Environmental Services

Swan Lake Water Quality Monitoring 2025 Annual Report

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List of Acronyms

DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
GIS	Geographic Information System
LED	Light Emitting Diode
MASL	Meter Above Sea Level
MDL	Method Detection Limit
OGS	Oil and Grit Separator
OMNRF	Ontario Ministry of Natural Resources and Forestry
PAC	Poly Aluminum Chloride
SAV	Submerged Aquatic Vegetation
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
TRCA	Toronto and Region Conservation Authority
VAC	(Swan Lake) Village Amenities Committee
WHO	World Health Organization

Executive Summary

Background

Swan Lake is situated in the City of Markham at the intersection of Sixteenth Avenue and Williamson Road. Swan Lake has an approximate area of 5.3 ha and a maximum water depth of 4.0 m from the edge of the Lake at 209 meters above sea level (masl). At an average elevation of about 208.2 masl (estimated or measured over the last decade), the lake maximum depth is 3.2 m and surface area is about 3.9 ha.

A gravel pit in the 1960s and 1970s, Swan Lake is currently a community feature with multiple trails and urban development surrounding it.

Several issues were discovered with Swan Lake in 2010, including high phosphorus levels and significant algal blooms during the summer months, which led to low oxygen levels and degraded fish habitats. A Phoslock treatment was administered in 2013 to reduce the phosphorus levels and algal blooms in Swan Lake.

In 2019, the City of Markham conducted a study to define a Water Quality Management Strategy for Swan Lake. The Strategy, finalized in July 2020, recommended a chemical treatment in 2021. In August 2021, 13 tonnes of Poly Aluminum Chloride (PAC) were applied to the Lake in a controlled manner over several days.

The Swan Lake Long-Term Management Plan, which was developed based on the 2019 Strategy and extensive consultation with stakeholders, was received by the Markham Sub Committee in November 2021 and approved by the Council in December 2021. It describes a phased adaptive approach, including Core, Complementary and Alternative measures, and periodic reviews to adapt the Plan to the Lake conditions.

This report summarizes management activities completed in 2025 and discusses observations at the monitored stations in the Lake throughout 2025.

Water Quality Management Activities

Core measures identified in the Long-Term Management Plan were implemented as planned from 2021 to 2025, including a second application of PAC in 2024 and planting of additional submerged aquatic vegetation following the PAC application, as it was expected that the improved water clarity following treatment would help establish the plants. A geese management program, a fish inventory and the removal of bottom-dwelling fish were completed annually.

In May 2025, 500 juvenile largemouth bass were stocked in the Lake following consultation with TRCA, MNRF, and by a private contractor. Fish stocking was identified as a Complementary measure in the 2021 Plan. This measure was brought forward to help balance the Lake's fish community.

Following the successful use of ultrasound technology to control algal blooms in a stormwater management pond in Markham, two similar units were installed at Swan Lake to further improve water clarity.

The Flow Diversion Feasibility Study was completed and the chloride treatment pilot project continued in 2025. Findings from the Flow Diversion Feasibility Study along with information on salt usage and chloride concentrations in runoff were used to update the water and chloride budget in anticipation of the Phase 1 Review.

As outlined in the 2021 Long Term Management Plan, a 5-year Review is being conducted. This Review summarizes the effectiveness of Core measures and evaluates additional Complementary measures to be considered in Phase 2.

Results- Lake Water Quality

Water quality monitoring of Swan Lake has been conducted annually since 2013 (except for 2014) to track water quality and the continued effectiveness of lake management efforts. The collected data presented in this report is part of the ongoing monitoring program that will allow for continuous assessment of the water quality in Swan Lake and will be used to implement and adapt the Long-Term Management Plan for Swan Lake.

Water quality is regularly monitored at two shoreline sites: the Dock and the Bridge, on a bi-weekly basis (from April to November). The Dock site is representative of deeper areas of the lake, while the Bridge site reflects shallow water conditions. Samples and measurements are taken at 0.5 m or 1 m increments for the depth of the lake. A level logger is used to record the water level in the Lake. A Dissolved Oxygen (DO) logger was also installed 1 m from the Lake bottom at the Dock site to record the diurnal changes in DO. In 2025, samples were also collected near the two ultrasound transducers (identified as the West and East units) to assess the effectiveness of the technology. Fewer samples were collected and analyzed in 2025 due to low water level at the Bridge site.

Trent University collected samples and launched loggers in Swan Lake in the summer of 2024 and 2025 to support a study on the environmental fates of lanthanum from La-modified bentonite in the ecosystem of Swan Lake. Data provided by Trent researchers have been incorporated in this report.

The following paragraphs provide the monitoring results for the 2025 monitoring period, as well as annual summaries of available data from 2016 to 2025. The figures include plots of measured DO and temperature, water clarity, nutrient concentration, chloride concentration, phytoplankton and geese count.

Swan Lake Water Quality Targets

Phosphorus concentration and clarity were compared to the interim targets developed for Swan Lake through the 2019 Water Quality Management Strategy. Trophic state was classified using total phosphorus concentrations to place observed conditions in the context of lake productivity. For DO and chloride, Federal and/or Provincial water quality Guidelines or Objectives are shown for perspective. It should be noted that Swan Lake is not a natural waterbody, and there is no requirement for it to comply with these guidelines and objectives. Where technically and economically feasible, the City will aim to meet these guidelines and objectives to protect and enhance the aquatic environment.

Dissolved Oxygen (DO), Temperature, and pH

The minimum DO concentration required for the protection of warm water fish is 5 mg/L for water temperatures up to 20 °C, and 4 mg/L for temperatures above 20 °C, based on the Provincial Water Quality Objectives (PWQO). DO concentrations at 1m below the surface and 1m above the lake bottom are shown below.

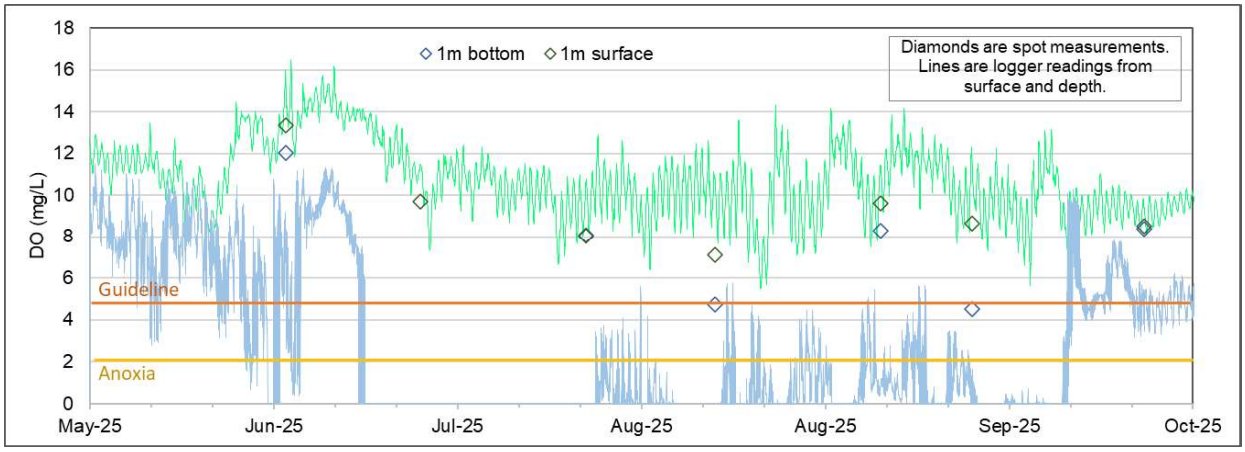
Day-time concentrations measured during biweekly visits were above the DO objective (above 7.0 mg/L at the surface and above 4.5 mg/L at 0.6 to 1 m from the bottom).

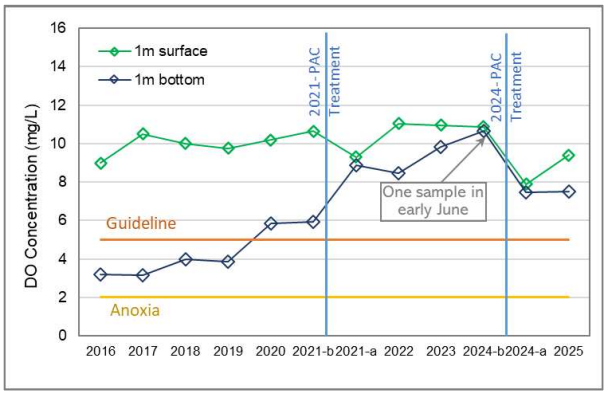
While measured daytime DO levels did not indicate anoxia during the sampling events, continuous measurements at the Dock as well as at the deepest point in the lake (i.e., monitored at a logger commissioned by Trent University) showed a decline in bottom water DO to low levels about 84% of the time during August and September, during a very dry and warm summer and fall. These declines could

have led to periodic anoxic episodes, increasing the potential for nutrient release from the sediments. However, the PAC treatments effectively bind phosphorus in the sediments, preventing its release even under anoxic conditions. Monitoring data support this effect, as surface and bottom phosphorus concentrations do not indicate anoxia-driven phosphorus enrichment, and overall bottom water DO has improved since the PAC treatments.

Lower DO concentrations could have lethal or sub-lethal (physiological and behavioral) effects on fish; however, some fish can acclimate to lower oxygen levels and survive concentrations between 1 and 3 mg/L. During anoxic episodes, which are temporary and generally restricted to a small area of the Lake at depths below about 2.5 m, they can also avoid low oxygen conditions.

Figure ES-2: 2025 Monitoring Results and 2016-2024 Annual Results- Dissolved Oxygen





Note 1: DO concentrations are shown at 1 m from the surface (average of 0.5 and 1 m) and 1.5 m from surface (0.6-1 m from the bottom). Logger data are also shown for the duration of the monitoring for the surface and deep water DO levels.
Note 2: Historical data are shown for the average of daytime measurements during growing period (June-Sep) unless otherwise indicated. Data before 2016 are not shown for legibility.

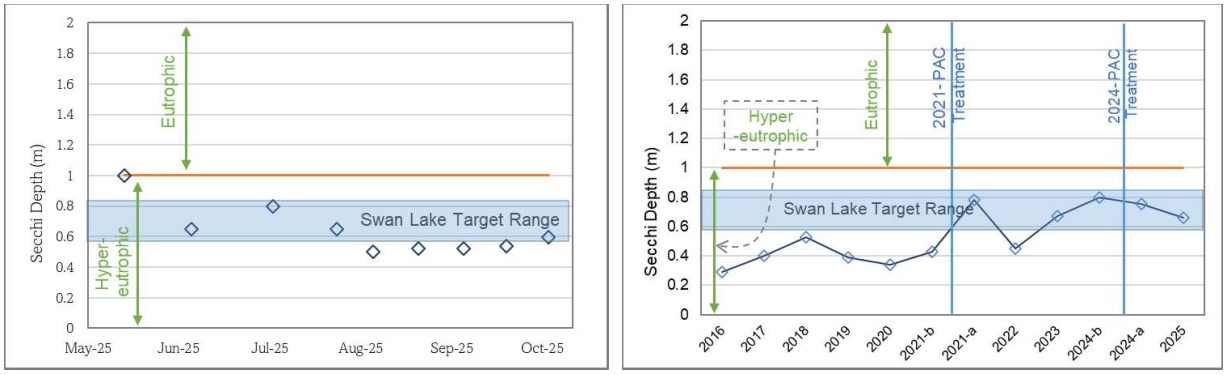
The pH measured at the lab was about 8 throughout the year. High daytime pH is consistent with high levels of algae. Algae take up carbon dioxide, a weak acid, from the water for photosynthesis, causing the water to become more basic (higher pH).

Water Transparency (Secchi Depth)

Secchi depth represents water transparency, which declines when the algae level increases. Secchi depth is often used as an indicator of trophic state, with average growing season values less than 1 m indicating

hyper-eutrophic conditions, and values of 1-2 m indicating eutrophic conditions. The proposed interim target for Swan Lake is 0.6-0.8 m based on correlation with the phosphorus target. In 2025, the average water clarity during the growing season was within the target, with occasional declines to 0.5 m later in the fall.

Figure ES-3: 2025 Monitoring Results and 2016-2025 Annual Results- Secchi Depth

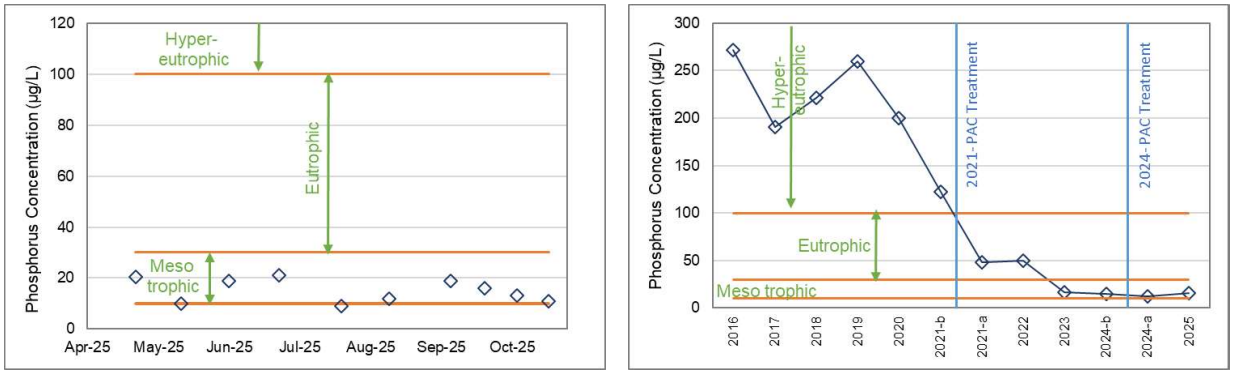


Phosphorus and Nitrogen Concentrations

Phosphorus concentration is the most important indicator of the trophic state in Swan Lake. It is an indication of how prone the Lake is to algae growth.

Phosphorus concentrations above 100 µg/L represent a hyper-eutrophic condition, which lead to high algae concentrations. In 2025, total phosphorus concentration in the top 0.5 and 1.5 m depths averaged under 16 µg/L during the growing season (under the 30 µg/L threshold for eutrophic condition, and well below the interim target of 50-100 µg/L). There was significant improvement in phosphorus concentrations after treatment by PAC.

Figure ES-1: 2025 Monitoring Results and 2016-2025 Annual Results- Total Phosphorus



Note 1: The 2025 values are averages of samples collected at 0.5 and 1.5 m from the surface. Samples were collected from the areas around the two ultrasound units (East and West) on April 24 and July 26.
Note 2: Annual concentrations are summaries of the growing period (June-Sep) unless otherwise indicated.

In 2025, total nitrogen concentrations over the growing season averaged about 0.60 mg/L generally reflecting mesotrophic conditions (below the 0.65 mg/L threshold for a eutrophic condition). In 2025, ammonia and nitrate concentrations (the forms available for uptake by biota) were generally very low (except in October), and nitrogen was mainly present in its organic form.

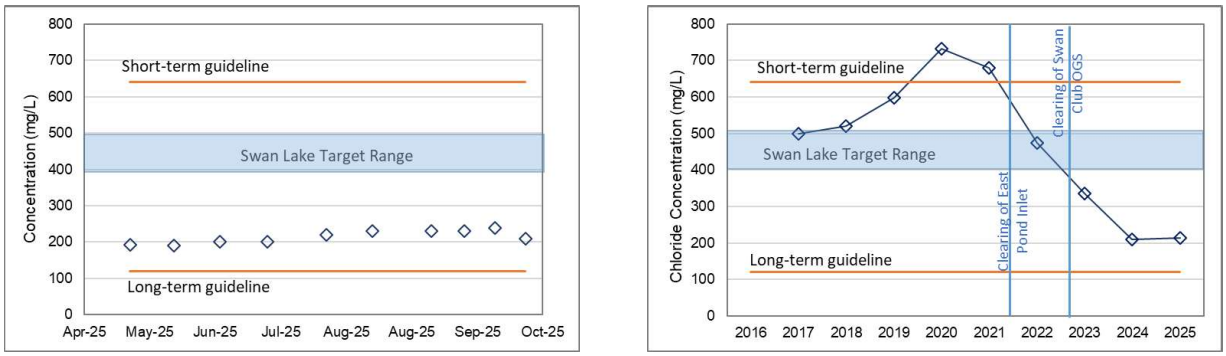
Chloride Concentration

Chloride concentration has been increasing in urban lakes as a result of de-icer application for winter maintenance of roads and walkways. Chloride does not biodegrade, readily precipitate, volatilize, or bioaccumulate. It does not adsorb readily onto mineral surfaces and therefore when introduced, concentrations remain high in surface water.

The Canadian Water Quality Guidelines for chloride developed for generic environmental data include a long-term guideline (120 mg/L) and a short-term guideline (640 mg/L). The site-specific interim target for chloride for Swan Lake is 400-500 mg/L consistent with 2013-2014 values.

In 2025, chloride levels were similar to 2024 at about 200 mg/L, which is below the target and declined considerably compared to previous years, continuing previous declines observed since 2020.

Figure ES-4: 2025 Monitoring Results and 2016-2025 Annual Results- Chloride

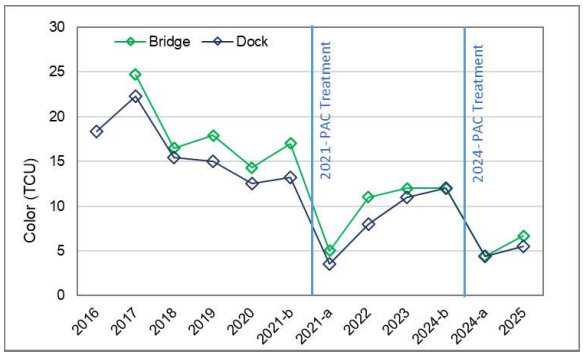


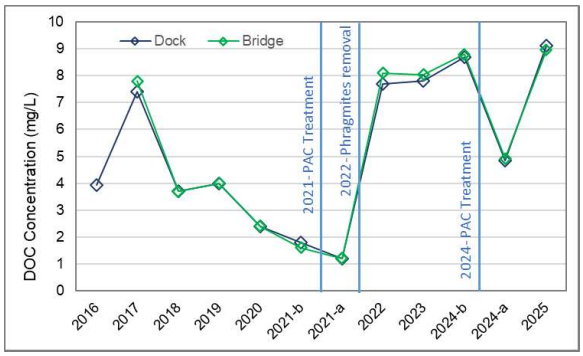
In 2025, water samples were collected from various inlets to the Lake and analyzed for chloride. These data were used to update the chloride mass balance following the completion of the Flow Diversion Feasibility Study.

Dissolved Organic Carbon and Color

Dissolved organic carbon (DOC) and colour indicate the organic content of lake water. In 2025, DOC ranged between 7 and 11 mg/L, with color ranging from 5 to 9 TCU at both stations. DOC in 2022, 2023 and 2024 (before the PAC treatment) was considerably higher than in previous years. The increase may potentially be associated with the remnants of Phragmites in the Lake, as the roots were not removed. Both colour and DOC declined sharply in 2024 following the PAC treatment, which precipitates organic matter. DOC increased to pre-treatment levels in 2025 while colour has remained low.

Figure ES-5: 2016-2025 Annual Results- DOC and Colour





Algal Growth

In 2025, very limited surface scums were observed along the shoreline around the Dock, as well as in the northern bay at the Bridge site. While the Lake was dominated by phytoplankton from late June, surface scums indicative of Cyanobacteria blooms were not widespread.

Samples were collected and sent to the laboratory for phytoplankton analysis. Test results showed higher diversity and similar cyanobacteria counts compared to 2024 at the Dock and the Bridge sites.

Six samples were analyzed for phytoplankton between April and October. The total cyanobacteria cell count ranged from 12,000 to 120,000 cells/mL, with values on three events above Health Canada's indicator value of 50,000 cells/mL for the potential production of cyanotoxins for primary contact recreation.

Several algal blooms with potentially toxic cyanobacteria were observed in years before 2011; however, testing completed before 2011 and following treatment (2013-2016) did not detect any Microcystin in the water. In 2016, a bloom was tested and resulted in a Microcystin concentration of 73 µg/L. Extended blooms were observed at several sites in 2018; however, cell density was at half of World Health Organization (WHO)'s threshold for significantly increased human health risk due to toxins. Since the 2021 PAC treatment, very limited surface scum has been observed at Swan Lake.

Geese Count

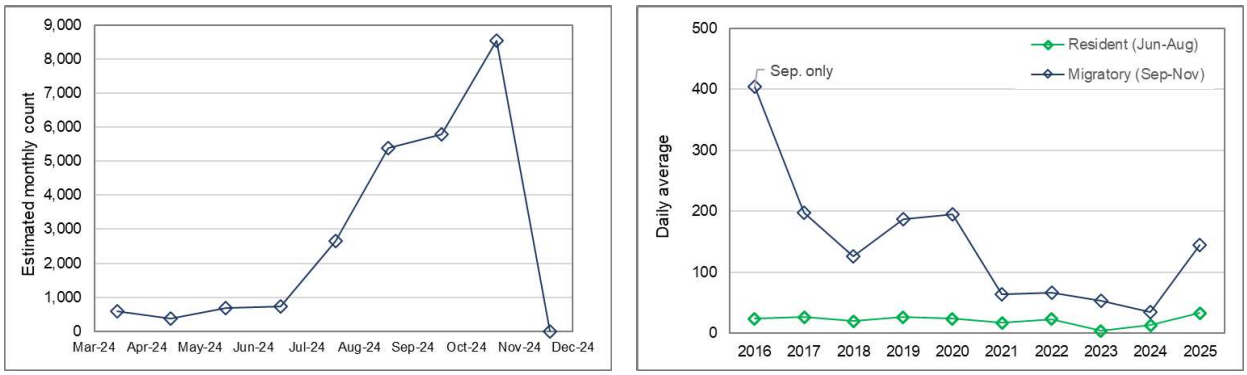
Geese are the primary external source of nutrients in the Lake. Therefore, active geese management is completed annually. The geese control program started in 2014, focusing on resident geese. The program extended to the management of migratory geese in 2016.

The 2024 and 2025 program focus of control was laser light, avian distress call and limited strategic zinc crackler pyro, as well as geese relocation. A laser emitter was installed on the south island emitting at 1 ft above water surface to prevent overnight goose populations from accumulating in Swan Lake.

The 2024 efforts were very effective in reducing the number of migratory geese visiting the Lake, further lowering the counts. Geese counts were higher in 2025, primarily due to natural population fluctuation, and partly because the laser lights that had been placed on the island were removed for product improvement.

The geese count data helped provide more certainty in the results and were used to more effectively schedule hazing efforts.

Figure ES-6: 2025 Monitoring Results and 2016-2025 Annual Results- Geese Count



Note 1: 2025 data are the sum of counts in each month, compensated for days with no count.
Note 2: Annual trends are shown as daily averages of counts over June-August and September to November, representing resident and migratory geese, respectively.

Fish Inventory

A fish inventory and removal campaign were completed in April 2025 to remove bottom-dwelling fish, which could interfere with the PAC treatment efficacy. A limited number of fish species were caught in the Lake, including Brown Bullhead, Fathead Minnow, as well as Goldfish and a hybrid of Carp/Goldfish.

Aquatic Vegetation Survey

During the 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.

Summary and Recommendations

Overall, the management activities in recent years that focused on the significant nutrient loadings identified in the water quality improvement study (i.e., chemical treatment and fish management to reduce internal loads and geese management to reduce external loads) were effective at improving water quality in the Lake as shown by reduced phosphorus and nitrogen concentrations, lower algae levels, improved dissolved oxygen levels, and the establishment of a submerged aquatic plant community. These improvements represent a positive step towards improving the aquatic habitat in the Lake and meeting the long-term water quality goals.

The 2026 monitoring program and management activities will follow the recommendation of the Long-Term Management Plan as updated by the Phase 1 Review.

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1. Introduction

Swan Lake is situated in the City of Markham at the intersection of Sixteenth Avenue and Williamson Road, as shown below in Figure 1. Swan Lake has an approximate area of 5.5 ha and a maximum water depth of 4.5 m (from the deepest point to the Lake edges at 210 meters above sea level). At an average elevation of about 208.2 masl (estimated or measured over the last decade), the lake maximum depth is 3.7 m and surface area is about 4.5 ha.

Formerly a gravel pit in the 1960s and 1970s, Swan Lake is currently a community feature with multiple trails and urban development.

Several issues were discovered with Swan Lake in 2010, including high phosphorus levels and significant algal blooms during the summer months, which led to low oxygen levels and degraded fish habitats. A Phoslock treatment was administered in 2013 to reduce the phosphorus levels and algal blooms in Swan Lake.

In 2019, the City of Markham conducted a study to define a Water Quality Management Strategy for Swan Lake (Freshwater Research 2020). The Strategy, which was finalized in July 2020, recommended chemical treatment starting in 2021. In August 2021, 13 tonnes of PAC were applied to the Lake in a controlled manner over several days.

The Swan Lake Long-Term Management Plan, which was developed based on the 2019 Strategy and extensive consultation with stakeholders, was received by Markham Sub Committee in November 2021 and approved by the Council in December 2021 (City of Markham 2021). It describes a phased adaptive approach, including Core, Complementary and Alternative measures, and periodic reviews to adapt the Plan to the Lake conditions.

Water quality monitoring of Swan Lake has been conducted annually since treatment in 2013 in order to track water quality and the effectiveness of management activities. The 2025 monitoring results presented in this report are part of the ongoing monitoring program that will allow for continuous assessment of the water quality in Swan Lake and help establish a long-term plan for the treatment of Swan Lake.

Trent University collected samples and launched loggers in Swan Lake in the summer of 2024 and 2025 to support a study on the environmental fates of lanthanum from La-modified bentonite in the ecosystem of Swan Lake. Data provided by Trent researchers have been incorporated in this report.

2. 2025 Management Activities and Studies

Core and Complementary activities planned in the Long-Term Management Plan and completed in 2025 included water quality (and biologic) monitoring, enhanced geese management, fish management, as well as ultrasound technology for algae control. An aquatic plant survey was also conducted as an additional activity in support of the program.

2.1 Geese Management

Geese reduction at Swan Lake is necessary due to the nutrient load they contribute to the Lake.

In 2025, the Wildlife Management Group Inc., an external consultant, was hired to use science-based and Environment Canada-approved techniques for managing Canada goose. Activities included nest depredation (nest monitoring, and subsequent removal between April and May), and adult goose mitigation through laser light, avian distress call and limited strategic zinc crackler pyro. It was noted that during many service visits conducted during daylight hours, no geese were observed on the water at Swan Lake. However, numbers increased during dusk and dawn fly-in periods. Service schedule was adjusted to address the rise in evening activity.

Stationary lasers were reinstalled on site; however, due to product improvements, the previous units were removed and not replaced in time for Fall applications. A summary of 2025 activities is provided in Appendix C.

The strobe lights purchased in 2020 at the request of Friends of Swan Lake Park were also installed on the Lake and the two adjacent stormwater management ponds. Strobe lights work by using a solar-powered LED light that flashes every two seconds and is intended to disrupt the geese's sleep patterns and discourage them from staying on the Lake.

2.2 Fish Management

The Long-Term Management Plan for Swan Lake (2021) has a provision for managing bottom-dwelling fish to reduce sediment disturbance.

Since 2021, the City has hired the TRCA annually to complete a fish inventory and removal operation.

A fish removal event was completed on April 25, 2025 using an electrofishing boat and a fyke net. The same electrofishing sampling transects used in previous years were repeated in 2025. All fish captured were identified and enumerated. Of the 745 Captured Brown Bullhead and Goldfish, 371 were euthenized. A summary of 2025 activities is provided in Appendix D.

In May 2025, 500 juvenile largemouth bass were added to the lake by a private contractor (Hidden Lane Fisheries from Smithville, ON), following consultation with TRCA and MNRF. Fish stocking was identified as a Complementary measure in the 2021 Long-Term Management Plan. This measure was brought forward to help balance the fish community in the Lake.

Initial discussions with the TRCA and MNRF considered the possibility of stocking with Bluegill, depending on availability from MNRF facilities. However, this option was not pursued because Bluegill feed on zooplankton, which could reduce grazing presure on algae and potentially worsen algae conditions.

2.3 Ultrasound Treatment

Following the successful use of ultrasound technology to control of algae blooms in a stormwater management pond in Markham, two similar units were installed at Swan Lake to further improve water clarity.

Ultrasound is a low-cost and durable method commonly used to control algae growth in water-holding facilities, including drinking water reservoirs. When deployed, the ultrasound device generates vibrations that rupture gas vacuoles within algae cells (structures that control buoyancy) causing the algae to sink to deeper, lower-light areas of the pond where they become inactive. The low-power ultrasound waves used have no impact on aquatic animals, birds, or humans.

The system selected for Swan Lake consisted of two Water IQ Pulsar 3000 units powered by a land-based solar panel. This is the same equipment used in the Markham stormwater pond, allowing staff to benefit from familiarity with installation, operation, and demonstrated performance. The transducers were anchored to cinder blocks and strategically positioned in the lake to maintain direct line-of-sight coverage of all areas where algae had been observed. One limitation encountered was the 100-metre cable length between the solar panel and each unit, which constrained placement options.

2.4 Chloride Management

The Long-Term Management Plan for the Lake suggests that the main mechanism for lowering chloride levels would be source control. Emerging technologies and the feasibility of stormwater flow redirection would be considered in later phases.

At the request of area residents and as directed by the Council, the following two measures were brought forward to Phase 1.

2.4.1 Chloride Treatment Study

The City engaged York University to carry out a pilot study to develop biochar adsorption techniques to remove nutrients and chloride from Swan Lake. The specific objectives of this study are:

Objective 1. Determine adsorption potential of Biochar to remove nutrients (phosphorus and nitrogen) and chloride from Swan Lake water, and

Objective 2. Use lab-scale units to test the biochar efficiency in the removal of selected nutrients and chloride.

This study is currently underway, and results are expected by the end of 2026.

2.4.2 Flow Diversion Feasibility Study

AECOM was retained to assess the feasibility of diverting stormwater runoff from Swan Lake without increasing the flood risk within the study area or locations downstream. Several flow diversion alternatives were assessed and modelled as part of this work. The results were subsequently used by the City to estimate potential impacts on Lake's water and chloride budget (see Appendix F).

2.4.3 Aquatic Plant Survey

Historically, submerged aquatic vegetation (SAV) was rare or absent throughout Swan Lake due to poor water clarity caused by excess phytoplankton biomass. While management efforts successfully reduced nutrient concentrations and phytoplankton levels, the Lake remained dominated by phytoplankton with limited improvements in water clarity, continuing to limit SAV. During the PAC treatment in 2024,

however, significant amounts of SAV was observed, with levels sufficient to hinder the movement of the boat in some areas. In 2025, an aquatic plant survey was completed by the City and AECOM to determine the aquatic plant community composition and estimate cover and biomass throughout the lake, and to track the success of colonization with improved water clarity and lower algae levels in recent years.

3. Monitoring Program

3.1 Annual Water Quality Monitoring

3.1.1 Locations

Water quality was monitored at two shoreline sites, the Dock, and the Bridge, as shown in Figure 1. The figure also shows the location of the two ultrasound units (East and West) installed in 2025, where samples were collected.

On average, the water depth at the Dock is approximately 2.5 meters, representing deep areas of the lake. The water depth at the bridge is about 0.5 meters, and it is used to represent the conditions of the shallow bays around Swan Lake. Field testing and sampling for laboratory analysis were completed at both sites to ensure the water conditions at Swan Lake were properly represented.

During the bi-weekly monitoring, samples and measurements were taken at 0.5 m or 1 m increments for the depth of the Lake. The dock site was the deeper of the two sites, allowing for sampling and monitoring from 0.5 – 2 m, whereas the bridge site was shallow, and sampling was typically only achievable under the surface, slightly above the bottom of the Lake to avoid sediment contamination.

Trent University placed two loggers at the deepest point (station T10 as shown on the Figure), which was about 3.5 m deep, at approximately 0.5 m and 2.75 m below the water surface.

Figure 1: Swan Lake and Runoff Monitoring Stations

Note: Stations sampled by Trent U are shown as circle. The loggers were installed at station T10.

3.1.2 Duration and Frequency

In 2025, water quality was monitored monthly in April and May and bi-weekly from June to October. A total of 11 sampling events were completed.

3.1.3 Parameters and Methodology

Vertical water quality profiling, water transparency readings (Secchi depth), and photographic documentation were performed during each site visit.

Field testing was done utilizing an YSI ProODO meter to determine the temperature and DO at each sampling interval over the vertical profile of the lake. To ensure accurate readings, the meter and probe were stored in a proper carrying bag and regularly calibrated as instructed in the handheld quick-start guide.

A HOBOware U26 oxygen logger was mounted at the Dock on March 31, 2025, and recorded the DO and temperature of the water every 15 minutes throughout the day. Before the first use, the logger was calibrated for DO at 100% saturation and 0% saturation (using a sodium sulfite solution). An anti-fouling guard was also installed on the sensor cover to protect against fouling. The sensor was placed 1m above the lakebed at the same location as the level logger.

Water transparency (as Secchi disk depth) was measured at both the dock and bridge monitoring sites. The Secchi disk was lowered into the water while rotating the handle until the black and white pattern of the Secchi disk was no longer visible. The water depth at which the Secchi disk was no longer visible was then recorded as a measure of the transparency (i.e., water clarity).

Water samples for laboratory testing were taken using a horizontal discrete-level water sampler at the target depths. Parameters analyzed at various stations and times included:

- Nutrients including Total Phosphorus (TP), ortho phosphorus, ammonia, nitrate, nitrite, Total Kjeldahl Nitrogen (TKN)
- Chloride, colour, Dissolved Organic Carbon (DOC), pH
- Phytoplankton (taxonomic identification, cell counts and cell density)

Observations of Swan Lake were noted, and photographs were taken during each monitoring/inspection site visit. Photographs provide a way to record the condition of vegetation and algae around Swan Lake. Completed inspection forms and photos can be found in Appendix A.

3.1.4 Targets and Thresholds

Generic thresholds for lake trophic classes representing gradients of biological productivity in lakes and relevant to Swan Lake, are provided in Table 1.

Table 1: Trophic State Classification

Parameter	Mesotrophic Condition (moderate productivity)	Eutrophic Condition (high productivity)	Hyper-eutrophic Condition (very high productivity)
Secchi Depth (m)	2 - 4	1 - 2	< 1
Total Phosphorus (µg/L)	10-30	31-100	100
Total Nitrogen (mg/L)	0.35-0.65	0.66-1.20	>1.20
Chlorophyll a (µg/L)	3.5-9.0	9.1 – 25	> 25

The 2019 Water Quality Management Strategy proposed a set of interim targets for Swan Lake to be used as triggers for management actions if the triggers are tripped in two consecutive years. Numerical values were defined for total phosphorus (100 µg/L) and Secchi depth (0.6-0.8 m), as updated in 2021 based on correlation with the phosphorus target.

For DO and chloride, Federal and/or Provincial water quality Guidelines[1] or Objectives[2] were considered for perspective. It should be noted that Swan Lake is not a natural waterbody, and there is no requirement for it to comply with these limits. Where technically and economically feasible, the City will aim to meet these objectives and guidelines to protect and enhance the aquatic environment.

The minimum DO concentration required for the protection of warm water biota is 5 mg/L for water temperatures up to 20 °C, and 4 mg/L for temperatures above 20 °C. Lower concentrations could have lethal or sub-lethal (physiological and behavioral) effects on fish. However, some fish can acclimate to lower oxygen levels and survive concentrations between 1 and 3 mg/L. Furthermore, fish can avoid areas of low oxygen concentrations.

The Canadian Water Quality Guidelines for chloride developed based on generic environmental data include a long-term guideline (120 mg/L) and a short-term guideline (640 mg/L). The long-term guideline was developed to protect the most sensitive life stage of the most sensitive aquatic life species against negative effects during indefinite exposure. The short-term guideline will protect most species against lethality during a sudden hike in chloride concentration for a short period (24-96 hrs). These guidelines may be over-protective for areas with an elevated concentration of chloride and associated adapted ecological community. For such circumstances, it has been suggested that site-specific (higher) targets be derived considering local conditions such as water chemistry, background concentrations, and aquatic community structure. The site-specific interim target for chloride in Swan Lake is 400-500 mg/L consistent with 2013-2014 values.

For total Microcystins, the Health Canada guideline for primary contact recreation was updated from 20 µg/L to 10 µg/L in 2022[3]. The 2022 guidelines also provide indicator values for the potential presence of cyanotoxins. The indicator guidelines for primary contact recreation include:

- Total cyanobacteria cells: 50,000 cells/mL
- Total cyanobacterial biovolume: 4.5 mm^3/L
- Total chlorophyll a: 33 µg/L

3.2 Runoff Monitoring

In the Swan Lake catchment, salt application for winter maintenance is mainly completed by the City's Road department and the Swan Lake Village Corporation.

Winter maintenance of 1 km of the catchment roads and sidewalks is completed by the City of Markham. The City prescribes and tracks the quantity of salt distributed to the City roadways based on current and future forecast models and temperatures to determine the required action and material usage in compliance with the desired level of service and O.Reg. 239/02 requirements.

The remaining roads and parking areas, as well as private walkways and driveways, are serviced privately. As per the Village Amenities Committee (VAC), the Village Corporation employs "a qualified,

[1] Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life (http://ceqg-rcqe.ccme.ca/en/index.html)
[2] Ontario Provincial Water Quality Objectives (PWQO) (https://www.ontario.ca/page/water-management-policies-guidelines-provincial-water-quality-objectives#section-13)
[3] Health Canada, 2022. Guidelines for Canadian Recreational Water Quality, Cyanobacteria and their Toxins, Ottawa, Ontario.

reputable cleaning and maintenance service employing Smart About Salt principles to plow/shovel and their insurance recommends the de-icing methods of rock salt, applied as necessary to maintain their insurance and mitigate potential claim".

Chloride in salting materials is readily dissolved in water and transported overland by runoff or infiltrated into soils, contaminating groundwater and surface water. A fraction of chloride in applied road salt is retained by soil and is not observed in surface runoff. As a result, salt loading to surface water occurs primarily in winter and spring during melt conditions but continues through the summer and fall via the discharge of impacted groundwater, dry deposition of dust to the lake surface, and non-point source runoff washing dry salt from land surfaces. Salt accumulated in the ponds could also be discharged into the Lake through the flushing of stormwater ponds.

In 2025, water samples were collected from various inlets to the Lake to quantify and determine the relative contribution of each source to chloride concentration in Swan Lake. Samples were collected from both ponds' inlets, as well as outfalls from the ponds and OGS's to the Lake.

Conductivity was also measured in a number of samples, as this parameter can be used as a surrogate for chloride. Samples were collected during one snowmelt event in March 2025.

3.3 External Data

Trent University collected water, sediment and biological samples and launched loggers in Swan Lake in the summer of 2025 to support a study on the environmental fates of lanthanum from La-modified bentonite in the ecosystem of Swan Lake. Data provided by Trent researchers included DO and temperature and Chl-a concentrations at the deepest point of the Lake.

3.4 Water Level Monitoring

In 2025, a Dipperlog vented data logger from Heron Instrument was installed at the Dock. The data logger recorded the pressure and temperature of the water every 15 minutes.

4. Monitoring Results

4.1 2025 Water Quality

The following sections discuss water quality results in 2025.

4.1.1 Dissolved Oxygen and Temperature

Table 2 provides the measured DO profile data over the 2025 monitoring period. At the Dock station, day-time surface and deep-water concentrations were above 7 mg/L on all sampling events. All measurements at the Bridge had a DO concentration above 5.2 mg/L with a summer average concentration of 5.7 mg/L. Based on these values, DO at both met the PWQO for warm water biota.

Table 2 also provides measured temperature profiles in 2025, indicating warm water throughout the depth in the summer months.

Profiles of temperature and dissolved oxygen at the Dock station (see Figure 2) indicate that Swan Lake was transiently stratified in June and September (when temperature decline is greater than 1 °C per m of depth). Transient stratification can cause reduced mixing and lead to anoxia at depth with the release of nutrients from the sediments.

Data collected by Trent University shows stratification during sampling events throughout the summer (Figure 3). The decline in DO occurs below the top of the thermocline where temperature decreases with depth by 1°C per m or more, reducing mixing and reoxygenation of the bottom water below that depth (~2 m below the surface).

In 2025, in addition to using the YSI ProODO meter for bi-weekly measurements of temperature and DO over the vertical profile, a continuous logger was also placed 1 m above the lake surface to measure the diurnal changes in DO. DO increases during daylight hours when photosynthesis occurs and decreases at night when respiration continues but photosynthesis does not.

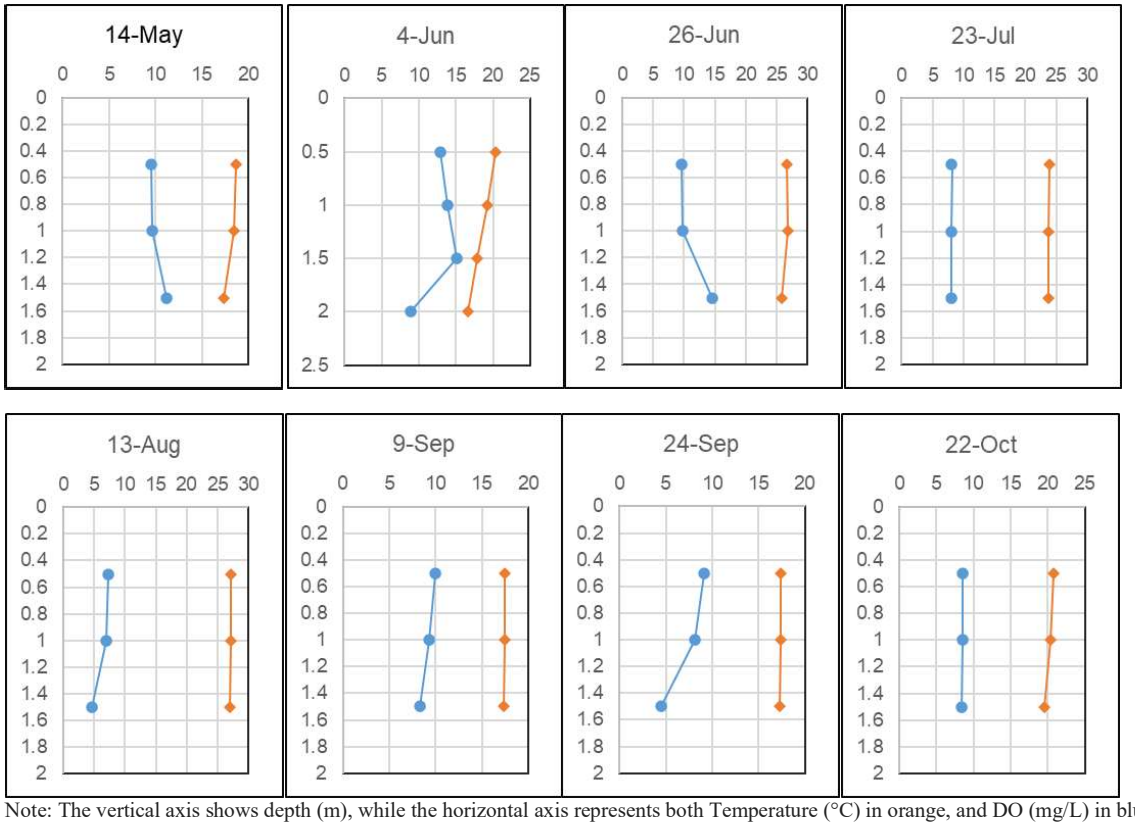
Continuous measurement of DO from April to October indicated that DO concentrations have a diurnal pattern, typical of freshwater lakes. These data are mostly consistent with the data logger used by Trent University researchers at the deepest point. While surface concentrations were always above 5 mg/L regardless of the time of day, deep water concentrations dropped to anoxic levels within ~1 m of the sediments for several days in each of the summer months, when there was minimal precipitation and warmer than usual weather.

Table 2: Measured Daytime DO and Temperature

	DO Concentration (mg/L)					Temperature (°C)				
	Bridge	Dock				Bridge	Dock			
	Depth (m)	Depth (m)				Depth (m)	Depth (m)			
Date	0.5	0.5	1	1.5	2	0.5	0.5	1	1.5	2
5/14/2025	9.9	9.6	9.6	11.2	-	18.8	18.7	18.4	17.3	-
6/4/2025	10.5	12.9	13.8	15.2	8.9	19.2	20.3	19.3	17.9	16.6
6/26/2025	5.4	9.6	9.8	14.6	-	24.4	26.7	26.8	25.8	-
7/23/2025	6.6	8.1	8.0	8.1	-	22.3	23.9	23.8	23.7	-
8/13/2025	5.2	7.2	7.0	4.7	-	24.4	27.1	27.2	26.9	-
8/25/2025	-	-	-	-	-	-	-	-	-	-
9/9/2025	-	9.9	9.3	8.3	-	-	17.4	17.4	17.3	-
9/24/2025	-	9.1	8.2	4.5	-	-	20.8	20.4	19.5	-
10/8/2025	-	-	-	-	-	-	-	-	-	-
10/22/2025	-	8.6	8.5	8.4	8.4	-	12.5	12.2	12.1	12.0

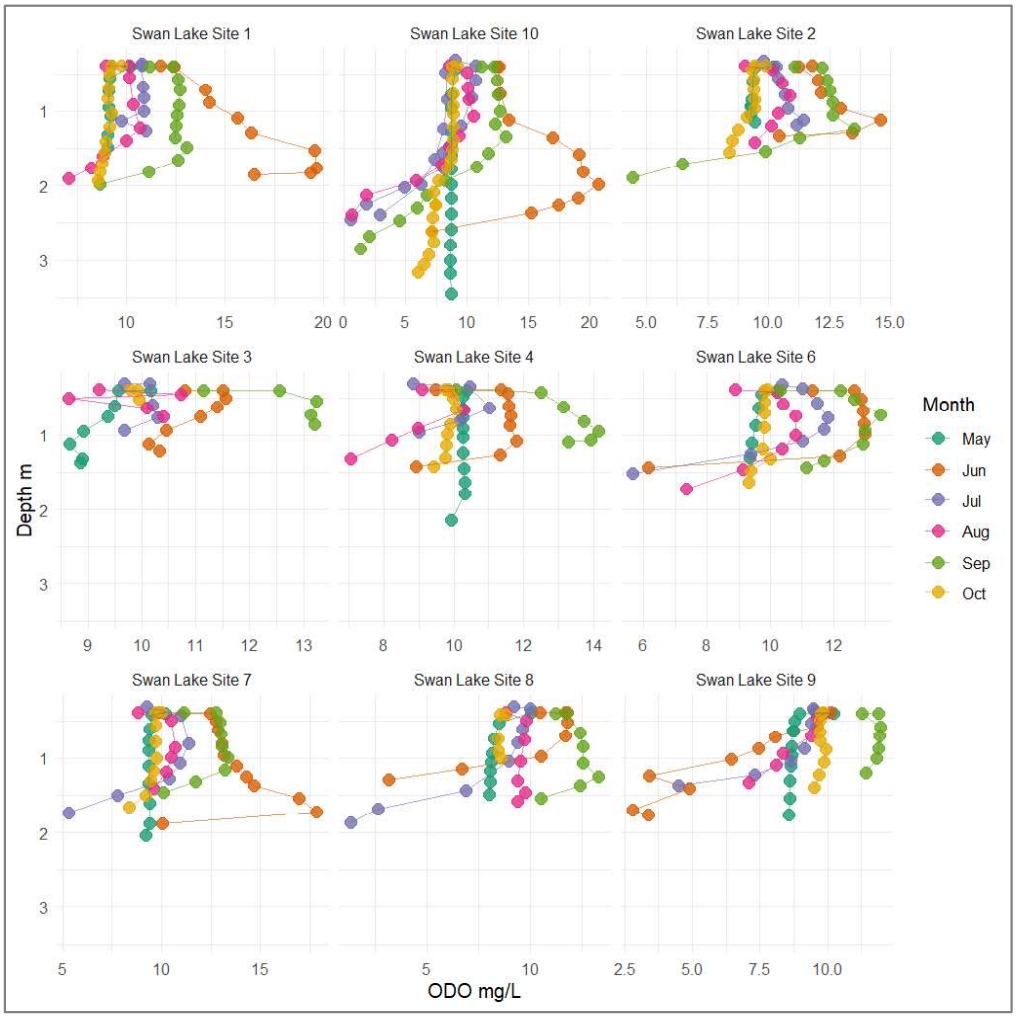
Note: fewer measurements at the Bridge site due to very low water level. No data for Aug. 25 and Oct. 8.

Figure 2: Temperature (orange) and DO (blue) Profile at the Dock Station in 2025



Note: The vertical axis shows depth (m), while the horizontal axis represents both Temperature (°C) in orange, and DO (mg/L) in blue.

Figure 3: Vertical Profiles of Dissolved Oxygen in 2025



Data courtesy of Trent University

4.1.2 Water Transparency

A robust measure of water transparency is the measurement of the Secchi disk depth, which is commonly used as an indicator of algal biomass.

Table 3 summarizes the results of the Secchi depth readings. Transparency (as Secchi depth) at the Dock station averaged 0.6 m over the growth season and was within the interim target for Swan Lake of 0.6-0.8 m and represented a hyper-eutrophic condition. Water transparency at the Bridge site was generally equal to the water depth.

Table 3: 2025 Secchi Depth Results (m)

Date	Dock	Bridge
14-May	1	0.4 *
4-Jun	0.65	0.5
26-Jun	0.8	0.5
23-Jul	0.65	0.3
13-Aug	0.50	0.15 *
25-Aug	0.52	0.15 *
9-Sep	0.52	0.15 *
24-Sep	0.54	0.15 *
8-Oct	0.60	0.15 *
22-Oct	0.65	0.15 *

* Water depth at site.

4.1.3 Nutrients Concentrations

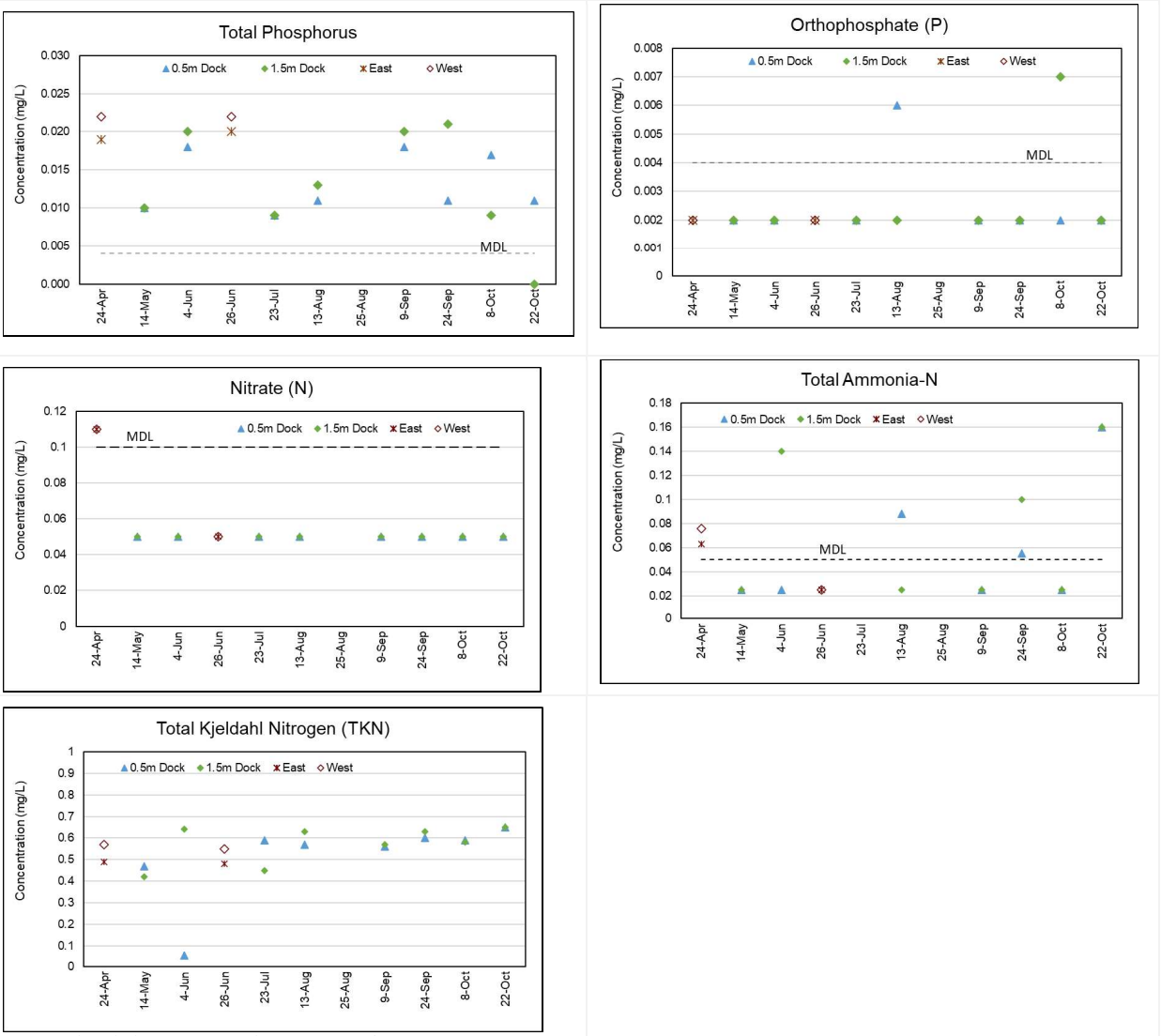
Samples collected during each visit were tested for TP, Orthophosphate, TKN, Nitrate, Nitrite, and Ammonia. The results can be found in Figure 4 for the Dock site and Figure 5 for the Bridge site. The Certificates of Analysis from Bureau Veritas Laboratories are in Appendix B. Nutrient concentrations are shown for the depths sampled.

Total phosphorus concentration at 0.5 and 1.5 m depths averaged under 16 µg/L during the growing season and was below 30 µg/L throughout the year, representing a mesotrophic condition.

Orthophosphate and total ammonia concentrations were low throughout this period in the surface and bottom water with few exceptions indicating that internal loading due to anoxia was not significant. In the late fall, total ammonia concentrations increased, likely due to reduced uptake by algae.

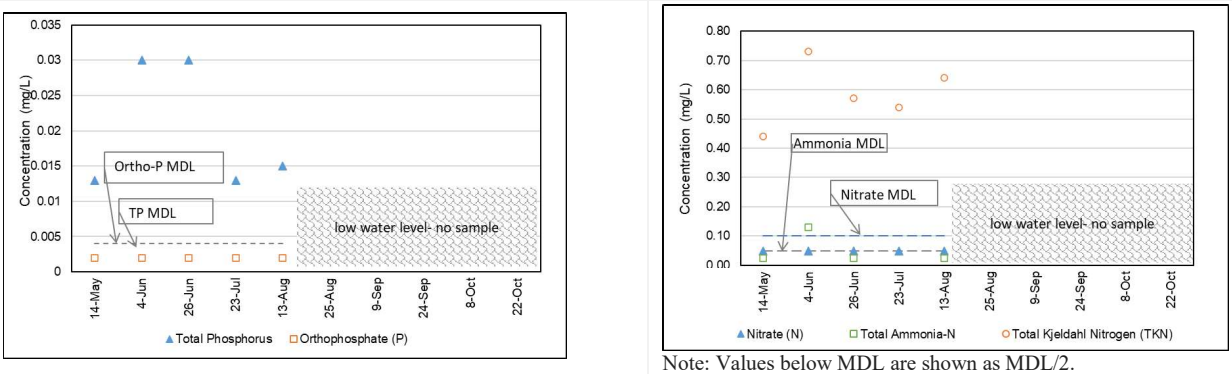
Total nitrogen concentrations over the growing season averaged about 0.62 mg/L (reflecting a mesotrophic condition). Total concentrations at the Bridge site averaged 0.73 mg/L between June and mid-August. Water level was too low for sample collection afterwards. Ammonia and nitrate are the directly bioavailable forms of nitrogen, with Ammonia being the most usable form for algae. In 2025, Ammonia and Nitrate concentrations were generally close to or below the Method Detection Limit (MDL), and nitrogen was mainly present as organic compounds (i.e., TKN less Ammonia) with the exception of fall samples. Bioavailable nutrient pulses (orthophosphate and ammonia) in late summer and fall, but which occurred at low levels, are consistent with the release of these nutrients due to episodic anoxia and the decomposition of organics, including aquatic plants and algae.

Figure 4: 2025 Measured Nutrients Concentrations - Dock Site



Note: Values below MDL are shown as MDL/2

Figure 5: 2025 Measured Nutrients Concentrations - Bridge Site



Note: Values below MDL are shown as MDL/2.

4.1.4 pH

pH measured at the lab ranged from 7.9 to 8.7 throughout the year, which, except for one sample, is within the PWQO range (6.5-8.5).

4.1.5 Chloride in Lake and Runoff

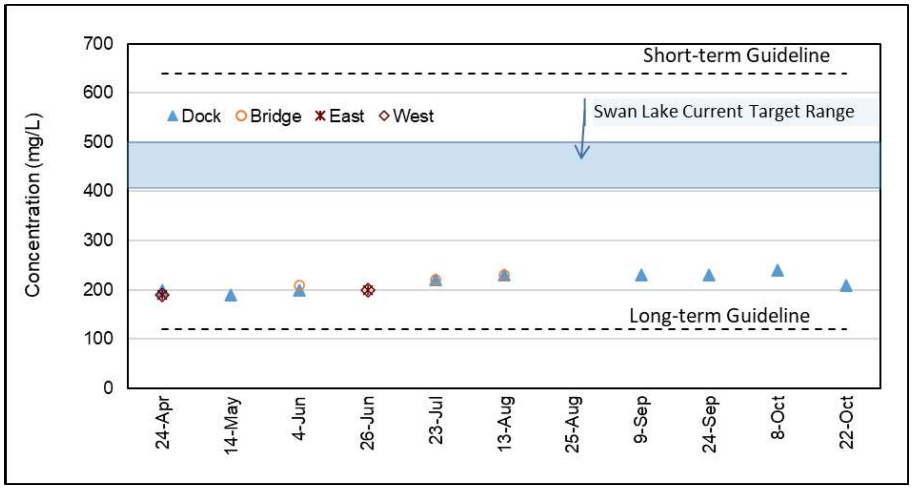
Surface samples collected during each visit were also analyzed for Chloride, as summarized in Figure 6.

Water quality testing results indicated that the samples contained between 190 and 240 mg/L of Chloride.

In 2025, chloride levels which had decreased considerably compared to 2021 and 2022 remained consistent with 2024 values at about 200 mg/L.

The Canadian Water Quality Guidelines for Chloride developed based on generic environmental data include a long-term guideline (120 mg/L) and a short-term guideline (640 mg/L). The long-term guideline has been developed to protect all organisms (present in Canadian aquatic systems) against negative effects during chronic indefinite exposure. The short-term guideline aims to protect most species against lethality during a sudden hike in chloride concentration for an acute short period (24-96 hrs). These guidelines may be over-protective for areas with an elevated concentration of chloride and associated adapted ecological community. For such circumstances, it has been suggested that site-specific (higher) targets be derived considering local conditions such as water chemistry, background concentrations, and aquatic community structure. Watercourse concentrations in Rouge River watershed urban areas and shallow groundwater concentrations in the GTA help characterize background concentrations and are consistently higher than the short-term guideline. The interim target for chloride is 400-500 mg/L consistent with 2013-2014 values. In 2025, all samples met these targets. In addition, Chloride levels were lower than the endpoint concentrations for all zooplankton species (259 – 454 mg/L) used to determine the long-term CWQG.

Figure 6: Chloride Concentrations in Swan Lake in 2025



In 2025, water samples were collected from various inlets to the Lake and analyzed for chloride.

These data were used to update the chloride mass balance following the completion of the Flow Diversion Feasibility Study (see Appendix F).

4.1.6 DOC Concentrations and Colour

Surface samples collected during each visit were also analyzed for DOC and Colour. The results are summarized in Table 4. Both DOC and colour dropped after the PAC treatment in 2024 and remained lower than pre-treatment levels throughout the season.

Table 4: Measured DOC and Color in 2025

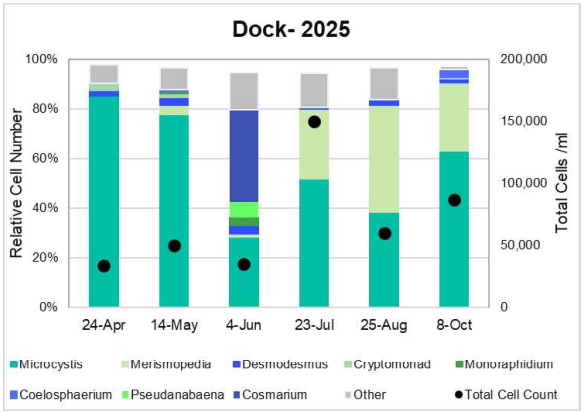
Date	Dock (East/West*)		Bridge	
	Colour	DOC	Colour	DOC
24-Apr *	5.0	5.8	-	-
14-May	6.0	7.2	9.0	7.6
4-Jun	5.0	7.2	8.0	9.3
26-Jun *	7.0	11.0	-	-
23-Jul	5.0	-	6.0	8.2
13-Aug	5.0	9.2	6.0	9.4
25-Aug	-	-	-	-
9-Sep	5.0	-	-	-
24-Sep	6.0	-	-	-
8-Oct	7.0	9.1	-	-
22-Oct	6.0	-	-	-

4.1.7 Algae Growth

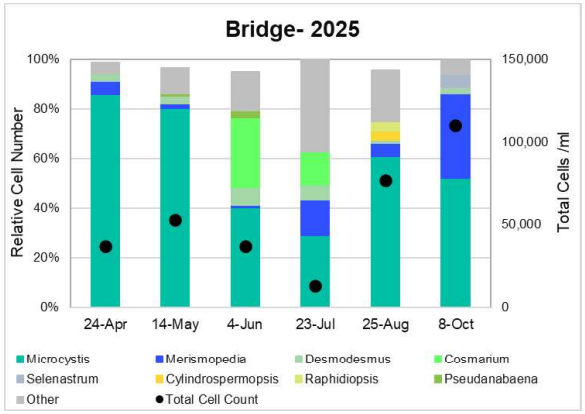
In 2025, six samples were collected for phytoplankton identification as shown in Figure 7. Total cyanobacteria cell counts were similar to 2024 and about 40% lower than in 2023, with average growing season concentrations at 65,000 and 44,000 cells/mL at the Dock and Bridge sites, respectively, compared to the Health Canada indicator guideline of 50,000 cells/mL for potential presence of cyanotoxins above primary contact recreational guidelines.

Besides the actual identification and counting of cells, analysis of chlorophyll-a (chl-a), which is the green algal pigment used in photosynthesis, provides a measure of algae biomass. Concentrations of chl-a were recorded by Trent University using an Enigma probe at a depth of 1 m, indicating an average of 23 µg/L over the growing season, which is within the range for eutrophic lakes (9.1-25 µg/L) and below the Health Canada chl-a indicator value for potential presence of cyanotoxins above primary contact recreational guidelines.

Figure 7: Planktonic Cyanobacteria Population in Swan Lake in 2025



Other genera present at less than 3% include: Gloeocapsa, Gomphosphaeria, Chroococcus, Cylindrospermopsis, Raphidiopsis.



Other genera present at less than 3% include: Gomphosphaeria, Chroococcus, Coelosphaerium, Pseudanabaena, Monoraphidium, Gonium.

4.2 Geese Count

In 2025, the geese count was completed by the consultant and City staff.

WMG recorded the number of geese observed during each visit. Staff counted the number of geese every two weeks, coinciding with the water quality sampling site visits. All counts and other wildlife observations were recorded in a geese count App developed using ArcGIS Survey123 software.

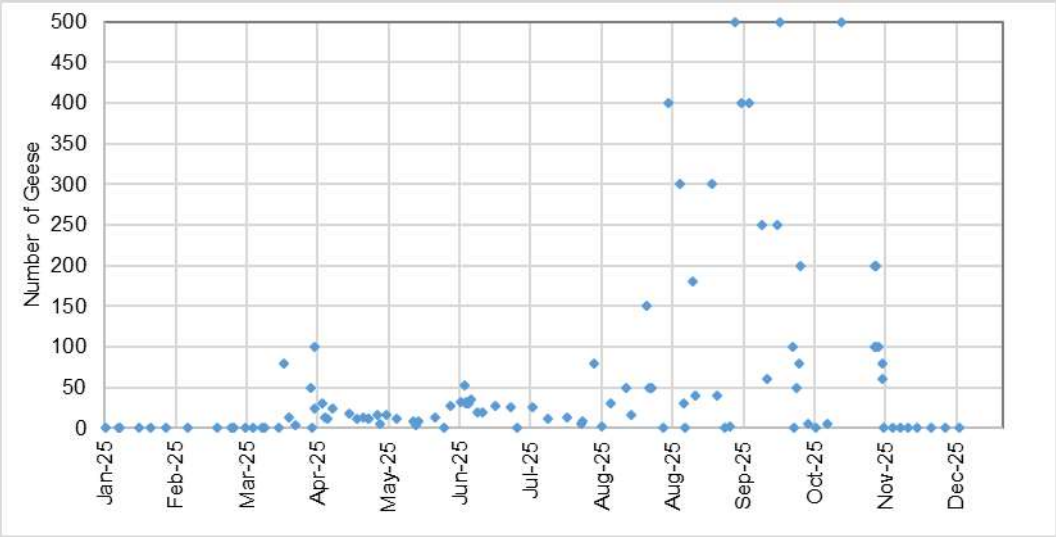
Figure 8 illustrates the number of geese counted at Swan Lake throughout the 2025 monitoring period.

In this figure, a significant increase in geese numbers is evident when they migrate south; however, the mitigation measures employed effectively reduced the number of geese present at different times of the day.

Any impact that strobe lights might have had on the geese count is not readily evident from the data.

In addition, nine nests and 33 eggs were managed at Swan Lake in April and May. The 2025 numbers show a reduction in total nests and egg counts compared to 2024. Geese nests were allowed to form a lining of goose down before removing eggs which proved successful in the prevention of re-nesting pairs.

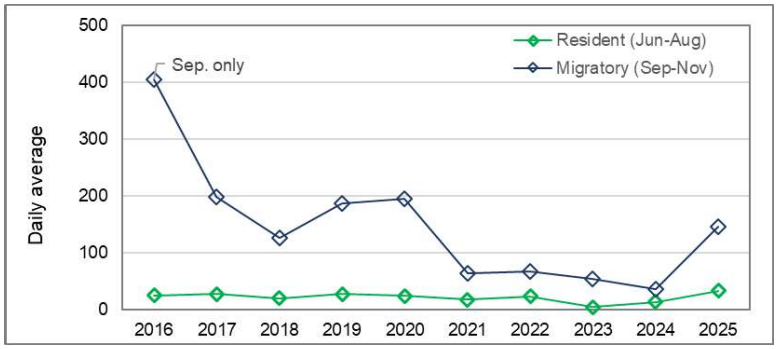
Figure 8: 2025 Geese Count Results at Swan Lake



Active geese management has been completed annually since 2014. The geese management program focused on resident geese at the beginning and extended to the management of migratory geese in 2016.

Daily Averages of counts are shown for each year in Figure 9. Data are summarized for June to August and September to November, representing resident and migratory geese, respectively. Despite a general increase in geese population in Southern Ontario, the numbers at Swan Lake have been controlled over the past years Goose counts were higher in 2025, primarily due to natural population fluctuations, and partly because the laser lights previously installed on the island were removed for product improvement.

Figure 9: Historical Geese Counts



4.3 Fish Inventory

Fish were captured using an electrofishing boat and a fyke on April 25, 2025 at the same electrofishing sampling transects from previous years. Fish captured in 2025 included Brown Bullhead, Fathead Minnow, Goldfish and a hybrid species of Goldfish and Common Carp. Common Carp was noticeably absent from the Lake.

A summary of the results so far is shown in Table 5. Differences in years could be explained by the timing of sampling (April vs. August) and the use of nets (e.g., fewer fathead minnows in 2023 when nets were not used).

Table 5: Fish Species Collected from Swan Lake Since 2021

Date	Method	Brown Bullhead	Common Carp	Fathead Minnow	Goldfish	Common Carp x Goldfish	Emerald Shiner
April-21	3 days electrofishing + 2 days nets	210	7	>10,000	-	-	-
August-22	1 day electrofishing, 1 day nets	80	20	875	-	-	-
August-23	1 day electrofishing	84	103	14	2	-	-
April-24	1 day electrofishing, 1 day net	193	1	1521	13	59	1
April-25	1 day electrofishing, 1 day net	391	-	3586	354	1	-

The 2021 Plan recommended monitoring and removal of benthic fish for five years. Following the 2025 work, TRCA advised that fish monitoring should continue annually and that invasive species should continue to be removed. They have recommended that in 2026 consideration should be given to returning some/all the Brown Bullhead to the lake (rather than removal) since they are a native fish, and it is important to have some benthic feeders in a lake ecosystem.

Following the 2025 stocking of largemouth bass, TRCA recommended monitoring the stocked fish and their spawning activity in 2026. TRCA also advised installing signage to remind the public not to release pet fish into the Lake.

4.4 Survey of Submerged Aquatic Vegetation

The planting of SAVs was implemented in 2023 and 2024 for a total of 3000 wild celery (*Vallisneria americana*) stems in fenced areas along the north shore of the Lake as a pilot project. In 2023 plantings were targeted around 30 cm -1 m deep as optimal growing depths for Wild Celery. Observations in 2024 indicated better establishment at the 20 cm depth areas, with an overall low rate of establishment at about

30%, potentially due to the turbidity and fluctuating water levels. In 2024, another 1500 stems were planted in a depth of about 20-40 cm. Naturally growing aquatic plants were also abundant in 2024. The rate of establishment for planted Wild Celery was overall very low in 2025.

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.

A summary of the 2025 aquatic vegetation survey is provided in Appendix E.

4.5 Water Quality Trends

Water quality monitoring of Swan Lake has been conducted annually since treatment in 2013 (except 2015) to track water quality and the effectiveness of implemented mitigation measures. The following paragraphs and Figure 10 provide a summary of water quality trends since 2016.

Dissolved Oxygen (DO)

Historical records of DO and temperature profile show that Swan Lake thermally stratifies during the summer despite its shallow depth. The majority of surface concentrations have been above 5 mg/L since 2014. In 2025, all day-time surface and bottom concentrations measured during sampling events at the Dock station were above 7 mg/L. DO concentrations, however, have a diurnal pattern, often decreasing at night. Data collected by two continuous loggers in 2025 indicated that deep water concentrations dropped to anoxic levels for several days in each of the summer months near the sediments at water depths greater than ~2.5 m, when there was minimal precipitation and warmer than usual weather potentially resulting in transient thermal stratification and reduced mixing of the bottom water.

Water Clarity (Secchi Depth)

In Swan Lake, Secchi depth has typically been quite low throughout the summer, but it increases in November, reflecting the end of the growing period for phytoplankton. The average annual values shown in Figure 10 are all below 1 m, . In 2025, water clarity averaged 0.6 m over the growth season.

Total Phosphorus (TP)

Average growing period (May - September) TP concentrations indicated hyper-eutrophic conditions in earlier monitored years except for the post-treatment years, 2013 and 2014. TP has been consistently lower since the 2021 treatment and dropped to below 30 µg/L in 2023 and has remained as such.

Nitrogen Compounds

Total nitrogen (TN) concentration over the growing period was 1.2 mg/L indicating a hyper-eutrophic condition in earlier years, except in the post-treatment year, 2014. TN dropped to concentrations reflecting mesotrophic conditions after the 2021 treatment and has remained as such.

Inorganic nitrogen compounds (NO_2, NO_3, and NH_3) have often been below detection limits, indicating relatively low levels of bioavailable nitrogen concentrations. In 2025, ammonia and nitrate concentrations were generally very low (except higher ammonia in the fall), and nitrogen was mainly present as organic matter.

Chloride

Chloride concentrations were increasing in Swan Lake reaching high levels in 2020 and 2021. Removing a blockage at the East Pond inlet and cleaning of the Swan Club OGS resulted in lower untreated flows (with higher chloride concentrations) to the Lake, lowering chloride concentration in Swan Lake post 2022. Chloride concentrations have been around 200 mg/L in 2024 and 2025.

DOC and Color

DOC in 2022, 2023 and 2024 (before the PAC treatment) was considerably higher than in previous years. The increase may potentially be associated with the remnants of Phragmites in the Lake, as the roots were not removed. Both colour and DOC declined sharply in 2024 following the PAC treatment, which precipitates organic matter. DOC increased to pre-treatment levels in 2025 while colour has remained low.

Algae Blooms and Cyanobacteria

Testing for algae blooms, cyanobacteria levels, and microcystin concentrations in Swan Lake has been carried out in various forms since 2011. Between 2011 and 2016, lake water was analyzed for microcystin toxicity, with only one detection recorded in 2016 at 73 µg/L (the recreational guideline is 20 µg/L).

In 2018, extended blooms were observed at several sites in the Lake, however cell density was at half of WHO's threshold for significantly increased risk for human health. Microcystin toxicity was measured with test strips in 2019 and 2020, and all samples were below 10 µg/L.

In 2021, samples were collected before and after chemical treatment and test results showed a significant reduction in concentrations following the treatment.

In 2022, limited algae scum was observed in early June and while the Lake was dominated by phytoplankton for the remainder of the monitoring period, surface scums were not widespread. The 2022 results showed lower diversity and higher total counts compared to 2021, but surface scums were not widespread. Total counts for 2022 may be erroneous and are not shown below.

The 2023 results indicated significantly lower cell counts compared to 2021, with an additional 40% decrease in 2024. The 2025 cell counts are similar to 2024.

Figure 10: Historical Water Quality Results (Growing-Season Averages)

4.6 2025 Water Level

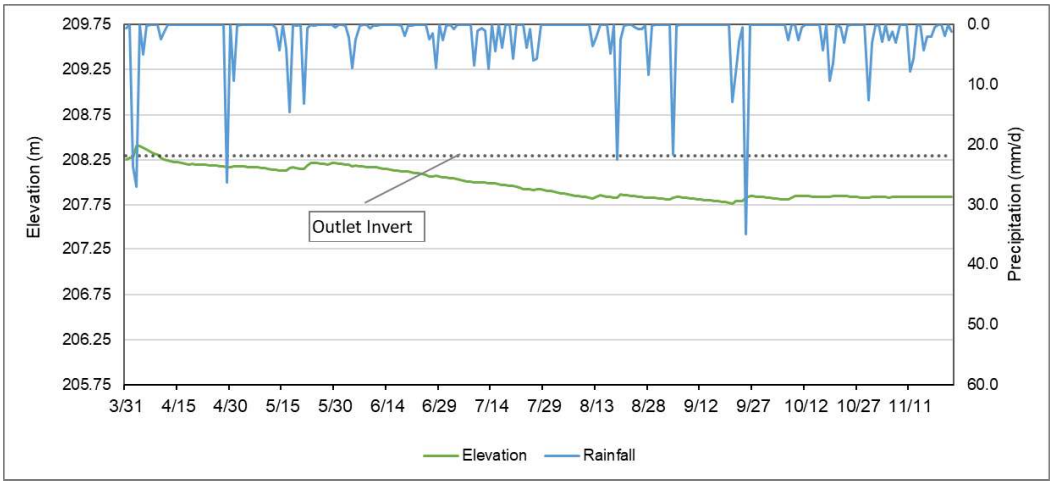
In 2025, the daily average water level changed from a maximum of 208.4 m in April to a low of 207.8 m throughout August to October. Total precipitation in 2025 was 620 mm, as recorded at the Markham Museum station.

The maximum water level recorded or estimated between 2017 and 2024 ranged from 208.25 m to 208.48, when total precipitation ranged from 670 to 1055 mm.

2025 was a very dry year during the summer and fall, which resulted in low water level and lower oxygen levels at depth.

Measured water level and daily precipitation data from the nearby rain gauge are shown in Figure 11.

Figure 11: Lake Elevation Records and Precipitation in 2025



5. Summary and Conclusions

5.1 Summary of Monitoring Results

Through the Swan Lake monitoring program, data collected in 2025 provide insight into long-term trends in water quality and will also help determine the need for and impact of management activities on Swan Lake.

Dissolved oxygen, temperature, and water transparency were measured at two stations through bi-weekly site visits. Profiles of temperature and dissolved oxygen indicated that Swan Lake was thermally stratified in June and September. The minimum dissolved oxygen concentration required for the protection of warm water fish is 5 mg/L, which was met in the surface water. Continuous measurements at depth indicated that DO dropped to anoxic levels for several days in the summer months at depths below about 2-2.5 m when there was minimal precipitation and warmer than usual weather.

pH measured at the lab was about 8, indicative of alkaline conditions due in part to high levels of photosynthesis by algae.

Transparency at the Dock station averaged at 0.6 m over the growing season and was within the interim target for Swan Lake of 0.6-0.8 m based on correlation with the phosphorus target.

Water samples were analyzed for nutrients (phosphorus and nitrogen compounds). Total phosphorus concentration in the 0.5 and 1.5m depth averaged 16 µg/L during the growing season (June-September) and throughout the year (reflecting moderately productive, or mesotrophic conditions). Concentrations also met the interim PWQO for total phosphorus of 20 µg/L for lakes to avoid nuisance concentrations of algae.

Total nitrogen concentrations over the growing season averaged about 0.62 mg/L (reflecting moderately productive, or mesotrophic conditions).

Chloride concentrations in the Lake were within the interim target range specified for the Lake (between 190 and 240 mg/L compared to 400-500 mg/L, which is the interim target), and were considerably lower than 2021 values, similar to 2024. Concentrations are similar to background concentrations reported in urban surface and groundwater systems in the GTA.

Chloride concentrations were also measured in stormwater runoff to the ponds and the Lake (from ponds, OGS's, and overland flow) during snow melt and spring freshet. The data were used to update the chloride balance to determine the relative contribution of each source to chloride concentration in Swan Lake.

In 2025, limited surface scum was found at both the Dock and Bridge sampling sites; however, the Lake was dominated by phytoplankton. Samples analyzed for cyanobacteria indicated total counts similar to 2024 and lower than 2023. Chlorophyll-a concentrations were below the hyper-eutrophic concentration.

Daily average water level at the logger location changed from a maximum of 208.4 m in April to 207.8 throughout August to October, reflecting a very dry year.

5.2 Summary of 2025 Management Activities and Studies

In 2025, geese management was completed through nest depredation and adult goose mitigation using laser light, avian distress call and limited strategic zinc crackler pyro. These mitigation measures have controlled over the past years despite a general increase in geese population in Southern Ontario. Any impact that strobe lights might have had on the geese count is not readily evident.

Fish management and the removal of bottom-dwelling fish was completed by the TRCA, and 371 Brown Bullhead and Goldfish were euthanized. Any Fathead Minnow and some of Brown Bullhead captured were released back to the Lake.

In May 2025, 500 juvenile largemouth bass added to the lake by a private contractor (Hidden Lane Fisheries from Smithville, ON), following consultation with TRCA, MNRF. Fish stocking was identified as a Complementary measures in the 2021. This measure was brought forward to help balance the fish community in the lake.

An evaluation of the SAV planting success and habitat conditions was completed in 2025, confirming the successful establishment of native SAV with abundant cover throughout the lake, consistent with a transition of the lake to more mesotrophic conditions.

Following the successful implementation of ultrasound technology to control of algae blooms in a stormwater management pond in Markham, two similar units were installed at Swan Lake to further improve water clarity.

The pilot study investigating the use of biochar adsorption techniques to remove chloride from Swan Lake water is ongoing, with results expected by the end of 2026.

The water and chloride budget for the Lake was updated using modeling results from the Flow Diversion Feasibility Study, together with information on salt usage and chloride concentrations in stormwater runoff.

5.3 Conclusions

Based on the measured nutrient concentrations in 2025, Swan Lake is classified as mesotrophic for total phosphorus (as well as nitrogen, but not for transparency; see Table 1 for definitions). Figure 12 provides a summary of phosphorus concentrations since 2010.

Overall, the management activities in 2021-2025 that focused on the significant nutrient loadings identified in the water quality management plan (i.e., chemical treatment and fish management to reduce internal loads and geese management to reduce external loads), were effective at improving water quality in the Lake as shown by reduced phosphorus concentrations, improved dissolved oxygen levels, and lower densities of cyanobacteria, together representing a shift from hyper-eutrophic to mesotrophic conditions. These improvements represent a positive step towards improving the aquatic habitat in the lake and meeting the long-term water quality goals.

In recent years, chloride levels decreased considerably, likely due to clearing the blockage at the East Pond inlet and the Swan Club OGS, which resulted in lower untreated catchment flows to the Lake.

While internal and external source controls successfully reduced nutrient concentrations, the Lake was dominated by phytoplankton, and water clarity did not improve substantially. The planting of SAVs started in June 2023 and continued in 2024 to help improve water clarity. Natural colonization of SAV, however, occurred with a dense cover throughout most of the lake in 2025.Two ultrasound units were installed in Swan Lake to help improve water clarity further.

In accordance with the 2021 Long Term Management Plan and following the completion of Phase 1 of the plan, a 5-year Review is being conducted. This Review will summarize the effectiveness of Core measures and evaluates additional Complementary measures to consider in Phase 2.

The 2026 monitoring program and management activities will follow the recommendation of the Long-Term Management Plan, as updated through the Phase 1 Review process.

Figure 12: Trophic State Classification for Swan Lake based on Phosphorus Concentration