Appendix M
Monitoring & Assessment

Framework for a Cayuga Lake Watershed Monitoring Plan

Draft

Contact Information

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Preface

The *Cayuga Lake Watershed Monitoring Plan Framework* was developed by the Cayuga Lake Watershed Intergovernmental Organization's Technical Advisory Committee (TAC). The Framework is intended to provide guidance for development of a *Long-term Monitoring Plan* for the Cayuga Lake Watershed. Furthermore, the *Framework*, and ultimately the *Long-term Monitoring Plan*, are intended to supplement the *Preliminary Cayuga Lake Watershed Characterization Study* (2000) and the *Cayuga Lake Watershed Restoration and Protection Plan* (in development), by providing the necessary information for the protection of the Cayuga Lake watershed into the foreseeable future.

I. Introduction

Cayuga Lake is one of the largest lakes in New York State (fifth largest on the basis of surface area). The lake and its surrounding watershed (Figure 1) support a wide range of human activities. The lake itself serves such disparate purposes as water supply and waste assimilation, while the watershed supports activities ranging from agriculture to industry. The lake and surrounding watershed are also a complex and important aquatic ecosystem. Activities within the watershed play a crucial role in determining the health of Cayuga Lake. The long-term health of the lake is dependent upon finding a proper balance between activities within the watershed and the ability of the lake to accommodate those activities on a sustainable basis. Defining and maintaining such a balance requires the implementation of a sound and sustained watershed monitoring program. Effective stewardship of such a complex ecosystem is not possible absent a thorough understanding of the system.

The development of a Watershed Monitoring Plan (Monitoring Plan) for Cayuga Lake should begin with a thorough assessment of previous and ongoing investigations within the basin. This *retrospective* study should evaluate and catalog all pertinent data and information on the lake and watershed. The Preliminary Cayuga Lake Watershed Characterization Study (2000) provides an overview of several past investigations, however, a more comprehensive effort may be warranted. Additional discussion of such a retrospective study is contained in Chapter 5 below.

Cayuga Lake has been monitored sporadically over the past century. Initial water quality investigations of the lake were conducted by two Wisconsin researchers during the early 1900s (Birge and Juday, 1914) in conjunction with their investigation of all of the Finger Lakes. This early work, albeit limited by the available tools of the day, provide important historical data about the lake. Since that initial foray, numerous other investigations of the lake have taken place. Studies conducted during the late 1960s and early 1970s resulted in publication of Lakes of New York State – Volume 1: Ecology of the Finger Lakes – Limnology of Cayuga Lake (Oglesby, 1978). Since the 1970's the lake has been the subject of several additional investigations, including: (1) Studies associated with Cornell's Lake Source Cooling project, and (2) New York State Department of Environmental Conservation study of the Finger Lakes. In addition to the lake itself, a number of tributaries within the watershed have a relatively long history of monitoring. For example, nutrient sampling has been conducted on Fall Creek for approximately 30 years (Bouldin, ?). In addition, there is a significant ongoing investigation of the Six Mile Creek watershed.

A number of the monitoring activities mentioned above are still underway, and several additional studies are on the drawing board. Given the current level of interest within the watershed, and the number of monitoring initiatives currently (or soon to be) in progress, this represents an ideal opportunity to establish an integrated Monitoring Plan for the watershed. Resource limitations make it imperative to look for ways to optimize existing and future monitoring activities. The Monitoring Planning process should look for opportunities to network and build upon existing monitoring activities within the basin, and to leverage available resources. Furthermore, the Monitoring Plan should focus upon addressing specific informational needs within the watershed.

The Monitoring Plan should be designed to answer questions of *who, what, where, when, why, and how*. For example: *Who* will be responsible for conducting the monitoring program (will it be run by lay volunteers, professional personnel, or a combination of both) ? *Who* will have access to the data collected ? *What* parameters will be monitored (and what methods and/or protocols will be used) ? *What* monitoring indicators will be used to assess water quality ? *Where* will monitoring activities occur (and will monitoring sites be permanent or temporary) ? *Where* will the data be housed ? *When* will monitoring occur (and should it be a one time or continuing effort) ? *Why* are certain monitoring activities occurring (and other activities not occurring) ? *How* will the monitoring program be funded and sustained ? How will the information be made available (Internet, library system, etc.) ?

This document is intended to establish a framework for answering these and other relevant questions. The Monitoring Plan is divided into 4 components as follows: (1) Lake, (2) Tributary, (3) Ground water and (4) Other Relevant Information. The first three components are further segmented into physical, chemical, and biological elements. While components are detailed separately below, it is essential that all components function as an integrated whole. For example, the nutrient level of a lake is an important determinant of its trophic status. However, the nutrient concentration within a lake is largely controlled by nutrient inflow from the lake's tributary system, and while nutrient loading is often dominated by storm-event flows, ground water discharge is also a factor due to its role in controlling the base flow of streams. Thus, attempts to assess the dynamics of lake trophic status are intimately related to tributary inputs, ground water discharge, and the activities taking place within each sub-watershed.

Several additional documents which were consulted in the development of this monitoring program, include: (1) The Lake and Reservoir Restoration Guidance Manual (EPA, 1990), (2) Lake and Reservoir Bioassessment and Biocriteria Technical Guidance Document (EPA, 1998), (3) Diet for a Small Lake (NYSDEC, 1990); and (4) Field Guide for Collecting and Processing Stream-Water Samples for the National Water-Quality Assessment Program (USGS, 1994). Other possible resources include monitoring plans from other lakes.

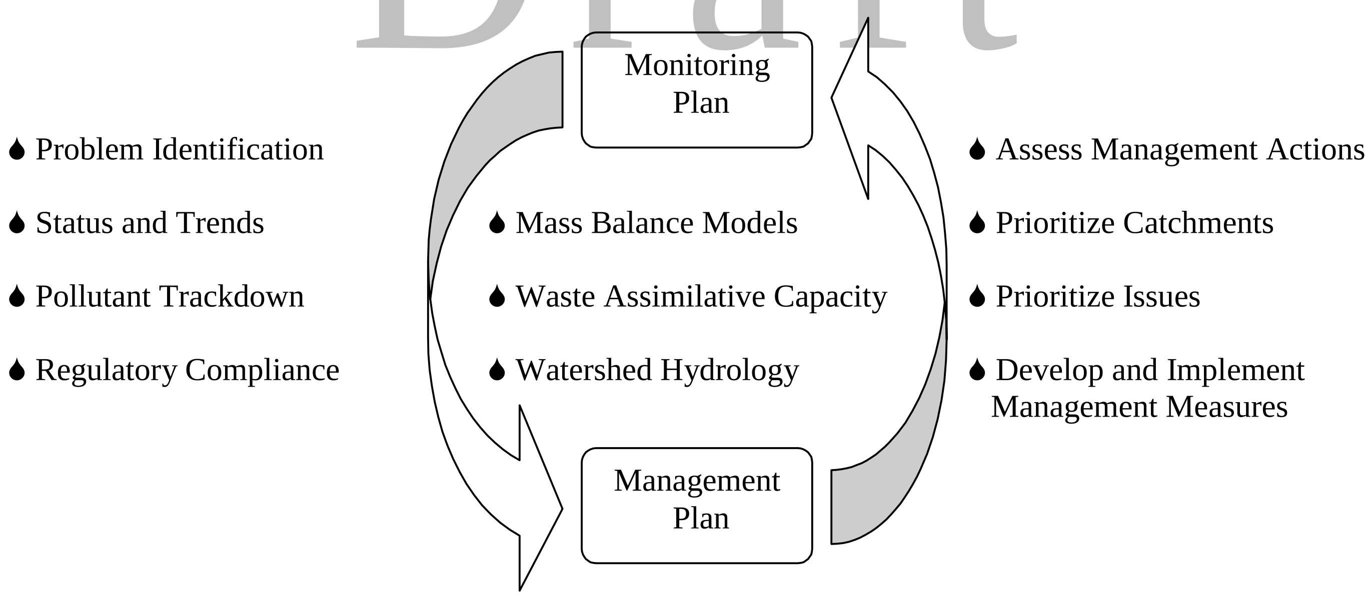
II. Purpose and Objectives

The purpose of the *Cayuga Lake Watershed Monitoring Plan* is to initiate collection of the necessary information to support effective stewardship and management of the lake and surrounding watershed. Specific objectives of the Monitoring Plan should include the following:

1. Gather *baseline* water quality data (both current and historical where available) and define *ambient water quality conditions* for the lake and tributary system.
2. Define historical *trends* in water quality.
3. Determine *compliance* with applicable water quality criteria.
4. Assist in the *identification* of pollution sources.
5. Provide the necessary information to assess the *assimilative capacity* of given water segments.
6. Provide necessary data for the development of *mass loading* estimates and *computer simulation models*.
7. Enable effective *prioritization* of sub-watersheds.
8. Evaluate the effectiveness of water quality management activities.

As mentioned above, the Monitoring Plan Framework, and eventually the Long-term Monitoring Plan, are intended to supplement the *Preliminary Cayuga Lake Watershed Characterization Study* and the *Cayuga Lake Watershed Management Plan*. The *Framework*, and eventually the *Monitoring Program*, will act to supplement and update the Characterization Study. The linkage between the Monitoring Plan and the Management Plan should be iterative (see Figure 2), and reflect the dynamic nature of the watershed.

Figure 2: Monitoring Plan / Management Plan Linkages



III. Lake

Cayuga Lake acts as a *sink* for contaminants released within the watershed and those reaching the watershed through atmospheric transport. As with any lake, Cayuga Lake by definition is the lowest point within its watershed. Thus, given that water flows down gradient, materials released within the watershed are transported to the lake via tributary flow. Furthermore, Cayuga Lake receives flow from Seneca Lake which itself receives inflow from Keuka Lake. While Cayuga Lake is naturally equipped to "assimilate" some level of contamination, its ability to effectively assimilative wastes (assimilative capacity) is inherently limited. Therefore, a primary focus of any lake monitoring program must be to track and assess water quality conditions within the lake.

Design of a lake monitoring protocol (monitoring sites, analytes, sampling frequency, etc.) should address the following: (1) identify and assess issues of concern within the lake, (2) provide sufficient spatial and temporal resolution, using appropriate statistical measures, to accurately characterize conditions within the lake, and (3) collect the necessary supporting information to understand lake dynamics.

Identification of *issues of concern* within the basin should begin with a thorough review of past studies (e.g., Cayuga Lake Watershed Characterization, Priority Waterbody List for the Oswego-Seneca-Oneida Basin, etc.). These previous studies should provide a reasonable overview of existing concerns within the basin. Recommendations for further retrospective investigations can be found in Chapter 5, below. Additional perspective may be gained by examining available databases and Geographical Information Systems (GIS), which can assist in defining the "universe" of potential contaminants within the watershed. For instance, a listing of the hazardous waste sites and associated contaminants within the watershed can help in defining which contaminants could conceivably reach the lake. While past investigations can provide valuable insight regarding issues of concern within the basin, additional study is warranted in most instances due to: (1) limited scope of previous efforts; and (2) dynamic nature of lake systems coupled with the need to assess temporal trends.

Selection of lake monitoring locations and determination of sampling frequency should be premised upon achieving an accurate characterization of the entire lake. As a general rule, the number of monitoring sites selected (or spatial representation) should be based upon the level of heterogeneity (physical, chemical, and biological) within the lake. Given the basic morphometry of Cayuga Lake, characterized by relatively shallow north and south termini and a deep middle basin, at a minimum there should be monitoring sites at both ends of the lake and one or more sites within the main, deep-water portion of the lake. Water column sample collection at deep water sites should include both epilimnetic and hypolimnetic samples during stratification, whereas, a single sample is appropriate for shallow water sites (< 5 m) and deep water sites under unstratified conditions. Consideration should also be given to establishing greater spatial resolution within areas of the lake deemed to be impaired or at risk. Other issues which should be considered when choosing monitoring sites include historical monitoring activities (continuity considerations) and logistical considerations (e.g., proximity to institutions and/or boat launch sites). Monitoring frequency should likewise be guided by a desire to accurately characterize the temporal heterogeneity within the system. Recommended sampling frequency will vary depending upon the parameter of interest. For example, sediment core sampling might be limited to a single occasion. On the other hand, certain water column parameters such as chlorophyll a' might require weekly or bi-weekly sampling. One final temporal issue which needs to be considered is the duration of monitoring at particular sites. Options include fixed (or index) sites and/or temporary sites. With a lake the size of Cayuga Lake it is often advisable to use a combination of the two approaches. A fairly limited number of fixed sites are established within the lake, which are monitored periodically throughout the year. These fixed sites provide a good level of temporal resolution and a reasonable level of spatial resolution. Spatial resolution is enhanced by conducting less frequent synoptic events on a greater number of "temporary" sites.

Given the reality of limited resources, the primary focus of the lake monitoring program will undoubtedly be on the specific issues of concern within the basin. While this is understandable and justifiable, it is important that a monitoring program remain sufficiently comprehensive for several reasons. *First*, it is important to understand the underlying mechanisms responsible for various water quality concerns. For example, consider the concerns regarding suspended sediment and phosphorus levels in the southern terminus of Cayuga Lake. While it is important to quantify the levels of these parameters within the south lake, it is equally important to assess the origins of these substances. This later charge will require an understanding of sediment and nutrient dynamics within the lake. This will entail collection of additional data (beyond merely existing concentration levels within the lake) including tributary information (e.g., stream flow and concentration of the parameters of interest) to quantify external loading to the lake, and meteorological information (e.g., wind velocity and direction) to assess resuspension. *Second*, the list of issues of concern within the basin are not cast in stone, and changes both within the basin and outside the basin could add or remove particular issues from this list. A monitoring program focused exclusively on "known" issues of concern is unlikely to detect new challenges to water quality. Thus, a long-term monitoring plan should be vigilant in assessing possible new threats to the lake, and revisit the issues of concern periodically.

Monitoring Plan elements should include physical, chemical and biological components within the lake. Once again, while these components will be discussed separately below, it is important to keep in mind the linkages between the various media specific components. A case in point being lake trophic indicators which are composed of physical, chemical, and biological indicators. The Monitoring Plan should also address both the water column and bottom sediments of the lake. Investigations directed at the water column provide a "snap shot" of current conditions within the lake, whereas, the bottom sediments provide a historical view of lake conditions. The following discussion will identify desired deliverables and the suite of parameters recommended for study.

Physical

Proposed deliverables from this portion of the Monitoring Plan should include: (a) Water Balance: understanding the hydrologic cycle within a lake is a crucial prerequisite to many other inquiries including loading estimates, mass balance modeling, etc. Furthermore, water quantity issues such as flood control and water level control require a thorough understanding of lake hydrology; (b) Residence Time: the time it takes for water to move through a lake has a bearing on water quality in several important regards. For example, residence time is an important determinant in the fate of suspended sediments and associated contaminants – in general, the longer the residence time the greater the opportunity there is for materials to settle out of the water column; (c) Energy Balance: solar radiation plays a central role in the primary productivity of a lake, and thermal stratification has a profound effect on the physical, chemical, and biological processes within a lake; (d) Circulation Patterns: processes, and (e) Particle Transport: dynamics (including sediment accumulation rate, sediment resuspension, etc.).

The physical parameters of importance within the water column of a lake include hydrologic and transport factors (e.g., inflow and outflow (both surface and groundwater), lake level, evaporation, current patterns, seiche activity, particle settling rates, etc.), thermal factors (temperature regimes, thermal stratification patterns, etc.), and water transparency factors (e.g., suspended sediment concentrations, turbidity levels, Secchi Disk depth, etc.).

Important physical parameters relating to the bottom sediments of a lake include sediment accumulation rates, sediment resuspension rates, and particle characteristics (grain size, porosity, density, etc.).

<u>Chemical</u>

Proposed deliverables from this portion of the study include: (a) Current Status: define current water quality conditions within the lake with respect to conventional limnological criteria and toxic contaminants, (b) Trends: assess water quality trends within the lake for both conventional limnological parameters and toxic parameters, (c) Assimilative Capacity: assess the lake's ability to sustainably assimilate chemical inputs – to include both the lake as a whole and selected portions of the lake, and (d) Contaminant Cycle: assess and define nutrient and contaminant cycling within the lake.

Chemical parameters of importance within a lake system include conventional limnological measures as well as toxic contaminants (organic and inorganic). A primary focus of water column monitoring activities should be to define and track the trophic status of the lake. Trophic indicators should include water clarity (actually a physical parameter), total phosphorus, and chlorophyll a' (actually a biological parameter). Other conventional chemical parameters of interest include dissolved oxygen, pH, specific conductance, major ions, other nutrient parameters (e.g., nitrogen series, silica, and soluble reactive phosphorus), etc. While this effort is envisioned as largely focused on the water column, it would be of significant value to assess historical trophic trends within the lake through use of paleolimnological methods (e.g., sediment cores).

The other major chemical parameters of interest within Cayuga Lake fall under the category of toxic contaminants. Toxic contaminants include organic contaminants (e.g., chlorinated organics such as PCBs or DDT, current-use pesticides, trihalomethanes, etc.) and inorganic contaminants (e.g., metals, ions, etc.). This effort should involve investigation of both current contaminant conditions and historical contaminant trends within the lake. Investigation of current conditions would be accomplished by monitoring the water column, whereas, assessment of historical conditions would involve paleolimnolgical methods (e.g., sediment cores).

<u>Biological</u>

Proposed deliverables from this portion of the investigation include (a) Food Web: define the existing food web for Cayuga Lake and possible threats to it's stability, and define the historical food web for the lake and evaluate major changes over time, (b) Nutrient Cycle: assess the biological portion of the nutrient cycle for the lake, (c) Exotic Species: monitor and assess the various exotic species (e.g., Zebra mussel, spiny water flea, Eurasian milfoil, etc.), and assess their importance to both the ecosystem and anthropogenic uses of the lake, and (d) Pathogens: monitor and assess pathogenic organisms (bacteria, parasites, etc.) within the lake and assess their importance to various uses of the resource.

The biological parameters of interest for this portion of the program include phytoplankton, zooplankton, fish (forage and larger), benthic organisms, macrophytes, and pathogens. Special emphasis should be afforded to the investigation of exotic organisms which can present significant challenges to the stability of aquatic systems.

IV. Tributaries

The tributary system of Cayuga Lake is the primary conduit for the delivery of required constituents, as well as, contaminants to the lake. Thus, effective stewardship and management of the lake requires a sound understanding of its tributary system. In addition, water quality conditions within the tributaries is of value in and of itself.

As with the lake monitoring component of the Monitoring Plan, design of the tributary monitoring protocol should be guided by similar criteria as follows: (1) identify and address issues and/or parameters of concern within the each sub-watershed – in this instance one must consider tributaries and the lake given the fact that the lake is acting as the receiving water, (2) provide sufficient spatial and temporal resolution to accurately characterize conditions within the tributaries, and (3) collect the necessary supporting information for understanding tributary and lake dynamics.

An appropriate starting point for the identification of issues of concern within sub-watersheds is previous investigations within the basin, and database and/or GIS information for the basin. Chapter V offers a more detailed discussion of a *retrospective study*.

It would be impractical, if not impossible, to monitor every tributary to Cayuga Lake. Rather, what is needed is a well-crafted monitoring approach capable of capturing the spatial and temporal variability of the basin. Basic spatial elements should include monitoring of the lake's major tributaries (located primarily within the southern end of the basin) and representative smaller tributaries (from the middle and northern part of the basin). Preliminary focus should be directed at the mouths of these tributaries so as to define total load for the catchment. Another approach that might be considered is a combination of fixed monitoring sites and rotating temporary sites. The "rotational monitoring" program would entail establishing temporary monitoring stations on certain tributaries for a set period of time (long enough to sufficiently characterize the given tributary). The station(s) could then be moved to another stream(s). This approach should not be considered as a replacement for fixed monitoring sites, but rather as a supplement to fixed sites. Temporal considerations are especially important in the design of a tributary monitoring program. It is crucial that tributary monitoring be conducted across various flow regimes (base flow, average flow, and storm-event conditions). This is particularly important in the derivation of pollutant loading estimates. Studies have shown that the majority of the load for many contaminants occurs during storm-events. Therefore, it is critical to capture storm-events as part of a tributary monitoring program. Storm-event monitoring is no easy task and requires significant commitment and expertise on the part of monitoring personnel. The weather conditions are by definition inclement, personnel must be prepared to respond on short notice, and equipment requirements (i.e., automatic samplers) can be costly and complex. Thus, given the level of effort required to conduct storm-event monitoring, it would likely need to be focused on priority catchments (e.g., southern catchment, major tributary systems). Another temporal consideration that should be considered, particularly in the context of so called "temporary stations", is the length of operation of a given site. Annual variations in weather patterns and resultant runoff necessitate operating these sites for longer durations in order to capture the natural variability.

Other considerations which are important in the selection of tributary monitoring locations include: (1) proximity to gaging site – to enable computation of loads, (2) logistical considerations such as stream access (e.g., bridge sites, etc.), and (3) safety issues (e.g., traffic issues, etc.). Finally, monitoring protocols may well vary from one catchment to another depending upon the issues of interest. As understanding of the watershed evolves, catchment specific monitoring protocols can be developed which better reflect local issues of concern.

Physical

Proposed deliverables form this component of the Plan include: (1) Water Balance: derive a water balance for the lake – this will require additional information such as meteorological information (e.g., rainfall, evaporation rate, etc.) and ground waterflows, and (2) Mass Load: develop mass loading estimates for various chemical parameters (nutrients, pesticides, etc.) – this will also require additional information such as chemical parameters of interest.

The most important physical parameter for an effective tributary monitoring program is stream flow. For example, stream flow is crucial to the derivation of mass loading estimates, and thus, indispensable to development of waste assimilation estimates and total maximum daily loads (TMDL). Other important physical parameters include suspended sediments, particle characteristics (size, density, etc.), and temperature (which can determine the mixing pattern for the inflow to the lake.

Chemical

Proposed deliverables from this component of the plan include: (1) Current Status: define ambient water quality conditions within the target tributaries; (2) Mass Load: derive mass loading of various chemical parameters, which would assist in derivation of TMDL where necessary – this will require additional information such as stream flow, and (3) Catchment Prioritization: for use in watershed management decisions.

The chemical parameters of interest within the tributaries are similar to those of interest within the lake. These include both conventional and toxic parameters. Phosphorus is the most important conventional chemical parameter of interest due to the fact that it is the limiting nutrient for primary productivity within Cayuga Lake. As discussed above, it is important to determine the mass loading of phosphorus from the tributary system, and, thus, it is important to monitor the tributaries under various flow regimes. It would also be of value to determine specific phosphorus species (SRP, TSP, etc.). Other conventional chemical parameters of import include major ions, nitrogen, and biochemical oxygen demand. Most of these activities would involve water column monitoring.

Toxic parameters of interest within the tributaries include organics such as chlorinated organics (e.g., PCBs and DDT) and current use pesticides (e.g., atrazine), as well as inorganic substances (e.g., metals). These efforts could involve both water column samples and benthic sediment samples. A common first step in attempting to characterize the toxics of concern (particularly hydrophobic substances) within a lake basin is to sample the benthic sediments from major tributary deltas within the basin. This activity affords a basin-wide perspective with respect to which contaminants are of concern within the lake basin, and provides a way to prioritize tributary catchments for additional investigation.

Biological

Proposed deliverables from this component of the Plan include the following: (1) characterize the biological integrity of target tributaries; (2) assess pathogen concerns for the tributary itself and as path of introduction to the lake; and (3) assess routes of introduction for nuisance exotic species (particularly from Seneca and Keuka Lakes and the Seneca-Cayuga Canal).

Parameters of interest within the tributary system include macroinvertebrates (for species richness and abundance, and tissue analysis), pathogens (cryptosporidium, giardia, E coli, etc.), exotic species, fish (for ecosystem assessment and fish tissue analysis), and periphyton.

V. Ground Water

The ground water system within the Cayuga Lake Watershed is an important resource to residents of the watershed. While most of the larger communities within the watershed depend upon surface water sources for potable waters, more rural communities rely primarily upon ground water for water supply. The ground water system in the Cayuga Lake Basin also functions as a secondary conduit for the delivery of water and chemical constituents (natural and man-made) to the tributaries and the lake. While the ground water resource does not supply the quantity of water delivered by the tributary streams during storm flow conditions, ground water is usually the source of the tributary flow during base-flow periods. The ground water component must be assessed and evaluated in order to understand the overall water quantity and quality being delivered from the sub-watersheds to the lake.

As discussed in the lake and tributary monitoring components of the *Monitoring Plan Framework*, design of the ground water monitoring protocol should be guided by similar criteria: (1) identify and address issues and/or parameters of concern within sub-watersheds as they affect the ground water system(s) (see Chapter V for details of the retrospective study), (2) provide sufficient spatial and temporal resolution to accurately characterize quantity and quality conditions and trends within the ground water system (both unconsolidated and bedrock aquifers) of the basin, and (3) collect the necessary supporting information for understanding ground water flow direction, rate, and quality.

It would be impossible, and impractical, to monitor ground water in all of the aquifers throughout the basin. A well-crafted monitoring plan, using benchmark aquifers, as well as existing monitoring programs for public (groundwater-based) water-supply systems should provide the desired spatial data needed to do an initial assessment of ground water resources within the watershed. Seasonal sampling of the resource should provide the basis to evaluate temporal trends in the quantity and quality of ground water over an annual cycle, and provide the basis for determining future monitoring frequency. **Consider Screening Study**. As time and monetary resources are made available, more in-depth analysis of the resource can be made.

The initial assessment of ground water resources within the watershed should consider the following: (1) Aquifer type: (a) Unconsolidated aquifers - generally sand and gravel deposits found in glacially-scoured valleys. The largest of these aquifers are generally found in south-draining valleys as well as in the inlet valley south of the lake. Other unconsolidated aquifers of varying size and permeability are found throughout the Cayuga Basin. These aquifers can be either unconfined (surficial) aquifers, or confined (buried) aquifers. (b) Bedrock aquifers - most of the basin is underlain by shale bedrock which generally has low to very low yields (< 5 gallons per minute). There are also two carbonate (limestone) units that cross the basin - the Tully Limestone found in the south-central part of the basin and the Onondaga/Bertie Limestone found in the northern part of the basin. The Tully Limestone is generally a massive unit but may have water-bearing zones at the top and bottom of the unit. The Onondaga/Bertie is more karstic (solution channels, sinkholes, and swallets) and has a high secondary permeability (in fractures and solution channels) and these features support the highest rates of ground-water movement within the basin. (2) Land use: The quality of shallow ground water is affected by land use patterns. Ground water in forested sub-basins generally exhibit natural conditions – exceptions may include areas with illegal or abandoned dumps, or those with significant logging operations. Land uses where chemicals and nutrients are used or disposed of (as identified in the GIS assessment – chapter VI) can also affect the quality of the ground water resource. The quality of deep ground water, either in confined aquifers or below the weathered and fractured bed-rock surface (generally greater than 20 ft. below the bedrock surface), are less affected by land use activities. While surface contamination is limited in these aquifers, natural "contamination" (hydrogen sulfide and high levels of mineral salts) can exist as a result of the slow movement of ground water through shale bedrock. Deep ground water, found in carbonate bedrock, is also affected by the surrounding shale units, but in karst situations, water quality can have a high degree of variability as surface contamination can move rapidly into deeper bedrock through

sinkholes and solution channels. (3) Topography and Geography: These factors influence the type of aquifer found in the basin and
rate of ground water movement. Steep slopes usually have thin unconsolidated deposits and the ground water is usually found at significant depth. The rates of ground water flow can vary substantially depending on the depth to ground water and the bedrock type. Minimal slopes usually have greater thicknesses of unconsolidated deposits (of varying permeability) and slower rates of ground-water movement.

Physical

Proposed deliverables from this portion of the plan would include: (1) Water-well network - Selection of representative aquifers and wells within those aquifers can be used to determine local and regional ground-water table configuration. Wells should represent major unconsolidated and bedrock aquifers, and could utilize domestic and community water-supply wells if no funding is available to drill monitoring wells. Most community water-supply wells will be located in unconfined surficial aquifers of either type. ? Unconsolidated aquifers - Unconfined (surficial) and confined (buried) unconsolidated aquifers in valley-fill situations. ? Bedrock aquifers - Shale and carbonate bedrock aquifers; (2) Water Balance Component - To further define the lake water balance and reduce the error term, a first approximation of the ground-water contribution to tributary streams and the lake should be made. For this approximation, seepage measurements at high, average, and low base-flow conditions can be made to determine, by aquifer type, the contribution of ground water to the surface water system. Ground water seepage directly to the lake cannot be determined directly, and would require a more intensive study of lake/ground water geochemistry.

Parameters of interest include water table level, recharge rates, flow paths, and discharge rates.

Chemical

Proposed deliverables from this component include: (1) Collection of ground water samples - Samples of ground water should be collected from the water-well network to define the "in-situ" quality of the ground water resource. During measurement of base flow on tributary streams, water samples can be collected to further define the quality of ground water as it enters the surface water system and to define ground-water loading to the tributaries and ultimately, the lake.

Chemical parameters to be measured should be similar to those chosen for the lake and tributary monitoring programs. Parameters of interest include both organic and inorganic contaminants. Particular emphasis should be placed on those chemicals which are known to occur within the basin or are suspected to be present based on methods such as GIS sub-watershed analysis.

Biological

Proposed deliverables from this portion of the plan include: (1) Assessment of pathogens: assess the potential for bacteriological contamination of potable water supplies; and (2) Stream ecology: assess the effect of ground water driven base flow on resident flora and fauna.

Parameters of interest include pathogen indicator organisms (E. coli, etc.) and macroinvertebrate communities.

VI. Other Information/Issues

While a well designed lake/tributary monitoring program is an important element in watershed stewardship, it ought not exist in a vacuum. Other important elements for an effective watershed monitoring plan include: (1) O*ther Data Components* - consideration should be given to other data components which do not necessarily fit within lake, tributary, or ground water categories, including atmospheric deposition and transport, and meteorological parameters, (2) *Quality Assurance/Quality Control* (QA/QC) – all monitoring components should include development of QA/QC plans, (3) *Retrospective Investigation* – development of a watershed monitoring plan should be preceded by a thorough literature review and data gap analysis to provide a temporal context to planned activities, (4) *Database and Geographical Information System (GIS)* – it is important to include discussions of data storage and dissemination in concert with monitoring plan development , (5) *Program Integration* – efforts should be made to integrate monitoring activities with other related activities (e.g., research activities, modeling efforts, management actions, etc.), and (6*) Resource Considerations* - such as infrastructure issues (e.g., who will conduct the monitoring), funding issues (e.g., funding needs, funding sources, etc.).

1. *Other Data Components*

Water quality within a given watershed can be influenced by activities outside of its immediate boundaries. The processes of atmospheric transport and atmospheric deposition can be important determinants of water quality. For example, the phenomenon of lake acidification is thought to be largely the result of these processes. Thus, it is important to evaluate the relative significance of atmospheric sources of contaminants. Atmospheric transport can be an important source of nutrients, metals, and/or organic contaminants.

Another important component of a watershed monitoring program is a meteorological network. Meteorological information can play an important role in issues such as sediment resuspension (via wind induced waves) and nutrient loading (via erosion and tributary loading). Important meteorological parameters include temperature, precipitation, evaporation, and wind (velocity and direction). There are several meteorological stations located within or proximate to the Cayuga Lake watershed. It is important that the Monitoring Plan be coordinated with these installations.

2. *Quality Assurance/Quality Control Considerations*

All elements of the Monitoring Plan should be supported with a defensible Quality Assurance/Quality Control (QA/QC) Plan. Many of the parameters of interest within Cayuga Lake and its tributaries are measured in the parts per million or, in some instances, parts per billion range. Thus, accurate quantification of ambient levels of these substances requires careful and precise sampling and analytical techniques. The implementation of a rigorous QA/QC Plan can ensure the accuracy of monitoring results. QA/QC samples should include field blanks, field replicates, matrix spikes, and performance samples.

QA/QC considerations are also an important consideration in evaluating what historical data to include in a centralized database or GIS (see below). It might be advisable to establish minimum QA/QC requirements, or establish QA/QC qualifiers for each data set.

3. *Retrospective Investigation*

As mentioned earlier, a retrospective investigation is an important initial step in the establishment of a watershed monitoring plan. A retrospective investigation would include a literature review of past studies, a review of current and/or ongoing studies, and a data gap analysis. A retrospective investigation provides valuable insight for the design of future monitoring efforts, and can improve the efficacy of prospective investigations in several ways. *First*, past studies provide a *context* in which to design future monitoring activities. For example, previous investigations can winnow the list of water quality parameters to be included, define issues of concern within the watershed, and identify possible “hot spots” within the basin. This contextual information can result in a more effective and efficient Monitoring Plan. *Second*, a data gap analysis can determine necessary additions to past or ongoing monitoring activities. *Third*, previous studies can provide *continuity* between past, current, and future investigations, and enable assessment of water quality trends. This can include continuity with respect to both time and space. *Fourth*, past studies can help to identify possible participants for future investigations. This can include citizen groups, agencies, institutions, and individuals. *Fifth*, evaluation of current/ongoing investigations can provide opportunities for collaborative efforts for future monitoring activities, which can result in mutual advantages.

Given the number of academic institutions in the area, a viable approach for such a retrospective investigation might be to sponsor one or more graduate students to conduct the study.

4. *Database Issues/GIS Issues*

A valuable tool in effectively bridging disparate monitoring elements, or monitoring elements of various vintages (past, present and future), is the development of an integrated data management program. Additionally, a Geographical Information System (GIS) provides a spatial representation of available information. Note: the term GIS will be used from this point forward to encompass the broader idea of a coupled data management program and GIS.

Ideally, a certain symbiosis would develop between a monitoring program and the associated GIS. For instance, as mentioned earlier, certain elements of the GIS (e.g., hazardous waste sites) can help to define the “universe” of potential contaminants within the watershed, and, thus, would provide important guidance to the monitoring program regarding possible contaminants of concern and/or areas of concern. In “exchange”, the monitoring program can help to “flesh out” the GIS by providing site-specific data within the watershed.

GIS coverage’s of interest include hydrography, land use, soils, ambient data sites, pollutant source locations, governmental boundaries, digital elevation models (DEM's), digital ortho quads (DOQ's), roads, political boundaries, data collection sites (all, active, inactive), SPDES sites - active/inactive, 'other' contamination sites, pesticide use information, public water supplies, etc.

Development of a central data repository could involve an Internet site, CDROM, or other distribution methods. Initial efforts could involve simply a cataloging of known studies.

A GIS can also function as a valuable integration tool by providing a focal point for program integration and the sharing of information. While a comprehensive GIS would represent an important step in program integration within the watershed, direct integration of various monitoring initiatives, which will be discussed next, would go even further in facilitating an effective and efficient monitoring program.

5. *Program Integration*

The sheer size and complexity of the Cayuga Lake Watershed, coupled with the scarcity of available resources for monitoring activities, provides strong incentive for collaborative efforts within the watershed. Collaborative efforts offer the potential for significant program efficiency and information transfer. Thus, substantial effort should be made to facilitate collaborative monitoring efforts within the watershed.

The Cayuga Lake watershed is well situated for such collaborative efforts given the wealth of academic, governmental, and citizen organizations within or adjacent to the watershed. There are numerous academic institutions (Cornell, Wells, State College of Environmental Science and Forestry, Syracuse University, etc.) with both significant technical expertise and a long history of interest in the Finger Lakes. There are also a number of governmental entities (United States Geological Survey, county health departments, soil and water conservation districts, etc.) with significant technical expertise and long term interest in the protection of water resources within the area. The watershed is also fortunate to possess an informed and engaged resident community capable of providing valuable input and support of monitoring activities. Finally there is presently considerable interest within the community to address water quality concerns within the lake and watershed. This current level of interest offers substantial opportunity for collaborative monitoring activities within the watershed.

Current monitoring activities within the watershed include citizen-based initiatives, governmental-based management activities, and academic and/or governmental research projects. While the goals and objectives of these seemingly disparate efforts are frequently different, there is often substantial commonality in monitoring and/or data requirements. Parties should attempt to identify opportunities for collaboration and/or cooperation across programmatic and institutional boundaries. For example, an academic investigation of food web dynamics within the lake would, of necessity, need to assess algal productivity within the system and evaluate the limiting factors for primary productivity. By comparison, resource managers and citizen groups are also likely to have interest in both the primary productivity of the system and the factors controlling algal productivity. Thus, coordination efforts could offer substantial benefits to both endeavors in terms of program efficiency (both funding and human resource) and data availability. Cooperative ventures are, perhaps, best directed at projects of mutual interest such as so called applied science initiatives. Activities such as watershed modeling activities and/or development of best management practices (BMPs) are examples of activities amenable to cooperative ventures. The success of such cooperative ventures requires a sustained dialog throughout the life of the project(s), and should seek to establish consistent methodologies between programs.

The most critical element to effective integration of watershed activities is the establishment of viable communication channels. Therefore, a proposed first step toward program integration might be the establishment of “Cayuga Lake Watershed Environmental Clearing House” in the form of a resource room within the watershed (perhaps at a local or academic library) and/or an Internet site. The first product might take the form of a catalog or inventory of ongoing or proposed monitoring initiatives within the watershed. Future activities might include publishing of an environmental newsletter, conducting periodic environmental workshops, and/or developing training materials (videos, computer materials, etc.).

Consideration must be given to how the monitoring program would be coordinated and executed. The monitoring program could include either a centralized approach, a diffuse (uncentralized) approach, or, most likely, a hybrid of the two. This will likely require one or more entities to take a lead on implementing the program. This could be carried out by the academic community, a government entity, or a private organization.

6. *Resource Considerations*

The development and implementation of a Cayuga Lake Watershed Monitoring Plan faces certain challenges related to resource issues. Resource issues range from who will conduct the monitoring to how will the activities will be funded.

a. Human Resource Issues

Implementation of a comprehensive monitoring program for the Cayuga Lake Watershed will require a significant effort by a fairly diverse group of individuals. The program will likely involve a combination of water resource professionals and trained “volunteers” As discussed in the previous section, if designed and implemented properly, significant efficiencies could be accrued by combining the skills of professionals with the enthusiasm and availability of volunteers. It is important, however, to remain cognizant of the strengths and limitations of potential participants. Certain monitoring efforts (e.g., sediment core investigations, mathematical modeling exercises, etc.) that are best suited for, or directed by, professional scientists. There are, however, ample opportunities for participation by the broader community. This is particularly true in instances where environmental professionals are consulted and the monitoring plan has sound QA/QC protocols. It would also be advantageous to establish training materials (e.g., videos, computer materials, etc.) and/or technology transfer workshops to enhance the monitoring capability of the resident community.

b. Infrastructure Issues

Implementation of a Cayuga Lake Watershed monitoring plan will require both building space for sample processing and equipment storage, and monitoring equipment. Many of these needs may be addressable from existing programs, however, there will likely be a need for supplemental funding for some of these needs.

c. Funding Issues

The implementation of a watershed monitoring program will require a sustained source of funding. Funding will be required for sample equipment, sampling personnel, sample analysis, and data interpretation Existing monitoring programs within the watershed may help to minimize funding requirements for future monitoring initiatives. In addition, as discussed above, there may be some creative approaches to securing funding by evaluating cooperative ventures between various entities. However, there will undoubtedly be a need to secure long-term funding for a sustained monitoring program within the watershed.

Funding options could include contributions from individual communities or external funding sources (federal, state, private).

d. Prioritization

It is often the case that monitoring needs exceed available funds to address those needs. As a result, methods to prioritize monitoring needs will need to be established. Prioritization should include both geographical considerations as well as parameter specific considerations.

References

Birge, E.A. and Juday, C. (1914), A limnological Study of the Finger Lakes of New York, No. 791, Bull. Fish., v. 32.

Birge, E.A. and Juday, C. (1921), Further limnological observations on the Finger Lakes of New York, No. 905, Bull. Fish., v. 37.

Oglesby, R.T., (1978). "The Limnology of Cayuga Lake", In Lakes of New York State – Volume 1 Ecology of the Finger Lakes (J. A. Bloomfield, ed.), Academic Press.

Monitoring Cayuga Lake Watershed

Current Programs 02.19.01

By Jose Lozano e-mail: JLL13@cornell.edu

The first part of this document is based on the findings of the Cayuga Lake Watershed Intermunicipal Organization, IO, preliminary assessment of the lake. It was prepared by Liz Moran and edited by the IO Technical Committee.

State agencies, notably NYSDEC and NYSDOH, conduct ambient monitoring programs to characterize water quality and the fish community. These programs identify any impairment to designated uses.

The NYSDEC Rotating Intensive Basin Survey (RIBS) program has one of its Intensive Network sites located in the Cayuga Lake watershed at Fall Creek in Ithaca. It is located one mile above the confluence of Fall Creek with Cayuga Lake. In addition to this site, three tributaries are included in the Biological Screening Network: Little Salmon Creek in Little Hollow, Big Salmon Creek in Genoa, and Salmon Creek in Ludlowville. Sites in the Intensive Network were monitored for a suite of physical and chemical parameters in 1995 –1996. The RIBS program returns to each basin on a five-year rotation; the next sampling is scheduled for 2000 – 2001.

Two federal agencies, USGS and USEPA, have included Cayuga Lake in research programs. A number of streams in the watershed have been gauged by USGS for various investigations. However, only Fall Creek, Sixmile Creek, Coy Glen Creek, and Cayuga Inlet are currently part of the USGS monitoring program.

Some long-term monitoring has been done by county and regional agencies such as the Soil and Water Conservation Districts. Users of the resource, for public drinking water supply, wastewater disposal, or noncontact cooling water, monitor to meet permit requirements.

Permitted Discharges to Cayuga Lake and its Tributaries

There are nine regulated municipal wastewater discharges to Cayuga Lake and its tributaries with a combined design flow slightly over 15 million gallons per day. Two cooling water discharges are permitted, AES Cayuga (formerly the NYSEG Milliken Station) and Cornell Lake Source Cooling (on line in June, 2000). One industrial facility, ADM Corn Sweeteners, holds a permit for a industrial discharge but has been inactive for several years (K. Barone NYSDEC, personal communication October 1999).

The communities of Ithaca, Dryden, Cayuga Heights and Lansing have recently submitted an application to NYSDEC for funding assistance with upgrades and expansion of their municipal wastewater treatment systems. The funding program is the state's Clean Water - Clean Air Bond Act. This intermunicipal proposal of August 1999 includes expansion of the service area into Lansing, with wastewater flows from the new service area directed to the Cayuga Heights Plant. Excess flows from Cayuga Heights would be directed to the Ithaca Area Wastewater Treatment Plant, which serves the City and Town of Ithaca and the Town of Dryden. The flow capacity of this plant would be increased from 10 to 13 million gallons per day, mgd.

One element of the proposal is to increase the phosphorus removal capacities of both the Ithaca Area and Cayuga Heights treatment plants by adding filtration to the treatment process. Both plants currently hold a Total Phosphorus, TP, limit of 1.0 mg/L in their State Pollutant Discharge Elimination System, SPDES, permit, consistent with the requirements of the International Joint Commission for wastewater treatment plants within the Great Lakes basin with a capacity greater than 1.0 mgd. Performance of the Ithaca Area Wastewater Treatment Plant is well below the 1.0

mg/L TP limit; average effluent concentrations are in the range of 0.5 – 0.6 mg/L. The Cayuga Heights plant has historically operated close to its permit limit of 1.0 mg/L for TP, although improvements have been made in recent months (Nick Hatala, Stearns & Wheler personal communication, September 1999).

NYSDEC policy for new discharges to lakes is to require an effluent limit of 0.5 mg/L for TP, recognizing the central role of phosphorus in eutrophication of inland lakes. When existing plants request an increase in permitted flow, it is NYSDEC policy to hold the discharge to the existing mass limit for TP, thus reducing allowable concentration proportional to the flow increase.
With filtration, both Cayuga Heights and the Ithaca Area wastewater treatment plants will be able to meet or exceed a TP limit of 0.5 mg/L.

There are also a number of stormwater permit holders in the watershed discharging to surface water or groundwater. Several municipal water filtration plants and Cornell University hold permits for the return of filtration backwash.

Biological characteristics of tributaries
There have been several investigations of macroinvertebrate communities of Cayuga Lake tributaries. Direct comparisons of the findings are complicated by differences in collection technique, taxonomic level of identifications, and indices used to evaluate the data. Overall, the macroinvertebrate data indicate slight impairment of streams in urban and agricultural areas.

According to Tom Chiotti, NYSDEC Fisheries Biologist, only Cayuga Inlet offers excellent habitat for salmonids based on substrate, stream cover, summer flows, and water temperatures. The other tributaries have various natural and human-induced restrictions to fish habitat. Several of the southern tributaries have impassable barrier falls close to the confluence with the lake. Water temperatures in the downstream segments are high during summer low flow periods. The lower reaches of Sixmile and Cascadilla Creeks are silted and open as they flow through the City of Ithaca (Chiotti 1980). Salmon, Fall, and Taughannock Creeks are important spawning areas for smelt in the early spring. There is also some movement of rainbow trout into these tributaries, Fall Creek in particular, during high flow conditions in the spring. Smallmouth bass also spawn in Fall Creek below the Ithaca Falls. Yawger, Paines and Great Gully Creeks offer very limited spawning and nursery areas for rainbow trout due to their summer low flows and high temperatures (Chiotti 1980).

The RIBS monitoring program indicates that iron concentrations in Fall Creek are above the applicable ambient water quality standard. Elevated iron levels are attributed to natural geochemistry. The RIBS program also detected seven heavy metals in Fall Creek sediments at concentrations above the assessment criteria. There are no federal or New York State standards in place for chemicals in sediment. The assessment criteria represent NYSDEC best professional judgment of the upper range of background (nonimpacted) levels. Assessment criteria for sediment metals are below levels that might adversely impact the environment.

Summary of areas of concern (by location, parameter and affected use)

There are several areas where additional data are needed to fully characterize the state of Cayuga Lake. Data gaps have been identified and are discussed in terms of their potential significance to the baseline assessment of use attainment.

Additional data needs

Baseline characterization of water quality and loading
The 1970 – 1971 work of Likens represents the only synoptic survey of baseline water quality of all tributaries to Cayuga Lake. These chemical profiles provide important insights regarding

quality of waters draining individual subwatersheds and total external loading to the Lake. There have been significant changes to loads of several subwatersheds over the last three decades; for example, salt loading to Gulf Creek has been greatly reduced, and the outfall of the Ithaca Area Wastewater Treatment Plant has been relocated from Cayuga Inlet. It is therefore recommended that a synoptic survey be conducted over at least one full year.

Monitored parameters should include: calcium, sodium, chloride, magnesium, potassium, sulfate and total alkalinity, total suspended solids, total P, total soluble P, soluble reactive P, and nitrate N. The sampling program should be conducted for at least one full year, with concentrated sampling during high flow events.

<u>Need for seasonal sampling</u>
The nitrate N data sets of Bouldin, Likens and the NYSDEC RIBS program highlight the need for sampling to occur over an entire year in order to characterize ambient concentrations and estimate annual loads. There is a strong seasonal signal in concentration of nitrate; maximum concentrations occur in winter and minimum in summer.

<u>Need for event sampling</u>
Based on the Fall Creek data set, most of the annual loading of sediment and phosphorus to Cayuga Lake occurs during high flow events; both the RIBS and Bouldin data sets demonstrate strong correlations between Total Suspended Solids, TSS, and flow and TP and flow. Including samples collected at high flows will greatly reduce the standard error of estimates of annual loading.

<u>Need for sampling to be linked to agricultural activities in the subwatersheds</u>
The July 1998 low level herbicide sampling of Yawger Creek, Salmon Creek and Paines Brook conducted by Eckhardt and colleagues of USGS illustrates the need to consider major land use activities in the watershed in designing a monitoring program.

<u>Need for additional flow monitoring</u>
Load estimates require accurate gauging in the watershed. Several gauging stations have been installed throughout the watershed and operated for various periods to meet specific program objectives. Only Cayuga Inlet, Fall Creek, Sixmile Creek, and Coy Glen Creek are currently gauged for flow. These stations monitor flow from approximately 204 square miles of the 744 square mile direct drainage. Reactivating the gauge at Salmon Creek would monitor an additional 81.7 square miles.

<u>Need for monitoring in various geological settings</u>
The work of Bouldin can be used to characterize background biogeochemical phosphorus concentrations and the incremental increase in concentration and load from agricultural areas. The Cayuga Lake watershed has diverse geological settings, and the results from Fall Creek may not be transferable to regions such as Yawger Creek, which drains an area of karstic limestone.

<u>Atmospheric deposition</u>
There are no recent data characterizing chemical quality of precipitation in the basin. This is important for load calculations as well as for general surveillance of acid precipitation.

<u>Macroinvertebrate screening of tributaries</u>
Species composition and abundance of the macroinvertebrate community is used as an indicator of water quality conditions. The biological community integrates the effects of different pollutant stressors and provides a holistic measure of their aggregate effect (EPA 1989). Benthic macroinvertebrates are good indicators of localized conditions. Because they have limited migration patterns or a sessile mode of life, they are well suited for assessing site-specific impacts of point and nonpoint discharges. Sampling is relatively easy and inexpensive.

The macroinvertebrate communities of several tributaries in the Cayuga Lake watershed have been assessed through various programs. Four sites were included in the 1995-1996 RIBS effort (Fall Creek, Salmon Creek at Ludlowville, Big Salmon Creek in Genoa and Little Salmon River in Little Hollow). Cascadilla Creek was sampled by Ichthyological Associates as part of Cornell's Generic Environmental Impact Statement for development of the Orchards. Peckarsky and her students have been tracking changes in the macroinvertebrate community at a number of sites along Cayuga Inlet following a fuel oil spill.

A team of scientists (Bain, Loucks, Lozano, Pendall, Steenhius) is to conduct a detailed diagnostic study of Land Use, Hydrology, Limnology and Bioassessment of the Sixmile Creek Watershed. The macroinvertebrate studies indicate that Sixmile Creek is slightly impacted.

There are other tributaries with water quality or land use data indicating that the biological communities could be stressed. We recommend that the macroinvertebrate communities of Taughannock Creek, Trumansburg Creek, Sixmile Creek, Yawger Creek (both branches) and Paines Brook be sampled. Sampling of the streams identified as impacted by agricultural chemicals would further the assessment of potential ecological impacts of trace concentrations of contaminants.

<u>Extent of streambank erosion</u>
Streambank erosion is listed as a primary source of pollutants for four water segments on the Priority Waterbody List: southern Cayuga Lake, Sixmile Creek, Fall Creek and Cascadilla Creek. With the exception of Sixmile Creek, no watershed level assessment of causes/contributing factors, historical perspectives on the extent of streambank erosion, or potential mitigating measures has been made. A watershed-wide preliminary inventory of road and stream banks erosion was conducted by Dave Zorn (summer 2K).

A systematic approach to estimating the extent of streambank erosion in the subwatersheds would help direct efforts on a "worst first" basis. Standardized approaches such as an inventory of erosion and sedimentation sites and aerial photography at regular intervals would help address this gap. Aerial photos would document changes in the geometry (i.e. meanders) and locations of stream channels. Reference sites along the streams could be surveyed to use in periodic quantitative assessment of changes in streambed elevation and channel slope. Photographic records from reference locations could be used to document changes to streambanks. Geology and land use information is needed at a small scale along with detailed maps of riparian areas and floodplains.

<u>Effectiveness of mitigating measures (Best Management Practices)</u>
Before and after monitoring is lacking on tributaries to estimate the reduction in export of sediment and nutrients from subwatersheds where remedial measures, such as streambank stabilization or stormwater controls has been implemented. Monitoring should occur over a range of hydrologic conditions, particularly high flow events.

<u>Ecological and human health effects of trace concentrations of agricultural pesticides</u>
Herbicides used in cultivation of corn (atrazine, metolochlor and metabolites) have been detected at low concentrations in monitored tributaries and in the lake. Concentrations are at least one order of magnitude below the most stringent water quality criteria or standard. The analysis has been conducted on filtered samples, and the chemicals detected have a high solubility in water. Additional assessment of human health and ecological impacts of these trace concentrations of chemicals is needed.

Based on land use and nitrate concentrations, Great Gully may also contain detectable concentrations of agricultural chemicals. This has not been assessed.

Some chemicals used in agriculture have limited solubility in water and would tend to be adsorbed by the sediment fraction. The potential for agricultural chemicals to be adsorbed to sediment particles and transported to the lake has not been fully assessed. Limited testing of lake sediments has not detected agricultural residues. However, testing has not been conducted in depositional areas of streams draining agricultural watersheds, nor in the lake at the mouths of tributaries.

Watershed sources of heavy metals detected in Fall Creek sediments

The 1995 –1 996 RIBS sampling program conducted by NYSDEC detected seven heavy metals above the assessment criteria, defined as the upper range of background levels but below thresholds that might cause adverse impacts. Nearshore sediments in southern Cayuga Lake also contained levels of some heavy metals above thresholds of ecological concern. Based on land use patterns and data from other areas, urban stormwater is the likely source of these heavy metals in Fall Creek. Additional sampling of tributary sediment in subwatersheds and stream reaches with different mixes of land use might help identify factors contributing to the presence and concentration of heavy metals.

Cayuga Lake Projects Directory

This compilation is only for current and planned programs. It covers staff at local agencies and universities. You are encouraged to submit the name and address of people involved in monitoring programs, and if possible a description of the project, to Jose Lozano jll13@cornell.edu , Environmental Labs - City of Ithaca, 525 Third St., Ithaca NY 14850.

Allee, David dja1@cornell.edu
Projects: Phosphorus TMDL development for Cayuga Lake

Anderson, Sharon ska2@cornell.edu Cayuga Lake Watershed Network Steward
Projects: Cayuga Lake watershed: Environmental Education and public participation,
Fall Creek watershed monitoring

Bain, Mark mbb1@cornell.edu
Projects: Ecology, bioassessment, and gap analysis of freshwater streams and lakes.
Watersheds: Six Mile Creek and Fall Creek.

Boyer, Elizabeth ewboyer@syr.edu
Projects: Digitizing Boulding's Fall Creek sediments and nutrients
extensive data base (1926 through 1993).

Callinan, Clifford cwcallin@gw.dec.state.ny.us
Projects: RIBS studies in Cayuga Lake. Modeling and development of waste allocations, and safe yield for lakes and reservoirs. Limnological investigations in fate and transport of toxic contaminants, trophic status, and sediment core investigations.

Cowen, Edwin eac20@cornell.edu
Projects: 3-D hydrodynamic modeling of Cayuga Lake

DeGloria, Stephen sdd4@cornell.edu
Projects: Multiscale framework and resource data (GIS) for characterization of the Cayuga Lake Watershed.

Eckhardt, David. USGS. daeckhar@usgs.gov
Projects: Water quality studies. Statewide appraisal of pesticide residues in the surface and ground water of New York.

Effler, Steven. Upstate Freshwater Institute. sweffler@upstatefreshwater.org
Projects: Physical, chemical and biological aspects of surface waters.

Hairston, Jr. Nelson ngh1@cornell.edu
Projects: Lake ecology projects. Phosphorus concentration sediment records
at the south end of Cayuga Lake.

Johnson, Robert rlj5@cornell.edu
Projects: Macrophyte composition and biological control in Cayuga Lake.

Kappel, William. USGS. wkappel@usgs.gov
Projects: Hydrogeology of the Cayuga Lake watershed

Karig, Daniel dek9@cornell.edu
Projects: Sixmile Creek Hydrodynamics.

Ketola, George. USGS. hgk1@cornell.edu
Projects: Fish (salmonoids and walleye) physiology and nutrition.

Kraemer, Thomas. USGS. tkraemer@usgs.gov
Projects: Geochemistry of naturally-occurring radionuclides as indicators of natural process and anthropogenic activity occurring within the lake basin.

Loucks, Daniel dp13@cornell.edu
Projects: Systems R&D for environmental resources planning & management. Several simulation models for flow, T, nutrients, sediments concentration, and bioassessment for the Fall Creek and Sixmile Creek Watersheds.

Lozano, Jose. Environmental Labs City of Ithaca. jll13@cornell.edu
Projects: Sixmile Creek watershed management plan, streambank stabilization and riparian buffer restoration. Cayuga Lake south, water quality monitoring.

McKenna, Jr. James. Tunison Lab of Aquatic Science. jim_mckenna@usgs.gov
Projects: Littoral zone fish assemblages of Northern Cayuga Lake

Marks, Peter plm6@cornell.edu
Projects: Changes in forest area and land use in the uplands around Cayuga Lake.

Moran, Elizabeth. EcoLogic LLC. ecmoran@ecologicllc.com
Projects: Thermal, water quality, and biological characterization of Cayuga Lake.

Mullins, Henry Dept. of Earth Sciences, Syracuse U, Syracuse NY 13244
Projects: Marine geophysical surveys of the Finger Lakes: Use of lake sediments as records of natural and anthropogenic environmental changes.

Oglesby, Ray rto1@cornell.edu
Projects: Cayuga Lake Watershed planning & management.

Packard, Susan. Nat. Audubon Soc./Cornell Lab of Ornithology
Projects: Cayuga Lake's quality as an ornithological habitat.

Peckarsky, Barbara blp1@cornell.edu
Projects: Macroinvertebrate community composition and structure at Cayuga Inlet

Penningroth, Steve smp7@cornell.edu
Projects: Citizen monitoring and bioassessment at the Fall Creek watershed

Rudstam, Lars. Cornell Biological Field Station. lgr1@cornell.edu
Projects: Zooplankton, fish, and mysid shrimp pelagic interactions in Cayuga Lake
Associates: Tom Chioti, NYS-DEC

Schneider, Rebecca rls11@cornell.edu
Projects: Streamsides and wetlands as critical components of Cayuga Lake. Wetland plant communities and groundwater. Ecological water resources protection.

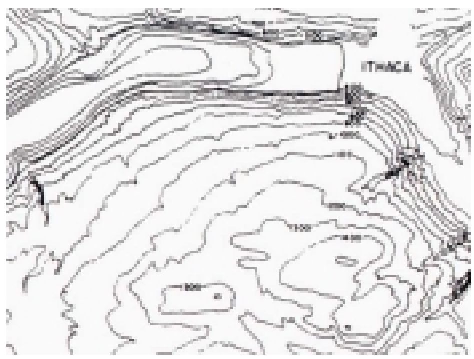
Steenhuis, Tammo tss1@cornell.edu
Projects: Modeling and simulation of tributaries to Cayuga Lake, Natural Resources planning and management

Yager, Richard. USGS. ryager@usgs.gov
Projects: Modeling of ground-water flow and transport. Sedimentation rates in Cayuga Lake.

Wagenet, Linda lpw2@cornell.edu
Projects: Cayuga Lake watershed planning and management.

White, William white@geology.cornell.edu
Projects: Sedimentation rates in Cayuga Lake

Vawter, Thomas. Wells College. tvawter@wells.edu
Projects: Benthic macroinvertebrates as indicators of water quality in two tributaries of Cayuga Lake (Paine's Creek and Great Gully)



Local Government Directory

Please contact Jose Lozano, jll13@cornell.edu, with the name, agency, and description of projects to be added to this directory.

Barber, Amanda
USDA Cortland County Soil and Water Conservation District
100 Grange Pl. Room 204, Cortland NY
Projects: Water Quality Coordinating Committee

Barnes, Jeff (607) 687-3553
USDA Tioga County Soil and Water Conservation District
Projects: Water Quality Coordinating Committee

Bertuch, Kathy kbertuch@cnyrpdb.org
Central New York Regional Planning and Development Board
Projects: Local Government Programs

Brower, Bob bbrower@co.cayuga.ny.us
Cayuga County Planning.
Projects: Water Quality Coordinating Committee

Dalrymple, Elaine (607) 535-9650
USDA Schuyler County Soil & Water Conservation District.
Projects: Water Quality Coordinating Committee

Eidt, Steve speidt@gw.dec.state.ny.us
NYS DEC Region 7 Chief
Projects: Watershed Management Plans - Permitting

Hackett, Kate khackett@tompkins-co.org
Tompkins County Water Resources Council (water quality coordinating committee)
Projects: Tompkins County watershed management coordination, aquifer program, and hydrography database.

Hurlbut, Sylvia ledyard@audubon.com
Cayuga Lake Watershed Intermunicipal Organization, Chair.
Local government contact. Cayuga Lake Restoration and Protection Plan.
Projects: Cayuga Lake Watershed Restoration and Protection Plan development

Malyj, James jcm@nyseneca.fcu.usda.gov
USDA Seneca County Soil & Water Conservation District (water quality coordinating committee
Projects: Water quality monitoring. Macrophytes control.

Landre, Betsy wrb@eznet.net
Finger Lakes- Lake Ontario Watershed Protection Alliance, FL-LOWPA
Projects: Coordinates counties alliance to promote watershed planning.

Lozano, Jose jll13@cornell.edu
City of Ithaca Environmental Laboratories (Drinking & Waste Water)
Sixmile Creek steambank & riparian buffers restoration. Cayuga Lake monitoring.

Reidy, Patrick pr@nycortland.fsc.usda.gov
Cortland County Soil and Water Conservation District
Projects: Fall Creek water quality monitoring

Schutt, Craig craigschutt@hotmail.com
Soil and Water Conservation District of Tompkins County
Projects: Salmon Creek and several other stream restoration programs,
Tompkins County flood hazard mitigation program

Zorn, David dzorn@frontiernet.net
Genesee/Finger Lakes Regional Planning Council
Projects: Cayuga Lake Watershed Restoration and Protection Plan
- Technical Coordination

Cayuga Lake wetlands program

Public Surface Water Systems in the Cayuga Lake Watershed			
System Location	Communities Served	Retail Population	Production (gallons/day)
Cayuga County			
Village of Cayuga	Village of Cayuga and portions of the Town of Aurelius north of the village along Rt. 90	600	1,710
Wells College	Village of Aurora	950	3,980
Cortland County	No Public Surface Water Systems		
Schuyler County	No Public Surface Water Systems		
Seneca County			
Seneca Falls	Town and Village of Seneca Falls	7,400	3,500,000
Tioga County	No Public Surface Water Systems		
Tompkins County			
Bolton Point Water System	Towns of Dryden, Ithaca, and Lansing and Villages of Cayuga Heights and Lansing	25,000	9,000,000
Cornell University	Cornell University and City of Ithaca	25,000	3,600,000
City of Ithaca	City of Ithaca	28,000	7,000,000

Sources: Cayuga County Health and Human Services Dept. - Environmental Health, Cortland County Health Dept. - Division of Environmental Health, Schuyler County Public Health Agency, Seneca County Public Health Dept., Tioga County Dept. of Environmental Health, Tompkins County Dept. of Health - Division of Environmental Health, 1999.

Public Groundwater Systems in the Cayuga Lake Watershed	
Name (Town)	Retail Population (persons unless otherwise noted)
Cayuga County	
Town of Genoa/King Ferry (Genoa)	800
Village of Union Springs (Springport)	2,000
Cortland County	
Elm Tree Golf Course (Virgil)	100
Trails End Campground (Virgil)	75
Virgil Elementary School (Virgil)	150
Schuyler County	
Blueberry Campground - seasonal (Hector)	25
Butternut Mobile Home Park (Hector)	21
Country Home Manor (Hector)	50
Potomac Campground - seasonal (Hector)	25
Seneca County	
Village of Interlaken (Covert)	644
Tioga County	
No Public Groundwater Systems	
Tompkins County	
17 Railroad (Dryden)	3 Businesses
A-1 Pizza (Dryden)	N/A
Annee T. Apartments (Dryden)	8 Apartments
Arrowbrook Farm (Dryden)	8 Apartments
B & B Mobile Home Park (Dryden)	7 Sites
Bailey Mobile Home Park (Danby)	14 Double Sites
Barangus Restaurant (Ulysses)	N/A
Beaconview Mobile Home Parks (Dryden)	44 Sites
Big Al's Get-N-Go (Dryden)	N/A
Boxwood Apartments (Newfield)	8 Apartments
Brook Woods Mobile Manor (Lansing)	20 Sites
Brookside Apartments (Ulysses)	8 Apartments
Brookside Mobile Home Park (Dryden)	4 Sies
Brookview Apartments (Dryden)	24 Apartments (50)
Buttermilk Apartments (Danby)	9 Apartments
Caroline Elementary School (Caroline)	N/A
Cayuga Nature Center (Ulysses)	100
Cecil's Restaurant (Lansing)	N/A
Cedar View Golf Course (Lansing)	49
Central NY Spiritualist Camp (Dryden)	20
Chef Yeppi Presents (Ithaca)	N/A
Clover Land Mobile Home Park (Newfield)	28 sites
CNG Transmission (Dryden)	4 Homes, 2 Community Buildings
Collegeview North (Enfield)	38 Sites
Common Ground Restaurant (Danby)	N/A
Congers Mobile Home Park (Dryden)	114 Sites
Corning Apartments (Dryden)	46 Apartments
Country Acres Mobile Home Park (Dryden)	102 Sites
Country Garden Apartments (Dryden)	20 Apartments
Country Garden Tea Room (Lansing)	N/A
Country Manor Estates Trailer Park (Dryden)	14 Sites (24)
Country Meadows Apartments (Dryden)	6 Apartments
Covenant Love Community School (Dryden)	N/A
Crooked Board Restaurant (Caroline)	N/A
Dalebrook Apartments (Caroline)	4 Apartments, 1 Post Office
Deerfield Apartments (Dryden)	6 Apartments
Deibler Apartments (Dryden)	8 Buildings
Depot Apartments (Caroline)	5 Apartments
Enfield Elementary School (Enfield)	N/A
Etna Mills Apartments (Dryden)	15 Apartments

Name (Town)	Retail Population (persons unless otherwise noted)
Fall Creek Parke Mobile Home Park (Dryden)	38 Sites
Fallbrook Apartments (Groton)	8 Apartments
Fenner Apartments Mobile Home Park (Lansing)	8 Sites
Fountain Glow Apartments (Dryden)	8 Apartments
Fountain Manor Apartments (Caroline)	24 Apartments
Frazoni Apartments (Dryden)	6 Apartments
Freeville Elementary School (Dryden)	N/A
Garden Trailer Park (Enfield)	6 Sites
George Jr. Republic (Dryden)	N/A
German Cross Road Apartments (Dryden)	9 Apartments
Glenwood Apartments (Ulysses)	8 Apartments
Gray Haven Motel (Ithaca)	49
Green Acres Mobile Home Park (Caroline)	12 Sites
Groton Golf & Recreation (Groton)	N/A
H & E Machine (Danby)	80
Hayts Trailer Park (Enfield)	6 Sites
Hickory Stick Apartments (Ulysses)	7 Apartments
Hill and Dale Apartments (Dryden)	8 Apartments
Hillendale Golf Course (Enfield)	N/A
Hillside Apartments (Dryden)	12 Buildings
Hillview Terrace Mobile Home Park (Danby)	57 Sites
Holland Apartments (Dryden)	14 Apartments
Hovlan Apartments (Lansing)	14 Apartments
Iacovelli Apartments (Dryden)	14 Apartments
ISA Breeders (Ulysses)	30
Island Grove Apartments (Dryden)	11 Apartments
J & S Midline Mobile Home Park (Dryden)	7 Sites
Jacksonville Apartments (Ulysses)	8-9 Apartments (18)
J-A-M Mobile Home Park (Lansing)	5 Sites
Jeslen Court Mobile Home Park (Groton)	22 Sites (49)
Jewell Properties (Dryden)	6 Apartments
Jim's Mobile Home Park (Newfield)	16 Sites
Jim's Place (Caroline)	Convenience Store
Keith Lane (Dryden)	8 Apartments
Knapp Apartments (Caroline)	8 Apartments, 1 Single-family home
Kuma Restaurant (Enfield)	N/A
Lake Country Community Mobile Home Park (Dryden)	149 Sites
Lake Ridge Point (Lansing)	N/A
Lake Road Apartments (Dryden)	8 Apartments
Lakeview Golf Club (Dryden)	N/A
Lakeview Village Mobile Home Park (Lansing)	30 Sites
Lansing Shore Apartments (Lansing)	23 Apartments
Lansing Town Park (Lansing)	N/A
Lansingville Mobile Home Park (Lansing)	10 Sites
Lehigh Crossing Apartments (Dryden)	24 Apartments
Linda's Corner Diner (Lansing)	N/A
Little Creek Mobile Home Park (Dryden)	100 Sites
LIU Apartments (Dryden)	12 Apartments
Livery Restaurant (Caroline)	N/A
Longhouse Co-op (Ithaca)	10 Units
Mandeville Apartments (Dryden)	5 Apartments, 2 Cabins
Marion Apartments (Caroline)	8 Apartments
Marquis Apartments (Dryden)	17 Apartments
Matychak Apartments (Caroline)	6 Apartments
McLean Elementary School (Dryden)	N/A
Meadowbrook Park (Newfield)	240 Sites, 18 Apts.
Mott Road Mobile Home Park (Dryden)	24 Sites (45)

Name (Town)	Retail Population (persons unless otherwise noted)
Mountain View Manor Mobile Home Park (Caroline)	17 Sites
Newfield Sunny's (Newfield)	4 Businesses
Norman Apartments (Enfield)	6 Apartments
Old 76 Club (Caroline)	N/A
Paradise Café (Ulysses)	N/A
Plantation Inn (Dryden)	N/A
Pleasant View Mobile Home Park (Dryden)	49 Sites
Ponderosa Apartments (Enfield)	5 Apartments
R. H. Treman Stae Park (Ithaca)	N/A
Rascal's Restaurant (Ulysses)	N/A
Red Barn Apartments (Caroline)	6 Apartments
Rendano Apartments (Lansing)	6 Apartments
Roman Village Restaurant (Groton)	N/A
Rose Inn (Lansing)	34
Sandy Creek Mobile Home Park (Enfield)	85 Sites
Seabring Inn (Newfield)	N/A
Shady Grove Mobile Home Park (Dryden)	18 Sites
Shagbark Apartments (Newfield)	8 Apartments
Shelter Valley Mobile Home Park (Dryden)	70 Sites
Siren's Restaurant (Groton)	N/A
Skyhook Apartments (Newfield)	24 Apartments
Special Childrens' Center (Ulysses)	N/A
Spruce Row Campsite (Ulysses)	N/A
Stoney Brook Apartments (Enfield)	14 Apartments
Sunrise Barn Apartments (Caroline)	5 Apartments
Sunset Townhouses (Enfield)	12 Apartments
Taughannock Falls State Park (Ulysses)	N/A
Teeter Trailer Park (Enfield)	6 Sites
Thorpe Apartments (Dryden)	5 Buildings
Town of Newfield	900
Tru Haven Apartments (Ulysses)	15 Apartments
Ulysses Square (Ulysses)	N/A
Unity House (Dryden)	10 Apartments
Upper Buttermilk Falls (Ithaca)	N/A
Valley Manor Mobile Home Park (Newfield)	186 Sites
Village of Dryden (Dryden)	2000
Village of Trumansburg (Ulysses)	2300
Ward's Trailer Park (Newfield)	70 Sites
Washington Heights Manufactured Home Park (Ulysses)	13 Sites
Werninck Apartments (Dryden)	10 Apartments
Werninck Subdivision (Dryden)	48
West Danby Water District (Danby)	264
White Apartments (Enfield)	8 Apartments
White Tail Crossing Cottages (Lansing)	4 Cottages
Willow Hill Mobile Court (Enfield)	16 Sites
Willowood Campground (Newfield)	N/A
Wonderland Motel (Ithaca)	80
Xtra Mart (Dryden)	N/A
	N/A = not applicable

Sources: Cayuga County Health and Human Services Dept. - Environmental Health, Cortland County Health Dept. - Division of Environmental Health, Schuyler County Public Health Agency, Seneca County Public Health Dept., Tioga County Dept. of Environmental Health, Tompkins County Dept. of Health - Division of Environmental Health, 1999.