

# CANADARAGO LAKE WATERSHED PARTNERSHIP

TOWN OF RICHFIELD · TOWN OF EXETER · TOWN OF OTSEGO · TOWN OF COLUMBIA · VILLAGE OF RICHFIELD SPRINGS  
CANADARAGO LAKE IMPROVEMENT ASSOCIATION · SUNY ONEONTA BIOLOGICAL FIELD STATION  
OTSEGO COUNTY SOIL AND WATER · HERKIMER COUNTY SOIL AND WATER



## WATERSHED PROTECTION PLAN

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## ***Acknowledgements***

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# Canadarago Lake Watershed

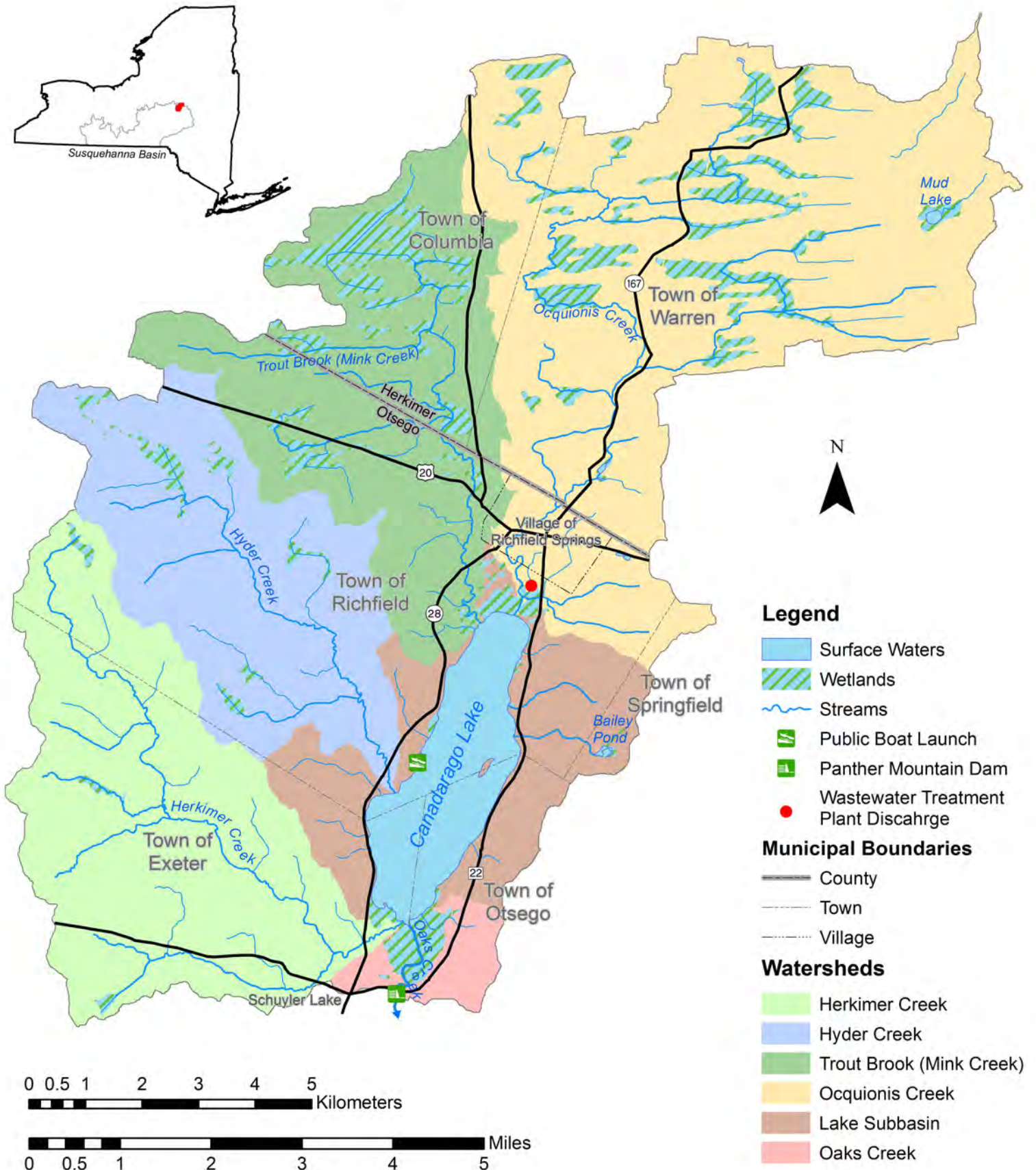


Figure 1. Canadarago Lake watershed, delineated by subbasin.

Table 1. Important measures concerning the management of Canadarago Lake.

Lake Statistics			
Surface Area	1,933.97	ac	782.65 ha
Max Depth	43.96	ft	13.40 m
Mean Depth	24.75	ft	7.54 m
Relative Depth			42.44 %
Volume	1.56 x10 <sup>10</sup>	gal	5.9 x10 <sup>7</sup> m <sup>3</sup>
Max Length	4.04	mi	6.50 km
Max Eff. Length	4.04	mi	6.50 km
Max Width	1.38	mi	2.22 km
Max Eff. Width	1.38	mi	2.22 km
Mean Width	0.75	mi	1.20 km
Shoreline Length	9.97	mi	16.05 km
Shoreline Development			1.62
Watershed to Lake Ratio			22:1
Areal Hypolimnetic Oxygen Deficit (AHOD)			1.10 mg·m <sup>-2</sup> day <sup>-1</sup>
Trophic State Index (1990-2013) (Carlson 1977)			47 (Meso-Eutrophic)

Table 2. Land use statistics for the Canadarago Lake Watershed (NLCD 2001; Homer et al. 2007).

Watershed Statistics				
Land Use	ha	ac	mi <sup>2</sup>	%
Forest	9,489.31	23,437.78	36.62	54.38
Agriculture	5,866.69	14,490.22	22.64	33.62
Wetland	973.71	2,404.98	3.76	5.58
Parks and Mowed Areas	741.63	1,831.75	2.86	4.25
Residential	191.95	474.10	0.74	1.10
Open Water	174.50	431.00	0.67	1.00
Commercial, Industrial	8.73	21.55	0.03	0.05
Rock, Quarry, Gravel	3.49	8.62	0.01	0.02
<b>Total</b>	17,450.00	43,100.00	67.34	100

## ***Introduction***

This publication is intended to be a comprehensive lake and watershed management plan for the community surrounding Canadarago Lake, aiming to help residents establish both social well-being in the community and sustainable ecological function within their water body. Protection of the lake's natural beauty and environmental integrity will be mutually beneficial for the local economy, homeowners, and wildlife inhabitants. This management plan comes after years of research on the lake and watershed, including *Canadarago Lake Eutrophication Study* (1972), *Limnology of Canadarago Lake* (1980), *The State of Canadarago Lake* (2011), *Canadarago Lake Beneficial Use Study: Hydrology and Hydraulics Study* (2011), and *Fisheries Survey of Canadarago Lake* (2012). The Canadarago Lake watershed is comprised of five towns (Columbia, Exeter, Otsego, Richfield, and Warren), two counties (Otsego, and Herkimer), the Village of Richfield Springs, and two New York State Department of Environmental Conservation (NYS DEC) regions (4 and 6) (Figure 1).

We began the process of drafting a lake and watershed protection plan by reaching out for partners and establishing the *Canadarago Lake Watershed Partnership*. This partnership includes the following agencies and organizations which have a vested interest in Canadarago Lake and/or its watershed:

- Canadarago Lake Improvement Association (CLIA)<sup>\*Founding entity</sup>
- Otsego County Soil and Water Conservation District (SWCD)
- Herkimer County Soil and Water Conservation District (SWCD)
- SUNY Oneonta Biological Field Station (BFS)
- Town of Richfield
- Town of Exeter
- Town of Otsego
- Town of Columbia
- Village of Richfield Springs
- NYS Department of Environmental Conservation: Region 4 Office (NYS DEC)
- Otsego County Planning Department
- Otsego Land Trust (OLT)
- Otsego County Conservation Association (OCCA)
- Catskill Regional Invasive Species Partnership (CRISP)

## **Goals and Priorities**

This partnership has enabled us to pool our resources and come together as a community to develop a bottom-up management plan for a local keystone natural resource. Following upgrades to the village of Richfield Springs wastewater treatment plant in 1973, the New York State high phosphate detergent ban in the same year, and over all reductions in watershed nutrient loading between 1970 and 2010, water quality within Canadarago Lake has

been on the upswing. This partnership has been charged with continuing these types of efforts within the lake and watershed to maximize future increases in overall lake health. Numerous groups, municipalities, and organizations are concerned with the water quality and management of natural resources within the Canadarago Lake watershed. Future public policy needs to focus on developing effective solutions to the following issues at a basin-wide scale. Many of these efforts are large scale

endeavors, which we recognize may require outside support and/or some degree of lake and watershed support personnel to help with the coordination, implementation, and structuring of these projects. By tackling the issues currently facing Canadarago Lake we hope to secure the overall integrity of the area- creating a more desirable destination for people and their families, improving the quality of life for year round and seasonal residents, and increasing property values within the region, as they are strongly tied to the condition of the lake.

### **About the Lake**

Canadarago Lake is a dimictic<sup>1</sup> lake of glacial origin located in northern Otsego County, NY. The lake sits within the north-eastern section of the Allegheny plateau, helping to make up the head waters of the Susquehanna River and Chesapeake Bay watersheds. The lake's 67 square mile drainage basin extends northward, and is comprised of large portions of both Otsego and Herkimer Counties. Canadarago Lake has a maximum depth 44 ft and a surface area of 1,934 ac, and has long been considered naturally eutrophic<sup>2</sup> (Fuhs 1973; Harr *et al.* 1980). An Island, known as Deowongo Island, is centrally located in the lake approximately 400 yards from the eastern shoreline. The lake ecosystem supports a diverse warmwater fishery, containing 37 species, making Canadarago a popular fishing destination for anglers from across greater New York State. Canadarago Lake is also home to various other types of recreational activities including motor cruising, rowing, canoeing, kayaking, and swimming. The village of Richfield Springs,

located north of the lake, is the largest population center within the watershed, being home to approximately 1,250-1,500 people. The lakeshore community has long been considered a blue collar demographic with many residents and users coming from nearby locations looking to relax, recreate, and enjoy the lake.

### **Survey Results**

In order to establish the primary social needs of local and seasonal residents, a blanket survey was distributed by mail throughout the watershed. This survey was comprised of 2,008 mailings, using the best available mailing list provided by the Otsego County Planning Department. Of the 2,008 surveys 288 were returned, with a return percentage of 14.4%. The key environmental issues identified by this survey included 1.Shoreline flooding and lake level, 2.Shoreline sanitary waste and septic systems, 3.Exotic species introductions, and 4.Algal blooms and aquatic plant growth. It was also noted that there was strong agreement between lakeshore and watershed residents regarding these top environmental issues. By establishing the primary social needs of the local residents, it was possible to develop a hierarchy for addressing issues within the watershed based upon both human need and recent scientific reports.

### **Lake Issues**

#### **Lake Level**

Canadarago Lake drains to the south through the lake's outlet, Oaks Creek. A small concrete weir known as Panther Mountain Dam is located approximately one mile downstream of the lake along Oaks Creek, and serves to stabilize minimum lake levels during the summer months. A 2009 hydrologic survey of Oaks Creek showed a gradual increase in streambed elevation between the dam and its confluence with

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<sup>1</sup> **dimictic:** lake or water body that undergoes both spring and fall turnover.

<sup>2</sup> **naturally eutrophic:** A lake that has become enriched with dissolved nutrients due to intrinsic factors, often occurring over geologic time and resulting in elevated plant and algal growth.

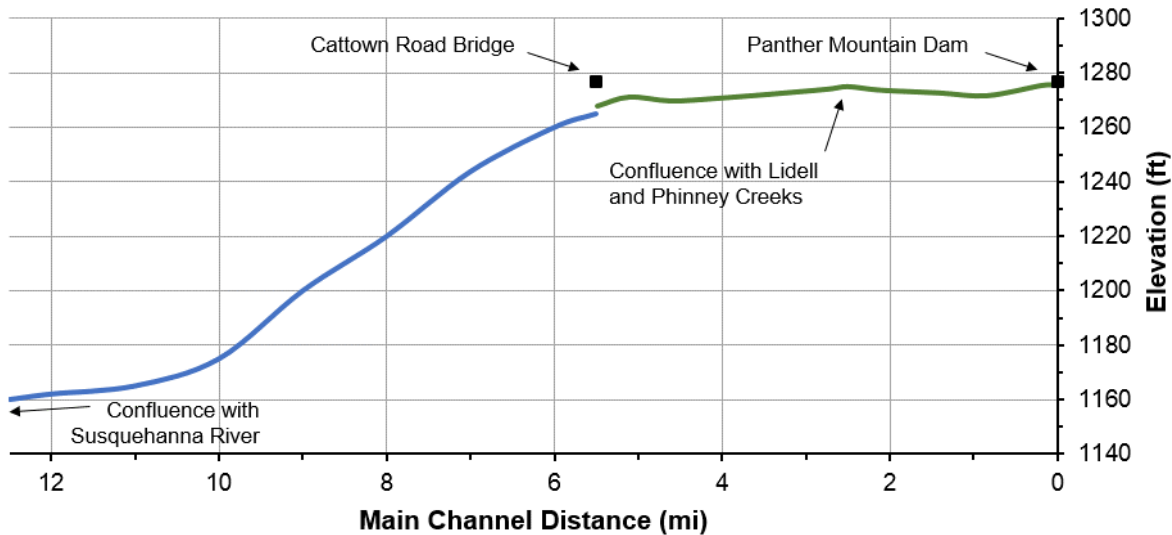


Figure 2. Cross section of Oaks Creek streambed elevation from Panther Mountain Dam to the Susquehanna River. Data Source: Malcolm Pirnie, Inc. 2011 (Green); extrapolated Susquehanna Basin LiDAR (Blue).

downstream Lidell and Phinney Creeks (Figure 2). This elevated stream bed creates a backup of water that limits outflow from the lake and reduces the effectiveness of the existing and proposed spillway. Dredging of Oaks Creek downstream of the dam, as described in Malcolm Pirnie, Inc. 2011, was found to be non-beneficial to creek flow. The study also indicated that a significantly increased amount of dredging would be required in order to create the proper slope necessary to benefit the drainage time of the lake, and was not further evaluated due to the potential significant impacts on Oaks Creek and associated costs. Other issues not formally investigated in Malcolm Pirnie, Inc. 2011 include, potential negative impacts on downstream infrastructure, draining of associated wetlands within the Oaks Creek basin, and lack of permitting support. Removal of the dam and spillway was found to maximize the lake drainage and flow of Oaks Creek, but would eliminate the ability to maintain a higher water surface elevation (WSEL) for recreational use.

### Approach

Repair of the dilapidated dam is necessary and poses an immediate risk if not addressed. According to Malcolm Pirnie,

Inc. 2011, the existing dam and spillway should be repaired in order to maintain the current functionality, and the concrete weir elevation should be lowered to allow for a lower winter level thereby creating additional spring flood storage. However, no modifications to the existing structure could both significantly reduce peak flood levels and maintain the existing summertime

*A large watershed to lake ratio also makes the lake more susceptible to flooding events.*

recreational lake level. Upon repair to the existing spillway, the concrete weir should be lowered one foot (WSEL 1,277 ft) below current height. This will allow for the installation of an additional I-beam and increase spillway control.

Mitigation of flood impacts should also be considered. Current weather patterns in New York State, specifically the Catskill Region, indicate a trend in increased average annual precipitation and intensity of storm events over the past 50 years (Figure 3). Continued increases in regional precipitation and runoff should be expected with continued global climate change (Burns *et.*

al 2007). A comprehensive appraisal of waterfront properties should be performed to identify high risk areas. Techniques for dealing with these areas could include the following.

- Developing a low lying property buyout plan.
- Physically raising properties and critical public infrastructure out of the floodplain.
- Relocating, eliminating, or establishing publically owned treatment facilities for low lying septic systems.
- Increase hydraulic retention in the upper watershed, through wetland creation and storm water control.
- Increase law enforcement at the public boat launch during flood events to prevent boat access and the subsequent negative impacts of boat wake on inundated properties.

has raised concerns about failing lake shore septic systems and their potential role in external nutrient loading and as a source of harmful pathogens. The effectiveness of lake shore septic systems are typically limited by the depth and porosity of soil (seasonally high ground water), depth to restrictive layers (fragipan, bedrock, etc.), surface area available (footprint), and distance from the respective water body (NDWRCDP 2004). Poor site conditions compounded by repeated flooding, and the recently reported 51% septic failure rate on neighboring Otsego Lake (McIntyre 2009), have all added to the septic concerns on Canadarago Lake.

Recent shoreline fecal coliform bacteria testing (2008-2013) has been inconclusive in the documenting full extent of the problem (Figure 4). According to Part 703 of the NYS Surface Water and Groundwater Quality Standards and

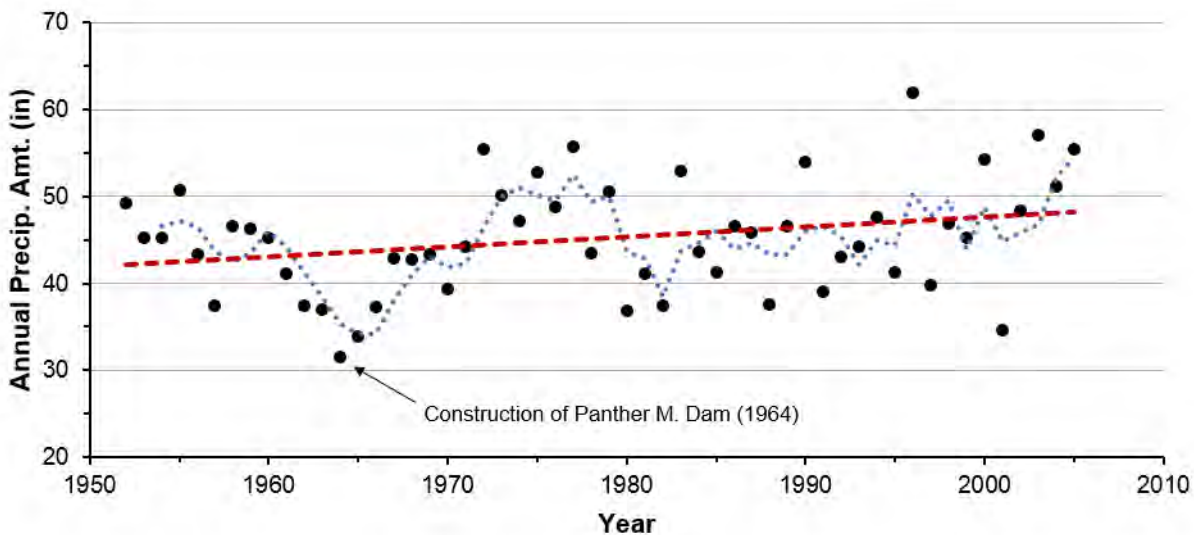


Figure 3. Mean annual precipitation for the Catskill Region 1952-2005. Trend line indicated in red. Data Source: Burns et. al 2007.

### Sanitary Waste

As of 2013, there are an estimated total of >625 homes, cottages, or camps along the 10 miles of shoreline surrounding Canadarago Lake. The vast majority of these dwellings rely on septic systems (onsite wastewater treatment systems) for sanitary waste treatment. The watershed partnership

Groundwater Effluent Limitations, the monthly geometric mean, from a minimum of five examinations, shall not exceed 200 colonies per 100 ml for recreational surface waters. Out of 109 samples collected, only one recorded reading was found to be above this threshold and was extremely high, 19 July 2010 in shoreline Zone 5 at >2,000



colonies/100 ml. Monthly fecal coliform bacteria averages were found to generally increase throughout the recreational season, peaking in July, suggesting that seasonal use may have an important impact on bacteria levels. A comprehensive septic system inspection program would be needed to draw further conclusions from this study.

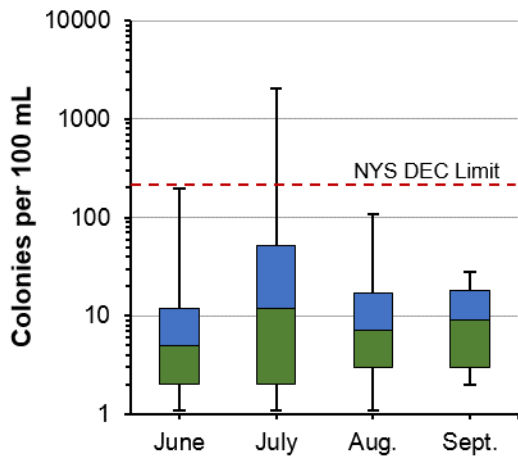


Figure 4. 2008-2013 Average monthly fecal coliform Levels, shown in logarithmic scale. Middle line indicates median levels, upper bar indicates maximum levels sampled.

### Approach

Community support is very limited for a comprehensive septic system inspection program, and given the high variability in lake water level it is questionable if a septic system inspection program would be effective in mitigating the issues at hand. Ultimately, any onsite wastewater treatment system inundated with water is in failure. Resources would best be used to establish a municipal sewer district around Canadarago Lake to provide wastewater treatment for shoreline residents. Lakes with municipal sewer districts tend to more closely resemble undeveloped water bodies; showing relatively lower levels of eutrophication<sup>3</sup> when compared to lakes

<sup>3</sup> **eutrophication:** the process by which a body of water becomes enriched in dissolved nutrients that stimulate plant and algal growth, mainly phosphorus (P) and nitrogen (N).

with high densities of personal shoreline septic systems (Moore *et al.* 2003). Canadarago Lake and its community are in a unique situation where the overall size of the lake is conducive to such a system and the lake is in close proximity to an active wastewater facility, the Richfield Springs Wastewater Treatment Plant which is located 0.5 mi (0.8 km) north of the lake. A municipal district could also potentially provide municipal drinking water to lakeshore residents, as many currently draw from the lake or wells drilled in the immediate vicinity, and Canadarago Lake is not zoned as a drinking water supply (New York State Department of Health 2011). These factors have led the partnership to strongly consider this option, and evaluate the potential of this prospective project with a feasibility study which is needed for further decision making. Revisions to this section of the plan are expected upon completion of that report.

- Conduct a shoreline municipal sewer and water district feasibility study.
- Update shoreline zoning laws to reflect an environmentally conscious minimum property size. Lakeshore property sizes have the potential to change dramatically upon completion of municipal districts if not zoned properly.

### Richfield Springs Wastewater Treatment Plant

The Richfield Springs Wastewater Treatment Plant is a 0.60 million gallon per day (MGD) municipal sewer system that services an estimated 1,250-1,500 people within the village of Richfield Springs, NY. The plant discharge is located 0.5 mi north of the lake along Ocquions Creek within the Canadarago Lake watershed (Figure 1). The facility has been updated as recently as 2010, with many updates over the years including the implementation of secondary

treatment phosphorus (P) removal in 1972, and other subsequent improvements in 1998, 1992 and 2002. Independent sampling of the plant effluent conducted by the SUNY Oneonta BFS (2008-2011) indicated that the plant was consistently below the total phosphorus (TP) limit of 0.5mg/L or 913 lbs/year as regulated by the state (Albright & Waterfield 2012; SPDES Permit #: NY0031411). Prior to phosphorus removal, it was calculated that 50% of the phosphorus budget entering the lake originated from the plant outflow (Helting & Sykes 1973). Increases in lake water quality over the past 40 years are generally attributed to this reduction in nutrient loading. Nitrogen (N) is not removed from effluent, the ammonia form is limited to 2.2 mg/L (June 1-Oct. 31) and 7.0 mg/L (Nov. 1- May 31).

### **Approach**

The success and proper functionality of the plant continues to be a concern of Canadarago Lake residents and lake users. In the interest of water quality and human health, the partnership would like to see that the Richfield Springs Wastewater Treatment Plant maintain compliance with their associated SPDES permitting. As part of the NYS Sewage Pollution Right to Know Act (2012), the partnership would expect that any overflows or discharges of untreated or partially untreated sewage not in compliance with SPDES Permit #: NY0031411 be reported to the Otsego County Department of Health (along with other required agencies). This notification system is designed to protect potential lake users and allow them to make informed decisions about fishing, swimming, and recreation in affected waters.

## **Primary Production**

### **1. Algal Blooms**

Lakes are often in a delicate balance between weed based and algal based

primary production<sup>4</sup>. Internal loading of phosphorus, caused by the depletion of oxygen within hypolimnion<sup>5</sup> during summer stratification, periodically results in seasonal blue-green algae (cyanobacteria) blooms in and around the period of fall overturn. These blooms are potentially harmful to human health, since they can commonly produce cyanotoxins. Fortunately, minimal recreational activity is taking place on the lake during this time period (October-November), lowering the probability of human interaction with a toxic bloom. Concentrations of blue-green algae within the lake have decreased overall since the 1960's and the algal community appears to be recovering from long periods of cultural eutrophication (Bailey 2014). It is presumed that the majority of public concern is generated by the presence of summertime, near shore aggregations of filamentous mat/surface scum forming algal types, which were sporadically observed in 2013. Readily available shoreline nutrients stemming from failing septic systems and/or runoff are assumed to play a key role in the formation of these near shore scums/mats. These surface aggregations can then be further concentrated by wind and wave activity further impacting near shore recreation.

### **2. Aquatic Plants (*Macrophytes*)**

Canadarago Lake has a relatively large littoral zone<sup>6</sup> (areas less than 18 ft depth; Brooking *et al.* 2014). The littoral zone within Canadarago Lake accounts for 30% of the benthic habitat and 65% of the lake's total volume. This area of the lake is capable of supporting large amounts of aquatic vegetation. Studies have indicated

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<sup>4</sup> **primary production:** biomass created by photosynthesis, naturally regulated by nutrition and herbivory.

<sup>5</sup> **hypolimnion:** cold, dense bottom layer of water in a thermally stratified lake.

<sup>6</sup> **littoral zone:** shallow areas near shore with adequate sunlight, capable of supporting aquatic vegetation.

that the lake has had a long history of predominant plant growth (Muenscher 1936; Harr *et al.* 1980; Albright & Waterfield 2012). The introduction of zebra mussels has also been documented to stimulate increased plant productivity, due to associated increases in water clarity, and deposition of nutrient rich detritus from the water column to the lake bottom through filter feeding. The use of large scale aquatic herbicide treatments, mechanical harvesting, and/or biomanipulation to reduce aquatic plant populations can often have undesirable results (harmful algal blooms, fishery decline, and resurgence of least desirable weeds). Aquatic herbicide treatments and mechanical harvesting are typically considered to be non-selective strategies, impacting both target and non-target plant species, favoring fast-growing exotic species in subsequent growth years. The impacts on non-target organisms varies when considering biomanipulation strategies, selective organisms such as the milfoil weevil (*Euhrychiopsis lecontei*), tend to limit undesirable outcomes when compared to non-selective organism such as grass carp (*Ctenopharyngodon idella*). In general, aquatic plant beds offer positive value for both the aquatic food web and sportsmen by providing essential fish habitat.

**Approach**

The partnership feels that the best way to continue to manage excessive aquatic plant and algal growth (primary production) is through a long term nutrient reduction strategy, with localized clearing of vegetation as needed (around docks, swimming areas, etc.).

- If aquatic plant growth is detrimental to recreational use, we ask that property owners and public facilities clear aquatic vegetation from localized areas surrounding docks and swimming areas as needed.

- Some potential removal options may include: hand harvesting, hydroraking, and/or benthic barriers. (State and local regulations may apply; contact NYS DEC region 4 office for more information)
- For visible blue-green algae blooms, a warning should be displayed on the CLIA website: <http://www.canadaragolake.com>

**Exotic Species**

***1. Non-native species not currently in Canadarago Lake***

The Canadarago Lake public boat launch is operated by the New York State Office of Parks Recreation and Historic Preservation (OPRHP) through the Glimmerglass State Park office located on neighboring Otsego Lake. The public boat launch is presumed to be the gateway for many of the invasive exotics which have become established within Canadarago Lake. The 2013 boat launch data shows that Canadarago

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*The species composition of the lake has changed more in the past 20 years, than in the preceding 200 years.*

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Lake is a popular destination, with boaters coming from across greater New York State. There is also a high risk of aquatic invasion from the Erie Canal which is located only 15 miles north of the lake (Coe 2013). Past introductions of invasive species have had negative impacts on the lake’s recreational use, shoreline and household infrastructure, aquatic food web structure, ecological community dynamics, and game fishery.

**Approach**

The prevention of future introductions is a far easier and more cost effective strategy for the management of invasive species, when compared to the eradication of a currently established

population. The prevention of future invasive species introductions to Canadarago Lake is a top priority of our partnership. Some strategies for accomplishing this goal are as follows.

- Stimulate community awareness about the potential impacts of invasive species through outreach and education.
- Continue participation in the Catskill Regional Invasive Species Partnership (CRISP) boat launch stewardship program for the monitoring and stewardship of the Canadarago Lake public boat launch.
- Pursue high pressure hot water washing facilities for the Canadarago Lake public boat launch.
- Consider local town legislation against the transport of harmful invasive species.

## 2. Alewives

Alewives (*Alosa pseudoharengus*) were first discovered in Canadarago Lake in 1999. Alewives have the potential to negatively impact the aquatic food web by consuming large numbers of zooplankton and larval fish. This can contribute to a rise in algal dominance and have a negative impact on the success of native fish reproduction.

### Approach

Invasive alewife populations can theoretically be kept in check through the establishment or supplementation of a predatory fish population, this strategy is known as a top-down control. The ongoing walleye (*Sander vitreus*) stocking program taking place in Canadarago Lake, is hoped to help control alewife populations through increased predation while supplementing a desirable game fish population for anglers.



Figure 5. Three devastating invasive species introduced to Canadarago Lake over the past decade. Top to Bottom: Zebra mussel, Alewife, and Starry stonewort. Not to Scale. Source: NYS DEC.

- Continue the NYS DEC walleye stocking program (40,000 fall fingerlings per year).

## 3. Zebra mussels

Based upon the largest individuals collected in 2002 it is estimated that zebra mussels (*Dreissena polymorpha*) have been present in Canadarago Lake since at least 2001, and that the initial invasion occurred sometime in 2000 (Horvath & Lord 2003). Zebra mussels have the ability to outcompete, live on, and kill native unionid clams. They also disrupt the food web through intensive filter feeding and deposition of detritus on the lake floor. Shoreline infrastructure and swimming areas have all been negatively impacted by the establishment of zebra mussels. In Canadarago Lake, they are of particular concern due to the relatively large amount of suitable habitat that exists within the lake; increasing the degree in which they continue to impact the lake.

### Approach

- At this point in time no management strategies exist for the control of zebra mussels.
- Provide lake users and shoreline property owners with the proper information about how to deal with and prevent the spread of zebra mussels to other uninfested water bodies.

## 4. Exotic plants (Macrophytes)

Canadarago Lake contains three major invasive exotic plant species, curly-leaf pondweed (*Potamogeton crispus*), Eurasian watermilfoil (*Myriophyllum spicatum*), and the macroalgae<sup>7</sup> starry stonewort (*Nitellopsis obtusa*). All of these species have contributed to the displacement of native species and overall decline in plant

<sup>7</sup> macroalgae: multicellular algae, similar to seaweed.

biodiversity since the 1930's (Muenscher 1936; Harr 1980; Albright & Waterfield 2012). Since its introduction to the lake sometime in the 1940's curly-leaf pondweed has become one of the most abundant if not the dominant pondweed within the lake. Eurasian watermilfoil was first documented in the lake in the late 1980's and also quickly became one of the most abundant plants in the lake. The most recently established exotic macrophyte in Canadarago Lake is starry stonewort. This species of macroalgae was first discovered in 2010, and is similar to the native musk grass (*Chara vulgaris*). Currently it is unclear what effects it will have on the plant community over time. It has the ability to form dense mats along the benthic substrate, choking out other plant species, and potentially impacting fish spawning habitat. Preliminary reports indicate that starry stonewort is becoming more common in the lake's north end and may have negative impacts on the native macrophyte community, and recreational use of the lake.

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*The Milfoil weevil, a native insect, has been proven to effectively feed on Eurasian watermilfoil.*

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**Approach**

- Continue to monitor the lake for changes in exotic plant populations, specifically looking for changes in starry stonewort abundance.
- Allow aquatic insects, milfoil weevil (*Euhrychiopsis lecontei*) and pyralid moth (*Acentria ephemerella*), to continue to control Eurasian watermilfoil populations.

**Fishery**

Canadarago Lake supports a diverse warmwater fish community (containing 37 species), making it a popular open-water and

ice fishing destination for anglers from across greater New York State. Predator fish populations within the lake include largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), and chain pickerel (*Esox niger*). Yellow perch (*Perca flavescens*) and sunfish (*Lepomis sp.*) are the dominant forage species, along with the recently introduced alewife (*Alosa pseudoharengus*) (Brooking *et al.* 2011). Ongoing studies of the lake have confirmed poor recruitment of walleye and yellow perch in recent years (2005-2014). Illegally introduced to the lake in the late 1990's, alewife have the ability to effectively prey on larval fish. Research indicates that walleye numbers could decline dramatically from alewife predation, and the effects on larval yellow perch could be similar but are not anticipated to be as dramatic (Brooking *et al.* 2011). The supplemental stocking of walleye is intended to offset the impacts of alewife predation on natural fish populations. In theory, the supplementation of walleye should boost the number that survive to adulthood and become top predators, leading to a food web structure in which walleye primarily consume small-medium sized alewife.

**Approach**

The fisheries of Canadarago Lake has been intensively studied by the Cornell Warmwater Fisheries Unit (CWFU) in partnership with the New York State Department of Environmental Conservation (NYS DEC) since the early 1970's. This contract will expire at the end of this sampling year (2014), currently there are no plans of renewing this contract. The NYS DEC Region 4 office will continue their efforts, including both

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*A final report of the CWFU research will be available in the spring of 2015.*

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fall stocking and fishery monitoring program.

- Increase stakeholder input in fisheries management.
- Continue the NYS DEC walleye stocking program (40,000 fall fingerlings per year) along with continued monitoring including electroshocking and bi-annual gillnetting surveys.
- Update strategy as needed based on the results of NYS DEC monitoring efforts.

### **Recreational Use**

According to the public opinion survey, the major recreational uses of Canadarago Lake include relaxing at residence, swimming, rowing/canoeing/kayaking, motor cruising, and fishing. The vast majority of people surveyed felt that public access to the lake is sufficient and that the present recreational patterns on the lake are of little concern. The greatest use of the lake occurs between the hours of noon and six in the evening, with greater use on weekends and holidays.

### **Approach**

- Support New York State boating regulations (NYS Navigational Law §30-79), paying special attention to the following:
  1. Boat vessel speed is limited to 5 mph when within 100 feet of the shore, a dock, pier, raft, float, or anchored boat. This regulation is still in effect regardless of the presence or absence of no-wake zone buoys.
  2. For houseboats, discharge of any sewage is not permitted on any land locked lake which is located completely within the borders of New York State. Sewage must be pumped out ashore using the

proper pump-out equipment and/or facility.

- Limit public boat launch access during flood events due to the negative impacts of boat wake on inundated properties.
- Pursue funding and gather local support for the installation and maintenance of no-wake zone buoys.

### **Shoreline Preservation**

The majority of the Canadarago Lake shoreline was once surrounded by miles of wetland (Muenscher 1936), providing a vegetative buffer protecting the shoreline and reducing the impact of water level fluctuation. Today much of this has been converted to residential development, for recreation and enjoyment of the lake's natural beauty. Lakescaping is a lawn design that lowers care and maintenance cost, reduces shoreline erosion/runoff, discourages or eliminates migratory bird (geese) impacts on lawn areas, and increases shoreline terrestrial and aquatic biodiversity (Henderson *et al.* 1999).

### **Approach**

The goal of lakescaping is to return 50-75% of the shoreline to a vegetated state, replacing monoculture lawns with a diversity of native wetland plants, shrubs, and trees- establishing shorelines which can withstand periods of high water and abuse, while restoring the lake's natural beauty and increasing lakeshore property values (Figure 6).

- Where possible, encourage lake shore property owners to return sections of shoreline to native vegetation (Figure 6).

### **Blueway Trail, Otsego Land Trust (OLT)**

Land trusts can serve as important partners for the conservation of natural resources and wildlife habitat in ecologically sensitive areas. The Otsego Land Trust

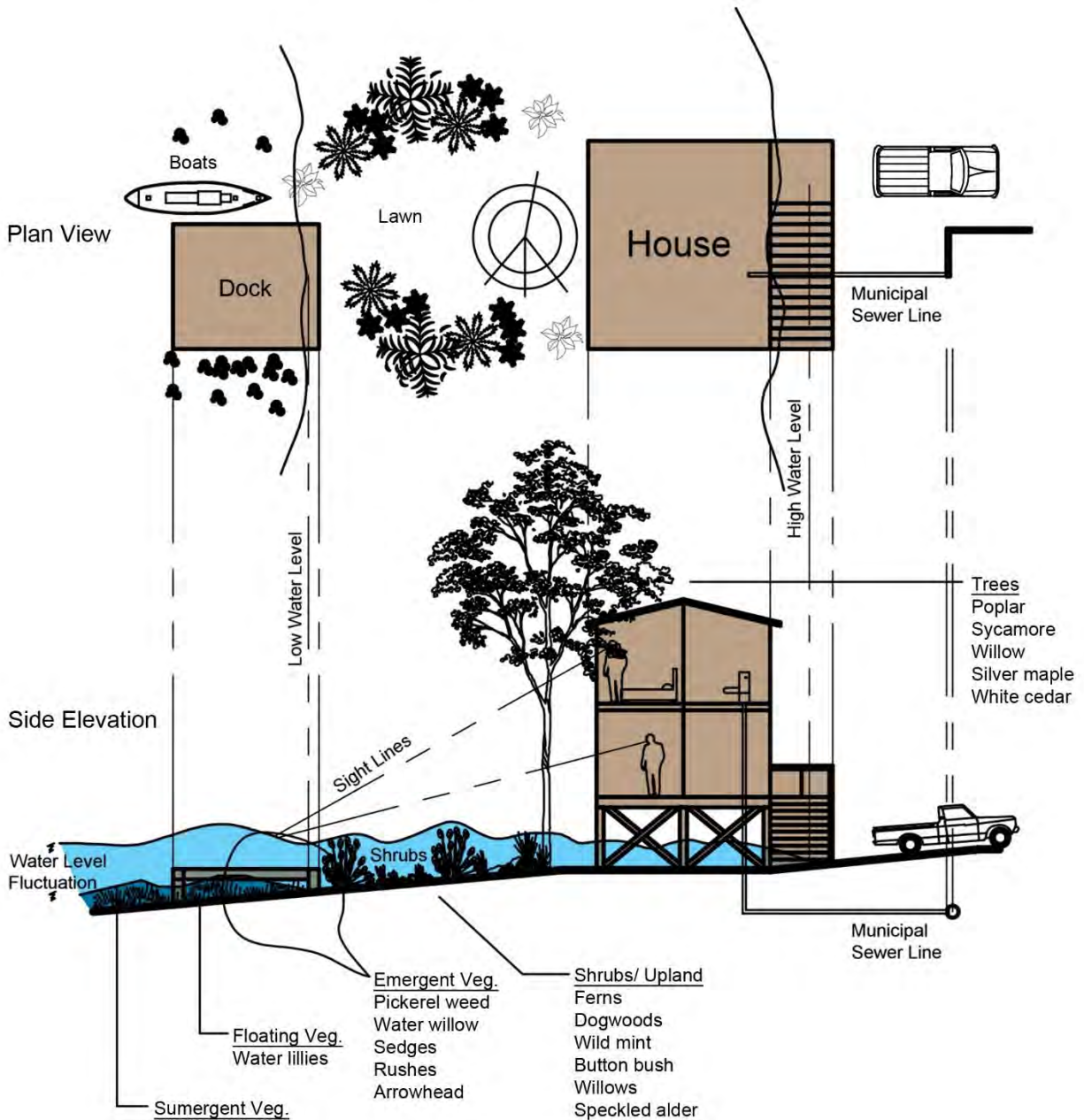


Figure 6. Idealized diagram of a home within a low-lying area along the Canadarago Lake shoreline. Not to scale.

(OLT) is a private non-profit organization that works with landowners and communities to protect healthy lands, clean waters, and the rural culture and history of the Upper Susquehanna River region, now and into the future. The Blueway Trail is a major land acquisition program focused on conservation of lands within the Upper Susquehanna basin, including the Canadarago Lake watershed (Figure 1). The

Blueway itself is a series of OLT owned properties and protected lands along these waters that provide public recreation (fishing, hiking, paddling, and bird watching), educational opportunities, and foremost, environmental preservation. On the shores of Canadarago Lake and Oaks Creek, OLT owns and stewards a series of public access sites and easement-protected properties (most notably Deowongo Island

and Fetterley Forest). A conservation easement is a voluntary legal agreement between a landowner and a land trust that permanently conserves a parcel of land, protecting the integrity of the land while remaining in private hands.

### **Approach**

Continued partnership with the Otsego Land Trust and the Blueway Trail has the potential to be an important watershed conservation resource for the community surrounding Canadarago Lake. Conservation easements can provide individual landowners with ability to protect the lake and the conservation value of their lands while still owning, working, and enjoying them. The OLT's commitment to water quality improvement through wetland preservation could help support a low lying property buyout plan, should funding become available. The Blueway project also offers the ability to increase public awareness about issues affecting Canadarago Lake through OLT sponsored public outreach and education.

## ***Streams and Tributaries***

### **Agricultural Management**

Land under agricultural production is currently estimated to account for 34% of the watershed (14,490 ac) (Table 2) (NLCD 2001; Homer *et al.* 2007), this is down from previous studies conducted in the 1970's which estimated agricultural lands at 51% (21,980 ac) (Harr *et al.* 1980). This change in land use has generally resulted from the return of marginal farm land back to woody or forested areas. In agricultural watersheds it has been shown that up to 90% of annual algal-available phosphorus (P) export comes from only 10 percent of the land area during a few relatively large storms (Pionke *et al.* 1997). Storm event monitoring within the lake's basin would suggest that large storm events play a crucial role in the overall

nutrient budget of Canadarago Lake (Bailey & Albright 2010).

### **Approach**

Long term management and reduction of agricultural runoff within the watershed is intended to support both local farmers and lake water quality by retaining nutrients (N, P) on agricultural lands and helping to prevent the accelerated eutrophication of the lake. The partnership would like to continue to support the efforts of the SWCD, NRCS, and the farming community at large through the implementation of agricultural best management practices (BMPs). These efforts should focus on a site's potential for surface runoff and/or erosion. Areas of high transport potential should be considered first and stabilized accordingly. Some steps in this process could include.

- Identification and remediation of specific locations of mass erosion.
- Increased riparian buffer zones (tree and vegetation planting).
- Implementation of various agricultural BMPs (conservation tillage, contour farming, crop rotation, terraces, ground cover management) and barnyard management projects.

### **Logging and Silviculture**

Flowing water in and around logging operations has a tremendous ability to transport loose soil. In general, every gallon of water flowing down a skid trail or through a log landing has the capacity to carry away several pounds of sediment (Chemung County SWCD 1997). Over time this water has the potential to wash away hundreds of tons of forest soil, negatively impacting both forest regeneration and downstream aquatic ecosystems.

### **Approach**

The use of forestry BMPs reduces the amount of forest soil that is washed away in



adverse weather conditions, helping to minimize the impacts on localized water bodies. Any logging operations within the Canadarago Lake watershed should follow the recommended practices outlined in the Silviculture Management Practices Catalog (NYS DEC 1993).

- Encourage landowners to properly plan logging operations using forestry BMPs to ensure successful and sustainable timber harvests.
- Support post-harvest stabilization efforts in highly erosive areas.
- Household tree and vegetation removal in environmentally critical areas, including the lake shoreline, should be conducted in accordance with state and local regulations. Local Shoreline Protection Area laws do apply.

### **Roadway Maintenance**

The New York State Department of Transportation (NYSDOT) offers environmentally related training which is available to all highway superintendents and staff. This is in an effort to maximize effectiveness of environmental programs and designs.

#### **Approach**

- Work with local highway departments to optimize area road maintenance practices with the intent to limit nutrient contributions to the lake from road maintenance operations within the watershed, paying close attention to the roadways immediately adjacent to the lake.
- Support SWCD in efforts to reduce erosion along municipal infrastructure. Including such practices such as hydroseeding and reinforcement of unstable banks and ditches.

### **Herkimer Creek Sedimentation**

In recent years there has been much concern over the sand bar developing at the southern end of Canadarago Lake. This sand bar is a raised bed of sediments occurring along the lake bottom at the confluence of Herkimer Creek and the extreme southern end of Canadarago Lake near the outlet of Oaks Creek, approximately one mile upstream of the dam (Figure 1). Studies have shown that Herkimer Creek is a massive contributor of suspended sediments and limiting nutrients (N, P) under high flow or storm runoff conditions (Bailey & Albright 2010). The sand bar was found to limit the degree to which the lake water level could be lowered to provide flood storage in advance of springtime high runoff conditions, but any gain in flood storage from removal of the sand bar was found to be negligible under flood conditions due to the controlling downstream streambed elevation (Malcolm Pirnie Inc. 2011). The creation of the Panther Mountain Dam in 1964 is presumed to have exacerbated the natural growth of this formation by raising the minimum lake level to WSEL 1,278 ft and reducing the potential ability of Oaks Creek to flush these sediments downstream. However, the primary cause of this sand bar is the high risk watershed of Herkimer Creek, which is susceptible to storm runoff and high rates of sedimentation during large rain events.

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*The sand bar is actually comprised of a silt-clay.*

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#### **Approach**

The removal of the sand bar would increase the aesthetics and navigational functionality of the southern end of the lake but addressing the sand bar alone would prove fruitless due to the high risk of its return in the near future. The partnership has concluded that the sediment load from

Herkimer Creek must be addressed and reduced before taking any action against the existing sand bar. Some potential runoff attenuation projects within the Herkimer Creek basin include the following.

- Identification and remediation of specific locations of mass erosion.
- Increase riparian buffer zones (tree and vegetation planting).
- Consider sediment retention basins along Herkimer Creek before the confluence with Canadarago Lake.
- Increase hydraulic retention in the upper watershed, through wetland creation and storm water control.
- Implementation of various agricultural and forestry BMPs (conservation tillage, contour farming, crop rotation, terraces, ground cover management).

### ***Continued Monitoring***

#### **Baseline Monitoring**

As part of their fishery study the CWFU annually collected a large amount of water quality data on Canadarago Lake, including monthly (May- October) temperature, dissolved oxygen, and water clarity (Secchi disk); surface total phosphorus, nitrate, and chlorophyll-a; and a vertical zooplankton tow. This study has come to an end as of 2014. The NYS DEC Division of Water last sampled Canadarago Lake in 2009, and are not scheduled to return until 2018. Water quality monitoring is an important tool for quantifying improvements in the lake as a result of management efforts.

#### **Approach**

- Work to reestablish an annual or semiannual sampling regime on the lake (May-October).
- Continue the NYS DEC fisheries monitoring including electroshocking and bi-annual gillnetting surveys.

### **Invasive Plant Monitoring**

Early detection is crucial when trying to prevent the establishment of newly introduced aquatic invasive species. CRISP boat launch stewards should be trained to identify important invasive/exotic plants. Some major invasive plants of concern that are currently not present in Canadarago Lake as of 2013 include, Brazilian elodea (*Egeria densa*), European frogbit (*Hydrocharis morsus-ranae*), hydrilla (*Hydrilla verticillata*), and Water chestnut (*Trapa natans*).

#### **Approach**

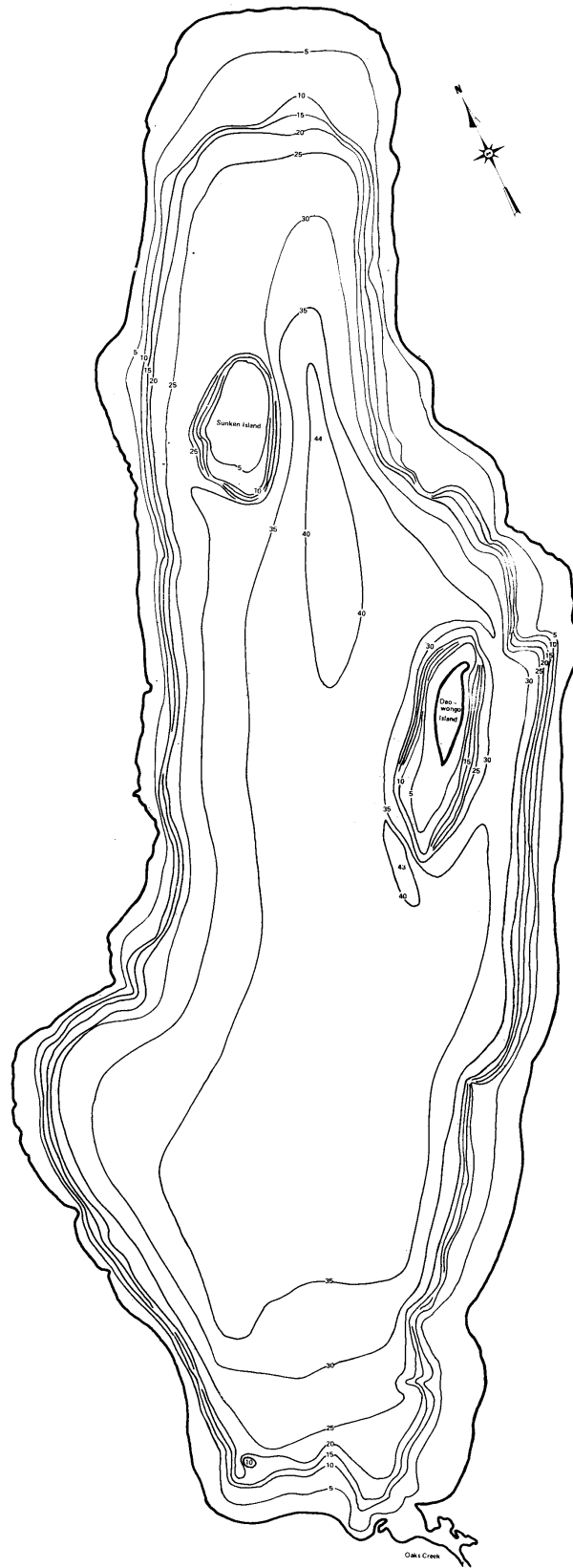
- In cooperation with volunteer members of the CLIA, the CRISP boat launch stewards should conduct an annual summertime plant survey within the lake in search of any newly established invasive plants. Submergent plants should be sampled using a plant rake and a modified version of the Point Intercept Rake Toss Relative Abundance Method (PIRTRAM) (Lord & Johnson 2006).
- Any new populations of invasive plants should be reported initially to the SUNY Oneonta Biological Field Station (BFS) and dealt with accordingly based on initial evaluation at that time.
- All lake users should be keeping an eye out for water chestnut, it was stopped from entering the lake twice in the summer of 2013 (Coe 2013), if discovered early it can be carefully removed and eradicated. If you think you have seen water chestnut on the lake please contact: [info@canadaragolake.com](mailto:info@canadaragolake.com)

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