II. Water Quality Status, Water Quality Issues and Areas of Concern

1. Water Quality Status

Cayuga Lake has a rich history of research activities. Physical, chemical, and biological conditions of the lake and its tributary streams have been investigated for decades. The lake and its watershed remain the focus of several long-term monitoring initiatives. However, important data gaps remain.

Cayuga Lake's water quality is generally very good. The lake is a valued and visible resource, serving as a public water supply and focal point for recreation. The fish community is diverse and productive. Overall, the tributary streams exhibit moderate to high water quality and habitat conditions that support a balanced biological community. However, there is evidence of habitat degradation along segments of the watershed's many streams. Much less is known about the quality of the groundwater. Limited testing indicates that groundwater quality is generally acceptable, although contamination has occurred in specific areas.

Despite the conclusion that water quality is generally very good, several types of pollution migrate from the watershed to the surface and groundwater resources of the basin. Through the watershed planning process much has been learned regarding specific types and sources of pollution that threaten the lake for its desired uses. This information has provided a technical basis for defining water quality issues (defined as pollution types and sources), geographical areas of concern (defined as sites in the lake or watershed that are sources of pollution), and has allowed for issues prioritization and strategies prioritization. The *RPP* is built on the foundation provided by this analysis. Priority areas reflect the significant sources and types of pollution that threaten the human uses and ecological integrity of the aquatic resources.

These issues prioritization, water quality issues, and areas of concern are summarized below, along with a discussion of additional data needed to set priorities and define effective remedial strategies. Links are provided to a monitoring plan designed to fill data gaps, support priority determinations, and track progress towards improvement. Chapter III discusses strategies, recommendations and management options designed for these issues and areas of concern.

<u>Priority Setting By The Intermunicipal Organization</u>

Issues of concern in the Cayuga Lake Watershed were gathered over the last several years from multiple sources including public forums (see Appendix B), the findings of the Preliminary Watershed Characterization Report (see Appendix C) and IO committees (see Appendix A). These issues were then developed into a list of 49 items by the IO Technical Committee that was then submitted to the IO for approval and ranking. Once the list of items was approved, each municipality was asked to complete the Cayuga Lake Watershed Issues Prioritization form (see Appendix D) through their IO representative. These forms were then compiled to produce a list of top ranked items on which to focus the *RPP* Strategies, Recommendations, and Management Options. The top ranked items (in order of ranking) with their associated code are as follows:

A - Agricultural Practices
S - Sediment Loading
DW - Drinking Water
WQS - Water Quality Standards
D - Development
SR - Stormwater Runoff
O - On-site Wastewater Systems
T - Tourism and Other Economic Development
C - Comprehensive Planning
WQ - Water Quality (also see Water Quality Issues section below)
N - Nutrient Loading
WW - Wastewater and Wastewater Treatment Plants
I - Infrastructure
E - Education
ER - Economic Revitalization & Sustainability

Refer to Appendix D for Description and Resources for the above ranked list

<u>Water Quality Issues</u>

There are several water quality issues that threaten the continued use of the resource as a high quality water supply and focus for recreation and aesthetic enjoyment. The following water quality issues, in priority order, pose the greatest long-term challenge to the ecosystem of Cayuga Lake and its watershed:

Sediment (S)

Sediment is a significant water quality, habitat, and use impairment issue, particularly in the southern tributaries and southern Cayuga Lake. The southern basin of Cayuga Lake is included on the State's Priority Waterbodies List (PWL) (see Appendix L); silt and sediment is listed as the primary pollutant. Six tributaries are included on the PWL with silt and sediment listed as the primary pollutant; the six tributaries include four southern streams (Cascadilla Creek, Fall Creek, Six Mile Creek, Cayuga Inlet), Yawger Creek, and Bolter tributary. Southern Cayuga Lake is also included on the 303(d) list, a national compendium of impaired waters requiring a watershed approach to restoration.

Sediment is a significant pollutant in many New York watersheds. It creates or contributes to a number of water quality problems both in streams and ultimately in the impoundments they feed. Excessive sediment concentrations in the water column can be harmful to aquatic life and will exacerbate the toxic effects of other pollutants. Suspended sediment in the water column can increase temperature. Sediment deposits within streams degrade habitat for macroinvertebrates and fish. Finally, and perhaps most importantly, sediment carries other types of contaminants into the aquatic system: nutrients, organic compounds including pesticides, and heavy metals.

Phosphorus (N)

Phosphorus is the limiting nutrient for algal growth in Cayuga Lake as it is for most inland lakes in the Northeast. Enrichment of lakes with phosphorus increases the level of plant and algal growth (primary productivity) and is associated with loss of water clarity. Recent monitoring data confirm that Cayuga Lake is mesotrophic, with moderate levels of primary productivity. However, the shallow areas at the northern and southern ends of the lake exhibit higher levels of phosphorus and productivity. NYSDEC considers both the northern and southern segments of Cayuga Lake as priority areas, indicating water quality concerns. Phosphorus sources include the two wastewater treatment plants discharging to the southern lake basin and runoff from residential and agricultural areas. Septic systems are considered by NYSDEC to be significant sources of phosphorus to the northern segment.

Fertilizers and Pesticides (F)

Fertilizers and pesticides have been detected in both tributary streams and the lake. Recent data provide direct evidence of chemical loss from the landscape and transport to the lake. Almost half of the land in the Cayuga Lake watershed is in active agriculture, and this land use contributes nitrate-nitrogen and pesticides (most notably, herbicides used in corn cultivation) to the lake. Residential and commercial areas are also a potential source of pesticides and herbicides. Using analytical methods with low detection limits, scientists from USGS and NYSDEC have documented trace concentrations of pesticides in the streams and lake. Concentrations of fertilizers and pesticides in groundwater are not well documented.

The herbicides are present at levels far below ambient water quality standards or guidelines based on toxicology and risk assessment. No exceedances of standards or guidelines developed to protect human health and the environment have been detected. However, long-term effects of exposure to trace concentrations of many of these chemicals, singly or in combination, are unknown. The monitoring program has also detected breakdown products of several herbicides in the lake. Concentrations of the breakdown products can be higher than the concentrations of the original compounds. The long-term health effects of exposure to these breakdown products are not well documented. Even when inputs are reduced, contaminants tend to persist in Cayuga Lake, due to the 9-12 year cycle of water replacement.

Organic compounds (OC)

There is localized contamination of groundwater in the Cayuga Lake watershed. The public water supplies in the Towns of Union Springs and Aurelius have detectable concentrations of trichloroethylene (TCE), an organic compound widely used as an industrial solvent, and several TCE breakdown products. Investigations are underway to identify the source(s) of the contamination. Monitoring of private and public wells is also being conducted and water is supplied to affected residents. Groundwater in the Village of Jacksonville has been contaminated by petroleum.

Trace Elements (H)

Limited monitoring has documented elevated concentrations of trace elements (heavy metals) in sediments of Fall Creek and nearshore areas of southern Cayuga Lake. Potential sources of these trace elements are industrial discharges, stormwater runoff, and/or atmospheric deposition. Adverse impacts of metals include toxicity to sediment organisms (such as aquatic insects and worms), and bioaccumulation within the food web. Extensive monitoring data from Cayuga Lake and the tributaries used for water supply document that concentrations of trace elements in water are low. Concentrations are consistently within limits developed to protect human health and the environment.

Pathogens (P)

Monitoring for the potential presence of pathogens (disease causing microorganisms) is very limited in the Cayuga Lake watershed. Pathogens originate from untreated or inadequately treated human sewage and wild and domestic animal waste. More data are needed to determine whether the issue poses a threat to the desired uses of the water resources.

Exotic species (ES)

Because of its connections to the Great Lakes through the Seneca River, Cayuga Lake is vulnerable to invasion by nonindigenous species of plants and animals. Two recent invaders are a focus of special concern due to their potential to alter the food web. These organisms are the zebra mussel (*Dreissena polymorpha*) and a predatory cladoceran zooplankton (*Cercopagis pengoi*). The macrophyte Eurasian water milfoil (*Myriophyllum spicatum*) is another introduced species that has, until recently, been a nuisance in Cayuga Lake.

2. Lake Level Management

The Canal Corporation of the New York State Thruway Authority manages water levels of eight Finger Lakes, including Cayuga Lake, and connecting canals. As discussed in the *Preliminary Watershed Characterization Report*, water levels are raised and lowered seasonally to protect recreational uses, increase storage capacity, and minimize the potential for flooding. Water flows from Cayuga Lake to the Barge Canal through a gated structure at Mudlock, where the change in elevation is only nine feet. During periods of high runoff the water surface elevation of the Canal can be higher than the lake, limiting management options for lowering lake levels.

High water levels can contribute to nonpoint source pollution by eroding shorelines and streambanks, inundating septic disposal fields, and saturating soils used for agriculture. Visible sediment plumes are evident in the spring. Water level management is an issue that is closely linked to the significant water quality threats facing the Lake and Watershed.

3. Areas of Concern (Geographical)

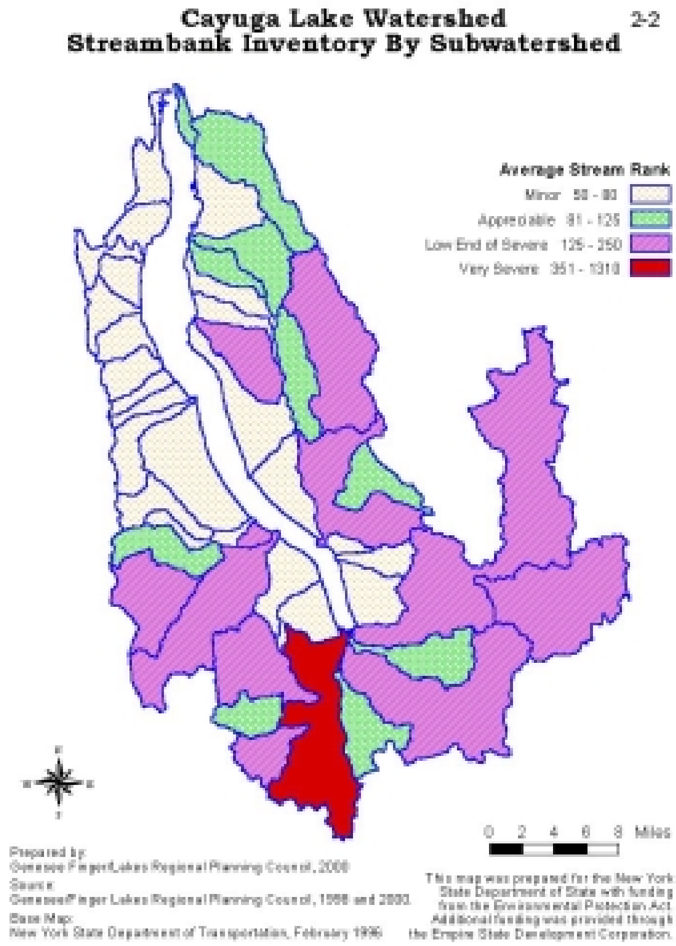
The Cayuga Lake watershed can be divided into a number of subwatersheds (see Map 2-1), which are defined as the land area draining to each tributary stream. The subwatershed is a useful unit of investigation, for a stream's concentration and loading of chemicals, sediment, and bacteria reflect the land use, geology, and hydrology of its drainage area. Assessing the relative contribution of substances from individual subwatersheds can help investigators and watershed managers identify priority areas within the larger watershed. Investigations at the subwatershed level have been conducted in support of the RPP. Findings are summarized in this section.

Sediment

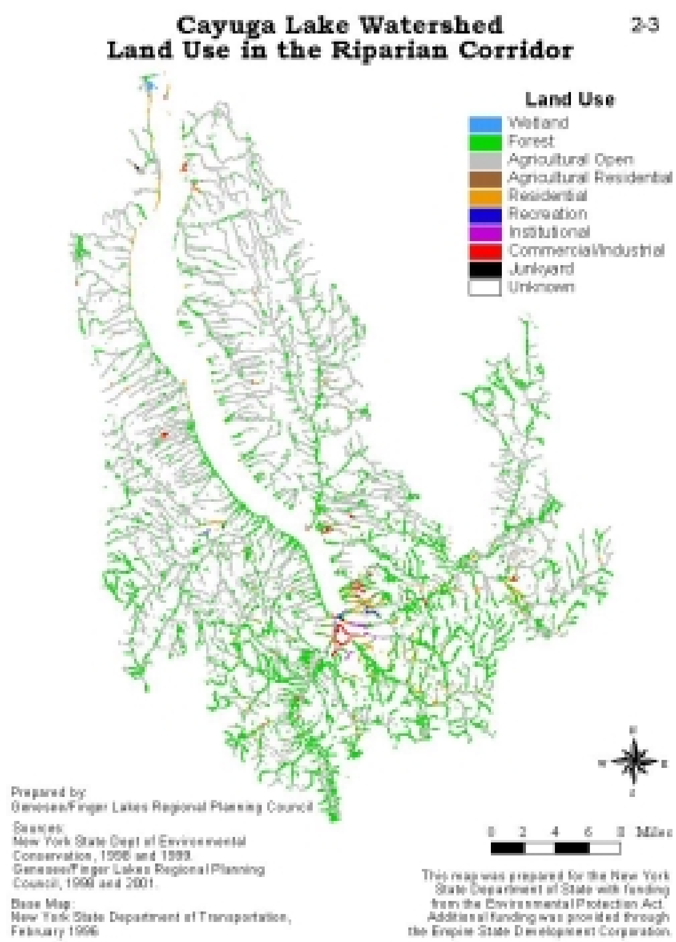
Sediment eroded from the landscape enters the extensive surface drainage network in the Cayuga watershed and ultimately flows to Cayuga Lake. Important sources of sediment include streambank erosion, losses from cultivated fields, land development practices, and erosion along roadways. Materials applied to impervious surfaces wash into streams during storms and snowmelt. Stormwater runoff is the primary mechanism of transporting sediment from the watershed to the lake and streams. Both field observations and models were used to identify specific areas within the watershed contributing sediment from eroding streambanks, cultivated fields, development activity, and roadways. As described in the following sections, the major sources are different for each stream. This analysis has provided a basis for targeting restoration actions to specific sources and locations in order to reduce overall sediment loading.

Streambank Erosion and Encroachment on Riparian Corridors

In the southern tributaries, the primary source of sediment appears to be streambank erosion. A detailed streambank survey was completed in 2000 (*see Cayuga Lake Preliminary Watershed Characterization* Section 3.4.1.2) documenting the severity and linear extent of bank erosion along major and minor streams throughout the watershed. The Salmon Creek subwatershed has severe erosion problems, as do Fall Creek (including the nested subwatershed Virgil Creek), and Sixmile Creek (a nested subwatershed of the Cayuga Inlet). Cayuga Inlet exhibits the most severe streambank erosion problems in the entire basin. Detailed results of this analysis are presented in the *Cayuga Lake Preliminary Watershed Characterization* Section 3.4.1.2 and the map of Streambank Inventory by Subwatershed (see Map 2-2). Specific very severe sites and recommendations for remediation are addressed in the Wetland, Shoreline & Riparian Corridor section of Chapter III.



Geology, soil characteristics, and slopes in these subwatersheds contribute to the extent of erosion and sedimentation. Areas with erodible soils and steep slopes such as the Fall Creek and Six Mile Creek subwatersheds are naturally vulnerable to streambank erosion. Disturbance of natural vegetation along the shorelines of streams (the riparian corridor) can accelerate erosion. Finally, destruction and fill of the extensive wetland areas that were historically present in southern Cayuga Lake has exacerbated sediment transport by removing a natural filtration process that captured sediment from these southern streams before it entered the lake.

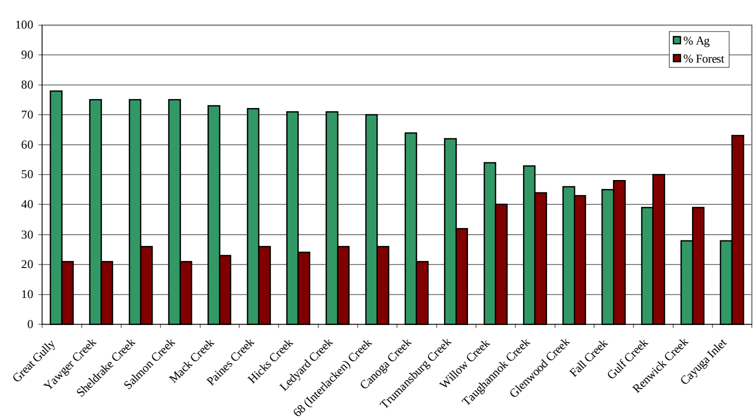


Land use along riparian corridors (see Map 2-3) throughout the watershed has been examined and results are summarized in Table 2-1. The majority of land within a corridor extending 150-ft along the tributary streams is categorized as "developed land"; agriculture is by far the dominant land use. Only a few subwatersheds (Renwick, Canoga, Gulf Creek and Glenwood) have more than nine percent of the riparian corridor in residential land uses. Consequently, impervious surfaces represent a very small fraction of the riparian corridor on a watershed-wide scale. Subwatersheds with a high percentage of the riparian corridor in developed land use are the most vulnerable to streambank erosion. These results (discussed further in the section entitled Wetlands, Shoreline, & Riparian Corridor Management Section) indicate that the smaller agricultural subwatersheds tend to have the greatest degree of encroachment of human activities within the riparian corridors.

Table 2-1
Percent of 150-ft riparian zone with developed land use, tributaries to Cayuga Lake

Subwatershed	Percent Agriculture	Percent Residential	Total Percent Developed	ENCROACHMENT RANK
Great Gully	78	3	81	**H**
Yawger Cr.	74	3	77	**H**
Sheldrake	70	4	74	**H**
Hicks Gully	68	4	74	**H**
Paines Cr.	70	3	74	**H**
Ledyard	68	3	71	**H**
Tributary 68	64	5	70	**H**
Direct Drainage	61	7	70	**H**
Mack Cr.	63	1	64	**M**
Trumansburg	57	6	63	**M**
Salmon Cr.	58	4	62	**M**
Canoga Cr.	46	16	62	**M**
Renwick Cr.	23	27	61	**M**
Taughannock	50	4	54	**M**
Glenwood	41	10	52	**M**
Willow Cr.	48	1	49	**L**
Fall Cr.	39	7	47	**L**
Gulf Cr.	37	9	46	**L**
Cayuga Inlet	28	8	38	**L**

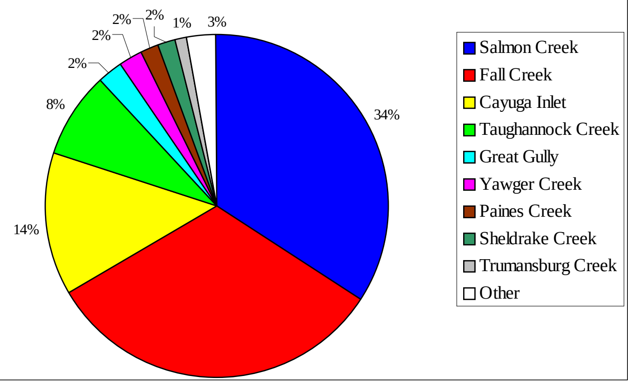
Figure 2-1. Percent Agriculture of Major Cayuga Lake Watersheds



Land Use & Development

Land use is also a factor in sediment loss. Agriculture, an important land use throughout the watershed, is most concentrated in the northern two-thirds of the watershed, on both the eastern and western shores. As displayed in Figure 2-1, active agriculture ranges from more than 70% of the land area in Great Gully and Yawger Creek to less than 30% in Cayuga Inlet.

Figure 2-2
Estimated Annual TSS Loss via Runoff
Kg/year



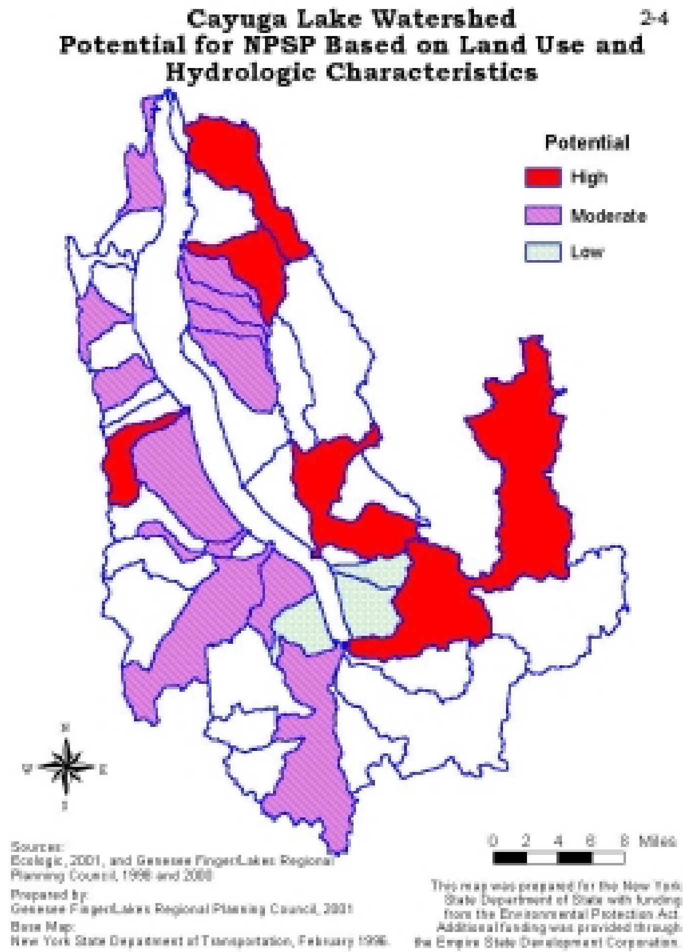
Simple loading models have been developed to estimate sediment loss based on land use and hydrologic conditions. As part of the technical analysis completed for the RPP, annual average sediment loss from agricultural runoff was estimated for the major subwatersheds in the Cayuga Lake basin. These results, displayed in Figure 2-2, provide a basis for defining priority areas. The importance of Salmon Creek, a relatively large subwatershed with a high percentage of the land area in active agricultural use, is evident. However, monitoring is needed to confirm the findings (a recommendation to install a stream gauge on Salmon Creek is included in the Monitoring & Assessment section).

Areas of concern for agricultural runoff, which has the potential to transport sediment, nutrients, animal waste (a source of pathogens and oxygen-demanding material) and pesticides are noted in Table 2-2 and associated Map 2-4 of Potential for NPS Based on Land Use and Hydrologic Characteristics.

Table 2-2. Subwatershed areas with highest potential for nonpoint source pollution, based on land use and hydrologic characteristics.

Potential for Nonpoint Source Pollution (Based on Annual Loading per Unit Area)	Subwatershed Areas
High	Salmon Creek Fall Creek Sheldrake Creek Great Gully Yawger Creek (including Yawger Tributary)
Moderate	Taughannock Paines Brook Hicks Creek Subwatershed 68 (Interlaken) Mack Brook Canoga Creek Cayuga Inlet Trumansburg Creek Ledyard Creek Willow Creek
Low	Gulf Creek Renwick Brook Glenwood Creek

The initial construction phase when land is cleared of vegetation and graded to create a proper surface for construction is one of the largest potential sources of erosion and sedimentation. When natural vegetation and topsoil are removed, the exposed area is particularly susceptible to erosion, causing transformation of existing drainage areas and disturbance of sensitive areas. Sediment loss from developed areas is potentially significant in the Cayuga watershed.



Roadways and Roadside Ditches

Stream networks are integrally linked to a more extensive network of roadside ditches. Although functioning only during storm events and spring runoff, there is evidence that, within the Cayuga Lake Watershed, this network of ditches significantly increases the total volume of discharge and degrades the quality of water flowing into creeks (Schneider 1999). Shoulder ditching practices can leave large areas of sediment exposed and vulnerable to erosion.

Runoff from rural roads can also contribute to water quality and habitat degradation of streams and lakes. Sand and sediment applied for winter deicing (see Appendix E - Deicing Inventory) can wash into road ditches and streams. Throughout the watershed are many storm drains with no provision for sediment removal.

The roadbank survey (*see Cayuga Lake Watershed Preliminary Watershed Characterization* Section 3.4.1.1) conducted in 2000 for this project provided detailed site-specific data in the Cayuga Watershed. All of the roads in the Watershed were surveyed for physical characteristics (slope, channel morphometry) vegetative cover, and the degree of erosion. Results highlight many areas where roadbanks themselves show signs of significant erosion and are a major source of sediment. This, in combination with the road ditch network, indicates a significant problem that directly affects wetlands, riparian corridors and ultimately Cayuga Lake.

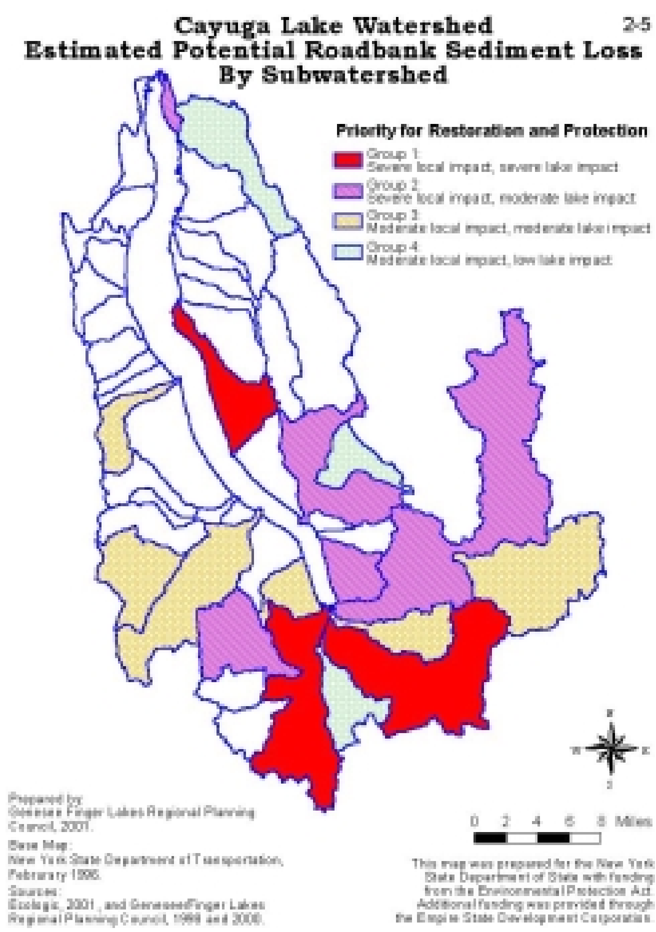
Results of the roadbank survey were used to calculate sediment loss per road mile on a subwatershed basis and provide a basis for identifying priority areas for restoration. These findings are displayed in Map 2-5 of Estimated Potential Roadbank Sediment by Subwatershed and Table 2-3. Specific very severe sites and recommendations for remediation are covered in the Stormwater Management & Erosion Control section of Chapter III.

Table 2-3. Estimated Annual Sediment Loss from Roadways and Restoration Priorities

Priority for Restoration and Protection	Streams	Estimated annual sediment loss from roadways	Estimated annual sediment loss per roadway mile
Group 1: Severe local impact, severe lake impact	Sixmile Creek Cayuga Inlet King Ferry Station area	More than 900 tons/yr	3-7 tons/mile/yr
Group 2: Severe local impact, moderate lake impact	Fall Creek Enfield Creek Lansing area Salmon Creek Cayuga Village area	250 - 700 tons/yr	2-4 tons/mile/yr
Group 3: Moderate local impact, moderate lake impact	Glenwood Creek area Cascadilla Creek Sheldrake Creek Taughannock Creek Virgil Creek Spring Brook	100-250 tons/yr	More than 2 tons/mile/yr
Group 4: Moderate local impact, low lake impact	Yawger Creek Buttermilk Creek Locke Creek	More than 100 tons/yr	More than 1 ton/mile/yr

Phosphorus

No recent synoptic survey of the tributaries to Cayuga Lake has been completed to identify subwatersheds where phosphorus concentrations are high and the loading is disproportionate to the hydrologic contribution. The modeling approach used to estimate sediment loading based on land use and hydrology also results in estimated phosphorus load from the subwatersheds. Recall that this simple modeling approach is best used to estimate the relative magnitude of annual loading. The effects of management practices on specific parcels are not accommodated. Because the majority of phosphorus entering streams from nonpoint source pollution is



associated with soil particles, the subwatersheds identified with high, moderate, and low potential for sediment loading are also ranked in this manner for phosphorus loading.

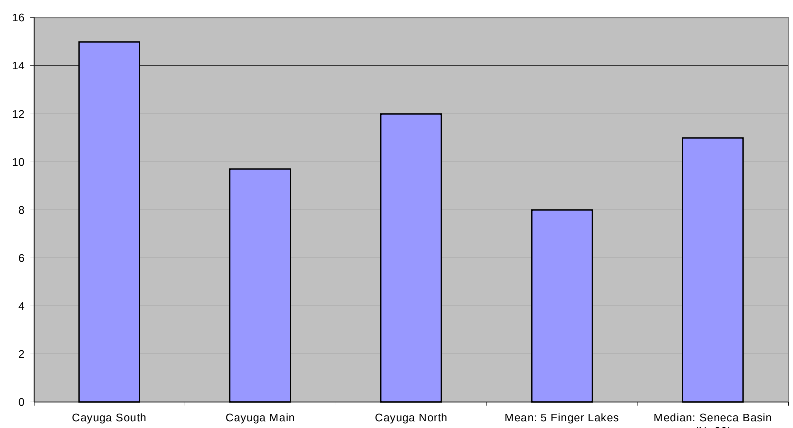
Phosphorus concentrations of Cayuga Lake are variable along the lake's 38-mile length. Concentrations are highest in the southern lake basin, where discharge from the Ithaca Area Wastewater Treatment Plant, the Cayuga Heights Wastewater Treatment Plant, and the two largest tributaries Fall Creek and Cayuga Inlet, all flow into the lake.

Table 2-4. Estimated Phosphorus Budget, Southern Cayuga Lake

Source	Annual average, pounds per day)	May – October average, pounds per day)	Actual Load (years of measurement, pounds per day)	Biological Availability of Phosphorus from this Source
Ithaca Area Wastewater Treatment Plant	83.4 (permit conditions)	83.4 (permit conditions)	33.7 (1998 – 2000 average performance)	High
Cayuga Heights Wastewater Treatment Plant	16.7 (permit conditions)	16.7 (permit conditions)	15 (1996 – 1999 average performance)	High
Fall Creek (average hydrologic year)	42	21	N/A	Low
Cayuga Inlet (average hydrologic year)	17	8	N/A	Low
Lake Source Cooling	2.3 (permit conditions)	4.6 (permit conditions)	1.9 (July – November 2000 average performance)	High

An estimated phosphorus budget for the southern lake basin would include the two streams and two wastewater treatment plants. In addition, phosphorus drawn from deep in Cayuga Lake is returned to the shallow southern basin by Cornell's Lake Source Cooling project (see Figure 2-3). This industrial cooling water return flow represents a new source of phosphorus to southern Cayuga Lake during May – October when the lake does not naturally mix.

Figure 2-3 Total Phosphorus Concentrations, Summer Average Upper Waters



Data: Cayuga South Cornell Lake Source Cooling, 1999-2000
Other Data: NYSDEC, 1996-1999
5 other large Finger Lakes include Seneca, Skaneateles, Owasco, Canandaigua, Keuka

Permit conditions are tabulated. However, performance of the wastewater treatment plants and the Lake Source Cooling facility are all consistently better than the permit limits (resulting in lower phosphorus loading). Engineering improvements to both wastewater treatment plants are planned to improve the phosphorus removal (see Appendix F -

Wastewater and Wastewater Treatment Plants). Final effluent limits from the two wastewater treatment plants are still under review and discussion; a determination of the revised permit limits has not been made. Estimates of the current phosphorus loads to southern Cayuga Lake are summarized in Table 2-4. Note that the phosphorus from Lake Source Cooling and the wastewater treatment plants is more biologically available (that is, more of the total phosphorus is in the soluble reactive form) than is the phosphorus from the two tributary streams. Phosphorus loading from the tributaries is typically much higher during the December – April period when flows are at their annual peaks.

Fertilizers and Pesticides

The lack of a recent synoptic survey of the tributaries to Cayuga Lake limits our ability to highlight specific subwatersheds with elevated concentrations of fertilizers and pesticides. NYSDEC monitors nitrate-nitrogen concentrations of Fall Creek as part of their Rotating Intensive Basin Survey (RIBS) program.

Fall Creek is also included in the statewide pesticide monitoring network, a joint program of USGS and NYSDEC. Herbicides used in corn cultivation are consistently detected at trace concentrations in Fall Creek. USGS completed a storm sampling program to measure pesticide concentrations in three tributaries draining agricultural subwatersheds in June, 1998. Samples were collected in Salmon Creek, Yawger Creek, and Paines Creek during a storm that occurred shortly after the herbicides metolachlor and alachlor had been applied. Peak concentrations of herbicides in these streams were 100 to 1000 times higher than detected in Fall Creek or Cayuga Lake. From the limited data available, it is clear that agricultural areas have the potential to export pesticides to the lake. Important data gaps remain regarding the relative significance of residential and commercial uses of pesticides on the quality of the lake and its tributary streams.

Organic Compounds

Groundwater quality data are limited. There are regions of the Cayuga Lake watershed with detectable concentrations of organic chemicals in the groundwater. These areas of concern are located in the Fleming-Union Springs-Aurelius area and in the Jacksonville area.

New York State Department of Health has released an initial Source Water Assessment Program (SWAP) Report for the Cayuga Lake Watershed (Appendix G). These reports analyze the hydrogeologic sensitivity of public water supply sources and integrate this information with a contaminant inventory. The goal is to define the overall susceptibility of a water supply source to contamination. When complete, the SWAP report will include both surface water and groundwater supplies. From the preliminary analysis of hydrogeologic sensitivity, wells in the Genoa-King Ferry Water District were designated as having a high sensitivity because of their location in an area of high conductivity (water moves through the soil too fast for adequate filtration and contaminants can reach water supply wells). Many other groundwater sources are also at risk of being influenced by surface waters. These areas will require continued protection to maintain the quality of the supply.

Trace Elements

Monitoring data documenting the concentrations and distribution of trace elements in the Cayuga Lake watershed are very limited. Fall Creek is monitored as part of the Rotating Intensive Basin Studies (RIBS) program, and seven heavy metals have been detected in sediments of this stream.

Pathogens

Microbiological testing is also very limited in the Cayuga Lake watershed. No specific geographical areas of concern are known.

Exotic Organisms

Exotic organisms including Eurasian water milfoil and zebra mussels are distributed throughout the lake.