Winona Chain of Lakes Adaptive Management Progress Update Executive Summary

Prepared for Alexandria Lakes Area Sanitary District

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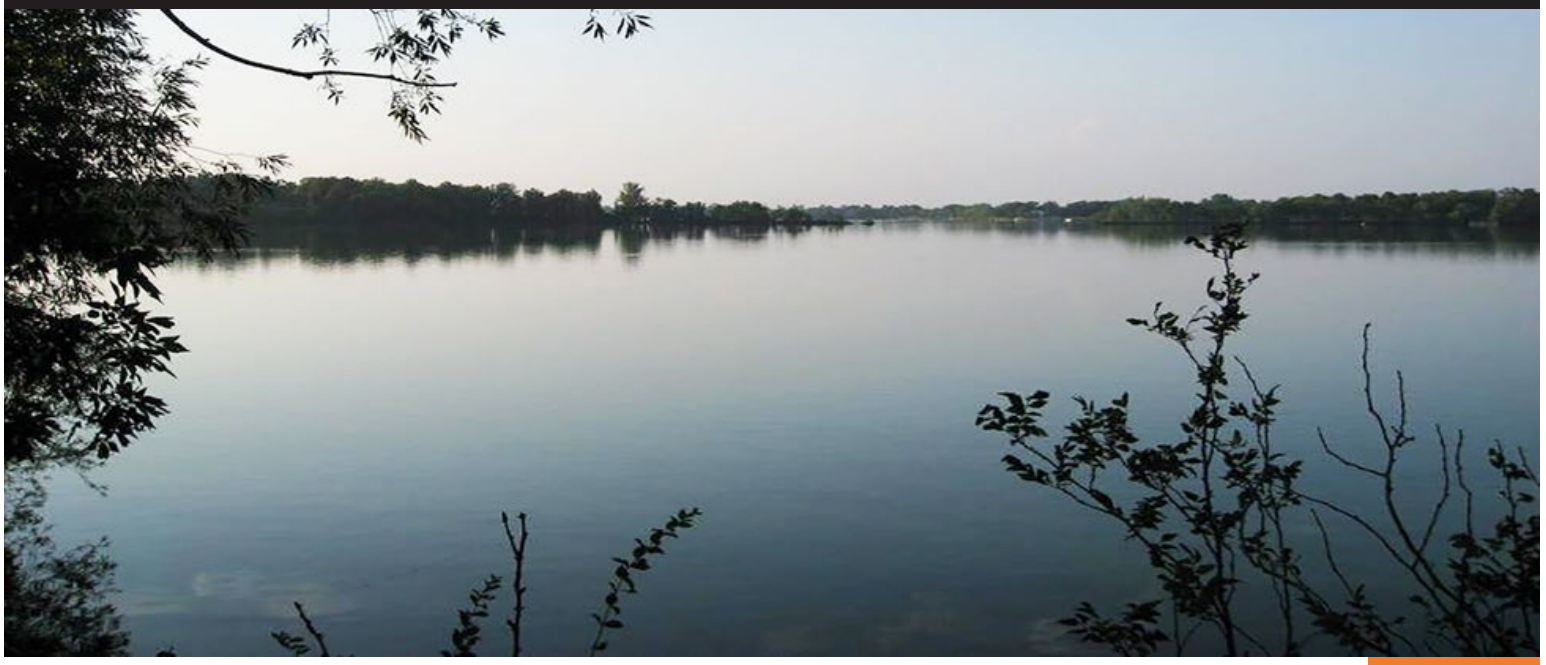
Stantec



Stantec

Executive Summary

Lake Winona is a shallow lake in Alexandria, MN that receives discharge from a wastewater treatment facility (WWTF) operated by the Alexandria Lakes Area Sanitary District (ALASD) as well as stormwater from the City of Alexandria. Lakes Agnes receives inputs from Lake Winona through three culverts (under Willow Drive, 3rd Avenue West, and Agnes Blvd Northwest). Lake Agnes then drains into Lake Henry which discharges through various channels and pipes to Lake Le Homme Dieu (MPCA 2021). Lakes Winona, Agnes and Henry are known collectively as the Winona Chain of Lakes.
The lakes have been negatively impacted by over enrichment of nutrients and high densities of common carp (carp), which contributes to poor water quality conditions. ALASD has invested considerable effort in the management and restoration of the Winona Chain of Lakes through multiple projects over the last few years.

The purpose of this report is to characterize the issues in the Winona Chain of Lakes, document ALASD's management efforts to-date, analysis of the progress towards attainment of regulatory and established management goals for the Winona Chain of Lakes and outline upcoming management actions. This Executive Summary provides an abbreviated high-level summary of the report contents and is intended be a standalone document where needed. Readers interested in detailed technical aspects, approaches, and progress efforts to improve water quality in the Winona Chain of Lakes, are directed to the report for additional context and information, or visit ALASD's website: https://alasdistrict.org/

The Problem

Like many lakes around the state, the Winona Chain of Lakes have experienced pollutant loading from the watershed which has negatively impacted water quality. The pollutants that are currently of greatest concern in the Winona chain of lakes is phosphorus and chloride. In addition, the lakes have been colonized by carp, a common aquatic invasive species that further degrades water quality when present in high densities. The impacts of excess phosphorus levels and high carp density on water quality are briefly described below.

PHOSPHORUS

Lakes Winona, Agnes and Henry have historically contained phosphorus levels that exceeded the State's standards. Excess phosphorus has led to algae blooms which causes cascading effects on aquatic life and habitat quality. Over time, phosphorus loads from the watershed can lead to accumulation in lake sediments which may be released under depleted oxygen conditions, a process known as internal phosphorus loading. In shallow lakes like Lake Winona, internal phosphorus loading may occur intermittently depending upon oxygen concentrations near the sediment-water interface and through sediment disturbance by wind or common carp. In deep lakes like Lakes Agnes and Henry, release of phosphorus from the sediments tends to occur primarily from deep locations where bottom waters are depleted of oxygen for long durations in summer and under winter ice. Continued phosphorus reductions from ALASD's discharge, total watershed reductions (e.g. stormwater), and reducing the internal phosphorus loads are required for water quality improvements and attainment of state shallow lake standards.

COMMON CARP

Carp are one of the most widely distributed aquatic invasive species in North America and commonly found in Minnesota lakes. (Chumchal et al. 2005, Bajer et al. 2009). Carp are bottom feeders that disturb the sediments and aquatic vegetation through their foraging behavior, which can increase turbidity in the lake, release sediment P, and uproot native vegetation. Because of their sediment-disturbing patterns, high carp density in shallow lakes like Lake Winona can be particularly damaging. Common carp are believed to have been introduced into Winona Chain of Lakes sometime after 2004 when a carp barrier dam between Lake Henry and Lake Le Homme Dieu failed. By the 2008 fisheries survey that was conducted by DNR, carp dominated the lake representing approximately 75% of the fish caught (by weight) in the survey (MPCA 2021). Since then, carp density in Lake Winona has increased substantially with recent surveys estimating population density over 4 to 8 times greater than the recommended ecological threshold for negative impacts on lakes, which is 133 lbs/acre.

CHLORIDE

Chloride pollution in Minnesota lakes is a growing problem, particularly in developed areas. The primary sources of chloride to our waters include road salt delivered in stormwater and overland drainage as well as from water softeners in wastewater discharge. Once chloride enters a lake, it either exits via an outlet or accumulates in the lake's bottom waters. Accumulation of chloride changes water density such that over time, the bottom waters become denser than the surface layers, which can disrupt the lake's natural mixing patterns. Currently, there are no feasible in-lake treatment options or to remove chloride in lakes. Likewise, removal of chloride from wastewater would require reverse osmosis which is prohibitively expense and introduces additional environmental impacts due to energy use and brine disposal challenges. Consequently, reducing the amount that enters the lakes from the surrounding areas and the volume delivered to the WWTF is critically important. ALASD is working with both private well owners (i.e. water softener rebate program) and public water suppliers to find solutions to reduce the chloride inputs from water softeners.

Adaptive Lake Management Plan

Reducing nutrient loads from multiple sources and reducing common carp density in Lake Winona is necessary to meet water quality standards in the Winona Chain of Lakes. In 2019, ALASD was awarded a Legislative-Citizen Commission on Minnesota Resources (LCCMR) grant to implement an adaptive lake management plan (Plan) for the Winona Chain of Lakes. The primary goals and activity of the grant work plan includes the following:

1. Alum treatment in Lake Agnes to reduce the internal phosphorus load by 90%.
2. Reduce carp density in Lake Winona to sustainable levels to prevent adverse impacts on water quality and submerged aquatic vegetation (SAV).

Several management actions have been implemented to-date through the LCCMR grant, which are summarized below. Additional details of the Plan activities, implementation and results can be found in the main body of this report.

Goal 1: Alum treatment in Lake Agnes to reduce the internal phosphorus load by 90%.

The first half of the prescribed alum dose was applied to Lake Agnes in September 2020 by SOLitude Lake Management, Inc. via barge as shown in Figure ES-1. The following year, Stantec collected post-treatment sediment cores to quantify the post-treatment internal P release rates following the application. The sediment core analysis showed an average 61% reduction (46% reduction from deep and 76%

reduction from moderately deep zones, respectively) in internal P release compared to pre-treatment conditions (Figure ES-2). The second half of the alum dose was applied in September 2022. Stantec will collect follow-up sediment cores in summer 2023 to quantify the sediment P release rate under anoxic (no oxygen) conditions following application of the full alum dose.

Figure ES-1. Alum application barge in Lake Agnes (September 22, 2022).

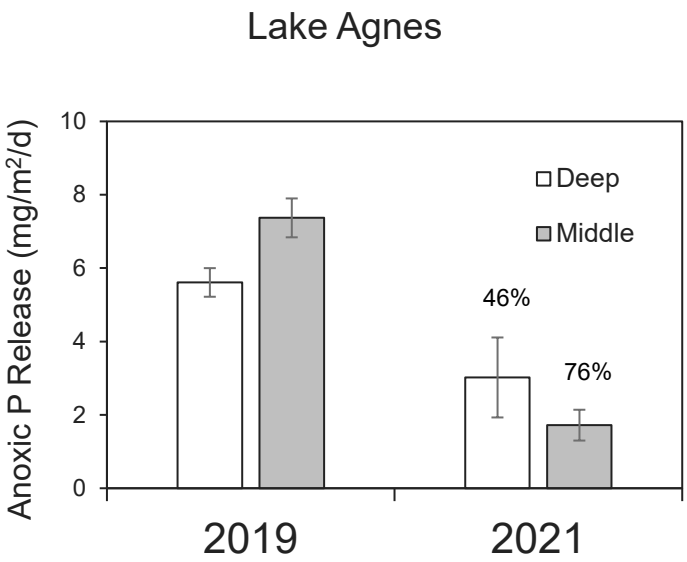


Figure ES-2. Pre-alum treatment phosphorus (P) release rates (2019) and post-application (2021) release rates. The first half of the prescribed alum dose resulted in an estimated 76% and 46% reduction in P release rates under anoxic conditions in the middle and deep zones of Lake Agnes, respectively.

Goal 2: Reduce carp density in Lake Winona to sustainable levels to prevent adverse impacts on water quality and submerged aquatic vegetation (SAV).

In 2019, the Stantec team conducted carp surveys in the Winona Chain of Lakes to 1) estimate population size and 2) track movement and behavior patterns to support carp removal efforts in Lake Winona. Carp surveys estimated over 36,000 individual carp were present in Lake Winona. In April 2021, a physical carp barrier was installed in the outlet between Lake Winona and Lake Agnes at Agnes Blvd NW to prevent migration of more carp into Lake Winona and to better constrain the location of carp for future removal efforts.

The first carp removal effort was initiated in October 2021 by Stantec, a subcontractor (WSB) and a local commercial fisherman (Terry Miller) using a large seine (Figure ES-3). WSB supported Stantec through radio-tracking of carp movement leading up to the removal event and herding the carp towards the commercial seine using underwater speakers. That event removed 4,918 individual carp (~31,131 lbs) from Lake Winona, which were transported to the commercial market for distribution.

Figure ES-3. Panel 3a shows setup of the commercial seine in 2021. Panel 3b shows one batch of carp prior to loading into the commercial truck for market distribution (Photo credit: WSB).

In late May 2022, a late spring and heavy rains led to above average water levels on Lake Winona and Lake Agnes for a few days which allow for some carp to pass over the rocks adjacent to the carp barrier. It is unknown how many carp were able to migrate into Lake Winona from Lake Agnes during this event. ALASD was notified of the carp barrier passage in fall 2022 by DNR. Stantec evaluated precipitation data, lake level data and the designs for the carp barrier to better understand conditions and evaluate options for preventing future migrations during high water levels. After consultation with the DNR, the decision was made to add additional rock around the barrier to raise the elevation slightly, which will be implemented in May 2023.

The second carp removal event occurred in October 2022 by Stantec, WSB and the same local commercial fisherman. The same seining technique was used in the 2021 and in 2022 removal events. In 2022, however, fewer carp were captured in the seine and only 1,611 individual carp were removed (~ 8,460 lbs). Some possible explanations for the lower amount captured in the second event include:

- Large woody debris on the bottom of Lake Winona caused the seine to be snagged which likely allowed some carp to pass underneath the seine.

- Carp could be avoiding the sampling gear.
- Carp may have congregated in more shallow areas outside of the seining area despite efforts to herd carp into the seine.

Future removal events using commercial seining would not likely result in greater removal numbers due to the complexity of the lakebed and associated interference with the commercial seine. Box-netting using carp-specific bait is not impacted by obstacles on the lakebed and has shown success in other Minnesota lakes. Recent population surveys indicate that the population density is still well above the adaptive management goal of 133 lbs/acre. The survey results also indicated a dominance of mature carp (average weight was 6 lbs and 23 inches in length) with few juveniles suggesting limited reproduction and expansion of the existing population within Lake Winona.

Estimating the population size of common carp is challenging and imprecise. While methods employed in Lake Winona are utilized broadly in Minnesota and elsewhere, there is a large range of uncertainty around the population estimate for carp. The current population estimate for Lake Winona is between 550-1165 lbs/acre, so additional removal efforts will be needed to meet the target density goal of 133 lbs/acre.

Improvements in the submerged aquatic vegetation (SAV) community in Lake Winona is a management goal from the Plan. In 2019, an SAV survey found only one species in Lake Winona (Sago pondweed), which was detected in only four out of 257 locations that were sampled in the survey. Until carp density has been reduced closer to the target density goal, we do not expect much improvement in the SAV community composition and distribution in Lake Winona. Per the grant work plan, another SAV survey will be conducted in 2023.

Water Quality Trends

PHOSPHORUS

The Lake Winona Total Maximum Daily Load (TMDL) determined that the allowable total phosphorus (TP) load from ALASD's discharge would be 665 kg/yr (noted by orange line in Figure ES-4) as defined in their NPDES permit and specified in the compliance schedule. ALASD's annual TP load to Lake Winona has been below the allowable TMDL load since 2012. Despite the load reductions from the WWTF, Lake Winona is still not meeting water quality standards (Table ES-1). The TMDL calls for a 98% reduction in internal P loads in Lake Winona which is not likely to occur with carp densities over 4 times higher than the population density goal noted in the Plan. The water quality of Lake Agnes and Lake Henry have improved and currently appear to be meeting the State's water quality standards. If similar trends continue for Lakes Agnes and Henry, these lakes should be candidates for delisting in the near future.

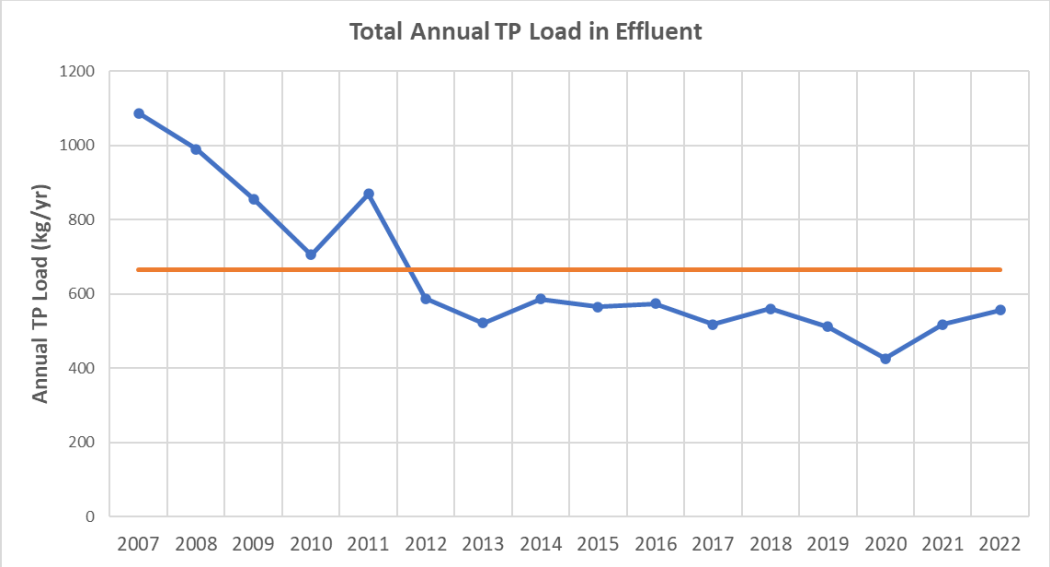


Figure ES-4 Total annual total phosphorus (TP) load to Lake Winona from ALASD's effluent discharge.

Table ES-1 Average total phosphorus (TP), chlorophyll-a and Secchi depth for years (2-12-2022). The state standard for each parameter and lake is shown in parentheses.

Lake	TP (µg/L)	Chlorophyll-a (µg/L)	Secchi depth (ft)
Winona	128 (≤ 75)	88 (≤ 20)	1.5 (≥ 1.0)
Agnes	53 (≤ 60)	20 (≤ 20)	5.4 (≥ 1.0)
Henry	36 (≤ 60)	15 (≤ 20)	6.9 (≥ 1.0)

CHLORIDE

Chloride has been monitored in the Winona Chain of Lakes by ALASD since 2020. Figure ES-5 shows the average concentration of chloride in surface waters for each year since 2020. Samples were also collected in the deep layers of Lakes Agnes and Henry which exhibit similar average annual concentrations as the surface water measurements. All three lakes are impaired due to exceedance of Minnesota's chloride standard for chronic conditions (230 mg/L), thus ALASD obtained a variance from the MPCA for the 252 mg/L max day chloride limit (expires 2028).

Chloride can significantly impact the ecological functioning of lake processes. For example, accumulation of chloride in lakes changes water density such that over time, the deep waters can become much denser than the surface waters, which can disrupt natural lake mixing patterns. Currently, there are no feasible in-lake treatment options to remove chloride in lakes so reducing loads through source control is critically important.

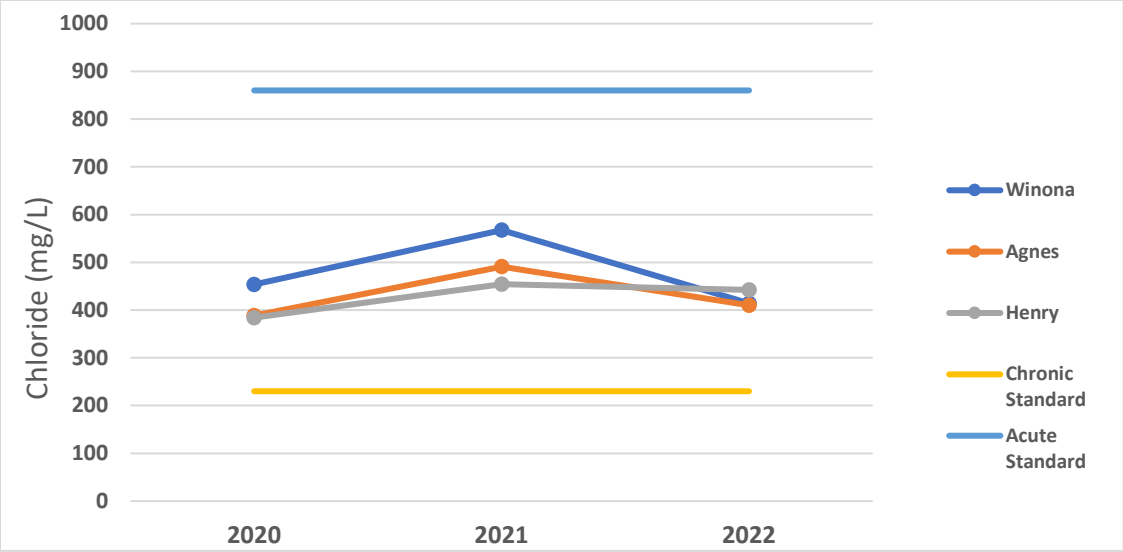


Figure ES-5 Average annual chloride concentrations in Lakes Winona, Agnes and Henry from 2020-2022. The orange and red lines represent the MN state chloride standard for chronic conditions (230 mg/L) and acute conditions (860 mg/L) in lakes.

Summary

ALASD has invested significant effort into the improvement of the Winona Chain of Lakes through implementation of the Adaptive Lake Management Plan. Several Plan activities have been implemented to-date which are briefly summarized below:

- A full alum treatment has been completed in Lake Agnes with a half-dose application in 2020 and the remaining half-dose in 2022. Post-treatment sediment cores collected in 2021 showed an estimated 61% reduction in potential internal P loading in Lake Agnes sediments. Sediment cores will be collected in 2023 to evaluate total load reductions following the second application.

- The carp barrier appears to be functioning as intended with the exception of the observed migration during high-water levels on May 30-31, 2022. ALASD has been implementing the Operations and Maintenance Plan for the barrier which includes monthly inspections and as-needed debris removal. Stantec, ALASD and DNR determined that the appropriate mitigation step is to add additional riprap to the carp barrier to raise the elevation slightly, which will be implemented in May 2023.

- Despite two carp removal events in Lake Winona, carp population density remains above the target biomass threshold of 133 lbs/ac. Using commercial seining techniques, over 6500 carp have been removed during two events. Future efforts using seining techniques are not likely to remove significant biomass due to challenges with the seine snagging large woody debris on the bottom and carp potential exhibiting gear avoidance. Box-nets using bait is another carp removal technique that has shown success in some Minnesota lakes and could be implemented in Lake Winona.

- Accurately estimating carp population density is challenging and labor intensive. Survey methods that have been employed in Lake Winona are likely overestimating the population size. Modifications to the methods (e.g. additional surveys on different days) would likely reduce some of the uncertainty in the population size.

- The 2019 SAV survey indicated extremely low plant density and diversity. Only one species of aquatic plants was found in just four locations in Lake Winona. With carp density well above the target, we do not expect the SAV community to establish until carp density is further reduced.
- Water quality has not changed in Lake Winona in recent years, but Lakes Agnes and Henry appear to be meeting water quality standards and may be considered for delisting in the future.
- Chloride concentrations in Lakes Winona, Agnes and Henry exceed the applicable state standard of 230 mg/L for chronic exposure. No feasible technology currently exists to remove chloride from lakes and methods to reduce loading from the WWTF are prohibitively expensive (i.e. reverse osmosis) so source-reduction is the most viable means for reducing loads to the lakes.

Next Steps

Several actions are required in the future by the LCCMR grant work plan and/or permits. A brief summary of these outstanding task is shown in Table ES-3 below.

Table ES-3. Summary of outstanding tasks and planned implementation period.

Outstanding Task	Requirement	Required Period of Implementation
Add additional riprap to carp barrier to prevent migrations during high water level	Required by Operations and Maintenance Plan as part of the Public Waters Work Permit for the carp barrier (#2020-2857)	May 2023
Continue implementing the Adaptive Lake Management Plan	LCCMR Work Plan and National Pollutant Discharge Elimination System Permit (NPDES; #MN0040738).	Plan schedule through 2023; NPDES permit expires Oct 31, 2025
Collect sediment cores from Lake Agnes in 2023 to estimate internal P load reduction after both alum applications	Specified task in LCCMR grant work plan	Summer 2023
SAV survey to be conducted in 2023	Specified task in LCCMR grant work plan	Summer 2023
Carp population surveys (Electrofishing CPUE)	Public Waters Work Permit for the carp barrier (#2020-2857)	2023, 2026, and 2027
Continue water quality sampling per requirements to maintain compliance	Public Waters Work Permit for the carp barrier (#2020-2857) and National Pollutant Discharge Elimination System Permit (NPDES; #MN0040738).	Plan schedule through 2023; NPDES permit expires Oct 31, 2025
Review carp barrier operations and maintenance plan and revised as needed	Public Waters Work Permit for the carp barrier (#2020-2857)	2025