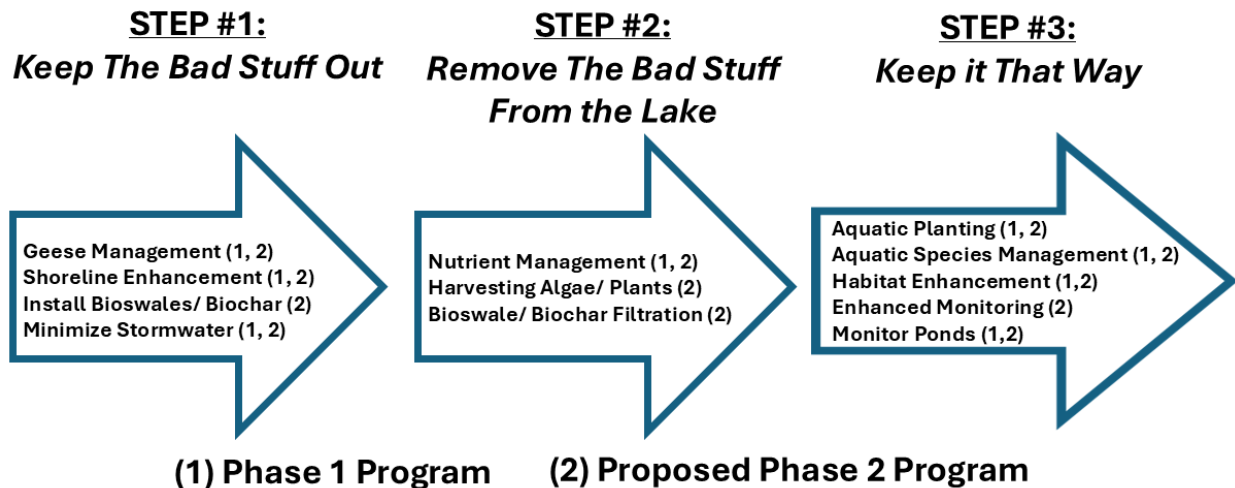


TOWARDS A SUSTAINABLE NATURALIZED WETLAND

Three Steps to Sustainability



Submission for Markham's Swan Lake Water Quality Review By



March 12, 2026

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EXECUTIVE SUMMARY

Swan Lake Park is a biodiverse 14 hectare municipal park located at 25 Swan Park Road in Markham. Swan Lake, within Swan Lake Park, covers 5.4 ha and has a history of poor water quality and poor aquatic habitat. University of Toronto biologists categorized Swan Lake as a “constructed wetland ” while Markham’s aquatic adviser referred to it as an “open wetland”.

Founded in 2019, the Friends of Swan Lake Park (“FOSLP”) are residents of Markham committed to the rehabilitation of Swan Lake and Swan Lake Park through environmentally best practices that will rehabilitate aquatic and terrestrial habitat and provide safe lake water for sustainable human and wildlife activity.

In December 2021, Markham Council approved the Swan Lake Long-term Water Quality Plan which describes a phased adaptive approach with specific actions outlined for Phase 1, the initial 5 years from 2021 – 2025.

In 2025, Markham staff initiated a review of the long-term plan with a view to seeking approval from the Markham Subcommittee in April 2026 for Phase 2, (2026 – 2030).

There were significant improvements in surface water quality attributable to the Phase 1 program and all of the Phase 1 goals were met. The Phase 1 program was designed to reduce algae and improve clarity through a program focused on reducing nutrients, primarily phosphorus. Reduction in nutrient levels exceeded the interim goals. Algae levels were reduced but not to the same degree as nutrients while clarity improved only marginally.

Other benefits arising from the Phase 1 program were improvements in oxygen levels and a significant increase in submerged aquatic vegetation. Chloride levels declined significantly, likely contributing to the return of the aquatic vegetation. The decline in chloride (from road salt) is attributed to clearance of a blockage in one of the stormwater pipes, however the decline also indicates the significant influence of the groundwater system on the dynamics of the lake.

Restatement of the Long-term Goal

The stated goal of the 2021 long-term plan is:

“To improve the overall health of Swan Lake, which will provide the opportunities for no-contact activities for the enjoyment of the community.”

It has been pointed out by several of FOSLP’s advisors and by Markham’s principal aquatic advisor that many of the differences between the actions within Phase 1 and those requested by FOSLP are primarily related to differences in goals.

This is substantially true. There are three differences in objectives that FOSLP would like to see addressed during Phase 2:

1) The Definition of “Health”

Swan Lake Park is one of the most biodiverse areas in Markham, largely attributable to the wetland elements within the park.

The rehabilitation of the water quality and aquatic life within Swan Lake is essential to stabilizing the park’s ecosystem and preserving this naturalized oasis in light of increasing urbanization of the area. Markham Council is in the final stages of approving a redevelopment plan for the nearby Mt. Joy area that will double the local population.



FOSLP’s definition of “health” includes all of the aquatic elements in the lake – in particular the lower level elements in the food chain (zooplankton etc.), that are essential components of a sustainable solution. Phase 1 monitored only selective elements of the aquatic environment. FOSLP’s advisors and FOSLP believe it is essential to monitor all of the aquatic elements during Phase 2. FOSLP has outlined the scope for an “Environmental Health Card” that captures the critical aquatic elements that should be monitored during Phase 2.

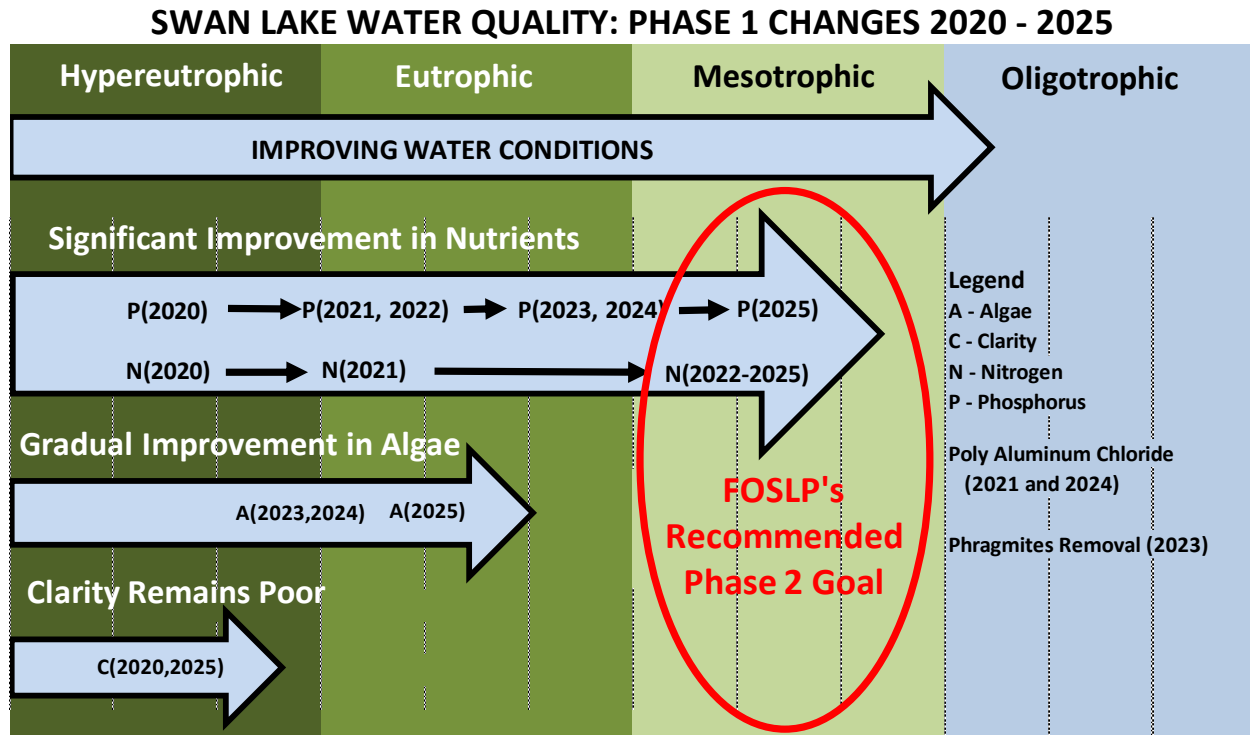
2) Strive for a Sustainable Solution

The stated objective for Phase 1 was to attain “Eutrophic” level conditions. This has been substantially accomplished. FOSLP’s objective is for an ecosystem that is as self-sustainable as possible with the need for minimal future interventions. It is why we stressed in 2021 establishing the long-term goal as being the more stable “mesotrophic” state. The significant improvements during Phase 1 make this a more attainable objective.

Lake Conditions and Community Options Associated With Trophic States

TROPIC STATE	AQUATIC ENVIRONMENT	COMMUNITY OPTIONS
<i>Oligotrophic</i>	Lack of plant nutrients keep productivity low, lake contains oxygen at all depths, clear water.	Swimming, paddle sports, wide range of fish options.
<i>Mesotrophic</i>	Moderate plant productivity, lower levels may lack oxygen in summer, moderately clear water and warm water fisheries only.	Paddle sports, swimming possible if monitored, good range of fish options.
<i>Eutrophic</i>	Contains excess nutrients, blue-green algae dominate during summer, algae scums are probable at times, lower levels lack oxygen in summer, poor transparency, rooted aquatic plant problems may be evident.	No swimming, paddle sports possible, limited range of fish options.
<i>Hypereutrophic</i>	Algal scums dominate in summer, cyanobacteria, few aquatic plants, no oxygen in lower levels, fish kills possible in summer and under winter ice.	No human interaction, potential health risk for humans and small animals.

Current results indicate that many of the critical elements, such as nutrients, are now within the definition of mesotrophic. The goal of Phase 2 should be to implement programs to further reduce algae and to improve clarity to the mesotrophic level. We recommend that Phase 2 goals target the “mesotrophic” range for all of the key metrics with the goal for chloride to be below the long-term Federal guidelines.



3) Return To a Naturalized State

Swan Lake has been described as a “closed-system” because it has no natural surface level streams. Evidence from Phase 1 reinforces the conclusion that the lake has a dynamic relationship with the groundwater system in the area, suggesting that it is demonstrating characteristics associated with a recharge area.

In June 2025, Markham Council agreed that as part of the Official Plan review, to consider FOSLP’s request that Swan Lake and Swan Lake Park be reclassified as Natural Heritage Lands. Both satisfy the criteria due to their biodiversity and the habitat they provide to a variety of species listed at risk. Within Natural Heritage systems, major water bodies are considered significant natural sources for recharging the aquifer. Swan Lake meets the technical criteria set out in Markham’s Official Plan and the Ontario guidelines for a “Key Hydraulic Feature”.

FOSLP recommends that tests be undertaken during Phase 2 to understand the chemical elements within the groundwater – this will define what a “naturalized” state for the lake could look like if all stormwater sources were eliminated and other elements were brought under control.

Swan Lake existed for over 20 years as a stand-alone pond created and influenced by groundwater sources. Detailed water quality assessments in the mid-1990's indicated relatively stable aquatic conditions. Since the addition of stormwater sources, conditions have deteriorated substantially. Chloride from the road salt, undermines the most sensitive forms of zooplankton that consume algae and help maintain a natural balance. There are no known ecological benefits associated with road salt and chloride. As long as stormwater inflows are permitted, a stabilized aquatic environment may not be attainable. Actions should be undertaken to minimize the impact of stormwater inflows and to develop a plan to substantially eliminate stormwater inflows and return the lake to its naturalized state.

Stormwater flows can be substantially eliminated for \$1.6 million. A large investment but one that has to be assessed in the context of the elements of the current program. The objective for Phase 2 should be develop lake conditions that are sustainable thereby minimizing the need for future interventions. This is a more likely outcome if chloride is removed from the system and the lake is allowed to go back to its natural state with the natural elements and groundwater as the primary influencers. There are some low cost efforts that can be implemented during Phase 2, including the installation of salt tolerant bioswales and once the city assumes control of the stormwater ponds, alterations to the Flow Splitters that will reduce inflows by 30% at a cost of \$125,000.

FOSLP's Recommend Goal for Phase 2:

“To improve the overall health of Swan Lake with the objective of sustaining a naturalized wetland which will provide the opportunities for no-contact activities for the enjoyment of the community.”

The following report is a revision of FOSLP's preliminary submission on December 3, 2025 to Markham staff . The revisions reflect the release by Markham of new water quality data for 2025, additional information on aquatic plants in the lake, and feedback arising from discussions with Markham staff in February 2026.

This report summarizes the analysis and recommendations by FOSLP's advisors and FOSLP's recommendations for actions to be included in the Phase 2 program reflecting this new information and the direct discussions with FOSLP and its advisors.

I) FOSLP's Proposed Actions for Phase 2

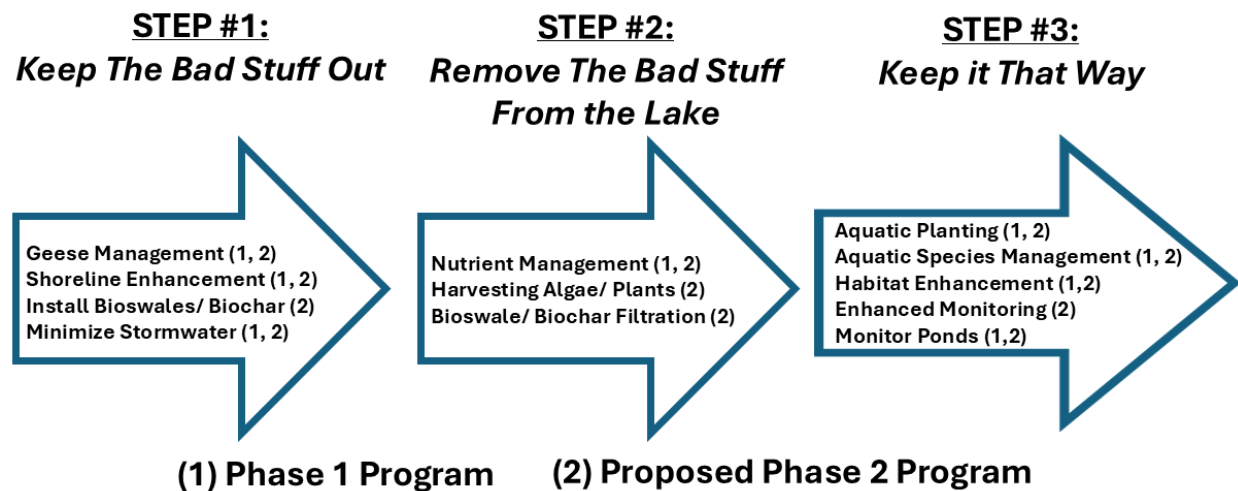
We recommend four core actions for Phase 2:

- A) Continue the comprehensive lake management actions undertaken during Phase 1
- B) Introduce an enhanced monitoring program that includes more aquatic elements
- C) Implement habitat and shoreline enhancements
- D) Initiate actions to minimize the impact of stormwater

A) Lake Management Program

Phase 2 should build upon the successes of Phase 1, while addressing directly continuing issues of excessive algae, poor clarity and high chloride levels. FOSLP proposes that actions during Phase 2 be structured to recognize three core steps to a sustainable ecosystem for Swan Lake:

Three Steps to Sustainability

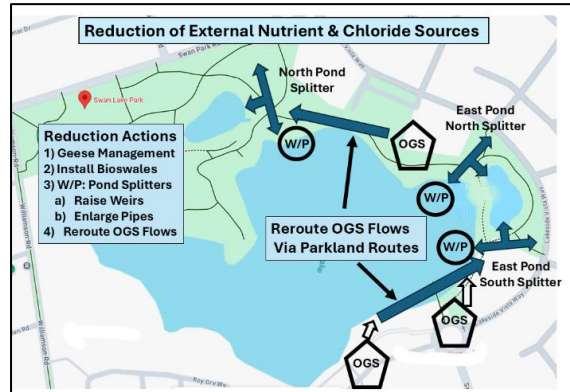


Continue Nutrient Reduction Efforts But Introduce Direct Actions on Algae, Turbidity and Chloride

Step #1: Keep the Bad Stuff Out

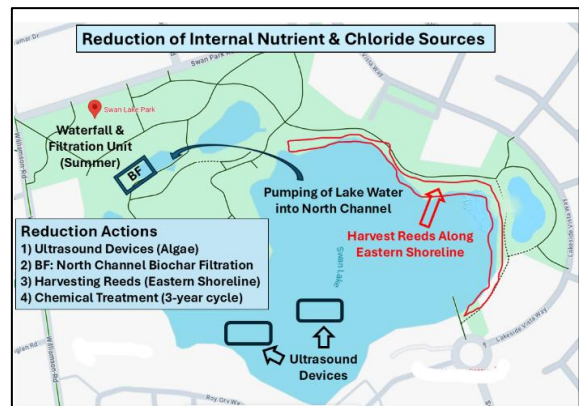
- 1) Continue the geese hazing and relocation program to reduce external sources of phosphorus and nitrogen.
- 2) Enhance the shoreline areas as recommended by the TRCA, Burnside and Noel to reduce the impact of nutrients and chloride entering the lake and to absorb nutrients already in the lake.

- 3) Minimize chloride inflows entering the lake
 - a) As recommended by Burnside, install bioswales at each of the six stormwater inflow sites and harvest the plants every 2-3 years.
 - b) Install a Biochar filtration unit at the Swan Club OGS
 - c) Reduce chloride inflows by 30% by altering the three splitters that control stormwater flows bypassing the ponds (Cost \$125,000)
 - d) Monitor contaminants entering the lake via untreated stormwater.



Step #2: Remove the Bad Stuff from the Lake

- 1) Continue with a program to remove phosphorus and nitrogen from the lake by:
 - a) Continue the 3-year PAC treatment program to contain phosphorus.
 - b) At least once during Phase 2, harvest the shoreline reeds in the fall to remove phosphorus, nitrogen and chloride from the ecosystem
 - c) Implement a Biochar filtration unit as a component of the recycling process through the North Channel.



- 2) Undertake a program to directly target algae by:
 - a) Continuing use of the ultrasound equipment, consider rotating locations.
 - b) Each spring harvest the algae that floats on the lake surface.

Step #3: Keep It That Way

- 1) Remove any returning phragmites and other invasive species from the shoreline
- 2) Continue with aquatic and shoreline planting to support aquatic and park wildlife
- 3) Continue with the fish management program and, if required, investigate the opportunity to stock zooplankton or mussels to support the algae management program
- 4) As recommended by NRSI, establish goals that align with Federal and Provincial guidelines and create triggers to address changes if conditions deteriorate.
- 5) As recommended by NRSI and Burnside, implement a comprehensive monitoring program that will monitor the eutrophic levels, aquatic habitat and aquatic life (zooplankton, Benthic Invertebrates), the sediments, stormwater inflows and the success of specific management actions undertaken during the rehabilitation program.

B) Enhanced Monitoring Program

A) Environmental Health Card

The Phase 1 monitoring program provided adequate monitoring of trophic levels of water quality but included only certain elements essential to an aquatic monitoring program and had very limited monitoring of contaminants (only chloride) entering the lake via stormwater.

In their reports, both R. J. Burnside^(d) and Natural Resources Solutions Inc. ^(e,f) outline the need for a more enhanced water quality monitoring program for Phase 2 that should include monitoring trophic levels and the results from the management actions but also provide more specific information on the contaminants entering the lake from stormwater sources, the elements in the sediments and the aquatic life within the lake.

FOSLP recommends that Phase 2 monitoring include more extensive monitoring of the aquatic elements based on the following frequencies.

Frequency of Testing for Environmental Health Card

	Phase 1	Phase 2
Inorganics (P, N, etc.)	Bi-weekly	Bi-weekly
Aquatic Life		
- Phytoplankton	Bi-weekly	Bi-weekly
- Microcystins	Bi-weekly	Bi-weekly
- Zooplankton		Bi-weekly
- Benthic Invertebrate		Annually
- Fish	Annually	Annually
Aquatic Vegetation	Once	Annually
Stormwater Inflows (1)	Spring	Spring, major rainfall events
Sediments	Once	Annually

Note: Phase 1 stormwater testing only monitored chloride.

Phase 2 testing should include Total Suspended Solids and other elements normally associated with stormwater

b) Engage University Researchers

In addition to the monitoring work undertaken by Markham and the TRCA, both Trent University and York University researchers were active during 2025. Trent undertook detailed physical water testing at 10 locations within the lake while York researchers initiated a done monitoring program. The two groups are now working to integrate their work.

We are fortunate to have two leading research teams interested in integrating Swan Lake into their research programs. Combined with Markham's needs for essential data to monitor its programs, there is an opportunity for Markham to formalize a water quality monitoring program that meets its core needs while providing baseline information for advanced

research that will provide Markham and others with critical information on the impact of lake management activities.

University researchers need data to support their advanced research programs, and the lake management activities underway in Swan Lake make it an attractive location for their research. Both the York and Trent research groups have the technical capabilities, and both have expressed an interest in participating in a co-ordinated and enhanced monitoring effort throughout Phase 2.

FOSLP is recommending that Markham undertake a co-ordinated water quality program during Phase 2 that leverages the talents of the university research teams, gives Markham the core information needed for Phase 2 while providing baseline data for the advanced research projects the university teams are undertaking.

The proposed outsourcing of the Environmental Health Card program is outlined in Appendix A1.

C) Habitat and Shoreline Enhancements

- 1) Re-engage the TRCA to strengthen the aquatic habitat and shoreline by:
 - a) Following through on the TRCA's "Restoration Opportunities" outlined in 2022.
 - b) Addressing shoreline habitat concerns raised by Noel.
 - c) Implementing the aquatic habitat enhancement recommendations outlined by Burnside to support aquatic life including structural habitat (woody structures, rock clusters).
 - d) Addressing the needs of park visitors and fishers by implementing the recreational shoreline enhancements recommended by TRCA in 2020 and supported by FOSLP in 2024.
- 2) If largemouth bass have difficulty surviving, consider Burnside's recommendation to deepen areas within the lake potentially by creating trenches linking the deeper portions of the lake. See Appendix A6.
- 3) Now that the cyanobacteria levels are significantly lower, FOSLP requests that the water fountain be brought back to a location near the dock.

D) Actions to Minimize the Impact of Stormwater

Friends of Swan Lake Park urges Markham to implement an action plan during Phase 2 to minimize the impact of stormwater on the lake ecosystem. During Phase 1, several important steps were completed, namely the completion of the Flow Diversion Report by AECOM and an update of the water and chloride budget. These reports confirm that there are practical solutions available to end Swan Lake's stormwater role.

We have not encountered any research that attributes positive environmental benefits to road salt while the harm caused by chloride is well documented. Little is known about the

lower-level aquatic elements within Swan Lake, such as the quantity and diversity of zooplankton, so we encourage Markham to adopt the proposed Environmental Health Card for Swan Lake. This annual report will provide meaningful information on the state of the environmental health and insight into the impact of chloride on the ecosystem and contribute to future lake management discussions.

There are four basic actions that we recommend be incorporated into Phase 2:

- 1) Enhanced monitoring of the stormwater infrastructure
- 2) Monitoring of contaminants from the stormwater sources
- 3) Analysis of issues arising from the Flow Diversion Report and the subsequent review related to refinements of the available flow reduction options and related costs and concerns about the potential impact, if any, on lake dynamics.
- 4) Development of a plan to phase out stormwater flowing into Swan Lake.

1) Enhanced Monitoring of Stormwater Facilities

It is important to continue the work started in Phase 1 to monitor the effectiveness of the existing stormwater infrastructure to avoid issues arising from future blockages.

During Phase 1, two blockages were cleared that impacted the effectiveness of the stormwater systems. The pipe at the East Pond that created the greatest bypass issue is prone to refilling through local erosion so routine monitoring is required. The two stormwater ponds, still under the control of the original developer, are 25 years old, nearing the time when a cleaning will be required. Our understanding is that a review during Phase 1 concluded that a cleaning was not required at that time.

Given the age of the ponds and the negative maintenance experience, we request annual reviews of the pond infrastructure and of the pond's effectiveness be undertaken during Phase 2 until Markham assumes control of the ponds.

2) Monitoring of Contaminants Entering the Lake

Approximately 45% of the stormwater inflow originates as untreated stormwater that has bypassed the two stormwater ponds – it is not pre-treated water from the ponds. The bypass flows have been described as the “second flush”, flows that arise during heavy rainstorms or snow melts. As such, they are expected to contain lower levels of any contaminants normally associated with stormwater. The other 55% of stormwater enters through three 25-year-old OGS units designed to remove heavy contaminants but not any contaminants that are soluble.

We are not aware of any testing that has been done for contaminants other than chloride that enter the lake via the stormwater sources. We request, as NRSI has recommended, that testing of stormwater sources include measuring other contaminants entering the lake.

3) Complete Analysis of Rerouting Options and Impact on Lake Levels

The Flow Diversion Report validated that viable options exist for rerouting stormwater. There is, however, the need for further refinement to the analysis:

- a) Developing revised estimates for the lower cost “Parkland” route options (Appendix A3)
- b) Refining the analysis of the changes to the Flow Splitters to identify the lowest risk options. (Appendix A3)
- c) Determine if there is any basis for the concern expressed about the impact of reduced stormwater inflows on lake levels. For over 20 years the lake levels were stable before any stormwater inflows were introduced. Current water flow analysis suggests that eliminating the stormwater inflows would not materially impact lake levels. (see Appendix A4). To address the concerns, we recommend further analysis of the lake dynamics be undertaken including the potential impact, if any, on eliminating stormwater inflows.
- d) The significant drop in chloride levels was wonderful news. It underscores the importance of good maintenance but also indicates the apparent positive influence of groundwater on the lake system. Appendix A4 summarizes some of the current information that illustrates the impact of the groundwater on the lake dynamics. Phase 2 should include further analysis to identify the contaminants in the groundwater and quantify the impact of groundwater on the lake’s system.

4) Phase 2 Actions to Minimize Impact of Stormwater Role

The Flow Diversion Report provided an estimate cost of \$1.75 million to reroute the Amica and Traffic Circle OGS flows. There is however a significantly lower-cost solution to rerouting the Amica and Traffic Circle OGS flows using the “Parkland” route (see Appendix A3) which avoids the costs of restoring paved roadways.

The Water and Chloride Budget estimated total annual chloride inflows at 2.95 tonnes. Applying the flow reduction estimates provided by the Flow Diversion Report, illustrates that rerouting all OGS flows and 65% of the pond bypass flows could reduce chloride inflows by 2.52 tonnes – an 85% reduction for a cost we estimate at \$1.6 million using the lower-cost Parkland routes.

	Parkland Route			
	Original Estimate	Cost Estimate	Potential Chloride Reduction	Cost Per Tonne
Rerouting Amica/TC OGS Flows	1,757,025	1,168,101	1.41	828,441
Rerouting Swan Club OGS Flows	275,072	275,072	0.25	1,100,287
Adjust Flow Splitters	124,787	124,787	0.86	145,101
Totals	2,156,884	1,567,960	2.52	622,206

The most cost-effective solution is the ability to reduce chloride inflows by 0.86 tonnes (30%) by adjusting the design of the Flow Splitters at a cost estimated by AECOM at \$124,767. However, the ponds remain under the control of the developer so this is not an action that can be initiated immediately. There are some actions that could be undertaken in the meantime such as further analysis of the design considerations on the Flow Splitters and analysis to alleviate concerns about the impact on lake levels.

The York University researchers have indicated that they are working to identify a more effective form of Biochar for the filtration analysis and could be ready for an installation of a field level test in 2027. The Swan Club OGS unit would appear to be the most feasible location for this test.

We request that Phase 2 include four actions to minimize the impact of stormwater inflows:

- 1) Install bioswales containing chloride tolerant plants at each of the six stormwater inlets and harvest every 2-3 years to remove chloride and nutrients from the ecosystem.
- 2) Complete the analysis related to redesign options for the Flow Splitters and any impact on lake levels with the objective of implementing the design changes once Markham has assumed control of the ponds (see Appendix A3).
- 3) Undertake an assessment of the impact of rerouting the stormwater flows on the lake dynamics. (Appendix A4)
- 4) Work with York University researchers to implement field level testing of Biochar filtering mechanism at the Swan Club OGS unit. (Appendix A2)

II) Phase 2 Recommendations by FOSLP Advisory Groups

In 2025, FOSLP engaged two groups of aquatic biologists, R.J. Burnside & Associates Ltd. (“Burnside”) and the Natural Resource Solutions Inc. (“NRSI”) to review the long-term water quality plan, the actions and outcomes of Phase 1, and to provide recommendations for actions during Phase 2 that would support a long-term sustainable outcome for Swan Lake.

Kathleen Elizabeth Noel, a local naturalist and FOSLP member who has led FOSLP-sponsored birding tours of Swan Lake Park outlined the environmental sensitivity of the shoreline.

Link’s to the advisors’ full reports are provided in the references section but their key findings and recommendations are outlined below in italics.

A) Noel: Shoreline Health and Its Role in Maintaining Water Quality

Kathleen Elizabeth Noel, a local naturalist and FOSLP member, notes that when discussing and addressing the issue of the water quality in Swan Lake, shoreline habitat improvement and restoration should be paramount. Swan Lake’s shorelines have become degraded due to several issues including the lack of emergent aquatic vegetation and terrestrial and native plants and shrubs.

Natural shorelines are known as ribbons of life for a reason and work as living filters to help improve and preserve water quality. Healthy, natural shorelines play an important role in filtering sediment and runoff, protecting against erosion, and absorbing excess nutrients. Furthermore, shorelines facilitate the exchange of resources between aquatic and terrestrial ecosystems, and therefore affect the functioning, ecological condition and health of both ecosystems.

She recommends several actions to strengthen and support the Swan Lake’s shoreline:

1. **Support and Sustain the Existing Biodiversity:** Swan Lake Park is incredibly biodiverse and home to a plethora of birds and wildlife. Native birds and wildlife benefit and stabilize shoreline health and water quality through the various roles they play in regulating nutrients and maintaining ecosystems. At least 184 distinct native species of birds, aside from Canada geese (*Branta canadensis*) have been recorded in the park, 15 of which are classified as species at risk under Schedule 1 of the Government of Canada’s *Species at Risk Act*. The park supports a diversity of mammals and amphibians, including two species of turtles rated as being of Special Concern under Schedule 1 of the Government of Canada’s *Species at Risk Act*, all with a reliance on Swan Lake.
2. **Native Shoreline Plants:** Having native vegetation along the shoreline is crucial for healthy water quality as it acts as a living filter which helps to catch pollutants and sediments from runoff before they can reach the water, preventing them from negatively impacting water quality.

Shoreline buffers are areas along bodies of water where plants grow and are not mowed or disturbed. Many native plants have deep root systems that can help to stabilize soils and will guard against erosion and help create vital habitats for wildlife. Shoreline plants can additionally help ameliorate water quality by providing shade, aiding in the cooling of water necessary to provide a healthier aquatic environment for native species of fish and other wildlife.

3. **Harvesting:** Planting native species of salt-tolerant plants (halophytes), including switchgrass (*Panicum virgatum*), sand dropseed (*Sporobolus cryptandrus*), prairie cordgrass (*Sporobolus michauxianus*), and sideoats grama (*Bouteloua curtipendula*), and employing harvesting methods to naturally manage excessive chloride levels in Swan Lake in the long-term. The harvesting process involves planting the native halophytes, allowing them to lay dormant over the winter months and flourish in the spring and summer and be cut at the base of the plant and removed from the site when they are mature the following fall. Research indicates that if this process is followed for at least three consecutive years, chloride levels in the soil drop and soil remediation is achieved. Less chloride in the soil would mean less chloride in the water, and an improvement in shoreline health and water quality as a result. This method is currently being employed to manage chloride levels at a number of parks throughout the City of Toronto, including Grenadier Pond in High Park, which has long faced issues with having excessive chloride levels that are twice the recommended level for aquatic long-term health and water quality.

Noel outlines three areas of concern.

- a) **Invasive Plant Species:** Invasive plant species disturb and degrade shoreline health and the environment as a whole, which in turn has a significant negative impact on water quality. In particular, many invasive plant species including, phragmites and dog-strangling vine (DSV), can decrease water flows and nutrient transportation. Other species of concern include Garlic Mustard, Yellow Iris, Common Tansies, and Burdock. She recommends a follow-up program to remove the returning phragmites and other invasive plant species.
- b) **Introduction of Biochar:** She expresses concern about the risk to the environment and native wildlife if biochar filters are employed at Swan Lake Park, noting that multiple scientific studies have detailed the health and environmental risks associated with biochar.
- c) **Installation of Goose Fencing:** Noel questions the effectiveness of goose fencing as a deterrent to geese and opposed the installation of fencing along the eastern shoreline. She is concerned that the fencing can be environmentally disruptive and contribute to the degradation of shoreline health and+ water quality through fragmentating and destroying the habitat for turtles, birds and other wildlife that help to maintain ecosystem balance.

B) Burnside: Aquatic Environment Recommendations

Following are excerpts from Burnside's Swan Lake Aquatic Conditions review^(d), revised February 26, 2026. (*Italics added*)

Executive Summary

- *R.J. Burnside & Associates Limited (Burnside) reviewed aquatic habitat conditions in Swan Lake at the end of Phase 1 of the Long-Term Water Quality Management Plan, on behalf of the Friends of Swan Lake Park, to guide recommendations for Phase 2.*
- *Despite improvements to overall water quality, internal nutrient loads and chloride concentrations may impede current and future ecological restoration efforts if left unaddressed.*
- *Construction of a bioswale system in the north channel or adjacent to stormwater/oil grit separator outlets could assist in water quality management by helping to remove and sequester internal nutrients and/or chloride loading.*
- *Elevated chloride concentration and predation from abundant Fathead Minnows may be suppressing zooplankton grazers (e.g., *Daphnia* spp.), although no study has yet confirmed this relationship.*
- *Burnside recommends assessing the present zooplankton community to determine whether the working hypothesis (i.e., low *Daphnia* spp. abundance may be contributing to elevated phytoplankton biomass) holds true. The initial survey may serve as a baseline to monitor if key zooplankton populations recover over the course of Phase 2.*
- *Largemouth Bass stocking in 2025 provides an opportunity to potentially reduce Fathead Minnows. Establishment of a population of bass may be supported by adding complex woody material structures. Future aquatic surveys (i.e., spring (i.e., winter kill) and summer during 2026) are recommended to determine whether current lake conditions are suitable for sustaining bass, especially to overwinter, or if further habitat modifications (e.g., deepening the pond or raising the lake level, addition of physical habitat) may be worth exploring to improve survivability.*
- *There are limited opportunities to use native Unionidae mussels or sunfish species to improve habitat quality.*
- *Due to turbidity from phytoplankton, efforts should focus on creating a sustained period of low turbidity before pursuing further submerged macrophyte restoration.*

Table 7: Summary of Recommendations to Improve Biological / Ecological Conditions During Phase 2

Biotic Group	Mechanism of Action	Effectiveness in Eutrophic Systems	Burnside Recommendations
Native Fish	<i>Biomanipulation via top-down control</i>	<i>Moderate – High minnow population may be suppressing desirable zooplankton.</i>	<i>Largemouth Bass stocking (>100 mm) may help reduce minnows if overwintering can be demonstrated. Determine whether Largemouth Bass stocked in 2025 survive until 2026 through spring (brief walk around) and summer (fish capture) surveys.</i>
Native Mussels	<i>Nutrient sequestration</i>	<i>Low – many native mussels sensitive to poor water quality.</i>	<i>Paper Pondshell may provide some filtration, but unlikely to contribute significantly.</i>
Zooplankton <i>(esp. Daphnia spp.)</i>	<i>Grazing on phytoplankton</i>	<i>Moderate to high – if predation and chlorides are controlled.</i>	<i>Analysis of zooplankton community recommended before considering stocking. Initial survey could serve as baseline to monitor changes cover Phase 2 activities.</i>
Macrophytes	<i>Nutrient sequestration, habitat</i>	<i>High local effect; supports DO and stability.</i>	<i>Further plantings not recommended until sustained periods of water clarity can be demonstrated.</i>
Habitat Complexity	<i>Increase habitat complexity</i>	<i>High – Placement of woody material (stumps with root mass and elevated logs) or boulder complexes may enhance available habitat for Largemouth Bass.</i>	<i>Swan Lake currently offers limited structural habitat. Establishment of a bass population may be aided by increasing habitat complexity through addition of woody debris complexes. Deepening not recommended – evaluate after spring / summer 2026 fish surveys to determine bass survivability.</i>

Nutrient Management

- *Construction of bioswale presents opportunity to further reduce internal nutrient levels*
- *Enhance the existing bioswale to provide opportunities to beautify section of Swan Lake*

Chloride Reduction

- *Maintain focus on source control (grit-separator rerouting, winter salt management, etc.)*
- *Target ≤ 120 mg/L Cl^- to aid restore zooplankton communities*
- *Reducing chloride inputs into Swan Lake is likely to improve biological / ecological conditions*

- *Creation of small bioswale-like structures at the outlets of SWM pond splitters or OGSs may provide opportunity to mitigate chloride inputs provided with the proper halophyte plantings (i.e., Cordgrass (*S. michauxianus*))*
- *Rerouting the stormwater outlets and OGSs present a hard-engineering option to chloride reduction*

Macrophytes Recommended by Burnside (Table 6)*Open Waters 0.5 m to 1.5 m Deep*

- *Pond Lily* *Nuphar variegata*
- *Water Lily* *Nymphaea odorata*
- *Pondweed* *Potamogeton richardsonii*
- *Pondweed* *Potamogeton pectinatus*

Shores and Waters to 0.5 m Deep

- *Wild Celery* *Vallisneria americana*

Shores and Waters to 0.25 m Deep

- *Arrowhead* *Sagittaria latifolia*
- *Cordgrass* *Sporobolus michauxianus*

10.0 Conclusion

Success of Swan Lake’s aquatic communities depends on improving water quality before attempting further biological restoration. Phase 1 has resulted in improved water quality from 2020; however, problems persist especially with elevated chlorides and internal nutrient load.

Further recovery may require

- 1) *Nutrient stabilization via bioswale*
- 2) *Chloride control by some means of reduction*
- 3) *Improvement to *Daphnia* spp. populations through reductions in chloride concentrations and selective predator stocking*

*Chloride-induced suppression of *Daphnia* spp. populations is likely exacerbating Swan Lake’s phytoplankton blooms. Increasing *Daphnia* spp. abundance can yield short-term improvements (< two years) in water clarity and phytoplankton control (Kibuye et al. 2021) and should be considered as part of broader lake-management planning. While some mechanism for chloride reduction is recommended, it alone will likely not resolve the issue. Creating or maintaining a population of Largemouth Bass may help to improve the *Daphnia* spp. populations through the reduction of Fathead Minnow. However, the current zooplankton community is unknown.*

Improvement to the water quality of shallow, eutrophic lakes, such as the case in Swan Lake, are impeded by its slow recovery, as it is hard for people to maintain interest (May et al. 2020). However, actions for the improvements of Swan Lake are promising, and should encourage managers to maintain support and interest.

C) NRSI: Elements of a Comprehensive Oxygenation Program

The following is an extract from NRSI's report on the review of management options and the effects of increased oxygenation in Swan Lake^(f).

7.0 Conclusions and Recommendations

Within Swan Lake, any management approach intended to increase DO concentrations must be designed not only to address existing DO deficiencies but also anticipate increases in biological oxygen demand (BOD) that will result from enhanced biological and microbial activity following oxygenation. As oxygen availability improves, aerobic bacteria, benthic invertebrates, and aquatic vegetation will become more active, increasing oxygen consumption and temporarily offsetting some of the initial gains in DO. Accordingly, any oxygenation strategy must account for these feedback effects and be implemented as part of a long-term, adaptive rehabilitation program. Importantly, effective DO enhancement within Swan Lake must also target the underlying causes of poor surface water quality,

Specifically, historic and ongoing nutrient and containment loading from high Canada Geese populations, stormwater inputs and the accumulation of nutrient-rich organic sediments. High organic matter concentrations, low sediment oxygen concentrations, and anaerobic bacterial processes may work against active oxygenation programs in Swan Lake. These conditions can consume oxygen more rapidly than it is introduced, thereby slowing the realization of measurable improvements reducing the effectiveness of direct oxygenation by continuously releasing nutrients and consuming available oxygen.

While active oxygenation can be highly effective in addressing short-term hypoxia and improving localized water quality, it rarely provides lasting improvements unless combined with integrated watershed and sediment management actions. Stand-alone oxygenation systems typically require continuous operation to maintain benefits, as discontinuation can lead to a rapid decline in DO concentration, often below pre-treatment level, due to increased BOD and residual nutrient release.

Increased oxygenation in shallow, nutrient-rich systems such as Swan Lake can lead to significant improvements, including:

- *Reduced internal nutrient loading and phosphorus release from sediments.*
- *Decreased bioavailability of heavy metals through oxidation.*
- *Improved surface water clarity and reduced frequency of harmful algal blooms.*
- *Enhanced biological diversity and productivity through improved aerobic habitat conditions.*

However, these benefits are typically realized gradually, as the system responds to improved redox conditions and enhanced biological cycling. Regardless of the oxygenation strategy employed, elevated biological oxygen demand (BOD) can also lead to a sudden decline in dissolved oxygen concentrations, potentially to levels lower than those observed prior to treatment, if oxygenation programs are discontinued without addressing the underlying causes of poor water quality. Effective long-term management will therefore require sustained oxygenation, regular monitoring, and adaptive operational adjustments to maintain DO levels sufficient to counteract high BOD and sediment oxygen demand.

7.1 Oxygenation Program Considerations

Oxygenation represents a viable and effective approach to improving surface water quality and aquatic habitat conditions within Swan Lake. Diffused aeration or fountain aeration systems would likely provide the most balanced combination of performance, reliability, and cost-effectiveness for this small, shallow, and nutrient-enriched lake. When paired with watershed-level nutrient management and ecological restoration efforts, these systems can form the foundation of a long-term strategy to enhance aquatic health, reduce eutrophication, and restore more natural lake function.

However, oxygenation alone will not fully address all water quality deficiencies or the underlying causes of degradation. To improve the effectiveness and sustainability of oxygenation measures, several key factors should be considered when developing and implementing an oxygenation program for Swan Lake.

- **Address Natural Mixing Limitations:** Any oxygenation program should aim to overcome the lack of natural circulation within Swan Lake to ensure adequate exposure of all areas to elevated DO concentrations.
- **Uniform Application:** Oxygenation should be applied uniformly across the lake to prevent the formation of localized hypoxic or anoxic zones.
- **Integrated Management Approach:** Oxygenation cannot resolve the underlying causes of poor surface water quality and should be implemented in conjunction with broader rehabilitation measures that address both historical and ongoing nutrient and contaminant inputs.
- **Continuous Operation:** Consistent, low-intensity operation is preferable to intermittent high-output cycles, as sudden fluctuations in DO can destabilize the system and increase BOD demand.
- **Hydrologic Connectivity:** Recirculation of water through the north channel is expected to provide only limited improvement in DO levels unless underlying nutrient concentrations are simultaneously addressed.
- **System Design:** System layout should provide full spatial coverage, including deeper basins and areas of low circulation, while avoiding disturbance of fine, nutrient-rich sediments.
- **Operational Schedule:** Continuous, steady operation will help maintain stable oxygen levels and minimize fluctuations in BOD and redox potential.

- **Monitoring Program:** Ongoing monitoring of DO, temperature, turbidity, and phosphorus concentrations should accompany installation to evaluate system effectiveness and inform adaptive management.
- **Integration with Rehabilitation Efforts:** Oxygenation should complement a broader restoration plan that includes sediment nutrient management, stormwater inflow treatment, and shoreline naturalization to improve long-term system stability.

In summary, successful improvement of water quality within Swan Lake will depend on an integrated approach that combines active oxygenation with nutrient load reduction, sediment management, and ecological restoration. These combined measures will enhance dissolved oxygen concentrations, promote stable redox conditions, and foster a more balanced and resilient aquatic ecosystem.

In Appendix A5, FOSLP outlines a proposed configuration for a comprehensive oxygenation program that will contribute to the management of sediment-based nutrients and enhance the aquatic environment within the lake.

Recently, the submerged aquatic plants that have taken hold in Swan Lake are expected to contribute to an increase in oxygen levels in the lake. Therefore, FOSLP recommends considering the implementation of the oxygenation enhancement techniques listed in Appendix A5 only if the expected improvement in oxygenation levels does not materialize.

Now that cyanobacteria levels are considered under control, FOSLP requests that the fountain be brought back near the dock area.



D) NRSI: Swan Lake Management Strategy Program Considerations

Following is an extract from NRSI's report on Swan Lake Management Options^(e) outlining their recommendations for a comprehensive oxygen, sediment and nutrient management program for Phase 2.

4.1 Swan Lake Management Strategy Program Considerations

Specific management and habitat restoration activities offer the potential to further support the improvement of water quality and aquatic habitat conditions within Swan Lake. These strategy considerations are intended to address some of the causes of degraded water quality conditions as opposed to addressing their symptoms, which support the foundation of an improved long-term strategy for Swan Lake to enhance aquatic ecosystem health, reduce eutrophication, and restore more natural lake function. Based on our understanding of the history of Swan Lake and its role in the wider stormwater system, both historic and ongoing high concentration nutrient loading is understood to be one of most significant factors contributing to the existing water quality conditions within Swan Lake. To support the enhancement of the surface water quality conditions within Swan Lake the following activities are proposed for consideration:

- **Comprehensive Oxygenation and Aquatic Vegetation Monitoring:** *It is understood that newly established aquatic vegetation communities within Swan Lake have the potential to naturally address previously identified low dissolved oxygen levels within Swan Lake. As such, supplemental oxygenation may no longer be an appropriate response to induce meaningful long-term improvements in surface water conditions. However, given the historic aquatic vegetation conditions it is important to monitor and track the establishment and overall condition of these aquatic vegetation communities and their implications to the overall dissolved oxygen conditions and generally support widespread aquatic ecosystem health.*
 - *The implementation of a standardized aquatic vegetation monitoring program would help to monitor for changes in the overall aquatic health, with dissolved oxygen condition monitoring included should aquatic vegetation communities not consistently establish. It is expected that the healthy establishment of new aquatic vegetation communities could significantly improve surface dissolved oxygen conditions and contribute to the improvement of overall surface water quality conditions.*
- **Sediment & Nutrient Management:** *Identifying and addressing the internal and external nutrient sources will directly influence long-term aquatic ecosystem condition stability. Mitigating and controlling the additional nutrient inputs that originate from stormwater and natural sources (e.g., goose droppings) is critical to addressing the underlying cause of the degraded aquatic ecosystem conditions in Swan Lake. While PAC and other phosphorus controlling chemical treatments temporarily help to mitigate surface water concentrations, it does not address the elevated concentrations within the sediment, nor does it influence long-term habitat stability. Following the*

implementation of targeted sediment and nutrient monitoring, the appropriateness of the additional chemical treatments can be further assessed.

An overall sediment and nutrient management strategy would support the characterization of overall sediment quality conditions throughout Swan Lake and support future management opportunities, including potential targeted sediment removal operations to address areas of significantly elevated sediment nutrient conditions.

While natural phosphorus loading from Canada Goose populations is understood to be short-lived, with most nutrients settling into the sediment, the Canada Goose monitoring and management operations completed to-date appear to have been effective at reducing resident goose populations, thereby helping to reduce additional external nutrient loading (Unckless and Makarewicz 2007). The continuation of these monitoring and management operations would support wider management and restoration operations and contribute to the improvement of surface water quality conditions.

A detailed sediment and nutrient management program, including the characterization of sediment conditions and the potential sediment and nutrient contributions into Swan Lake from upstream stormwater management facilities, as well as a detailed characterization of the sediment conditions throughout Swan Lake would help to direct restoration and management strategies. These would aid in addressing the underlying sources of degraded aquatic habitat conditions within Swan Lake and support the long-term improvement on surface water and aquatic ecosystem quality conditions.

- **Chloride Management:** *Chloride concentrations have declined somewhat but remain above the long-term exposure guidelines. Addressing the inputs from upstream stormwater management, either by addressing outflow to Swan Lake or through application of targeted chloride-reducing measures (such as biochar), is critical to achieving any long-term improvements in surface water and aquatic ecosystems quality. It is understood that the overall chloride targets are to be reexamined and potentially revised as part of the City of Markham's 2025 Water and Chloride Budget program. Additional supplementary filtration and chloride reduction programs similar to those recommended by the FOSLP as part of their December 2025 submission has the potential to significantly reduce Swan Lake's annual chloride loading, contributing to the overall improvement of the surface water quality conditions.*
- **Enhanced Monitoring Program:** *It is suggested that the water quality monitoring program be expanded and/or enhanced to include sediment quality monitoring (aligned with the Sediment Quality Guidelines for the Protection of Aquatic Life) and should consider the addition of sampling locations to help support the characterization of the existing conditions within Swan Lake, and to provide additional context for supplementary treatments and rehabilitative measures (such as limited targeted removal of contaminated or high concentration sediment*

deposits). Previous sediment monitoring, completed in 2020, was in line with the assessment of the risk of eutrophication but did little to assess the overall health and suitability of the aquatic ecosystem. Ideally, this monitoring would continue on an annual basis during and following any restoration and management activities to monitor changes in sediment conditions.

- **Shoreline Habitat Enhancement:** Shoreline restoration and plantings would help to support the development of aquatic ecosystem structure, stabilize the nearshore aquatic ecosystem conditions, and contribute to the ongoing aquatic vegetation establishment program. Enhanced riparian habitats would also help to mitigate some of the natural nutrient and sediment loading. Engaging the Toronto and Region Conservation Authority to advise and support shoreline enhancements, included as part of the FOSLP's December 2025 Markham's Swan Lake Water Quality Review, would strengthen the aquatic and shoreline enhancement program. But, as with other management strategies, shoreline enhancements would be most effective when implanted alongside measures that anticipated root causes of degraded water quality conditions, high nutrient concentration sediments.

It is understood that one management strategy being considered involves the removal of excessive nearshore invasive aquatic plants (e.g., phragmites), previously completed in 2022. Future aquatic vegetation removals have been proposed by the FOSLP to remove additional aquatic vegetation has the potential to contribute to further reducing internal organic nutrient loading going forward. However, given the high legacy concentrations of organic nutrients within the sediment, this proposed strategy would not provide a notable improvement to the overall conditions but would need to be applied along with other management strategies.

- **Algae Management:** The continuation of ultrasonic control measures, to inhibit algae bloom formation, has the potential to support natural ecosystem stabilization, improving surface water clarity and supporting aquatic vegetation growth. Similarly, direct algae treatment chemical applications have the potential to address the risk of algae blooms but would do little to address the perceived root causes of the degraded aquatic ecosystem within Swan Lake, the historic and ongoing high concentration nutrient sediments.

No single Swan Lake Management Strategy component will completely address the potentially degraded water quality or remove impediments to improving the conditions within the local aquatic ecosystem. However, the integration of a combination of these strategies has the potential to improve and enhance the overall sediment and water quality conditions and foster a more balanced and resilient aquatic ecosystem within Swan Lake. It is recommended that future Swan Lake Management Strategies consider the following components to enhance the effectiveness of individual management strategies and contribute to the improvement and enhancement of both sediment and water quality conditions within Swan Lake:

- Inclusion of a sediment quality monitoring program within Swan Lake and the adjacent Stormwater Ponds to characterize the existing conditions and support wider sediment

and nutrient management programs. It is recommended this program continues through Phase 2 and 3 to monitor for changes in sediment loading and quality conditions.

- *Implementation of an improved chloride management program, as identified as part of the City of Markham's 2025 Water and Chloride Budget program, and potential supplementary methods such as stormwater pond bypassing or filtration would help to address the elevated chloride concentrations recommendations. It is recommended this measure be implemented during Phase 2.*
- *Shoreline habitat enhancement and rehabilitation to contribute to the enhancement of aquatic habitat and nearshore aquatic ecosystem conditions, supporting the ongoing aquatic vegetation establishment program while mitigating some of the natural nutrient and sediment loading.*

5.0 Conclusions

Within Swan Lake the overall water quality monitoring program completed between 2021 and 2024 provides an appropriate, if scoped, high-level assessment of the water quality conditions as they relate to the risk of eutrophication. The parameters included as part of the overall Swan Lake Monitoring Program offer a high-level assessment of the potentially degraded surface water quality conditions and the effectiveness of the treatment and remediation activities as part of the overall Swan Lake Management Strategy. Based solely on the results of the water quality monitoring program, the existing management activities appear to have had some success at improving the water quality conditions within the lake. However, even though many of the water quality parameters met the identified guidelines/targets, several were still noted to be in exceedance. With that said, the high-level nature of the water quality parameters included as part of the monitoring program, and the guidelines applied as part of the annual analysis, limit the overall comprehensiveness of the monitoring program and the conclusions that can be drawn from observable water quality trends as they relate to the health of the aquatic ecosystem.

Given artificial nature of Swan Lake, its urbanized nature, and proximity to the local Stormwater Management Ponds, the monitoring guidelines established as thresholds for hyper-eutrophic conditions are attainable and reasonable minimum thresholds. Achieving these minimum thresholds would present an appropriate starting point to support future strategies as the management of Swan Lake moves from a restoration/mitigation to improvement/enhancement approach.

In addition, the eutrophication focus of the monitoring program limits the ability to address the effects of historic and ongoing nutrient and contaminant loading on aquatic ecosystem health or to assess the effectiveness of the treatment and remediation activities completed to-date. It is, therefore, difficult to properly identify and address the underlying sources of many of the surface water quality concerns.

The expansion and enhancement of the water quality monitoring program, including the additional sampling recommendations, would improve the comprehensiveness of the monitoring program and support greater refinement of the overall management and

restoration strategies for Swan Lake. This expansion and enhancement is recommended to include a combination of additional analysis guidelines (such as the PWQO, Recreational Water Quality Guidelines, and CCME Guidelines for the Protection of Aquatic Life), additional spring freshet and significant precipitation sampling events, and the inclusion of aquatic health-specific monitoring components (such as benthic macroinvertebrate, zooplankton, fish community composition, aquatic vegetation, or native herpetofauna)

E) NRSI: Water Quality Monitoring Program Enhancements

Following is an extract from NRSI's report on Swan Lake Management Options^(e) outlining their recommendations for enhancements to the water quality monitoring program.

4.0 Water Quality Monitoring Program Enhancements

While the overall Swan Lake Water Quality Monitoring Program, if applied correctly, is appropriate to meet the intent of a high-level eutrophic condition characterization, the opportunity exists to expand it to provide a more comprehensive and high-resolution water quality characterization to support the overall Swan Lake Water Quality Management Plan.

The following water quality monitoring program components are recommended for consideration to further refine the water quality monitoring program. These adjustments would help provide additional context to characterize the existing aquatic ecological conditions and ecosystem health. These recommendations include:

- *Additional spring freshet and significant precipitation event (i.e., wet event) sampling to account for potential stormwater input effects on surface water conditions;*
- *Inclusion of PWQO Guidelines alongside Swan Lake Monitoring Program guidelines;*
- *Inclusion of Recreational Water Quality Guidelines for water clarity;*
 - *Inclusion of minimum and maximum water clarity readings, alongside the applicable targets/guidelines, as part of the annual water quality analysis to detail the range in conditions;*
- *Inclusion of CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life guidelines for parameter analyses;*
- *Completion of all water quality monitoring components identified as part of the Swan Lake Monitoring Program on an annual basis;*
 - *A summary of omissions or alterations in monitoring from workplan components outlined as part of each annual report;*
- *Include complete bi-weekly water quality results as part of each annual report, along with explanations for any gaps in water quality sampling coverage;*
- *The inclusion of aquatic health-specific monitoring components to increase the comprehensiveness of the monitoring program.*
 - *Annual aquatic health monitoring can include the inclusion of benthic macroinvertebrate, zooplankton, and fish community composition, aquatic vegetation biomass, or composition assessment, herpetofauna nesting and overwintering assessment.*

F) References/ Links to Full Reports

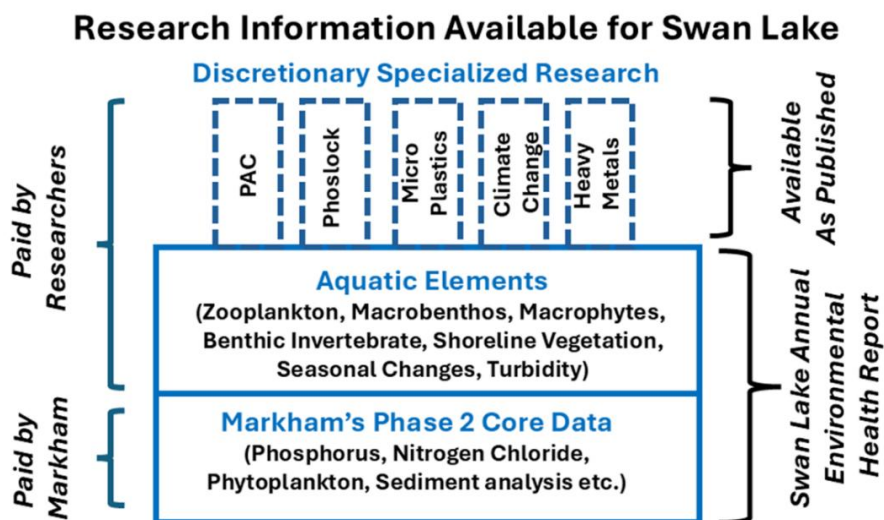
- a) Swan Lake Long-term Water Quality Plan, City of Markham, November 2021
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- b) Consolidated Report, Swan Lake Flow Diversion Assessment, AECOM, May 2025
[Agenda Package - Markham Sub-Committee_Jun18_2025.pdf](#)
- c) Swan Lake Water Flow and Chloride Analysis, Markham, November 3, 2025
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- d) Swan Lake Aquatic Conditions Review, R.J. Burnside, February 26, 2026
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- e) Swan Lake Long Term Management Plan, Natural Resource Solutions Inc. March 9, 2026
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APPENDIX A: FOSLP BACKGROUND REPORTS

A1): Outsourcing of Environmental Health Card

Friends of Swan Lake Park has held discussions with researchers from York University and Trent University about integrating their research efforts in a manner that would address Markham’s needs for monitoring of the water quality in Swan Lake through Phase 2 (2026 – 2030) of the water quality plan. This section outlines a proposal for an integrated water monitoring program for Swan Lake that would be managed by the York and Trent researchers and provide Markham with a comprehensive annual Environmental Health Card for Swan Lake.

This collaborative approach provides Markham with the opportunity to support the development of the next generation of leading Canadian researchers while addressing its needs for quality information on the water conditions in Swan Lake. The following chart illustrates the proposed relationship.



Collection of Water Quality Data During Phase 1

During Phase 1 of the Swan Lake water quality plan (2021 – 2025) Markham staff undertook physical water sampling. The samples were gathered initially biweekly and then monthly throughout Phase 1 but were physically limited to near shore areas – the dock and the bridge. The analysis included measures of inorganic elements such as phosphorus, nitrogen and chloride plus biological measures of phytoplankton and microcystins. Lab analysis was undertaken at the York-Durham Regional Environmental Laboratory in Pickering, Ontario. Markham staff documented their findings into a water quality report submitted to the Markham Subcommittee each year.

Other investigations into the aquatic health of the lake included an inventory of fish in the lake by the TRCA from 2022 – 2024 commissioned by Markham and an assessment of the Benthic Invertebrate in 2022 by an independent contractor engaged by FOSLP.

In 2025, Trent University researchers, led by Dr. Huy Dang, collected water samples to support their research on the impact on the aquatic food chain of lanthanum and aluminum originating in the Phoslock and Poly Aluminum Chloride treatments. Monthly from May to October, Scott Stebbing, a researcher from Trent, collected high-resolution vertical profiles of water quality data (pH, redox potential, oxygen level, electrical conductivity, chlorophyll-a for algal concentrations and phycocyanin as a surrogate for blue-green algae) from 10 locations throughout the lake. In addition, continuous monitoring devices were installed at a single location in the lake to collect hourly data on chlorophyll and oxygen levels from May to November 2025. They also collected samples of macrophytes, plankton, invertebrates, tadpoles, and fish for elemental analysis.

From May to December, researchers from York University undertook drone monitoring of the water quality in Swan Lake. This process provided a seasonal analysis of the changes in chlorophyll, turbidity and suspended solids throughout the growing season in all areas of the lake.

In 2026, the York and Trent researchers initiated an exercise to share data gathered via physical sampling and drone sensing to develop an integrated assessment and cross validation of the water quality measurements for 2025.

Proposed Phase 2 Environmental Health Card

The researchers from York University and Trent University have the capacity to provide Markham with an annual “Environmental Health Card” of Swan Lake based on a comprehensive monitoring program. The data collection process will be designed to meet Markham’s basic needs for Phase 2 plus the elements essential to continuing research needs. Agreement amongst the parties is required but the following list illustrates some of the expected core components:

- a) Periodic physical water samples, taken by drones, which would provide:
 - i. Monthly or Bi-weekly drone images and physical samples. Number of locations and depths to be discussed.
 - ii. Measures of Inorganic Elements consistent with Markham’s previous analysis plus any additional measures required for Phase 2 monitoring.
 - iii. Measures of variety and density of phytoplankton consistent with Markham’s previous analysis
 - iv. Measures of the variety and density of zooplankton
 - v. Annual measures of diversity of Macrobenthos and Benthic Invertebrate
 - vi. Annual measures of diversity and quality of fish.
- b) An assessment of lake-wide patterns based on drone monitoring to provide a seasonal analysis of the changes in chlorophyll, turbidity and suspended solids, throughout the lake integrated with the findings derived from the physical samples.
- c) An assessment of the coverage and density of macrophytes and shoreline vegetation.

Benefits to the Contributing Parties:

For Markham:

- a) An annual analysis of the core elements essential to monitoring Phase 2 management actions.
- b) Receipt of a comprehensive lake-wide Environmental Health Card on the water quality throughout the growing season, an analysis beyond Markham's current capabilities.
- c) An assessment of the extent and state of the macrophytes within the lake
- d) Outsourcing of a labour-intensive process to parties motivated to undertake quality driven processes.
- e) An opportunity to support the development of the next generation of research talent and advance Canada's environmental research into freshwater systems.

For Researchers,

- a) The opportunity to refine processes related to the integration of drone monitoring with traditional physical procedures for monitoring water quality.
- b) Solid baseline water quality data required to support their advanced research on the impact of heavy metals, microplastics and other elements on aquatic life.
- c) Access to a local water body to support their ongoing research that enables advanced training and global knowledge translation for the next generation of research scientists.
- d) A long-term, consistent testing framework that enables research teams to train and sustain quality research staff and refine processes while providing insight into long-term factors and trends impacting the lake.

Contribution of the Parties:

The researchers will be responsible for providing the human resources, equipment and other physical resources required to:

- a) Undertake the drone imagery and the collection of physical water samples
- b) Analyze the contents of the water samples – either in their own labs or through external organizations such as the York-Durham Regional Environmental Lab
- c) By February 28th of each year, submit an annual report to Markham summarizing the water quality findings of the previous growing season with comparisons to changes from previous years.

Markham will be required to provide:

- a) An outline of expectations for the minimum data collection and related analysis required in the annual report. For Phase 2, Markham's aquatic advisor has recommended the basic testing requirements as:
 - Bi-weekly reporting on elements that monitor eutrophication and chloride
 - Monthly reporting on phytoplankton
 - Monitoring of oxygen levels
 - Periodic monitoring of Total Suspended Solids (TSS) and total metals
 - Periodic monitoring of sediments
 - Possible event-based or winter monitoring
- b) An annual financial contribution to be negotiated.

A2) Options For Ending Swan Lake's Stormwater Management Role

Why High Levels of Chloride Matter

Swan Lake is a former gravel quarry with no natural surface level inflows nor outflows but there are six stormwater sources that direct almost three tonnes of chloride each year into the lake. In 2025, there were 17.4 tonnes of chloride in Swan Lake.

Chloride does not break down and will accumulate within the lake over time, impairing the health of aquatic plants and many forms of aquatic species.

The Federal government's Canadian Water Quality Guidelines ("CWQG") for chloride were established based on the sensitivity of 28 different species to chloride levels. Current levels of 200 mg/L of chloride in Swan Lake are well in excess of a safe environment for most of the species, including zooplankton, on which the federal guidelines were based.



Zooplankton are a beneficial element in freshwater because certain species consume phytoplankton (microscopic algae and microbes).

A healthy zooplankton colony would be an important contributor to controlling algal growth, but the high level of chloride is undermining the existence of zooplankton in Swan Lake.

Research by McClymont¹ concludes that the CWQ Guidelines are too high to adequately protect zooplankton communities. The study's findings were that "At the CWQG (120 mg Cl/L), zooplankton abundances and biomasses were reduced by 30% - 77% ..." and notes that other studies have associated low zooplankton levels with increased phytoplankton abundance and increased frequency of harmful algal blooms and the risk of cyanobacteria.

In 2018, several Canadian environmental associations asked the Ontario government to create an Ontario water quality guideline for chlorides to address the shortcomings of the Federal guidelines.

In their report, R. J. Burnside^(d) notes that Zooplankton, especially Daphnia spp, are the dominant grazers of phytoplankton in temperate waters like Swan Lake however current levels of chloride are above the chronic exposure range for some Daphnia species. In 2020,

¹ The Effects of Increasing Chloride Concentration and Temperatures on Freshwater Zooplankton Communities, A.C. McClymont, Queen's University, 2020

a researcher from Queens University came to Swan Lake to take samples of *Daphnia* but was unable to detect any.

Burnside notes that it is possible to stock zooplankton species but recommends that an inventory first be taken to determine which species have survived in Swan Lake before undertaking a stocking program.

Other studies suggest high chloride levels can lead to lower oxygen levels by diminishing aquatic plant life. Controlling oxygen and chloride levels opens up more natural biomanipulation options for the management of water quality in Swan Lake.

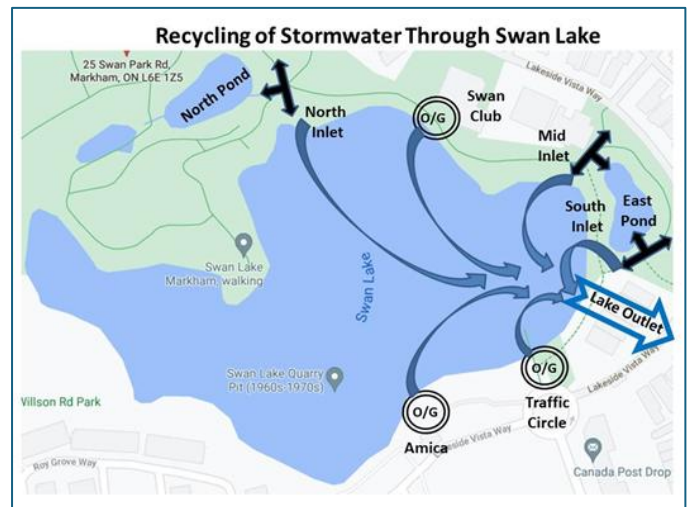
In their study of the water quality issues in Lake Wilcox in Richmond Hill Ontario, University of Waterloo researchers identified chloride as one of the factors contributing to the release of nutrients from the sediment.

A successful rehabilitation plan requires addressing the chloride levels with the goal of restoring a healthy zooplankton community.

1) Sources of Chloride

In November 2025, Markham released the Swan Lake Water and Chloride Budget^(c) which estimated the annual inflow of chloride for the 3-year period 2022 – 2024 from the six sources averaged 2.95 tonnes per year.

In March 2025, Markham released the Flow Diversion Assessment report^(b) by AECOM that estimated the volumes of stormwater entering the lake from three Oil Grit Separators (“OGS”) and from three inlets carrying stormwater that bypasses the two stormwater ponds.



2) Eliminating Chloride Inflows

The Flow Diversion Assessment outlined options for reducing the stormwater inflows. Approximately 85% of the chloride entering Swan Lake could be eliminated by:

- Rerouting 100% of the flows of the three Oil Grit Separators (“OGS”) that account for 56% of the chloride entering the lake.
- Reducing the remaining 44% of chloride that enters the lake in stormwater bypassing the stormwater ponds by 66%.

The Flow Diversion Report estimated the total cost at \$2.2 million. FOSLP estimates that by using a lower cost “parkland” route, the costs of rerouting the OGS flows could be reduced by 33%, an alternative not considered in the Flow Diversion Assessment. Details of the lower cost options are provided in Appendix A3.

The estimated combined costs of a Parkland Route and alterations to the flow splitters is \$1,567,960, a reduction of \$588,000 while still reducing inflows by 85%.

	Original Estimate	Parkland Route		
		Cost Estimate	Potential Chloride Reduction	Cost Per Tonne
Rerouting Amica/TC OGS Flows	1,757,025	1,168,101	1.41	828,441
Rerouting Swan Club OGS Flows	275,072	275,072	0.25	1,100,287
Adjust Flow Splitters	124,787	124,787	0.86	145,101
Totals	2,156,884	1,567,960	2.52	622,206

3) Complementary Options for Reducing Chloride Inflows:

Reducing flows bypassing the two stormwater ponds is the most cost-effective approach. At a cost of \$125,000, chloride inflows could be reduced by 30%. Unfortunately, both ponds remain under the control of the original developer so Markham cannot implement these changes until they “assume” responsibility for the ponds.

Rerouting the OGS flows is expensive, and staff have recommended deferring these costs pending further assessment of the chloride levels during Phase 2.

There are, however, some low-cost options that could be implemented during Phase 2 that would reduce the impact of chloride and address some of the chloride already in the lake.

a) Bioswales at the Stormwater Inlets and the North Channel

There are shoreline plants, halophytes, that are effective at absorbing chloride and nutrients. Burnside has recommended that bioswales containing halophytes be created around the shorelines near the stormwater sources. Periodic harvesting and removal of these plants every 2 – 3 years would remove the chloride, phosphorus and nitrogen from the ecosystem.

In 2023, phragmites was removed from the eastern shoreline. It is expected that contributed to the reduction of phosphorus, nitrogen and chloride during that period.

b) Biochar Filtration

Researchers from York University are testing the use of Biochar to remove chloride and nutrients from samples of water from Swan Lake and are prepared to undertake a field test of the use of Biochar to remove chloride during Phase 2.

i. Filtration of OGS Stormwater Flows

Flows from the three Stormceptor oil grit separators release directly into the lake. Keeping the OGS units in place serves an important function by removing the heavy contaminants that would clog the filtrate. The goal is to capture flows from the OGS units and filter the flows before they enter the lake.

The lake is regulated to a depth of 208.3 m above sea level. The filtration process requires a vertical drop of the stormwater through the filtrate.

OGS Unit	Elevation	Above Lake
Amica	208.23	-0.09
Traffic Circle	208.25	-0.05
Swan Club	208.94	0.64

Only the Swan Club OGS unit appears to have the elevation needed to support a filtration chamber. Markham has estimated that the Swan Club OGS unit attributes on average 0.25 tonnes per year, or 8% of the total entering the lake. There are three options for the reducing chloride inflows the Swan Club OGS unit:

- a) Reroute flows to the North Pond at cost of \$234,468 - \$275,072
- b) Adding a Biochar filtering processes between the OGS unit and the lake to capture the chloride before it enters the lake
- c) Create bioswale including halophytes, harvest periodically.

Swan Club OGS Outlet

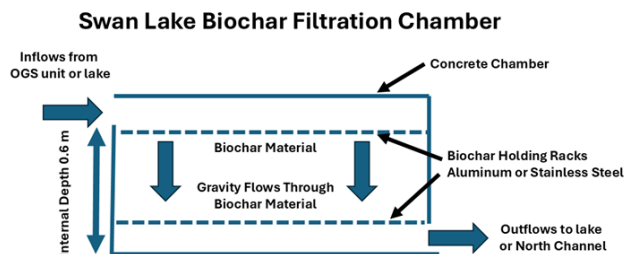


ii. Filtration of Chloride Already in the Lake

The second application of the Biochar filtration process would be to add a filtration unit as part of the process of recycling water through the North Channel. This would remove chloride, phosphorus and nitrogen from the lake water.

Water from the lake would initially be pumped into the filtration unit and then flow out to the North Channel.

A similar structure could be installed to filter flows from the Swan Club OGS unit.



A3) Refinements to Flow Diversion Report

In March 2025 Markham released a Flow Diversion Report^(b) outlining possible ways in which the stormwater flows into Swan Lake could be rerouted away from the lake. Markham staff^(c) have estimated that each year the stormwater inflows contribute 3 tonnes of chloride (5 tonnes of road salt) each year. The Flow Diversion Report outlined viable options that could reduce inflows by 86%.

There are three scenarios outlined in the Flow Diversion Report that warrant further analysis:

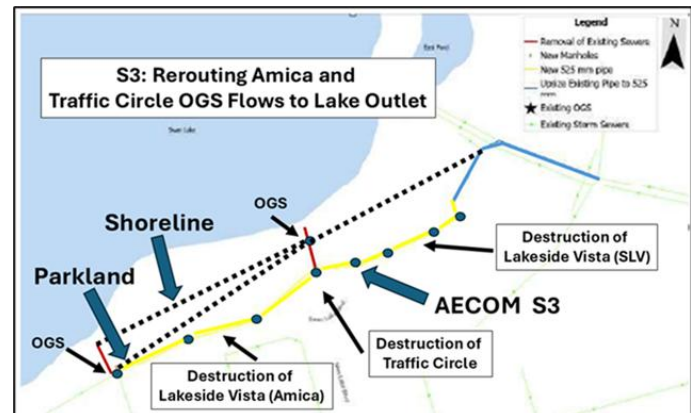
- A) S3: Reviewing the route and costs of rerouting the Amica and Traffic Circle OGS flows to the lake outlet via the park, rather than along the roadways.
- B) S4: Reviewing the costs related to rerouting the Swan Club OGS units to the North Pond, and
- C) S5: Revising the analysis of the benefits and back flow risks associated with altering the design of the flow splitters at each pond.

A) S3: Alternative Parkland Route

FOSLP estimates that the costs of rerouting the Amica/ Traffic Circle OGS flows could be reduced by 34% by using a “Parkland Route”, an alternative not considered in the Flow Diversion Assessment.

The S3 estimates for the Amica/ Traffic Circle OGS units assumes destruction and replacement of three area roadways, replacement of six manholes and relocation of related utilities.

A lower cost alternative route is available through the park area, ending at the lake outlet. It provides minimal disruption to road services, avoids area utilities and minimizes restoration costs. Assuming parkland restoration costs for parkland areas at 33% of the cost of restoring the roadways, the total costs can be reduced by \$588,000.



The Amica OGS unit is in the middle of Amica’s driveway. Removal of this unit will disrupt the roadway in that area and require repair. However, it is possible to avoid these costs by leaving the OGS unit intact and installing a new catch basin unit to capture the stormwater flows before it enters the lake. This would require a new collector, so while the Shoreline Route may be less disruptive, it may be only marginally cheaper.

The Traffic Circle (“TC”) OGS unit is already in the park so it can be removed without significant roadway repair costs and without impacting local utilities so there would seem to be no benefit to leaving it in place. The costs of installing new catch basins, rather than replacing existing, may also result in further cost reductions.

Costs Savings Using Parkland to Reroute OGS Units

S3: Amica OGS to Lake Outlet	Roadway		Parkland Route	
			Adjustment	Total
Supply & Install Stormsewers	674,830	38%	100%	674,830
Supply & Install Maintenance Holes	202,449	12%	100%	202,449
Allowance for catchbasin replacements	50,612	3%	100%	50,612
Sewer Replacement Costs	927,891	53%		927,891
Utility Reconnection	101,225	6%	0%	-
Restoration of Roadway/Parkland	727,909	41%	33%	240,210
Total Costs	1,757,025	100%		1,168,101
% Original Cost				66%

B) S4: Swan Club to North Pond

The S4 route is already substantially within the park area. The Swan Club OGS unit is in a parking lot, so removal will require repair to the paved area. It may be possible to leave the OGS unit in place and pick up the stormwater inflows before they enter the lake to minimize repair costs. Again, the savings may not be material.



The S4 estimate included costs for relocating utilities etc. that are not relevant, but the estimate may require an adjustment to reflect repair costs to the park pathways and parkland areas.

S4: Swan Club OGS to North Pond	Original		Parkland Route	
			Adjustment	Total
Supply & Install Stormsewers	180,375	66%	100%	180,375
Supply & Install Maintenance Holes	54,113	20%	100%	54,113
Allowance for catchbasin replacements	13,528	5%	100%	13,528
Sewer Replacement Cost	248,016	90%		248,016
Utility Reconnection	27,056	10%	0%	-
Restoration of Roadway/Parkland	-	0%		27,056
Total Costs	275,072	100%		275,072

Revised Cost Estimates

The estimated combined cost of a Parkland Route and alterations to the flow splitters is \$1,567,960, a reduction of \$588,000 while still reducing inflows by 85%.

	Original Estimate	Parkland Route		
		Cost Estimate	Potential Chloride Reduction	Cost Per Tonne
Rerouting Amica/TC OGS Flows	1,757,025	1,168,101	1.41	828,441
Rerouting Swan Club OGS Flows	275,072	275,072	0.25	1,100,287
Adjust Flow Splitters	124,787	124,787	0.86	145,101
Totals	2,156,884	1,567,960	2.52	622,206

C) S5: Addressing Potential Flow Splitter Concerns

The issues arising from the report related to adjusting the flow splitters is not related to costs, rather a review of ways to mitigate any risks associated with the various options. Our request is that certain scenarios be run to ensure that any changes to the design minimizes back flow risks.

The report notes that raising only the weirs may introduce some “basement flooding risk” in the East Pond area but did not indicate which inlet was of concern. There was no similar concern expressed about the North Pond area. As noted on pg. 53 (S5b), upsizing of the pond inflow pipes “reduces the backwater caused by the limit of the 450 mm pipe”, suggesting that the basement flooding risk is avoided.

Three aspects of the S5 analysis be revisited to identify the options that will minimize risks.

a) Confirm that the Model Appropriately Reflects the Existing Configuration

It is not clear from the report that the analysis reflects the differences in the design of the three inflow strictures for the three splitters. The North Pond Splitter and South Splitter in the East Pond have comparable designs, just differences in the size of the circular inflow pipes. However, the North Splitter in the East Pond, which serves the largest catchment area, has a materially different box culvert inflow structure.

The 2.4 m x 0.9 m Box Culvert is comparable to a 1650 mm diameter circular pipe in terms of area, though the flow management impact is likely different. Our request is to confirm that the Box Culvert structures were appropriately reflected in the analysis.

Dimension of System Serving Inflows to Flow Splitters

	North Pond	East Pond	
Catchment Area	12.6 ha	19.3 ha	
Splitter Details		South	North
Inflow System to Splitter	1050 mm	675 mm	Box Culvert 2.4 m x 0.9 m
Outlet to Pond	450 mm	450 mm	450 mm
Outlet to Lake	1050 mm	675 mm	1.8 m x 0.9 m
Current Flows to Lake (m3)	2,573	1,360	4,310
Potential Reduction	65%	45%	74%
Estimated Flows (m3)	892	750	1,107

b) Alter the Sequence of Changes

The analysis assumed a sequence of first raising the weirs and then enlarging the pipes. An analysis of the reverse sequence should be undertaken.

Only enlarging the inflow pipes to the pond should not add to backflow pressures so an assessment of the benefits of increasing the pipes sizes as the initial step, without raising the weir height, would provide a benchmark of the benefits arising from the lowest risk option.

The additional benefits or additional risks associated with increasing the weir height can then be assessed.

c) Assess the Benefits/Risks of Incremental Changes to the Weir

The North Pond weir could be raised by 0.2 m, but the analysis only increased the weir by 0.1 m. The design of the East Pond will support an increase in the weir height by 0.3 m but that was the only option considered. An analysis of the impact for each splitter of increases in weir height by increments of 0.1 m to the maximum height should highlight the safest options.

Other Areas That May Require Further Analysis**i. East Pond and Foundation Collector System (“FDC”).**

It is our understanding that the FDC system upstream from the East Pond serves homes in the immediate area adjacent to the East Pond and operates independently of the collector systems that feed into the East Pond. Therefore, we question the concerns about the impact of raising the weirs on basements in the immediate area but agree that a “connectivity test” should be undertaken before implementing the changes.

ii. North Pond

On pg. 41, the report notes that “it remains uncertain whether the surcharge conditions in the downstream sewer of the North Pond, along Williamson Road, would impose any restrictions on pond outflows. Such restrictions could potentially impact the effectiveness of the upgrade options. The capacity of the downstream sewer on Williamson Road is not analyzed in the study, further investigation is required to confirm the downstream condition.”

The outflow mechanism from the North Pond will not be altered and it is not clear that any of the proposed changes would impact the conditions or issues downstream nor impact the effectiveness of the proposed changes. During a heavy rainfall event, a deterioration of the effectiveness of the proposed changes should not be a material concern since bypass flows are expected under those conditions.

Determine if any additional analysis is warranted related to the North Pond before proceeding with changes.

A4) Understanding the Role of Groundwater

Historical documentation attributes the creation and maintenance of lake levels at approximately 208.0 MASL from the mid-1970’s to the mid-1990’s to local groundwater sources.

In June 2025, Markham Council agreed that as part of the Official Plan review, to consider FOSLP’s request that Swan Lake and Swan Lake Park be reclassified as Natural Heritage Lands. Both satisfy the criteria due to their biodiversity however Swan Lake also meets the technical criteria set out in Markham’s Official Plan and the Ontario guidelines for “Key Hydraulic Features”.

Within Natural Heritage systems, major water bodies are considered significant natural sources for recharging the aquifer.

Evidence gathered during Phase 1, indicates that the groundwater may be a significant factor that should be factored into lake management discussions. Three factors need to be investigated;

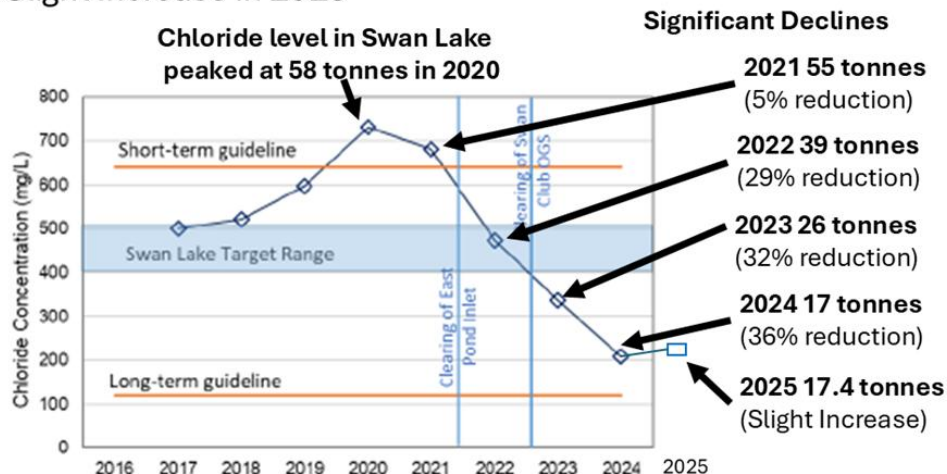
- a) The impact of “flushing” by groundwater.
- b) The chemical elements in the groundwater.
- c) The Impact, if any, of rerouting stormwater flows away from the lake on lake levels.

a) Impact of Flushing

Chloride levels in Swan Lake rose dramatically from 2018 – 2020. This was attributed to a blockage in one of the pipes in the North Splitter in the East Pond which prevented stormwater flows from entering the East Pond which resulted in a significant increase in untreated stormwater flows directed into the lake. Since this blockage was cleared, chloride levels have declined significantly and have levelled off but there are still over 17 tonnes of chloride active in the water column.

Even after the blockage was cleared, the annual chloride inflows are estimated at 3 tonnes. Despite significant annual additions in chloride, there was a material drop in chloride levels from 2020 through 2024 with a slight increase in 2025.

Significant Decline in Chloride Levels 2021 - 2024
Slight Increase in 2025



Inflows reduced once blocked pipe cleared. Reasons for reductions are not clear.

The decline in chloride levels illustrates the dynamics of the factors influencing the lake.

The 2024 water monitoring report attributes the decline to a reduction of inflows of road salt due to unclogging of input sources plus “dilution by cleaner water”.

Two factors need to be considered in understanding “dilution”:

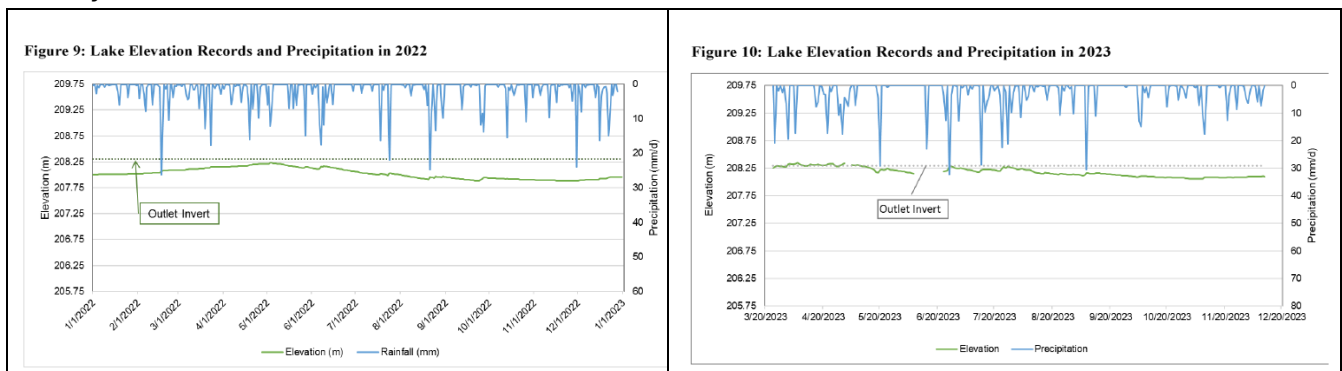
- i) Where did the chloride already in the lake go?
- ii) Where did the “freshwater “ come from.

i. Where Did Chloride Already in the Lake Go?

Water leaves the lake three ways:

- Evaporation (no impact on chloride)
- Lake outlet (will remove chloride)
- Groundwater (will remove chloride)

During 2022 and 2023 chloride levels declined approximately 30% each year. However, the lake levels during the late spring and summers of 2022 and 2023 were very low and there was very little outflow through the stormwater outlet. The chloride laden water had to go somewhere so the groundwater was the only outflow option that could account for such a significant decline during those years.



The summer of 2024 was cooler with greater levels of precipitation and higher lake levels than in 2022 and 2023, but chloride levels continued to decline, suggesting the impact of both groundwater and loss through the lake outlet.

ii) Where Did the Freshwater Come From?

“Dilution” requires that the outflow be replaced by freshwater. In November 2025, Markham staff released a “Water and Chloride Budget”^(c) model for Swan Lake that indicates that water loss to evaporation from the lake exceeded the volume attributable to direct precipitation.

Towards a Sustainable Naturalized Wetland

For the period 2009 – 2024, the lake lost on average 17% more to evaporation than it gained from direct precipitation.

In the hot, dry summers of 2022 and 2023, precipitation minus evaporation was unlikely the source of freshwater.

Impact of Natural Elements 2009 - 2024			
	Direct Precip	Evap oration	Precip less Evap
Annual	37,302	- 46,887	- 9,585
Dec - May	16,802	- 15,992	810
June - Nov.	20,500	- 30,895	-10,395
Percent of Lake Volume	33%	-49%	-17%

The water budget analysis calculated the average water flows for the period 2009 – 2024. The “balancing” entry incorporates amounts not directly attributable to identified sources and implicitly incorporates the impact attributable to groundwater (“Balance”). The Flow Diversion Report estimated the lake volume at 62,640 m³, so the net inflows attributed to groundwater (and other factors) represents on average a net inflow of 16% of the lake volume.

Month	Balance	Balance		Precip less Evap
		Inflows	Outflows	
Jan	- 2,082	-	2,082	1,677
Feb	- 1,037	-	1,037	1,277
Mar	- 174	-	174	8
Apr	846	846	-	312
May	4,917	4,917	-	4,206
Jun	5,297	5,297	-	4,060
Jul	4,212	4,212	-	5,159
Aug	2,490	2,490	-	3,356
Sep	1,109	1,109	-	1,186
Oct	- 1,756	-	1,756	1,810
Nov	- 1,663	-	1,663	1,556
Dec	- 2,300	-	2,300	2,366
Annual	9,859	18,871	- 9,012	- 9,585
Dec - May	170	5,763	- 5,593	810
June - Nov.	9,689	13,108	- 3,419	- 10,395
Percent of Lake Volume	16%	30%	-14%	-15%

The net monthly groundwater (“Balance”) inflows occur during the summer months when water is lost to evaporation. It appears the lake levels are stabilized by groundwater inflows during the summer.

A breakdown of the “Balance” values indicates that groundwater inflows were averaging 30% of the lake volume while groundwater outflows averaged 14% supporting a conclusion of the “flushing” impact of groundwater on the lake system.

These monthly numbers reflect the net changes in water flows per month. We do not know the gross inflows into the lake, nor the gross outflows each month. So, the “flushing” action is likely significantly greater than 30%.

The outflow portion will take the chloride and other elements away from the lake while the groundwater inflows may contribute other elements, including chloride.

During Phase 2, an analysis of the groundwater elements and flow impacts is required to determine the potential “balance” between lake elements and elements inflowing from groundwater sources.

b) Contents of Groundwater

It has been suggested that the levelling off of chloride levels in the lake in 2024 and 2025 may reflect an “equilibrium” point between external sources and groundwater sources.

The lake was created naturally by groundwater but there is no data on the contents of contaminants in the groundwater entering Swan Lake. An analysis of the contents will help determine what is the natural “equilibrium” point attainable through lake management options. This is particularly relevant in relation to the contaminants being directed into the lake by the stormwater system. Chloride is the most notable, but there may be other elements as well.

Two activities are required to understand the natural equilibrium of the lake:

- 1) More information on the contaminants entering the lake via the stormwater system
- 2) Testing of groundwater sources to determine what are the natural influences on the lake. This will help understand the “floor” values that are attainable through lake management activities.

c) Impact on Lake Levels

Concern has been expressed that rerouting 35,000 m³ of stormwater away from the lake may have a negative impact on lake levels.

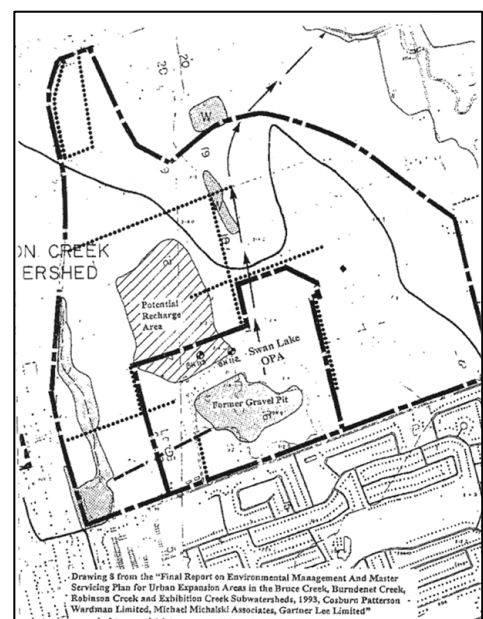
Markam’s recent water flow analysis provides estimates that suggest lake outflows consistently exceed any inflows from the stormwater system.

Month	Stormwater System	Lake OutFlow	Net Inflows (Outflows)	Percent of Lake Volume
Annual	35,121	- 38,644	- 3,523	-6%
Dec - May	14,546	- 17,153	- 2,607	-4%
June - Nov.	20,575	- 21,491	- 916	-1%

Historical Assessment of the Impact of Groundwater

The lake filled naturally in the 1970’s and existed in a stabilized state for more than 20 years before the stormwater system was introduced.

The adjacent chart was included in a Peto MacCallum report identifying the “potential recharge area” which extends into the north-west portion of the park.



The following section, extracted from a November 1993 report by Peto MacCallum Ltd., outlines the natural state of the lake prior to the introduction of the stormwater system.

2.1.1 Site Settings and Land Use History

The site is located within a broad physiographic region known as the Peel Plain, a level-to-undulating tract of clay soils. Its principal physiographic feature is the Markham-Pickering till plain, a bevelled, partly drumlinized and fluted plain. The Pleistocene geology of the area has been shaped by glacial activity. The native soils consist of a sandy to clay bouldery till locally underlain by sand and gravel deposits. Historically, these deposits have been extracted as a source of road base granular out of the Groves gravel pit which formerly operated on the site.

Locally, the physiography of the site has been altered by relatively large volumes of fill materials stockpiled around the lake. Geodetic ground surface elevations range between approximately 205 and 221 m over the site.

Surface drainage in the area generally occurs through the Little Rouge Creek tributaries of the Rouge River which flow southeastwards. However, there are no obvious surface drainage outlets from the lake. Surface flows are generally directed southwestwards and away from the site. ***Hydrogeological records of water wells on the site indicate static groundwater table elevations ranging between 207 and 209 m. The elevation of the water level of the lake is approximately 208 m, confirming that the lake probably originated from groundwater within the same aquifer.*** An analysis of static water level elevations indicates that the regional groundwater flow is directed southwestwards or southwards with an average hydraulic gradient of about 1%. ***[Emphasis added]***

Historically, gravel extraction operations on the site began as early as the 1850s. However, the operations were phased out during the 1870s when the site was acquired by the Grove family. In 1962, the gravel operations resumed out of the Grove Pit under the ownership of Warnock and Johnson. Groundwater was struck around 1970 and the pit became a lake. Shortly thereafter the gravel pit operations discontinued.

2.2.2 Groundwater

Seepages of groundwater were observed in boreholes 3,4,5 and 6 during drilling. Groundwater, probably regional, was encountered in all of the boreholes with the exception of boreholes 7, 8, 9 and 13 and observation well 4. Groundwater was encountered in test pits 5, 9,10, 11, 12, 17, 18, 33, 39, 40, 43 and 44. Depths to groundwater/wet cave ranged between 1.0 and 7.6 m below grade. ***By November 3, 1993, approximately five weeks after installation, the groundwater levels stabilized at 2.7 to 5.7 m below grade, elevation 208.0 +/-, in observation wells 2,3,4 and 5. In observation well 1, the water level was noted to be close to the ground surface on that date.*** An analysis of the static water level elevations indicated that in November, 1993, the regional groundwater flow was directed southwestwards with an average hydraulic gradient of about 1%. ***[Emphasis added]***

A5) Comprehensive Oxygenation Program for Swan Lake

In its report^(f) on oxygenation options for Swan Lake, Natural Resource Solutions Inc. (“NRSI”) outlined the potential benefits of a comprehensive oxygenation process for Swan Lake.

NRSI noted that oxygenation represents a viable and effective approach to improving surface water quality and aquatic habitat conditions within Swan Lake. When paired with watershed- level nutrient management and ecological restoration efforts, these systems can form the foundation of a long-term strategy to enhance aquatic health, reduce eutrophication, and restore more natural lake function.

NRSI concluded that increased oxygenation in shallow, nutrient-rich systems such as Swan Lake can lead to significant improvements, including:

- Reduced internal nutrient loading and phosphorus release from sediments.
- Decreased bioavailability of heavy metals through oxidation.
- Improved surface water clarity and reduced frequency of harmful algal blooms.
- Enhanced biological diversity and productivity through improved aerobic habitat conditions.

Within Swan Lake, NRSI stated that any management approach intended to increase Dissolved Oxygen (“DO”) concentrations must be designed not only to address existing DO deficiencies but also anticipate increases in biological oxygen demand (BOD) that will result from enhanced biological and microbial activity following oxygenation.

NRSI outlined key factors to consider in the design of a comprehensive oxygenation system:

- **System Design:** System layout should provide full spatial coverage, including deeper basins and areas of low circulation, while avoiding disturbance of fine, nutrient-rich sediments.
- **Uniform Application:** Oxygenation should be applied uniformly across the lake to prevent the formation of localized hypoxic or anoxic zones.
- **Continuous Operation:** Consistent, low-intensity operation is preferable to intermittent high-output cycles, as sudden fluctuations in DO can destabilize the system and increase BOD demand.

The following section outlines a proposed configuration for a comprehensive oxygenation program based on NRSI’s analysis that will contribute to the management of sediment-based nutrients and enhance the aquatic environment within the lake.

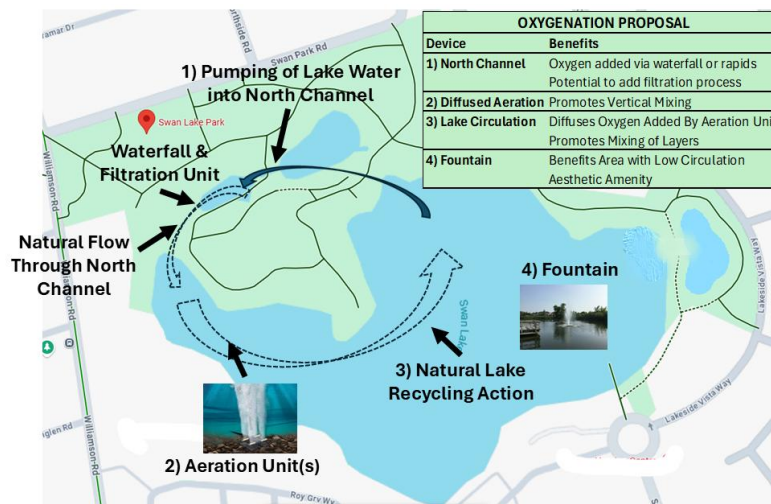
The submerged aquatic plants that have recently taken hold in Swan Lake are expected to contribute to an increase in oxygen levels in the lake. Therefore, FOSLP recommends considering the implementation of the following oxygenation enhancement techniques only if the expected improvement in oxygenation levels does not materialize.

Based on NRSI’s guidance, FOSLP’s comprehensive oxygenation system contains four components that will incorporate the critical design recommendations.

Four Components

Benefits

1) Recycling Lake Water Through the North Channel	a) Oxygen added through the North Channel b) Potential to add filtration mechanism using Biochar or Chlorocel in the North Channel to remove nutrients and chloride.
2) 1 – 2 Aeration units near the deeper areas in the lake	a) Primary source for new oxygen b) Mixing of the layers locally
3) Circulation throughout the lake created by North Channel recycling	a) Disperses oxygen from the aeration units b) Mixes layers within the lake
4) Fountain Near the Dock	c) Adds oxygen in an area not likely impacted by North Channel circulation d) Returns a popular lake amenity



Examples of Aeration Options

Bubblers

Bubblers add oxygen and will mix the layers.

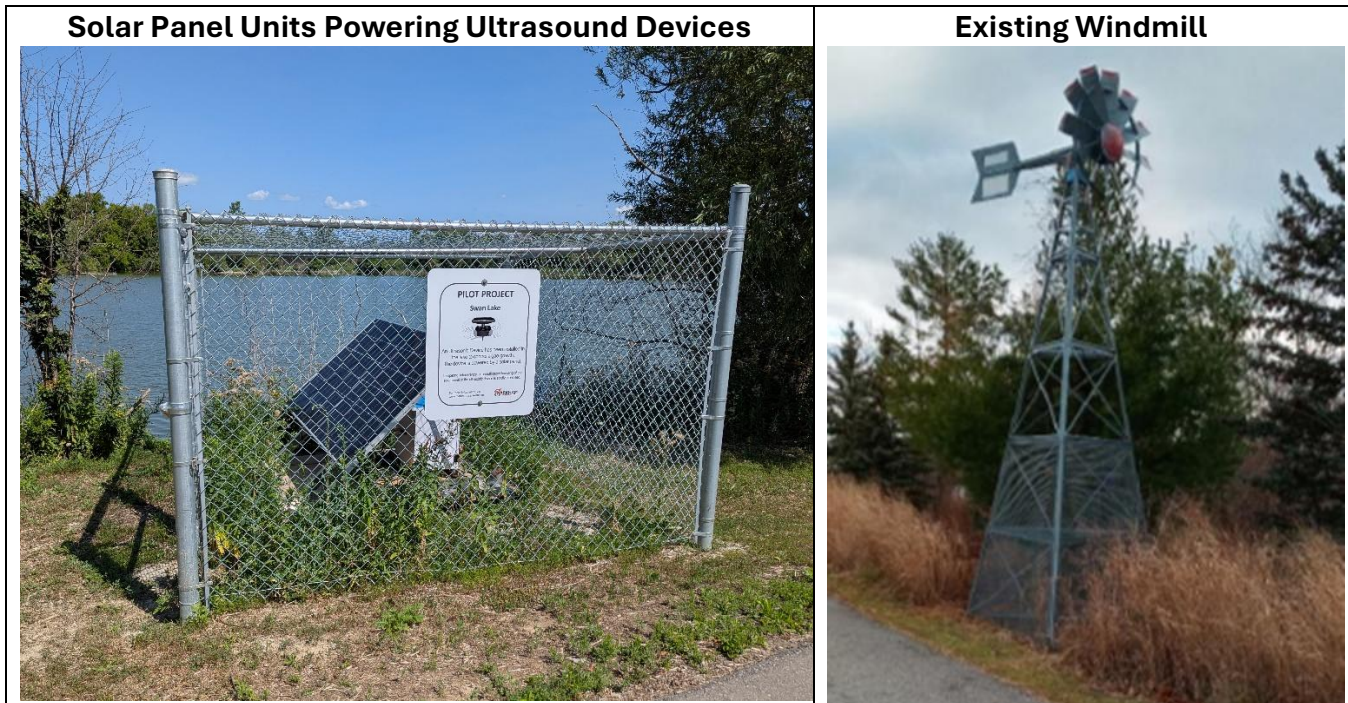


Solar Bee® Lake Circulators

Active lake circulation can be limited to only the top layer or to treat the bottom water.



The units would be operational consistently from April through November powered by the new solar panel complex on the Amica shoreline and repurposed windmill.



Recycling through the North Channel

The North Channel, about 100 metres long, is designed as an emergency spillway for overflow from the north stormwater pond (SWP #104); however, it has rarely been used. The channel is typically dry, though during wet periods it will hold water from the runoff from the surrounding parkland.

Removing water from the lake and returning it through the North Channel to the lake oxygen enhanced with possibly fewer nutrients could provide a natural enhancement to the water quality in the lake and reduce the dependency on future chemical treatments. A small portion of the channel is a bioswale which it may be possible to extend. It also may be feasible to circulate water from the lake into Turtle Inlet, creating a decorative waterfall. Turtle Inlet is a small, shallow inlet that has potential to be enhanced as a bioswale.

Pumping Options

It is essential to clarify the primary objectives of recycling water via the North Channel and Turtle Inlet:

- a. If the emphasis is primarily oxygenation of the lake, then a high-volume pump may be required.
- b. If the emphasis is a combination of filtration and oxygenation, then pumping lower volumes in line with the capabilities of the filtration process will be needed.
- c. If the bioswale is the primary tool for filtration then very low flow rates may be required.

Swan Lake contains approximately 80,000 m³ of water. To recycle that volume over the 7-month period from April – October period would require a pump capable of pumping 360 m³ /24 hour.

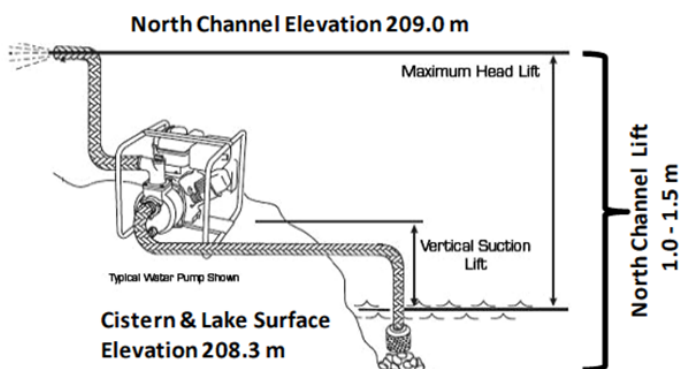
A small “cottage” style pump (1.0 – 1.5 hp), connected to a continuous power source, could recycle 13% - 54% of the lake water through the North Channel.

Driven by either solar sources or by repurposing the existing windmill on the north pond, assuming 50% efficiency, the small pumps would have the capability to recycle 7% - 27% of the 80,000 m³ of lake water over the summer months which may be sufficient for a filtration process.

Greater lake circulation and improved levels of oxygenation could be achieved if industrial scale pumps, such as those used by Markham’s stormwater management department, were deployed. With more powerful pumps, it may be possible to recycle more than 100% of the lake water through the North Channel each season.

To reduce the energy required for the pumps it may be feasible to create cisterns at the start of the North Channel and near Turtle Inlet. The distance from the edge of the lake to the North Channel or Turtle Inlet is approximately 50 - 100 m. A downward sloping pipe from the lake to the cistern could provide a gravity-fed mechanism for getting lake water to the North Channel or Turtle Inlet without pumping. Water in the cistern will rise to the level of the lake water. Pumps would be required to raise the water from the cistern to the North Channel or to a waterfall.

It may be possible to install a filtering process as the lake water enters the cistern.



The eastern end of the North Channel is at an elevation of 209.0 m. or 0.7 m. above the regulated lake level.

Depending on the location of the intake head within the cistern, the maximum head lift height to the North Channel surface is expected to be 1.0 – 1.5 m.

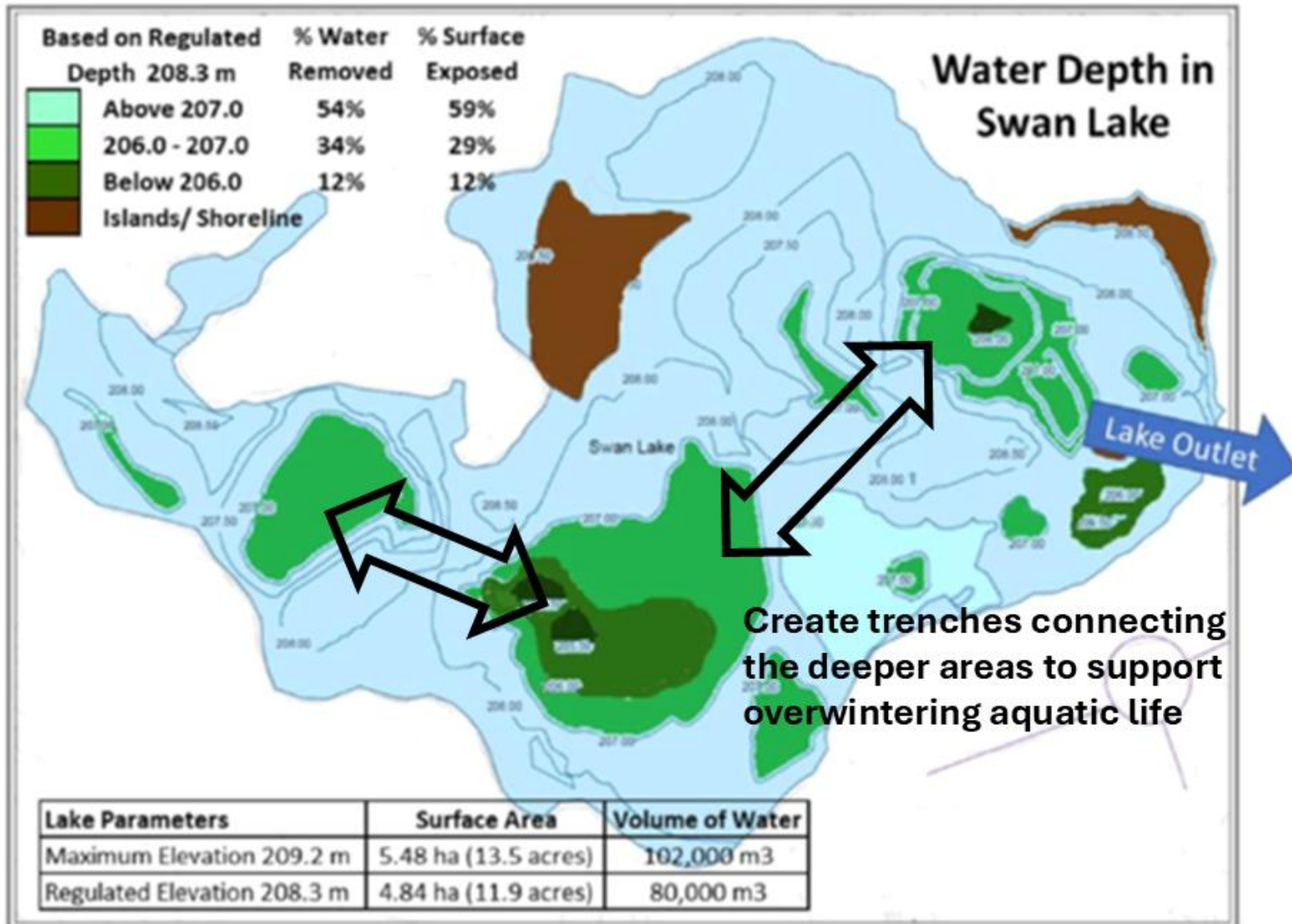
Creation of a decorative waterfall into Turtle Inlet may provided a means for increasing oxygenation content and could be accomplished by pumping the water 5 m higher to approximately 214.0 m.

Regulating Rates of Flow To Minimize Disruption of Sediments

In discussions during Phase 1, concern had been raised that circulation through the lake would stir up the sediments, causing the release of more nutrients from the sediments and increasing turbidity. Any potential impact of flows disrupting sediments can be minimized in two ways:

- 1) By dispersing the inflow sources. Water can be picked up in 2-3 different locations in the north-east area of the lake, dispersing the inflow.
- 2) The rate of flow through the North Channel can be regulated by the pumping actions. In the initial year of operation, a low rate of flow to would minimize any possible disruption. The flow action may initially alter the pattern of the sediments. Flow rates can be increased in subsequent periods based on any observed impact on turbidity.

A6) Creating Overwintering Haven for Aquatic Species



APPENDIX B: PHASE 1 ACTIVITIES

B1) Lake Management Outcomes

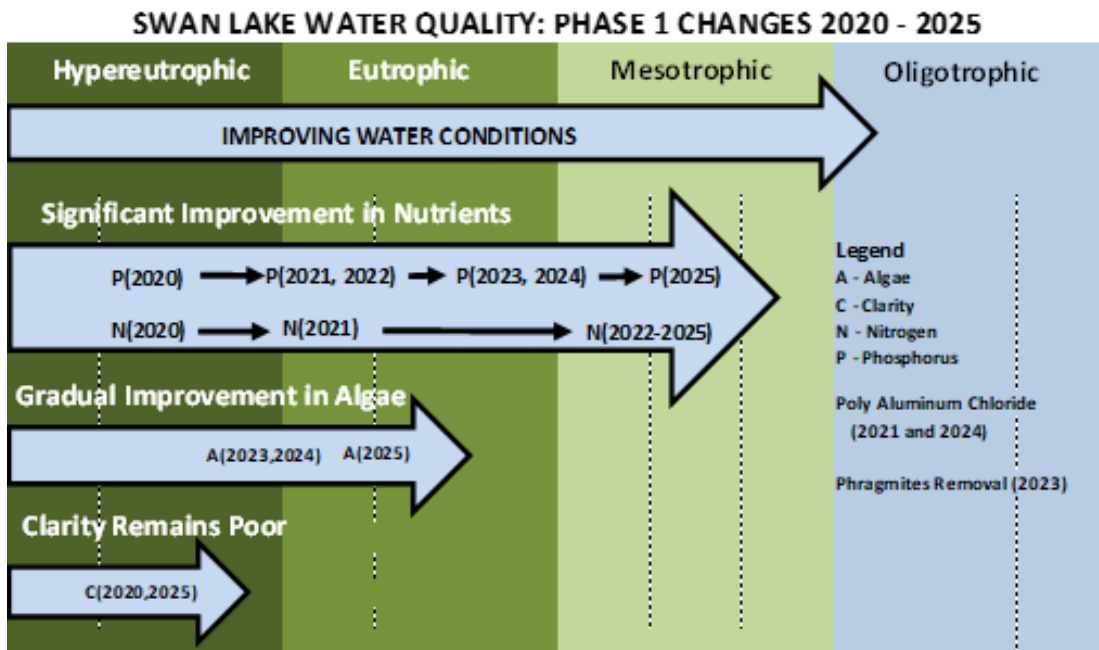
Swan Lake has a history of algal blooms and in 2020 a high level of cyanobacteria was reported. Phase 1 actions were primarily focussed on reducing algae and cyanobacteria through a program targeted to reduce two nutrients essential to the growth of algae, phosphorus and nitrogen. It was stated that the reduction in phosphorus and nitrogen would lead to a reduction in algae and improvement in oxygen levels.

Through their droppings, Canada geese were considered to be the primary “external” source of phosphorus and nitrogen entering the lake. A geese management program was implemented to reduce both the summer resident geese population and to reduce the number of geese staying on the lake during the migration season.

The sediments were considered to be the primary storehouse of nutrients already in the lake. Two treatments of polyaluminum chloride (“PAC”) were applied in 2021 and 2024 to reduce the “Internal” source of phosphorus.

In 2022, the TRCA was engaged to remove phragmites from the eastern shoreline of the lake and the North Pond. It is likely that the harvesting of these reeds contributed to the reduction of phosphorus, nitrogen and chloride in the ecosystem during this period.

Phase 1 activities resulted in a significant decline in phosphorus, nitrogen and cyanobacteria; however, only limited progress was made in reducing algal levels in the lake. Clarity and turbidity remain poor.



FOSLP is recommending that Phase 2 actions be focussed on sustaining the improved nutrient levels but with additional actions that will directly reduce the high levels of chloride, algae and improve turbidity with enhancements to support the aquatic habitat.

Aquatic Plants

During the review discussions, Markham provided the following summary of aquatic plants identified during the past two years. The full report has yet to be released.

“During the second PAC application in 2024, significant amounts of aquatic vegetation comprised primarily of Small Pondweed (*Potamogeton pusillus*) were observed and at times hindered the movement of the application boat. This was the first observation of any significant amounts of submerged aquatic vegetation in the lake. In 2025, a comprehensive survey was conducted to characterize the existing aquatic plant community. The survey found that SAV was abundant throughout the lake with generally moderate to high robustness (cover) at depths less than 2 m, and variable cover from high robustness to absent at depths greater than 2 m. The plants were dominated by the native species including Muskgrass (*Chara* spp.) and Canada Waterweed (*Elodea canadensis*) and lower abundances of Small Pondweed and Curly-leaved Pondweed (*Potamogeton crispus*). The newly established SAV community is consistent with improved water clarity and reduced algae levels in recent years. ”

In 2024 the TRCA was engaged to plant wild celery (*Vallisneria americana*) to establish a test base for macrophytes. The program has had limited success with only 30% of the plants taking hold and only those in shallow water. The TRCA attributes the poor results to fluctuating water levels and poor clarity in the water.

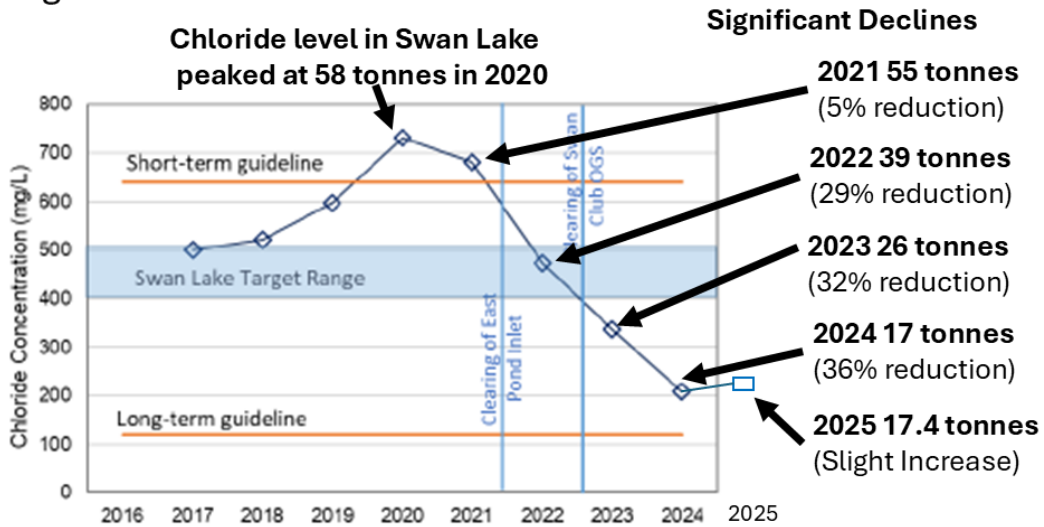
Significant Decline in Chloride Due to Flushing Action

Swan Lake has no natural surface level inflows nor outflows but there are six stormwater sources that direct almost three tonnes of chloride into the lake each year. Chloride does not break down and will accumulate within the lake over time, impairing the health of aquatic plants and many forms of aquatic species.

The other notable change during Phase 1 was a significant decline in chloride levels in the lake. The chloride levels in Swan Lake rose dramatically from 2018 – 2020. This was attributed to a blockage in one of the pipes preventing stormwater flows from entering the East Pond and resulting in a significant increase in flows directed into the lake. Since this blockage was cleared, chloride levels have declined significantly and have levelled off but there are still over 17 tonnes active in the water column and more stored in the sediments.

Though reduced, chloride levels remain well above the Federal guidelines for safe aquatic life.

Significant Decline in Chloride Levels 2021 - 2024
Slight Increase in 2025



Inflows reduced once blocked pipe cleared. Reasons for reductions are not clear.

The decline in chloride levels illustrates the ability of the stormwater outflows and the groundwater system to flush chloride from the lake. Markham’s Flow Diversion Assessment^(b) has identified actions that could reduce stormwater inflows into the lake by 85%. If implemented, it is possible that the flushing action could reduce the existing chloride levels below the Federal guidelines, an essential step in stabilizing aquatic life in the lake.

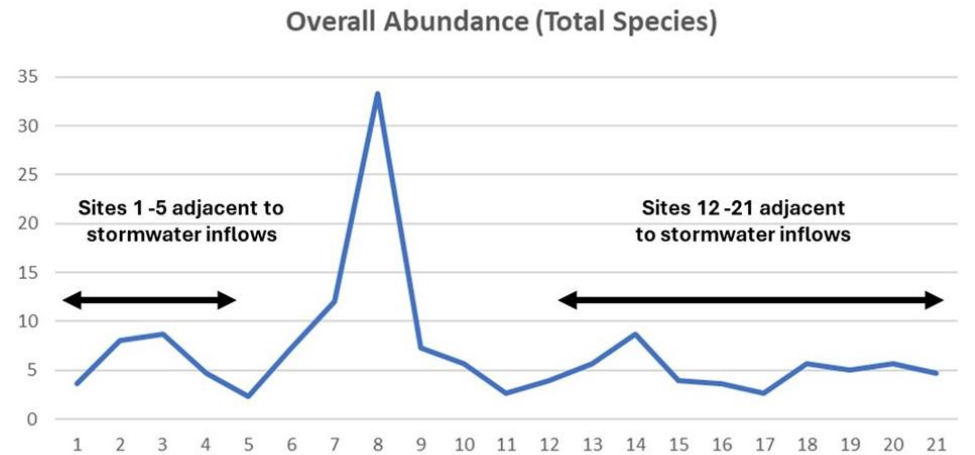
FOSLP is requesting that Phase 2 include an analysis of the natural chloride levels in the groundwater entering Swan Lake. This information will provide a baseline as to what level of chloride would be sustainable if external stormwater sources were removed.

B2) Phase 1 Lake Monitoring

Throughout Phase 1, there were several groups with different perspectives involved in monitoring the water quality and habitat in Swan Lake.

Markham took physical water samples on a routine basis throughout Phase 1. Initially tests were taken bi-weekly and lately monthly at two near-shore locations at the dock and bridge. The focus was on monitoring the nutrients, oxygen, phytoplankton and other organic elements with the goal of assessing the eutrophication level of the water and the success of various management actions. The Markham program included an annual fish inventory program undertaken by the TRCA but did not attempt to monitor aquatic elements such as zooplankton and Benthic Invertebrate. There was some testing of the sediments in 2020 to help with the design of the chemical applications.

Presence of Ephemeroptera (Mayfly), Plecoptera (Stonefly) and Trichoptera (Caddisfly), or EPT, are indicators of good water quality and overall ecosystem health. In 2022, FOSLP engaged Chris Reeves to undertake an inventory of the Benthic Invertebrate. He observed that significantly fewer species were identified in areas adjacent to the stormwater sources but overall concluded that given the taxa found and percentage of EPT species identified, Swan Lake could be rated as fair or intermediate water quality based on his findings.



Dr. Huy Dang of Trent University provides oversight into work by researchers from Trent, Laval University and the Institut National de la Recherche Scientifique (Quebec City) who have been active in Swan Lake over the past three years. Their focus has been on the impact of the heavy metal elements in the chemicals used to reduce phosphorus (Phoslock and Polyaluminum Chloride) on aquatic life.

In 2025, researchers from Trent gathered extensive data including temperature, oxygen (two depths) and chlorophyll over time with very high resolution and have compiled vertical profiles of various parameters (pH, temperature, oxygen, redox, and electrical conductivity) at 10 sites around the lake. This data will be released in 2026 once the research is published.

In 2025, researchers from York University partnered with Friends of Swan Lake Park to form the Swan Lake Citizen Science Lab (“SLCSL”).

The objective was to bring advanced technical capabilities of drone monitoring, artificial intelligence, Virtual Reality and simulation to bear on the environmental elements in Swan Lake and Swan Lake Park.



Throughout the growing season, SLCSL project leader, Dr. Ali Asgary collected drone-based multispectral imagery of Swan Lake. The drone imagery provides the basis for three water quality measures:

- 1) Normalized Difference Chlorophyll Index (NDCI)
- 2) Normalized Difference Turbidity Index (NDTI)
- 3) Normalized Difference Water Index (NDWI)

The drone imagery can detect chlorophyll, but it cannot differentiate whether the source is algae or aquatic plants. The researchers from Trent and York undertook to work to integrate their physical and drone imagery to align the drone techniques with the physical monitoring program.

B3) TRCA Phase 1 Activities and Recommendations

The Toronto and Region Conservation Authority (“TRCA”) was involved in three core lake management activities during Phase 1:

- a) The TRCA undertook a fish inventory program that included the removal of certain “bottom feeding” and invasive species that were considered to be undermining the Phase 1 program.
- b) Phragmites was removed in the fall of 2022 along the eastern shoreline and at the North Pond. It is likely that the removal of these reeds also resulted in the removal of phosphorus, nitrogen and chloride from the lake system. No estimate has been made of the potential reductions.
- c) The TRCA was engaged to plant wild celery (*Vallisneria americana*) to establish a test base for macrophytes. The program has had limited success with only 30% of the plants taking hold and only those in shallow water. The TRCA attributes the poor results to fluctuating water levels and poor clarity in the water. No mention was made of the potential impact of chloride levels.

In addition, Markham engaged the TRCA to advise on shoreline enhancements. The TRCA outlined their recommendations for shoreline enhancements and “Restoration Opportunities” at a public meeting on April 26, 2022.



The TRCA’s 2022 recommendations included:

- a) An invasive plant species removal program for phragmites and dog-strangling vine.
- b) An outline of shoreline restoration opportunities that would address the lack of emergent aquatic, terrestrial native plants, shrubs and shallow water habitat.
- c) Revegetation of the shoreline to create a diverse naturalized shoreline.
- d) Recommendations for the installation of additional stonework along the shoreline to limit geese access.

- e) Recommendations for reducing degradation of the shoreline by park users by controlling park visitors access to the lake by installing recreational nodes.

As part of the program to constrain access for the geese, Markham staff proposed the installation of permanent fencing as a geese deterrent, rather than the more costly stone work program proposed by the TRCA.

At the June 2025 meeting of the Markham Subcommittee, Kathleen Elizabeth Noel outlined her concerns about the impact of the fencing on the habitat and staff agreed to discuss the issue with the TRCA before proceeding.



Photo courtesy of Cindy Fowler

Subsequently, staff proceeded with the installation of cedar post and paddle board fencing in 2025 noting that design provisions were made regarding wildlife concerns. The project will also entail the planting of approximately 200 native plants to form a low-growing natural border.

In 2024, FOSLP requested that Markham proceed with a scaled down version of the TRCA recommendations for recreational nodes, requesting that two (N1 & N5) rather than four nodes be added to the shoreline, plus requested an additional viewing area (E4) on the western shoreline be added to serve park visitors in the western section of the park.

Markham staff recommended against the installation of recreational nodes due to equity with other parks. There are, however, only two other parks containing a major water body. FOSLP is requesting that these additional enhancements be implemented during Phase 2.

FOSLP Proposed Shoreline Amenities May 2024



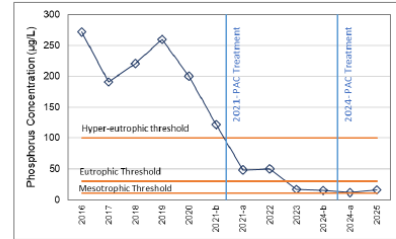
B4) Preliminary Water Quality Results (February 2026)

The following details preliminary water quality results were released by Markham staff during discussions on Phase 2 plans.

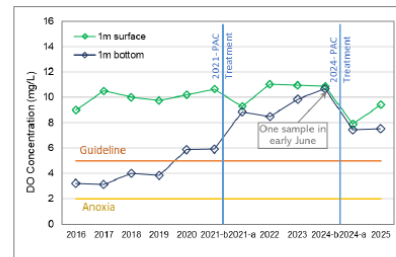


Water Quality- Nutrients and Oxygen

- Total Phosphorus:
 - Average under 30 µg/L during growing season (within Mesotrophic condition)
 - Decreased after each treatment
- Total Nitrogen:
 - Average below 0.65 mg/L during growing season (within Mesotrophic condition)
 - Dominant forms not bioavailable
- Dissolved Oxygen:
 - Surface concentration > 5 mg/L all year
 - Bottom concentration showed a decline during dry months
 - Observed anoxia is spatially limited, episodic, and confined to a small deep-water area



Phosphorus



Dissolved Oxygen



Water Quality- Algae and Clarity

- Algal growth:
 - Surface bloom very limited since treatment
 - Recent Cyanobacteria cell numbers declined significantly since treatment
 - Chlorophyll-a within eutrophic state and below Health Canada chl-a indicator value for potential presence of cyanotoxins above primary contact recreational guidelines
- Clarity: Mostly within target, average growing season met target



Algal bloom before treatment (photo from July 2020)



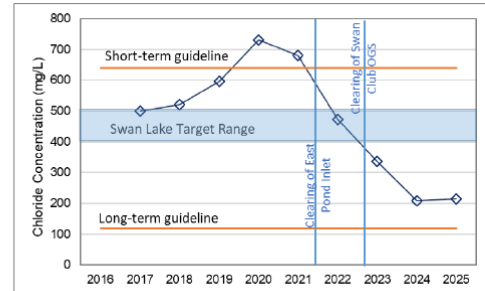
Very limited surface bloom since treatment (photo from July 2025)





Water Quality- Chloride

- Chloride enters the Lake through winter maintenance:
 - Swan Lake Village Corporation
 - City roads
 - Residents north of the Lake
 - AMICA Corporation to the south
- Previously on upward trend likely due to blockages, which resulted in untreated flows to the Lake
- Since 2021 decreased due to clearing the blockage at the East Pond inlet and Swan Club OGS
- Long-term guideline derived to protect *the most sensitive life stage of the most sensitive aquatic species* over the long term



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Fish Management

- Removing bottom-dwelling fish to prevent sediment disturbance.
- Fish in the Lake included Common Carp, Brown Bullhead, and Fathead Minnow.
- 500 juvenile largemouth bass added in May 2025.



Bass stocked in May 2025

Submerged Aquatic Vegetation

- 3000 stems of wild celery planted in fenced locations on the north site in 2023 and 2024
- Naturally growing aquatic plants were also abundant in 2024 and 2025
- Further SAV planting will be assessed through the five-year review process
- 2025 survey indicated SAV was abundant throughout the lake



Aquatic Vegetation Survey in July 2025

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Program Outcomes

- Significant improvements in water quality and habitat have been realized, including aquatic vegetation and fish community
- Water quality now consistently meets expectations for shallow urban water bodies
- Innovative technologies and academic research are actively being evaluated
- Phase 1 of the Long-Term Management Plan has successfully met all established goals and targets.

Strategic Plan – 2020 to 2026
Building Markham's Future Together



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