30)
Grapes	5/1	10/1	--	--
Hay	4/15	5/15, 6/15, 7/15, 8/15, 9/15	--	Manure (4/14)
Winter Wheat	10/15	7/15	Plow (9/15)	Urea (4/30) 20-20-0 (5/15)
General Agriculture	5/21	9/15	Field Cultivator (5/1)	Urea (4/30) 20-20-0 (5/20)

Note:
Grazing on pasture begins on April 1 for 185 days.

3.1.1.5 Soil Type

Soil types were obtained from the Soil Survey Geographic database (NRCS 2020). The high-resolution (10-m) data were used in SWAT and include information on soil properties such as the hydrologic soil group, soil horizon, bulk density, Universal Soil Loss Equation (USLE), hydraulic conductivity, available water capacity, and percentage material (i.e., percent sand, silt, clay, rock). The soil groups are classified as A, B, C, and D where soil group A has the highest infiltration capacity and lowest runoff potential, and soil group D has the lowest infiltration capacity and highest runoff potential (see Figure A3-4).

3.1.1.6 Meteorological Inputs

Daily meteorological data were obtained from five National Oceanic and Atmospheric Administration (NOAA) stations within or near the Seneca-Keuka watershed (Aurora Research Farm, Elmira, Geneva Research Farm, Mecklenberg 4 SW, and Penn Yan Airport). Rainfall and other data (e.g., minimum and maximum temperature) from these five stations were evaluated spatially, and for completeness (i.e., any gaps in the data record)—based on this review, two stations (Geneva Research Farm and Mecklenberg 4 SW) were used to specify meteorological inputs for the various sub-watersheds in the SWAT model (see Figure A3-5). Specifically, the Geneva Research Farm station was assigned to 10 sub-watersheds, and the Mecklenberg 4 SW weather station was assigned to 18 sub-watersheds.[3]

Additional climate data required by SWAT includes relative humidity, solar radiation, wind movement, and cloud cover. These were provided through the internal SWAT model weather generator.

3.1.1.7 Point Sources

Section 2.5.4.3 of the 9E summarizes 81 discrete point sources that exist within the Seneca-Keuka watershed. Five of these are considered major dischargers and 76 were minor dischargers with less than 10,000 gallons/day of sewage treatment effluent (Figure A3-6). Because the SWAT model is being used to evaluate tributary loadings to Seneca and Keuka lakes, it only includes those point sources with available sediment and/or total phosphorus data that discharge to the 20 HUC12 subbasins located upstream of the Seneca Lake outlet. That is, the model excludes point sources that discharge directly to the lake or at locations downstream of tributary water quality monitoring locations. The dischargers and the constant daily loads represented in the SWAT model are provided in Table A3-2.

[3] As described in Section 3.1.3, while there are 20 HUC12 sub-watersheds, a few additional (smaller) subbasins were generated in SWAT due to the addition of outlet points at certain hydrologic and water quality monitoring locations along the stream network, for a total of 28 sub-watersheds.

Table A3-2
Point Source Discharges Included in SWAT Model

HUC12 / Sub-Watershed	Discharger	Discharger Status	Flow (MGD)	Sediment (pounds/year)	Total Phosphorus (pounds/year)
Wilson Creek – Seneca Lake / Reeder Creek	Five Points Correctional Facility	Minor	0.32	6,550	2,455
Indian Creek – Seneca Lake	Greenidge Station	Major	84	2,716	--
Wilson Creek – Seneca Lake / Reeder Creek	Hillside Children's Center	Minor	0.044	--	216
Castle Creek – Seneca Lake	Marsh Creek WWTP[1]	Major	3.1	105,312	3.39
Keuka Lake Outlet	Penn Yan (V) STP	Major	1.3	48,945	2,567
Hector Falls Creek – Seneca Lake	Watkins Glen	Major	11	31,447	--

Note:
1. The reported values for Marsh Creek WWTP may have been influenced by potential outlier(s).

3.1.2 Model Simulation Period

A daily time step was employed with SWAT over a total simulation period of 14 years, extending from January 1, 2007, through December 31, 2020. This simulation period was chosen to capture a broad range weather and flow conditions and maximize the application of the available data. However, as noted in Section 3.2.1.2, model calibration focused on the latter six years of that simulation period (2015 through 2020) which represented the period of highest quality monitoring data. The years prior to the calibration period (2007 through 2014) essentially provided "spin-up" time for the model to equilibrate initial model conditions.

3.1.3 Sub-Watershed and Hydrologic Response Unit Delineation

The Seneca-Keuka watershed is comprised of 20 HUC12 sub-watersheds. The delineation of subbasins in the SWAT model, using the inputs discussed in Section 3.1, resulted in 28 individual sub-watersheds that are generally comparable to the HUC12 scale. A few additional (smaller) subbasins were generated in SWAT due to the addition of outlet points at certain hydrologic and water quality monitoring locations along the stream network (see Figure A3-7). 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. To limit the number of small HRUs, thresholds were set at 3% for each land use type within a sub-watershed and 5% for each soil type and slope category. Application of these user-specified thresholds created over 57,000 HRUs within the Seneca-Keuka watershed ranging in size from less than 1 acre to over 1,400 acres, with an average size of 7 acres.

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. For the SWAT model, a three-step, sequential calibration process was performed: 1) watershed hydrology calibration; 2) sediment load calibration; and 3) nutrient load calibration. Calibration progressed in this stepwise manner since watershed hydrology drives sediments and nutrient loadings, and sediment loadings, in turn, impact nutrient loadings. For each of these three steps, 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. This calibration process also included a sensitivity analysis to assess model output sensitivity to changes in various model input parameters (see Section 3.3).

3.2.1.1 Hydrology Calibration Approach

Hydrologic model calibration focused on data collected from the USGS flow monitoring stations located on Catherine Creek at Montour Falls (No. 04232200) and Sugar Creek at County House Road at Guyanoga (No. 0423245850) over the period April 2019 through December 2020. While a considerable amount of hydrologic data was available throughout the watershed, much of these data were not ideal for calibration of the hydrologic model. Ideally, a long-term, continuous hydrologic record that captures a range of flow conditions at various locations (preferably daily average flow) is needed for robust hydrologic model calibration. There are only two locations in this watershed with a continuous long-term record of daily average flow (the USGS gage in the Keuka Lake Outlet at Dresden and in the Seneca River near Seneca Falls); however, the measurements at these locations are affected by control structures, so their utility for model calibration was limited. In other words, the fluctuations and water volumes observed at these stations are not always in direct response to precipitation events, making it difficult to use these locations for a traditional hydrologic calibration. Therefore, model calibration focused on the two remaining USGS flow monitoring locations in the watershed that are not affected by control structures (Catherine Creek at Montour Falls [No. 04232200] and Sugar Creek at County House Road at Guyanoga [No. 0423245850]; see Figure A3-8). These two locations have relatively short periods of record available to support model calibration (April 2019 through December 2020).

Calibration of the model hydrology was performed based on a visual evaluation of goodness-of-fit between the model predictions and data, and statistical model-to-data comparisons using the performance ratings described in Section 3.2.2.

Additional flow data collected by the Finger Lakes Institute (FLI) at several other locations in the watershed during 2020 (Figure A3-8; see 9E Section 2.4.2 for further details) were used for hydrologic model validation (discussed in Section 3.4).

3.2.1.2 Water Quality Calibration Approach

The same type of calibration approach described above for the model hydrology (i.e., combination of visual goodness-of-fit and statistical model-to-data comparisons) was used for calibration of sediment and water quality parameters. Based on the available tributary monitoring data for the Seneca-Keuka watershed, the water quality calibration focused on total suspended solids (TSS) and total phosphorus (TP).[4] As described in Section 3.1.2, the watershed model simulation period was a 14-year period between 2007 and 2020; however, model calibration focused on the 6-year period between 2015 and 2020, which had the largest amount of data deemed suitable for model calibration. Model calibration also focused on a select subset of sub-watersheds for which water quality data are available, including Big Stream, Catherine Creek, Kashong Creek, and Sugar Creek (see Figure A3-8). In addition to data availability, these subbasins were selected for calibration because they include subbasins from both the Seneca and Keuka watersheds, and they represent a range of land use conditions. For example, Kashong Creek is a predominantly agricultural sub-watershed while Catherine Creek has a higher proportion of forested area. Water quality data are available for other sub-watersheds; however, those data were reserved for model validation (see Section 3.4).

While a considerable amount of water quality data has been collected from the various tributaries selected for calibration (and validation) in this watershed, the frequency of those data is not sufficient to support a robust model calibration at relatively short time scales (i.e., daily or monthly). Therefore, model calibration was performed on an annual time scale by comparing SWAT model predictions of annual TSS and TP loads to data-based estimates of those loads derived using the site-specific data. Contemporary measurements of paired flow and TSS/TP concentrations needed to calculate loading are relatively sparse (typically less than 10 samples are available in each of the calibration and validation sub-watersheds, and most of those data were collected in 2020, with a few samples collected in 2018 and 2019). Therefore, a tool known as FLUX32 was used to develop annual data-based TSS and TP loads for comparison with the SWAT model predictions during each year of the model calibration period (2015 through 2020).[5] This is a tool that is commonly used to evaluate flow and concentration relationships, and calculate material loads in streams.

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[4] It should be noted that the modeling QAPP stated the model calibration would also include soluble-reactive phosphorus (SRP). However, based upon a review of available SRP tributary data, it was determined that those data were insufficient to support model calibration.

[5] FLUX32 was developed by the U.S. Army Corps of Engineers, in conjunction with the Minnesota Pollution Control Agency (MPCA). Additional information about FLUX32 can be found on the MPCA website: https://www.pca.state.mn.us/wplmn/flux32.

3.2.2 Calibration Targets

As noted above and described in the modeling QAPP, the process of model calibration included a combination of visual goodness-of-fit between model predictions and observed data at various locations (i.e., comparison of time-series of model-predicted and observed flows) and statistical comparisons between model predictions and data using metrics such as Nash Sutcliffe Model Efficiency (Nash and Sutcliffe 1970) and Percent Bias (PBIAS). Results were compared to the thresholds of model acceptance for the metrics presented in Table A3-3 (Moriasi et al. 2007). Consideration was given to applying more sophisticated statistical methods of model calibration (e.g., methods such as a probabilistic Monte Carlo calibration approach where various distributions of model input parameters are generated), but the site data were deemed insufficient to support this type of approach.

Table A3-3
General Performance Ratings for Recommended Statistics from Moriasi et al. 2007

Performance Rating	RSR	NSE	PBIAS (%)		
			Streamflow	Sediment	Nutrients
Very good	0.00 ≤ RSR ≤ 0.50	0.75 < NSE ≤ 1.00	PBIAS ≤ ±10	PBIAS ≤ ±15	PBIAS < ±25
Good	0.50 < RSR ≤ 0.60	0.65 < NSE ≤ 0.75	±10 ≤ PBIAS < ±15	±15 < PBIAS ≤ ±30	±25 ≤ PBIAS < ±40
Satisfactory	0.60 < RSR ≤ 0.70	0.50 < NSE ≤ 0.65	±15 ≤ PBIAS < ±25	±30 < PBIAS ≤ ±55	±40 ≤ PBIAS < ±70
Unsatisfactory	RSR > 0.70	NSE ≤ 0.50	PBIAS ≥ ±25	PBIAS ≥ ±55	PBIAS ≥ ±70

Notes:
Performance ratings from Moriasi et al. 2007 based on a monthly time step.
RSR: Root Mean Square Error-observations standard deviation ratio
NSE: Nash-Sutcliffe coefficient of model efficiency (Nash and Sutcliffe 1970)

The general performance ratings shown in Table A3-3 apply to a typical dataset that would include long-term, continuous measurements with lower levels of uncertainty. However, given the limited number of high certainty measurements within the Seneca-Keuka watersheds, these thresholds were considered general guidelines for model performance. It should also be noted that a broader range of acceptable goodness-of-fit measures exist for water quality than for hydrology because there is typically a much greater amount of uncertainty and variability in water quality grab samples than there is in hydrology measurements (see Table A3-3). Any deviations of the model from these performance criteria are discussed in Section 3.2.4.

3.2.3 Model Parameterization

The following is a summary of the primary parameters adjusted to calibrate the watershed model.

3.2.3.1 Hydrology

To calibrate the total flow balance within the watershed, the baseflow, peak flows, and timing of the hydrograph were evaluated. Adjustments to parameters controlling baseflow and surface runoff were made in SWAT during model calibration. Specifically, the snowpack temperature (SUB_SMPTMP), groundwater delay (GW_DELAY), and baseflow alpha factor (ALPHA_BF) were adjusted. The SUB_SMTMP was set at 5°C. The GW_DELAY was adjusted from 31 days to 20 days and ALPHA_BF was adjusted from 0.014 days to 0.1 days. The surface runoff was adjusted by reducing the surface runoff lag factor (SURLAG) from 4 days to 2 days.

In addition, during the hydrology calibration, the potential evapotranspiration (PET) method was switched from the Penman-Monteith method to the Hargreaves method, which is a temperature-based PET method.

3.2.3.2 Sediment

Sediment loads were calibrated primarily through the adjustment of the carrying capacity (i.e., the amount of sediment transported for a given flow) parameters at the sub-watershed level. The parameters adjusted during calibration included the following:

- PRF: the peak rate adjustment factor was adjusted to 1.95 for the Seneca sub-watersheds and 1.5 for the Keuka sub-watersheds.
- SPCON: the linear parameter for calculating sediment deposition and resuspension was adjusted to 0.0002 for sub-watersheds where data were available to support this adjustment.
- SPEXP: the exponential parameter for calculating sediment deposition and resuspension was revised and set to 2 for all sub-watersheds.

3.2.3.3 Total Phosphorus

Total phosphorus loads were calibrated through the adjustment of parameters at the HRU level for the different land uses and steeper slopes. The parameters adjusted during calibration included the following:

- AI2: the fraction of algal biomass related to phosphorus was adjusted to 0.01.
- BIOMIX: the biological mixing efficiency was set to 0.4.
- ERORGP: the phosphorus enrichment ratio for sediment was adjusted for specific land use categories throughout the watershed. Specifically, forest and wetland areas were set to 0.05, urban areas were set to 0.2 and agricultural land uses were set to 1.0 or 1.2.
- FILTERW: a vegetated filter strip was applied to HRUs where the slope was greater than 16%.

- GWSOLP: the concentration of soluble phosphorus in groundwater was adjusted by land use where values ranged from 0.05 milligrams per liter (mg/L; forested) to 1.0 mg/L (alfalfa, corn, soybean, and winter wheat).
- PSP: the phosphorus availability index was set at 0.7.
- The initial concentrations for organic and soluble phosphorus in the soil layer were adjusted to 0.1 milligrams per kilogram (mg/kg) and 50 mg/kg, respectively to allow the model to initialize the soil phosphorus concentrations.
- SOL_P_MODEL: the updated soil phosphorus model routine was selected.

3.2.4 Calibration Results and Model Performance

3.2.4.1 Hydrology

As noted in Section 3.2.1.1, the hydrologic component of the model was calibrated to data at two USGS monitoring locations within the Seneca-Keuka watershed (Catherine Creek at Montour Falls [No. 04232200] located in the headwaters of Catherine Creek, and Sugar Creek at County House Road at Guyanoga [No. 0423245850]; see Figure A3-8). These two USGS gages have a relatively short (April 2019 through December 2020), but continuous hydrologic record that captured a range of flow conditions.

Figures A3-9 and A3-10 show comparisons of monthly average flow data and model predictions at Catherine Creek and Sugar Creek, respectively. For Catherine Creek, the model and data generally show good agreement on a monthly timescale (Figure A3-9; bottom panel). This is further supported by model performance ratings of "Good" based on the Nash-Sutcliffe coefficient of model efficiency (NSE) and PBIAS values (NSE = 0.65; PBIAS = 0.71%). A comparison of total cumulative volume (model versus data) for the period between April 2019 and December 2020 is shown in Figure A3-11. The percent difference in volume between the model and data for Catherine Creek is relatively small (less than 2%), with the model slightly underpredicting the data.

For Sugar Creek, the monthly-averaged model results and data show reasonable agreement during the calibration period (see Figure A3-10). One exception is the period between July and December 2019 where the model overpredicts the data by about a factor of two—it was determined that the rainfall at the Geneva Research Farm (upon which the SWAT model was based) was approximately 50% higher than rainfall measured at a Cornell rainfall gauge located more proximal to the Sugar Creek subbasin (in Branchport, New York) during summer/fall 2019. The observed difference in rainfall explains the overestimation of flow in the model during this period. As a result, the model performance at this location was rated "Unsatisfactory" based on the NSE and PBIAS statistics; however, this performance rating (which can be explained by a localized difference in rainfall) does not mean that the overall model performance is poor. The difference in total cumulative volume of water between model and data for Sugar Creek was approximately 20% (Figure A3-11).

3.2.4.2 Water Quality

As described in Section 3.2.1.2, the water quality component of the SWAT model (sediment and TP) was calibrated to annual data-based loads estimated using FLUX32 between 2015 and 2020 at four locations: Catherine Creek, Big Stream, Kashong Creek, and Sugar Creek. Results of the sediment and TP calibration are discussed below.

3.2.4.2.1 Sediment

Figure A3-12 shows a comparison of model-predicted and data-based annual sediment loads from 2015 through 2020 at each of the four sub-watersheds selected for calibration. In general, this figure shows very good agreement between the model and data. Specifically, the model captures both the observed year-to-year variations in loading, and the relative difference in loading across the four sub-watersheds. As noted in Section 3.2.1.2, these sub-watersheds were selected for calibration because they include subbasins from both the Seneca and Keuka watersheds, and they represent a range of conditions. For example, Catherine Creek is predominately forested, while Kashong Creek is predominately agricultural. Also, the Catherine Creek sub-watershed occupies a higher elevation area with steeper slopes and less well-drained soils, while the Kashong Creek sub-watershed has gentler slopes and more well-drained soils. The model is able to reasonably simulate sediment loading across this range of watershed conditions.

Table A3-4 provides a summary of annual average sediment loading in each sub-watershed during the 6-year calibration period (model and data), and the NSE and PBIAS performance statistics calculated for each. The PBIAS statistic indicated “Very Good” or “Good” model performance in all four sub-watersheds; however, the NSE rating was “Very Good” for Big Stream and Catherine Creek, but “Unsatisfactory” for Kashong Creek and Sugar Creek. The amount of monitoring data available to develop the data-based (FLUX32) loads is limited, so an unsatisfactory rating in the NSE statistic does not necessarily indicate that overall model performance is poor.

Table A3-4
Sediment Calibration Results

Watershed	Calibration Location	SWAT Average Annual Sediment Load (tons/year)	FLUX32 Average Annual Sediment Load (tons/year)	NSE Performance Rating	PBIAS Performance Rating (%)
Seneca	Big Stream	22,944	26,487	0.8 (Very Good)	13.4 (Very Good)
	Catherine Creek	25,502	23,551	0.9 (Very Good)	-8.3 (Very Good)
	Kashong Creek	9,663	10,885	-0.7 Unsatisfactory)	11.2 (Very Good)
Keuka	Sugar Creek	2,286	1,986	0.3 (Unsatisfactory)	-15.1 (Good)

3.2.4.2.2 Total Phosphorus

Figure A3-13 shows a comparison of model-predicted and data-based annual TP loads from 2015 through 2020 at each of the four calibration locations. Reasonable agreement was achieved between the model and data at three of the four locations (Big Stream, Kashong Creek, and Sugar Creek). In addition, the relative distribution of TP loads across these three sub-watersheds (that have different sizes and land use composition) looks reasonable. However, the model significantly overpredicts the annual TP loads estimated for Catherine Creek—upon further review, it was determined that the poor agreement between model and data at this location is likely due to an underestimation of the data-based loads at this location. Specifically, the TP monitoring data for this sub-watershed does not appear to capture the impact of a large storm event that occurred on June 20, 2019, that was observed in other nearby sub-watersheds. For example, a high TP concentration in the Big Stream sub-watershed was measured during this event (990 micrograms per liter [µg/L]), but the measured TP concentration in Catherine Creek was relatively low (78 µg/L). This lack of TP response at the upper end of the hydrograph in Catherine Creek has a significant impact on the annual TP loading estimated using FLUX32.

Table A3-5 provides a summary of annual average TP loading in each sub-watershed during the 6-year calibration period (model and data), and the NSE and PBIAS performance statistics calculated for each. The PBIAS statistic indicated "Very Good" or "Good" model performance in all sub-watersheds except Catherine Creek (see explanation above regarding Catherine Creek). NSE ratings are "Satisfactory" in Big Stream, but "Unsatisfactory" in the other three sub-watersheds. As noted in Section 3.2.2, the PBIAS statistic has different ranges of acceptability for hydrology and water quality parameters in recognition of the greater degree of uncertainty/variability in water quality grab samples; the NSE metric does not account for this. Given the relatively limited amount of monitoring data available to develop the data-based (FLUX32) TP loads, an unsatisfactory rating in the NSE statistic does not necessarily indicate that overall model performance is poor.

Table A3-5
Total Phosphorus Calibration Results

Watershed	Calibration Location	SWAT Average Annual TP Load (kg/year)	FLUX32 Average Annual TP Load (kg/year)	NSE Performance Rating	PBIAS Performance Rating (%)
Seneca	Big Stream	8,942	10,396	0.6 (Satisfactory)	14.0 (Very Good)
	Catherine Creek	7,890	3,189	-17.5 (Unsatisfactory)	<-70 (Unsatisfactory)
	Kashong Creek	8,938	10,474	-0.6 Unsatisfactory)	14.7 (Very Good)
Keuka	Sugar Creek	3,083	2,309	-1.7 Unsatisfactory)	-33.5 (Good)

3.3 Sensitivity Analysis

Sensitivity analysis refers to a process of assessing the model's response to changes in key model parameters. Sensitivity analysis apportions variation in model output, either qualitatively or quantitatively, to sources of variation in both model input data and, more commonly, the various parameters in the model that affect the performance or calibration of the model. Considering the computational challenges of running the SWAT model in an iterative fashion, a one-at-a-time sensitivity analysis was performed during model calibration. For this analysis, various parameters were adjusted to a low and high value (one at a time, and within a reasonable range based on professional judgment) and the model was run to evaluate the impact on predicted flows, TSS, and TP. Changing parameters one-at-a-time ignores correlations between parameters and, consequently, introduces a limitation of this approach. However, given the restricted time and resources for this project, a one-at-a-time sensitivity approach aided in narrowing down the list of model parameters efficiently.

3.4 Model Validation

3.4.1 Approach

The model validation process includes comparison of model predictions to data collected during a period of time or at watershed locations that were not considered during calibration. 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.

3.4.2 Validation Results and Model Performance

3.4.2.1 Hydrology

Validation of the hydrologic component of the model was performed using flow data from four FLI monitoring locations at Castle Creek, Reeder Creek, Kashong Creek, and Cold Brook. These data were collected by FLI from March to October 2020—because this is a relatively short period of record, these data may not necessarily capture the full range of flow conditions at these locations. Nonetheless, model predictions and data were compared on a monthly-average basis at these four locations (Figure A3-14). There is relatively good agreement between model predictions and data over this period at all four locations. That is, the range of uncertainty in the model predictions and data overlapped significantly as indicated by the error bars. No comparison is shown for June through October in Kashong Creek since that stream was essentially dry on various occasions during that period, complicating model-data comparisons.

3.4.2.2 Sediment

Figure A3-15 shows a comparison of model-predicted and data-based annual sediment loads from 2015 through 2020 at each of the four sub-watersheds selected for model validation (Reeder Creek, Castle Creek, Wagener Glen, and Cold Brook). For reference, this figure also includes the four calibration locations discussed previously. The four validation locations represent sub-watersheds containing a high percentage of agricultural and/or forested land. However, Reeder Creek and Castle Creek (located in the Seneca watershed) also contain a relatively high proportion of developed land (nearly 20%). Both Cold Brook and Wagener Glen (located in the Keuka watershed) are predominately forested.

Figure A3-15 shows that there is relatively good agreement between model-predicted and observed sediment loads at the validation locations, indicating the model parameters selected during calibration result in reasonable model predictions for those locations.

3.4.2.3 Total Phosphorus

Figure A3-16 shows a comparison of model-predicted and data-based annual TP loads from 2015 through 2020 at each of the four sub-watersheds selected for model validation (and the four calibration locations). Model-predicted loads in Reeder Creek, Castle Creek, and Wagener Glen show reasonable agreement with the data-based loads. A larger difference between model and data is observed in Cold Brook; however, the relative distribution of loading across the various watersheds is reasonable. That is, both the model and data indicate that the largest TP loading among these four sub-watersheds is coming from Cold Brook.

4 Keuka In-Lake Model (BATHTUB)

BATHTUB is a relatively simple in-lake water quality model that was developed and applied to Keuka Lake to evaluate the potential impacts of reduced watershed nutrient loading on Keuka Lake water quality conditions. The primary inputs to the Keuka in-lake model were flows and TP loads discharged from the Keuka Lake watershed as derived from the calibrated SWAT watershed model. Calibration of the Keuka in-lake model focused on a pooled dataset that overlapped with the watershed model calibration period described above (i.e., 2015 to 2020).

The BATHTUB model has an internal procedure to assist with model calibration. This procedure derives least-squares estimates for model calibration factors, calculated from log-transformed observed and predicted concentrations of the nutrients being simulated. The primary model calibration factor was the nutrient sedimentation (loss) rate. Calibration error targets for the Keuka in-lake model are ±15% mean error for TP on a lake-wide basis.

4.1 Model Set Up

The Keuka Lake BATHTUB model was set up as a single segment with a single tributary. NYSDEC performed an analysis on the spatial variability of water quality data of the east, west, and south branches of Keuka Lake. The analysis concluded that there were no statistical differences in key water quality parameters (Prestigiacomo and McCaffrey 2020), hence the lake was modeled as a single segment. As such, individual tributary flows and loads were summed across all the Keuka Lake subbasins and were represented in BATHTUB as a single tributary.

BATHTUB offers numerous model set-up options depending on site characteristics, availability of in-lake nutrient data, and the desired empirical formulations relating nutrient concentrations to water quality indicators (Walker 1999). Model Option No. 3 (fixed second order), was used to predict in-lake TP concentrations. This model was selected because it has been calibrated to U.S. Army Corp of Engineers (USACE) reservoirs and met the modeling objectives of fitting the observed data while minimizing the change in calibration factors and the uncertainty of the model predictions.

4.2 Model Inputs

Individual tributary flows and loads were summed across the 5 HUC12 sub-watersheds in the Keuka Lake watershed and were represented as a single tributary to the one-segment Keuka Lake model. The lake morphology and observed nutrient data from the 2018 Citizens Statewide Lake Assessment Program and 2018 Finger Lakes Water Quality Report were used as inputs and are shown in Table A4-1. The precipitation data came from the Penn Yann Airport Station and the average and coefficient of variance were calculated for the model simulation period (2015 through 2020).

Table A4-1
Lake Morphology and Water Quality Data

Parameter	Value	Source
Surface Area, km^2	47	NYSDEC (2019)
Mean Depth, m	30.5	Clinkhammer et al. (2019)
Length, km	31.6	Clinkhammer et al. (2019)
Total Phosphorus, ppb	7	NYSDEC (2019)
Precipitation, m	0.71	NOAA (2020)
Drainage Area, km^2	453.3	SWAT Model

All other global variables required by the model, including atmospheric loads, were kept at the default values specified by BATHTUB. The atmospheric loads are presented in Table A4-2.

Table A4-2
BATHTUB Atmospheric Loading

Parameter	Value (kg/km2-yr)
Total Phosphorus	30
Ortho Phosphorus	15

4.3 Model Calibration

The BATHTUB model was calibrated against lake nutrient data using the model's built-in calibration procedure (Walker 1999) The calibration factor for TP was 1.3 as determined by least-squares regression of the log-transformed observed and predicted concentrations (Walker 1999). This calibration factor is within the range used by other BATHTUB model applications in New York State (Tetra Tech 2015).

TP calibration results are presented in Table A4-3. Due to the simplicity of the model set-up (single segment with single integrated tributary), the observed and predicted TP concentrations are in precise agreement. Similarly, the uncertainty bounds in modeled TP concentrations closely match those of the data.

Table A4-3
Total Phosphorus Calibration Results

	TP, µg/L	TP CV
Observed	7 ± 0.4	0.06
Predicted	7 ± 1.5	0.21

4.4 TP Load Response

The calibrated BATHTUB model of Keuka Lake can be used for predicting in-lake TP concentrations under different TP loading scenarios. That is, the statistical relationships between external TP loading and in-lake TP concentrations inherent in the calibrated model can be applied to predict how the lake would respond to changes in external loadings. This relationship is presented graphically in Figure A4-1, which shows the mean TP concentration +/- the standard error of the mean for a range of external TP loadings from 0 to 20,000 kg/year. Under current watershed TP loading conditions of approximately 9,300 kg/year, the in-lake TP concentration is approximately 7 µg/L. Figure A4-1 indicates that a 50% reduction of watershed TP loading would result in a steady-state concentration of TP in the lake of approximately 5.5 µg/L. The model output data is also included in Table A4-4.

The model is based on statistical relationships between external loadings and in-lake concentrations of TP, hence, there is no time component integrated into the assessment. The temporal response of Keuka Lake TP concentrations to reductions in external loadings is driven by numerous factors, most notably the hydraulic residence time of the lake, which is the average time a water molecule resides in the lake. For Keuka Lake, the hydraulic residence time has been estimated between 6 and 8 years (NYSDEC 2019a). Hence, an instantaneous reduction in watershed TP loadings of 50% would require approximately three hydraulic retention times or between 18 and 24 years for the lake to reach its new steady-state concentrations of 5.5 µg/L.

Table A4-4
Keuka Lake BATHTUB Model TP Load Response Summary

Scale Factor	Total Tributary Flow, hm^3/yr	TP Tributary Load, kg/yr	Predicted In Lake TP, µg/L	CV	Low Predicted TP, µg/L	High Predicted TP, µg/L
0.20	225.8	1864.9	3.6	0.23	3.0	4.4
0.40	225.8	3729.9	4.7	0.21	3.9	5.7
0.60	225.8	5594.8	5.5	0.21	4.6	6.7
0.80	225.8	7459.8	6.3	0.21	5.2	7.6
1.00	225.8	9324.7	7.0	0.21	5.8	8.5
1.20	225.8	11189.7	7.6	0.21	6.3	9.2
1.40	225.8	13054.6	8.2	0.21	6.8	9.9
1.60	225.8	14919.5	8.8	0.21	7.2	10.6

Scale Factor	Total Tributary Flow, hm^3/yr	TP Tributary Load, kg/yr	Predicted In Lake TP, µg/L	CV	Low Predicted TP, µg/L	High Predicted TP, µg/L
1.80	225.8	16784.5	9.3	0.21	7.7	11.2
2.00	225.8	18649.4	9.8	0.21	8.1	11.8

5 Watershed Model Management Scenarios and Results

As described in Section 1.3, the calibrated and validated watershed model was used to support the 9E by providing a quantitative assessment of the relative contributions of point and non-point sources of nutrients within the watershed under current conditions. The model was also used to assess anticipated changes in TP loadings associated with potential future land management practices and/or changes in climatological conditions. A such, three scenarios were evaluated using the SWAT model to determine the impact on the phosphorus load in the Seneca-Keuka watershed. These scenarios included: 1) the addition of a cover crop during the non-growing season; 2) an increase in precipitation to simulate the effects of climate change; and 3) the implementation of no till crops. A summary of the management scenarios modeled are discussed in more detail below.

5.1 Cover Crops

A winter wheat cover crop was applied to land uses classified as generic row crops, corn, or soybeans. The winter wheat was planted in the fall after the primary crop was harvested. The cover crop was then harvested in mid-April prior to the start of tilling and fertilization in the spring. The addition of the winter wheat cover crop reduced the TP load on average by approximately 20% over the entire watershed, with reductions ranging from 5% to 41% for the individual HUC12 sub-watersheds.

5.2 Climate Change

To evaluate the effects of climate change on TP loading in the watershed, the full precipitation record used as input to the SWAT model was increased by 10%. This 10% increase is based on estimates provided in the 2018 National Climate Assessment for the northeastern United States[6]. This increase in precipitation resulted in an increase in TP load by approximately 18% on average over the entire watershed (ranging from 9% to 27% for the individual HUC12 sub-watersheds).

5.3 Changes in Tillage/Fertilization Practices

A model simulation was conducted to evaluate the impacts of a change in tillage practices in the watershed from conventional to conservation tillage. Conservation tillage is a farming practice that generally results in leaving crop residue from the previous growing season on the land to prevent soil erosion and runoff, followed by partial clearing before planting the next crop. Examples can include no-tilling, strip-tilling, and ridge-tilling. To simulate this scenario in SWAT, the conservation tillage option was selected and applied to all land uses classified as general row crops, alfalfa, corn, soybeans, and winter wheat. While it was anticipated that this change in tilling practice would result in a net reduction in total phosphorus load, SWAT predicted a net increase of approximately 8%.

[6] https://www.globalchange.gov/nca4

Upon further review, it was determined that this result is likely due to the fact that the base calibration of the model includes surface application of manure and fertilizer; the change in tillage from conventional to conservation resulted in less complete incorporation of the manure and fertilizer into the soil, and thus increased nutrient loading. Results of this scenario indicate that a change in fertilization practices (e.g., fertilizer placement rather than broadcasting) would need to be coupled with change in tillage practices to be effective.

6 Summary

As described in Section 3, the watershed (SWAT) model developed to support the Seneca-Keuka watershed 9E has been reasonably calibrated and validated to observed hydrologic, sediment, and total phosphorus loading conditions in this watershed. Further, the Keuka in-lake model (BATHTUB) described in Section 4 has also been sufficiently calibrated to the observed total phosphorus concentrations in that waterbody. As noted in the modeling QAPP, oversight of the modeling work described herein was provided by the project Technical Advisory Committee consisting of Dr. Liz Moran (EcoLogic), Ian Smith (Finger Lakes Institute), Dr. Lewis McCaffrey (NYSDEC), and Anthony Prestigiacomo (NYSDEC). Results of the final model calibration and validation were reviewed with NYSDEC and NYSDOS on July 12, 2021. It was determined at that time that the model calibration was sufficient for the purposes of using the model to evaluate current TP loadings in the Seneca-Keuka watershed, and to evaluate potential management scenarios in the 9E. Results of those evaluations of current and future loading conditions (based on the model described herein) are presented in the 9E.

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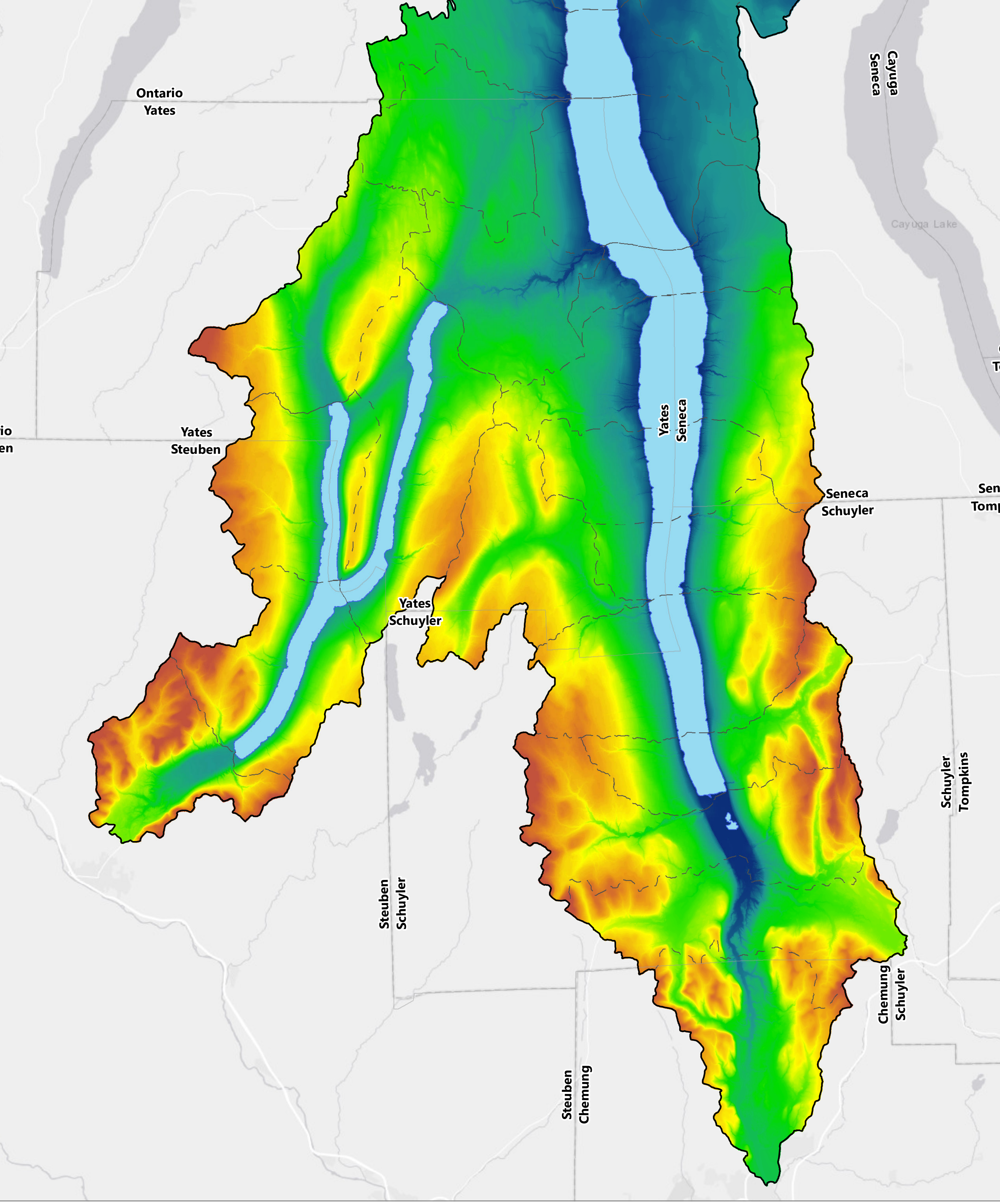

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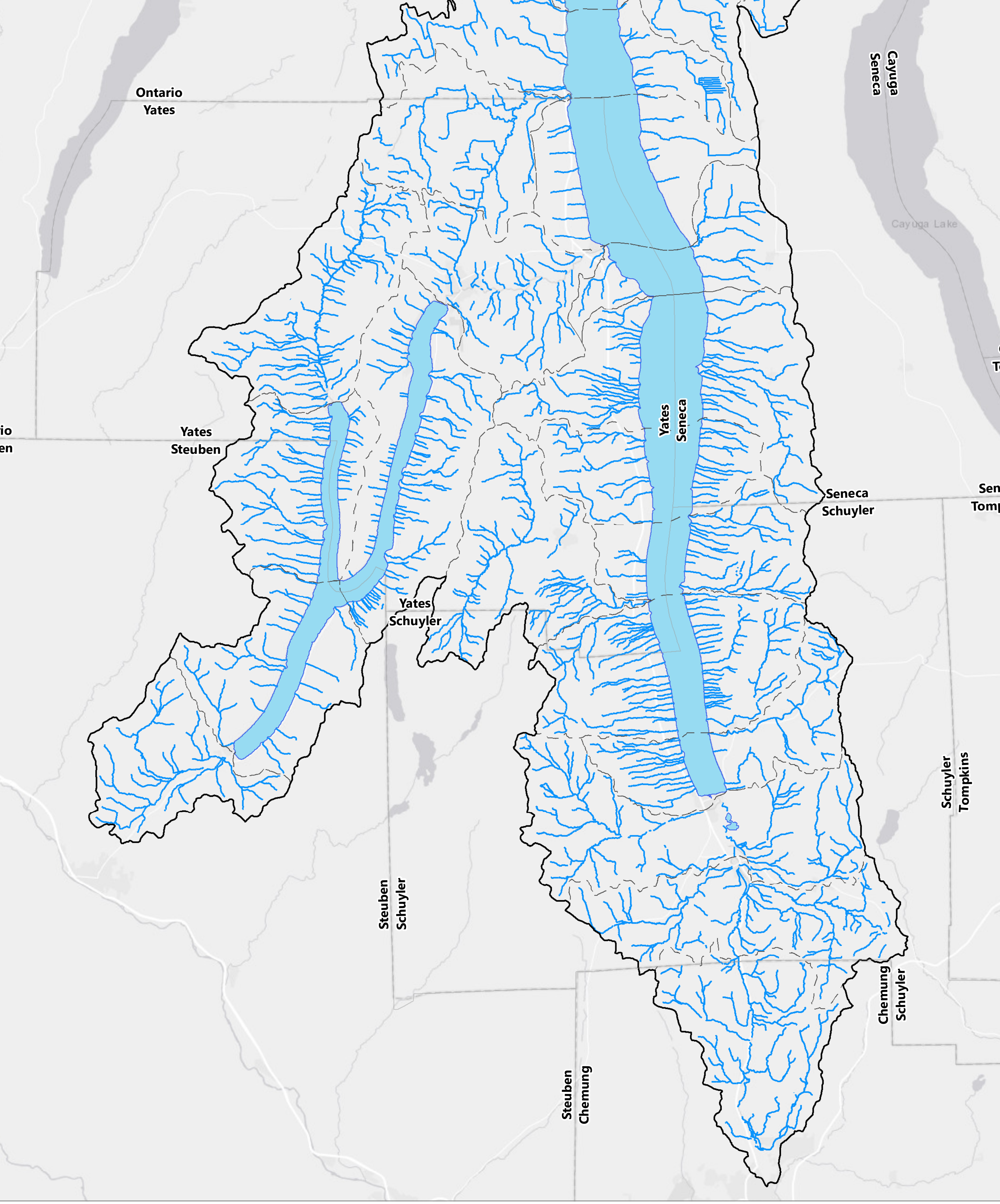

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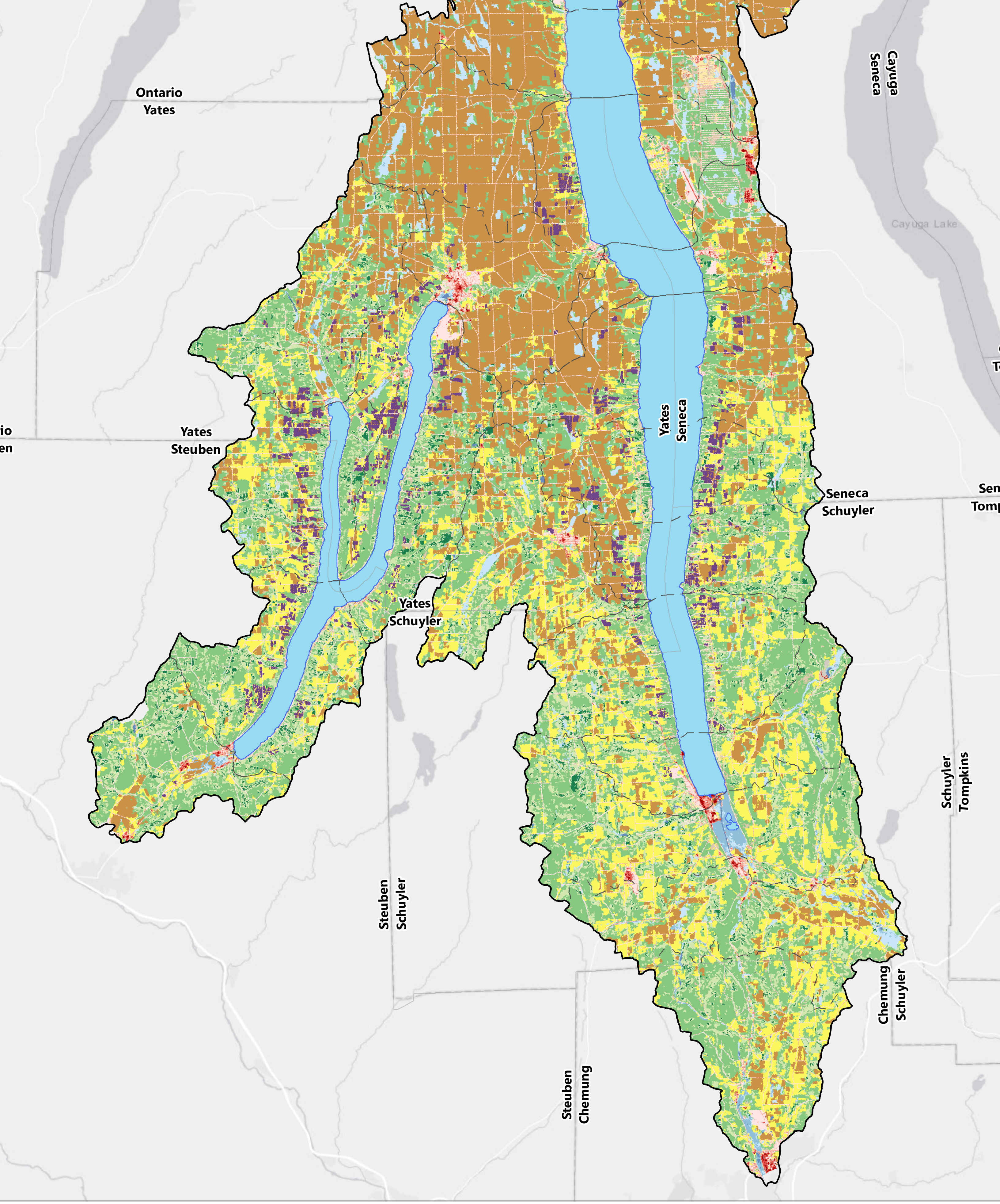

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NLCD Land Cover

Open Water

Developed, Open Space

Mixed Forest

Shrub/Scrub

Grassland, Herbaceous

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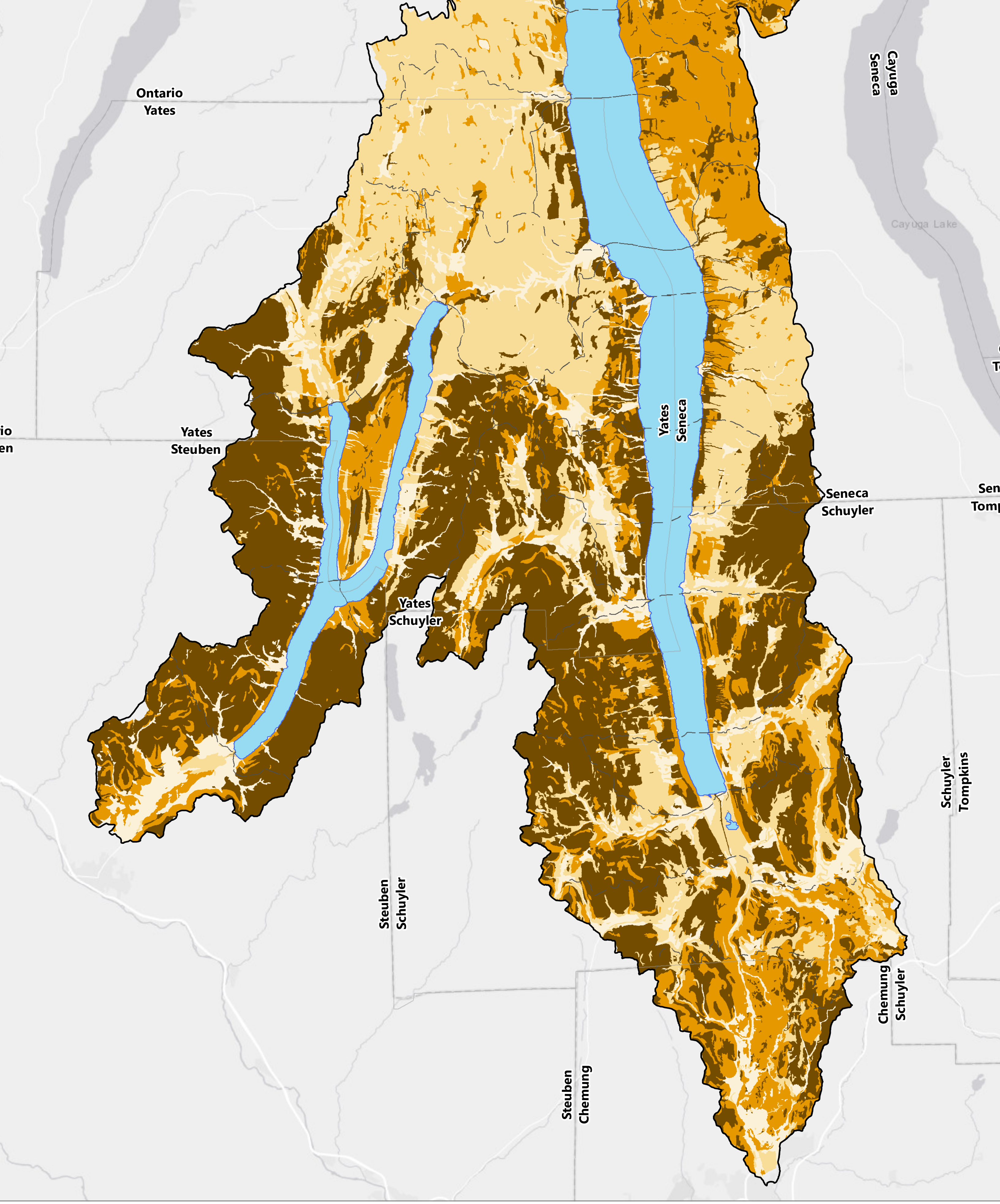

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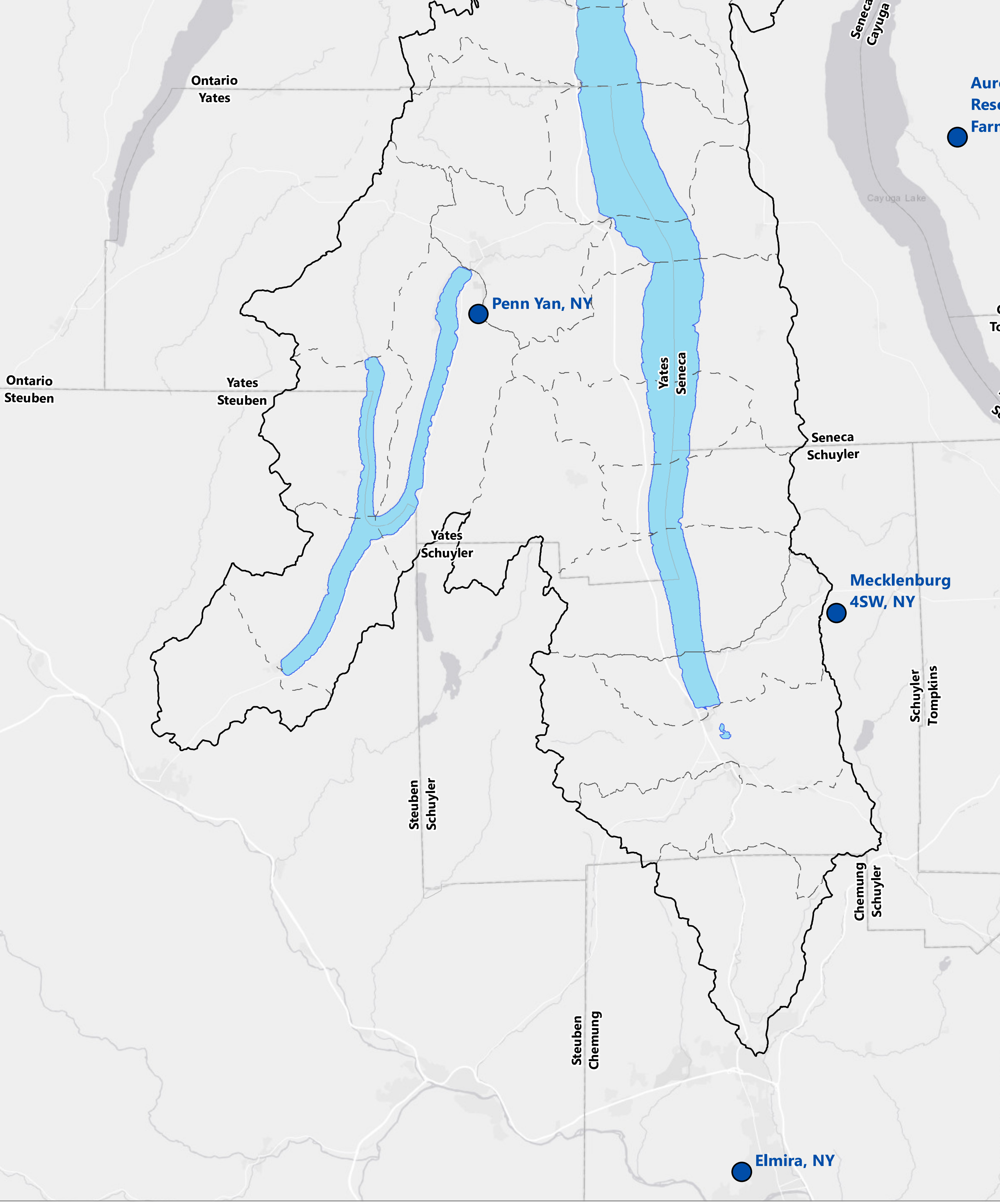

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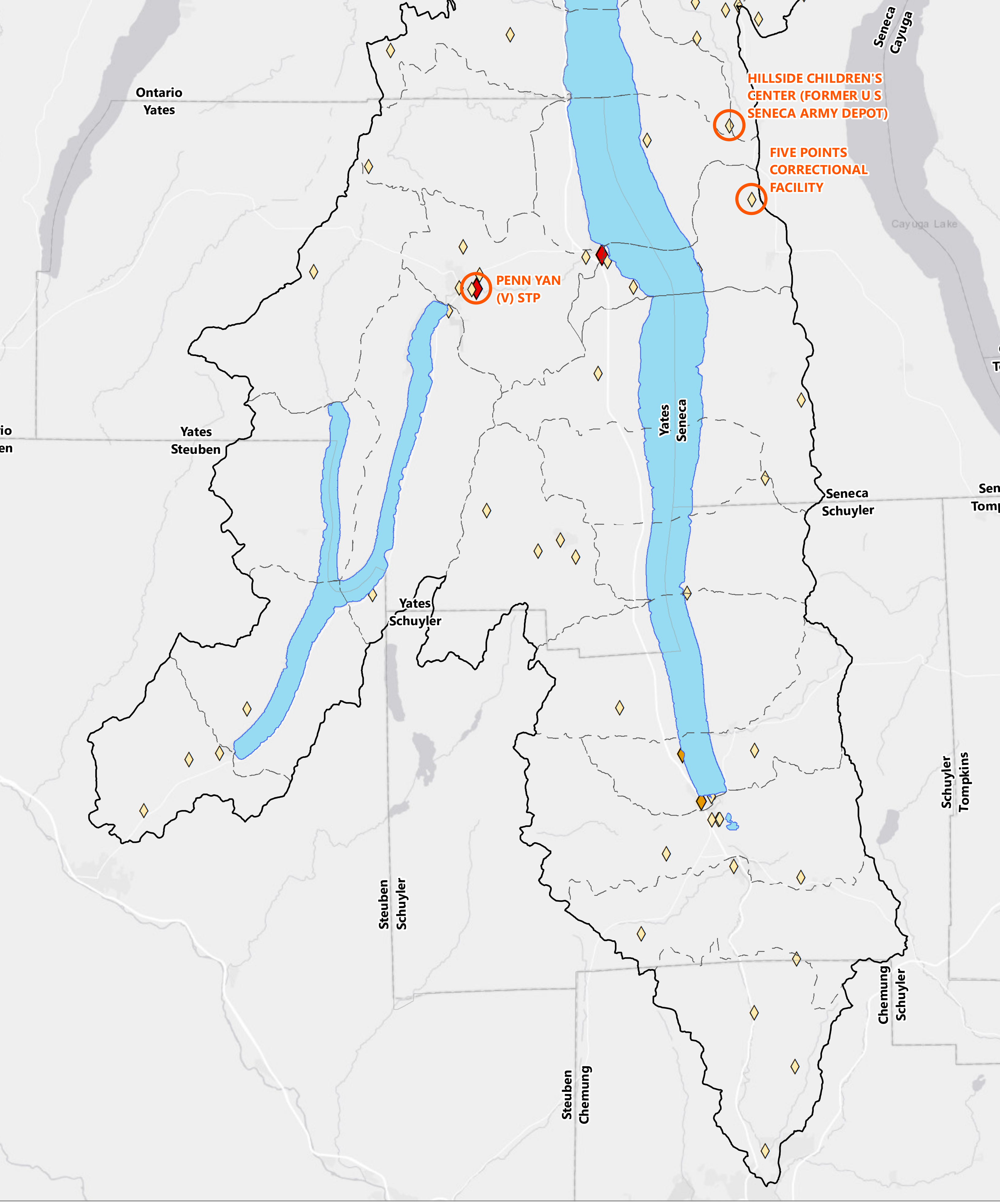

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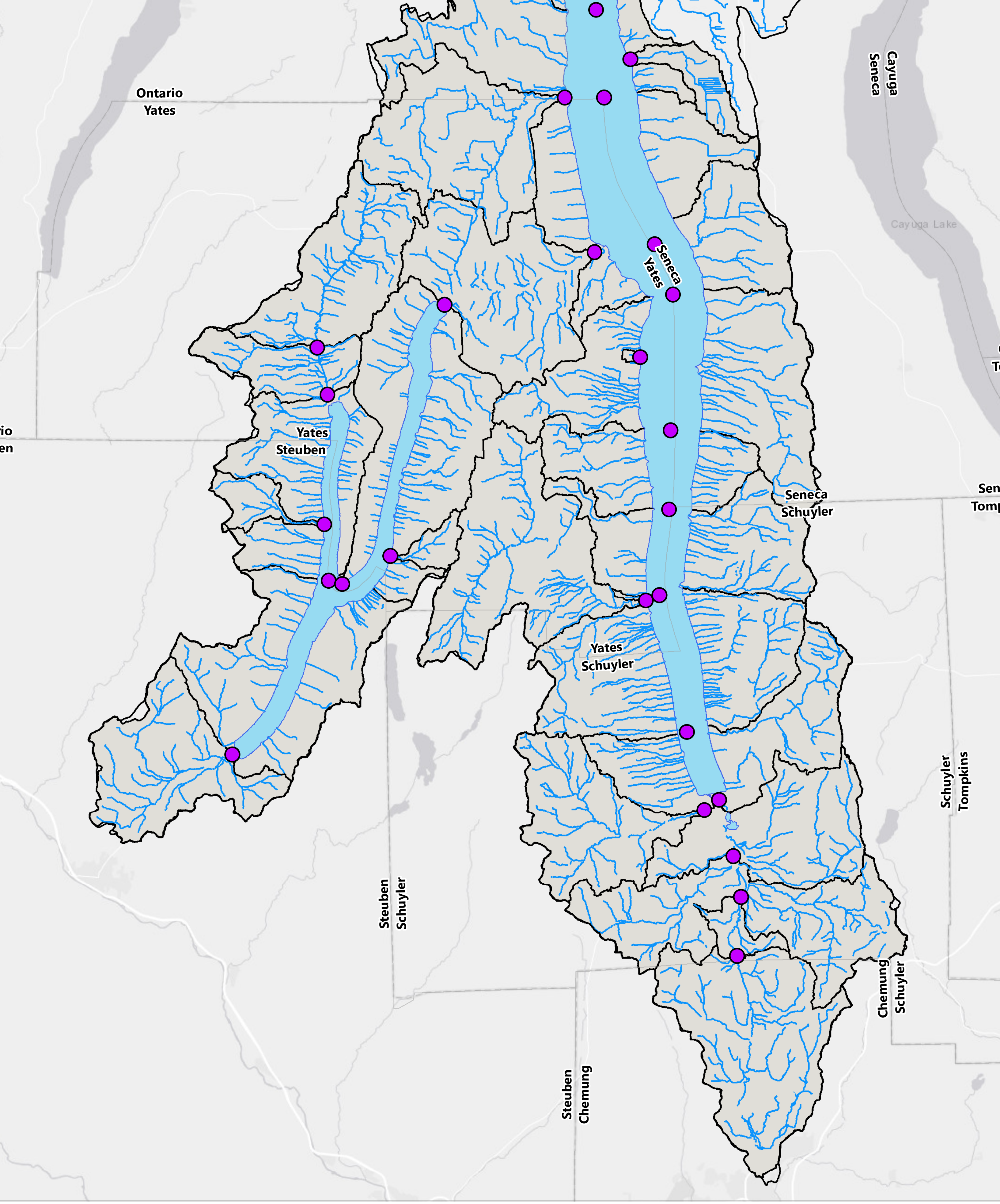

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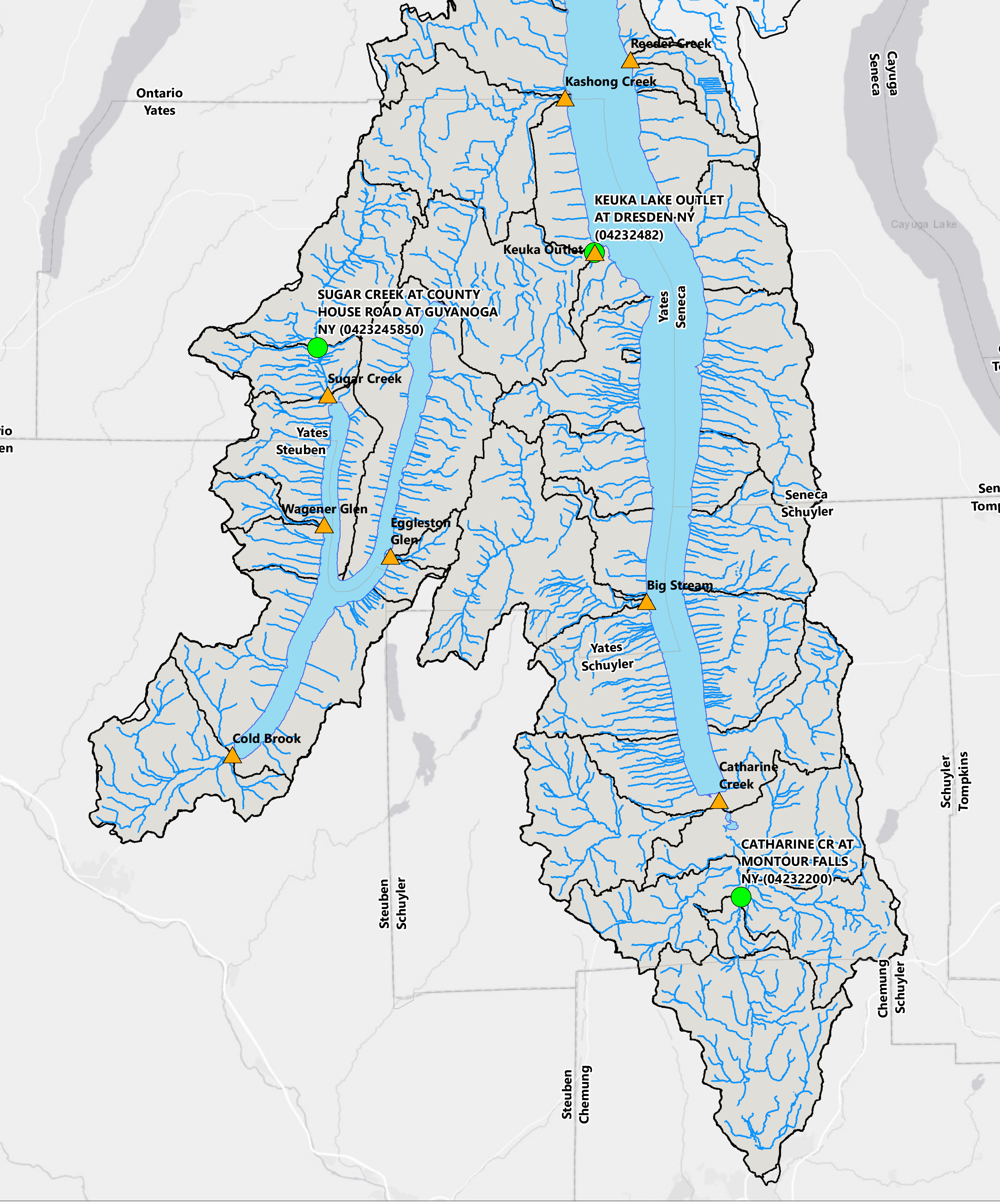

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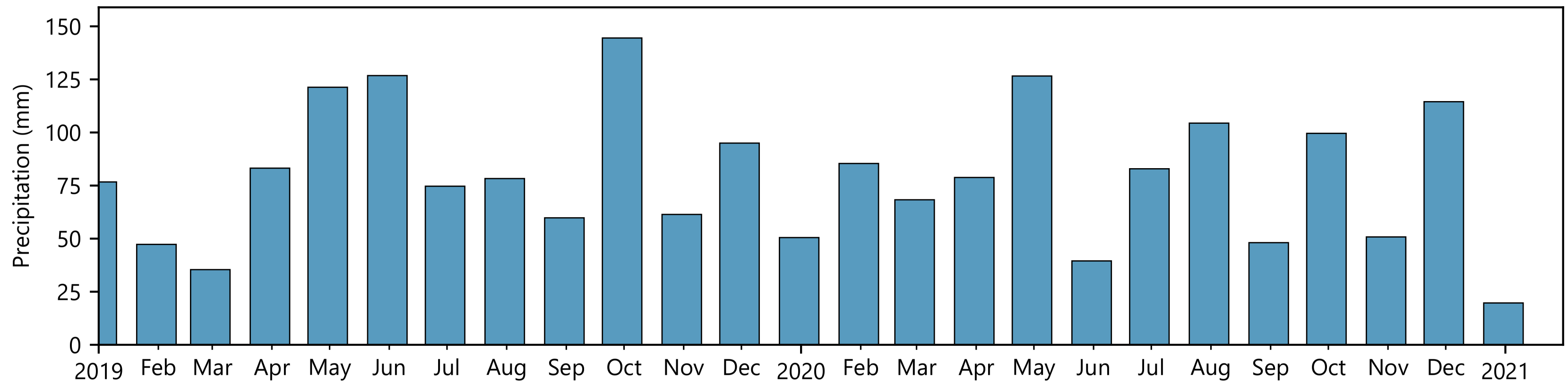

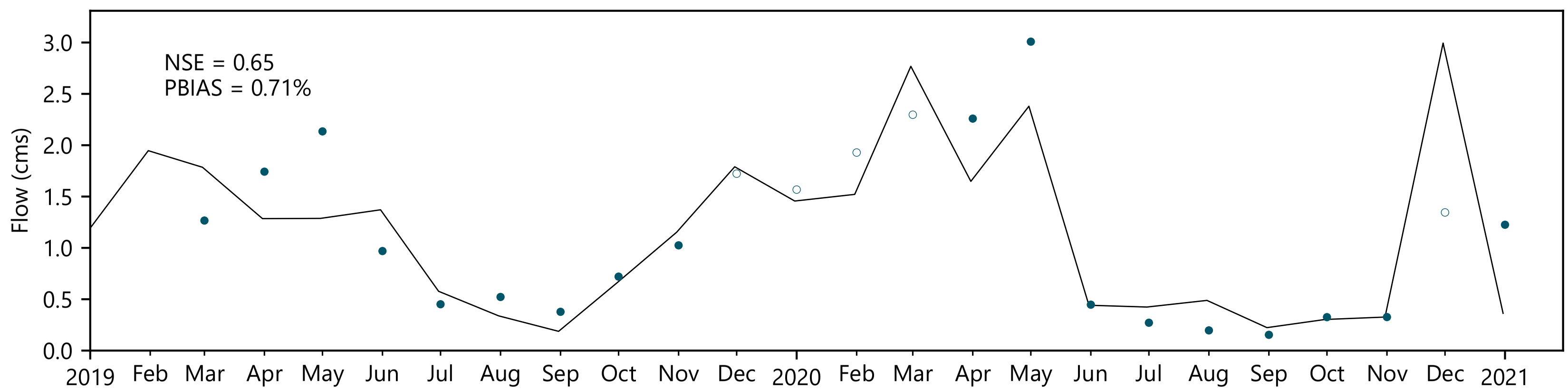

Notes:
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The period of record used was 01/01/2007 through 01/10/2021.
2. The USGS stream flow is from the USGS gage at Catherine Creek at Montour Falls, NY (No. 04232200).
The period of record for the gage is 03/27/2019 to 01/10/2021.
3. The record shown is from 01/01/2019 to 01/10/2021.
4. Flows are monthly averages and precipitation is monthly sum.

Precipitation
USGS Measured Flow
USGS Estimated Flow
ArcSWAT Flow

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Figure A3-9
Monthly Model/Data Comparison for Catherine Creek
Seneca-Keuka Watershed Model Report
Seneca-Keuka Watershed Nine Element Plan

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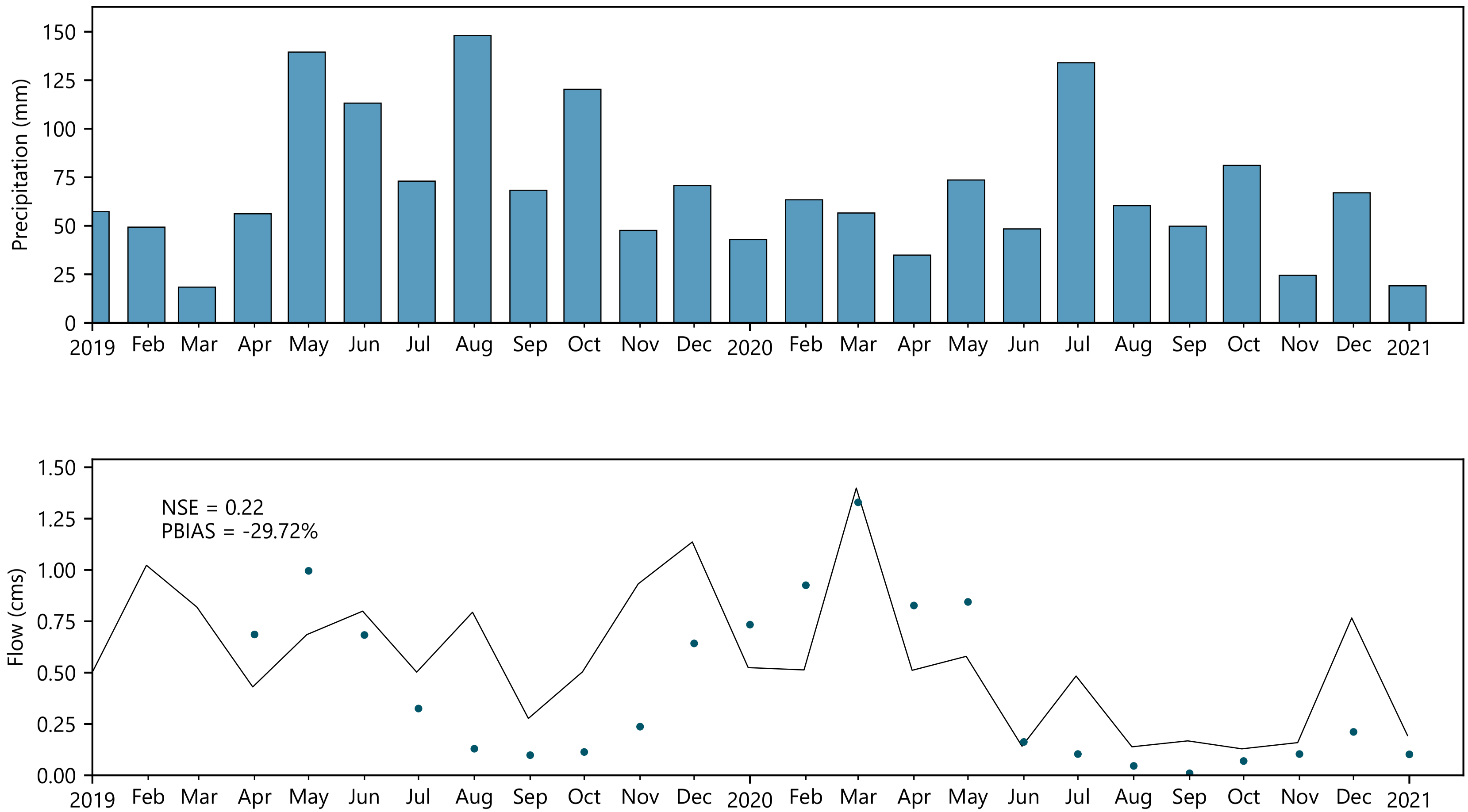

Notes:
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   The period of record used was 01/01/2007 through 01/10/2021.
   The January 2021 precipitation data is interpolated.
2. The USGS stream flow is from the USGS gage at Sugar Creek at County House Road at Guyanoga, NY (No. 0423245850).
   The period of record for the gage is 04/10/2019 to 01/21/2021.
3. The record shown is from 01/01/2019 to 01/10/2021.
4. Flows are monthly averages and precipitation is monthly sum.

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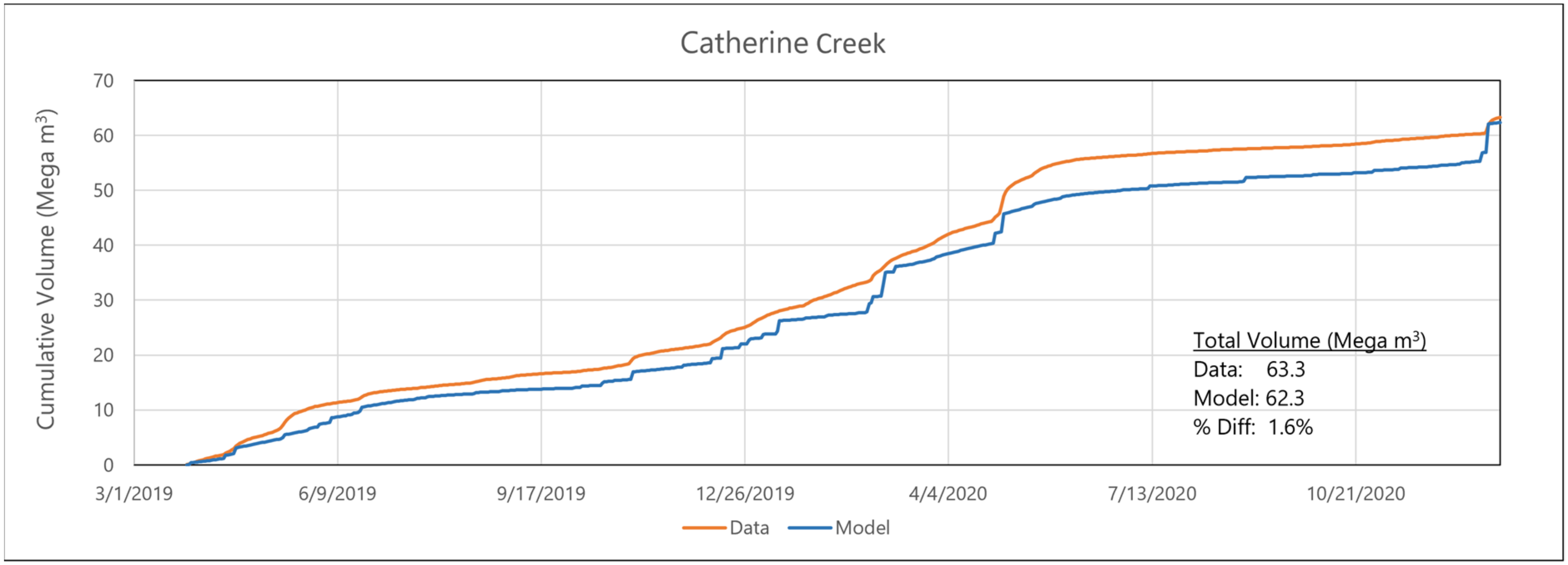
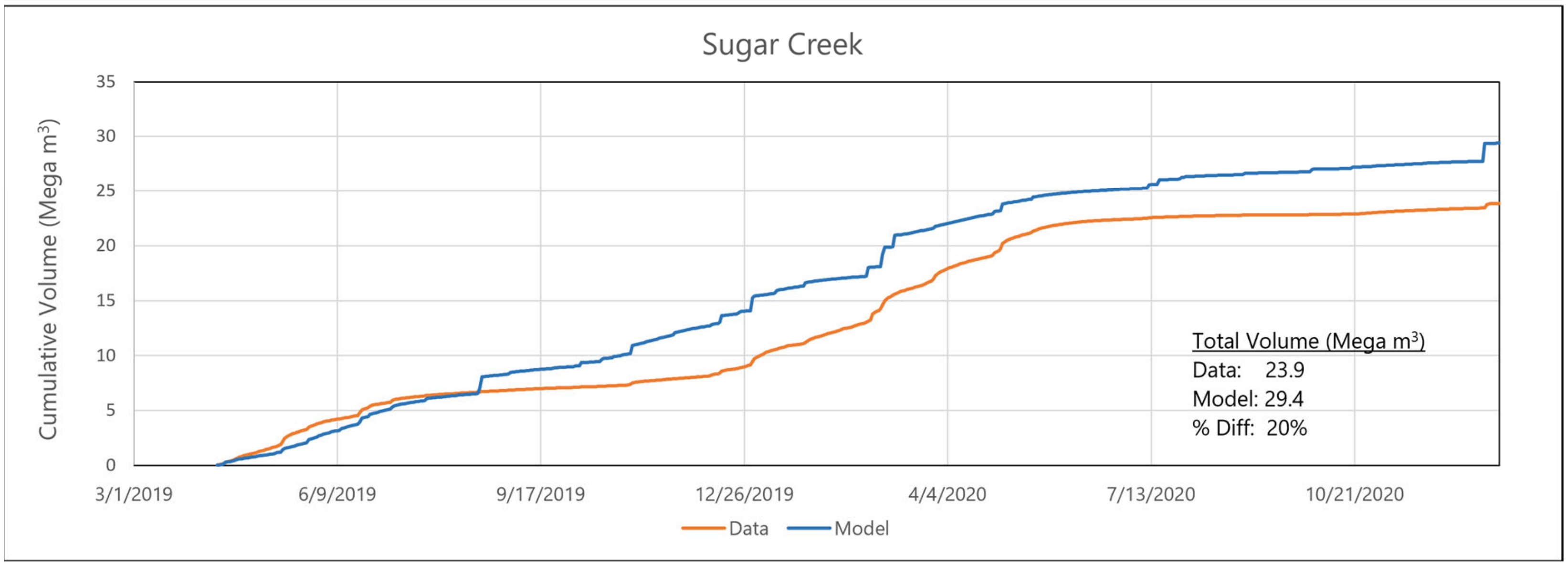
Figure A3-10
Monthly Model/Data Comparison for Sugar Creek
Seneca-Keuka Watershed Model Report
Seneca-Keuka Watershed Nine Element Plan





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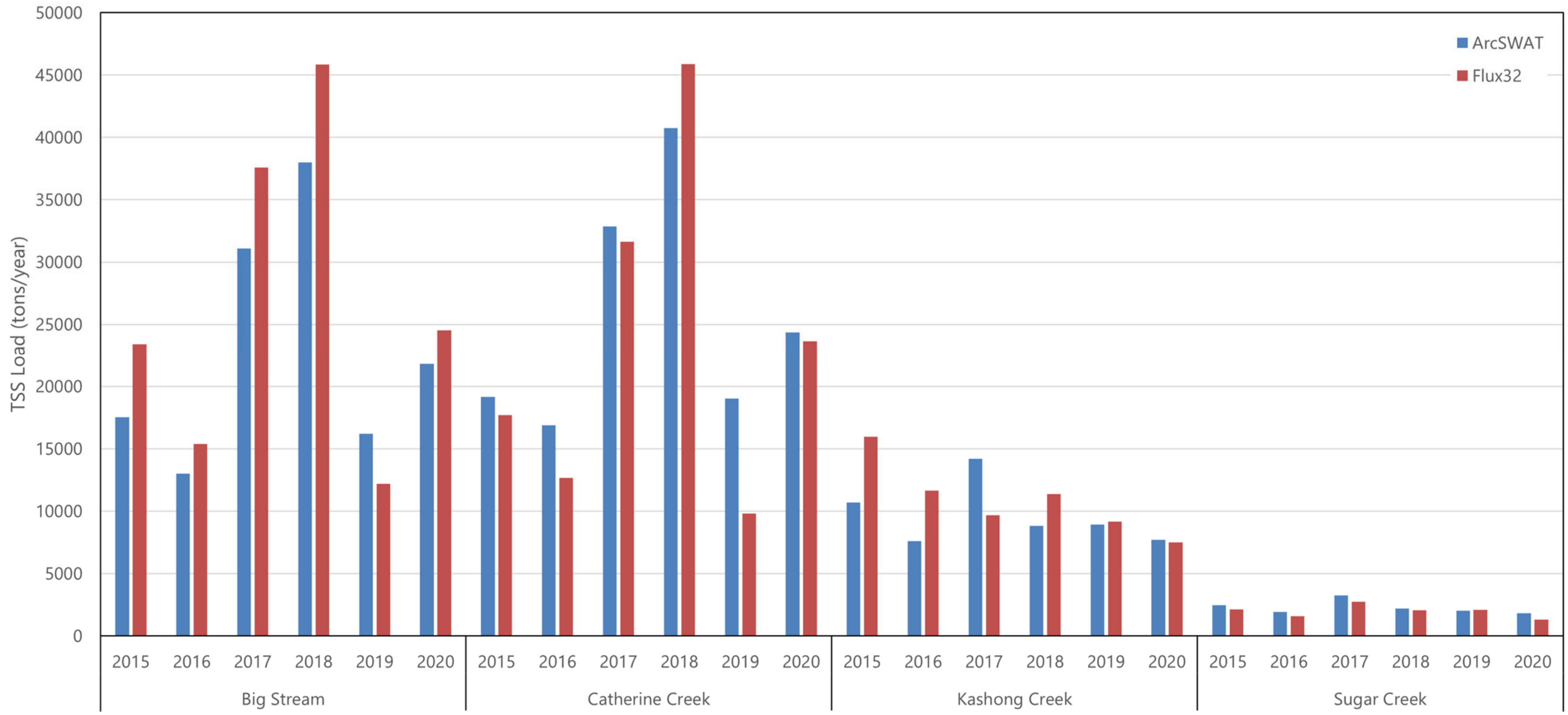

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Figure A3-12
Annual Total Suspended Solids Load at Calibration Locations
Seneca-Keuka Watershed Model Report
Seneca-Keuka Watershed Nine Element Plan

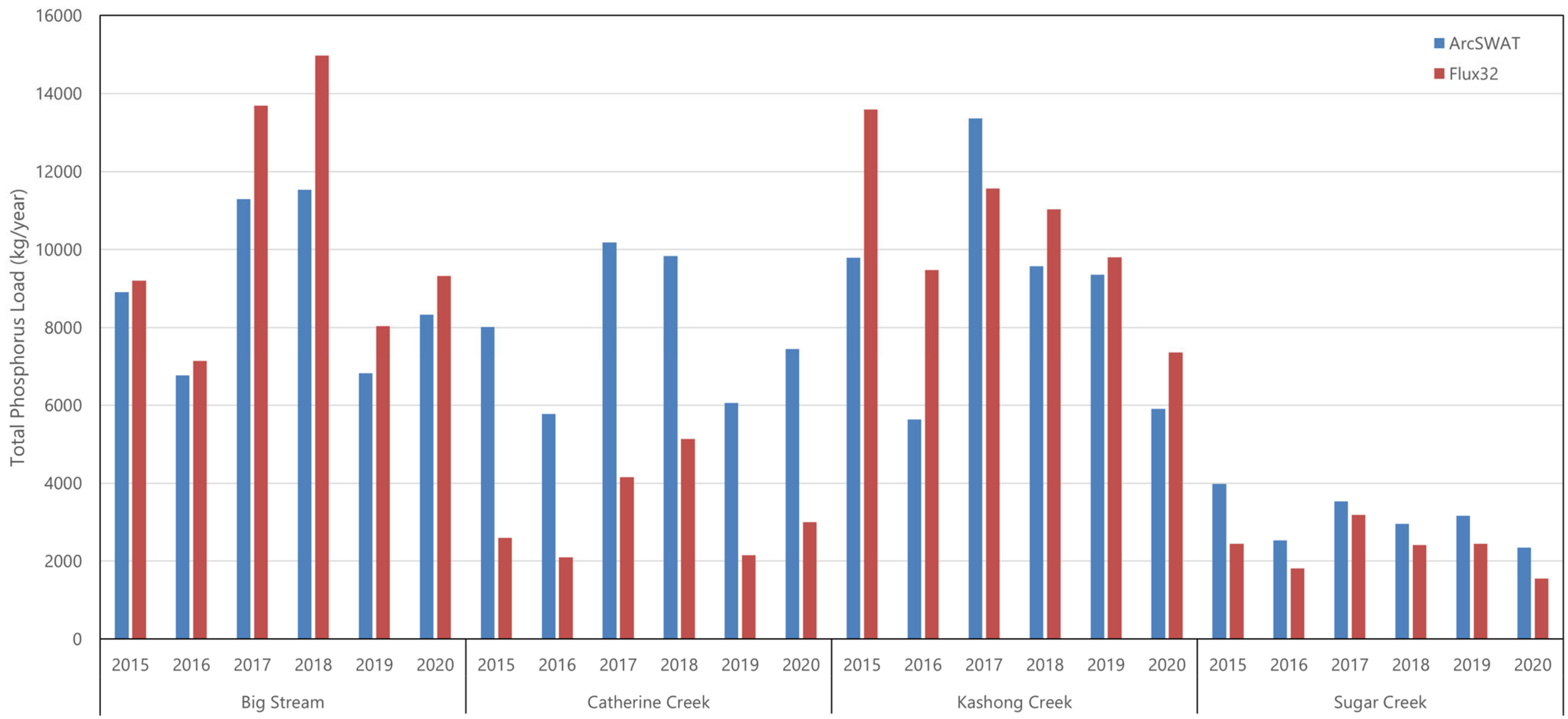

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Figure A3-13
Annual Total Phosphorus Load at Calibration Locations
Seneca-Keuka Watershed Model Report
Seneca-Keuka Watershed Nine Element Plan

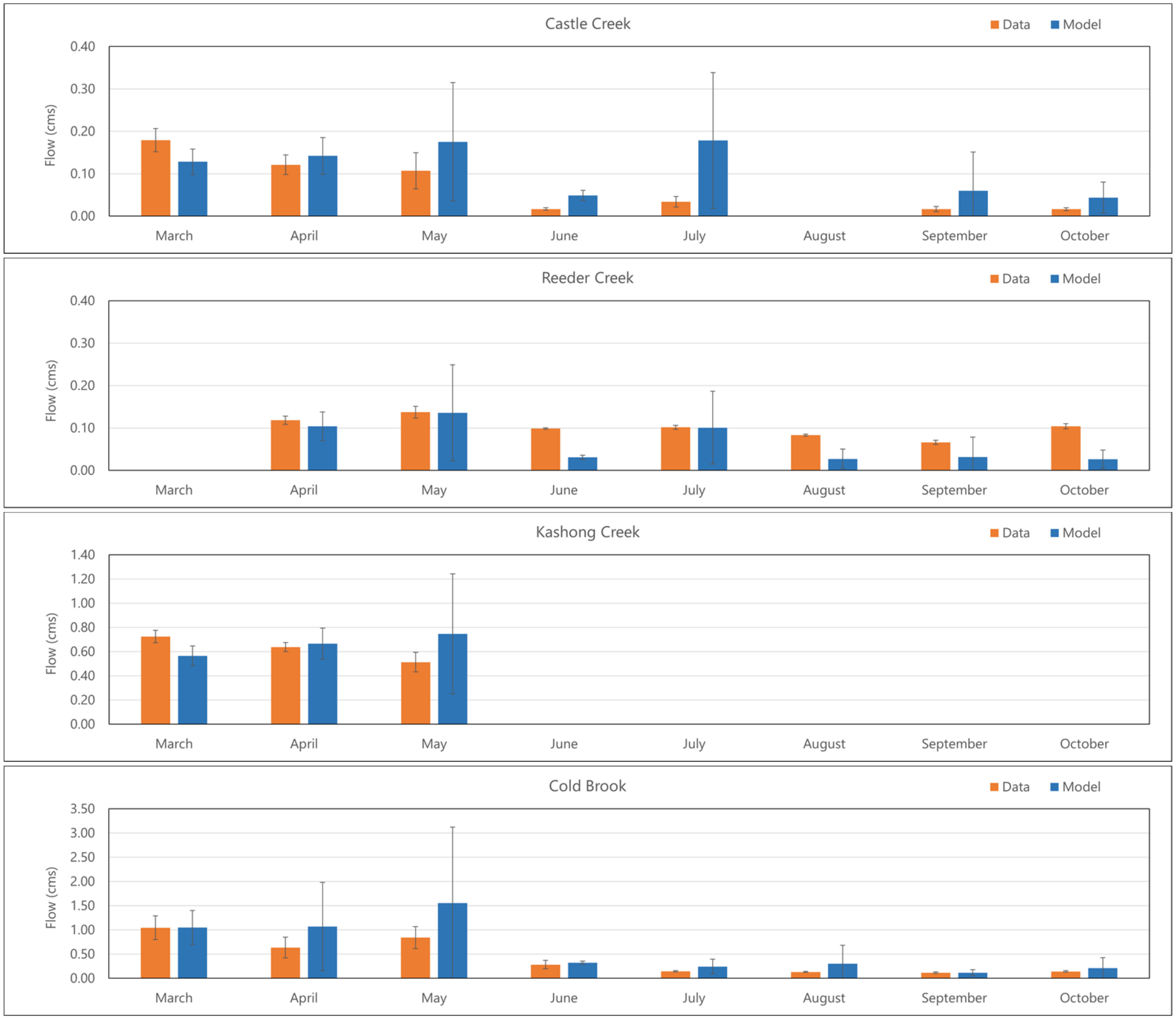

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Figure A3-14
Hydrology Validation
Seneca-Keuka Watershed Model Report
Seneca-Keuka Watershed Nine Element Plan

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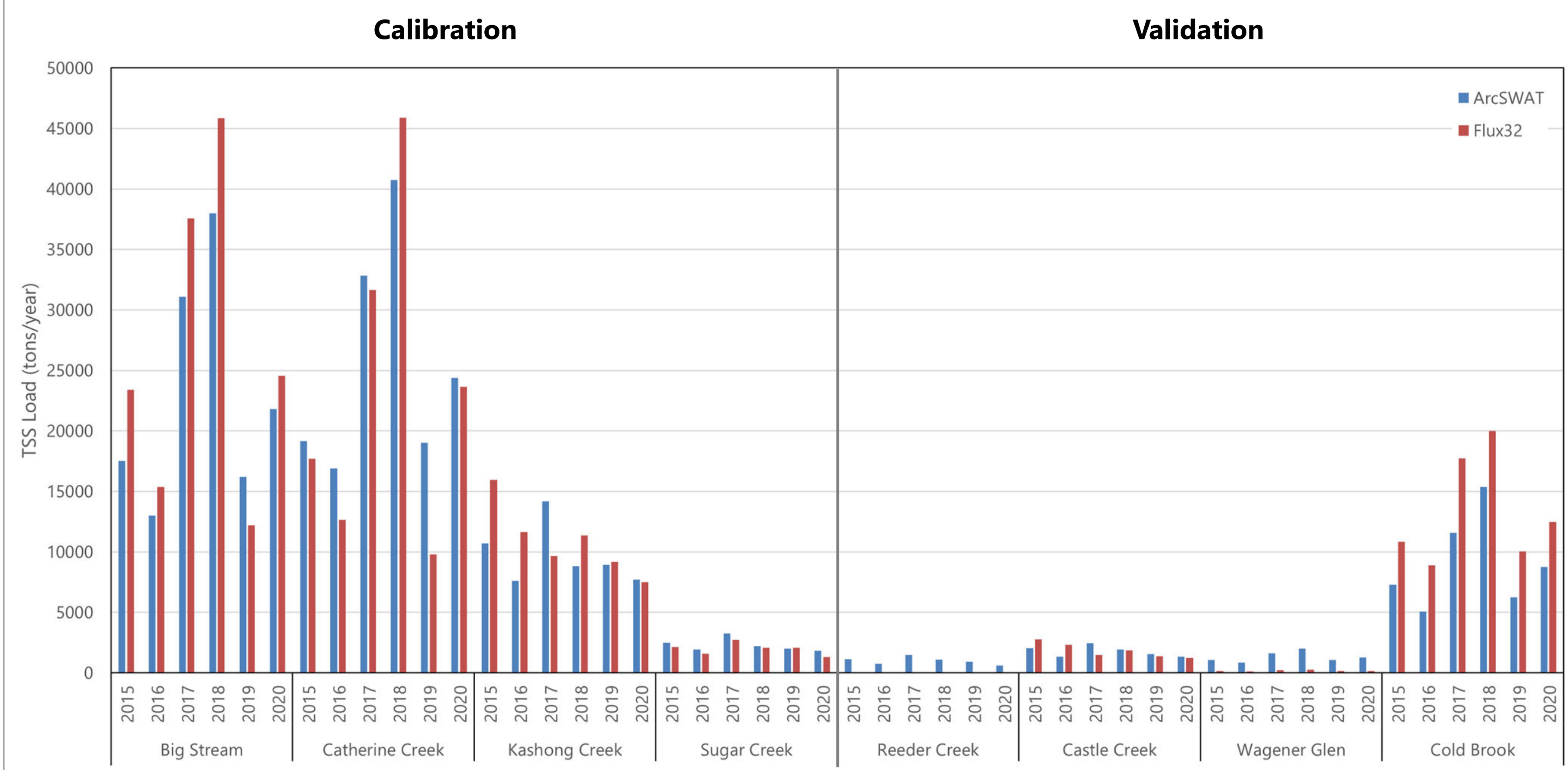

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Figure A3-15
Annual Total Suspended Solids Load at Validation Locations
Seneca-Keuka Watershed Model Report
Seneca-Keuka Watershed Nine Element Plan

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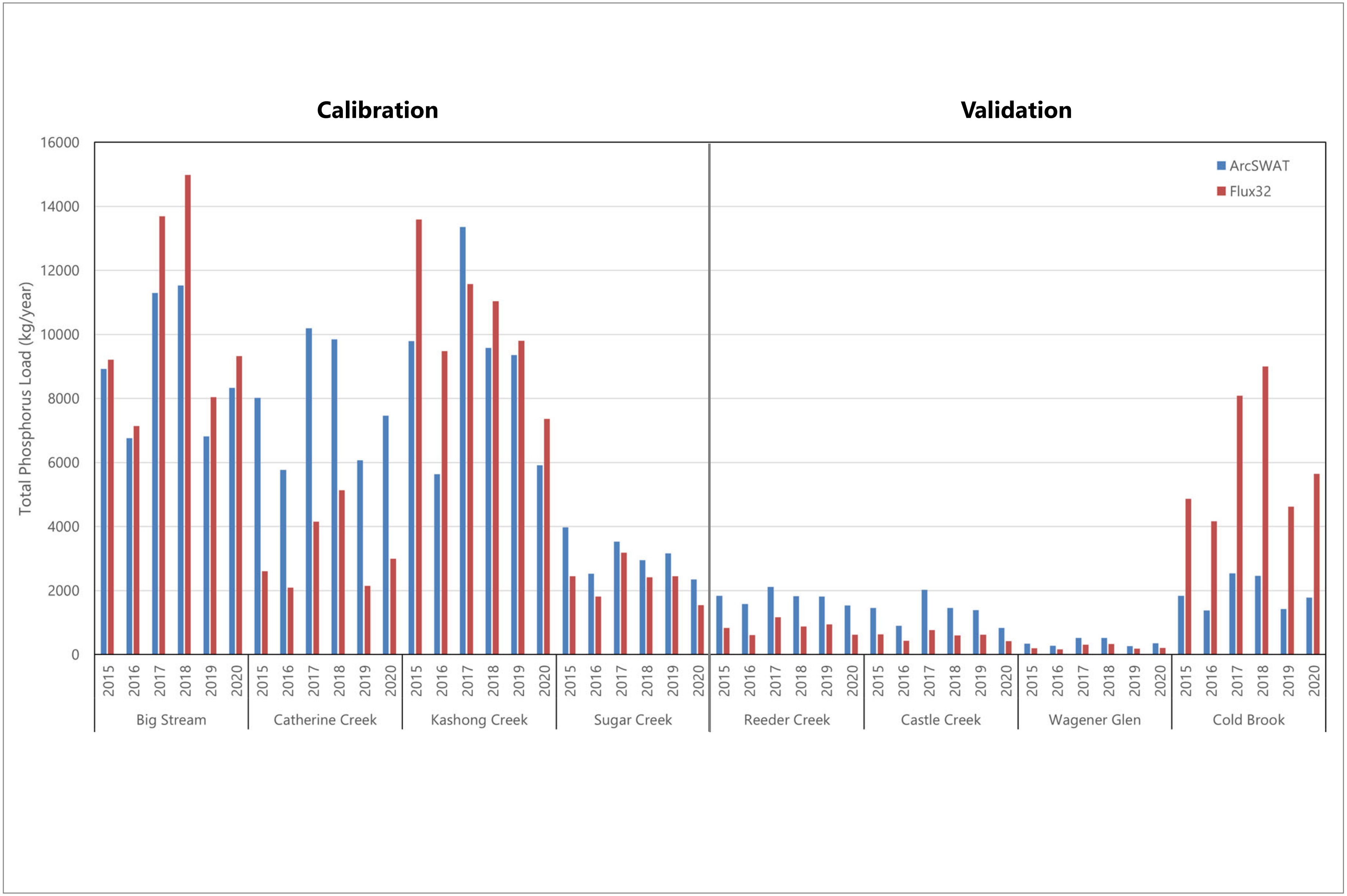

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Figure A3-16
Annual Total Phosphorus Load at Validation Locations
Seneca-Keuka Watershed Model Report
Seneca-Keuka Watershed Nine Element Plan

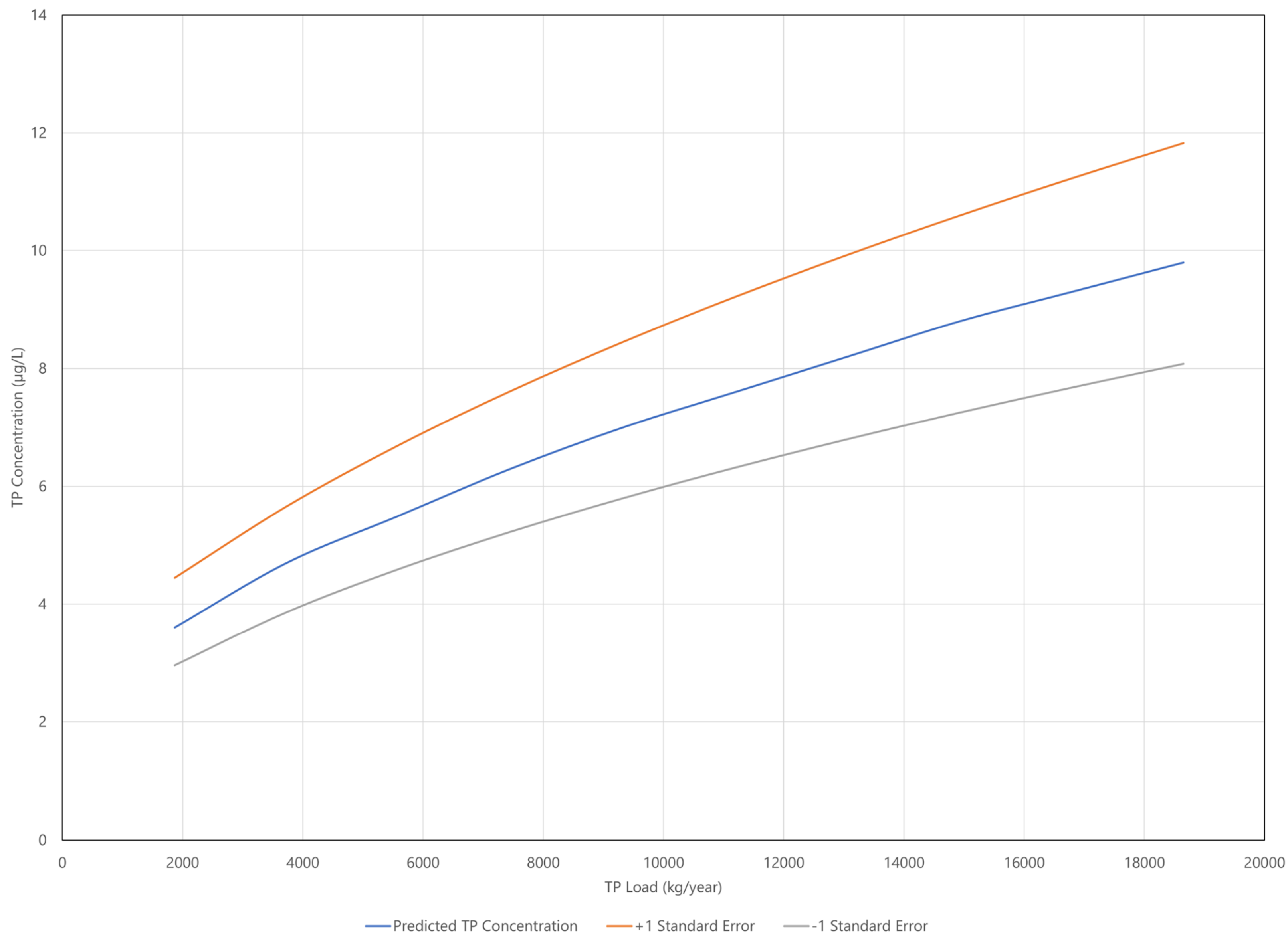

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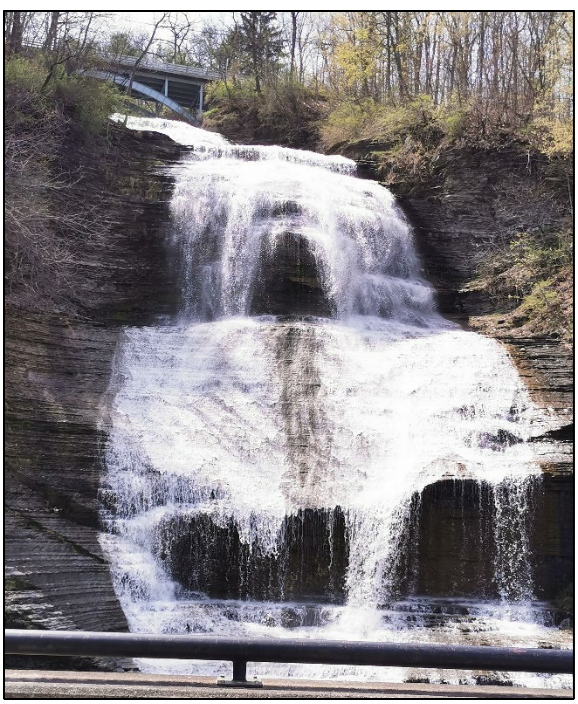
Figure A4-1
Keuka Lake TP Load Response
Seneca-Keuka Watershed Model Report
Seneca-Keuka Watershed Nine Element Plan

Appendix D
Seneca-Keuka Watershed Land Use Regulations and Local Law Assessment

Seneca-Keuka Watershed Land Use Regulations and Local Law Assessment



A Report Prepared for the:

Seneca Keuka Watershed 9E Project Advisory Committee

By:

CRP3072/5072: The Land Use & Environmental Planning Workshop

Emile Bensedrine, Danielle Fernandes, Jessica Geary, Nick Kakheladze, Nusaibah Khan, Minzie Kim, Cynthia Liao, Anna Lu, Mark Minton, Lin Khant Oo, Luke Slomba

Course Instructor: George Frantz

Department of City & Regional Planning, Cornell University

This report was prepared with funding provided by the New York State Department of State under Title 11 of the Environmental Protection Fund.

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The Department of City & Regional Planning at Cornell University is the home of leading programs in urban and regional planning, historic preservation planning, and regional development. Its faculty, students, and alumni work to transform planning and the lives of the world's citizens by bridging social and economic concerns, physical design and sustainability, utilizing a diverse tool kit of methods and ways of critical thinking. For more information, visit: https://aap.cornell.edu/academics/crp/about

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Section 1: Overview of the Project and Watershed

Introduction

The Seneca-Keuka Watershed Land Use Regulations and Local Law Assessment provides a critical understanding of the regional demographic and development trends, along with the 41 municipalities' land-use regulations. Regional trends, local laws, and regulations can have an immense impact on the water quality of Seneca Lake and Keuka Lake and the watershed as a whole. Local laws relating to elements of water quality are inconsistent throughout the municipalities, and this contributes to water quality challenges in the region. Suggesting better land-use regulations that are uniform throughout the watershed that some municipalities may not have considered in the past will ultimately strengthen cohesion regionally and ensure water quality protection now and in the future.

This assessment aims to incorporate our findings into the 9 element Seneca-Keuka watershed report and provide insight for the leadership spearheading the plan. By including our assessment into the plan, we hope to educate city officials, farmers, and citizens of each municipality on ways to improve their land use regulations and local laws. We also hope that this analysis will bring Seneca and Keuka leaders together to ensure water continues to be protected, and to solve land use issues that are occurring on a regional scale. Most importantly, the assessment may assist the 9 element committee in providing regional solutions to continue maintaining a healthy, resilient, and high-quality watershed.

Watershed Profile

Seneca and Keuka lake contain more than half of the water in the Finger Lakes and are within the Seneca-Keuka watershed. The Seneca-Keuka watershed is a part of the larger Oswego River/Finger Lakes watershed (Figure 1) (NYDEC 2021). The Oswego River/Finger Lakes watershed is one of the largest in New York State and drains 5,100 square miles.

Water flows west to east in the watershed, with Keuka Lake supplying water to Seneca Lake. Keuka Lake is fed by the Keuka Inlet, Sugar Creek, Glen Brook, and Wagener Glen Creek and then drains into the Keuka Outlet. From the outlet, the water travels to Seneca Lake (Ecologic and Anchor QEA 2021). Additional water that flows into Seneca Lake comes from Catherine Creek, located at the Lake's southern end. The outflow of Seneca Lake is the Seneca River/Cayuga-Seneca Canal (Ecologic and Anchor QEA 2021).

Broadly speaking, both Seneca and Keuka Lake’s respective surface waters are classified AA. Water bodies classed as AA water bodies are suitable for drinking water, culinary purposes, recreation, and fishing (Ecologic and Anchor QEA 2021).

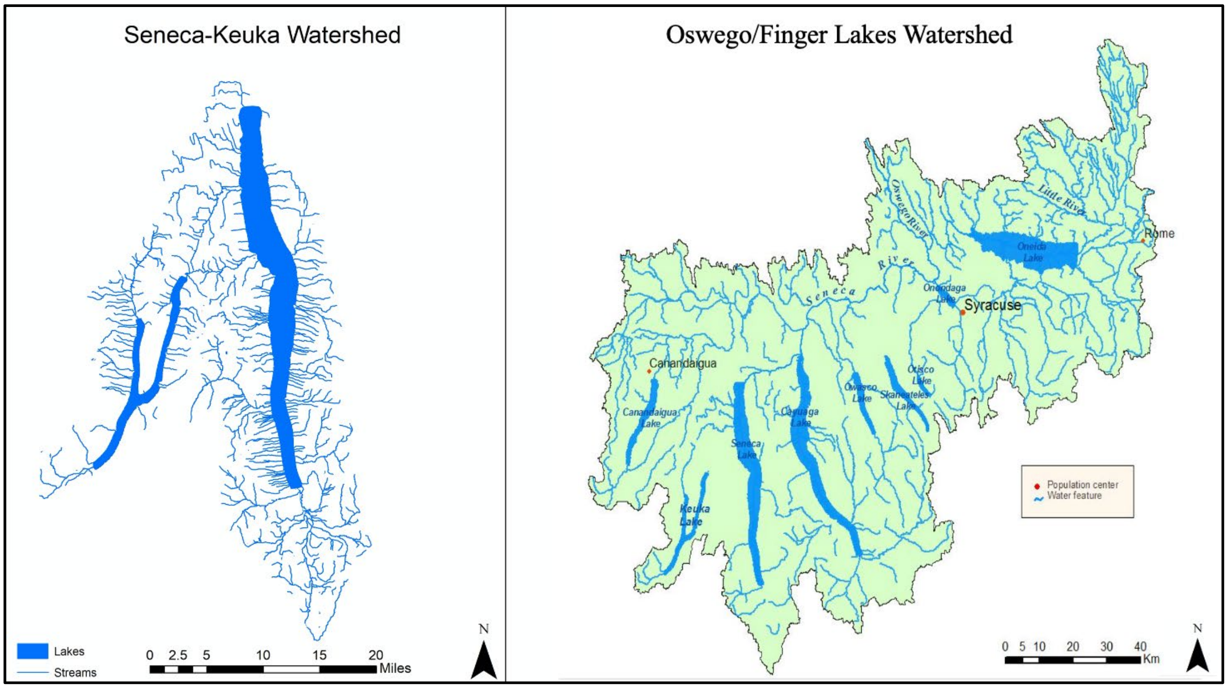


Figure 1: GIS map of the Seneca Keuka Watershed (left) and the Oswego Finger Lakes watershed (right). *Data Source:* (NYDEC 2021)*. Maps: Left- Cornell University; Right- NYDEC.*

Section 2: Regional Trends

Overview

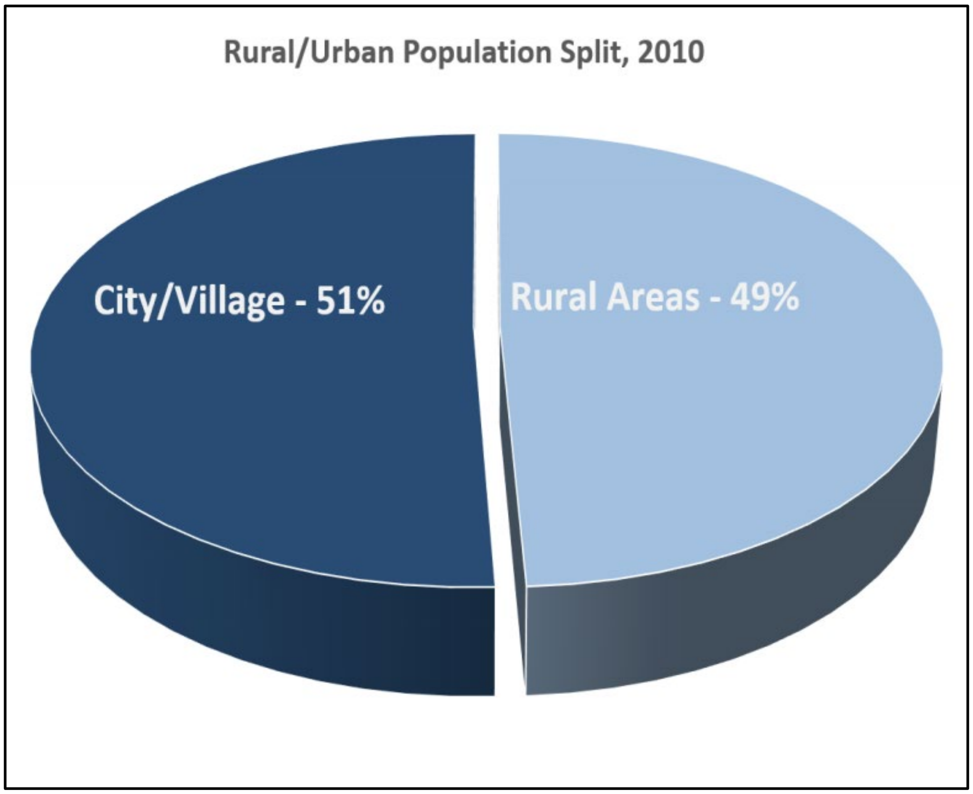
Regional trends are insightful and can better assist officials in implementing sound land use laws and regulations to mitigate water quality impacts. The team found that regionally there is not a consistent growth or decline in terms of population trends. In certain municipalities, there was significant growth between 1980 and 2010, such as in Romulus, Barrington, and Hector, while there is was substantial population decline in others. Demographic patterns also give key insights into development patterns. Regionally, the growth of single-family residential housing and wineries is changing the watershed's landscape.

Regional Demographic Trends

The Seneca-Keuka Lake watershed region contains parts of 6 counties, with a total of 42 municipalities, comprised of 30 towns, 11 villages, and 1 city[1]. The total regional population is

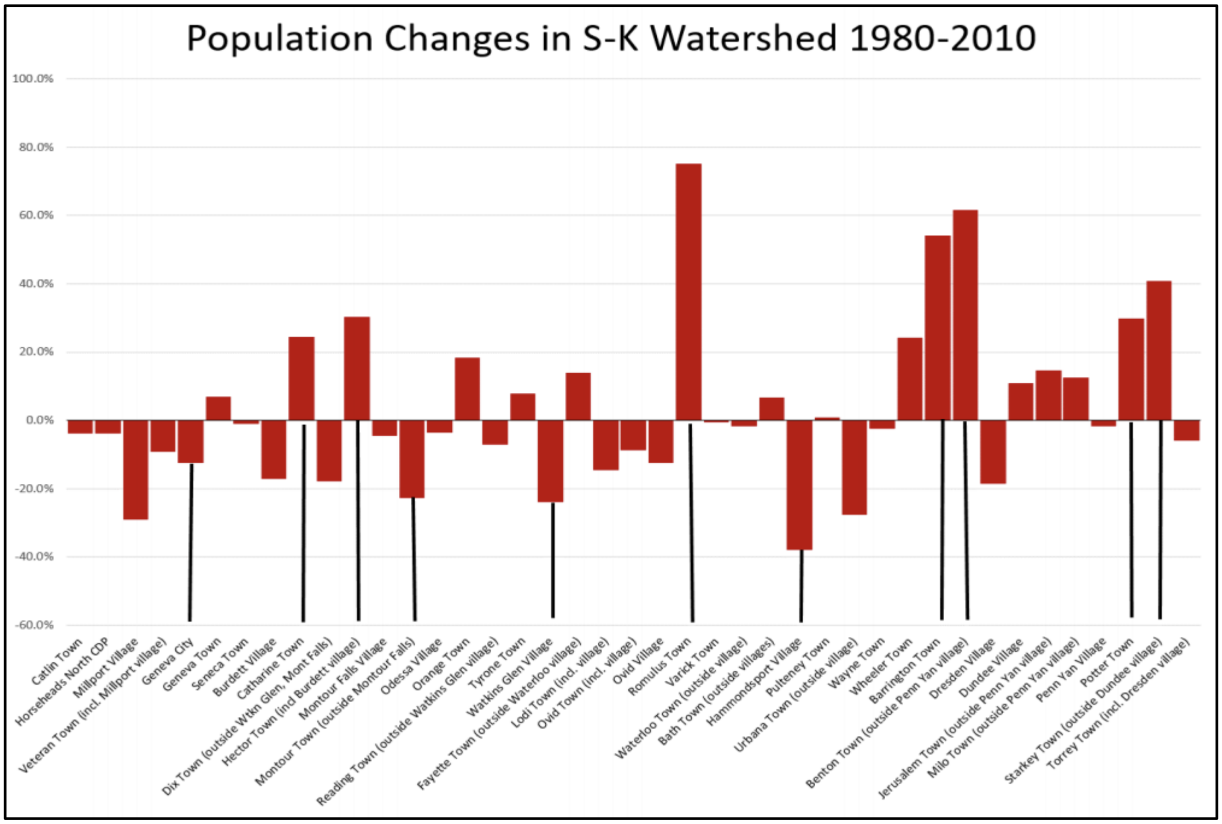
[1] In addition, there are approximately 70 acres of land in the Town of Phelps at the north end of the watershed, and approximately 420 acres of land in the Town of Cayuta in the southeast corner of the watershed.

currently approximately 64,600, with 51% of it being urban and 49% rural in 2010. In the time period 1980-2010, the total population experienced an increase of 680 persons (1.1% growth). Looking at each municipality, 24 out of 41 experienced negative population growth. The 17 municipalities that experienced positive growth are almost all towns except the village of Dundee. In towns with growing populations, growth can be attributed to growing Plain Sect (Amish, Mennonite) populations, the prison population at Five Points Correctional facility which opened in 2000, and, possibly, an influx number of transplants from Ithaca, Elmira, and Corning (which are about half an hour commuting distance away).



Of the six counties in the Seneca-Keuka Lake watershed, the only two that have experienced positive population growth are Seneca county (15.5%) and Yates county (16.9%). These two counties are the two counties in the watershed with extensive Plain Sect populations, and Seneca County is home to the Five Points Correctional facility.

The average median household income of the watershed region is about $54,437, which is about 83% of the average median household income in New York State of $65,323 (in 2018). Also observed is a positive relationship between population growth and the median household income in 2018 as municipalities with higher median household income tended to also experience larger population growth. The town of Milo however is an exception, with the second lowest median household income in 2018 ($37,228) but accompanied by a 12.48% increase in population (10th in the entire region). This lower than average household income coupled with higher population growth indicates a substantial Plain Sect community in the town. (Their lower incomes however are offset by much lower than average cash outlays for consumer goods and food.)



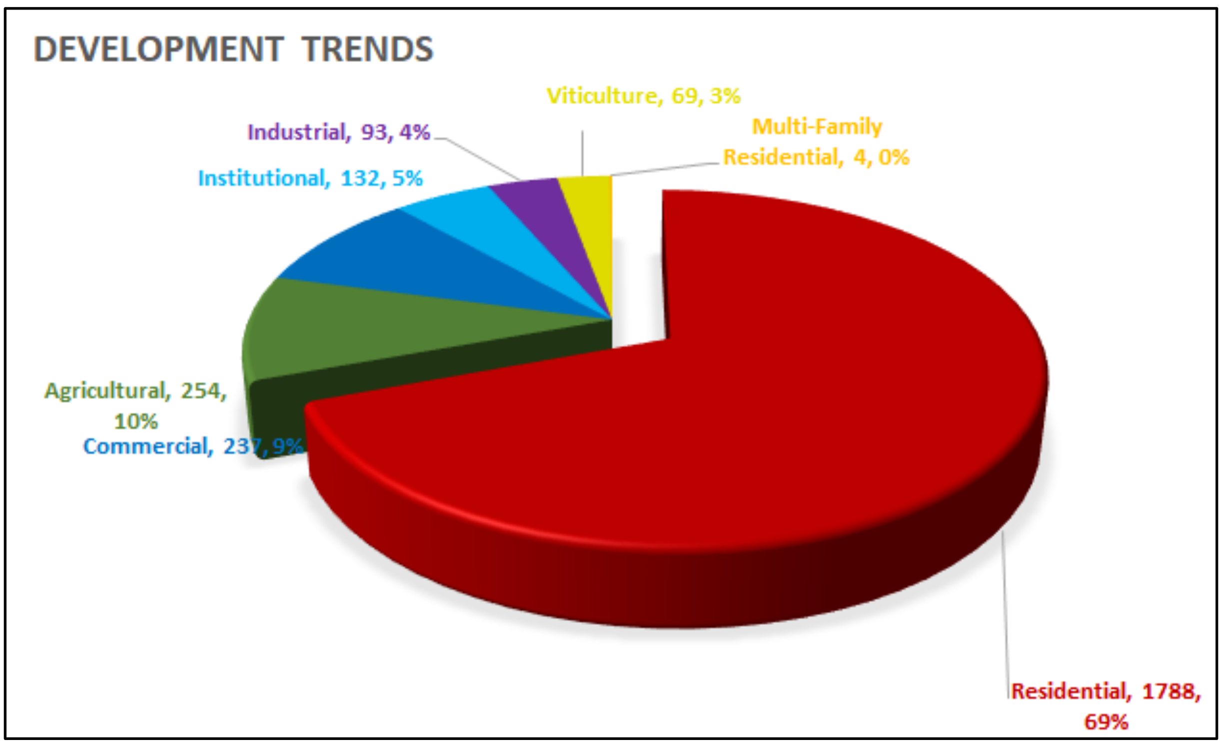
Regional Development Trends

Development trends in the watershed were analyzed to understand where development has been occurring. The team tracked the location of new single-family residential housing units, multifamily housing units (rental as well as owner-occupied), government and institutional buildings, industrial development, new farmsteads, retail/commercial, wineries/breweries, and distilleries over a 25-year period. Using the New York State GIS Orthoimagery, the team was able to identify development changes between 1994 and 2019/2020 through satellite image interpretation. If a new development appeared in the most recent imagery, the coordinate points were noted and a color coded marker dot was added on to ArcMap. Municipalities further interested in viewing the watershed digitally can use the link in the footnote.[2]

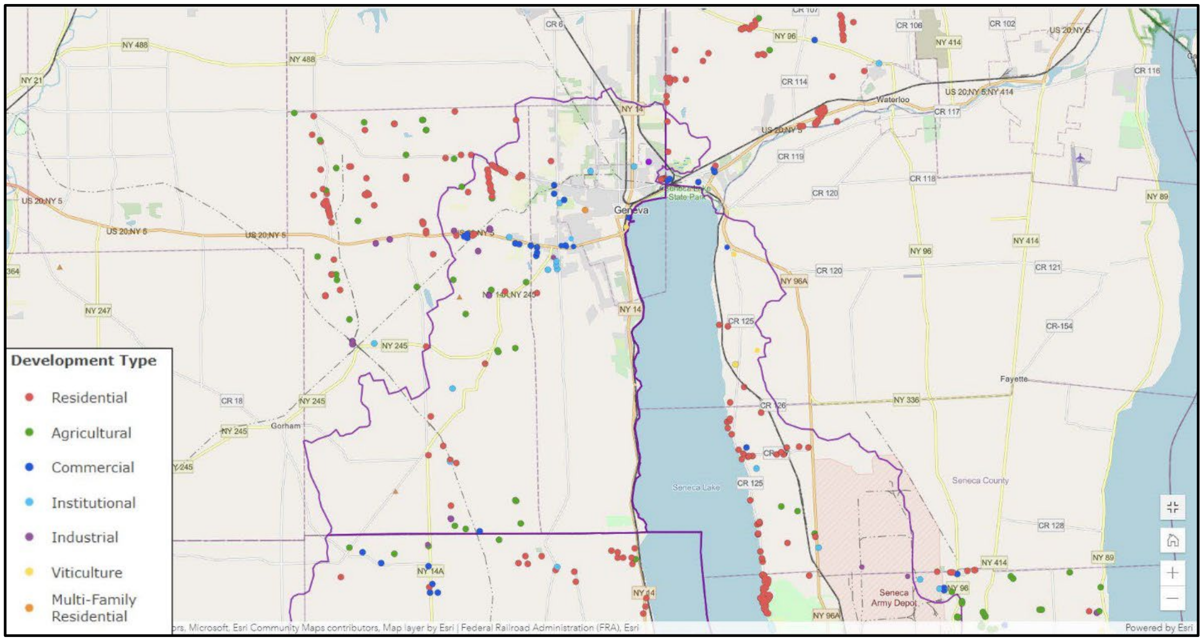
[2] https://www.arcgis.com/home/webmap/viewer.html?webmap=d55883e3784d4e53a36fdda08ceb4f24

The map (see below) shows that a majority of the new development is in the form of single-family homes scattered throughout the watershed. There has been a significant increase in lakefront homes as well as commercial development along the waterfront around Keuka Lake, such as in Penn Yan, Hector, and Benton. Significant growth is also found along Seneca lake in Romulus. Additionally, the map shows the expansion of the wine industry in the Town of Hector, Benton, Pulteney, and Starkey. This is shown through the significant increase in wineries in these towns. Specifically, in Hector 18 wineries have been established between the 1990s and the present .

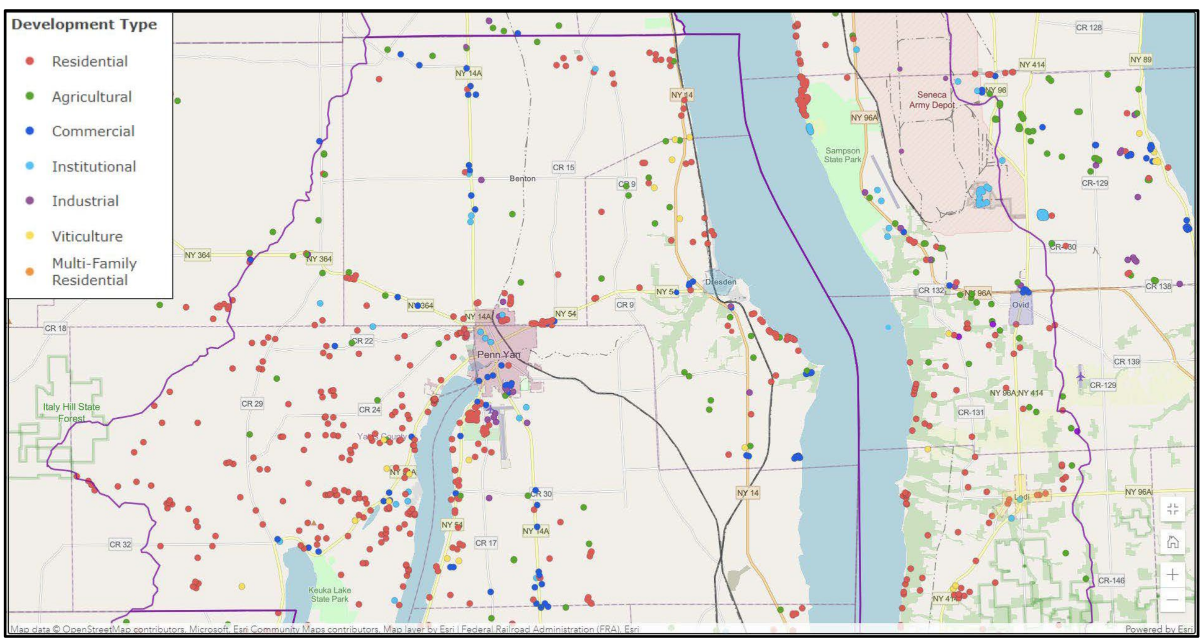
The map also indicates over 180 new farmsteads in the watershed, demonstrating the increase in Amish and Mennonite farms, and also continue demand for need to preserve agricultural land. Although not completely new development and therefore not directly noted on the map, ground-level analysis of the watershed discovered many additional agricultural expansions. Farms have erected new barns, stables, silos, and warehouses on existing plots, demonstrating a healthy and growing agricultural sector within the watershed.



The chart above shows the development trends within the watershed. Single-family homes comprise nearly three-quarters of all new development in the last 25 years. Much of the new commercial development is located along the NYS Route 14A corridor between Geneva and Dundee. New industrial development in the region is almost entirely small scale shops such as contractor's base operations, woodshops, and metal shops. They are often on the same property where the owner(?) lives, as are many of the new retail enterprises. Many new industrial buildings can be seen around Starkey and Dundee in the south and to the west of Geneva in the northern sector of the watershed[3].

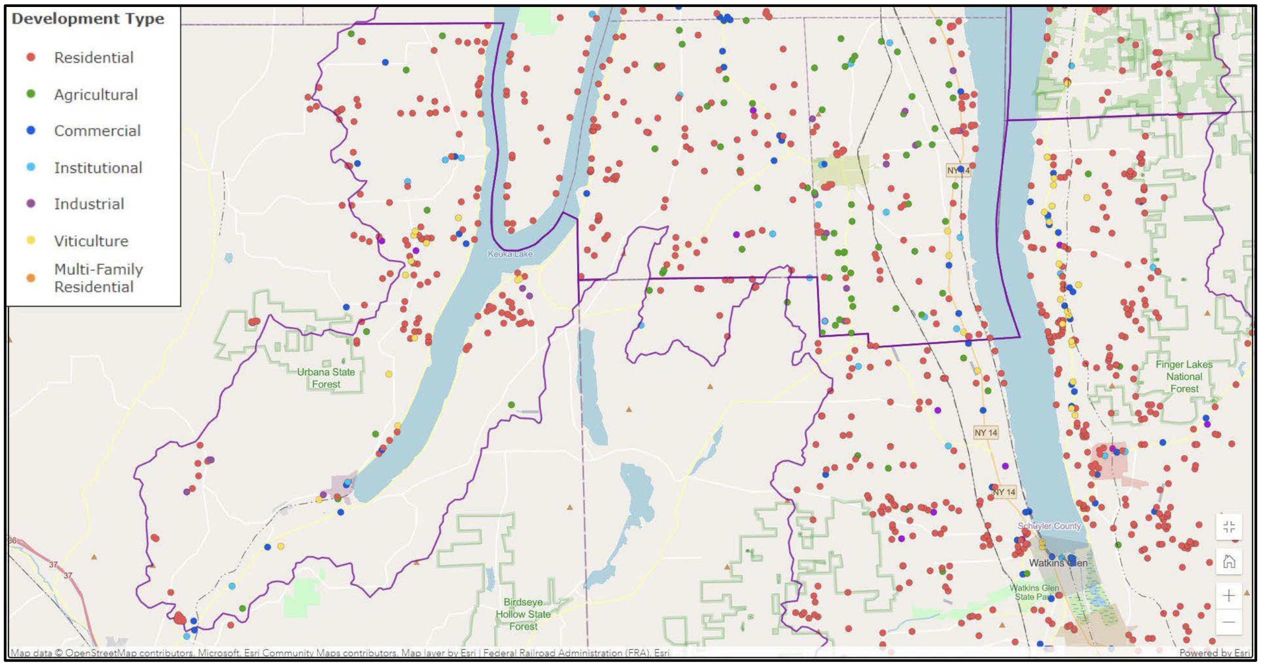


Map 1 of 4. Development in the Seneca-Keuka watershed by type, 1994-2019/2020.

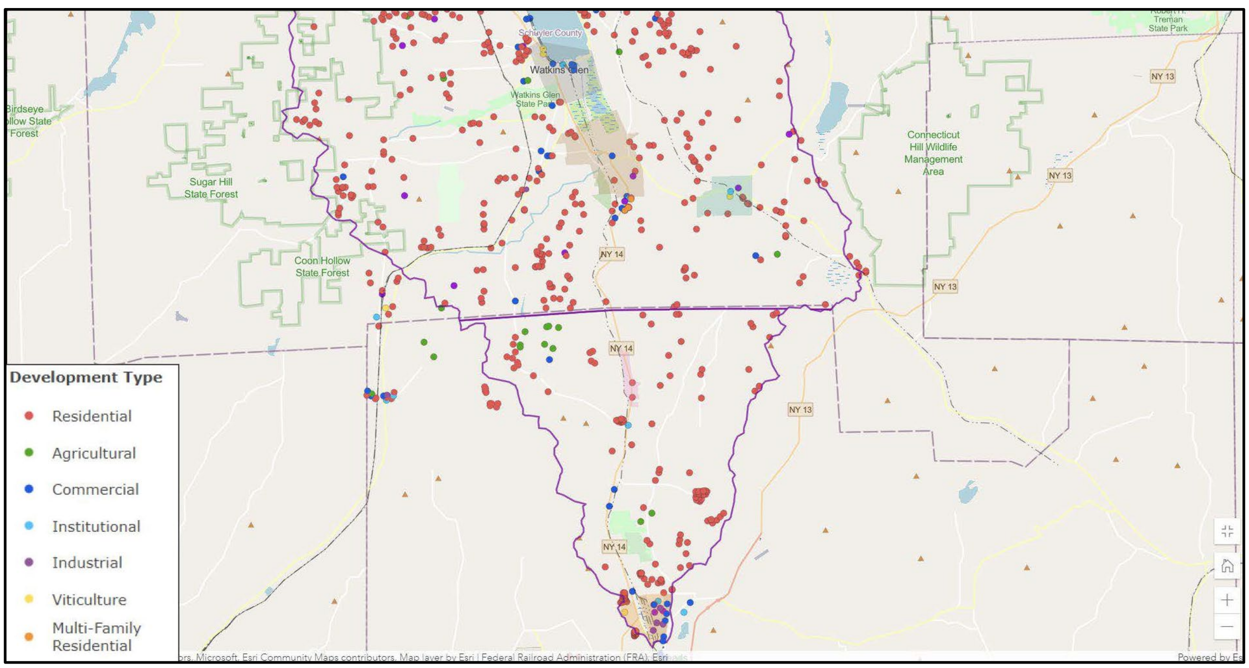


Map 2 of 4. Development in the Seneca-Keuka watershed by type, 1994-2019/2020.

[3] One challenge in interpreting the satellite imagery is the growing number of large, non-farm storage buildings and personal shops in the region that are similar in appearance to industrial buildings. Further field verification is needed to confirm whether these are industrial or non-industrial.



Map 3 of 4. Development in the Seneca-Keuka watershed by type, 1994-2019/2020.



Map 4 of 4. Development in the Seneca-Keuka watershed by type, 1994-2019/2020.

New farmsteads can be found throughout the region, but are concentrated in the areas surrounding Penn Yan and Dresden. Noticeably, there has been a lack of medium-density residential development, with only three new apartment complexes or condominiums discovered within the watershed.

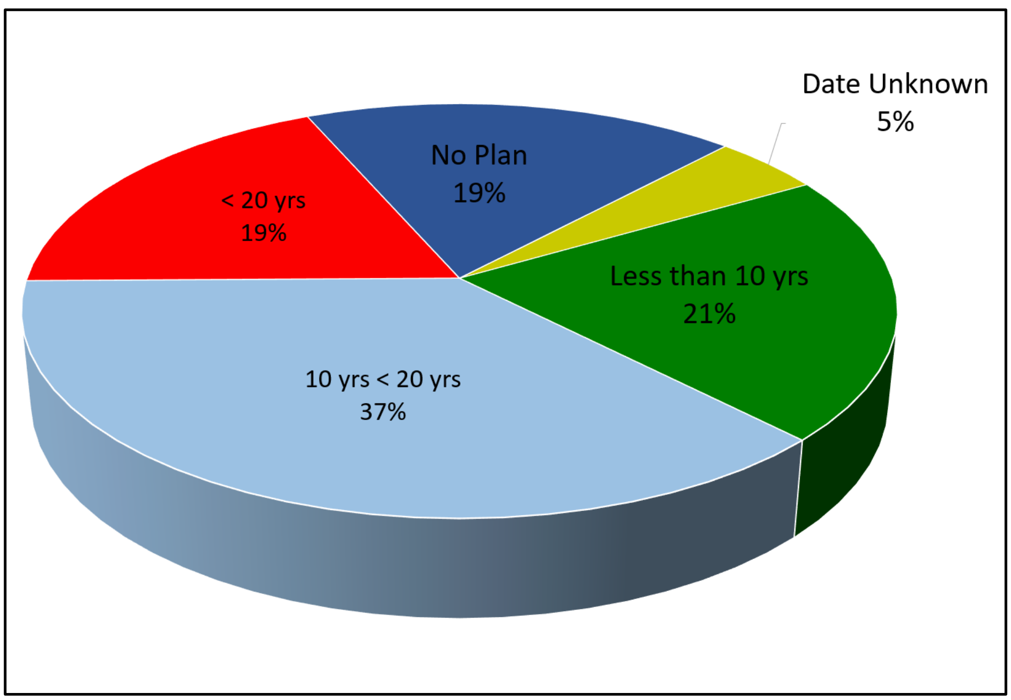
Section 3: Assessment of Land Use Plans and Regulations

Overview

The type and the extent to which watershed protection planning and regulations are in force across the Seneca-Keuka watershed vary greatly across the region. While some municipalities have a very comprehensive range of land-use regulations, some have very few. Appendix A identifies the 14 land use regulations the team assessed for each municipality within the watershed and also identifies whether each municipality has the regulation in place. With the watershed facing increasing strain on a yearly basis, it is imperative that there be inter-municipal unity to ensure a lasting commitment to protecting the watershed.

Comprehensive Plan

Of the municipalities reviewed, only 27% of the watershed municipalities had a comprehensive plan that is up to date according to standard practice (developed within the past 5-10 years). Approximately 37% and 19% of municipalities have a comprehensive plan that is 10-20 years old or over 20 years old, respectively. Another 19% of the watershed lacks any comprehensive plan. It is also important to mention that in many comprehensive plans, there is little or no mention of water resource protection.



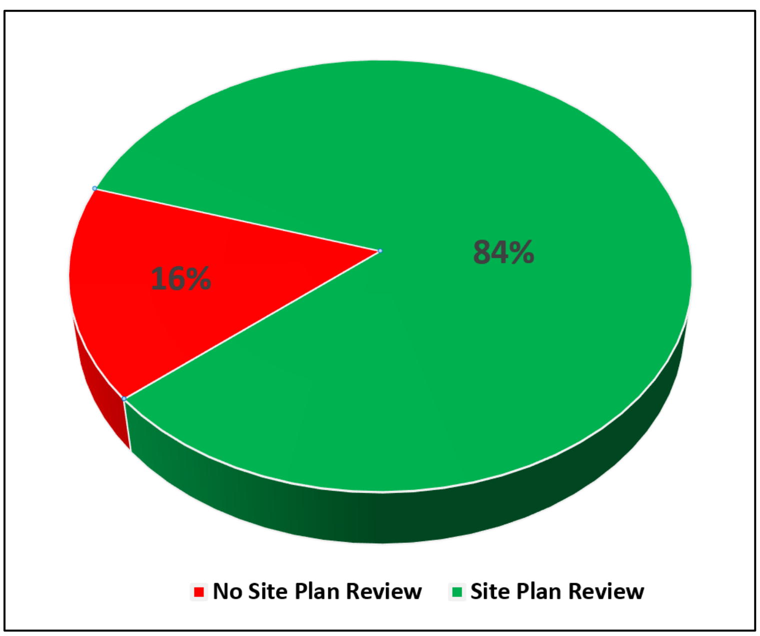
Age ranges for municipal comprehensive plans in Seneca-Keuka watershed.

Zoning

Many municipalities that have adopted comprehensive plans have also adopted zoning—as it is foundational for regulating land use. Of the municipalities in the watershed, 23% however do not have any zoning regulations in effect. This percentage however has been decreasing over the years. Since 2015 some 17 municipalities in the watershed have either adopted zoning or updated existing zoning regulations.

Taking a deeper look at the local land use regulations in force across the watershed we found that:

- 75% of municipalities have adopted cluster development and/or subdivision regulations.
- 43% have adopted Planned Unit Development (PUD) laws.
- 45% of municipalities have erosion and sedimentation control laws.
- 59% have a watershed inspector either on the municipal or county level.
- 68% have a wastewater management code.
- 78% do not have docks and moorings law.
- 61% do not have a record of adopting flood damage prevention law. (This may be due to the fact that many such local laws were adopted in the 1980 or earlier. They may be in force but in paper form only.



Percent of municipalities with Site Plan Review regulations in Seneca-Keuka watershed.

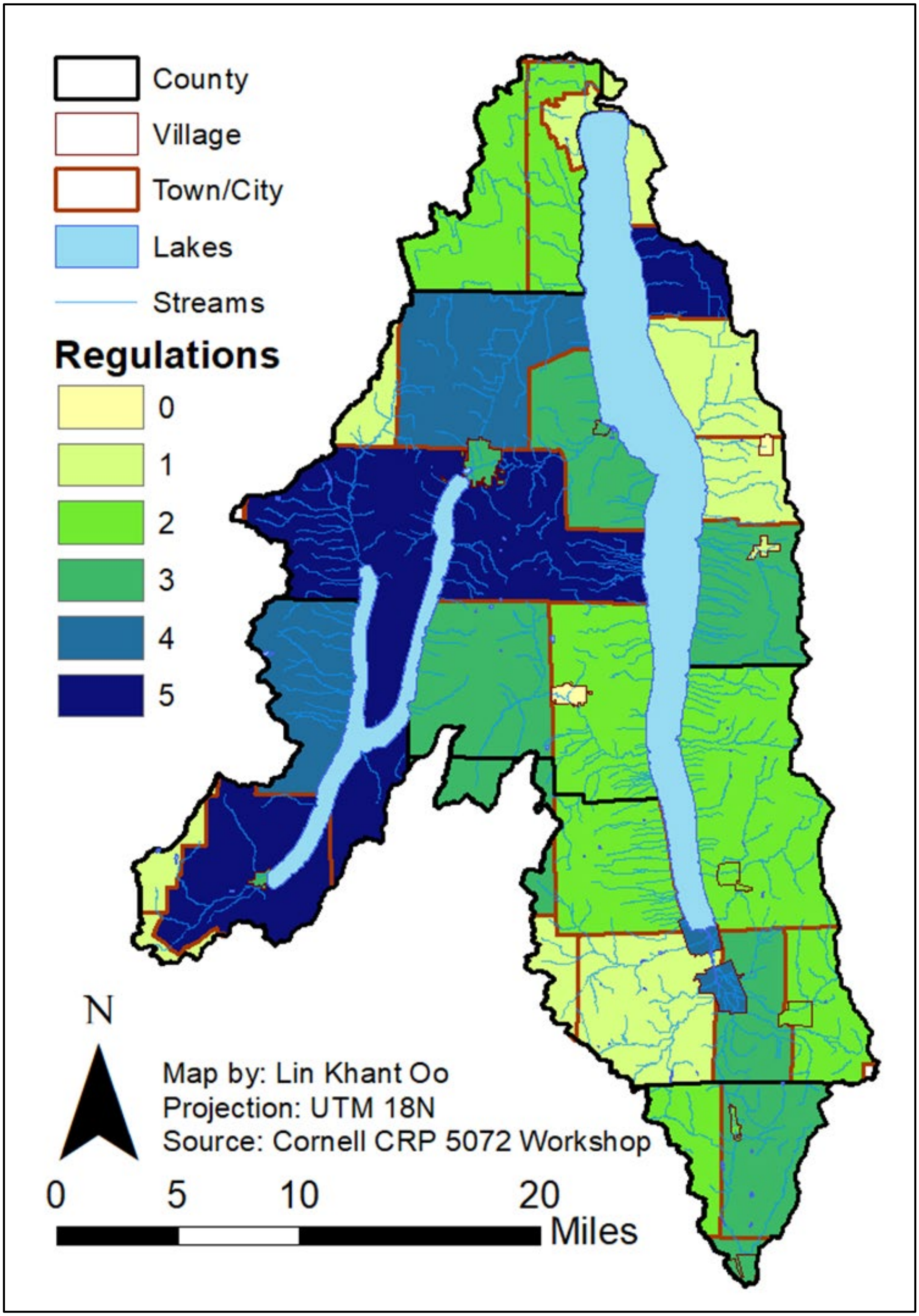
Water Quality Regulation Assessment Map

The assessment of water quality-related local regulations in the Seneca-Keuka watershed region focuses primarily on five types of regulations:

- Erosion/Sedimentation Control Law
- Watershed Inspector
- Wastewater Management Code
- Docks and Moorings Law[4]
- Flood Damage Prevention Law

The map on the next page shows each municipality in the watershed color ranked according to the number of the above water quality-regulations they have adopted. Overall, regulations are very thorough and consistent among municipalities that lie within the Keuka Lake sub-watershed. Residents and municipalities in that watershed have a long history of collaboration through the Keuka Watershed Improvement Cooperative, and the Keuka lake Association citizens' advocacy group. There is opportunity however for municipalities to enact many of these regulations, and there is great opportunity for creative, inter-municipal solutions for this multifaceted issue.

[4] *It must be noted that not all municipalities have docking and mooring law because they do not all have a shoreline, and therefore they show up as having a lower score than those that do.*


County
Village
Town/City
Lakes
Streams
Regulations
0
1
2
3
4
5
N
Map by: Lin Khant Oo
Projection: UTM 18N
Source: Cornell CRP 5072 Workshop
0
5
10
20
Miles

Section 4: Assessment of Individual Municipal Land Use Regulations

This section provides a breakdown of municipal land use regulations related to water resource protection, by municipality. For each municipality local laws that have been adopted are listed. Following the list of adopted local regulations are recommendations for actions each municipality can take to enhance protection of water resources. These recommendations are a starting point to help municipalities identify both weaknesses in their approaches to water quality protection, and opportunities to exploit. Water quality management is a regional issue which will be more easily addressed through regional cooperation and exchanges of ideas and experiences.

Chemung County

Town of Catlin

Documents Reviewed:

- Zoning Law, 1999
- Site Plan Review, (Article 9 of Zoning Law)
- Subdivision Law, 1999
- Flood Damage Prevention Law, 1987
- Planned Unit Development Code, [repealed]

Recommendations for Future Action:

- Create a comprehensive plan to better guide land use decisions and protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Amend the Zoning Law to enhance the effectiveness of riparian buffers by including water bodies in addition to streams, and including requirements for planting and maintaining appropriate vegetation within riparian buffer areas.
- Amend the Flood Damage Prevention Law to better regulate the location of manure pits and barnyards to prevent discharge of high levels of nutrient pollution caused by flood events.
- Collaborate with Chemung County to enhance codes or guidelines to more effectively address erosion control and on-site wastewater treatment systems, including required inspections and setbacks from waterways, wetlands, and floodplains.
- Appoint a Watershed Inspector jointly with neighbouring Towns or through Chemung County.
- Continue to implement stormwater best management practices in Town highway maintenance operations including the ditch and drainage maintenance program, and also maintenance to unpaved roadways to minimize potential for flooding and erosion problems.

Municipality	County	Comprehensive Plan (year adopted)	Zoning Regulations (year adopted/updated)	Site Plan Review Law	Planned Unit Development	Subdivision Law	Cluster Development/ Subdivision	Erosion/Sedimentation Control Law	Watershed Inspector	Wastewater Management Code	Docks & Moorings Law	Flood Damage Prevention Law
Barrington Town	Yates	2007	2012	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No
Benton Town	Yates	2012	1992	Yes	No	Yes	Yes	Yes	Yes	Yes	No	1989
Burdett Village	Schuyler	Yes	No	No	No	No	No	No	Yes*	Yes*	No	No
Catharine Town	Schuyler	2006	2016	Yes	Yes	Yes	Yes	Yes	Yes*	Yes*	No	1997
Catlin Town	Chemung	No	1999	Yes	No	Yes	Yes	Yes	No	No	No	1987
Cayuta Town	Schuyler	No	No	No	No	No	No	No	Yes*	Yes*	No	1987
Dix Town	Schuyler	2001	2016	Yes	Yes	Yes	Yes	No	Yes*	No	No	No
Dresden Village	Yates	2004	2008	Yes	No	Yes	Yes	No	Yes*	Yes	No	2008
Dundee Village	Yates	1969	1975	Yes	Yes	Yes	Yes	No	Yes*	No	No	Yes
Fayette Town	Seneca	2006	2008	Yes	No	Yes	No	No	No	No	No	Yes
Geneva City	Ontario	2016	1968	Yes	Yes	Yes	Yes	No	No	No	No	1987
Geneva Town	Ontario	2015	2018	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes
Hammondsport Village	Steuben	1990	2001	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	1987
Hector Town	Schuyler	2001	2020	No	No	No	No	No	Yes*	Yes*	No	1987
Horseheads Town	Chemung	1971	1982	Yes	Yes	Yes	No	Yes	No	No	Yes	1996
Horseheads Village	Chemung	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	1996
Italy Town	Yates	2005	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Jerusalem Town	Yates	2006	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	2009
Lodi Town	Seneca	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes
Lodi Village	Seneca	2010	2007	No	No	No	No	No	No	No	No	Yes
Millport Village	Chemung	No	2005	No	No	No	Yes	Yes	No	No	No	1999
Milo Town	Yates	2013	2021	Yes	Yes	Yes	Yes	Yes	Yes*	Yes	Yes	1997
Montour Falls Village	Schuyler	2007	2010	Yes	No	Yes	Yes	Yes	Yes*	Yes*	No	1993
Montour Town	Schuyler	2007	2008	Yes	No	Yes	Yes	Yes	Yes*	Yes*	No	Yes
Odessa Village	Schuyler	No	2005	Yes	No	Yes	Yes	Yes	Yes*	Yes*	No	No
Orange Town	Schuyler	2012	No	Yes	No	No	No	No	Yes*	Yes*	No	No
Ovid Town	Seneca	2019	No	No	No	No	No	No	No	No	No	Yes
Ovid Village	Seneca	No	No	No	No	No	No	No	No	No	No	No
Penn Yan Village	Yates	2017	2004	Yes	Yes	Yes	Yes	No	Yes*	Yes	Yes	1987
Phelps Town	Ontario	2007	2012	Yes	No	Yes	No	No	No	Yes	No	1987
Potter Town	Yates	1979	2010	Yes	No	Yes	No	No	Yes*	Yes	No	Yes
Pulteney Town	Steuben	Yes	2015	Yes	No	Yes	Yes	Yes	Yes*	Yes	Yes	Yes
Reading Town	Schuyler	1993	2018	Yes	No	No	No	No	Yes*	Yes*	No	No
Romulus Town	Seneca	2001	2020	Yes	No	Yes	Yes	Yes	No	No	No	Yes
Seneca Town	Ontario	2013	2008	Yes	No	Yes	Yes	No	No	Yes	No	Yes
Starkey Town	Yates	2014	2015	Yes	Yes	Yes	No	No	Yes*	No	No	Yes
Torrey Town	Yates	2008	2011	Yes	Yes	Yes	Yes	No	Yes*	Yes	No	2010
Tyrone Town	Schuyler	2008	No	No	No	Yes	Yes	Yes	Yes*	Yes*	No	No
Urbana Town	Steuben	1990	1988	Yes	No	Yes	No	Yes	Yes	Yes	Yes	1987
Varick Town	Seneca	2006	2019	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Veteran Town	Chemung	2004	2019	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes
Waterloo Town	Seneca	2000	2011	Yes	Yes	Yes	No	No	No	No	No	Yes
Watkins Glen Village	Schuyler	1993	2012	Yes	No	No	No	Yes	Yes*	Yes*	No	1987
Wayne Town	Steuben	2010	2018	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

* In Schuyler County and Yates County, watershed inspectors/inspection services are provided by the county.

Summary table of local municipal land use regulations in the Seneca-Keuka watershed.

- Develop and promote guidelines to encourage the use of green infrastructure in new stormwater management facilities such as detention/retention ponds; also attempt natural conveyance restoration wherever possible.

- Amend clustered development (and subdivision) regulations to ensure better guidance to landowners, developers and Town officials on how to identify environmentally sensitive areas, active farmland and viewsheds, and direct development away from such areas.

<u>Town of Horseheads</u>

Documents Reviewed:

- Comprehensive Plan, 1971
- Town of Horseheads Zoning Ordinance, 1982
- Town of Horseheads Subdivision Ordinance, 1995
- Flood Damage Prevention, 1996
- Stormwater Management and Erosion Control, 2005
- Illicit Discharge Detection and Elimination, 2007

Recommendations for Future Action:

- Create a new comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.

- Amend the Zoning Ordinance to create riparian buffer overlay zones extending a set distance from streams, ponds, wetlands and other waterbodies that better control the type and intensity of development within the buffer, and include requirements for planting and maintaining appropriate vegetation within the riparian buffer areas.

- Amend the Zoning Ordinance to update Site Plan Review procedures to promote the use of green infrastructure systems for stormwater management.

- Collaborate with Chemung County to strengthen its Sanitary Code to better regulate on-site wastewater treatment systems, including inspection processes, as well as setbacks from waterways, wetlands, and floodplains.

- Amend subdivision regulations to permit Cluster Subdivision design in addition to conventional subdivisions, and incorporate design guidelines to ensure protection of environmentally sensitive areas, active farmland and viewsheds through environmentally-sensitive design.

<u>Village of Horseheads</u>

Documents Reviewed:

- Zoning, Code of the Village of Horseheads, 2002
- Village of Horseheads Comprehensive Plan, 2010
- Stormwater Management and Erosion Control Law, 2008
- Flood Damage Prevention Law, 1996

Recommendations for Future Action:

- Maintain and update as needed the existing comprehensive stormwater management program and MS4 permit compliance requirements within the Elmira urbanized area. Maintain Phase II stormwater compliance including Village stormwater management, erosion and sediment control, and flood damage prevention laws.

- Amend the Zoning Code to create riparian buffer overlay zones extending a set distance from streams, ponds, wetlands and other waterbodies that better control the type and intensity of development within the buffer, and include requirements for planting and maintaining appropriate vegetation within the riparian buffer areas.
- Develop and promote guidelines to encourage the use of green infrastructure in new stormwater management facilities such as detention/retention ponds; also attempt natural conveyance restoration wherever possible.

<u>Village of Millport</u>

Documents Reviewed:

- Zoning Code, 2005
- Mitigation Action Plan, 1999

Recommendations for Future Action:

- Create a new comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Amend the Zoning Ordinance to create riparian buffer overlay zones extending a set distance from streams, ponds, wetlands and other waterbodies that better control the type and intensity of development within the buffer, and include requirements for planting and maintaining appropriate vegetation within the riparian buffer areas.
- Amend the Zoning Ordinance to update Site Plan Review procedures to promote the use of green infrastructure systems for stormwater management.
- Collaborate with Chemung County to strengthen its Sanitary Code to better regulate on-site wastewater treatment systems, including inspection processes, as well as setbacks from waterways, wetlands, and floodplains.

<u>Town of Veteran</u>

Documents reviewed:

- Comprehensive Plan, 2004
- Town of Veteran Zoning Ordinance, 2019
- Subdivision Local Law Town of Veteran, 2002
- Stormwater Management and Erosion Control, 2008
- Illicit Discharge Detection and Elimination, 2008

Recommendations for Future Action:

- Update the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Amend the Zoning Ordinance to create riparian buffer overlay zones extending a set distance from streams, ponds, wetlands and other waterbodies that better control the type and intensity of development within the buffer, and include requirements for planting and maintaining appropriate vegetation within the riparian buffer areas.
- Amend the Zoning Ordinance to update Site Plan Review procedures to include design standards that promote the use of green infrastructure systems for stormwater management.
- Amend subdivision regulations to permit Cluster Subdivision design in addition to conventional subdivisions, and incorporate design guidelines to ensure protection of environmentally sensitive areas, active farmland and viewsheds through environmentally-sensitive design.
- Collaborate with Chemung County to strengthen its Sanitary Code to better regulate on-site wastewater treatment systems, including inspection processes, as well as setbacks from waterways, wetlands, and floodplains.

Ontario County

City of Geneva

Documents reviewed:

- Comprehensive Plan, 2016
- Zoning Code, 2020
- Flood Damage Prevention, 1997

Recommendations for Future Action:

- Amend the Zoning Code to incorporate storm water management and erosion control requirements, to include green infrastructure standards to treat stormwater to better control urban runoff pollution.
- Amend the Zoning Code to include riparian zones as buffer areas within the city, including along Castle Creek and an unnamed creek on the east side of the city.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Review and update as appropriate the Flood Damage Prevention Law adopted in 1989 to reflect changes in policies and practices in floodplain management and disaster resilience.

Town of Geneva

Documents reviewed:

- Comprehensive Plan, 2015
- Zoning Code, 2017

- Subdivision Law, 1997
- Flood Damage Prevention, 1987

Recommendations for Future Action:

- Amend subdivision regulations to incorporate design guidelines to ensure protection of environmentally sensitive areas, active farmland and viewsheds through environmentally-sensitive design.
- Develop green infrastructure standards to better control urban runoff pollution in built up areas, enhance water quality in Castle Creek and other Seneca Lake tributaries.
- Collaborate with the City of Geneva on a watershed-based approach to stormwater management and urban runoff pollution control in the Castle Creek watershed.
- Continue to implement stormwater best management practices in Town highway maintenance operations including the ditch and drainage maintenance program, and also maintenance to unpaved roadways to minimize potential for flooding and erosion problems.
- Consider a uniform Docking and Mooring Law in collaboration with other Towns on Seneca Lake.
- Appoint a Watershed Inspector jointly with neighbouring Towns or through Ontario County.

Town of Gorham

Documents Reviewed:

- Comprehensive Plan, 2009
- Zoning Law, 2013
- Subdivision Regulations, 1969, amended 2006
- Soil Erosion and Sedimentation Control Law,
- Flood Damage Prevention Law, 1996
- On-site Individual Wastewater Treatment Systems Law, 2000

Recommendations for Future Action:

- Amend the Zoning Law to create riparian buffer overlay zones extending a set distance from streams, ponds, wetlands and other water bodies that better control the type and intensity of development within the buffer, and include requirements for planting and maintaining appropriate vegetation within the riparian buffer areas.
- Amend subdivision regulations to incorporate design guidelines to ensure protection of environmentally sensitive areas, active farmland and viewsheds through environmentally-sensitive design.
- Continue to implement stormwater best management practices in Town highway maintenance operations including the ditch and drainage maintenance program, and also maintenance to unpaved roadways to minimize potential for flooding and erosion problems.
- Appoint a Watershed Inspector jointly with neighboring Towns or through Ontario County.

Town of Phelps

Documents Reviewed:

- Comprehensive Plan, 2007
- Zoning Law, 2012
- Subdivision regulations,

Recommendations for Future Action:

- Update the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Adopt provisions for clustered development within existing land subdivision regulations that incorporate protections for water resources such as riparian buffers and stormwater management provisions.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Review and update as appropriate the Flood Damage Prevention Law adopted in 1987 to reflect changes in policies and practices in floodplain management and disaster resilience.
- Appoint a Watershed Inspector jointly with neighboring Towns or through Ontario County.

Town of Seneca

Documents Reviewed:

- Comprehensive Plan, 2013
- Public sanitary sewer regulations, 2014
- Subdivision regulations, 2010
- Zoning Law, 2018

Recommendations for Future Action:

- Develop green infrastructure standards to better control urban runoff pollution in built up areas, enhance water quality in Castle Creek and other Seneca lake tributaries.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Amend Sect. 105.0 of the Zoning Law (Floodplain Regulation) to better regulate the location of manure pits and barnyards to prevent discharge of high levels of nutrient pollution caused by flood events.
- Amend the Zoning Ordinance to create riparian buffer overlay zones extending a set distance from streams, ponds, wetlands and other water bodies that better control the type and intensity of development within the buffer, and include requirements for planting and maintaining appropriate vegetation within the riparian buffer areas.
- Appoint a Watershed Inspector jointly with neighboring Towns or through Ontario County.

Schuyler County

Village of Burdett

Documents reviewed:

N/A: The village has not implemented land use or growth management regulations.

Recommendations for Future Action:

- Adopt a comprehensive plan to create a community vision for its future, guide land use decisions, protect community character, and enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Adopt a zoning law with site plan review that can incorporate basic protections for water resources such as appropriate land uses, riparian buffers and stormwater management provisions.
- Adopt subdivision regulations with provisions for clustered development and which also incorporate protections for water resources such as riparian buffers and stormwater management provisions.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- There are no mapped floodplains in Burdett village, however with increasing potential for severe weather due to climate change, flood potential in portions of the village along Mill Creek should be re-evaluated.

Town of Catharine

Documents reviewed:

- Comprehensive Plan, 2001
- Zoning Law and Subdivision Regulations, 2016
- Flood Damage Prevention Law, 1989

Recommendations for Future Action:

- Update the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Review and update as appropriate the Flood Damage Prevention Law adopted in 1989 to reflect changes in policies and practices in floodplain management and disaster resilience.
- Amend Art. IV, Sect. 2(B) to prohibit construction of manure storage within floodplain areas to prevent discharge of high levels of nutrient pollution caused by flood events.

Town of Cayuta

Documents reviewed:

- Wastewater Management Law
- Flood Damage Prevention Law, 1987

Recommendations for Future Action:

- Adopt a comprehensive plan to create a community vision for its future, guide land use decisions, protect community character, and enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Adopt a zoning law with site plan review that can incorporate basic protections for water resources such as appropriate land uses, riparian buffers and stormwater management provisions.
- Adopt subdivision regulations with provisions for clustered development and which also incorporate protections for water resources such as riparian buffers and stormwater management provisions.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Review and update as appropriate the Flood Damage Prevention Law adopted in 1989 to reflect changes in policies and practices in floodplain management and disaster resilience.

<u>Town of Dix</u>

Documents reviewed:

- Comprehensive Plan, 2001
- Zoning Law, 2016

Recommendations for Future Action:

- Update the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Amend the Zoning Ordinance to create riparian buffer overlay zones extending a set distance from streams, ponds, wetlands and other water bodies that better control the type and intensity of development within the buffer, and include requirements for planting and maintaining appropriate vegetation within the riparian buffer areas.
- Amend subdivision regulations to incorporate design guidelines to ensure protection of environmentally sensitive areas, active farmland and viewsheds through environmentally-sensitive design.

<u>Town of Montour</u>

Documents reviewed:

- Comprehensive Plan, 2007 (Joint plan with Town of Montour)
- Zoning Law 2008

Recommendations for Future Action:

- Amend the Zoning Ordinance to create riparian buffer overlay zones extending a set distance from streams, ponds, wetlands and other waterbodies that better control the type and intensity of development within the buffer, and include requirements for planting and maintaining appropriate vegetation within the riparian buffer areas.

- Amend conservation subdivision regulations to incorporate design guidelines to ensure protection of environmentally sensitive areas, active farmland and viewsheds through environmentally-sensitive design.

Village of Montour Falls

Documents reviewed:

- Comprehensive Plan, 2007 (Joint plan with Village of Montour Falls)
- Zoning and Subdivision Law 2020
- Watershed Inspector

Recommendations for Future Action:

- Update the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Amend the Zoning Ordinance to update Site Plan Review procedures to promote the use of green infrastructure systems for stormwater management.
- Amend the Zoning Ordinance to create riparian buffer overlay zones extending a set distance from streams, ponds, wetlands and other waterbodies that better control the type and intensity of development within the buffer, and include requirements for planting and maintaining appropriate vegetation within the riparian buffer areas.

Odessa Village

Documents Reviewed:

- Zoning Ordinances 2015

Recommendations for Future Action:

- Create a Comprehensive Plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Update existing Zoning Ordinance to include a more coherent Subdivision Law segment.
- Adopt green infrastructure and wetland protection standards, specifically regarding Wastewater Management Codes and Flood Damage Prevention Laws.
- Create riparian buffers - Incentivize or mandate a riparian buffer in Zoning Codes to minimize runoff and pollution from plots of land.

Town of Reading:

Documents Reviewed:

- Town of Reading Comprehensive Plan 2017
- Town of Reading Local Land Use Law 2018

Recommendations for Future Action:

- Amend the Zoning Ordinance to create riparian buffer overlay zones extending a set distance from streams, ponds, wetlands and other water bodies that better control the type and intensity of development within the buffer, and include requirements for planting and maintaining appropriate vegetation within the riparian buffer areas.
- Amend subdivision regulations to incorporate design guidelines to ensure protection of environmentally sensitive areas, active farmland and viewsheds through environmentally-sensitive design.
- Establish erosion and sedimentation laws to account for steep slopes within the Town, targeting the lakeshore, and along gullies.
- Adopt a Flood Damage Prevention Law to better protect floodplain areas from inappropriate development and to regulate the location of manure pits and barnyards to prevent discharge of high levels of nutrient pollution caused by flood events.

Town of Tyrone

Documents Reviewed:

- Comprehensive Plan, 2004
- Subdivision Regulations, 2008

Recommendations for Future Action:

- Update the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Adopt a zoning law with site plan review that can incorporate basic protections for water resources such as appropriate land uses, riparian buffers and stormwater management provisions.
- Adopt a Flood Damage Prevention Law to better protect floodplain areas from inappropriate development and to regulate the location of manure pits and barnyards to prevent discharge of high levels of nutrient pollution caused by flood events.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.

Village of Watkins Glen

Documents reviewed:

- Comprehensive Plan, 2017
- Zoning Law and Map, 2018

Recommendations for Future Action:

- Amend Section 9.12.1 of the Zoning Law, Stormwater Management and Erosion Control Requirements, to include green infrastructure standards to treat stormwater to better control urban runoff pollution in built up areas, and enhance water quality in Glen Creek, Seneca Lake and Barge Canal.

Seneca County

Town of Fayette

Documents Reviewed:

- Comprehensive Plan, 2006 (Towns of Fayette & Varick)
- Land Use Regulations, 2008
- Subdivision of Land Regulations, 2008

Recommendations for Future Action:

- Update the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Collaborate with Seneca County to strengthen its Sanitary Code to better regulate on-site wastewater treatment systems, including inspection processes, as well as setbacks from waterways, wetlands, and floodplains.
- Adopt a Wastewater Management Law and appoint a Watershed Inspector jointly with neighboring Towns or through Seneca County.
- Adopt a uniform Docks and Mooring Law in collaboration with other Towns on Seneca Lake.

Town of Lodi

Documents Reviewed:

- Comprehensive Plan of 2013

Recommendations for Future Action:

- Update the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Adopt a zoning law with site plan review that can incorporate basic protections for water resources such as appropriate land uses, riparian buffers and stormwater management provisions.
- Adopt a Flood Damage Prevention Law to better protect floodplain areas from inappropriate development and to regulate the location of manure pits and barnyards to prevent discharge of high levels of nutrient pollution caused by flood events.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Collaborate with Seneca County to strengthen its Sanitary Code to better regulate on-site wastewater treatment systems, including inspection processes, as well as setbacks from waterways, wetlands, and floodplains.
- Adopt a Wastewater Management Law and appoint a Watershed Inspector jointly with neighboring Towns or through Seneca County.
- Adopt a uniform Docks and Mooring Law in collaboration with other Towns on Seneca Lake.

Town of Ovid

Documents Reviewed:

- Comprehensive Plan, 2019

Recommendations for Future Action:

- Adopt a zoning law with site plan review that incorporates basic protections for water resources such as appropriate land uses, riparian buffers and stormwater management provisions.
- Adopt subdivision regulations that incorporates basic protections for water resources such as appropriate land uses, riparian buffers and stormwater management provisions, and providing for conservation/cluster subdivision alternatives to provided flexibility in subdivision design to enhance protection of environmentally sensitive areas.
- Adopt a Flood Damage Prevention Law to better protect floodplain areas from inappropriate development and to regulate the location of manure pits and barnyards to prevent discharge of high levels of nutrient pollution caused by flood events.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Collaborate with Seneca County to strengthen its Sanitary Code to better regulate on-site wastewater treatment systems, including inspection processes, as well as setbacks from waterways, wetlands, and floodplains.
- Adopt a Wastewater Management Law and appoint a Watershed Inspector jointly with neighboring Towns or through Seneca County.
- Adopt a uniform Docks and Mooring Law in collaboration with other Towns on Seneca Lake.

Town of Romulus

Documents Reviewed:

- Zoning Law, 2020
- Subdivision Regulations, 2006

Recommendations for Future Action:

- Update the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Amend the subdivision regulations to add specific provisions for clustered development for protections for water resources such as riparian buffers and stormwater management provisions, agricultural lands, and scenic viewsheds.
- Adopt a Flood Damage Prevention Law to better protect floodplain areas from inappropriate development and to regulate the location of manure pits and barnyards to prevent discharge of high levels of nutrient pollution caused by flood events.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Collaborate with Seneca County to strengthen its Sanitary Code to better regulate on-site wastewater treatment systems, including inspection processes, as well as setbacks from waterways, wetlands, and floodplains.

- Adopt a Wastewater Management Law and appoint a Watershed Inspector jointly with neighboring Towns or through Seneca County.
- Adopt a uniform Docks and Mooring Law in collaboration with other Towns on Seneca Lake.

<u>Town of Varick</u>

Documents Reviewed:

- Comprehensive Plan, 2006 (Towns of Fayette & Varick)
- Zoning Ordinance, 2019
- Subdivision Regulations, 2016

Recommendations for Future Action:

- Update the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Amend Section 307 of the Zoning Ordinance, Special Flood Hazard Area Overlay Zone, to specifically exclude location of manure pits and barnyards to prevent discharge of high levels of nutrient pollution caused by flood events
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Collaborate with Seneca County to strengthen its Sanitary Code to better regulate on-site wastewater treatment systems, including inspection processes, as well as setbacks from waterways, wetlands, and floodplains.
- Adopt a Wastewater Management Law and appoint a Watershed Inspector jointly with neighboring Towns or through Seneca County.
- Adopt a uniform Docks and Mooring Law in collaboration with other Towns on Seneca Lake.

<u>Town of Waterloo</u>

Documents Reviewed:

- Comprehensive Plan, 2017
- Zoning Law, 2011
- Site Plan Review Law 2011
- Town of Waterloo Flood Damage Prevention Law

Recommendations for Future Action:

- Review and amend where necessary the Flood Damage Prevention Law to better protect floodplain areas from inappropriate development, and to regulate the location of manure pits and barnyards to prevent discharge of high levels of nutrient pollution caused by flood events.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Collaborate with Seneca County to strengthen its Sanitary Code to better regulate on-site wastewater treatment systems, including inspection processes, as well as setbacks from waterways, wetlands, and floodplains.

- Adopt a Wastewater Management Law and appoint a Watershed Inspector jointly with neighboring Towns or through Seneca County.
- Adopt a uniform Docks and Mooring Law in collaboration with other Towns on Seneca Lake.

Steuben County

Town of Bath

Documents reviewed:

- Bath & Savona Economic Development Plan, 2012
- Site Plan Review Law, 2006
- Subdivision of Land Law, 1967
- Flood Damage Prevention Law, 1983

Recommendations for Future Action:

- Adopt a zoning law that would permit better regulation of growth and development, protect valued agricultural lands and open space lands, and incorporate basic protections for water resources such as riparian buffers and stormwater management provisions.
- Amend the Site Plan Review Law (Chapter 96 Town of Bath Code) to incorporate basic protections for water resources such as appropriate land uses, riparian buffers and stormwater management provisions including green infrastructure.
- Amend the Subdivision Law (Chapter 107 Town of Bath Code) to permit clustered or conservation subdivision design with design standards the provide protection for water resources such as riparian buffers and stormwater management provisions, agricultural lands, and scenic viewsheds.
- Review and amend where necessary the Flood Damage Prevention Law to better protect floodplain areas from inappropriate development, and to regulate the location of manure pits and barnyards to prevent discharge of high levels of nutrient pollution caused by flood events.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Collaborate with Steuben County to strengthen its Sanitary Code to better regulate on-site wastewater treatment systems, including inspection processes, as well as setbacks from waterways, wetlands, and floodplains.
- Adopt a Wastewater Management Law and appoint a Watershed Inspector jointly with neighboring Towns or through Steuben County.

Village of Hammondsport

Documents Reviewed:

- Comprehensive Plan, 2016
- Land Use Regulations, 2016
- Site Plan Review Law, 1991
- Subdivision Regulations, 2008
- Wastewater Management Law, 2011

- Uniform Docking and Mooring Law, 2006
- Flood damage Prevention Law, 1995

Recommendations for Future Action:

- Amend the Site Plan Review Law to incorporate basic protections for water resources such as riparian buffers and stormwater management provisions.
- Amend the Site Plan Review Law to incorporate green infrastructure standards to treat stormwater to better control urban runoff pollution from commercial and industrial development.
- Review and amend where necessary the Flood Damage Prevention Law to better protect floodplain areas from inappropriate development, and to regulate the location of manure pits and barnyards to prevent discharge of high levels of nutrient pollution caused by flood events.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.

Town of Pulteney:

Documents Reviewed:

- Comprehensive Plan, 2016
- Land Use and Zoning Regulations, 2016
- Subdivision Regulations, 2008
- Wastewater Management Law

Recommendations for Future Action:

- Amend the site plan review provisions of the Land Use and Zoning Regulations (Section 718(A)(2)) to incorporate basic protections for water resources such as appropriate land uses, riparian buffers and stormwater management provisions including green infrastructure.
- Amend the Land Use and Zoning Regulations and zoning map to enhance water quality protection through incorporation of riparian buffer zones and environmental protection overlay districts (EPOD) for steep slopes, stream corridors, wetlands and other water bodies.
- Amend the Subdivision Law to permit clustered or conservation subdivision design with design standards that provide protection for water resources such as riparian buffers and stormwater management provisions, agricultural lands, and scenic viewsheds.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Review and amend where necessary the Flood Damage Prevention Law to better protect floodplain areas from inappropriate development, and to regulate the location of manure pits and barnyards to prevent discharge of high levels of nutrient pollution caused by flood events.

Town of Urbana

Documents Reviewed:

- Comprehensive Plan
- Zoning Code, 2016
- Site Plan Review, 1992
- Subdivision Law, 1985
- Wastewater Management, 2012
- Docks and Mooring Law, 2006
- Flood Damage Prevention Law, 1987

Recommendations for Future Action:

- Review and update as appropriate the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Amend the Site Plan Review Law to supplement the existing Critical Areas Overlay District by incorporating riparian buffer zones into zoning & site plan review.
- Amend the Site Plan Review Law to incorporate green infrastructure standards to treat stormwater to better control urban runoff pollution from development.
- Amend the Subdivision Law to permit clustered or conservation subdivision design with design standards to provide protection for water resources such as riparian buffers and stormwater management provisions, agricultural lands, and scenic viewsheds.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.

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Town of Wayne

Documents Reviewed:

- Comprehensive Plan,
- Subdivision Regulations, 2005
- Land Use Regulations, 2018
- Uniform Docking and Mooring Law

Recommendations for Future Action:

- Amend Section 3.0 (Supplemental Regulations) of the Land Use Regulations to establish specific minimum setbacks for riparian buffer zones for stream corridors, wetlands and other water bodies.
- Amend Section 3.0 (Supplemental Regulations) of the Land Use Regulations to incorporate green infrastructure standards to treat stormwater to better control urban runoff pollution from commercial and industrial development.
- Amend the Subdivision Regulations to include more explicit design standards for clustered subdivisions to better protect water resources such as riparian buffers and stormwater management provisions, agricultural lands, and scenic viewsheds.

<u>Town of Wheeler</u>

Documents Reviewed:

- Comprehensive Plan, 2014

Recommendations for Future Action:

- Adopt a zoning law that would permit better regulation of growth and development, protect valued agricultural lands and open space lands, and incorporate basic protections for water resources such as riparian buffers and stormwater management provisions.
- Adopt a subdivision review law design with design standards the provide protection for water resources such as riparian buffers and stormwater management provisions, and permit the use of cluster/conservation subdivision design to better protect agricultural lands, and scenic viewsheds, as well as provide protection for water resources.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Collaborate with Steuben County to enhance codes or guidelines to more effectively address erosion control and on-site wastewater treatment systems, including required inspections and setbacks from waterways, wetlands, and floodplains.
- Adopt a Wastewater Management Law and appoint a Watershed Inspector jointly with neighboring Towns or through Steuben County.

Yates County

<u>Town of Benton</u>

Documents Reviewed:

- Comprehensive Plan, 2012
- Zoning Code, 1992
- Subdivision Regulations, 2009

Recommendations for Future Action:

- Review and update as needed the Zoning Code in order to incorporate newer approaches to land use regulation and growth management, including provisions to better protect community character, protect valued agricultural lands and open space lands, and incorporate basic protections for water resources such as riparian buffers and stormwater management provisions.
- Amend the site plan review provisions of the Zoning Code to incorporate green infrastructure standards to treat stormwater to better control urban runoff pollution from commercial and industrial development.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Adopt a Wastewater Management Law and appoint a Watershed Inspector jointly with neighboring Towns or through Steuben County.
- Adopt a uniform Docks and Mooring Law in collaboration with other Towns on Seneca Lake.

Town of Barrington

Documents Reviewed:

- Comprehensive Plan, 2007
- Zoning Law Draft, 2020
- Subdivision Law, 2013
- Steep Slopes Law, 2011
- Uniform Docking & Mooring Law
- Wastewater Management Law 2011

Recommendations for Future Action:

- Review and update as appropriate the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Amend the Zoning Law to include the provisions of Art. 5(G)(4)(b) of the Subdivision Law as Site Plan Review design standards to better protect water resources through designation and maintenance of riparian buffers.
- Amend the Zoning law to incorporate green infrastructure standards to treat stormwater to better control urban runoff pollution from development.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.

Village of Dresden

Documents Reviewed:

- Comprehensive Plan 2004
- Zoning Code, 2008
- Wastewater Management Law, 2015
- Flood Damage Prevention Law, 2008

Recommendations for Future Action:

- Review and update as appropriate the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Amend the Zoning Code to include site plan review design standards to better protect water resources through designation and maintenance of riparian buffers.
- Amend the Zoning law to incorporate green infrastructure standards to treat stormwater to better control urban runoff pollution from development.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Adopt a uniform Docks and Mooring Law in collaboration with other Towns on Seneca Lake.

Village of Dundee

Documents Reviewed:

- Comprehensive Plan, 1969
- Zoning Ordinance, 1975 (amended 1989, 2011)
- Subdivision Law, 1975
- Site Plan Review Law, 2006
- Flood Damage Prevention Law, 1987

Recommendations for Future Action:

- Review and update as appropriate the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Amend the Zoning Ordinance and Site Plan Review Law to include design standards to better protect water resources through designation and maintenance of riparian buffers.
- Amend the Site Plan Review Law to incorporate green infrastructure standards to treat stormwater to better control urban runoff pollution from commercial and industrial development.
- Amend the Subdivision Law to permit cluster subdivision in the village. Currently there are a number of large undeveloped parcels, covering about 25% of the village land area, that in the future may be subject to development. Well-crafted cluster subdivision regulations can permit development of compact, walkable neighborhoods while protecting valued natural open space, scenic viewsheds, and water resources.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Adopt a Wastewater Management Law and appoint a Watershed Inspector jointly with neighboring Towns or through Steuben County.
- Review and amend where necessary the Flood Damage Prevention Law to better protect floodplain areas from inappropriate development.

Town of Italy

Documents Reviewed:

- Comprehensive Plan, 2005
- Zoning Ordinance,
- Subdivision Code, 2009
- Flood Damage Prevention

Recommendations for Future Action:

- Review and update as appropriate the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Amend the Zoning Ordinance to incorporate green infrastructure standards to treat stormwater to better control urban runoff pollution from commercial and industrial development.

- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Amend the Subdivision Regulations to permit clustered subdivision design to better protect water resources such as riparian buffers and stormwater management provisions, agricultural lands, and scenic viewsheds.
- Review and amend where necessary the Flood Damage Prevention Law to better protect floodplain areas from inappropriate development, and to regulate the location of manure pits and barnyards to prevent discharge of high levels of nutrient pollution caused by flood events.

Town of Jerusalem

Documents Reviewed:

- Comprehensive Plan, 2006
- Zoning Ordinance, 2012
- Subdivision Code, 2009
- Steep Slopes Law, 2008
- Wastewater Management Code, 2010
- Flood Damage Prevention, 1997

Recommendations for Future Action:

- Review and update as appropriate the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Amend Section 160(12) of the Zoning Ordinance to include stronger standards to better protect water resources through designation and maintenances riparian buffers.
- Amend the Zoning Ordinance to incorporate green infrastructure standards to treat stormwater to better control urban runoff pollution from commercial and industrial development.
- Amend the Subdivision Regulations to include more explicit design standards for clustered subdivisions to better protect water resources such as riparian buffers and stormwater management provisions, agricultural lands, and scenic viewsheds.
- Review and amend where necessary the Flood Damage Prevention Law to better protect floodplain areas from inappropriate development, and to regulate the location of manure pits and barnyards to prevent discharge of high levels of nutrient pollution caused by flood events.

Town of Milo

Documents Reviewed:

- Comprehensive Plan 2013
- Zoning Law, 2021
- Keuka Lake Uniform Dock and Mooring Law
- Flood Damage Prevention Law, 1997

Recommendations for Future Action:

- Amend the Zoning Law to better protect water resources through designation and maintenance of riparian buffers, and to incorporate green infrastructure standards to treat stormwater to better control urban runoff pollution from commercial and industrial development.
- Review and amend where necessary the Flood Damage Prevention Law to better protect floodplain areas from inappropriate development, and to regulate the location of manure pits and barnyards to prevent discharge of high levels of nutrient pollution caused by flood events.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.

Town of Potter

Documents Reviewed

- Comprehensive Master Plan, 1979
- Zoning Law, 2010
- Subdivision Regulations, 2011

Recommendations for Future Action:

- Update the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Amend the Zoning Law to include stronger standards to better protect water resources through designation and maintenance of riparian buffers.
- Amend the Zoning Ordinance to incorporate green infrastructure standards to treat stormwater to better control urban runoff pollution from commercial and industrial development.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Review and amend where necessary the Flood Damage Prevention Law to better protect floodplain areas from inappropriate development, and to regulate the location of manure pits and barnyards to prevent discharge of high levels of nutrient pollution caused by flood events.

Village of Penn Yan

Documents reviewed:

- Comprehensive Master Plan, 2000
- Zoning Law, 2004
- Site Plan Review, 1996
- Subdivision of Land, 1990
- Keuka Lake Uniform Docking and Mooring Law, 2006
- Flood Damage Prevention Law, 1987
- Wastewater Management Law, 2012

Recommendations for Future Action:

- Review and update as appropriate the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.

- Amend the Zoning Law to include stronger standards to better protect water resources through designation and maintenance of riparian buffers.
- Amend the Zoning Ordinance to incorporate green infrastructure standards to treat stormwater to better control urban runoff pollution from commercial and industrial development.
- Amend the Subdivision Regulations to include more explicit design standards for clustered subdivisions to better protect water resources such as riparian buffers and stormwater management provisions, agricultural lands, and scenic viewsheds.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Adopt a Flood Damage Prevention Law to better protect floodplain areas from inappropriate development, and to regulate the location of manure pits and barnyards to prevent discharge of high levels of nutrient pollution caused by flood events.

<u>Town of Starkey</u>

Documents Reviewed:

- Comprehensive Plan, 2014
- Zoning Law, 2015
- Subdivision Regulations, 2021
- Flood Damage Prevention Law, 2003

Recommendations for Future Action:

- Amend the Zoning Law to incorporate green infrastructure standards to treat stormwater to better control urban runoff pollution from commercial and industrial development.
- Amend Section 5.71 of the Zoning Law to exclude manure pits and barnyards from the FW-1 Floodway District in order to prevent potential discharge of high levels of nutrient pollution during flood events.
- Amend the Zoning Law to include stronger standards to better protect water resources through designation and maintenance of riparian buffers.
- Amend the Subdivision Regulations to include more explicit design standards for clustered subdivisions to better protect water resources such as riparian buffers and stormwater management provisions, agricultural lands, and scenic viewsheds.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.

<u>Town of Torrey</u>

Documents Reviewed:

- Comprehensive Plan, 2008
- Zoning Law, 2019
- Flood Damage Prevent Law 2010

- Planned Unit Development Law, 2008
- Subdivision Law, 2013
- Wastewater Management Law, 2014

Recommendations for Future Action:

- Review and update as appropriate the comprehensive plan to incorporate newer practices and approaches to planning, and to better guide land use decisions, protect community character, and also enhance the protection of local water resources and promote intermunicipal partnership in watershed planning efforts.
- Adopt an erosion and sedimentation control law to ensure future growth and development does not adversely affect the environment, particularly water resources.
- Amend the Zoning Law to better protect water resources through designation and maintenance of riparian buffers, and to incorporate green infrastructure standards to treat stormwater to better control urban runoff pollution from commercial and industrial development.
- Amend Section 160(12) of the Zoning Ordinance to create riparian buffer overlay zones extending a set distance from streams, ponds, wetlands and other water bodies that better control the type and intensity of development within the buffer, and include requirements for planting and maintaining appropriate vegetation within the riparian buffer areas.
- Amend the Zoning Ordinance to incorporate green infrastructure standards to treat stormwater to better control urban runoff pollution from commercial development.
- Adopt a uniform Docks and Mooring Law in collaboration with other Towns on Seneca Lake.

Section 5: Enhancing Water Quality Protection

The Toolbox

Listed below are additional recommendations for municipalities to consider. The Section 4 Assessment has identified recommendations for each municipality. Officials can find further details concerning those suggestions in this chapter.

Comprehensive Plans

The planning profession suggests updating comprehensive plans once every five to ten years. Comprehensive plans are living documents that change as the non-static town changes. To create successful vibrant communities,

municipalities should assess if their target goals are being met, and to understand if their community's desires and wishes have changed since the last comprehensive plan.

Conservation Overlay District

An overlay district provides additional protection to natural or historic resource assets that are targeted for protection. Overlay districts are superimposed on a conventional zoning district that addresses areas of concern from the public or the municipality. Two important resources in the watershed includes all tributaries, the lakes, and the historical buildings found throughout many municipalities. This type of district is enacted in the zoning law. As exemplified by the town of Geneva, this type of zoning district may incorporate land that is within 50 feet from a New York State Department of Environmental Conservation wetland, shore, or adjoining slope of 15% grade or more (Town of Geneva 2012). The district further prohibits development adjacent to streams, rivers, lakes, and wetlands, and ultimately reduces the amount of impervious surfaces.

Cluster Subdivision Design

In many of the towns' comprehensive plans, the communities highlight their desire to protect its rural character with some indicating that their population is slowly increasing. For these reasons, it is essential to preserve agricultural farmland by creating a cluster subdivision or zoning law.

Specific well-designed cluster development guidelines should be in place in subdivision or zoning laws to further protect environmentally sensitive areas and to preserve open space and scenic viewsheds. These guidelines will identify clear thresholds of where and when this type of development is required and the minimum requirement for approval. Sound cluster development practices encourage builders to maximize a parcel's potential by increasing the density of new construction in one section, such as in less productive soils or in the woods, while leaving prime agricultural areas undeveloped (Genesee/Finger Lakes Regional Planning Council 2009). This particular type of development reduces the amount of impervious surfaces like parking through designs such as flag lots.

Docks and Mooring Law

A dock and mooring law regulates lakeshore docks, moorings, and other lake-side structures. Proper dock and mooring laws will protect the viewshed, water quality, prevent erosion and sedimentation near the shoreline, avoid interfering with public enjoyment, and mitigate disruptions while fish spawn. Regulations are important if any new docks and moorings are built in the future or maintenance and repair are required on the pre-existing structures. Detailed and specific regulations by the village of Penn Yan (Penn Yan 2017), and most importantly, the Keuka Lake Uniform Dock and Mooring Law should be used as examples to develop its own law (Keuka Lake Association n.d.).

Erosion and Sediment Control Law

All towns and villages can greatly impact the watershed through development. Future development should be regulated by an erosion and sediment control plan within each town. Towns should require developers to create this type of plan that explains the permanent and temporary erosion control measures to minimize erosion and sedimentation before, during, and after construction with the plan approved by the town. An erosion and sedimentation control law should also include the retention and protection of natural vegetative areas, exposing the smallest practical area of land for development, and provide adequate draining facilities to accommodate increased runoff caused by changing soil and surface conditions during and after construction (Village of Watkins Glen 2018). Helpful guidance for implementing this law, created by the New York State Department of Environmental Conservation, is called “Specifications for Erosion and Sediment Control” (Lake Jr 2016). The village of Watkins Glen can also serve as an example of this particular law within the watershed.

Floodplain/Flood Damage Prevention Law

Establish a floodplain law and enforce it through a floodplain manager to prevent future development in high-risk areas that can damage property and harm people. The town of Starkey is an excellent example of a floodplain law detailing the delineation of the floodway, permitted uses, special uses, and provisions.

Green Infrastructure

Green infrastructure practices such as permeable pavement, bioswales, rain gardens, the disconnection of downspouts, amongst other practices, can reduce the amount of water entering the watershed. Watershed inspectors, the Seneca Lake Pure Water Association, or other organizations should educate citizens, businesses, and municipalities on the benefits of green infrastructure and ways to implement it. Municipalities should use federal and state funding sources to implement a green infrastructure project, such as the Clean Water State Revolving Fund (US EPA 2017).

Landmark Preservation Law

Significant local historical and architecturally significant buildings can be found within the region. Municipalities should establish a historical landmarks committee to identify potential historic structures and to protect current ones. Municipalities should also assess the identification of houses for their architecture and cultural value in the future. Furthermore, some towns do not have any national historic landmarks and should therefore try to designate one based on local landmarks of importance. Landmark protection is invaluable for communities to protect their community's identity as development occurs.

Pervious/Permeable Pavement

The creation of new wineries has often brought unsustainable impervious pavement. The permeable pavement for the parking lots can reduce the amount of pollution and stormwater from entering the watershed by capturing it and allowing it to seep into the ground. Implementing this particular green infrastructure practice will reduce development impacts on the watershed and make new wineries sustainable.

Planned Unit Development Zoning

Adopting a Planned Unit Development zoning law can be beneficial for municipalities that are growing or near growing ones. Planned unit developments allow for an efficient use of land, encourage various types of housing, and preserve large tracts of agricultural land. Planned unit developments are also cost effective. The New York State Legislative Commission on Rural

Resources created “A Guide to Planned Unit Development,” which exemplified a model planned unit development ordinance (NYS Legislative Commission on Rural Resources 2005).

Riparian Buffer Zones

Riparian buffers can protect water quality, prevent erosion and sedimentation, and reduce nonpoint source pollution. Many municipalities do not have specific subdivision regulations to protect riparian buffers and should be mandatory for developers in order to obtain subdivision approval. Municipalities should incorporate a minimum 30-foot riparian buffer into the site plan review process. Vegetation requirements and use restrictions should also be incorporated (Kased et al., n.d.). NYSDEC’s 2010 Stormwater Management Design Manual can guide the town in creating riparian buffers.

Short Term Rental Ordinance

As the Finger Lakes continue to grow in agricultural and lake related tourism, short term rental ordinances should be in place. Recently, properties have been bought and converted into short term rentals, affecting the quality of life for neighboring residents in various towns. The Town of Geneva and Village of Watkins Glen recently adopted ordinances to combat this issue and should be looked at for guidance. Like Geneva, municipalities should adopt an ordinance that ensures that property owners live in the house for a minimum of 7 months of the year. To limit the number of people that are showing up in a rental property, there can be limits on the number of people who can sleep in a room depending on square footage of the space.

Site Plan Review

A process where a new development is reviewed by a municipality and its staff to determine if it is in accordance with zoning regulations. During the site plan review process, the developer also must ensure that the New York State Environmental Review procedures have been satisfied to determine that the construction before during and after will not cause significant environmental damage.

Subdivision Law

Subdivision ordinances govern the division of a large piece of land into smaller parcels. A developer must have a plat or sketch detailing the proposed project's location and the dimensions of roads and buildings. Subdivision ordinances should require assessing potential impacts on farmland and design standards to reduce the impacts of new subdivisions on productive land. Ultimately the subdivision process allows a town to evaluate the subdivision and determine if it is consistent with the comprehensive plan, any NY certified agricultural districts in town, and whether it will require additional public services. The process also assesses potential impacts on agricultural lands and farm operations.

Wastewater Management Law

A wastewater management law is essential to preserve and protect the watershed and public health since the number one source of nonpoint source pollution comes from on-site wastewater treatment systems (Kased et al., n.d.). A wastewater management code is important to implement since homes in various municipalities across the watershed are connected to a septic system and also are found along the waterfront. Included in the code are design standards and requirements for new residential construction, replacement of the system, and routine inspections. Torrey and the Keuka Watershed Improvement Cooperative's model local wastewater treatment law are excellent examples of wastewater management codes.

Watershed Inspector

Consider adopting a watershed inspector for your specific municipality or speak to the county to discuss adopting a county inspector similar to that implemented in Yates or Schuyler counties. Watershed inspectors should be used regardless of one's nearness to the lake since the actions that occur upstream may affect those downstream. The inspector ensures compliance with federal, state, and local rules and regulations to protect the below and above groundwater resources and the county's public health. Municipalities can use watershed inspectors to test septic system leaching and sewage failures affecting the broader watershed's groundwater and the lake.

Wetland Buffers

To avoid negative impacts from human development, formal wetland regulations should include 50-150 feet buffers that must be in place to protect those that exist in the town (Washington State Department of Ecology 1992). Officials should also ensure that state and federal wetland regulations are also followed when projects arise. Wetlands provide various ecosystem services such as filtering sediment, chemical detoxification, nutrient removal, flood protection, shoreline stabilization, and groundwater recharge. They are considered an exceptionally productive ecosystem and provide fish and wildlife habitat (Kased et al., n.d.). Some municipalities have indicated in their comprehensive plan that their town values the protection of natural resources and wetlands but does not incorporate the protection of them in their regulations.

Zoning Laws

Zoning laws indicate where and how various types of land uses are located and how they will operate within a municipality. Zoning ordinances can ensure the protection of natural resources and water quality while also providing development in areas that are appropriate. Municipalities across the watershed and within the Finger Lakes region can serve as examples of what to incorporate into the zoning ordinances.

Using Soil Maps in Local Water Quality Protection Planning

Land disturbance in close proximity to water resources has the potential for sediment and nutrient pollution and impacting water quality in local lakes and streams. The threat of such pollution can increase when the underlying soils have severe restrictions or limits such being erodible, or exhibit other characteristics such as severe limitations on onsite septic systems, and areas of waterlogged soils or shallow depth to water table. The presence of one or more of these soils attributes in proximity to a tributary stream, waterbody or wetland can be utilized to identify areas within the watershed that warrant protection from development.

The Natural Resources Conservation Service has developed the Web Soils Survey (WSS) interactive map (https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm) that permits public access to soils maps and some simple analytical tools. It permits professionals and non-professionals access to soils mapping in their community. By using the Web Soils Survey to map specific soils having these constraints, users can identify specific land parcels of land for protection as open space, in effect tying open space protection to water quality protection in the watershed. Actions to enhance water quality protections on such parcels could include:

1. No-build riparian buffer zones to steer land disturbances away from the water resources on the property;
2. Use of conservation subdivision design to permit development of the larger parcel in accordance with permitted building densities, while preserving lands that provide protection for water resources;
3. Use of conservation easement or fee simple acquisition of specific lands of unique value in the protection of water resources and other ecological assets, along the lakes, as well as tributaries.

The key soil related attributes are:

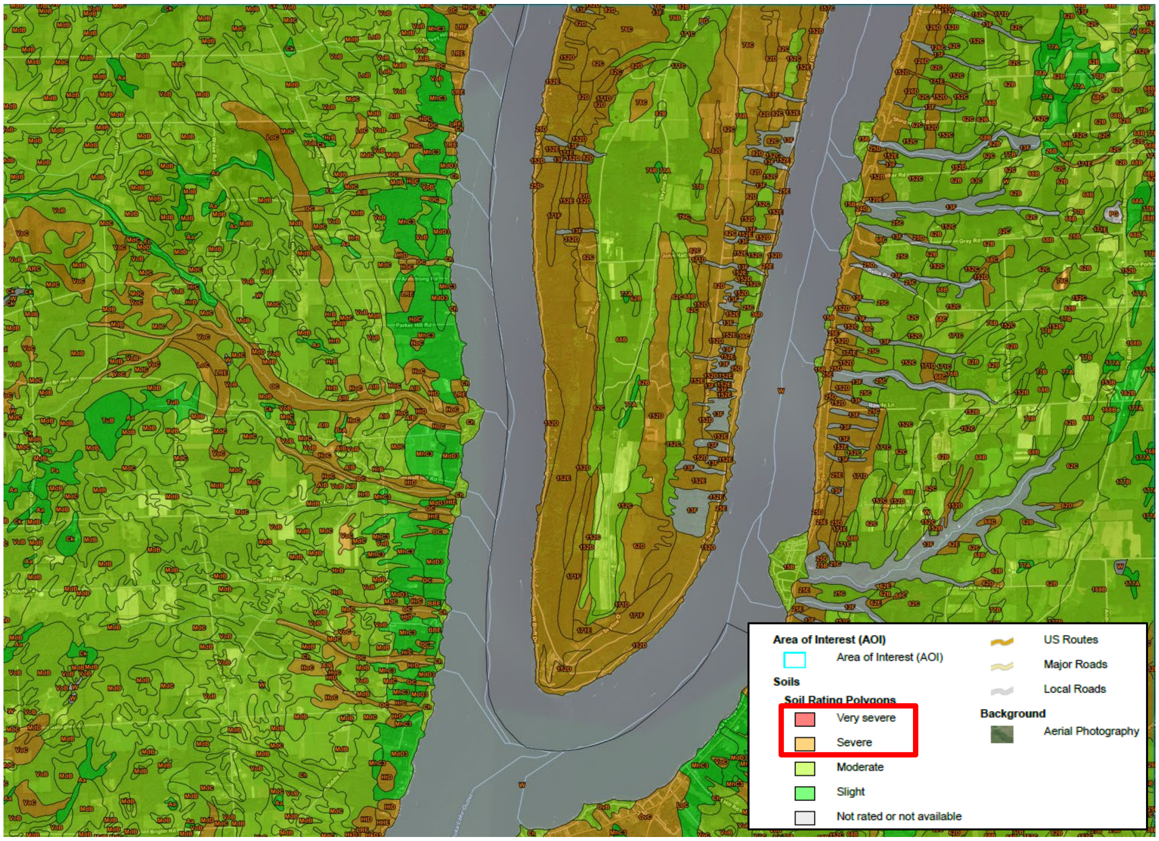
1. areas of erodible soils;
2. areas where there are severe limitations on onsite septic systems;
3. areas dominated by hydric soils.

Map data can be obtained from the NRCS Web Soil Survey under the Land Classifications and Land Management headings. Areas of erodible soils can be identified and mapped utilizing the Erosion Hazard (road/trail) Land Management category. This category rates the hazard of soil loss from unsurfaced roads and trails, which can be similar to the types of land disturbance that occur in rural areas due to development. Areas where severe limitations for onsite septic systems exist can be identified and mapped utilizing the Septic Tank Absorption Fields (NY) Land Management category. Finally, areas that have a high probability of containing wetlands can be identified and mapped utilizing the Hydric Rating by Map Unit Land Classification category.

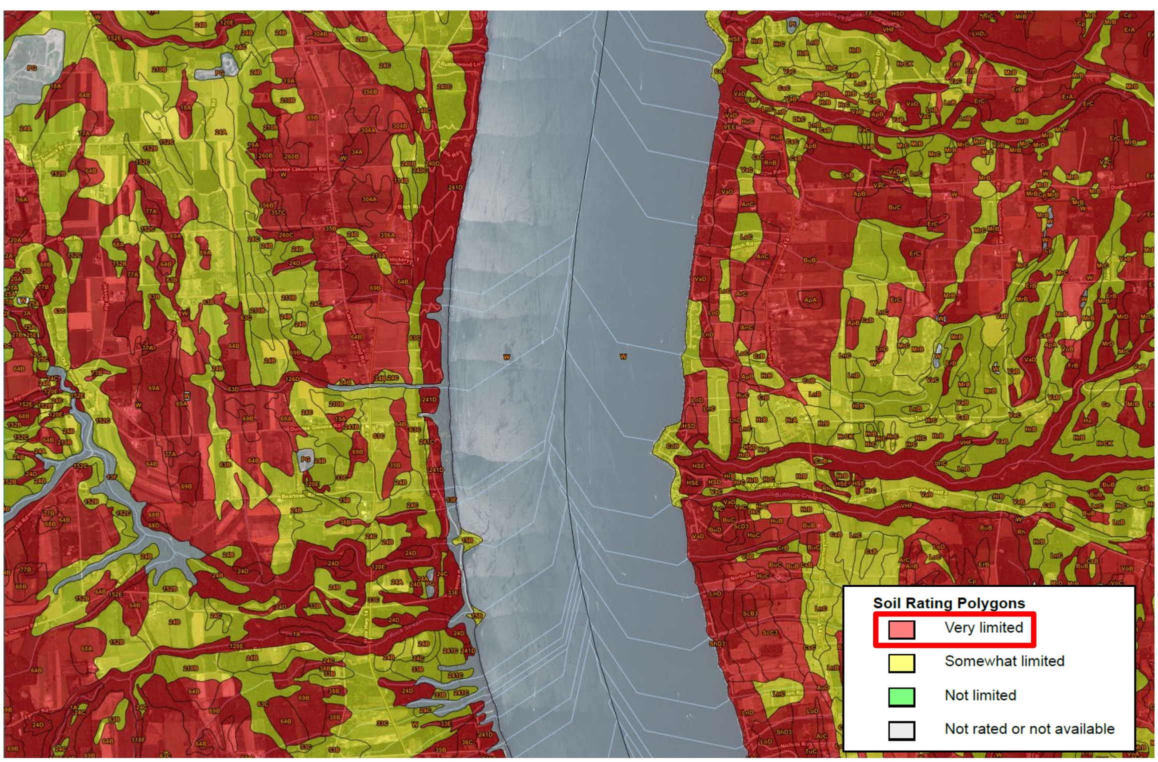
Local governments can access and utilize the Web Soil Survey mapping feature in their comprehensive planning and land use regulations to address water quality protection objectives, by identify areas in the community where future development should be directed away from. The mapping information can be utilized in site plan and subdivision review process to document potential adverse environmental impacts on water resources of a proposed development. In the case of subdivision review, it can be utilized to identify parcels where conservation subdivision can be utilized to protect water resources, while permitting development

For the purpose of identifying and prioritizing individual land parcels for the acquisition of conservation easements, these soils would be given numerical values that could be combined with other attributes as a means to score such parcels for protection.

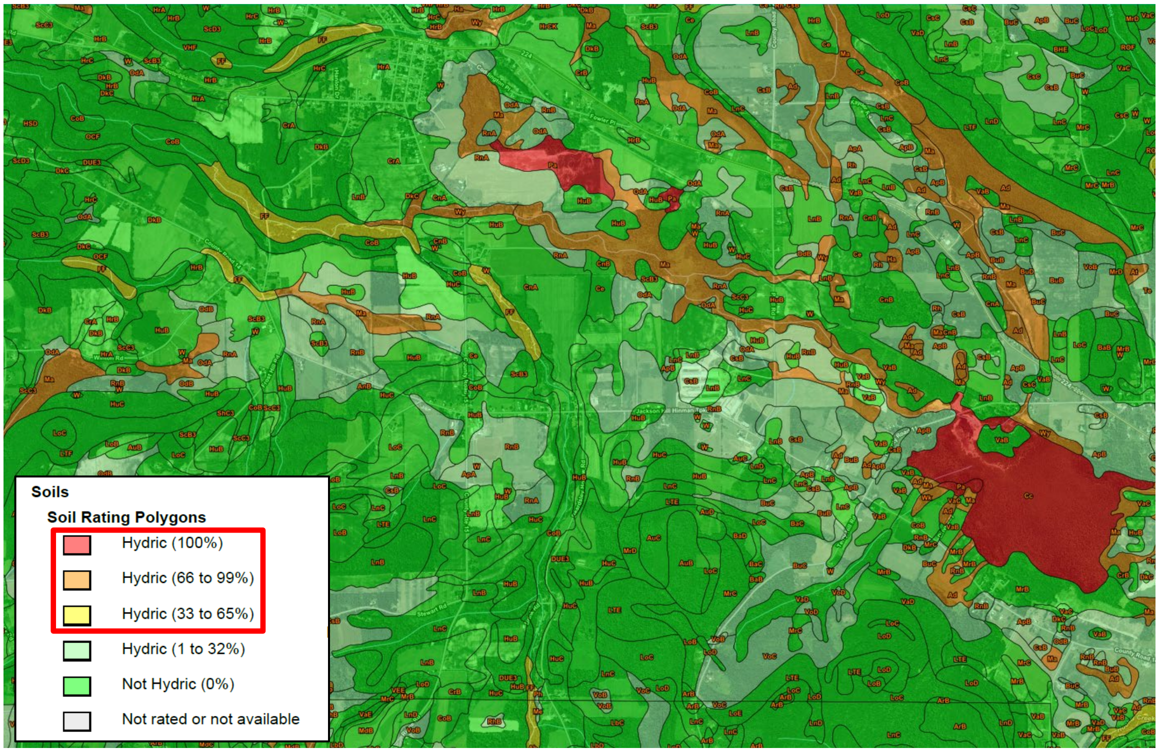
The three maps below, of sections of the Keuka Lake, Seneca Lake, and Catlin Mill Creek watersheds, illustrate the three key soils attributes where development and other site disturbance can impact water quality in streams and lakes. Also following is a table listing the soils groups with “severe” or “very limited” restrictions associated with development.



Map 1. Erosion Hazard (road, trail construction) soils, portion of Keuka Lake watershed.



Map 2. Soils ratings for Septic Fields Absorption, portion of Seneca Lake watershed.



Map 3. Hydric Soils ratings, southern portion of Catlin Mill Creek watershed.

The NRCS Web Soil Survey can be a very useful tool for local and county governments in identifying areas where attention should be given to ensure water resources are protected.

Other Strategies

Clean-Up Day Events

Municipalities across the watershed, regardless of whether they are located, should facilitate clean-up days on the side of roads where trash is commonly disposed of. Likewise, municipalities and non-profits should implement clean-up days on the public shoreline to facilitate watershed education.

Regional Leadership

The Keuka Lake Watershed Land Use Planning guide is an intermunicipal action strategy that should be used as an example for implementation in the Seneca Lake region (Genesee/Finger Lakes Regional Planning Council 2009). The Watershed Land Use Planning guide is a collaborative process that brings local officials, land use planning experts, and concerned citizens together to create a resilient Keuka watershed. The report is developed similar to a comprehensive plan that promotes a vision of environmental stewardship, smart growth, and preservation of the rural character surrounding Keuka lake. The ultimate goal of the guide is to understand current land use conditions and provide specific recommendations for future use and development throughout the watershed.

Roadside Ditches

Hundreds of miles of roadside ditches are found in the watershed. Improperly designed ditches result in numerous consequences such as increased flooding, streams running dry, wells becoming empty, the groundwater table declining, streambank erosion, and polluted drinkable water (Schneider 2010). Well designed and maintained ditch systems are critical to protecting our watershed and include these practices:

- When clearing ditches, do not scrape off significant amounts of vegetation and seed to grass immediately after maintenance to avoid erosion.
- Identify deep shaped, V-shaped, or steeply sloping ditches that can create a higher velocity of water and erosion and redesign them to be shallow, trapezoidal, or rounded.
- Ditches can influence flooding downstream. Therefore, municipalities should disconnect the ditches from the stream and divert the water to an infiltration basin, retention basin, or wetland.

Tile Drain Improvement

The region is heavily centered around agricultural production, and for some time, the USDA provided technical assistance and monetary aid to farmers to install tile drains. A study in Vermont indicated that subsurface tile drains increased total annual water output by 10-25%(Vermont Agency of Agriculture, Food and Markets 2017). Tile drains also carry a significant amount of phosphorus, which can be impactful in a heavily agricultural region like this one.

Municipalities can implement various solutions to reduce the phosphorus load and excessive stormwater from entering the watershed. These two factors can have damaging flooding and environmental impacts. Numerous solutions to implement include:

- Design Strategy 1- Redirect the tile water to a detention basin or other types of green infrastructure that can hold and release water slowly into the ground after a severe rainstorm. As a result, this action can reduce pollution coming from drinking water.
- Design Strategy 2- The collection of water from tiles is stored in a water control structure and slowly releases that water into the drainage system.
- Design Strategy 3- Limit the amount of manure that is spread over the tiles to reduce phosphorus entering them.

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