

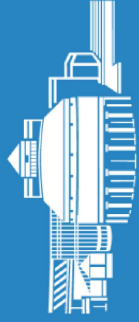
Swan Lake

Annual Meeting with Markham Subcommittee

May 11, 2023

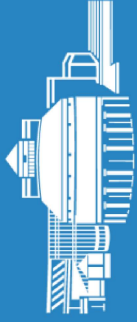
Environmental Services

**Authors: Robert Muir, Manager, Stormwater
Zahra Parhizgari, Sr. Environmental Engineer, Stormwater**

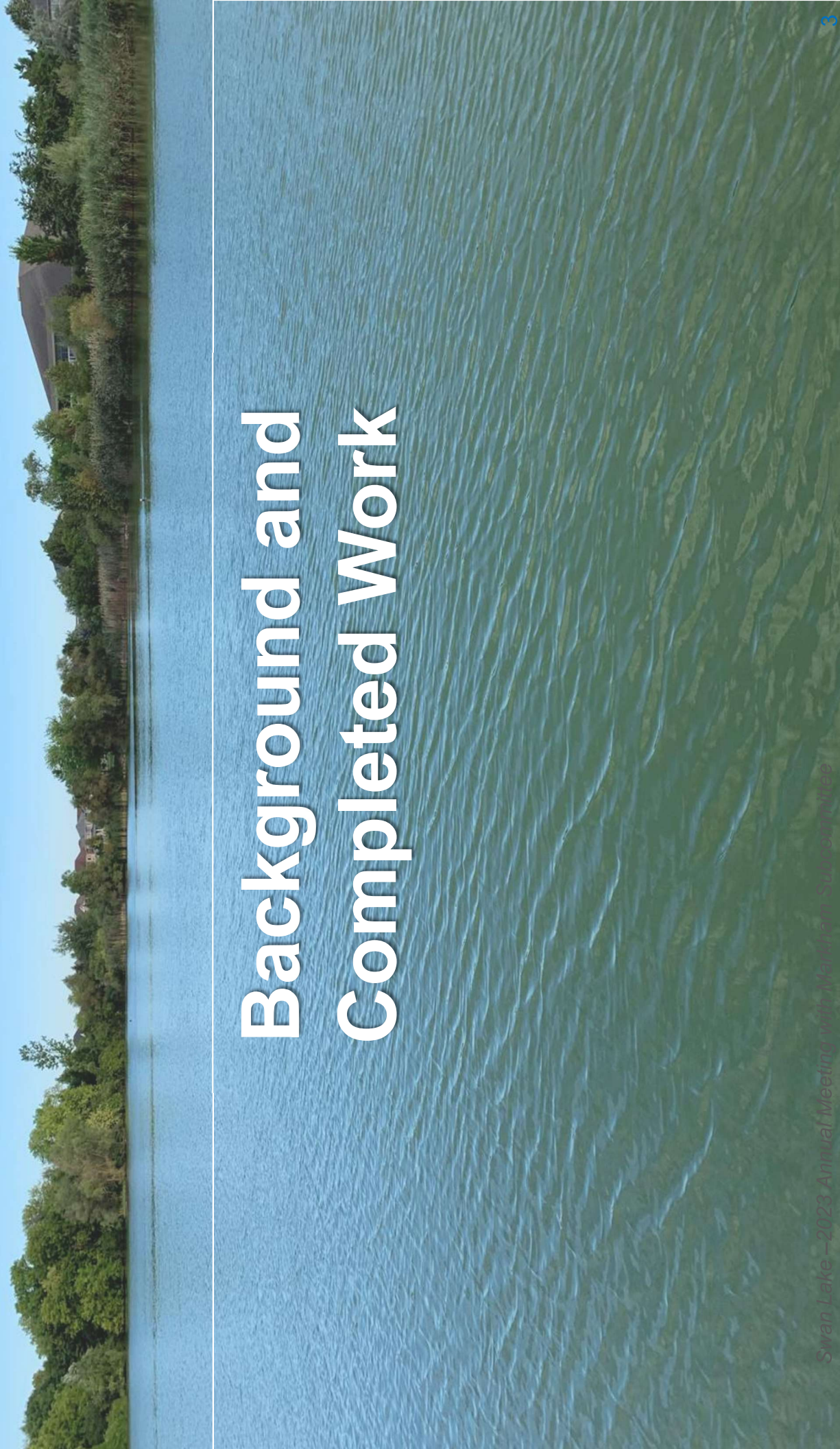


Agenda

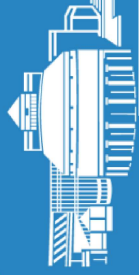
- Background and Completed Work
- 2022 Water Quality Results:
 - Nutrients and Eutrophication
 - Chloride Concentration
- Review of Three Research Initiatives:
 - Chemical Oxygenation
 - Chloride Treatment
 - Survey of Lower Level Aquatic Life
- Review of FOSLP Towards a *Comprehensive Restoration Plan for Swan Lake*
- 2023 Plan and Recommendations:
 - Core Measures
 - Submerged Aquatic Vegetation Planting
 - Flow Diversion Feasibility Study
 - Assessment of New Technologies for Chloride Treatment



BUILDING MARKHAM'S FUTURE TOGETHER
2020 – 2023 Strategic Plan



Background and Completed Work



Background and
Completed Work

2022 Water Quality Results

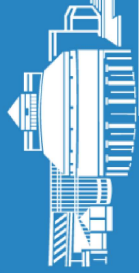
Review of FOSLP Proposals

2023 Plans and
Recommendations

Location and History

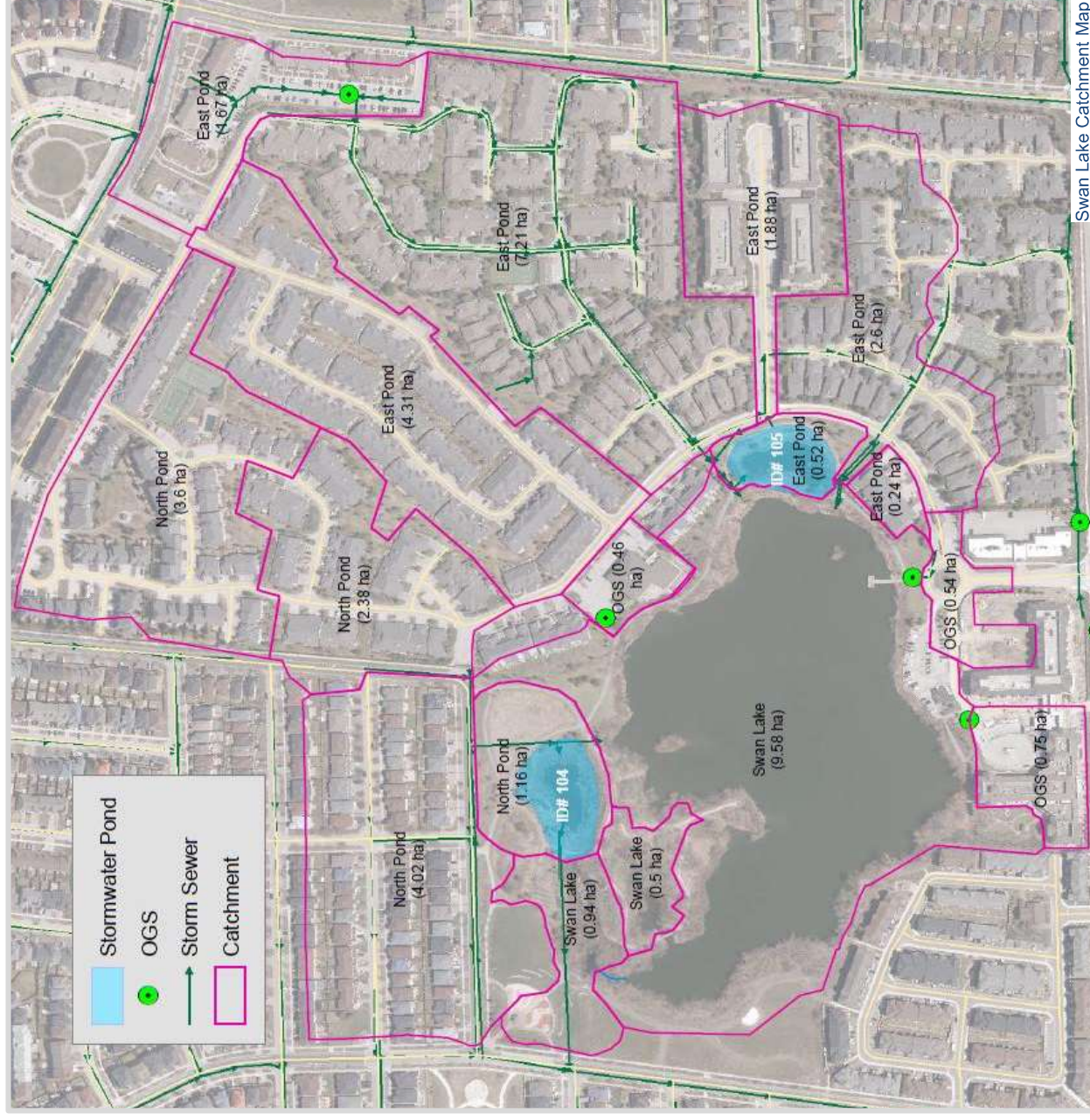
- Area: 5 ha, max depth: 3.5m
- Gravel pit in the 1960s and 1970s; construction waste dump in the early 1980s
- Lake formed when pumping for the gravel pit ceased operations
- Environmental Management Study for the Swan Lake Community in 1993 and several studies until 2008
- Water quality issues from 2010 and possibly earlier

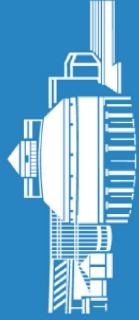




Catchment

- Started as farmlands
- Changed to residential community, including a gated community and senior housing development
- About 45 ha:
 - Community & infrastructure (75 %)
 - Open water including the Lake (15%)
 - Tree canopy or parks (10 %)
- Two stormwater management ponds and three oil and grit separators





Background and Completed Work

2022 Water Quality Results

Review of FOSLP Proposals

2023 Plans and Recommendations



ISSUES

- Closed system resulting in contaminant build-up
- Internal source of phosphorus highly bio-available
- External source of phosphorus, mainly geese dropping, difficult to control
- High chloride concentration due to winter maintenance activities
- Most of the catchment is privately serviced

Issues and Opportunities

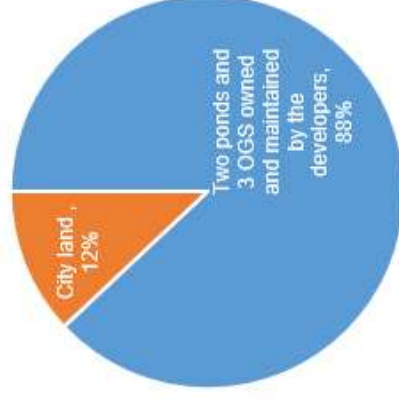
- Swan Lake and park are well used amenities with strong community support for sustainable solutions
- Existing stormwater management infrastructure to treat most of runoff



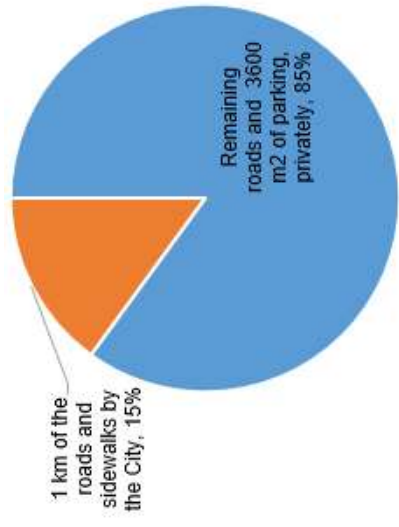
OPPORTUNITY

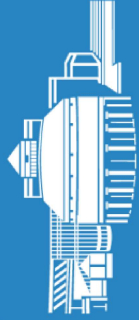
Maintenance responsibility

Runoff Treatment



Winter Maintenance





Background and Completed Work

2022 Water Quality Results

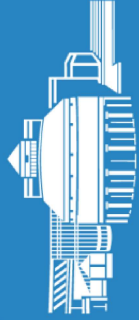
Review of FOSLP Proposals

2023 Plans and Recommendations

Management Timeline



Measures	Phase 1 (Years 1-5)	Phase 2 (Years 6-10)	Phase 3 (Years 11-25)
Core Measures	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Complementary Measures		<input checked="" type="checkbox"/>	
Alternative Measures			<input checked="" type="checkbox"/>
5-yr review	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>



Background and
Completed Work

2022 Water Quality Results

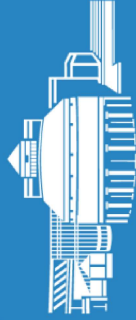
Review of FOSLP Proposals

2023 Plans and
Recommendations

2022 Council Resolutions

MINUTES AND NOTES OF THE SEPTEMBER 6, 2022 MARKHAM SUB-COMMITTEE

1. That the deputation from Fred Peters and the Friends of Swan Lake Park Presentation, “Action Plan For Restoration of Swan Lake and Swan Lake Park” be received; and,
2. That the minutes of the May 11, 2022 Markham Sub-Committee Swan Lake Meeting be received; and,
3. That General Committee endorse the recommendation from the May 11, 2022 Markham Sub-Committee Meeting;
 - a. That the Staff report and presentation on the “Swan Lake- 2021 Water Quality Status and Updates” be received; and,
 - b. That the FOSLP presentation “Action Plan For Restoration of Swan Lake and Swan Lake Park” and York University presentation on the research it is proposing on the use charcoal filter system to remove nutrients and chloride be received and referred to Staff; and further,
 - c. That Markham Sub-Committee request that Staff report back on the feasibility, and implications of designating Swan Lake a natural heritage asset, as part of the Official Plan update; and,
4. That Staff review and report back to Committee on the feasibility and costs of the following research initiatives:
 - a. Chloride Removal;
 - b. Oxygen Enhancement; and,
 - c. Survey of Lower Level Aquatic Life; and,
5. That Council approve a technical analysis of Swan Lake to assess the feasibility of proposed changes to determine if the infrastructure within Swan Lake can support the proposed changes; and,
6. That this recommendation be forwarded to the 2023 Budget Committee for consideration; and further,
7. That Staff be authorized and directed to do all things necessary to give effect to this resolution.



Background and Completed Work

2022 Water Quality Results

Review of FOSLP Proposals

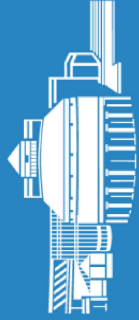
2023 Plans and Recommendations

2022 Measures

Phase 1 Core Measures (Years 1-5)	
Activity	
Water quality monitoring and annual reporting to Subcommittee	<input checked="" type="checkbox"/>
<i>Enhanced</i> Geese management	<input checked="" type="checkbox"/>
Removal of benthic-dwelling fish	<input checked="" type="checkbox"/>
Maintenance of stormwater management facilities	<input checked="" type="checkbox"/>
Community Engagement	<input checked="" type="checkbox"/>
Shoreline planting / Improvements	<input checked="" type="checkbox"/>
Chemical oxygenation pilot project	Reviewed
New technologies for chloride treatment *	
Fish management plan and fish stocking (by MNDMNR) *	Pending improved water quality
Planting of submerged plants *	Planning underway
Flow Diversion Feasibility Study **	

* Originally planned for Phase 2

** Originally planned for Phase 3



Background and
Completed Work

2022 Water Quality Results

Review of FOSLP Proposals

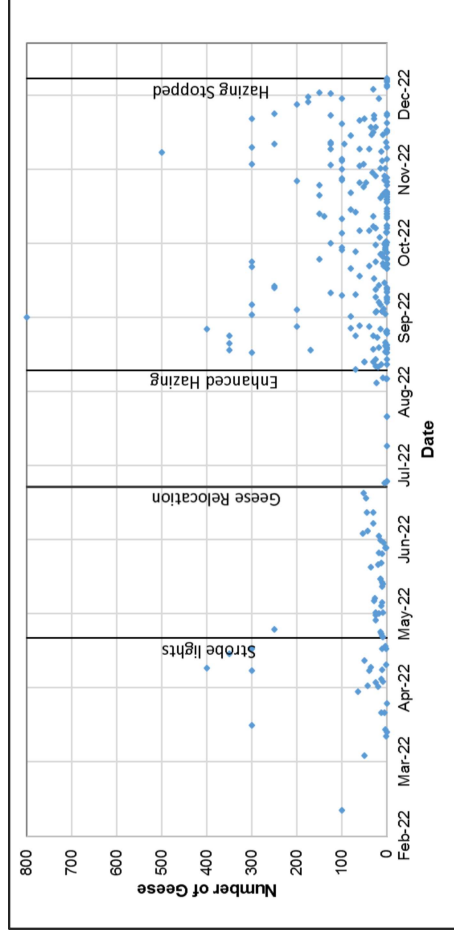
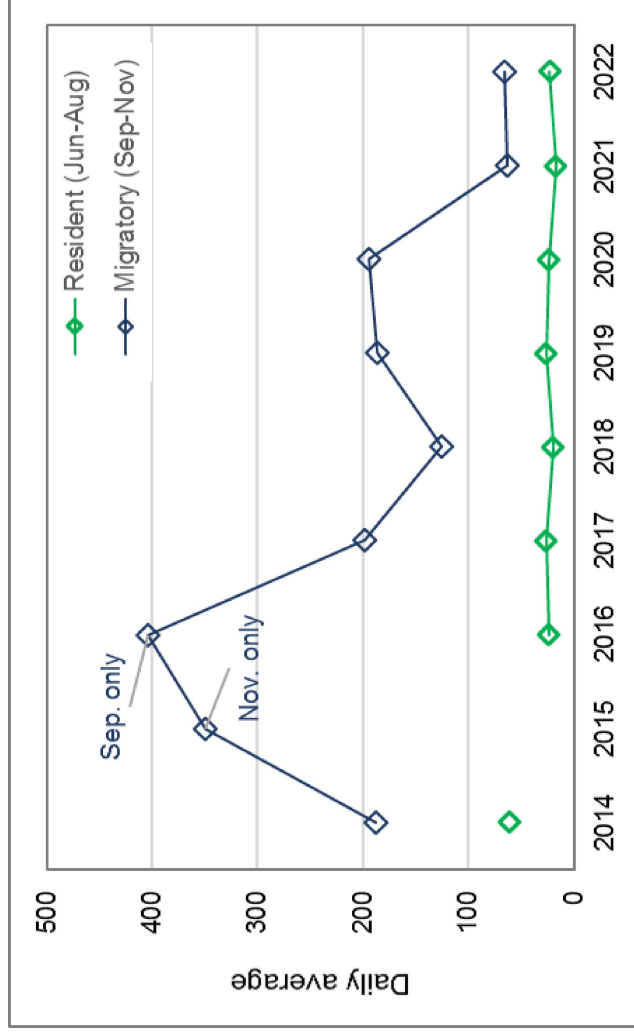
2023 Plans and
Recommendations

Geese Management

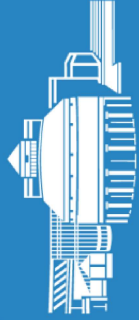
- Geese relocation and hazing and egg/nest management
- Increased hazing frequency reduced the number of geese present at different times of the day
- Any impact that strobe lights might have had is not readily evident from the data



Swan Lake Geese Count Survey QR Code



* Some assumptions have been made in calculating the daily average for each year to fill in data gaps.



Background and
Completed Work

2022 Water Quality Results

Review of FOSLP Proposals

2023 Plans and
Recommendations

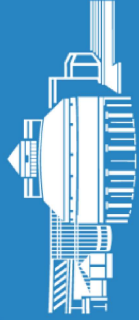
Fish Management

- Removal of bottom-dwelling fish (to avoid disturbance of sediment)
- Fish inventory (Common Carp, Brown Bullhead, and Fathead Minnow)
- Fish management plan and fish stocking pending improved water quality and planting of submerged aquatic vegetation

Storm System Maintenance

- In November 2021 the East pond inlet was cleared
- Assumption process underway
- Clearing of the blocked outlet from Swan Club OGS has been requested





Background and
Completed Work

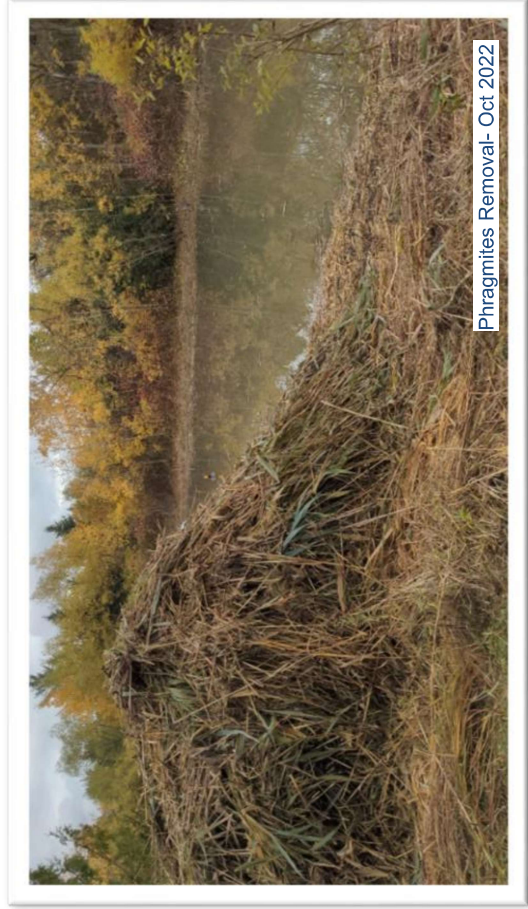
2022 Water Quality Results

Review of FOSLP Proposals

2023 Plans and
Recommendations

Shoreline Improvement (Parks Department)

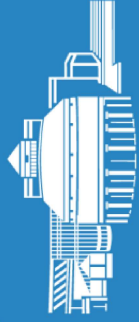
- Shoreline improvement: Phragmites removal
- Design and consultation



Phragmites Removal- Oct 2022

Swan Lake Designation (Planning Department)

- Council direction: Review feasibility and implications of designating Swan Lake a natural heritage asset as part of the Official Plan update
- Supporting studies underway:
 - Natural Heritage Inventory and Assessment Study completed in 2021
 - Future phases (2022/2023) will consider the Greenway System across Markham for potential ecological enhancements, costs and priority setting



Background and
Completed Work

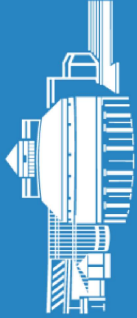
2022 Water Quality Results

Review of FOSLP Proposals

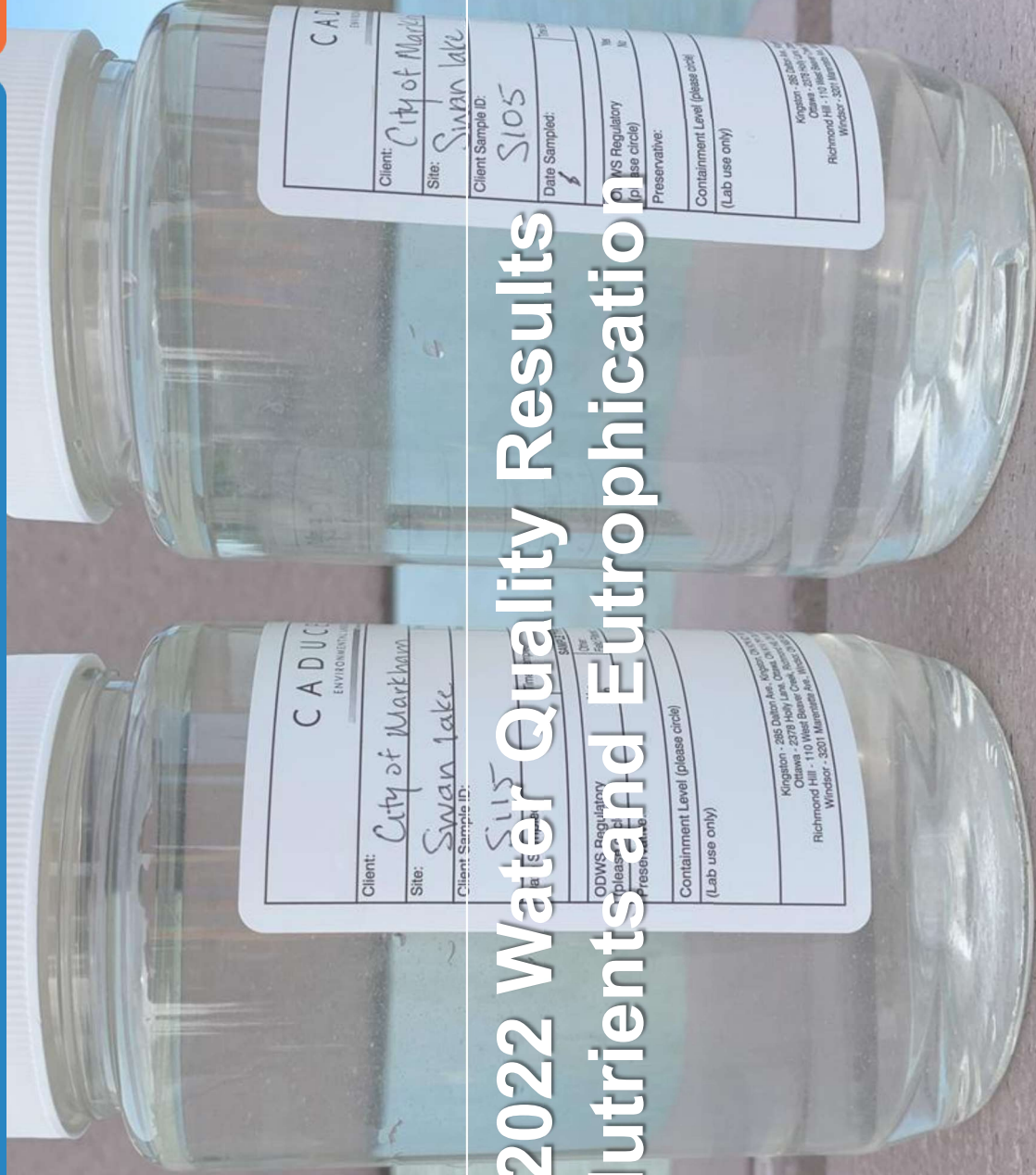
2023 Plans and
Recommendations

Community Engagement

- Ongoing conversation with residents
- Swan Lake Park walkabout
- Markham Lions Club (Adopt a Park Program)
- Discussions with TRCA (geese and fish management, shoreline and submerged planting)
- Met researchers engaged by FOSLP (Fleming College and York University)
- Discussions with Trent University researchers
- Met with FOSLP on April 19, 2023



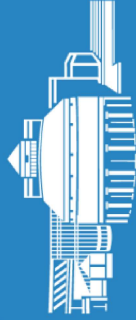
BUILDING MARKHAM'S FUTURE TOGETHER 2020 – 2023 Strategic Plan



2022 Water Quality Results Nutrients and Eutrophication

Client:	City of Markham
Site:	Swan Lake
Client Sample ID:	S105
Date Sampled:	
ODWS Regulatory (please circle)	
Preservative:	
Containment Level (please circle)	
(Lab use only)	
Kingston - 285 Dutton Ave. Kingston, ON N6A 5R6 Ottawa - 2378 Holly Ln. Oshawa, ON L1G 4C2 Richmond Hill - 110 West Beaver Creek, Richmond Hill, ON L4B 1N2 Windsor - 3301 Marquette Ave. Windsor, ON N9A 6K5	

Client:	City of Markham
Site:	Swan Lake
Client Sample ID:	S105
Date Sampled:	
ODWS Regulatory (please circle)	
Preservative:	
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Background and
Completed Work

2022 Water Quality Results

Review of FOSLP Proposals

2023 Plans and
Recommendations

Lake Processes

- Excessive amount of phosphorus and nitrogen results in algae growth
- As the algae die and decompose, the process consumes dissolved oxygen (DO)
- Low DO concentrations could have lethal or sub-lethal (physiological and behavioral) effects on fish

Eutrophic Classifications (based

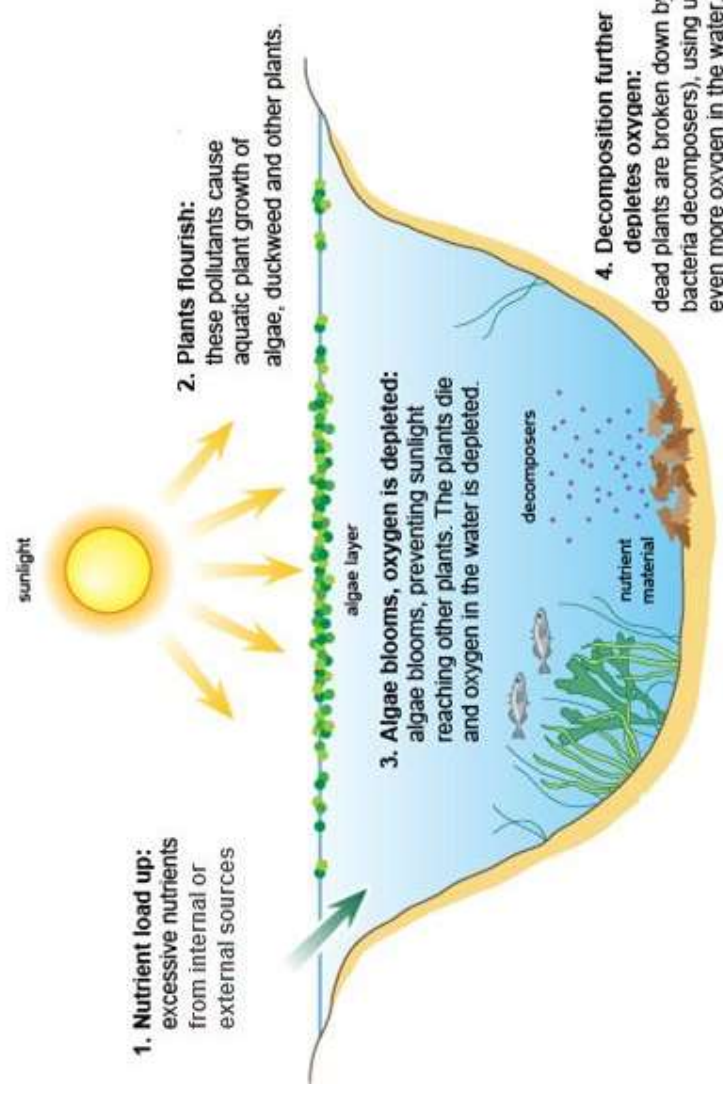
on DO, phosphorus, clarity):

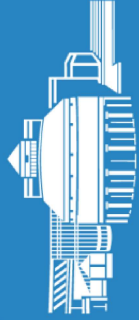
Oligotrophic: pristine

Mesotrophic: clear with some submerged plants

Eutrophic: somewhat unclear, lots of planktonic plant growth

Hypereutrophic: unclear, with frequent algal blooms





Background and Completed Work

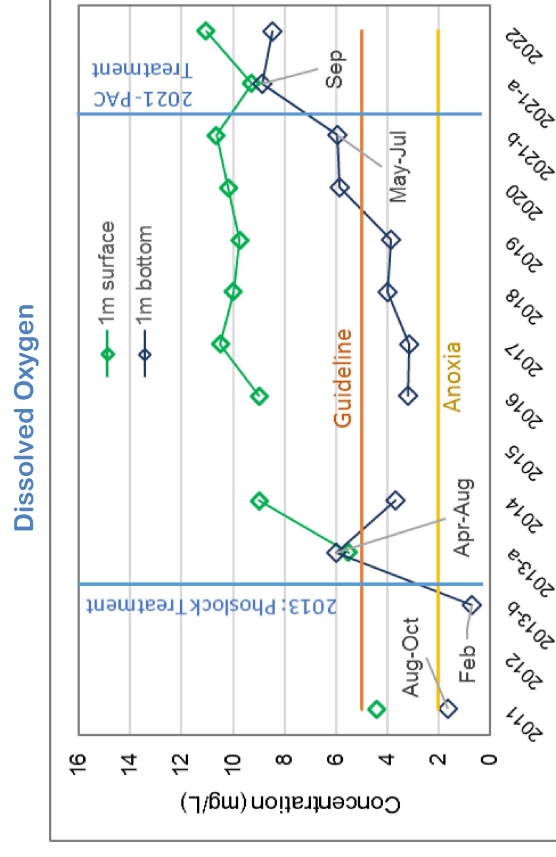
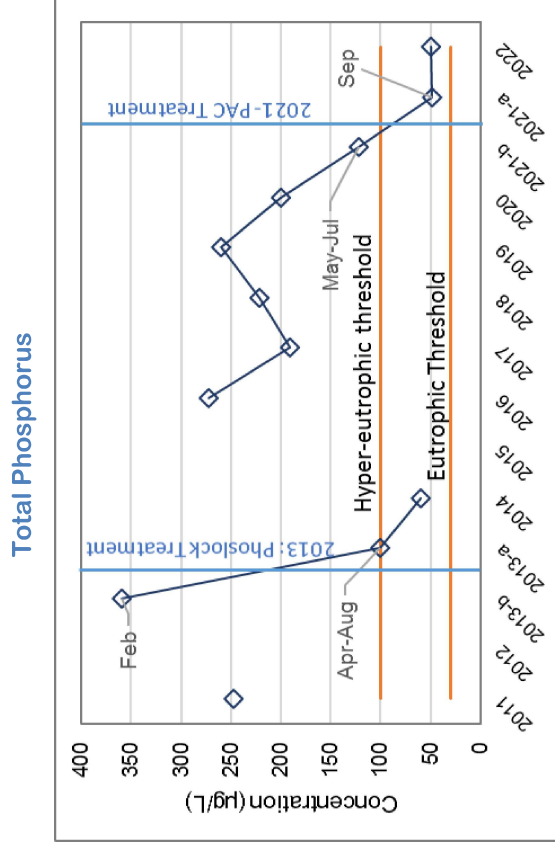
2022 Water Quality Results

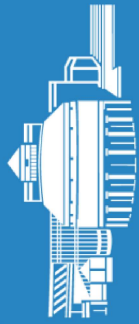
Review of FOSLP Proposals

2023 Plans and Recommendations

Water Quality- Nutrients and Oxygen

- **Total Phosphorus:**
 - Average under 50 µg/L during growing season
 - Decreased significantly after each treatment
- **Total Nitrogen:**
 - Average about 0.6 mg/L during growing season (limit 1.2)
 - Dominant forms not bioavailable
- **Dissolved Oxygen:**
 - Surface concentration > 9.5mg/L all year
 - Bottom concentration mostly >5mg/L
 - Increased compared to previous years





Background and
Completed Work

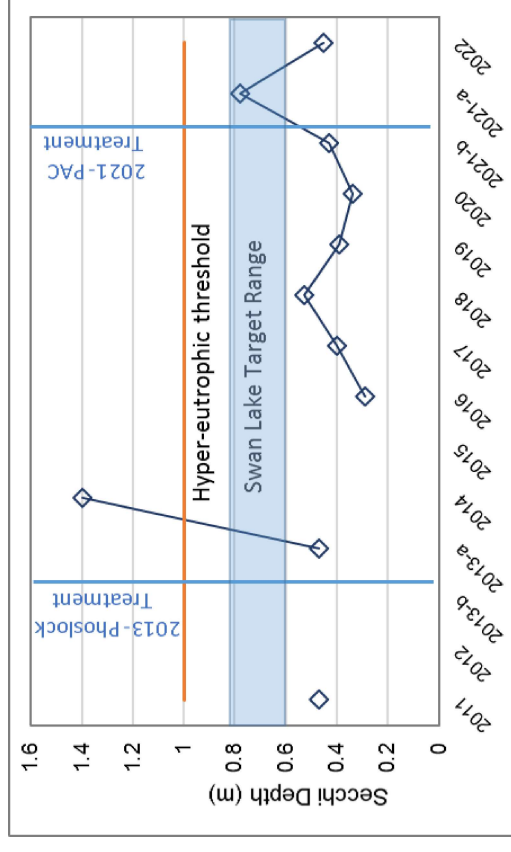
2022 Water Quality Results

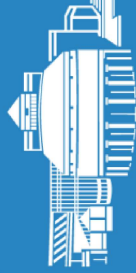
Review of FOSLP Proposals

2023 Plans and
Recommendations

Water Quality- Algae and Clarity

- Algal growth:
 - Peaked in June and September
 - Cell numbers increased from 2021
 - Microcystis measured below the recreational limit; however, it is probable that values were higher in other locations in the Lake
- Clarity:
 - Above >0.5 until June
 - Low clarity after first bloom





Background and Completed Work

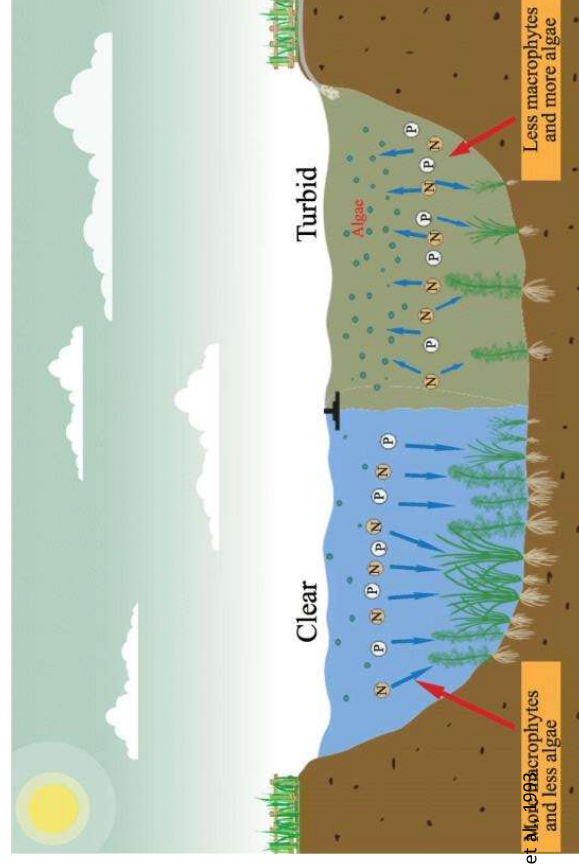
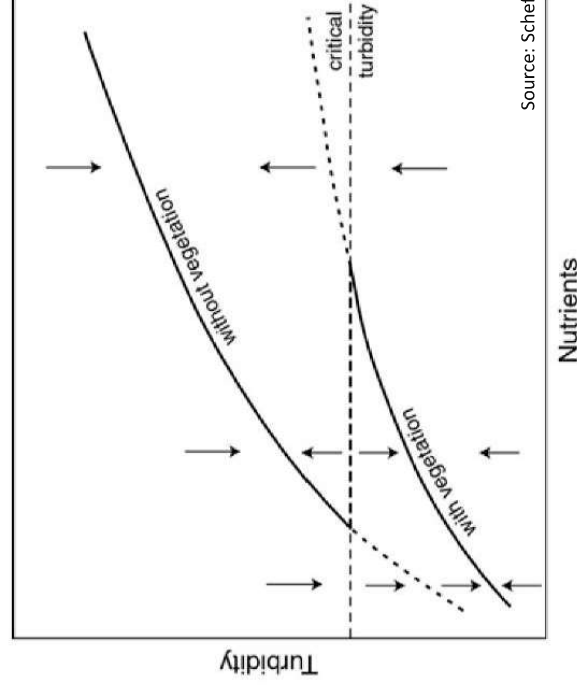
2022 Water Quality Results

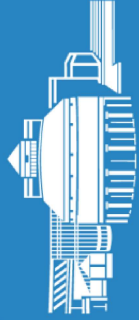
Review of FOSLP Proposals

2023 Plans and Recommendations

Alternative Equilibria in Shallow Lakes

- Generally, water turbidity is directly related to nutrient loading
- However, shallow lakes can have two ‘alternative equilibria’ for the same nutrient concentrations:
 - A turbid state, dominated by high algal blooms
 - A clear state, dominated by aquatic vegetation
- When a lake is in turbid state, reduction of nutrients alone may not bring it back to the clear state and habitat intervention is required.





Background and
Completed Work

2022 Water Quality Results

Review of FOSLP Proposals

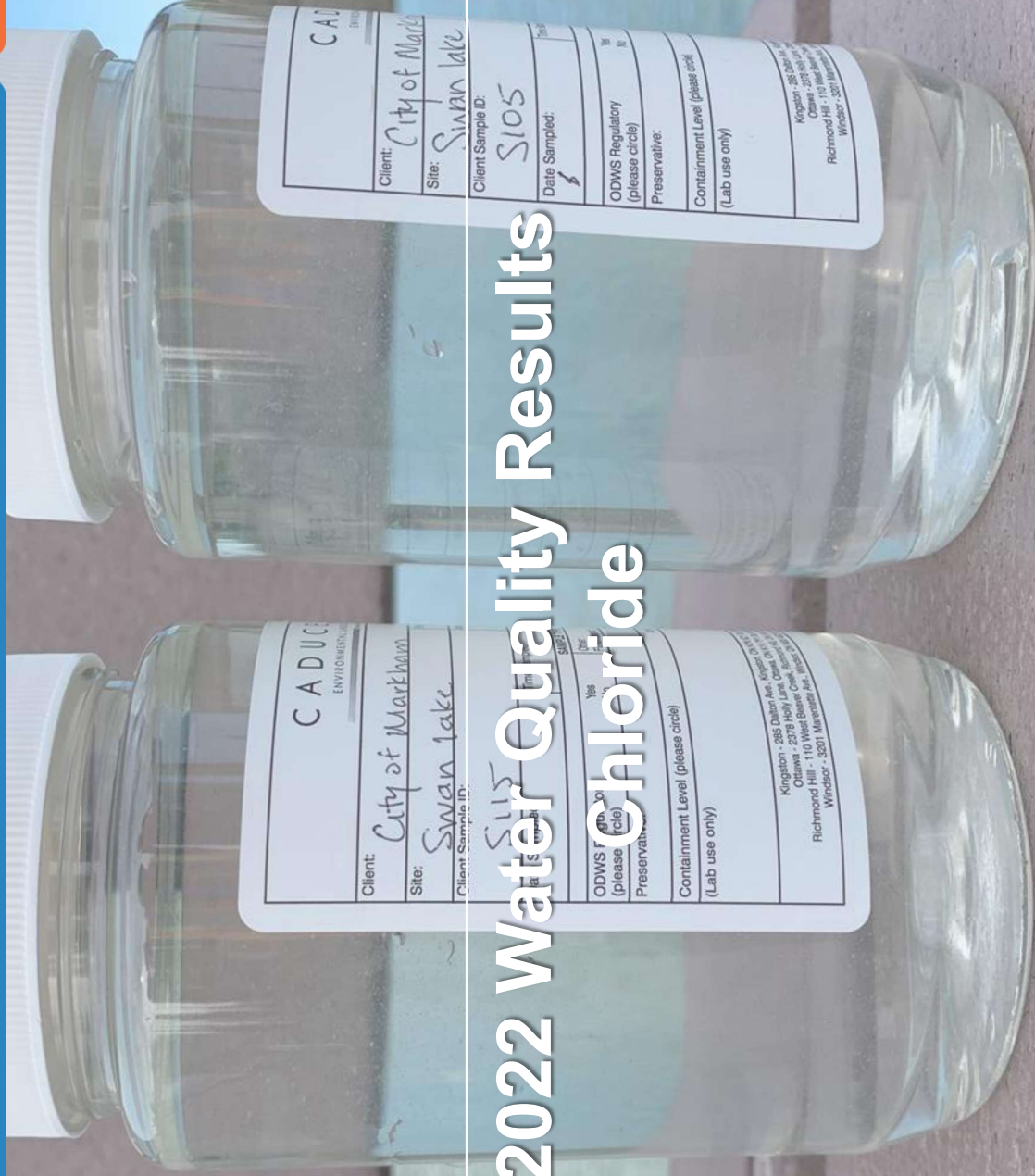
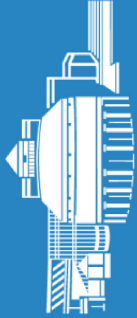
2023 Plans and
Recommendations

Turbid State in Swan Lake

- Phosphorus and nitrogen concentrations reduced after treatment and geese management
- Low clarity and high algae growth continued
- Planting of submerged aquatic vegetation (SAV) will encourage the change of state
- It will also:
 - Provide habitat for zooplankton, which grazes algae
 - Fix sediment and reduce nutrient release



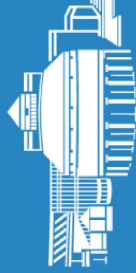
Aquatic vegetation



2022 Water Quality Results Chloride

CADUCO ENVIRONMENTAL	
Client:	City of Markham
Site:	Swan Lake
Client Sample ID:	S105
Date Sampled:	
ODWS Regulatory (please circle)	Yes <input type="checkbox"/> No <input type="checkbox"/>
Preservative:	
Containment Level (please circle)	
(Lab use only)	
Kingston - 285 Dutton Ave. Kingston, ON N1Y 2K1 Ottawa - 2378 Holly Ln. Oshawa, ON L1H 7R7 Richmond Hill - 10 West Beaver Creek, Richmond Hill, ON L4B 1N1 Windsor - 3301 Marquette Ave. Windsor, ON N9N 1L5	

CADUCO ENVIRONMENTAL	
Client:	City of Markham
Site:	Swan Lake
Client Sample ID:	S105
Date Sampled:	
ODWS Regulatory (please circle)	Yes <input type="checkbox"/> No <input type="checkbox"/>
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Background and
Completed Work

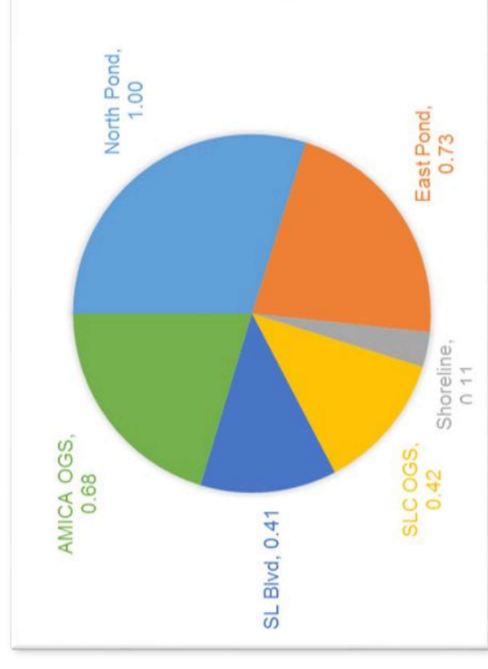
2022 Water Quality Results

Review of FOSLP Proposals

2023 Plans and
Recommendations

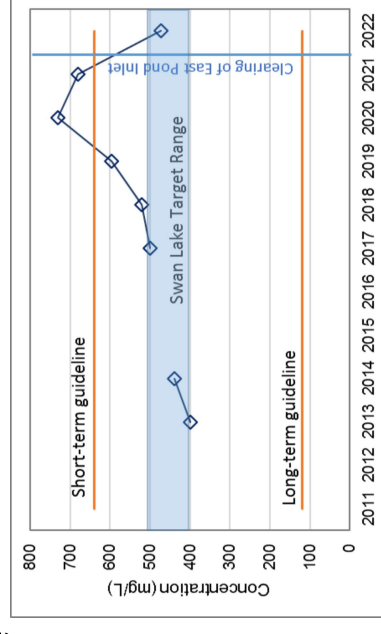
Winter Maintenance and Salt Usage

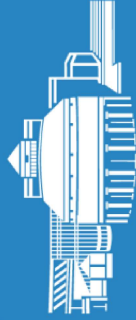
- Salt Usage:
 - Swan Lake Village Corporation : 14 km road (~ 30 tonnes/yr) & driveways/ walkways/parking (~70 tonnes/yr)
 - City roads: 1.1 km (~3 tonnes/yr)
 - Residents north of the Lake
 - AMICA Corporation to the south
- Chloride Estimates:
 - Runoff sample collections
 - About 3.5 tonnes of chloride contributes to the Lake
 - Contribution higher during ~2018-2021 when the inlet to East pond was blocked.
 - Annual variations depending on the amount of snow and salt application



Initial estimate of chloride contribution to the Lake (tonne/yr) from each source based on modeled flows and salt usage data

Values will be refined through the Flow Diversion Study.





Background and
Completed Work

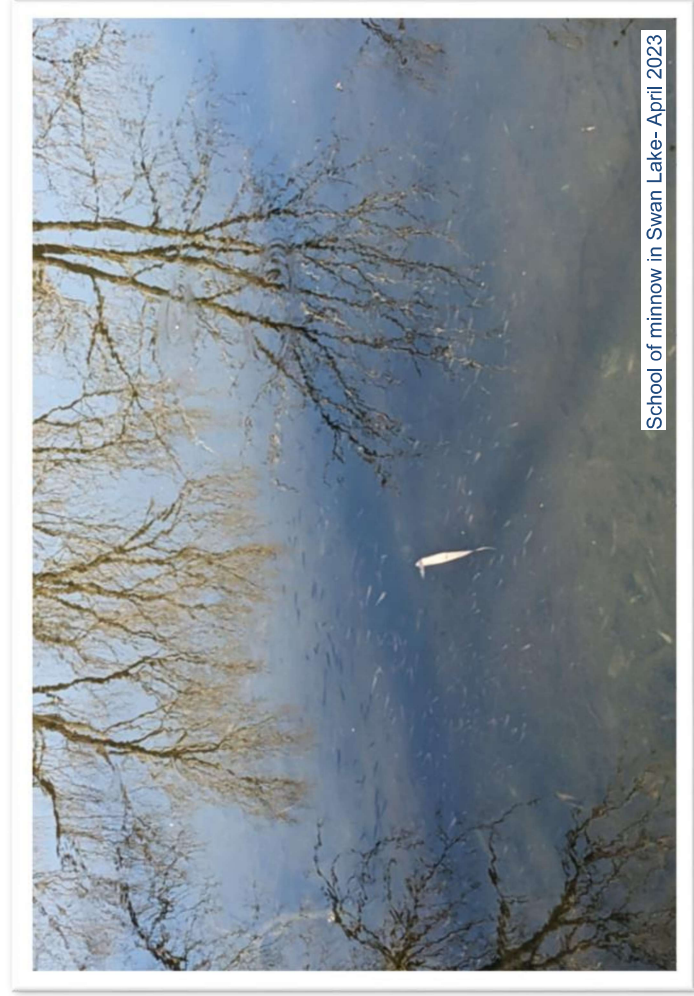
2022 Water Quality Results

Review of FOSLP Proposals

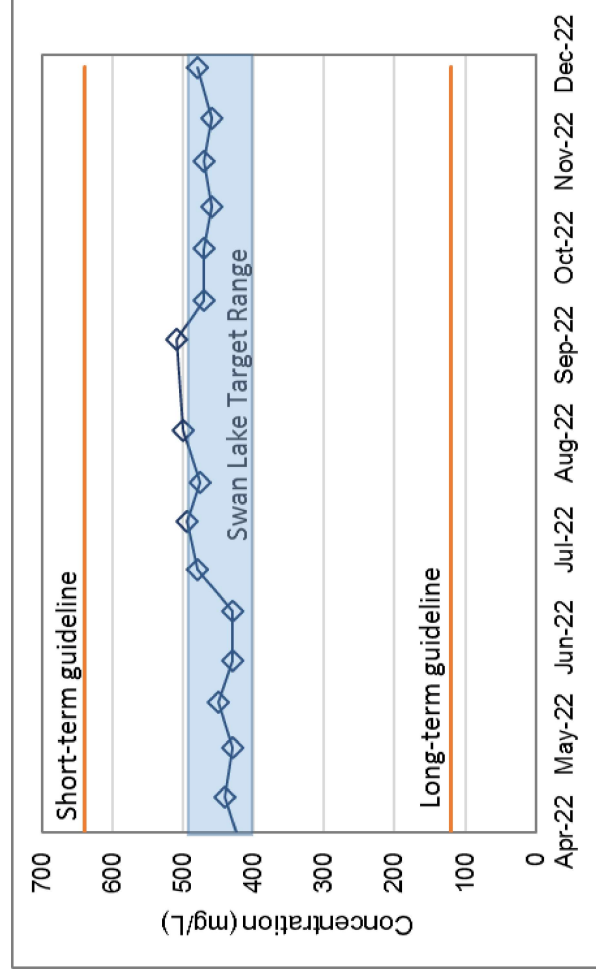
2023 Plans and
Recommendations

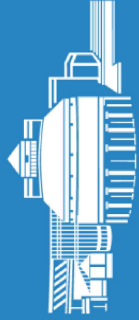
Chloride Concentrations

- Chloride concentrations were increasing in Swan Lake, but dropped considerably in 2022, likely due to clearing the blockage at the East Pond inlet.
- Chloride guidelines are for protecting the most sensitive species and may not be suitable targets for the Swan Lake system
- Swan Lake interim target is already being met

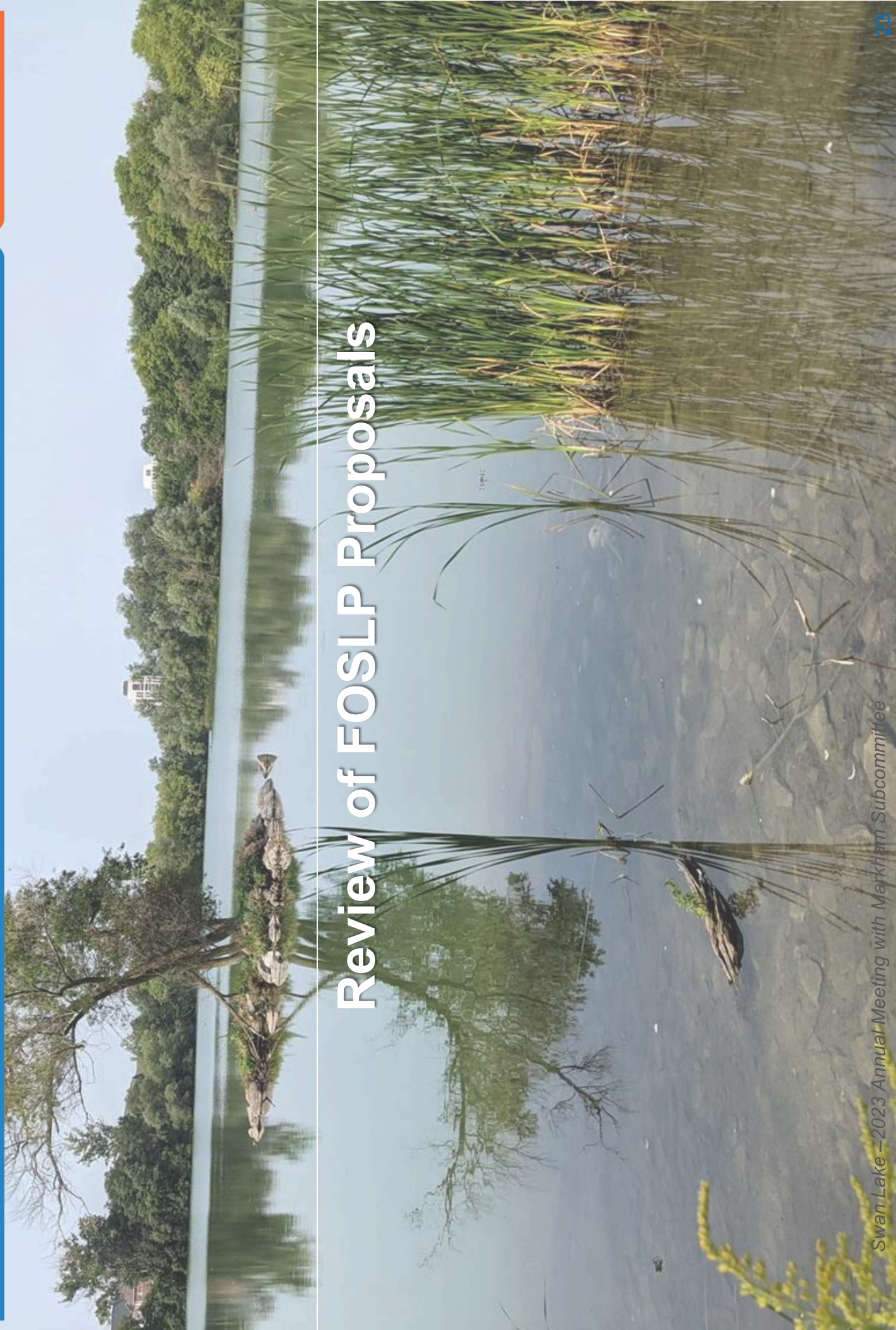


School of minnow in Swan Lake- April 2023

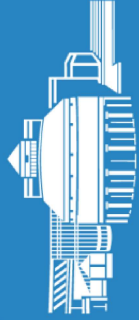




BUILDING MARKHAM'S FUTURE TOGETHER 2020 – 2023 Strategic Plan



Review of FOSLP Proposals



Background and Completed Work

2022 Water Quality Results

Review of FOSLP Proposals

2023 Plans and Recommendations

Chloride Treatment

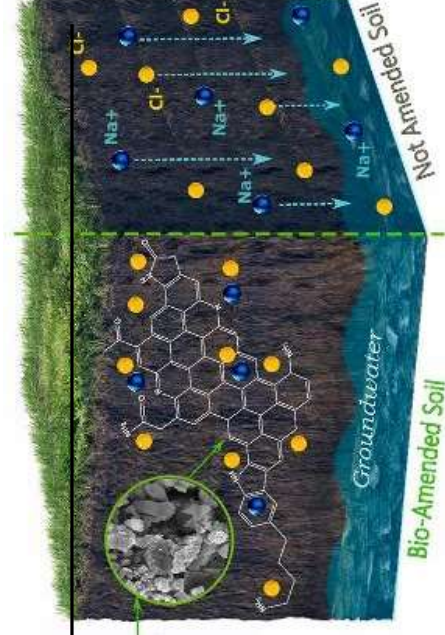
FOSLP Proposal

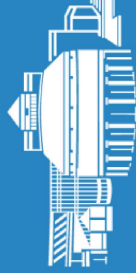
Evaluation

City's Plan

- Chloride Removal using Biochar**
- Biochar Removal mostly at research stage with few experiments for chloride (mostly nutrients)
 - Concentration of chloride is already within City interim target range with no apparent effect on biota
 - MECP recommends source identification and reduction before treatment
 - Costs: \$200-300K (material and equipment) + labor and other cost

- Source control measures on public and private properties will be pursued
- Opportunities to reduce loadings will be sought through Flow Diversion Study
- Chloride treatment research in 2024 as positive results could be a valuable tool





Background and Completed Work

2022 Water Quality Results

Review of FOSLP Proposals

2023 Plans and Recommendations

Chemical Oxygenation

FOSLP Proposal

Evaluation

City's Plan

Oxygen Enhancement using Calcium Peroxide
* Lab testing for \$37K
* proposed by Fleming College's Centre for Advancement of Water and Wastewater Technologies

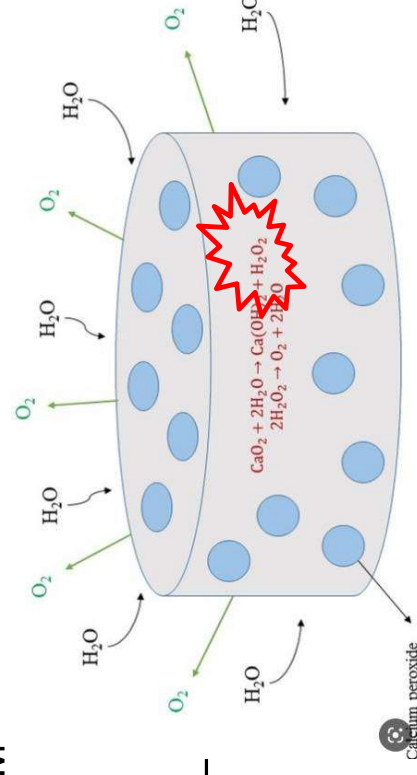
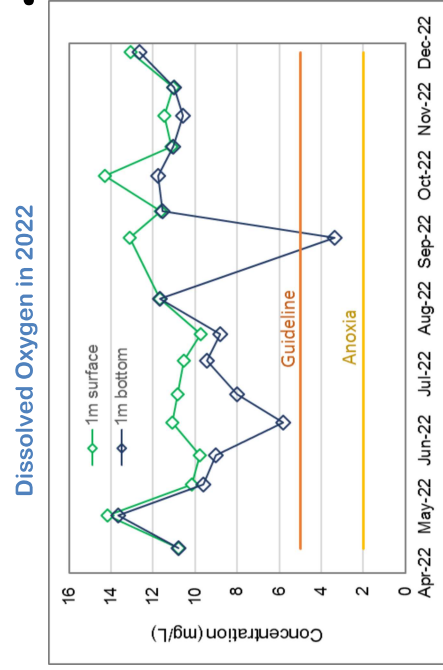
- Potential for aquatic toxicity and interference with chemical treatment
- Method at research stage and needs further stages of research to ensure safety

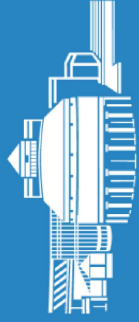
- Managing the root cause by reducing nutrient loads (internal and external) and improving habitat
- Recent measures improved DO significantly; no need for immediate intervention

- DO is already above guidelines

- Will continue to measure DO

- Costs: \$150k to \$1,500M (material) + application cost





Background and Completed Work

2022 Water Quality Results

Review of FOSLP Proposals

2023 Plans and Recommendations

Survey of Lower Level Aquatic Life

FOSLP Proposal

Evaluation

City's Plan

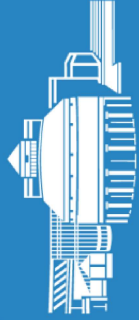
Survey of Lower Level Aquatic Life (Phytoplankton, Zooplankton, Protozoa)

- Phytoplankton identification already done
 - No benefit in identification of others for the overall health of Swan Lake
 - Targets not available and results will not be actionable
 - Ongoing habitat improvement will increase diversity and abundance
- Monitoring parameters already targeted for improvement in Phase 1, including nutrients, oxygen, chloride and phytoplankton
 - Future opportunity through a research project by Trent U looking at bio-accumulation of rare earth elements (REE's) in biota



Zooplankton sampling net





Background and
Completed Work

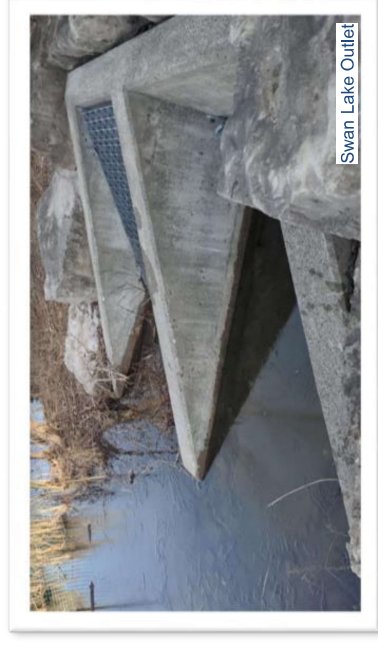
2022 Water Quality Results

Review of FOSLP Proposals

2023 Plans and
Recommendations

Drawdown and Sediment Removal

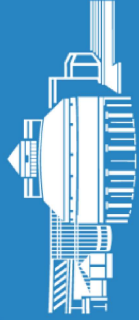
- FOSLP's report Towards a Comprehensive Restoration Plan (Draft Apr. 14, 2023)
- Assumes sediment removal is necessary for water quality improvement
- Draw the Lake down to 207.0 MASL to remove water
- Assumes lake will be refilled with rainfall and groundwater in 1-3 seasons
- Remove exposed sediment
- Storage on site or disposal off-site



Swan Lake Outlet



Typical pond sediment



Background and Completed Work

2022 Water Quality Results

Review of FOSLP Proposals

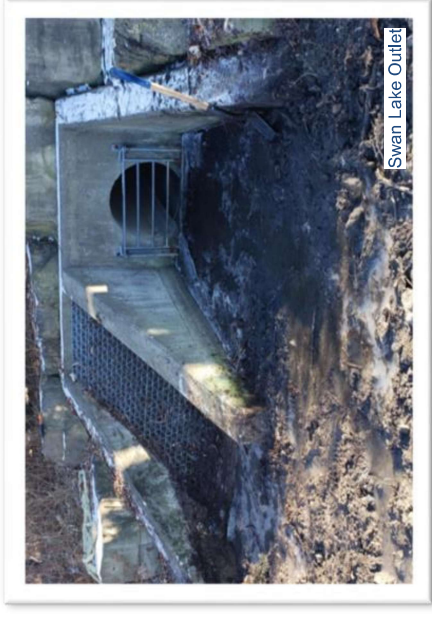
2023 Plans and Recommendations

Lake Dewatering Implications

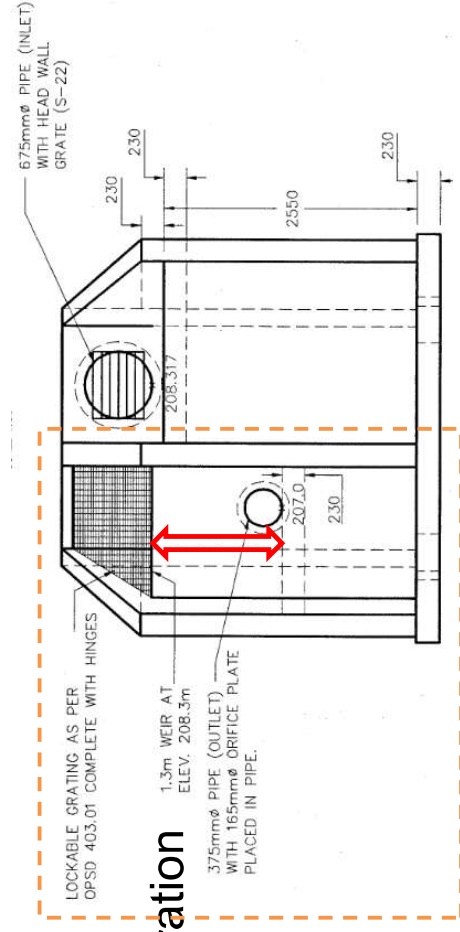
- Drawdown feasibility:
 - Excavate a trench 1.3m deep in the Lake
 - Pump water from lower areas
- Refilling calculation:
 - Evaporation not considered (> rainfall)
 - No basis for groundwater flow estimate
- Ecological impacts:
 - On the lake during dewatering
 - On receiving water- regulatory issues (PWQO exceedance, sediment impacts on fisheries if filtration is not applied)

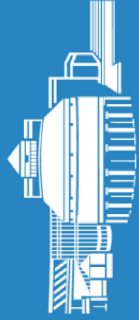


Snapping turtle in Swan Lake
Photo courtesy of Mark Henschel



Swan Lake Outlet





Background and
Completed Work

2022 Water Quality Results

Review of FOSLP Proposals

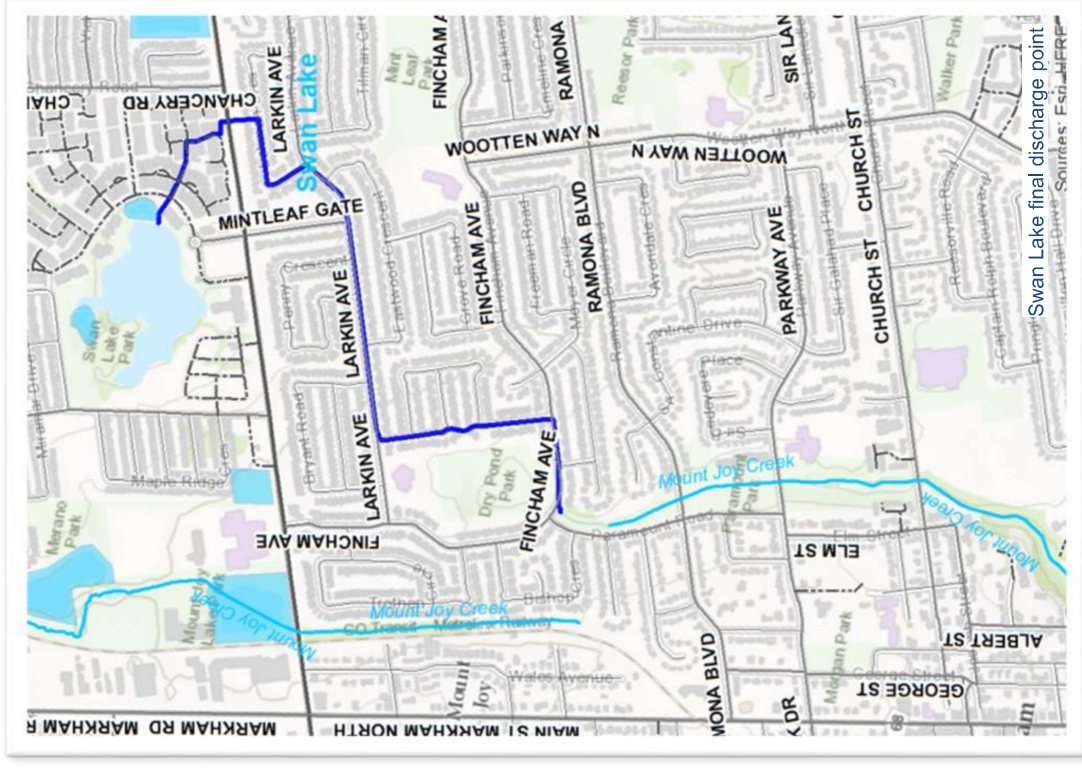
2023 Plans and
Recommendations

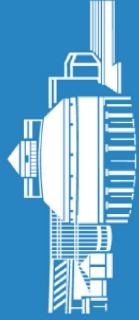
Regulatory Context for Discharging Downstream

- Ontario water management: policies, guidelines, provincial water quality objectives (PWQO):
 - Policy 1: In areas which have water quality better than the PWQO, water quality shall be maintained at or above the Objectives.
 - Policy 2: Water quality which presently does not meet the PWQO shall not be degraded further and all practical measures shall be taken to upgrade the water quality to the Objectives.

Parameter	PWQO/CCME	Mt. Joy Creek*	Swan Lake
Total phosphorus	30 µg/L	70 µg/L (policy 2)	>100 µg/L (pre treatment) 50 µg/L (post treatment)
Dissolved chloride	120 mg/L	350 mg/L (policy 2)	~ 500 mg/L in 2022

* Rouge River in Box Grove; average of values for 2014–2018 (latest 5-year of available data)





Background and
Completed Work

2022 Water Quality Results

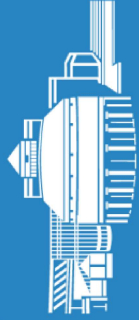
Review of FOSLP Proposals

2023 Plans and
Recommendations

Sediment Storage or Disposal Issues

- Several scientific studies and experts have recommended against disturbing sediment in Swan Lake (Gartner Lee Limited, 2006; Freshwater Research 2019; AECOM 2022)
- Extensive long-duration disruption to the park (multiple years)
- Substantive damage to the park on staging and drying areas
- Former dump sites contamination
- Sediment needed in lake to grow aquatic plants
- Other Storage issues:
 - Space for on-site storage not available (5000-8000 m³)
 - Contaminated leachate from stored sediment
 - Containment (concrete walls) unsightly and not-environmental friendly and costly
- Transport and disposal costly





Background and Completed Work

2022 Water Quality Results

Review of FOSLP Proposals

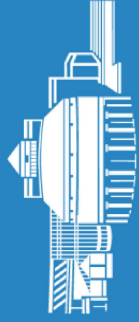
2023 Plans and Recommendations

Other FOSLP Proposals/Statements (April 2023)

FOSLP Proposal/ Statement

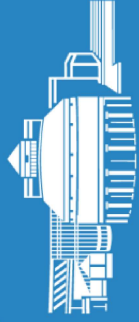
Evaluation

- Current programs do not improve nitrogen and Dissolved Oxygen
- Lake processes are interconnected and need to be managed as such
- Geese management and chemical treatment using PAC has improved phosphorus, nitrogen and oxygen concentrations as evident in actual measurements in 2021 and 2022
- Further oxygen enhancement is required as the Lake has no surface-level inflow
- Oxygen levels have improved by lowering nutrient levels, and will be further improved through habitat modification (e.g. submerged aquatic vegetation (SAV) planting)
- Proposals include recirculation through the north channel and chemical oxygenation
- Recirculation with be very disruptive and could increase water temperature (as per FR report); Chemical oxygenation too costly; potential impact on aquatic community
- As per the approved Plan, recirculation could be considered in Phase 3 if necessary
- New research on impact of oxygenation on P release
- Research could be done independently by others as long as it is not interfering with the City's approved program
- New research on impact of CI on P/N release
- The current team (City and consultants) already includes all the skills listed; however, a workshop could be considered after Phase 1 completion (2026)
- Water quality workshop



BUILDING MARKHAM'S FUTURE TOGETHER 2020 – 2023 Strategic Plan

2023 Plans and Recommendations



Background and
Completed Work

2022 Water Quality Results

Review of FOSLP Proposals

2023 Plans and
Recommendations

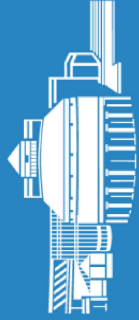
2023 / 2024 Planned Activities

CORE MEASURES:

- Water quality monitoring and annual reporting to Subcommittee
- Geese management
- Maintenance of stormwater management facilities
- Community engagement
- Chemical treatment planning for 2024
- Shoreline improvements (Parks)

COMPLEMENTARY AND ALTERNATIVE MEASURES:

- Planting of Submerged Aquatic Vegetation
- Flow Diversion Feasibility Study
- Assessment of New Technologies for Chloride Treatment



Background and
Completed Work

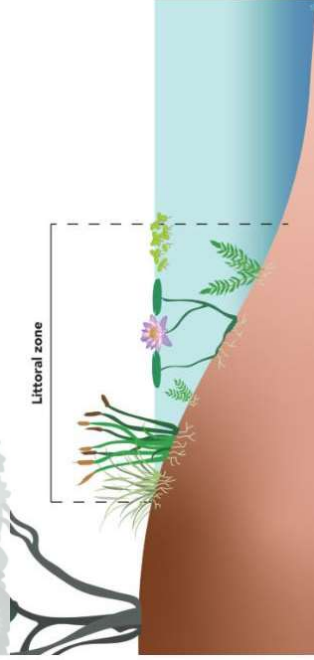
2022 Water Quality Results

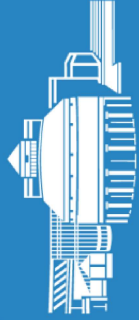
Review of FOSLP Proposals

2023 Plans and
Recommendations

Submerged Aquatic Vegetation Planting

- Planned for Phase 2 of the Long-Term Plan to help solidify the sediment and provide fish habitat.
- Moved to Phase 1 after a review of 2022 water quality results by our limnologist consultant
- Submerged aquatic vegetation (macrophytes) can compete with and help mitigate algae (phytoplankton) growth
- Macrophytes will increase water clarity, which in turn, enhances their own growing conditions.
- Consultation with TRCA underway for a pilot project around the bridge site (turtle inlet)





Background and
Completed Work

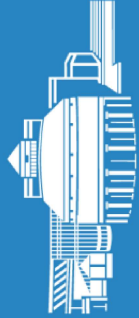
2022 Water Quality Results

Review of FOSLP Proposals

2023 Plans and
Recommendations

Flow Diversion Feasibility Study

- Alternative measure in Phase 3: evaluate/design structural modifications such as lake water recirculation and stormwater redirection
- FOSLP proposal to reduce Swan Lake's role in the 'local stormwater management regime' by rerouting the flows ... in order to control chloride concentrations.
- Flow Diversion Feasibility Study: Technical analysis to assess the feasibility of proposed changes to determine if the infrastructure within Swan Lake can support the proposed changes.
- A consultant will be hired in 2023 for this study following data collection/digitization of private sewer infrastructure.
- If a technically feasible option is found for flow diversion, which is also effective in chloride reduction, a Municipal Class Environmental Assessment may be required to engage all stakeholders (including private landowners and York Region) and identify a preferred alternative.



Background and Completed Work

2022 Water Quality Results

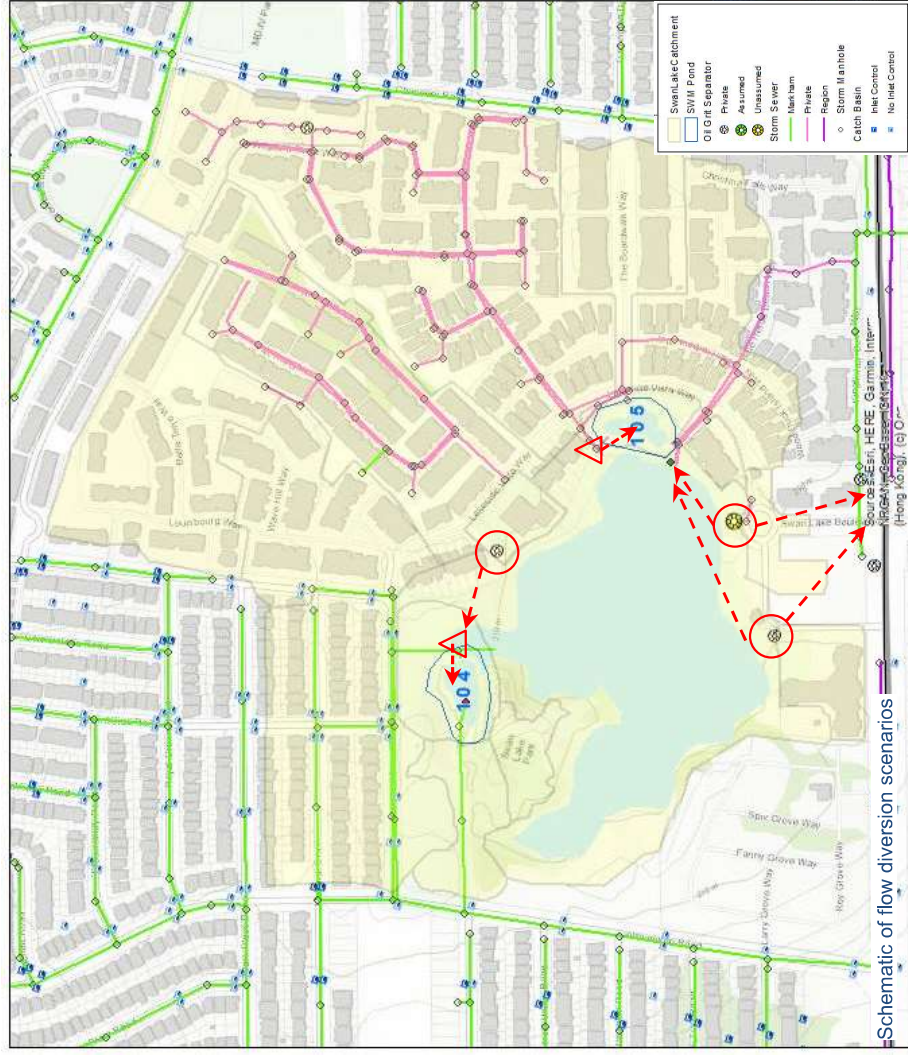
Review of FOSLP Proposals

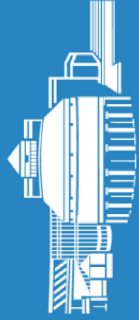
2023 Plans and Recommendations

Flow Diversion Feasibility Study - Scenarios

Source	Scenario
AMICA OGS and Swan Lake Blvd OGS	Redirect flows to 16 th Ave sewer
	Redirect flows to Lake Outlet
	Redirect the first-flush (most pollutant-laden runoff) in a small diversion sewer
Swan Lake Club OGS	Redirect flow to North Pond Splitter
East Pond and North Pond	Adjust the flow splitter weir to reduce flow bypass to the Lake
	Expanding the storage capacity to reduce flow bypass to the Lake *
	Redirecting flows toward Swan Lake to supply potentially cleaner, cool groundwater
Foundation Drain Collectors	Combination of the above scenarios

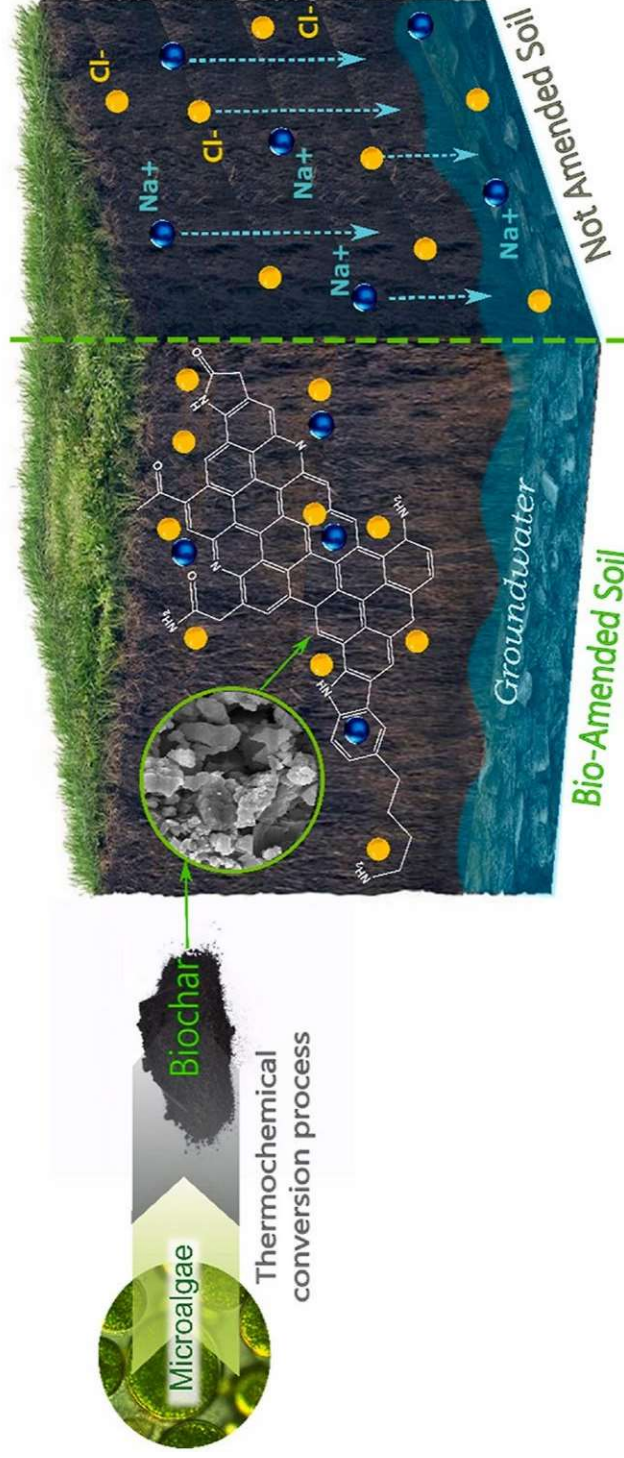
* To consider if the redirecting scenarios increases flood risk and if less costly than any sewer capacity upgrades





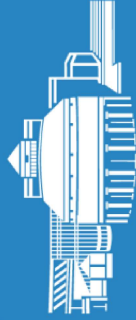
Assessment of New Technologies for Chloride Treatment

- Initially planned for 2027 at a cost of 50K
- Advanced to 2024
- Discuss/refine scope of work with researchers
- Lab-scale units to test the biochar efficiency



Pahlavan et al 2023

<https://www.sciencedirect.com/science/article/abs/pii/S0045655230043993?via%3Dihub>



BUILDING MARKHAM'S FUTURE TOGETHER 2020 – 2023 Strategic Plan

Background and Completed Work

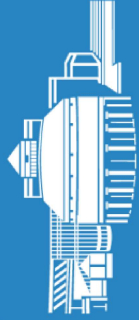
2022 Water Quality Results

Review of FOSLP Proposals

2023 Plans and Recommendations

Evaluation and Plan Summary

Plan	Measure	Allocated Budget	Additional Costs	Assessment	Recommendation
Core measure	Water quality monitoring	30K/yr	-	Required for decision making	Implement annually
	Geese management	70K/yr	-	Proven efficiency	Implement annually
	Chemical treatment	150K/3yrs	-	Proven efficiency	Plan in 2023 Implement in 2024
Complementary measure	Planting Submerged Aquatic Vegetation	20K (pilot)	TBD	Potential for competing with algae and increasing water clarity	Implement in 2023
	Assessment of New Technologies for Chloride Treatment (for Biochar)	50K for initial lab test	200-300K (material/equipment) + operation (TBD following lab test)	Test as no other feasible technology exists	Research in 2024
	Oxygen Enhancement using Calcium Peroxide	-	37K initial lab testing + \$\$ for additional testing; 200-1,600K/yr implementation	DO levels high in 2022; Potential impacts on Swan Lake and other treatments; costly	Not recommended
Alternative measure	Flow Diversion Feasibility Study	150K	TBD for implementation (initial estimate 5M)	Informs source reduction strategy for chloride	Implement in 2023/2024
-	Survey of Lower Level Aquatic Life	-	20-50K (nominal)	No tangible benefit	Not recommended
-	Drawdown and Sediment Removal	-	1.5-3.7M (FOSLP estimate for storage option)	Uncertainties and issues re Lake refilling timeline, ecological impacts on the Lake and downstream during dewatering, Sediment quality and, storage space and contamination leachate, disposal cost, park disturbance	Not recommended



Background and
Completed Work

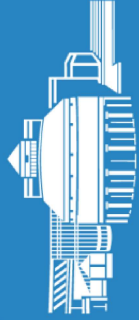
2022 Water Quality Results

Review of FOSLP Proposals

2023 Plans and
Recommendations

Recommendations

1. THAT the report entitled “Swan Lake- 2022 Water Quality Status and Updates” be received;
2. AND THAT Staff continue to implement the Long-term Management Plan for Swan Lake approved by Council in December 2021, including advancement of submerged aquatic vegetation, research into chloride treatment, and flow diversion evaluation (previously in Phases 2 and 3 of the Plan);
3. AND THAT Staff report back annually on water quality results and evaluation of adapted Core and Complementary measures for consideration in Phase 2 of the Plan through the Markham Sub-Committee with the participation of the Friends of Swan Lake Park;
4. AND THAT the next review of the Plan will be in 2026 (after the completion of Phase 1 and other measures as listed under item 2);
5. AND THAT Staff be authorized and directed to do all things necessary to give effect to this resolution.



Questions?



Report to: Markham Subcommittee

Meeting Date: May 11, 2023

SUBJECT: Swan Lake- 2022 Water Quality Status and Updates
PREPARED BY: Robert Muir, Environmental Services, Ext. 2357
 Zahra Parhizgari, Environnemental Services, Ext. 2867

RECOMMENDATION:

1. THAT the report entitled “Swan Lake- 2022 Water Quality Status and Updates” be received;
2. AND THAT Staff continue to implement the Long-term Management Plan for Swan Lake approved by Council in December 2021, including advancement of submerged aquatic vegetation, research into chloride treatment, and flow diversion evaluation (previously in Phases 2 and 3 of the Plan);
3. AND THAT Staff report back annually on water quality results and evaluation of adapted Core and Complementary measures for consideration in Phase 2 of the Plan through the Markham Sub-Committee with the participation of the Friends of Swan Lake Park;
4. AND THAT the next review of the Plan will be in 2026 (after the completion of Phase 1 and other measures as listed under item 2);
5. AND THAT Staff be authorized and directed to do all things necessary to give effect to this resolution.

PURPOSE:

The purpose of this report is to present:

- 2022 water quality results and implemented measures;
- Review of the feasibility and cost of FOSLP’s research initiatives and other proposals; and
- Scope of work for 2023

BACKGROUND:

On November 16, 2021, Staff provided a report and presentation to the Markham Subcommittee titled [Swan Lake Water Quality Management Plan](#), outlining the history of Swan Lake management activities up to that point and a Long-Term Management Plan for Swan Lake Water Quality (the Plan) for the next 25 years. The Plan was developed based on a scientific evaluation of issues and opportunities for lake management and an assessment of several lake management measures designed with input from stakeholders (see here for [Meeting Minutes](#)).

The Swan Lake Long-Term Management Plan follows an adaptive management approach, through which management activities would be adjusted to maximize benefits and minimize impacts. The Council endorsed this phased approach on December 14, 2021 (see here for [General Committee Meeting Minutes](#) and [Council Meeting Minutes](#)).

As per resolutions 7, 8, and 9 of the December 14, 2021 meeting, Staff presented the first annual Subcommittee report on May 11, 2022. This report included the 2021 water quality results and evaluation of the adapted Core and Complementary measures, a High-Level Water Flow Analysis, and the Friends of Swan Lake Park (FOSLP) “Holistic Approach to Realizing Community Goals (see here for [Markham Subcommittee Report and Presentation](#)).

The motions that the Subcommittee recommended for consideration at the September 6, 2022 General Committee meeting (see here for [Meeting Minutes](#)) included directing Staff to review and report back to the Committee on the feasibility and costs of the following research initiatives (resolution #4):

- a. Chloride Removal;
- b. Oxygen Enhancement; and,
- c. Survey of Lower Level Aquatic Life

That Council also approved a technical analysis of Swan Lake to assess the feasibility of proposed changes to determine if the infrastructure within Swan Lake can support the proposed changes (resolution #5).

That Markham Sub-Committee also requested that [the Planning Department] Staff report back on the feasibility, and implications of designating Swan Lake a natural heritage asset, as part of the Official Plan update (resolution #3c).

The following Discussion presents the 2022 Water Quality Results, a review of three research initiatives to address resolution #4, and a description of the scope of work for the 2023 activities, including a flow diversion study to address resolution #5.

The City hired a senior aquatic scientist from AECOM to review the 2022 results and comment on the feasibility and impact of the proposed research initiatives. This report reflects the feedback received from AECOM.

DISCUSSION:

2022 Water Quality Results and Implemented Core Measures

The Phase 1 Core Measures completed in 2022 include:

- Annual monitoring
- Enhanced geese management
- Fish management

Staff collected water quality data through the Swan Lake monitoring program from January to December 2022. These data provide insight into long-term trends in water quality and help

determine the need for and impact of chemical treatment of Swan Lake (see Attachment A for the 2022 Annual Report).

Contractors completed Geese management by chasing (“hazing”) geese with border collies, oiling eggs and managing nests, and by relocation of geese in the spring. Hazing frequency was modified in 2021 to focus on the migration seasons. The increased hazing frequency (starting in mid-August) effectively reduced the number of geese present at different times of the day to about 50% of the geese numbers in 2020.

A fish inventory and removal campaign was completed to remove bottom-dwelling fish, which could interfere with the chemical treatment efficacy. Only three fish species were caught in the Lake through this intensive effort: Common Carp (non-native), Brown Bullhead, and Fathead Minnow. Of these, only Fathead Minnow was found in abundant numbers and this main fish species was left in Swan Lake.

The management activities in 2022 focused on the significant nutrient loadings identified in the Long-Term Plan (i.e., fish management to reduce internal loads from the lake bottom and geese management to reduce external loads). While these activities successfully reduced nutrient concentrations, the Lake was dominated by phytoplankton, and water clarity did not improve. This could be partly due to the absence of aquatic vegetation (submerged macrophytes), which has been replaced by phytoplankton (algae) due to low water clarity.

In 2022, chloride levels decreased considerably compared to 2021, likely due to clearing the blockage at the East Pond inlet, which resulted in lower catchment flows from the inlet bypass to the Lake.

Feasibility and Cost/Benefit of Three Research Initiatives

a. Chloride Removal using Biochar

Chloride concentrations have been increasing in urban lakes due to de-icer application for winter maintenance of roads and walkways. In Swan Lake, chloride concentrations were between 400 and 500 mg/L from 2012 to 2018 but increased sharply between 2018 and 2021 when the inlet to the East Pond was blocked. The concentrations declined to under 500 mg/L after the said blockage was removed. Average chloride concentrations are now below the short-term guidelines for the protection of aquatic life (640 mg/L). However, they are within the interim targets defined for Swan Lake (400-500 mg/L) and can support most aquatic biota.

The City plans to further improve chloride levels by exploring measures to reduce chloride load into the Lake as outlined in the Long-Term Plan. To support these measures, Staff started collecting runoff samples and salt usage data in 2021 to quantify chloride loads and determine the relative contribution of each catchment area. This information will help identify the most efficient strategy for reducing chloride loading to the Lake. In addition, the Plan has provisions for research into chloride removal technologies in Phase 2, if required.

In May 2022, FOSLP shared a proposal from York University for “[Research into Removal of Nutrients and Chlorides from Swan Lake](#)”, which proposed “lab-scale units to test the biochar efficiency on the removal of selected nutrients” (and chloride) at an estimated cost of \$43,200.

FOSLP requested support from the City for this research initiative in Phase 1 of the Plan, and in September 2022, the Council directed Staff to review and report back on the feasibility and cost of chloride removal using this method.

Staff and the City’s consultant (AECOM) reviewed this proposal (see Attachment B) and did not find any application of biochar for chloride removal, except for one recent computational study (no experiments involved) demonstrating “the potential of amending soils with algal biochar as a dual-targeting strategy to sequester carbon and prevent de-icing salt contaminants from leaching into water bodies”¹. However, since there is currently no feasible and cost-effective technology for removing chloride from freshwater bodies, using biochar, if successful, will be a valuable lake management tool.

Capital costs for full-scale implementation will vary depending on the application methodology developed. Active treatment will require treatment equipment (pumps, pipes, and installation at a cost of about \$200-300k as per the reference² used by York U), a building to house the equipment (about \$300k for 100 m² at \$3000/m²)³, and specialist Staff to operate the system (about \$130k)⁴. If passive treatment is deemed feasible (e.g., leaving pales of biochar in water), implementation costs will be much lower.

The application may pose a significant threat as pollutant release (e.g., of heavy metals) or desorption may occur if biochar not used properly⁵.

Based on this assessment, Staff recommends that the lab-scale tests proposed by York University be completed, and if the results are promising, pilot or field-scale experiments follow suit in the future. The Swan Lake life-cycle budget has accounted for \$50,000 for the assessment of new technologies for chloride treatment in Phase 2 of the Plan (in 2027), and Staff recommend this budget be advanced to Phase 1 (2024).

Full-scale implementation will be assessed based on the results of this experiment, including performance and implementation costs, the Lake’s water quality, and aquatic habitat health at the time.

b. Oxygen Enhancement using Calcium Peroxide

On March 24, 2021, FOSLP provided a ‘Literature Review of Potential Engineering Solutions for the Restoration of Swan Lake by Fleming College’s Centre for Advancement of Water and Wastewater Technologies (CAWT).

Staff and the City’s consultant at the time (Freshwater Research) reviewed this document as part of the scoping exercise to determine considerations to develop an overall water quality program. The review concluded that, of the various approaches discussed, chemical oxygenation using calcium peroxide (CaO₂) “could be an interesting study and lead to potential applicability”. It also noted that this “is a novel potential treatment option for anoxic lake sediments. It has only been investigated in model systems and has not been proven in whole lake applications.... Therefore, this method is at a research state and not recommended as a ready-for-use approach for Swan Lake.” and “Material costs seem to be high and should be considered.”

In May 2022, CWAT submitted a proposal through FOSLP on the [‘Development of a Scope of Work for Research into Water Quality on Swan Lake’](#) for the use of “oxygen release

¹ <https://www.sciencedirect.com/science/article/abs/pii/S0045653523004393?via%3Dihub>

² https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/hydro/klamath-river/khsa-implementation/technical-documents/2021-11-15_Biochar-filter-final-rpt.pdf

³ <https://www.statista.com/statistics/972912/-building-costs-ontario-canada-by-type/>

⁴ <https://www.jobbank.gc.ca/marketreport/wages-occupation/20827/ON> (assuming payroll burden 2x salary)

⁵ <https://www.mdpi.com/2073-4441/12/12/3561>

compounds”. This research, at \$37,000, would include laboratory-scale testing of sediment samples from Swan Lake.

In September 2022, the Council directed Staff to review and report on the feasibility and cost of oxygen enhancement using the proposed method.

Staff and the City’s consultant (AECOM) reviewed this proposal (see Attachment B) and found that apart from one study on a pond, all the cited research was based on laboratory-scale investigations and on water and sediment from waterbodies receiving domestic sewage, which are very different from Swan Lake.

Due to these differences, in addition to the research quoted above, additional investigations will be required to account for the complex physical, chemical, and biological processes in Swan Lake that could affect or be altered by the treatment, including:

- Impact on pH increase and dissolution of metals, which can have unintended consequences for aquatic toxicity
- Impact on prior and future chemical treatments involving Phoslock or PAC, as the high pH generated by CaO_2 may cause the release of previously immobilized phosphorus in the sediment
- Impact of peroxide at the sediment surface on the microbial community. Peroxide could also degrade organic matter and release phosphate.

Staff met with CWAT on November 16, 2022, to discuss the feasibility and cost of in-lake implementation of this approach (assuming the laboratory-scale testing would be successful). Subsequently, we obtained a quote for the supply of calcium peroxide for a one-time application at a dosage of 100 or 1000 g/ m^2 (the range used in available literature). At \$30.04/kg, the material cost for a surface area of about 5 ha (50,000 m^2) would amount to \$150k to \$1,500M. Additional fees will be involved, including labor and equipment costs for application (spreading from a boat rowing slowly over the whole surface of the Lake), at an estimated cost of \$50-100k (based on the 2021 PAC application).

Staff does not support the proposal to use calcium peroxide for oxygen enhancement due to the potential impacts of this proposal on the Swan Lake environment. Material costs will also be prohibitive. In light of recent improvements made by the approved management measures (i.e., reducing internal and external sources of nutrients), resulting in high oxygen levels in 2022, further chemical alteration of the system is not recommended.

c. Survey of Lower Level Aquatic Life

The third proposal brought forward by FOSLP in 2022 was a survey of lower-level aquatic life to “take a measure as a benchmark for future success”.

The City is currently monitoring parameters targeted for improvement in Phase 1, including total phosphorus, Secchi transparency, chloride and the frequency of algae blooms. The City is also collecting phytoplankton samples for cell counts and identification, which are used for understanding the algae community.

Interim targets have been developed for these noted monitored parameters, which are correlated with improvements in aquatic health. Information already being collected can be used to assess and improve the management plan’s effectiveness and achieve habitat improvements.

Monitoring of other lower level aquatic life, such as zooplankton, will not provide any benefit to the overall health of Swan Lake, nor do monitoring results of such monitoring have a defined target to evaluate against. Therefore, Staff does not recommend expanding the monitoring program to include zooplankton or other lower level aquatic life.

Review of FOSLP 2023 Proposal

On April 14, 2023, FOSLP provided a draft report entitled ‘Towards a Comprehensive Restoration Plan for Swan Lake’ indicating that the 2021 Long-Term Management Plan ‘needs to be updated to incorporate solutions to the chloride issues and to address the need for oxygenation’. It also proposes a water quality workshop to choose between two possible outcomes of ‘Water Treatment Only’ and ‘Treat Water and Sediment’. The report concludes that the Lake water should be drawn down and discharged into the downstream Rouge River to remove chloride from the Lake. Based on the FOSLP’s estimate, the Lake will be refilled with rainwater and groundwater in 1-3 seasons. When the lake bed is exposed, about 5,000-8,000 m³ of sediment would be removed and stored on the lake shoreline. Leaching of contaminants from sediment pore water would be prevented using geotextile material or a concrete wall.

In response to the recurring challenge by FOSLP that the approved Long-Term Plan only focuses on phosphorus and has no impact on other nutrients (i.e., nitrogen) and does not improve dissolved oxygen, all stakeholders should be reminded that:

- Source control efforts, including external load reduction by geese management and internal load management through chemical treatment, reduce both nitrogen and phosphorus, as evident by the 2022 monitoring results.
- Current management measures successfully improved oxygen levels. Low oxygen level is a symptom best managed by tackling the root cause (high nutrient levels) through source control.

The FOSLP report asks for dramatic measures such as Lake drawdown for chloride removal. Staff’s assessment is that this proposition would serve an unnecessary objective while involving several significant issues and would be very costly and disruptive, i.e.,:

- The Long-Term Plan has defined interim targets of 400-500 mg/L of chloride that are consistent with historical values in the Lake (2012-2103) and also considering the location of this waterbody in the watershed (close to values measured in Rouge River)⁶. These targets can support various aquatic life such as water flea and minnows (abundantly observed in the Lake). The long-term guideline of 120 mg/L are for the protection of the most sensitive species and are not applicable to Swan Lake (FOSLP report also uses this guideline as a benchmark for runoff, which is not relevant). Therefore, there is no rationale for the proposed costly, disruptive interventions to reduce current chloride concentrations.
- Ecological impacts on the Lake and the downstream receiving water have not been considered in the FOSLP proposal. Dewatering will significantly disrupt the Lake ecosystem, and discharging the Lake water into Rouge River, which is already deteriorated, will have regulatory implications/potential impacts.
- Lake refilling with precipitation and groundwater over 1-3 seasons is ambitious. The FOSLP report does not account for the impact of evaporation (higher than precipitation), and the groundwater recharge rates cited are not valid. A groundwater model is not

⁶ https://sustainabletechnologies.ca/app/uploads/2021/10/2016-2020-SWQ-Report-v11_FINAL_AODA-FA.pdf

available for this area, and it is not possible to quantify the aquifer recharge or discharge rates. Therefore, due to limited data considered in the proposed concept, the estimated timelines for refilling the lake are uncertain/unreliable.

- Several scientific studies and experts have recommended against disturbing sediment in Swan Lake due to the unknown and potentially contaminated portions of the lakebed. The FOSLP plan therefore risks disturbing and releasing of contaminants, contrary to past recommendations.
- Sediment is needed to support plant growth in the Lake, a measure which is being advanced by the City. Therefore, the proposed concept will interfere with other management measures.
- The FOSLP proposal to store sediment on the Lake shore does not consider the available space for storage nor does it have a viable solution for leachate control. Containment within proposed concrete walls is expected to be unsightly, not environmentally friendly, and costly.
- Dewatering and sediment removal will involve multiple years of park closure and significant disturbance to the park area and amenities.

To manage chloride in the lake, the City will continue seeking source control options, including opportunities that may arise through the Flow Diversion study and research into a biochar application for reducing chloride levels in the Lake. Therefore, pursuing the FOSLP's lake drawdown and sediment storage proposition is not recommended.

Staff agrees with a water quality workshop or another form of consultation with the stakeholders after the Flow Diversion Study and the second chemical treatment is completed and once sufficient data are available to inform discussions. This workshop could be held in 2026 to discuss the path forward and update the Long-Term Plan as necessary. A workshop in early 2024 as proposed by FOSLP is therefore considered to be premature and is not recommended.

2023 Scope of Work

a. Phase 1 Core Measures

In 2023, the planned Phase 1 Core measures will continue, including water quality monitoring, geese management, and fish management. The scope of geese management has been expanded to further reduce the number of resident and migratory geese. In addition, planning for the next chemical treatment (in 2024, i.e., three years after the first one) will occur, including pre-consultation with the Ministry of Environment, Conservation, and Parks (MECP).

b. Introducing Submerged Plants

Phase 2 of the Long-Term Plan included provisions for introducing native submerged plants in Swan Lake to help solidify the sediment and provide fish habitat.

After a review of 2022 water quality results by the City's limnologist consultant, it was determined that the introduction of submerged aquatic plants (macrophytes) should be advanced to Phase 1 so that beneficial plant communities can compete with and help mitigate algae (phytoplankton) growth. Macrophytes will increase water clarity, which in turn, enhances their own growing conditions. Aquatic plantings will complement existing management activities.

Staff has started working on this initiative and is aiming to undertake a pilot in 2023.

c. Flow Diversion Scope of Study

In June 2021, FOSLP submitted a report to the City entitled ‘Pathway to Sustainable Water Quality: Ending Swan Lake’s Stormwater Management Role’. The report asked that in order to control chloride concentrations, Swan Lake’s role in the ‘local stormwater management regime’ should be reduced by rerouting the flows from the Oil and Grease Separators (OGSs) and stormwater flows bypassing the ponds, and ‘restoring the Lake water level to its natural depth’.

These proposals were presented to the Markham Subcommittee in November 2021 under a presentation entitled ‘A Holistic Approach to Realizing Community Goals’. Staff responded in a memo to FOSLP in March 2022 as follows (see the [General Committee Meeting Agenda of September 6, 2022](#)):

- The current stormwater management system provides flood protection in the Swan Lake catchment area, and any change may increase flood risk upstream or downstream.
- Source control has been determined as the primary means of chloride control in Phase 1.
- Structural change to the stormwater management system (e.g., through diversions) and lake operations may be considered if other Core and Complementary measures do not achieve the set targets.
- When the Markham Village Project 2 Area design advances, the role of the Lake and any change in flow patterns can be modelled and confirmed.

In September 2022, Council directed Staff to undertake “a technical analysis of Swan Lake to assess the feasibility of proposed changes to determine if the infrastructure within Swan Lake can support the proposed changes”. This study, planned for 2023/2024, will include a technical analysis of the potential impacts of implementing various scenarios on flooding upstream or downstream of the Lake. In addition, the technical feasibility and cost of implementing each scenario, including mitigation options for any flooding impacts, will be determined. Scenarios may include:

- Redirecting flows:
 - from AMICA OGS and Swan Lake Blvd OGS to 16th Ave. sewer
 - from AMICA OGS and Swan Lake Blvd OGS to the Lake outlet
 - “first flush” flows from AMICA OGS and Swan Lake Blvd OGS to 16th Ave. sewer (i.e., redirect the most pollutant-laden runoff in a small diversion sewer)
 - from Swan Club OGS to the North Pond
- Adjusting the flow splitter weir for the East Pond and North Pond to reduce flow bypass to the Lake
- Expanding the storage capacity in East Pond and North Pond to reduce flow bypass to the Lake (to consider if the redirecting scenarios increases flood risk and if less costly than any sewer capacity upgrades)
- Redirecting flows from some Foundation Drain Collectors toward Swan Lake (i.e., supply potentially cleaner, cool groundwater)
- Various combinations of the above scenarios

The City will use the results of this analysis to build a chloride budget model and determine potential impact of each scenario on chloride concentration in the Lake.

This analysis will be of a technical nature and depending on the outcome and other considerations (e.g., system ownership), a Municipal Class Environmental Assessment may be required to engage all stakeholders and identify a preferred alternative.

Planning for both the 2024 chemical treatment and the research into chloride treatment technologies will also be completed in 2023.

Summary of Evaluation and 2023 Plan

Plan	Measure	Allocated Budget	Additional Costs	Assessment	Recommendation
Core measure	Water quality monitoring	30K/yr	-	Required for decision making	Implement annually
	Geese management	70K/yr	-	Proven efficiency	Implement annually
	Chemical treatment	150K/3yrs	-	Proven efficiency	Plan in 2023 Implement in 2024
Complementary measure	Planting Submerged Aquatic Vegetation	20K	-	Potential for competing with algae and increasing water clarity	Implement in 2023
	Chloride Removal technologies (assessment done for Biochar)	50K	200-300K (material/equipment) + operation, or lower *	Test as no other feasible technology exist	Research in 2024
	Oxygen Enhancement using Calcium Peroxide	-	37K initial lab testing + \$\$ for additional testing; 200-1,600K/yr implementation	DO levels high in 2022; Potential impacts on Swan Lake and other treatments; costly	Not recommended
Alternative measure	Flow Diversion Study	150K	TBD for implementation (initial estimate 5M)	Informs source reduction strategy for chloride	Implement in 2023/2024
-	Survey of Lower Level Aquatic Life	-	20-50K (nominal)	No tangible benefit	Not recommended
-	Drawdown and Sediment Removal	-	1.5-3.7M (FOSLP estimate for storage option)	Uncertainties and issues re Lake refilling timeline, ecological impacts on the Lake and downstream during dewatering, Sediment quality and, storage space and contamination leachate, disposal cost, park disturbance	Not recommended

* Depending on the outcome of the research planned for 2024.

FINANCIAL CONSIDERATIONS:

No financial impact.

HUMAN RESOURCES CONSIDERATIONS:

Not applicable.

ALIGNMENT WITH STRATEGIC PRIORITIES:

This report aligns with the areas of strategic focus as follows:

- **Safe, Sustainable, & Complete Community:** the proposed strategy will support the enhancement of the natural environment and built form through sustainable integrated planning, infrastructure management and services.
- **Stewardship of Money & Resources:** the strategy proposed will provide a reasonable cost-effective level of service.

BUSINESS UNITS CONSULTED AND AFFECTED:

Not applicable.

RECOMMENDED BY:

Eddy Wu,
Director, Environmental Services

Mary Creighton,
Acting Commissioner, Community Services

ATTACHMENTS:

Attachment A - 2022 Annual Water Quality Report

Attachment B - Review of Research Initiatives