Lake Cornelia and Lake Edina Water Quality Improvement Project

Feasibility Study/Preliminary Engineering Report

Photo by Larry Olson

Prepared for
Nine Mile Creek Watershed District

June 2020

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Certifications

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota.

June 10, 2020

Janna Kieffer
PE #: 43571

Date

Acronyms

µg/L	microgram per liter
AACE	Association for the Advancement of Cost Engineering
BMP	best management practice
cfs	cubic feet per second
DWSMA	Drinking Water Supply Management Area
FIN	Fishing in the Neighborhood
GIS	geographic information systems
HP	horsepower
HSG	hydrologic soil group
LiDAR	light detection and ranging
MIDS	Minimal Impact Design Standards
MnDNR	Minnesota Department of Natural Resources
NMCWD	Nine Mile Creek Watershed District
NRCS	Natural Resources Conservation Service
NWL	normal water level
RPBCWD	Riley Purgatory Bluff Creek Watershed District
SAFL	Saint Anthony Falls Laboratory
SRP	soluble reactive phosphorus
TDP	total dissolves phosphorus
TP	total phosphorus
UAA	Use Attainability Analysis
VHS	viral hemorrhagic septicemia
YOY	young of the year

1 Introduction and Project Background

1.1 Introduction

This report summarizes and assesses the feasibility of potential actions for improving the water quality of Lake Cornelia and Lake Edina, located downstream of Lake Cornelia. It is prepared in response to a water quality study the Nine Mile Creek Watershed District (NMCWD) completed for Lake Cornelia and Lake Edina in 2019 (Reference (1)).

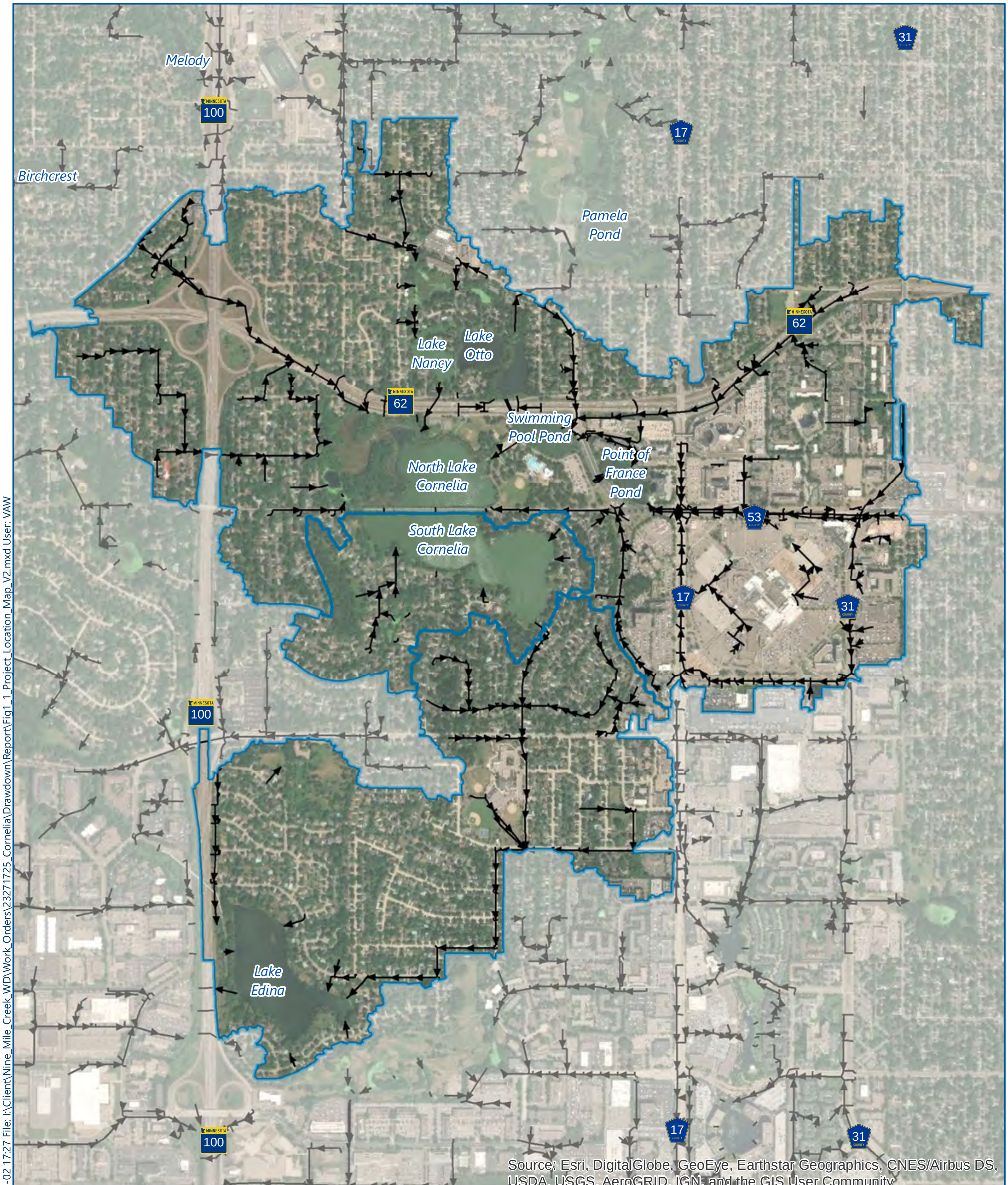
1.2 Project Background

The NMCWD was established by the Minnesota Water Resources Board in 1959 and consists of land that drains into Nine Mile Creek. The District encompasses approximately 50 square miles in southern Hennepin County and includes portions of the cities of Bloomington, Edina, Eden Prairie, Hopkins, Minnetonka, and Richfield (Figure 1-1). Nine Mile Creek has two branches; the north branch is fed by groundwater and stormwater and begins in Hopkins. The south branch originates in Minnetoga Lake and surrounding wetlands in Minnetonka. The north and south branches join north of Normandale Lake, just south of Interstate 494 in Bloomington. Lake Cornelia is located approximately 0.4 miles east of the north branch of Nine Mile Creek.

Stormwater management within the urbanized Nine Mile Creek watershed was guided initially by the District's Overall Plan dated March 1961. That plan was revised by the Watershed District in April 1973, as prescribed by the Minnesota Water Resources Board. The 1973 revised Overall Plan guided development in the District until it was further revised in May 1996, March 2007 and again in the 2017 Nine Mile Creek Watershed District Water Management Plan (amended 2018, 2019), in accordance with the Metropolitan Surface Water Management Act and Watershed Law: Minnesota Statutes Chapters 103B and 103D, respectively (Reference (2)).

The water quality in Lake Cornelia and Lake Edina is often poor, primarily due to excess phosphorus in the lakes which fuels algal growth and decreases water clarity. The 2019 water quality study found that phosphorus in Lake Cornelia comes from several sources, including stormwater runoff from the watershed (external source) and internal sources such as nutrient-rich sediments and decomposition of invasive curly-leaf pondweed. The study found that phosphorus in Lake Edina primarily comes from stormwater runoff within the watershed and flows from upstream Lake Cornelia.

The water quality study identified several recommendations to improve water quality in Lake Cornelia and downstream Lake Edina. This feasibility study report evaluates several water quality improvement approaches to address concerns associated with excess phosphorus in Lake Cornelia and Lake Edina as well as the prevalence of curly-leaf pondweed in Lake Cornelia. The report also evaluates options to revive a healthy native fish population in Lake Cornelia.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Major Watersheds

Storm Sewer

0 600 1,200 1,800

Feet

Project Location

Lake Cornelia and Lake Edina Water Quality Improvement Project

Edina, Minnesota

FIGURE 1-1

2 Lake Cornelia and Lake Edina Overview

The characteristics of Lake Cornelia, Lake Edina, and their watersheds are described in the following sections.

2.1 Lake Cornelia

2.1.1 Lake Cornelia Characteristics

Lake Cornelia is a shallow lake with a northern and southern basin, which are connected by a storm sewer pipe beneath West 66th Street. North Cornelia, spanning 19 acres, has a maximum depth of 7 feet, and a mean depth of approximately 3 feet. South Cornelia, with a water surface area of 33 acres, has a maximum depth of 8 feet, and a mean depth of approximately 4 feet. Runoff that flows through Lake Cornelia drains to Lake Edina, which ultimately discharges into the North Fork of Nine Mile Creek.

2.1.2 Watershed Characteristics

North Cornelia receives stormwater runoff from a relatively large watershed (863 acres) (Figure 2-1). Land use within the highly developed watershed includes a large commercial area (including the Southdale Shopping Center and Fairview Southdale Hospital), portions of Highway 62 and Highway 100, residential areas (high and low density), and Rosland Park. Most of the runoff from the highly impervious commercial area drains through a series of waterbodies (i.e., Point of France Pond and Swimming Pool Pond) prior to reaching North Cornelia. In addition to flows from North Cornelia, South Cornelia receives runoff from a relatively small, residential watershed (112 acres).

2.1.3 Lake Cornelia Water Quality

Water quality in Lake Cornelia is poor, with summer-average total phosphorus and chlorophyll *a* concentrations well above the state standard for shallow lakes (Figure 2-2). The poor water quality is primarily due to excess phosphorus in the lake, which fuels algal growth and decreases water clarity (Figure 2-3). The phosphorus in Lake Cornelia comes from several sources, including stormwater runoff from the watershed (external source) and internal sources such as nutrient-rich sediments and decomposition of curly-leaf pondweed. Fish activity, specifically the disruption caused by bottom-feeding species such as bullhead, carp and goldfish, may also be decreasing water clarity. Additional information around these sources of phosphorus in Lake Cornelia can be found in the 2019 water quality study (Reference (1)).

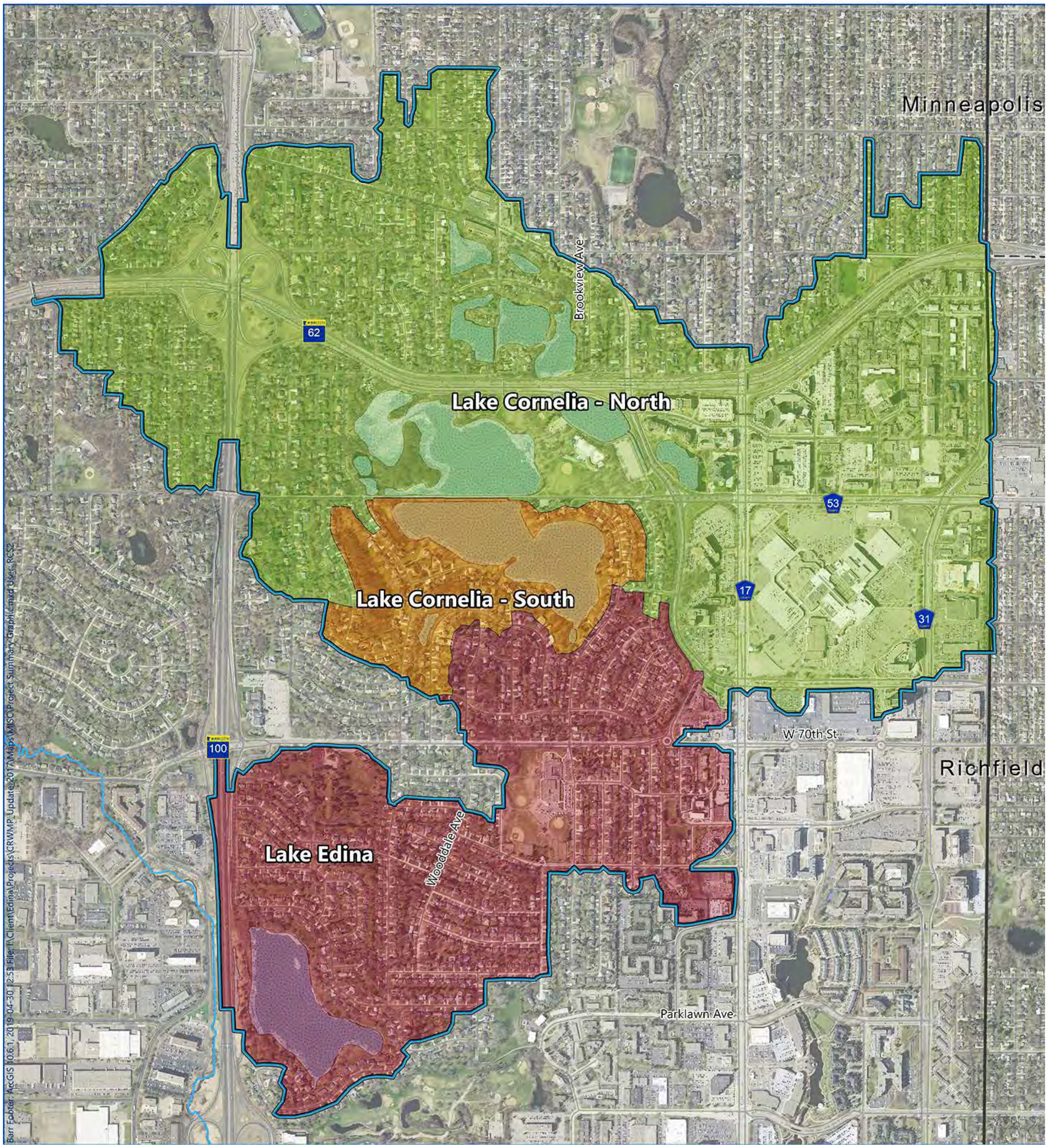


Figure 2-1 Lake Cornelia and Lake Edina Watersheds

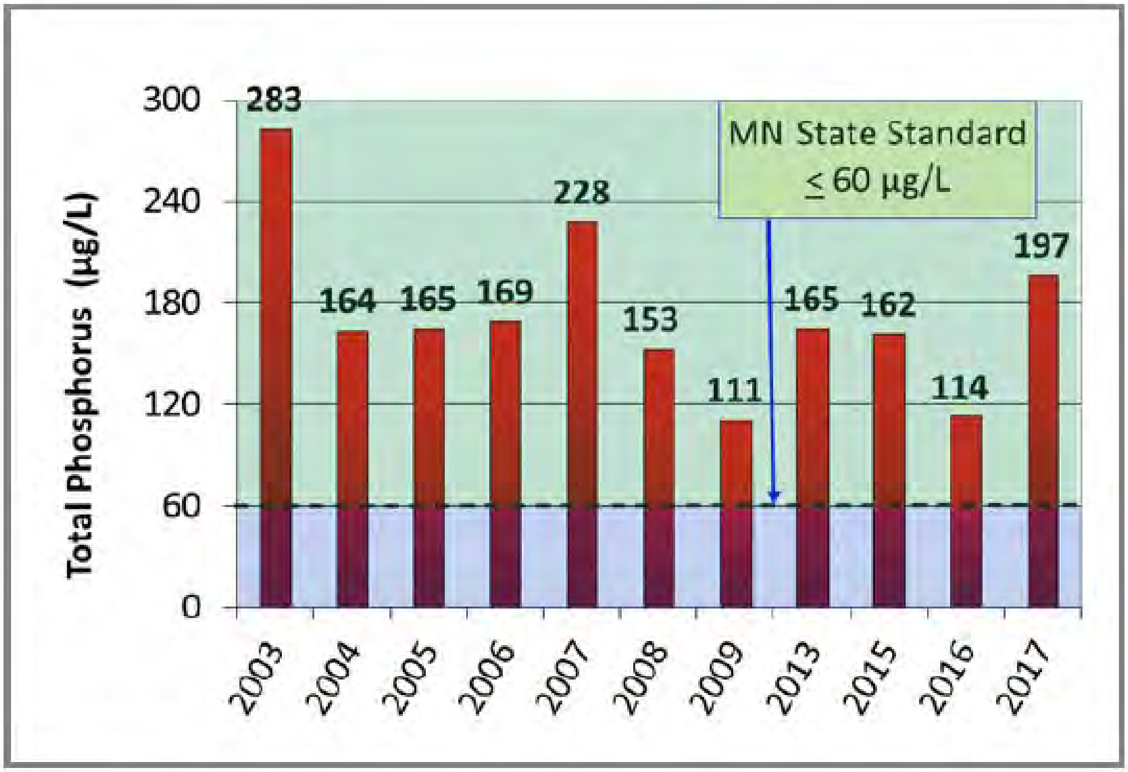


Figure 2-2 **Summer average phosphorus concentrations in Lake Cornelia (North Basin) have historically been well above the state standard for shallow lakes**

Figure 2-3 **Photos of Blue-green Algae in Lake Cornelia (North Basin) (2017)**

2.2 Lake Edina

2.2.1 Lake Edina and Watershed Characteristics

Lake Edina is a shallow, 25-acre lake with a maximum depth of 5 feet and a mean depth of approximately 3 feet. The Lake Edina watershed encompasses approximately 400 acres (Figure 2-1). Land use within the watershed is primarily low-density residential, with smaller portions of high-density residential, commercial, institutional (Cornelia Elementary School), and park.

2.2.2 Lake Edina Water Quality

Water quality in Lake Edina, located downstream of Lake Cornelia, is also poor, with summer-average total phosphorus and chlorophyll *a* concentration generally not meeting the state standard for shallow lakes (Figure 2-4).

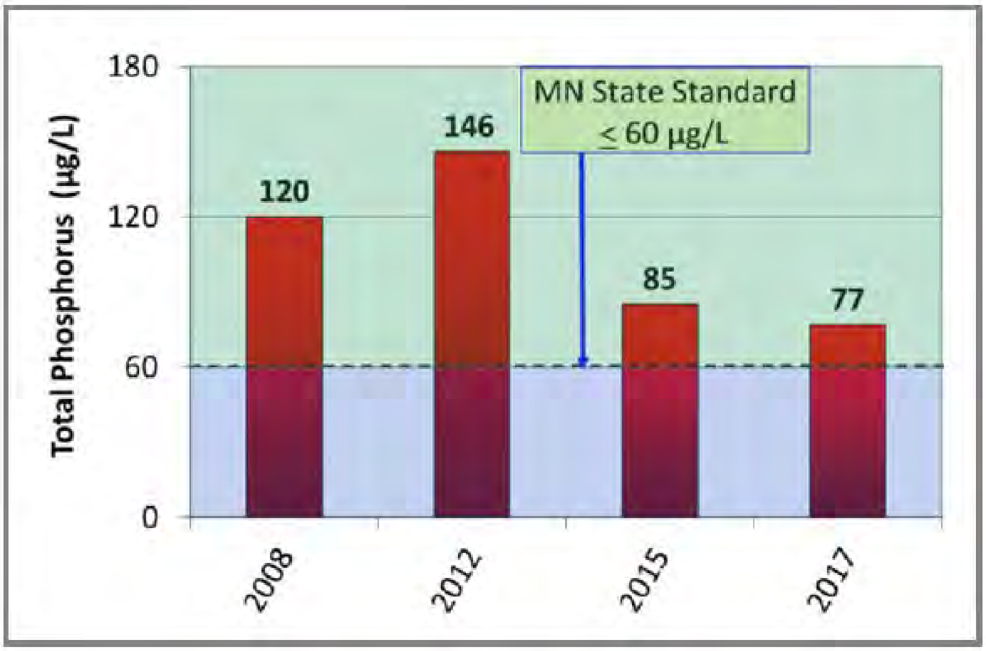


Figure 2-4 Summer average phosphorus concentrations in Lake Edina have historically been above the state standard for shallow lakes

The poor water quality is primarily due to excess phosphorus in the lake, which fuels algal production and decreases water clarity. Phosphorus in Lake Edina comes from several primary sources, including stormwater runoff from the watershed and flows from upstream Lake Cornelia. Curly-leaf pondweed has been observed at low levels in Lake Edina in recent years, but was not observed in spring of 2020.

Water quality in Lake Edina is highly influenced by the water quality of Lake Cornelia. While this report primarily evaluates management strategies and recommendations for Lake Cornelia, associated watershed-level improvements are expected to yield some level of indirect water quality benefit to Lake Edina.

3 Summary of Evaluated Management Practices

The goals of this project are to evaluate the feasibility and cost effectiveness of the management strategies recommended by the 2019 Use Attainability Analysis (UAA) study to help improve Lake Cornelia and Lake Edina water quality, including:

- Stormwater treatment system in Rosland Park to remove additional phosphorus from stormwater flowing through Swimming Pool Pond prior to discharge into Lake Cornelia;
- Other watershed management best management practices (BMPs), including stormwater retrofit BMPs in the Lake Edina watershed and opportunities for treatment of upstream ponds
- Curly-leaf pondweed management in Lake Cornelia;
- Installation of a winter aeration system in Lake Cornelia to minimize winter kill of predator fish and reduce recruitment of bottom-feeding fish; and
- Other fishery management strategies, including potential stocking of predator fish and removal of goldfish and other bottom-feeding fish in Lake Cornelia and upstream hydraulically-connected waterbodies.

One of the recommendations of the 2019 water quality study, conducting an alum treatment of Lake Cornelia to minimize release of phosphorus from lake-bottom sediments, was completed by NMCWD in the spring of 2020. The objective of this preliminary engineering study is to evaluate the feasibility of the other recommended management activities for Lake Cornelia and Lake Edina. The following sections of the report summarize the findings of the feasibility evaluation and recommendations for lake and watershed management practices:

- Section 4 Stormwater Treatment in Rosland Park
- Section 5 Other Watershed BMPs
- Section 6 Curly-leaf Pondweed Management
- Section 7 Fishery Management
- Section 8 Conclusions and Recommendations

4 Stormwater Treatment in Rosland Park

The 2019 water quality study concluded that stormwater runoff is a major contributor of phosphorus to Lake Cornelia, representing 48% to 76% of contributions to North Cornelia in modeled years. The study recommended implementation of a stormwater BMP located in Rosland Park to remove phosphorus from water flowing from the Swimming Pool Pond to North Lake Cornelia. Swimming Pool Pond (DNR wetland 679W) receives runoff from approximately 410 acres, which represents approximately 47% of the total area tributary to North Lake Cornelia (Figure 4-1).

This feasibility study included two phases of analysis: (1) evaluation of conceptual BMP designs and selection of a preferred concept by the NMCWD and City of Edina, and (2) feasibility analysis and preliminary design of the selected conceptual BMP. Each of these phases are described in subsequent sections.

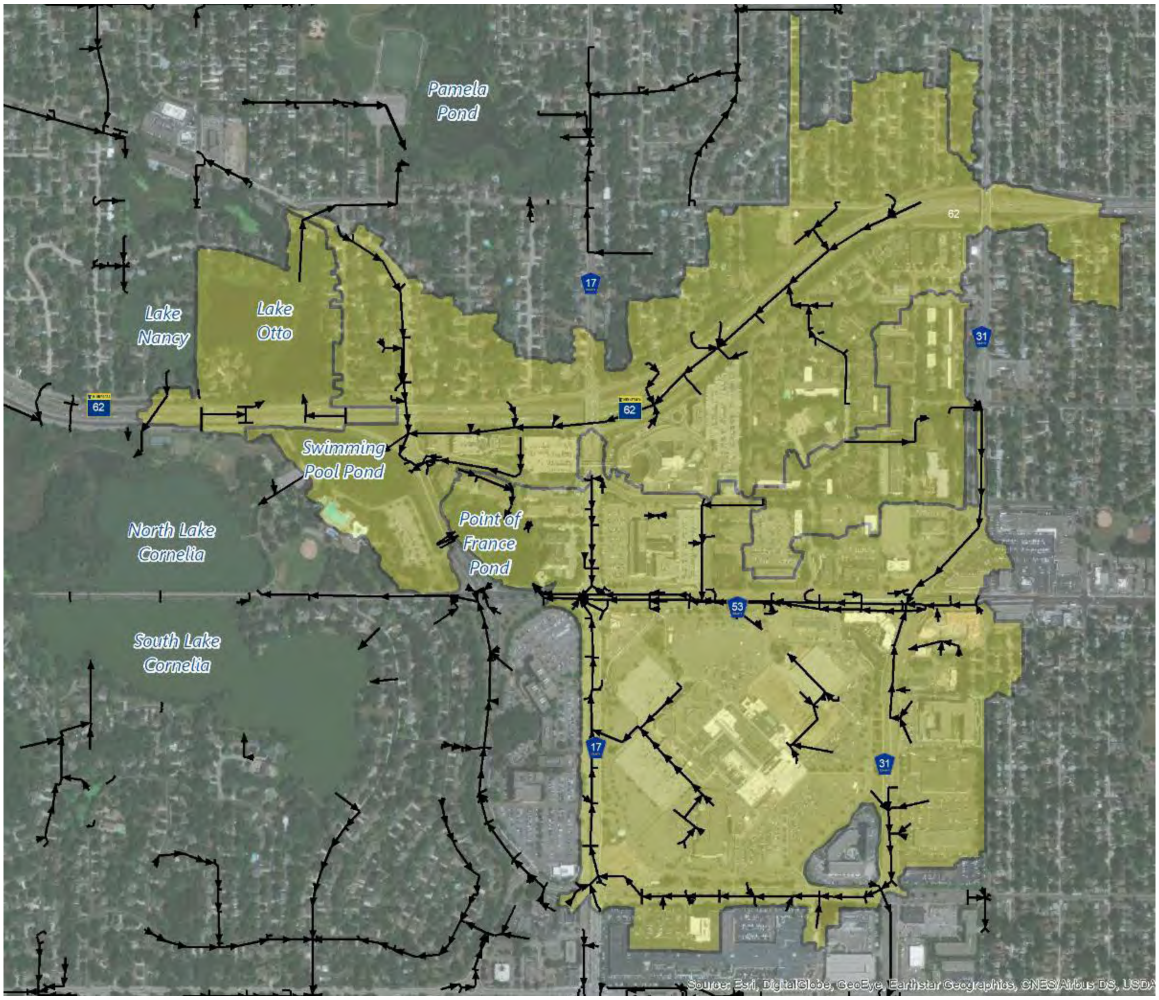


Figure 4-1 **Runoff from approximately 410-acres, shown in yellow, flows through Swimming Pool Pond**

4.1 Conceptual Design Options

Three high-level stormwater management concepts for a BMP at Rosland Park were developed and presented to NMCWD, City of Edina, and Edina Parks and Recreation Commission staff throughout a series of meetings in fall 2019. Throughout these meetings, the preliminary concepts were modified to match the visions and constraints of the various stakeholders involved.

Initially, two BMP design concepts were developed for consideration by NMCWD and City of Edina staff. Concept #1 was a subsurface filtration treatment vault located under the existing parking lot between Swimming Pool Pond and North Cornelia, similar to the BMP evaluated as part of the 2019 water quality study. Concept #2 was a "stream-like" series of small, shallow surface filtration basins within the nearby green space at the park, with water from Swimming Pool Pond being pumped to the upstream end of the chain of BMPs. Preliminary presentation of this concept incorporated solar energy generation to power the pump. Based on feedback obtained from NMCWD and City of Edina staff, Concept #2 was revised to include a pump-driven filtration treatment vault located at the edge of the North Parking lot, instead of the "stream-like" series of small filtration basins. In this revised option (Concept #3), water would be pumped from Swimming Pool Pond into an above-ground treatment vault, with the pump potentially powered (or offset) by solar energy generation. After passing through the filtration system, treated water would be discharged to Lake Cornelia. Concept #3 reflects the City's desire to minimize the BMP footprint and associated impacts on current or future park use.

At a November 20, 2019, meeting with NMCWD and City of Edina Staff, Concept #3 was identified as the preferred stormwater feature concept. The above-ground filtration vault design would allow for more design flexibility and increased treatment capacity, would simplify operation and maintenance of the filtration system, would minimize parkland impacts, and would provide an opportunity to incorporate public art or education into the feature to make the system not only a functional means of reducing phosphorus to Lake Cornelia, but an attractive element of the park as well.

The stormwater treatment concepts, including the preferred Concept #3, were presented to the Edina Parks and Recreation Commission on December 10, 2019, and the NMCWD board of managers on December 18, 2019. At that meeting, the NMCWD board of managers approved moving forward with Concept #3. A copy of the December 18, 2019, presentation is included as Appendix A.

4.2 Feasibility Analysis/Preliminary Design

Following direction from NMCWD and the City of Edina, feasibility analysis and preliminary design for the proposed filtration vault (Concept #3) began in late-December 2019. Feasibility analysis included performing a site characterization and developing a hydraulics analysis using XPSWMM. The preliminary design phase included developing filtration media recommendations and further defining the filtration vault sizing, height, flow regime, and pumping regime. Each of these phases are discussed in detail in the subsequent sections.

4.2.1 Site Characterization

Site characterization for the proposed filtration vault in Rosland Park included a review of geographic information systems (GIS) data to understand the existing topography, soil conditions, park features, existing storm sewer upstream and downstream of Swimming Pool Pond, and Swimming Pool Pond bathymetry. Figure 4-2 shows several existing site features, including topography, storm sewer, and bathymetry for Swimming Pool Pond. The topographic information shown in the figure is based on Minnesota Department of Natural Resources (MnDNR) light detection and ranging (LiDAR) data developed in 2011. Storm sewer information (e.g., diameters, invert elevations, etc.) were obtained from the City of Edina. Bathymetry information for the water bodies surrounding Rosland Park, including Swimming Pool Pond, North Cornelia, and Point of France Pond, were also provided by the City of Edina. Bathymetric information for Lake Otto was collected by NMCWD as part of this study.

Existing soil information within Rosland Park is limited; soils in this area do not have a Natural Resources Conservation Service (NRCS) hydrologic soil group (HSG) classification designated. Given that much of the area around Lake Cornelia was part of a large wetland complex prior to develop in the 1960s and beyond, the soils throughout much of the low-lying park areas are likely hydric. Soil boring analysis is recommended for the next design phase to better understand soil stability for construction.

Review of existing park infrastructure and vegetation was another important aspect of site characterization, as it was important to site the filtration treatment vault in a location that minimizes park impacts. Figure 4-2 shows the existing park features in the proposed project area, including detailed aerial imagery and locations of several existing disc golf course holes. Nearmap imagery was used for this analysis. The most recently available satellite imagery of the project area is from April 5, 2020, and has 3-inch resolution, which allowed for detailed review of the park features.

Rosland Park BMP
Site Characterization
Lake Cornelia and Lake Edina
Water Quality Improvement Project
Edina, Minnesota

FIGURE 4-2

4.2.1.1 Swimming Pool Pond Outlet Structure

Discharge from Swimming Pool Pond is controlled by an outlet structure located on the west side of the pond near the parking lot for the disc golf course and playground (see Figure 4-2). The outlet structure, constructed in the mid-1960s, controls the water level at elevation 862.9 feet. Original construction drawings of the Swimming Pool Pond outlet structure indicate flow capacity is restricted within the structure by a 10-inch steel pipe with a 3-¾" orifice opening. City of Edina staff conducted a field investigation to confirm the configuration of the Swimming Pool Pond outlet in April 2020 and found that the existing metal plate with a 3-¾" orifice appears to have been removed at some point in the past as the orifice plate restricting flows into the 10" steel pipe was not visible during the site visit. Therefore, discharge from Swimming Pool Pond appears to now be controlled by a 10" steel pipe rather than a 3-¾" orifice. The storm sewer pipe between the outlet structure and North Lake Cornelia is an 18-inch reinforced concrete pipe (RCP).

4.2.1.2 Lake Otto Outlet

Lake Otto (MnDNR wetland 678W) is located just north of Trunk Highway 62, is connected to Swimming Pool Pond via two 60-inch diameter corrugated metal pipes (CMP). Although detailed information on these pipes is not available, a site visit confirmed that the pipes are both fully submerged below the normal water elevation, therefore acting as equalizer pipes between Lake Otto and Swimming Pool Pond. The two 60-inch diameter storm pipes are believed to be owned by the Minnesota Department of Transportation (MnDOT).

4.2.1.3 Point of France Pond Outlet Structure

Point of France Pond (MnDNR wetland 680W) is located southeast of Swimming Pool Pond on the east side of Valley View Drive and north of West 69th Street. Water levels in this pond are controlled at 863.4 feet by two 60-inch wide weir structures that were installed in the mid-2000s as part of a pond dredging and improvement project conducted by the City of Edina. The weir structures tie into two existing 66-inch CMP. With the reconfiguration of the Point of France outlet structure, water levels in Point of France Pond are controlled independently of water levels in Swimming Pool Pond.

4.2.1.4 Water Quality in Swimming Pool Pond

In 2018, University of Minnesota researchers partnered with the City of Edina and NMCWD to conduct a pilot study in Swimming Pool and Point of France Ponds to assess the effectiveness of applying iron filings to pond sediments to reduce the release of phosphorus from the sediments. The first step of the pilot study was to assess the extent of sediment phosphorus release occurring to determine if the waterbodies were good candidates for the proposed iron filings. In March 2019, the University of Minnesota researchers published their findings indicating that minimal internal phosphorus release was occurring in Swimming Pool Pond and Point of France Pond (Reference (3)).

The 2019 University of Minnesota report, included as Appendix B, was reviewed and used to better understand existing water quality in Swimming Pool Pond. Water quality samples were taken at six locations throughout Swimming Pool Pond from May through September 2018 in the epilimnion (surface layer) and hypolimnion (bottom layer). Samples were analyzed for total phosphorus (TP), total dissolved phosphorus (TDP), and soluble reactive phosphorus (SRP). TP represents all phosphorus fractions measured in the sample, whether particulate or dissolved. TDP represents the fraction of phosphorus that filters through a 0.45 micron pore size filter (organic and inorganic). SRP represents the readily bioavailable inorganic form of phosphorus (PO_4^{3-}), sometimes also referred to as orthophosphate. This water quality data helped to characterize the phosphorus loading that will be treated in filtration vault.

Table 4-1 provides a summary of the water quality data obtained at the six sampling sites. The sampling data generally shows that the TP concentrations in Swimming Pool Pond can range widely throughout the year. Within the epilimnion, the maximum TP concentration measured of 181 µg/L (August 22, Site 3) was 134 µg/L greater than the lowest TP concentration measured (May 16, Site 6). The observed percent fraction of TP that was either TDP or SRP also ranged quite substantially between sampling events.

Table 4-1 Summary of Water Quality Data for Swimming Pool Pond from May through September 2018[1]

Sampling Location	Average TP (Range) (µg/L)	Average TDP (Range) (µg/L)	Average SRP (Range) (µg/L)	Average %TDP (Range)	Average %SRP (Range)
Epilimnion	95 (47–181)	33 (6–58)	13 (1–30)	37% (9%–80%)	15% (1%–36%)
Hypolimnion	100 (67–152)	32 (6–51)	15 (1–23)	33% (8%–52%)	18% (1%–28%)

[1]Data summarized from Appendix B of *Assessment of Internal Phosphorus Loading in Swimming Pool Pond and Point of France Pond, City of Edina* (Reference (3)).

Figure 4-3 summarizes measured phosphorus concentrations in the epilimnion from one of the sampling sites (Site 3). The green points represent the grab sample TP measurements that were taken. The orange and purple points show the percent of the sample that was measured as TDP and SRP, respectively. This data indicates that the TP concentrations generally increased in the late summer and early fall. As the TP concentrations increased, a decrease in the percent of the sample that was TDP and SRP was observed. This indicates that a higher percentage of the sample was particulate rather than dissolved phosphorus in the late summer and early fall. The increase in particulate fraction is likely due to an increase in algal growth at the end of the growing season. Conversely, at the start of the sampling period, the TP concentrations are lower and a higher percentage of the sample is dissolved phosphorus. This wide range of concentrations and fractions of phosphorus throughout the growing season observed in Swimming Pool Pond help inform design decisions for the proposed filtration vault.

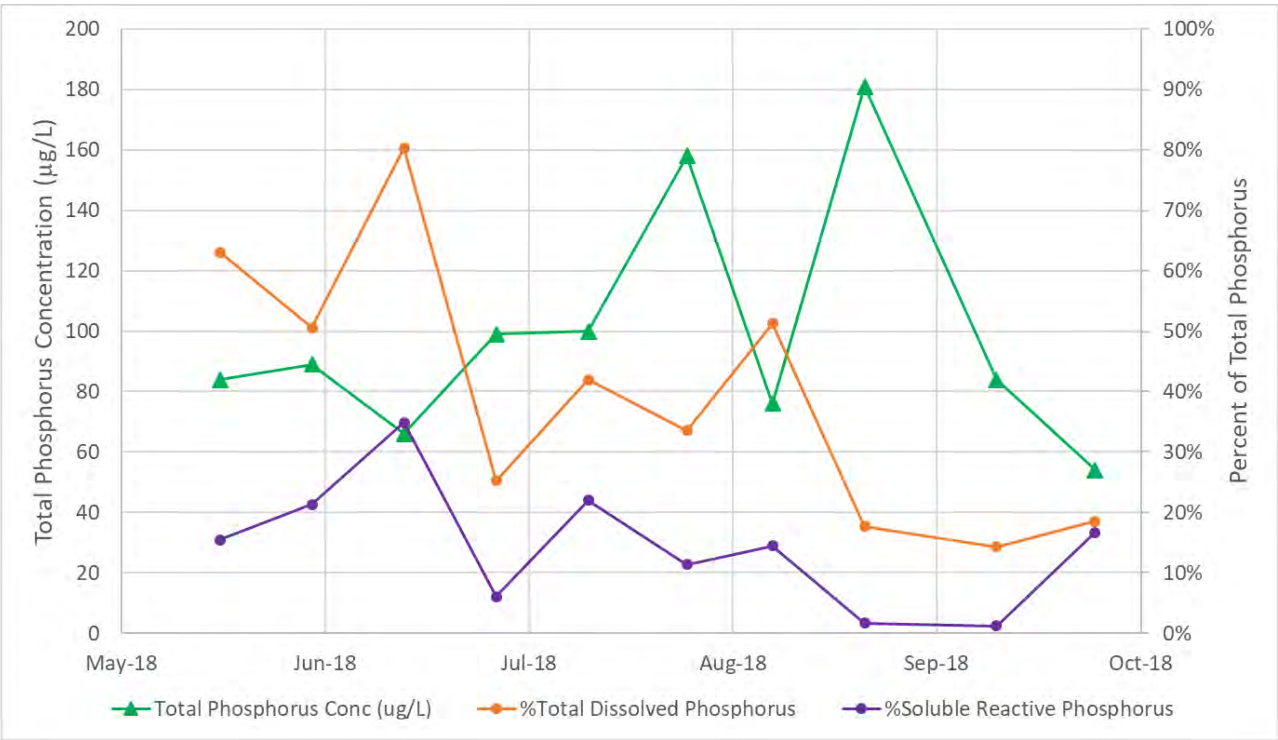


Figure 4-3 Swimming Pool Pond Sampling Site 3 (Epilimnion) TP Concentrations and Percent TDP and SRP over time

4.2.2 Design Considerations

A number of design factors were considered during preliminary design including:

- Size and aesthetics of filtration vault system
- Treatment pumping rate;
- Daily and annual treatment (pumping) duration;
- Pumped drawdown depths of Swimming Pool Pond and Lake Otto;
- Pollutant removal effectiveness (selection of treatment media); and
- Operations and maintenance

These design factors are discussed in detail in the following subsections.

4.2.2.1 Filtration Vault Size and Aesthetics

Figure 4-4 shows the location of the proposed filtration vault system in relation to Swimming Pool Pond and the nearby parking lot. Feedback during conceptual design indicated a preference to minimize the size and impacts to open space usage in the park; the filtration vault footprint has been optimized to meet these preferences. The preliminary filtration vault design assumes the footprint of the filtration vault is approximately 1,200 square feet (100 feet wide by 12 feet deep), similar to Concept #3 developed during the conceptual design phase.

Figure 4-4 Location of the Proposed Filtration Vault System in Rosland Park

Due to the prominent size of the filtration vault and it location within the park (adjacent to the parking lot), the aesthetics of the BMP are an important consideration. Several renderings were developed to show potential design variations that would create a visually-appealing park amenity (see Figure 4-5 through Figure 4-8). Details of the aesthetics will be determined as part of final design. Suggestions of incorporating park signage, public art, and/or educational signage or features into the final design have been discussed.

Figure 4-5 Rendering showing the approximate size and location of the concrete filtration vault with limestone facing on vault walls

Figure 4-6 **Rendering showing the concrete filtration vault with partially-buried vault walls and a low limestone wall**

Figure 4-7 **Rendering showing the concrete filtration vault with tiered wall planted with shrubs and flowering plants**

Figure 4-8 Rendering showing the concrete filtration vault with tiered wall planted with native grasses

4.2.2.2 Treatment Pumping Rate

Because the proposed filtration vault at Rosland Park is above ground and higher in elevation than water levels in Swimming Pool Pond, a gravity-driven system is not feasible and a pump will be necessary to convey water from the pond to the treatment vault. The pumping rate selected to treat water from Swimming Pool Pond is dependent on BMP size, cost, and filtration rate/capacity of the selected filtration media. A treatment flow rate of 1.0 cubic feet per second (cfs) was selected for preliminary design as it meets the initial criteria. A 4 to 5 horsepower (HP) pump is required to meet this flow rate. During detailed design, flowrates can be optimized to analyze the effectiveness of a variable pump, which allows flowrates to be adjusted for climatic conditions and optimized to match the media filtration rate throughout the media life.

4.2.2.3 Daily and Annual Treatment Duration

The daily and annual pumping duration impacts the volume of water passed through the proposed filtration vault and also impacts the pollutant removal effectiveness and the life of the filtration media. Treating a larger volume of water must be balanced with media treatment potential. Some filtration media have limitations pertaining to the duration of inundation. For example, if spent lime is exposed to longer inundation periods, the material can lose stability and its useful life is reduced. If iron-enhanced sand or iron fillings are exposed to longer inundation periods, phosphate that was previously captured by the media can be released when oxygen levels are too low. To improve media pollutant removal effectiveness, inundation periods of no longer than 12 hours per day for the filtration vault are recommended. Two daily pumping regimes are currently being considered: (1) 12 hours pump on, 12 hours pump off and (2) 2 hours pump on, 2 hours pump off throughout the course of 24 hours. Daily pumping duration can be optimized in the field after installation.

The proposed annual treatment duration is from April 15 through November 15. The annual treatment duration may need to be modified each year based on the onset of freezing temperatures.

4.2.2.4 Pumped Drawdown Depths of Swimming Pool Pond and Lake Otto

Operation of the proposed pump will be dependent on water levels in Swimming Pool Pond; the pump will operate when water levels are higher than or slightly below the control elevation. There are a number of factors to consider when selecting a draw down depth, including:

- Optimization of volume treated (the greater the depth pumped, the greater the treatment volume);
- Permitting requirements;
- Impacts to riparian land owners, including Lake Otto residential properties; and
- Impacts to riparian habitat areas

The depth of drawdown below the control elevation of Swimming Pool Pond (and Lake Otto) was given much consideration as part of this feasibility and preliminary design analysis, with a goal of balancing maximizing the volume of water pumped to the filtration system with minimizing impacts of pumping on riparian land owners riparian of Swimming Pool Pond and Lake Otto. A hydraulic modeling analysis was conducted to help determine how much water would be treated under various pumping scenarios and what impacts the pumping scenarios would have on water levels. Pumping scenarios included evaluation of pumped drawdown depths of 3 inches and 6 inches. A pumping scenario that isolates Lake Otto from Swimming Pool Pond by constructing a weir at the Lake Otto outlet was also considered; however, considerable construction constraints and associated costs make this option undesirable.

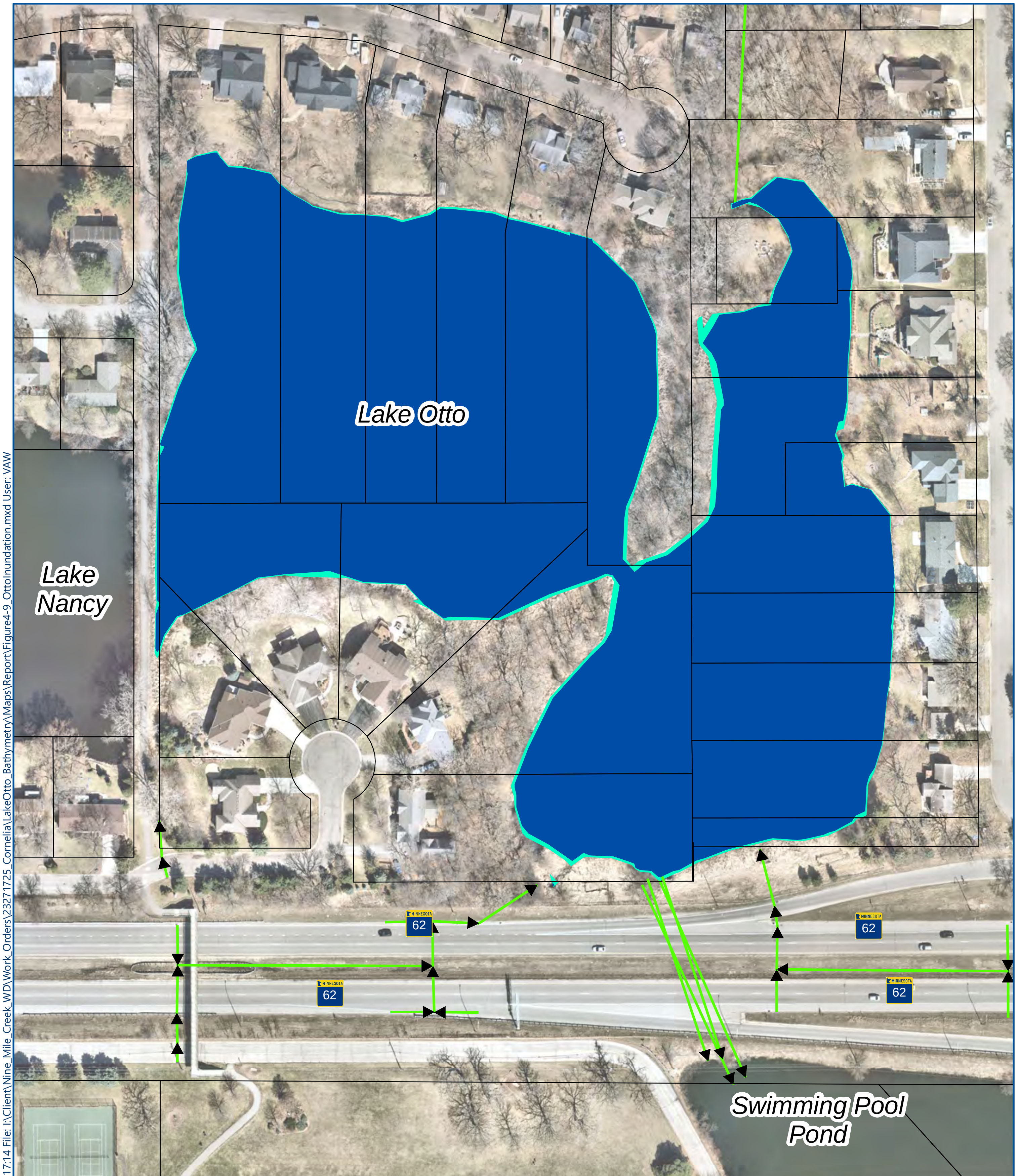
Based on results of the modeling analysis and communication with NMCWD and City of Edina staff, the recommended pump draw down depth is 3.6 inches (0.3 feet) below the control elevation of 862.9 feet. Under this scenario, the pump would turn off when water levels in Swimming Pool Pond reach 0.3 feet below the control elevation. Figure 4-9 compares the inundation extents of Lake Otto when water levels are at the control elevation and when they are 3.6 inches lower. Additional information on the hydraulic modeling analysis is included as Appendix C.

As summarized in Table 4-2, the amount of water pumped to the proposed filtration vault on an average annual basis under the 3.6 inch drawdown scenario is 108 acre-feet per year. This treatment volume represents approximately 52% of the flow between Swimming Pool Pond and North Cornelia, on average. The volume of water treated by the proposed BMP will vary year-to-year, depending on climatic conditions; model results based on 35-years of precipitation data indicate the annual volume of water treated will range from 60 to 130 acre-feet.

Table 4-2 Summary of Amount of Water Pumped/Treated by Proposed Filtration Vault

Scenario	Average Annual Pumped Volume (ac-ft)[1]	Range Annual Pumped Volume (ac-ft)[1]	% of Discharge from Swimming Pool Pond Treated
Pump turns off when 3.6 inches below normal water level	108	61–143	52%

[1] Treatment season is April 15 through November 15.



Inundation extent with water level lowered by 3.6 inches (Elevation 862.6)

Inundation extent at current normal water level (Elevation 862.9)

Parcel Boundary

Storm Sewer

N

Feet

0 75 150

Lake Otto Inundation Extents Comparison

Lake Cornelia and Lake Edina Water Quality Improvement Project

Edina, Minnesota

FIGURE 4-9

Results from the 35-year hydraulic modeling analysis also were used to evaluate potential impacts on water levels in Swimming Pool Pond and Lake Otto under various pumping scenarios. Water level fluctuations in these waterbodies are typical, with water being higher than the control elevation following rain or snowmelt events and water being lower than the control elevation during dry periods due to evaporation and/or interaction with groundwater. However, some additional water level fluctuation will occur with the proposed pumping at Swimming Pool Pond. Table 4-3 compares the estimated frequency of lowered water levels under existing conditions and the recommended 3.6-inch pumping depth scenario for Swimming Pool Pond and Lake Otto.

Table 4-3 Summary of Water Level Fluctuation in Swimming Pool Pond and Lake Otto under Recommended Pumping Scenario

Scenario	Average days/treatment period[1] Swimming Pool Pond and Lake Otto greater than 3 inches below existing NWL	Average days/treatment period[1] Swimming Pool Pond and Lake Otto greater than six inches below existing NWL
Existing conditions	25 (12%)	5 (3%)
Pump turns off when 3.6 inches below normal water level	108 (50%)	13 (6%)

[1] Treatment season is April 15 through November 15.

4.2.2.5 Filtration Media Selection and Pollutant Removal Effectiveness

A three-chamber filtration vault is proposed to test three different filtration treatment media types, with a goal of assessing and ultimately using the media that most effectively removes phosphorus. Figure 4-10 shows a plan view of the proposed treatment vault, with each treatment media chamber approximately 35 feet long, 12 feet wide, and 3 feet deep. These dimensions are anticipated to allow for sufficient contact time of the treatment media for pollutant removal.

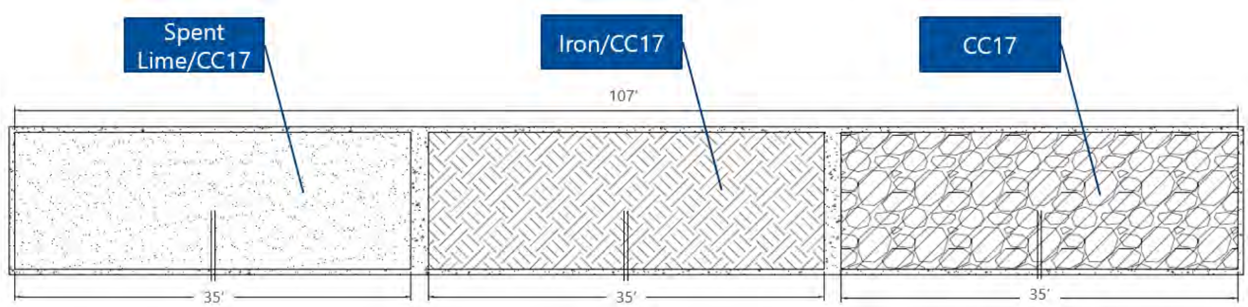


Figure 4-10 Plan View of Three-Chamber Filtration Vault

Figure 4-10 identifies three different filtration media that are recommended for use in the proposed filtration vault: CC17, a spent lime and CC17 combination (they are separate layers in the cell), and an iron and CC17 combination. Swimming Pool Pond receives stormwater from an approximately 410-acre watershed. As the runoff flows through Swimming Pool Pond, most of the large sized solids and attached phosphorus particles are removed through sedimentation; hence the solids and phosphorus particles that leave Swimming Pool Pond are small. It is important that the media used in the filtration vault be able to filter these small solids and phosphorus particles. All of the recommended media have this filtration capacity.

CC17 Filtration Media

CC17 is a crushed limestone ($CaCO_3$) material that has greater solubility than most limestone materials. The CC17 media acts primarily as a filter. This media can remove particulate phosphorus (the small and large particles) and a limited amount of dissolved phosphorus. This media will serve as a control to determine what phosphorus mass can be removed by simple filtration. However, the benefit of this media is that it has high hydraulic conductivity (e.g., it can filter a lot of water) and can filter a significant amount of water with a limited footprint.

Spent Lime + CC17 Filtration Media

Spent lime is a waste byproduct of drinking water treatment and consists of newly precipitated and consolidated calcium carbonate. Spent lime is similar to the other media in that it filters solids and particulate phosphorus, however, it also removes dissolved phosphorus (ortho-P or PO_4,, also known as SRP) by raising the pH of the treated water thereby causing the precipitation of calcium phosphate ($CaPO_4$). The main benefit of spent lime is that it has very high hydraulic conductivity and can treat large volumes of water. Spent lime is also a waste material and this provides a beneficial reuse of this material. The CC17 media would be added to the bottom of the filter bed to capture small particulate phosphorus particles.

Iron-enhanced CC17 Filtration Media

Because sand has a low hydraulic conductivity relative to the other filtration media considered, it is not recommended for use in the filtration vault (the footprint of a sand filter at this site would need to be approximately 10 times larger to achieve similar treatment benefits). Instead of iron-enhanced sand filtration, we are proposing to test an iron-enhanced-CC17 filtration media. This filter media should have significantly higher treatment capacity than iron-enhanced sand and be able to remove dissolved phosphorus. Iron actively binds organics, solids, and dissolved phosphorus which is often referred to as ortho-P (the resultant iron and phosphate compound is $FePO_4$).

Table 4-4 summarizes the phosphorus removal estimates for each of the evaluated filtration media. The table also summarizes filtration rates, necessary contact time, and required filtration vault sizing based on these parameters for each of the evaluated filter media. The removal efficiency values are based upon small and large scale test systems designed and evaluated by Barr on other projects. The filtration rates were either examined in the field or estimated from literature values.

Prior to design and construction, it is recommended that testing of the proposed filtration media be considered, including evaluating the hydraulic conductivity of the CC17 and iron-enhanced CC17 media and conducting bench scale testing of the media for phosphorus removal effectiveness.

Table 4-4 Summary of Evaluated Filtration Media

Filtration Media	Total Phosphorus Removal Estimate (range)	Approximately Filtration Rate (feet/hour)	Estimated Required Contact Time (minutes)	Required Vault Size at 1.0 cfs Flow ($feet^2$)[1]
CC17 aggregate	45%	12 – 24	10 -20	<1,200
Spent lime	65% (8%–92%)	>24	10 – 20	<1,200
Iron-enhanced sand	80% (70%–92%)	0.33	<1	10,800
Iron-enhanced CC17 aggregate	80% (70%–92%)	6 – 12	<1	<1,200

[1] During the conceptual design phase, stakeholders determined that a vault size less than 1,200 ft^2 was preferred

4.2.2.6 Operations and Maintenance

Ease of operating and maintaining the filtration vault is paramount in ensuring long-term function of the BMP. The following filtration vault design features are proposed to assist with operations and maintenance:

- A lockable surface grate that can be lifted by hand to allow for easier maintenance. The entire grate can be removed to allow full access to filter media so it can be maintained and replaced by hand or with equipment.
- Valves on the filter discharge pipes to regulate flow through the filters to maximize treatment effectiveness.
- Visible filter discharge pipes so that flow rates from each of the treatment cells can easily be inspected. Little or no flow from the discharge points indicate the filters are plugged and need maintenance.
- Filter discharge pipes that are easy to access to allow for the easy collection of filtered water samples for testing.
- A variable-drive pump so that the treatment flow rate can be adjusted for climatic conditions or media filtration rate changes over the life of the media.

The anticipated maintenance requirements for the proposed filtration vault include:

- Removing accumulated debris from surface of the filter approximately two times per year, which will likely include manually removing/replacing the grate, raking the surface of the filter media, and removing debris with a vac truck.
- Replacing filter media every 2 or 3 years, which will likely include manually removing/replacing the grate, removing filter media with a vac truck, and disposing of the material (may require landfill disposal).
- Periodic pump station maintenance.

- Periodic maintenance of skimmer at pump intake.

4.2.3 Water Quality Benefits

The total phosphorus removal estimates for the three recommended treatment media (CC17, CC17/Spent Lime, Iron-enhanced CC17) and the modeled average annual treatment volume were used to estimate the average annual pounds of total phosphorus removed by the treatment vault. As described in Table 4-4, the estimated total phosphorus removal efficiency for CC17, CC17/Spent Lime, and Iron-enhanced CC17 are 45%, 65%, and 80%, respectively. Assuming that each media chamber is supplied with equal volumes of water from Swimming Pool Pond, the combined total phosphorus removal efficiency for the entire treatment vault is anticipated to be approximately 63%.

The TP loading to the treatment vault was estimated based on three years (2015, 2016, and 2017) of phosphorus loading results from the p8 water quality model developed for the 2019 UAA water quality study (Reference (1)). Based on the modeling results, the average total phosphorus concentration discharging from Swimming Pool Pond for the months of April through November was approximately 116 µg/L. This modeled concentration is slightly higher than the average TP concentration measured in Swimming Pool Pond in 2018 by the University of Minnesota (Reference (3)). Average TP concentrations measured from May through September were 95 and 100 µg/L in the epilimnion and hypolimnion, respectively. Comparing the monitoring dates to rainfall data from the Minneapolis Airport, only two of the samples were collected on days where precipitation was recorded at the airport, in which rainfall depths were less than 0.1 inches on both days. Therefore, it appears that larger spikes in total phosphorus concentrations from major runoff events are not captured in the University of Minnesota monitoring data (measurements of internal loading were the main focus of the study). The p8 model data represents an average of dry and wet weather conditions; therefore, an average TP concentration of 116 µg/L was used as the loading estimate to the treatment vault.

Table 4-5 summarizes the average annual volume of water pumped and associated total phosphorus removal estimate for the recommended pumping drawdown scenario. The average annual removal of 22 pounds of phosphorus from the filtration vault is anticipated. In the 2019 UAA for Lake Cornelia and Lake Edina, the average TP removal estimate for the Spent Lime/CC17 Vault from April through September was approximately 20 pounds, which resulted in an approximate decrease in the summer average TP concentration of North Cornelia by approximately 5 µg/L. Due to the similarity in estimated pounds of phosphorus removed for the feasibility-level designed three-chamber treatment vault, a similar reduction in TP concentration in North Cornelia can be expected with this design.

Table 4-5 Rosland Park Treatment Vault Total Phosphorus Removal Summary

Scenario	Average Annual Pumped Volume (Range) [ac-ft][1]	Average Total Phosphorus Load to Vault (Range) [pounds]	Total Phosphorus Removal Efficiency Estimate	Average Annual Total Phosphorus Removal (Range) [pounds]
Pump turns off when 3.6 inches below normal water level	108 (61–143)	34 (19–45)	63%	22 (12–28)

[1] Treatment season is April 15 through November 15.

4.2.4 Permitting

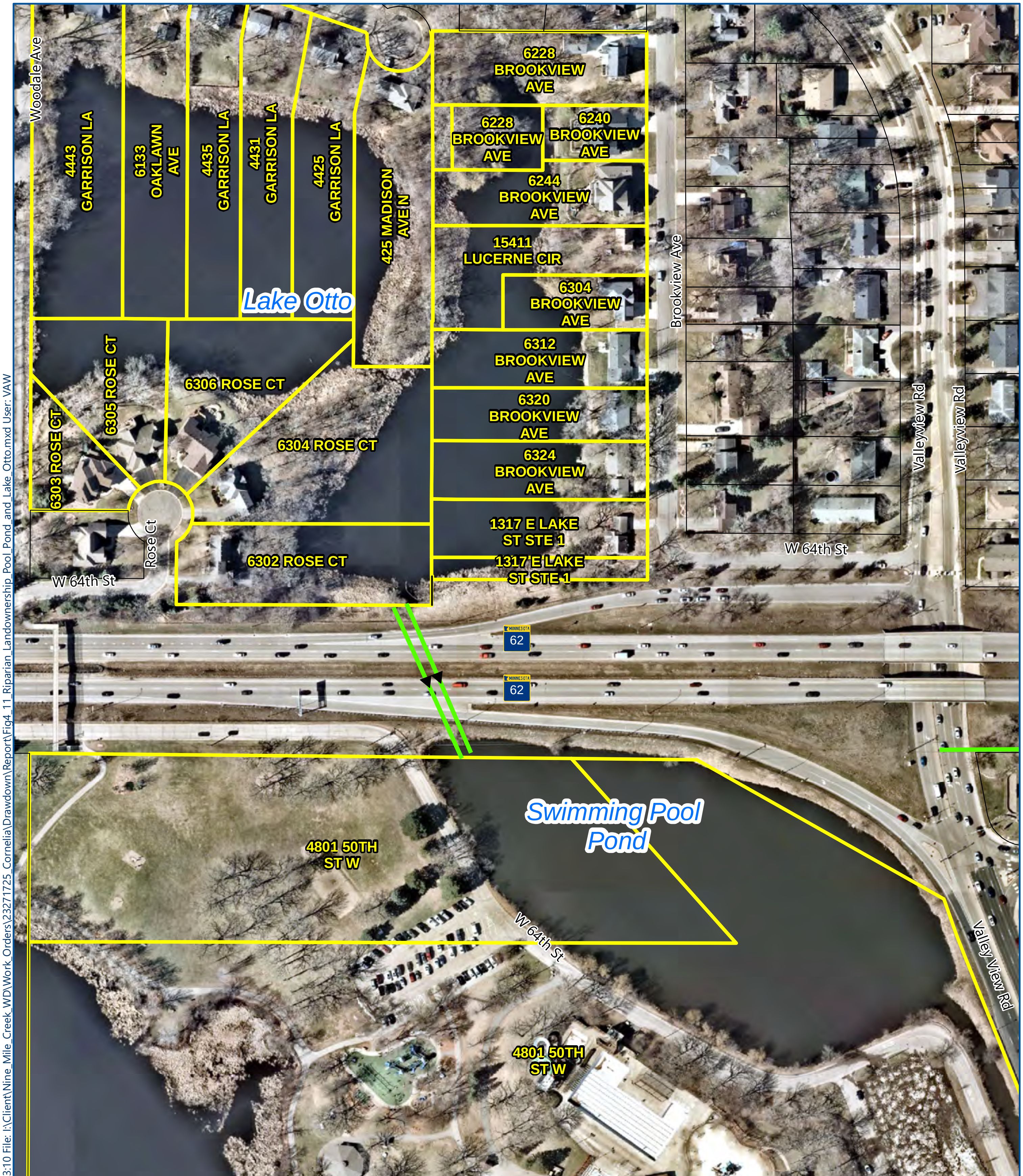
Based on preliminary discussions with staff from the MnDNR, the proposed pumping from Swimming Pool Pond will require a water appropriations permit. A Work in Public Waters permit could also be required, depending on the extent of proposed pumping draw down depth. Preliminary discussions with MnDNR staff indicated a Work in Public Waters permit would not be necessary if the pumping draw down depth is less than one half foot. Notification of impacted riparian landowners and an accounting of support will be required as part of the permitting process. Figure 4-11 shows the landowners riparian to Swimming Pool Pond and Lake Otto. Both of these permits have a permitting timeframe of 90–150 days and will include a 30-day public comment period.

It is not anticipated that a permit will be necessary from MPCA for the proposed filtration vault. However, discussion with MPCA staff regarding the proposed BMP and proposed filtration media is recommended prior to or early in the design process to confirm.

NMCWD will need to obtain the necessary rights to construct the proposed filtration vault on property owned by the City of Edina. It is anticipated that NMCWD and City of Edina will enter into a cooperative agreement upon ordering of the project. A permit for construction of the proposed filtration vault will also be required from NMCWD.

4.2.5 Opinion of Probable Cost

A feasibility-level design cost estimate was developed for the Rosland Park filtration vault and is shown Table 4-6. The opinion of probable cost provided generally corresponds to standards established by the Association for the Advancement of Cost Engineering (AACE). A class 3 feasibility-level opinion of cost was used based on the level of project definition (between 10% and 40%), wide-scale use of parametric models to calculate estimated costs (i.e., making extensive use of order-of-magnitude costs from similar projects), and uncertainty with an acceptable range of between -15% and +20% of the estimated project cost. A more detailed opinion of probable cost for the proposed filtration vault in Rosland Park is included in Appendix D.



Parcel Adjacent to Lake or Pond

Parcel Boundary

Riparian Landowners to Swimming Pool Pond and Lake Otto

Lake Cornelia and Lake Edina Water Quality Improvement Project

Edina, Minnesota

FIGURE 4-11

Table 4-6 Rosland Park Treatment Vault Feasibility-Level Cost Estimates

Item Description	Estimated Cost
Mobilization/Demobilization (10%)	$40,000
Safety, Erosion Control, and Site Prep	$20,000
Pump Station - Complete	$110,000
Intake and Discharge Pipes, Manholes, and Appurtenances	$55,000
Stormwater Filter Vault and Filter Material - Complete	$200,000
Paving and Vegetation Restoration	$15,000
Contingency (30%)	$132,000
Construction Subtotal	**$572,000**
Engineering and Design (30%)	$172,000
Estimated Total Cost for Construction	**$744,000**
Low Range (-15%)	$632,000
High Range (+20%)	$892,000
+Public Art/Education	$50,000–$100,000

4.2.6 Cost-Benefit Analysis

The estimated annualized cost per pound TP removed is summarized in Table 4-7. This cost assumes an estimated annual operations and maintenance cost of approximately $11,000 for annual power costs, filter media adjustments approximately every 3 years, annual vac truck usage to removed debris and sediments, pump maintenance, and periodic skimmer maintenance.

Table 4-7 Rosland Park Treatment Vault Feasibility-Level Cost Estimates

BMP	Feasibility-Level Cost Estimate[1]	Feasibility-Level Cost Range (-15% - +20%)	Estimated Life of Project	Estimated Annualized Cost per Pound TP Removed
Rosland Park Treatment Vault	$744,000	$632,000–$892,000	30 years	$2,200

[1] Feasibility-level cost estimate does not include annual costs for operations and maintenance. Cost does include engineering and design estimate

[2] Feasibility-level estimated annualized cost per pound total phosphorus removed assumes an annual maintenance cost of approximately $11,000 and an inflation rate of 3%.

5 Other Watershed Best Management Practices (BMPs)

The 2019 UAA study for Lake Cornelia and Lake Edina confirmed that stormwater runoff is a major contributor of phosphorus to Lake Cornelia and Lake Edina. In North Cornelia, external phosphorus loading from the watershed ranged from 48% to 76% of annual phosphorus sources in modeled years (Reference (1)). For South Cornelia, the main contribution of phosphorus comes from North Cornelia; direct watershed phosphorus loading does contribute phosphorus, but to a much smaller extent than the other sources due to the relatively small size of the direct watershed (13% of the size of the direct watershed to North Cornelia). The two main sources of phosphorus loading to Lake Edina are the upstream lakes (North and South Cornelia) and the direct watershed runoff.

Reducing external phosphorus loading is an important part of any lake management strategy. For lakes like Lake Cornelia that have been exposed to significant external nutrient loadings for extended periods of time, appreciable sediment and nutrients have accumulated in the lake bottom sediments. As contributions from the watershed continue, phosphorus will continue to build-up over time in the lake sediments, increasing the internal loading potential and worsening water quality conditions in the lake.

The first Use Attainability Analysis for Lake Cornelia was developed by NMCWD in 2006, and revised in 2010 to reflect additional water quality monitoring data and evaluation of additional watershed Best Management Practices (BMPs). Similar to the conclusions of the 2019 UAA update, previous analyses indicated that while implementation of watershed BMPs can improve water quality in Lake Cornelia, there are no “silver bullets”. Significant improvements in lake water quality will require a combination of watershed and in-lake management practices.

As part of the 2019 UAA study, several watershed best management practices (BMPs) were evaluated to assess their effectiveness in reducing phosphorus loading to Lake Cornelia and Lake Edina. Numerous potential BMPs were considered, including review of the watershed BMPs evaluated as part of the previously-completed UAA. Criteria used in the evaluation included cost effectiveness, land availability, maximizing benefit to the Lake Cornelia and Lake Edina chain of lakes, dissolved phosphorus removal, and building on effectiveness of existing stormwater treatment systems. Ultimately, the stormwater treatment BMP in Rosland Park was recommended because it meets many of the target criteria, including the greatest predicted improvements per unit cost and availability of public land.

To expand on the evaluation conducted as part of the 2019 UAA, this study also included a high-level evaluation of other potential BMP opportunities to reduce watershed phosphorus loading to Lake Cornelia and Lake Edina. The sections below summarize the high-level evaluation of stormwater BMP retrofit opportunities in the Lake Edina watershed and discussion regarding opportunities for treatment in ponds upstream of Lake Cornelia.

5.1 Stormwater BMP Retrofit Opportunities in Lake Edina Watershed

Watershed runoff comprises a significant portion of the external phosphorus loading to Lake Edina, ranging from 35% to 45% of annual phosphorus sources in modeled years (Reference (1)). A high-level watershed analysis was conducted as part of this study to identify potential opportunities to implement stormwater BMPs in the Lake Edina watershed, with a focus on partnership projects on publicly-owned lands. Two properties were identified for potential to incorporate infiltration-based BMPs: Cornelia Elementary School, owned by Edina Public Schools, and the open green space area between Lynmar Lane and Bristol Boulevard owned by the City of Edina (from this point forward referred to as Lynmar basin). These two areas were selected due to the availability of open green space adjacent to impervious surfaces (e.g., streets, parking lots, buildings, sidewalks, playground), soils conducive to infiltration capacity, a high level of visibility for educational opportunities, and low to moderate Drinking Water Supply Management Area (DWSMA) vulnerability.

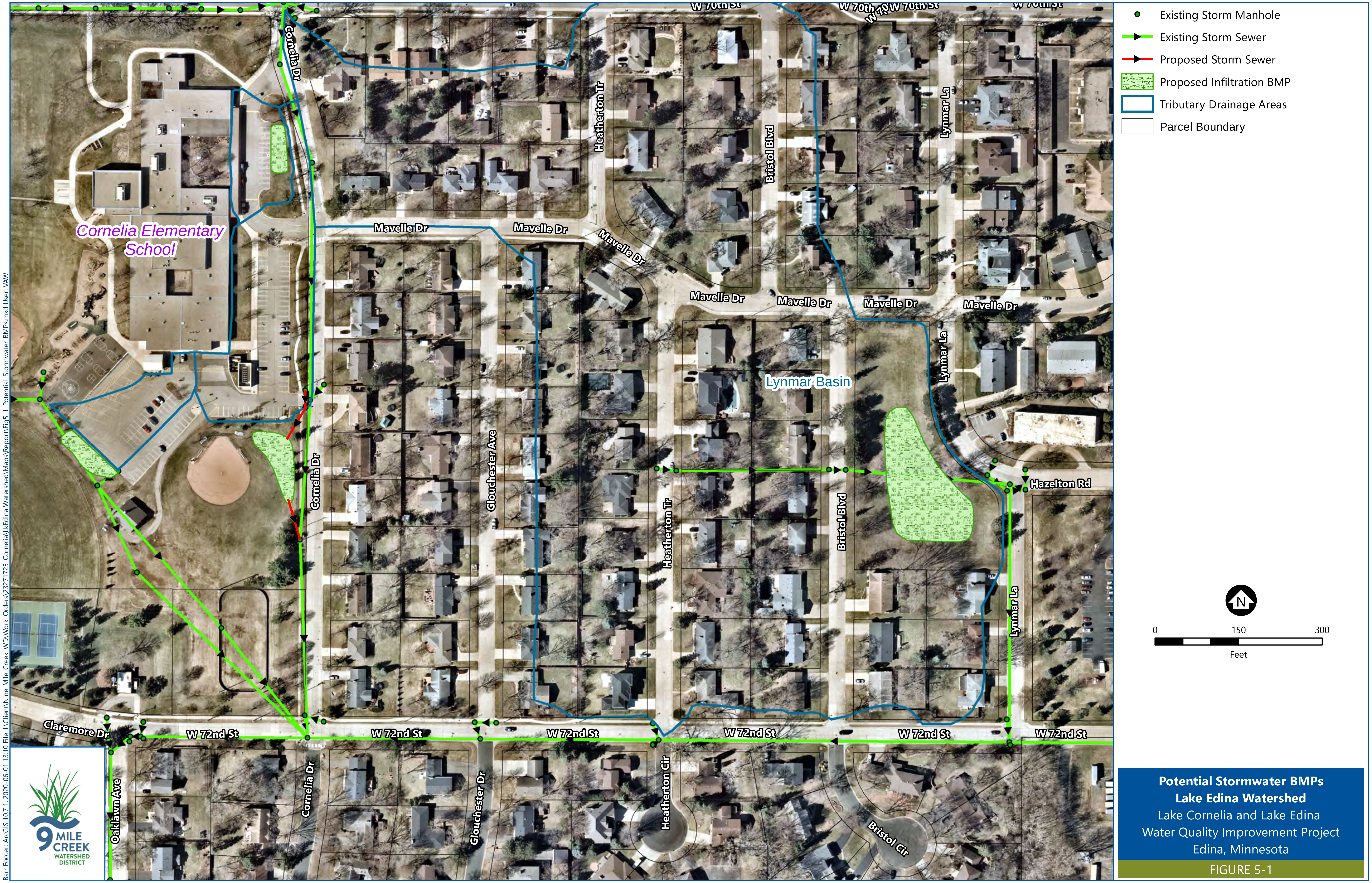
Figure 5-1 shows the locations of potential stormwater infiltration BMPs at Cornelia Elementary School and the Lynmar Basin. Three BMPs are located at Cornelia Elementary School and one larger infiltration-BMP is located within the Lynmar Basin. The rain gardens proposed at Cornelia Elementary School would collect and infiltrate stormwater runoff primarily from the school parking lots. The stormwater infiltration feature within the Lynmar Basin would collect runoff from an 18-acre residential watershed. This basin currently receives stormwater, but serves more as a dry pond, providing flood detention but minimal water quality benefits, based on currently available information. Table 5-1 summarizes the tributary watershed information for each conceptual watershed-level BMP and also discusses preliminary BMP sizing. More detailed sizing of the stormwater BMPs would be optimized in future design phases to coordinate the desires of NMCWD and the landowners.

If the NMCWD is interested in pursuing implementation of stormwater BMPs on these sites, the next step would be to contact the property owners to discuss partnership opportunities. The City of Edina has indicated potential interest in preliminary discussions. Edina Public Schools has not been contacted yet. It is recommended that the NMCWD consider preparing some sketches/renderings of the conceptual design for stormwater rain gardens prior to meeting with Edina Public Schools and City of Edina.

Table 5-1 Lake Edina Watershed Infiltration-BMPs Watershed and Sizing Summary

Location	BMP Name	Total Watershed Area (acres)	Impervious Area (acres)	Impervious %	Approx. BMP Area ($feet^2$)	BMP Depth (inches)	Concept Treatment Volume (ac-ft)	Concept Treatment Depth (inches)
Cornelia Elementary School	CES_North	0.5	0.3	63%	1,200	18	0.03	1.1
	CES_West	0.5[1]	0.5	100%	1,900	18	0.05	1.1
	CES_South	1.6	1.2	73%	3,700	18	0.10	1.1
Lynmar Basin	Lynmar Basin	18.1	11.0	61%	24,400	24	1.0	1.1

[1] Playground and parking lot redevelopment has occurred since Twin Cities LiDAR was collected (2011). There exists uncertainty in the total tributary area to CES_West. The total tributary area is possibly larger and needs additional investigation for BMP sizing.



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5.1.1 Opinion of Probable Cost

Concept-level opinions of probable cost were developed for the two potential BMP projects within the Lake Edina watershed (Cornelia Elementary School and Lynmar Basin). The opinions of probable cost summarized in Table 5-2 generally correspond to standards established by the AACE. Class 5 opinions of cost were used based on the limited project definition, wide-scale use of parametric models to calculate estimated costs (i.e., making extensive use of order-of-magnitude costs from similar projects), and uncertainty with an acceptable range of between -30% and +50% of the estimated project cost.

5.1.2 Cost-Benefit Analysis

The water quality benefits of the concept-level infiltration basins located at Cornelia Elementary School and Lynmar Basin were estimated using the MPCA Minimal Impact Design Standards (MIDS) calculator. The estimated annual total phosphorus removals are approximately 3.6 and 20.5 pounds from the Cornelia Elementary School basins and the Lynmar Basin, respectively. The estimated annualized cost per pound of total phosphorus removed is also summarized in Table 5-2.

Table 5-2 Lake Edina Watershed Infiltration-BMP Concept-Level Cost Estimates

Location	Concept-Level Cost Estimate[1]	Concept Level Cost Range (-30% - +50%)	Estimated Life of Project	Estimated Annualized Cost per Pound TP Removed[2]
Cornelia Elementary School (3 Infiltration BMPS)	$332,000	$233,000–$498,000	30 years	$5,500
Lynmar Basin (1 Infiltration BMP)	$512,000	$359,000–$768,000	30 years	$1,500

[1] Concept-level cost estimates do not include annual costs for operations and maintenance. Costs do include engineering and design estimates.

[2] Concept-level estimated annualized cost per pound total phosphorus removed assumes an annual maintenance cost of approximately 10% of estimated construction costs per site and an inflation rate of 3%.

5.2 Opportunities for Treatment of Ponds Upstream of Lake Cornelia

Following completion of the 2019 UAA, there were follow-up questions posed by the NMCWD board of managers regarding opportunities to reduce phosphorus to Lake Cornelia by treating upstream ponds. Internal phosphorus loading in stormwater ponds or natural waterbodies that receive stormwater discharge (from this point forward referred to as ponds) has been increasingly identified as an issue in Minnesota. There are generally two causes of internal phosphorus loading in ponds: (1) high phosphorus in pond bottom sediment resulting from years of sediment accumulation and the occurrence of low oxygen during the summer months, and (2) an abundant population of fish such as carp, bullheads, and goldfish which disturb bottom sediments and cause phosphorus to release into the water column. In many cases ponds are afflicted by both problems—they have high phosphorus in bottom sediments as well as an abundant population of bottom-foraging fish.

Given the root cause of internal phosphorus loading in ponds, there are generally three viable approaches to reducing internal phosphorus loading:

- Remove and eliminate the bottom feeding fish such as carp;
- Bind the phosphorus in the pond bottom sediment by adding aluminum (alum), iron (e.g., iron filings, per the studies conducted by the University of Minnesota), or calcium (e.g., spent lime [calcium carbonate], which is currently being studied); and
- Aerate to improve oxygen concentrations.

Removing fish such as carp has been shown to be successful in the Ramsey Washington Metro Watershed District (Casey Lake and Markham Pond), with carp removal leading to significantly reduced phosphorus concentrations within the water column at the pond outlet. Lower turbidity and increased aquatic plant abundance occur in conjunction with carp removal. It should be noted that any activity (such as carp removal) that increases pond clarity also leads to the increased abundance of aquatic plants. This is often associated with the abundant growth of filamentous algae which for some residents is worse aesthetically than a turbid pond.

The use of alum (aluminum is the main component) is a well-established method for reducing internal phosphorus loading, and this approach is being implemented at Lake Cornelia. Alum treatment of stormwater ponds has become more common in recent years, as the amount of information regarding the potential for phosphorus release from ponds has increased. The longevity of this approach is generally not known and will likely be dependent upon the watershed size tributary to the ponds and sediment loads. If an alum treatment is conducted, follow-up analysis (e.g., sediment coring) will be needed every 2 to 4 years to determine if it is still effective. If a treatment is considered, it will be necessary to do a pH-buffered treatment consisting of a mixture of alum and sodium aluminate.

The use of iron is a potentially viable approach to reduce internal phosphorus loading in ponds, but this approach is considered experimental at this point. The short- and long-term benefits of treatment using iron to prevent release of phosphorus from lake- or pond-bottom sediments are still unknown. A study was conducted by the University of Minnesota Saint Anthony Falls Laboratory (SAFL) to evaluate the benefit of treating Swimming Pool Pond and Point of France Pond with iron to reduce internal P loading. The study concluded that "Present conditions in the Swimming Pool Pond and Point of France Pond suggest that the ponds are providing treatment of phosphorus. Thus, chemical treatment of sediment to reduce internal phosphorus loading is currently not recommended." (Reference (3)).

The use of spent lime is also a potentially viable approach to reduce internal phosphorus loading in ponds, but is also considered experimental at this point. Spent lime is a waste material; repurposing of that material to treat phosphorus is an attractive attribute. However, there are potential challenges in identifying an approach to apply spent lime as it is a solid material that is largely insoluble in water. As such, spent lime needs to be ground and spread in some manner. The short- and long-term benefits of treatment using spent lime to prevent release of phosphorus from lake- or pond-bottom sediments are still unknown. Barr Engineering staff and its research partners are currently conducting a study funded by the Minnesota Stormwater Research Council to evaluate the effectiveness of using spent lime to reduce internal P loading in ponds.

Aeration may also help by increasing oxygen in the water column and reduce the rate of phosphorus release from bottom sediments. The effectiveness of aeration in reducing phosphorus release from bottom sediments is highly variable, depending on numerous factors including equipment, water body size, depth, and configuration, and watershed characteristics. The appropriate aeration approach, such as a fountain or forced air bubbler, would need to be evaluated on a pond-by-pond basis. One potential drawback of aeration is that it may reduce settling of particulate phosphorus delivered to ponds during storm events. Periodic maintenance is typically required to keep the aerators operational and on-shore storage of equipment (aerators and pumps) is often required.

Before considering further management action, it must be determined if a pond is exporting phosphorus as a consequence of internal phosphorus loading. Phosphorus monitoring at the ponds' inlet and outlet (or within the water column) is needed to establish the magnitude of internal phosphorus loading and phosphorus export from the pond. Full-year monitoring in the spring, summer, and fall would be necessary to quantify the magnitude of phosphorus export. Once it is established that a pond or series of ponds are releasing phosphorus, appropriate mitigation approaches can be identified and applied if the magnitude of phosphorus export justifies the action.

It is expected that carp and goldfish management efforts at Lake Cornelia will also benefit upstream ponds if there is a connection (e.g., active fish passage) between Lake Cornelia and these ponds. If there is a connection, it will be important to reduce or eliminate carp and goldfish populations in those ponds as well as in Lake Cornelia. Before additional upstream pond management activities are conducted, it is recommended that enough time is given to assess the benefits of carp and/or goldfish control efforts under consideration for Lake Cornelia. The carp and goldfish Passive Integrated Transponder (PIT) tagging and tracking study being undertaken by NMCWD (see Section 7), will allow the NMCWD to better understand the connectedness of Lake Cornelia and upstream ponds as it pertains to fish movement.

6 Curly-leaf Pondweed Management

The presence of curly-leaf pondweed and its mid-summer die-off negatively impacts the water quality of Lake Cornelia. Monitoring results presented in the 2019 water quality study indicate that curly-leaf pondweed contributes to up to 17% of the annual phosphorus loading to North Cornelia and up to 23% of the annual phosphorus loading to South Cornelia. Accordingly, management of curly-leaf pondweed is an important component of a long-term management plan for Lake Cornelia.

Curly-leaf pondweed has been observed in Lake Edina in recent years at low levels. The 2019 water quality study concluded that internal phosphorus loading from curly-leaf pondweed die-off/decay is minimal in Lake Edina.

Effective control of aquatic invasive species can require long-term management. A long-term curly-leaf pondweed management goal of reducing presence of the invasive plant until neither curly-leaf pondweed nor turions are observed in the lake would be most protective of Lake Cornelia and downstream lake ecosystems. However, this long-term management goal would require intensive treatment that may not be sustainable for the duration needed to be successful. As such, a more immediate goal of Lake Cornelia curly-leaf pondweed management is to reduce the extent and density of the invasive plant throughout the lake such that it doesn't significantly hinder growth of the native plant community and mid-summer die off of curly-leaf pondweed does not cause reduced water quality.

This feasibility study evaluates two alternatives for curly-leaf pondweed management: annual herbicide treatment (current approach) and a lake drawdown.

6.1 Annual Herbicide Treatments

The City of Edina has been conducting annual herbicide treatments in Lake Cornelia since 2017 to reduce the impact of curly-leaf pondweed die-back on water quality in Lake Cornelia and downstream Lake Edina and to help promote a healthy native aquatic plant population. Results of the spring 2020 pre-treatment plant survey indicate that annual treatments are having some level of effectiveness in reducing the population of curly-leaf pondweed in Lake Cornelia (Reference (4)). Since 2017, pre-treatment monitoring indicates a decrease in curly-leaf pondweed presence at sampling sites (Figure 6-1). Density of sampled curly-leaf pondweed has decreased as well. While annual herbicide treatments can reduce the extent and density of curly-leaf pondweed, this approach may necessitate long-term annual herbicide treatments to be effective.

The City of Edina anticipated conducting an herbicide treatment of Lake Edina in 2020 to manage curly-leaf pondweed. However, a pre-treatment survey in spring of 2020 found little or no curly-leaf pondweed in the lake.

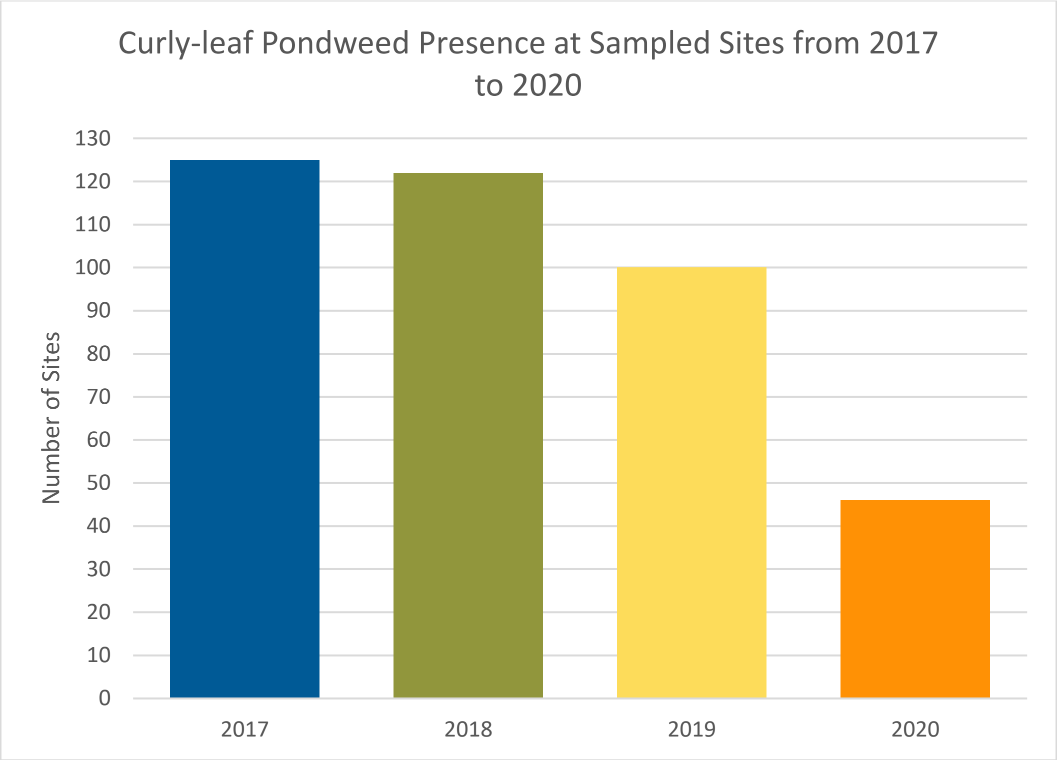


Figure 6-1 Curly-leaf Pondweed Presence at Sampled Sites from 2017 to 2020

6.1.1 Permitting

Herbicide treatment would require an Invasive Aquatic Plant Management Permit from the MnDNR. The permit requires completion of a pre-treatment vegetation survey and may require follow-up monitoring depending on the terms of the permit.

6.1.2 Opinion of Probable Cost

The planning-level opinion of probable cost for herbicide treatment of the curly-leaf pondweed in Lake Cornelia is approximately $28,000 per year of treatment, with a range of $26,000 to $34,000 (-10% to +20%). This estimate includes preparation of contract documents, permitting, and herbicide application. The cost estimate also includes potential costs related to monitoring that may be deemed appropriate or required by the MnDNR as part of permitting, including temperature measurements, herbicide residue monitoring, and aquatic plant monitoring. Note that the cost estimate included in the UAA study for herbicide treatment of Lake Cornelia was lower than the cost described in this report because it did not include costs incurred by city staff related to contracting and permitting, or monitoring costs. A detailed opinion of probable cost for the curly-leaf pondweed herbicide treatment is included in Appendix D.

6.2 Lake Drawdown

Another potential method to control curly-leaf pondweed is to draw down Lake Cornelia to allow the lake bed to freeze over the winter. Curly-leaf pondweed primarily propagates through production of dormant vegetative propagules called turions. Turions are produced in late spring, remain dormant in sediment through the summer, and germinate under cooler water conditions in the fall. A winter freeze can kill the turions, thus disrupting curly-leaf pondweed's reproductive cycle.

A high-level evaluation of conducting a drawdown to control curly-leaf pondweed in Lake Cornelia was included as part of this feasibility study due to the success of this approach in other lakes, including several in the NMCWD, and the desire to avoid recurring management activities. The sections below discuss drawdown background and methods, and a high-level feasibility assessment of a draw down in Lake Cornelia, including permitting, opinion of probable cost, and other considerations.

6.2.1 Background on Drawdown as Management Method

Several other waterbodies in the region have used drawdown as a means to achieve water quality objectives. A successful shallow lake restoration was conducted in Big Muskego Lake in southeast Wisconsin using a combination of several in-lake treatments, including an 18-month drawdown period. This drawdown resulted in the consolidation of sediments in addition to allowing for the removal of rough fish populations and reestablishment of native aquatic plant species. Sediment consolidation was desired for the reduction of future sediment resuspension, although the extent of consolidation was limited by rain and flood events during the drawdown period.

The NMCWD completed a drawdown on Southwest and Northwest Anderson Lakes in Eden Prairie in fall 2008. The drawdown was conducted using electrical pumps to dewater a significant portion of each lake in an effort to significantly reduce and potentially eliminate curly-leaf pondweed from the two lakes. The goal of the project was to expose as much of the lake sediment as possible to freezing conditions during the 2008-2009 winter season and chemically treat any remaining open water areas. Freezing the lake sediment was expected to effectively kill the young curly-leaf pondweed plants and the curly-leaf pondweed turions. Monitoring conducted in 2015 found several floating fragments of curly-leaf pondweed in Southwest Anderson Lake, but rooted curly-leaf pondweed plants were not. In Northwest Anderson Lake, curly-leaf pondweed was present but rare in the east end of the lake and was not found in the west portion of the lake. Overall, the drawdown effort has remained successful in controlling curly-leaf pondweed.

Three Rivers Park District performed a successful lake level drawdown on Cleary Lake in Scott County, Minnesota to control curly-leaf pondweed (personal communications with John Barton). The initial Cleary Lake drawdown was not a complete drawdown because of a restriction in the outlet channel which limited the volume of water that would flow out of the lake by gravity. As a result, the initial drawdown was only effective at controlling curly-leaf pondweed over the portions of the lakebed exposed to freezing conditions. Therefore, the Park District did a complete drawdown the following year by modifying the outlet channel and installing temporary pumps to completely dewater the lake. The Park District has indicated the drawdown was extremely effective at controlling curly-leaf pondweed.

The NMCWD also conducted a drawdown of Normandale Lake in Bloomington in fall 2018. The initial drawdown was conducted using diesel pumps to dewater a significant portion of the lake in order to install a new bypass pipe which would drain the lake by gravity. The pipe was installed in November 2018 and was successful in keeping the majority of the lake drawn down over the 2018–2019 winter season.

Freezing the lake bottom sediments killed many of the curly-leaf pondweed turions; sediment samples taken in the fall of 2019 found that the number of turions had decreased dramatically. Aquatic plant surveys conducted in June 2019 and May 2020 indicate reduced frequency and density of curly-leaf pondweed throughout Normandale Lake.

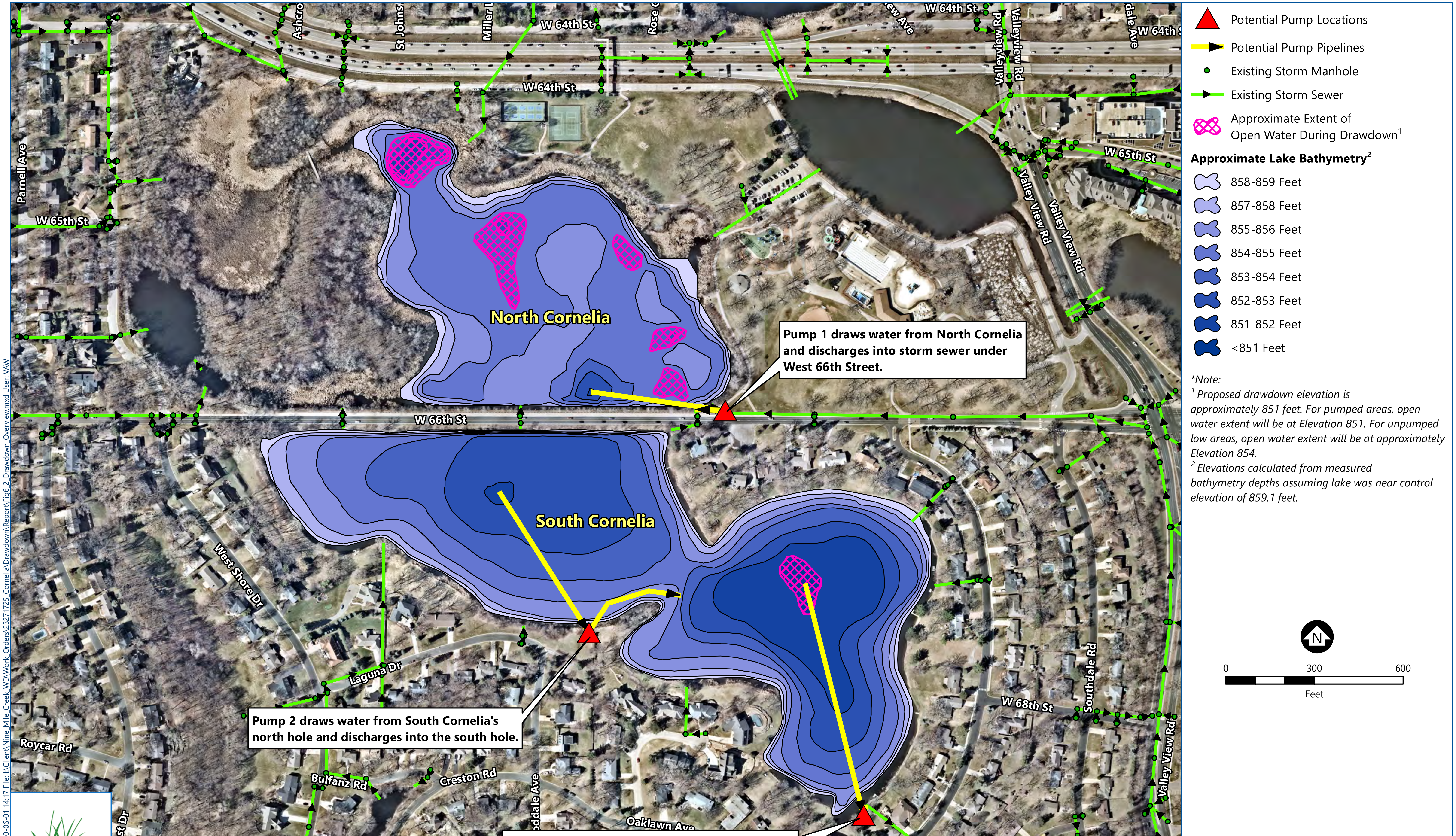
6.2.2 Drawdown Method

Outlet modification, siphoning and temporary pumping are drawdown methods that have been used in similar projects. Modifying the outlet to draw down the lake by gravity is not feasible since a large portion of the lake is below the elevation of the outlet weir and downstream storm sewer. Siphoning could be used to draw the lake down below the outlet elevations but difficulties in maintaining and re-priming the siphon once the lake is drawn down and then receives inflow in response to precipitation events, especially during winter months, make this option impractical. Installing temporary pumping is the only feasible option for dewatering Lake Cornelia. Temporary pumps have the potential to quickly draw the lake down in the late summer and can be easily turned on and off as needed to keep the lake drawn down over the fall and winter months. Based on similar projects, it is assumed that diesel pumps with mufflers would be used to reduce noise in this residential area.

Figure 6-2 shows the approximate lake bathymetry of Lake Cornelia. As shown, there are several deeper holes throughout both the North and South basins. Three temporary pumping stations would be needed to draw down most of North Cornelia and the two deep holes in South Cornelia as shown in Figure 6-2. Pump 1 would be located on the southeast side of North Cornelia in the park area and would pump water from North Cornelia to the north hole in South Cornelia through the 15-inch diameter storm sewer under West 66th Street. Pump 2 would be located on city of Edina property on the south side of South Cornelia and would pump water from South Cornelia’s north hole to its south hole. Pump 3 would be located on private property or stormwater easement, if available, on the southeast side of South Cornelia near the lake outlet and would pump water from South Cornelia’s south hole over the existing outlet weir and into the downstream storm sewer. For this level of study, it is assumed that the pumping capacity at all three locations would be the same.

A lake level drawdown goal of approximately 851 feet was used for this high-level drawdown feasibility analysis. Figure 6-2 also shows the extent of open water within the lake at a drawdown elevation of 851 feet. For this analysis, it was assumed that the deeper hole on the far north side of the North basin and other smaller low areas would not be pumped, so would remain as open water to an elevation of approximately 854 feet.

The pumps would need to run continuously from mid-August to mid-September to draw down lake levels to the target elevation of 851 feet. After the lake is drawn down, the pumps would need to be run periodically to drain inflows due to precipitation events or potential groundwater inflows. For this study it is assumed that the pumps would need to run approximately 50 percent of the time from mid-September through February; this could vary widely depending on precipitation and climate conditions.



Lake Drawdown Overview

Lake Cornelia and Lake Edina Water Quality Improvement Project

Edina, Minnesota

FIGURE 6-2

6.2.3 Lake Drawdown Analysis

A predictive spreadsheet water balance model was created to evaluate several drawdown options in terms of how quickly Lake Cornelia could be drawn down in the fall, how likely the lake will remain drawn down over winter, and how quickly lake levels can rebound in the spring. Daily inflows to the lake were estimated based on P8 model results. Daily outflows from the lake were calculated using a rating curve that accounts for the existing outlet structure. Sixty-nine years of precipitation data (1949–2018) were input into the model to predict the water surface elevations in the lake over a wide range of actual climatic conditions. The model was also set up to predict the lake responses to the various drawdown options by allowing the user to vary the size of pumps as well as the dates that the pumps are turned on.

6.2.3.1 Drawdown Timing

The amount of time for Lake Cornelia to draw down to its target elevation of 851 feet is dependent on the starting elevation of the lake, pumping capacity, and amount precipitation received during the draw down period. Table 6-1 summarizes the time to draw down the lake with three different pump capacities (given in gallons per minute or gpm) assuming the lake starting elevation is at its control elevation of 859.1 feet and there are no watershed inflows during the drawdown period. While the assumption of no watershed inflows during the drawdown period is unlikely, the information summarized in the table provides a general comparison of timing with the various pumping capacity scenarios.

Table 6-1 Time to Draw Down Lake to Elevation 851 Assuming no Inflows

	2,000 gpm Pumps	3,000 gpm Pumps	4,000 gpm Pumps
Days to Drawdown to Elevation 851[1]	27	18	14

[1] Assumes lake starting elevation is at control elevation of 859.1 feet and no inflows during the drawdown period

For the Normandale Lake drawdown project, MnDNR indicated a preference for the lake to be drawn down by September 15 to minimize impacts to the area's turtle community as it prepares for winter hibernation. The predictive spreadsheet water balance model was used to evaluate the three pumping capacities, assessing the likelihood of meeting the DNR's September 15 drawdown guideline if the drawdown begins on August 15. Starting the drawdown earlier than August 15 had minimal impact on meeting the September 15 drawdown guideline or the overall effectiveness of a fall drawdown since summer precipitation events tend to fill the lake back up.

Figure 6-3 shows the likelihood (% of years modeled) of drawing the lake down to an elevation of 851 feet on a given date for each of the pump capacities, based on the predictive water balance model. The modeling shows that the 2,000 gpm pumps will succeed in drawing down the lake to the elevation of 851 feet by September 15 in less than 10 percent of the modeled years. On the other hand, increasing the pump capacity to at least 3,000 gpm improves the likelihood of drawing the lake down by September 15 to 77 percent. Increasing the pump capacity from 3,000 gpm to 4,000 gpm has less impact on the likelihood of drawing down the lake by September 15 (77% versus 90%). Under all three pump capacities, lake levels occasionally bounce back up during the fall and winter in response to rainfall events. However, increasing the pump capacity to at least 3,000 gpm decreases the amount of time it takes for the lake to draw back down.

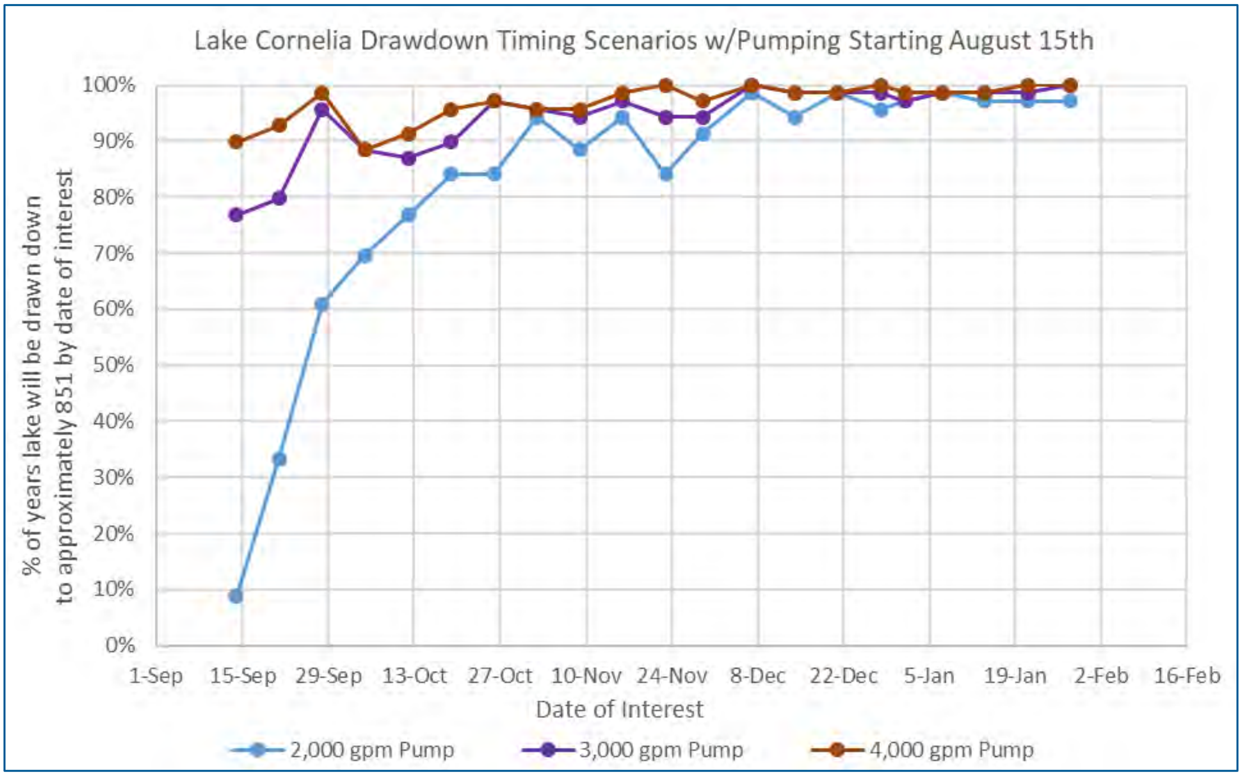


Figure 6-3 Drawdown Effectiveness of Various Pump Capacities, based on August 15 Start Date

6.2.3.2 Maintaining Winter Drawdown Conditions

A lake drawdown would allow much of the lake bed to freeze over the winter. Maintaining the drawdown over the winter months is important to maximize the extent to which and amount of time the sediments are frozen. Rainfall or snowmelt events do occasionally happen during the winter months and the resulting increased inflows from the Lake Cornelia watershed can cause the lake level to quickly bounce up. The predictive water balance model was used to evaluate the likelihood of maintaining low lake levels during the months of December through February for each of the evaluated drawdown options, based on a 69-year time period representing a wide range of climate conditions. Figure 6-4 shows the percentage of years that the drawdown target elevation of 851 feet was exceeded at least once during a given month due to a rainfall or snowmelt event. Model results indicate that, while all three pump sizes will perform fairly well at keeping the lake levels below the target elevation of 851, increasing the pump size to at least 3,000 gpm will keep the likelihood of exceeding the target elevation in any given month to less than 26 percent. Increasing the pumping capacity from 3,000 gpm to 4,000 gpm has less impact on the likelihood of exceeding the target elevation.

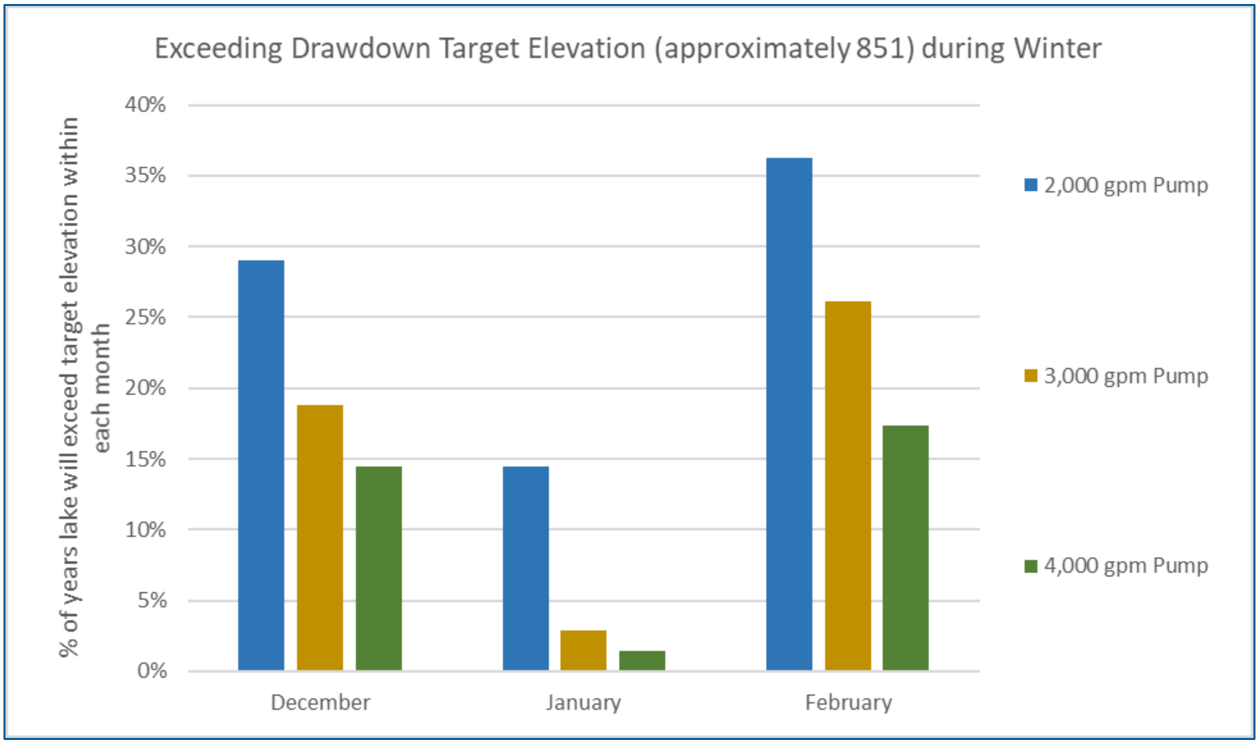


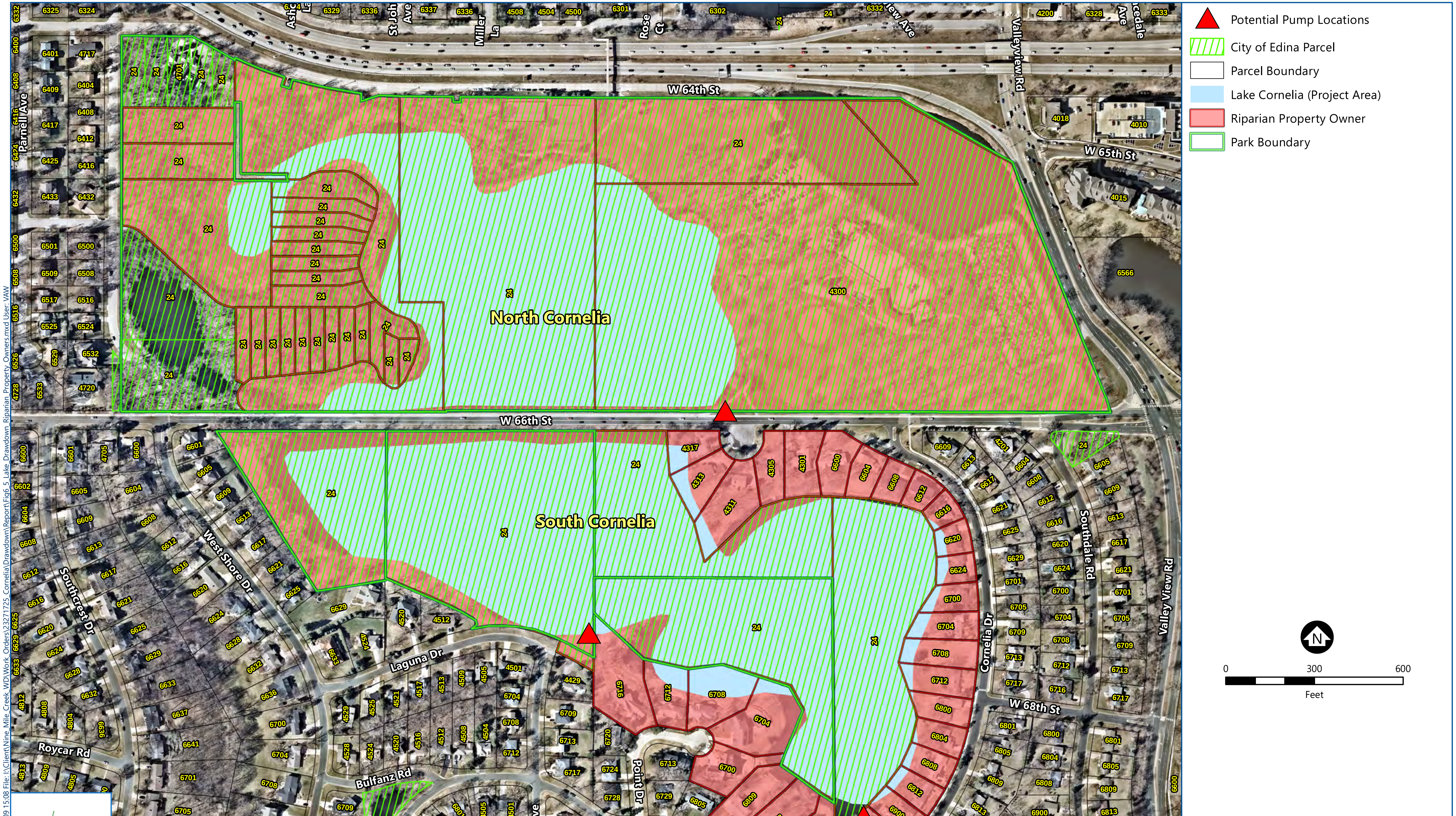
Figure 6-4 Effectiveness of Maintaining Drawdown Conditions during Winter Months

6.2.4 Permitting

Conducting a lake drawdown would require approval from the MnDNR through a Work in Public Waters Permit. Under Minnesota Statute Section 103G.408, 75 percent of the riparian landowners must authorize a drawdown. The City of Edina owns all of the property adjacent to North Lake Cornelia and approximately half of the shoreline property around South Lake Cornelia. South Lake Cornelia has 31 private, riparian landowners; 24 landowners (75%) would need to authorize the drawdown for it to proceed Figure 6-5 identifies the riparian property owners around Lake Cornelia.

The pumping stations needed to pump water from North Lake Cornelia and from the west half of South Lake Cornelia can be located on City of Edina property. NMCWD would need to obtain the necessary rights to use property owned by the City of Edina in a cooperative agreement between the two entities for the project. NMCWD would also need to obtain the necessary rights to use private property near the South Lake Cornelia outlet. A pump would need to be located on private property near this outlet to pump the water out of the east half of South Lake Cornelia and over the outlet weir.

Permits/approvals for the drawdown may also be required from the City of Edina, U.S. Army Corps of Engineers, the MPCA and NMCWD, depending on dewatering method.



Lake Drawdown
Riparian Property Owners
Lake Cornelia and Lake Edina Water Quality Improvement Project
Edina, Minnesota

FIGURE 6-5

6.2.5 Opinion of Probable Cost

A planning-level opinion of probable cost has been developed for the 3,000 gpm pump capacity option (Table 6-2). Costs were not developed for the 2,000 gpm pump scenario because the pump capacity is too low based on the model results discussed in the preceding sections. Likewise, costs were not developed for the 4,000 gpm pump scenario since there is very little benefit to using the larger pump capacity. The planning-level opinion of probable cost for conducting a winter drawdown in Lake Cornelia using 3,000 gpm pumps is approximately $1,829,000, with a range of $1,281,000 to $2,744,000 (-30 percent to +50 percent). The opinion of probable cost is based on engineering judgement, experience with similar projects, and review of actual bid values from recent, similar projects. A detailed opinion of probable cost for a drawdown of Lake Cornelia is included in Appendix D.

The opinion of cost was developed assuming the pumps would need to run continuously from mid-August to mid-September and then run approximately 50 percent of the time from mid-September through February. The opinion of costs include an expected accuracy range (-30 percent to 50 percent), based on the current extent of project definition, wide-scale use of parametric models to calculate estimated costs (i.e., making extensive use of order-of-magnitude costs from similar projects or proposals), and project uncertainty.

6.2.6 Other Drawdown Considerations

Temporary pumping would likely require construction of temporary enclosures to store the pumps, minimizing the potential for vandalism or accidents. Pumping during winter months introduces the potential for complications related to flash freezing, frazil ice, etc. The pumps would need to be checked daily in times of extreme cold to ensure they are functioning properly. The pumps would operate on diesel fuel and would need to be refueled daily when running. The pumps will also need noise baffling for noise reduction due to their proximity to residential areas.

Table 6-2 Summary of Estimated Costs for Lake Drawdown, Assuming 3,000 gpm Pump Capacity

Items	Estimated Cost
Mobilization/Demobilization	$5,000
Pump set-up, rental, and removal (3,000 gpm pump)	$507,300
Daily servicing (including refueling and maintenance) during initial 30-day drawdown period[1]	$137,400
Periodic servicing (including refueling and maintenance) to maintain drawdown[1]	$388,800
Site restoration	$7,500
HDPEP inlet and outlet pipes for all three pipes (2,400 Feet Total)	$36,000
Construction subtotal:	**$1,082,000**
Construction contingency (30%)	$325,000
Estimated construction cost	**$1,407,000**
Planning, engineering, and design (30%)	$422,000
Total	**$1,829,000**
Low range (-30%)	$1,281,000
High range (+50%)	$2,744,000

[1] Cost estimate assumes one month of continuous pumping (August 15 through September 15) followed by 6.5 months of intermittent pumping (September 15 through March 1) to keep the lake drawn down. The cost estimate assumes pumping 50% of the time during the intermittent period but this could vary widely depending on precipitation and climate conditions.

7 Fishery Management

7.1 Overview of Lake Cornelia Fishery

The NMCWD commissioned a fisheries assessment in 2018 to gain a more complete understanding of the fishery of Lake Cornelia and connected water bodies, including quantifying the common carp (*Cyprinus carpio*) population. The fish survey included Lake Cornelia (North and South), and upstream waterbodies Lake Nancy, Swimming Pool Pond, and Point of France Pond; the 2018 survey did not include Lake Otto. Figure 7-1 shows North and South Cornelia and the upstream waterbodies and the storm sewer that connect the various waterbodies.

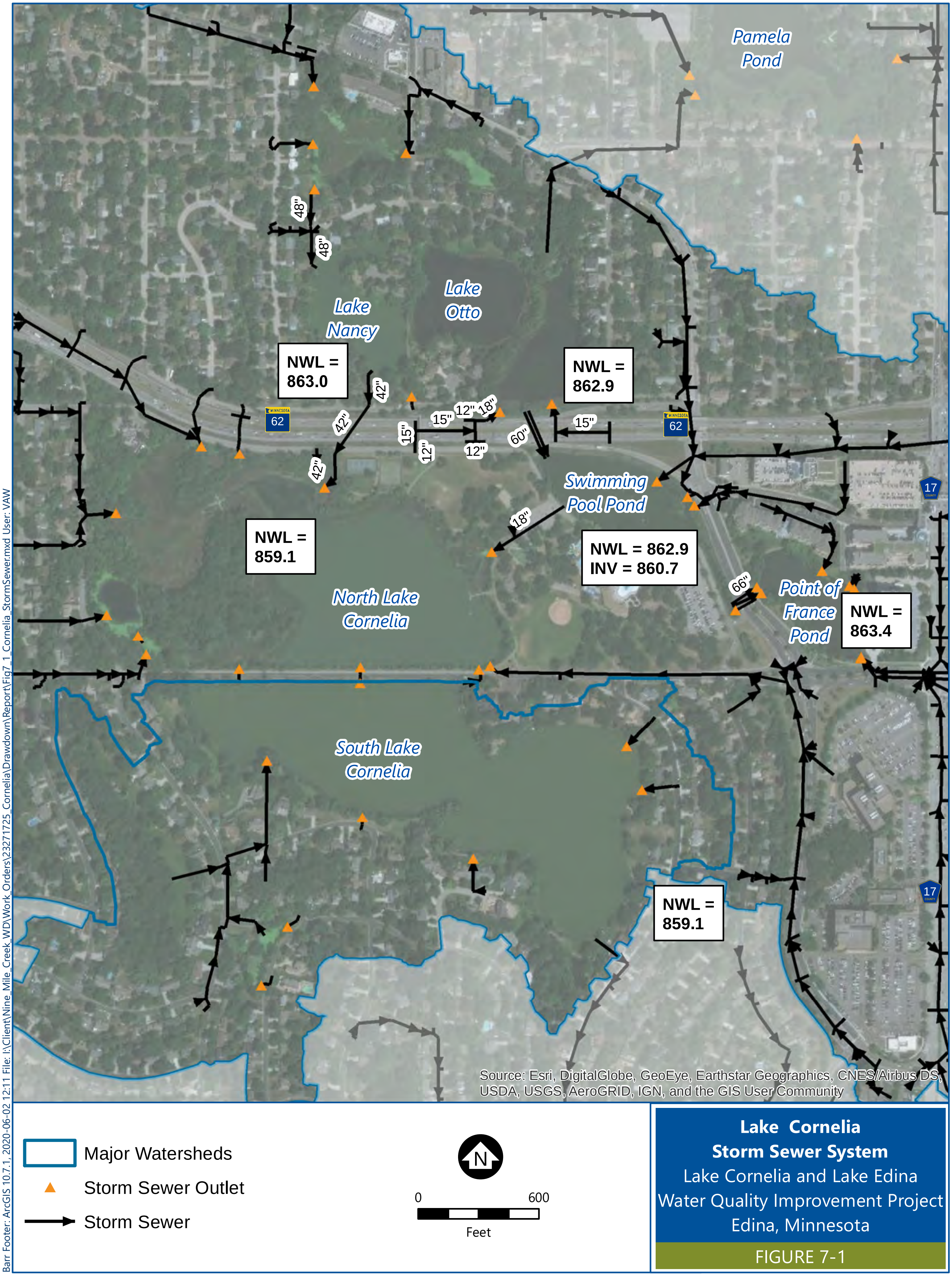
Overall, the fish sampled in the Lake Cornelia system were small in size and species richness was limited, likely a result of the 2017–2018 winterkill and past winterkills that have occurred (Reference (5)). Common carp populations were relatively low in Lake Cornelia. Conversely, goldfish (*Carassius auratus*) were found in large numbers in Lake Cornelia. Goldfish were the most abundant fish species captured through electrofishing and were determined to have an established breeding population. While most of the goldfish captured were young of the year (YOY) or one year old, fully-grown fish up to 14.4 inches in length were also captured. While carp were found in lesser numbers in Lake Cornelia, they were more abundant in Point of France Pond and are being included in consideration of management options.

Similar to carp, goldfish have the potential to negatively impact water quality by increasing in-lake turbidity due to benthic feeding habits (Reference (6), Reference (7)). The bottom-feeding fish can also increase in-lake nutrient levels and contribute to blue-green algae blooms from nutrient cycling through the fish gut (Reference (8), Reference (9)). Goldfish have also been documented to reduce growth of aquatic plants (Reference (6)). With the high numbers of goldfish in the Lake Cornelia system and their potential to reduce water quality, management options to reduce the goldfish population are being considered by NMCWD and its partners.

The sections below provide additional information regarding goldfish and potential management approaches to help reduce the goldfish and carp populations and maintain a healthy fishery in Lake Cornelia.

7.2 Goldfish Literature Review

While a relatively large amount of research has been conducted on common carp and their impact on water quality in Minnesota, limited research is available regarding goldfish and goldfish/carp hybrids. A literature review was conducted as part of this feasibility study to better understand the characteristics of goldfish and goldfish/carp hybrids and their role and movements within lake systems. Results of the literature search are summarized below.



Lake Cornelia Storm Sewer System

Lake Cornelia and Lake Edina Water Quality Improvement Project

Edina, Minnesota

FIGURE 7-1

7.2.1 Influence of Goldfish

Goldfish have a high tolerance to hypoxic conditions and can also survive prolonged periods of low temperatures (Reference (10), Reference (11), Reference (12), Reference (13), Reference (14)). Goldfish are omnivorous and can use a variety of food or prey items, including vegetation, during various life stages and/or seasonal periods (Reference (12), Reference (15), Reference (16)). As identified in the 2019 UAA study (Reference (1)), Lake Cornelia is a highly disturbed system with frequent winterkill, which creates conditions suitable for success of goldfish populations (Reference (12), Reference (17)) and reduced success of native fishes (Reference (18)). Rapid growth of young goldfish allow them to quickly grow past the size available to typical predators (Reference (19)). Frequent winterkill in Lake Cornelia contributes to a lack of native fish, including predator fish such as northern pike that could select for small goldfish as a soft-rayed food source (Reference (20)).

7.2.2 Hybridization

Goldfish hybridization with common carp has been documented and is likely occurring in Lake Cornelia as potential spawning areas may overlap (Reference (21), Reference (22), Reference (23), Reference (24), Reference (12)).

7.2.3 Goldfish Control Methods

Several potential methods for controlling the goldfish population in Lake Cornelia are discussed below. Integration of management methods has been shown to be successful and is the recommended approach for Lake Cornelia (Reference (25), Reference (26), Reference (27), Reference (28), Reference (29)). Integrated efforts to control nuisance populations of fish can consider a combination of a number of techniques, including removal, drawdown, stocking, reduced access to spawning areas, habitat improvement, and winterkill mitigation.

7.2.3.1 Removal

Physical removal of goldfish has been successful in some circumstances (Reference (8)) using a combination of monofilament gill nets and electrofishing. Goldfish also may be susceptible to capture in appropriately mesh size baited nets due their highly developed olfactory and tactile systems used for foraging similar to common carp (Reference (30), Reference (31), Reference (32), Reference (29), Reference (15), Reference (33), Reference (34)). Maxwell (Reference (5)) documented successful capture of goldfish using both electrofishing and trap (fyke) nets.

7.2.3.2 Biologic (Predation)

No successful documentation of biologic control of goldfish or goldfish/carp hybrids was found as part of the literature review. Indirect evidence of the impact of native fish populations on goldfish is via Laird and Page (Reference (35)), where in Illinois goldfish were noted as unable to compete with native fish and could only survive in severely disturbed areas.

Stocking a certain species of fish such as bluegill, northern pike, or largemouth bass to control another species of fish is documented as one of the least successful type of fish control programs when used as the only element of a control effort (Reference (36)). Bajer et al (Reference (37)) documented that bluegill predation on common carp eggs can achieve control of the species; however similar documentation of the effect of bluegill predation on goldfish eggs was not found at part of the literature review. Conditions and requirements for successful bluegill populations is well documented and can be compared to conditions in Lake Cornelia (Reference (38), Reference (39), Reference (40), Reference (41)). However, conditions in Lake Cornelia are not currently well suited to establishment of a successful bluegill population.

7.2.3.3 Drawdown

Lake level drawdown can have an impact on success of goldfish spawning success. Yamamoto et al (Reference (14)) noted that as little as a 12-inch drawdown following spring goldfish spawning reduced spawning success of goldfish and other cyprinds.

7.2.3.4 Reduced Access to Spawning Areas

Common carp actively seek winterkill waters as preferred spawning areas; no documentation was found to suggest that goldfish target similar spawning areas (Reference (42)). However, goldfish do spawn on vegetation during May-June, and warming water temperatures trigger spawning (Reference (23), Reference (24)). Large areas of Lake Cornelia with high densities of vegetation may contribute to success of goldfish larva (Reference (14)). Fish barriers can be an effective method to reduce access to spawning areas.

7.2.3.5 Chemical control

Chemical toxicants for removal of undesirable fish populations is documented as one of the more successful fish control techniques (Reference (36), Reference (43)). Use of chemical toxicants, however, can generate conflicting views by lake users, residents, or the community at large making the use of chemical control mechanisms dependent on public acceptance. The use of chemical toxicants as part of an integrated pest management program for control of nuisance fish species that includes habitat manipulation, stocking etc. has been shown to be successful (Reference (27)).

7.2.3.6 Winterkill Mitigation

Review of the 2018 fishery data indicate that the Lake Cornelia fishery tends to be heavily influenced by frequent winterkill events, evidenced by a low number of bluegill and other predator fish. The frequency of winterkills and the availability of connected shallow waterbodies that winterkill which likely act as nurseries, are most likely preventing bluegills and other sunfish from effectively controlling goldfish within the system. Management activities such as winter aeration can help to prevent winterkill and promote survival of predator fish.

7.3 Recommended Goldfish and Carp Management Approach

Based on the literature review of goldfish in lake systems and currently-available information regarding the fishery in Lake Cornelia, an integrated approach to goldfish and carp management using a combination of management actions is anticipated to be the most successful option. The following management approach is recommended:

1) **Conduct removal of goldfish and carp in combination with mitigation of recurrent winterkill through the use of winter aeration**
As identified in the literature review, there are several potential methods for goldfish removal, including biological control, lake drawdown, physical removal and chemical control. A combination of physical removal and biological control (predation) is the preferred approach at this time (versus lake drawdown and/or chemical treatment), as removal efforts can be selective/targeted to goldfish to reduce impacts to other fish and wildlife. However, additional information is needed to assess the potential effectiveness of removal efforts, including monitoring of the goldfish and carp populations in the Lake Cornelia system to understand their movements (assess feasibility of targeted removals) and assess the efficacy of baited box nets for removal of goldfish (see Section 7.4).

2) **Stock native fish following removal of large numbers of goldfish and winterkill mitigation.**
Stocking of native fish such as bluegill, largemouth bass and/or pike is likely to reduce success of goldfish following initial removal of a large biomass of the existing goldfish population and mitigation of winterkill to allow for native fish populations to survive for more than just a few seasons. Stocking of native fish will be affected by availability of disease free fish stocks in the region (Reference (44)).

7.4 Winter Aeration to Prevent Fish Kill

A comprehensive evaluation was conducted by Barr's subconsultant, Gantzer Water, to evaluate the feasibility of installing a winter aeration system that could be used in either North or South Cornelia, or both basins, to prevent periodic winter fish kill, promote the establishment of a self-sustaining native fish population, and reduce the carp and goldfish population in Lake Cornelia. The detailed report, developed by Gantzer Water, is provided in Appendix E.

Four different types of aeration systems were considered and evaluated according to the following criteria:

- Effectiveness
- Minimal potential aesthetic effects (on the lake and on shore)
- The system should not affect the normal winter ice thickness
- Ease of maintenance

7.4.1 Aeration Methods Considered

This section describes the types of aeration systems considered.

7.4.1.1 Full Lift Aeration

A full lift aeration system injects air into a tube at the bottom of the lake to draw water to the lake surface where the water is aerated. This system is often described as a "tube within a tube" system where open water is present at the top of the tube. A raft is also necessary to hold equipment and anchor the tube in place. See Figures 7 and 13 in the Gantzer report (Appendix E).

7.4.1.2 Full Lift Oxygenation

A full lift oxygenation system uses 95% pure oxygen that is injected at the bottom of the lake inside a tube. The tube draws water to the lake surface where it then cascades down the sides of the outer tube. This system is largely the same as the full lift aeration system except the oxygen injected into the water provides the aeration rather than contact of lake water with the atmosphere. See Figure 13 in the Gantzer report (Appendix E).

7.4.1.3 Oxygen Enhanced Full Lift Aeration

An oxygen-enhanced full lift aeration system uses air that is injected at the bottom of the lake inside a tube that draws water to the lake surface. This is also a "tube within a tube" system; however, as water cascades down the sides of the outer tube, 95% pure oxygen is injected to add additional oxygen to the lake water. There is open water at the top of the tube, and a raft would be necessary to hold equipment and anchor the tube in place. See Figures 9 and 13 in the Gantzer report (Appendix E).

7.4.1.4 Side Stream Saturation

A side stream saturation aeration system is very different from the others evaluated in that water is withdrawn from the lake, aerated with 95% pure oxygen, and discharged back into the lake. With this design there is no raft and there typically would not be any open water or thin ice. This design was considered because it is efficient, would have minimal aesthetic disturbance, and shouldn't affect usage of the lake by residents (i.e., winter ice thickness is not anticipated to be impacted).

7.4.2 Recommended Aeration Method

The side stream saturation system was identified as the preferred approach as it will be most capable of meeting the criteria identified for this project, which include efficiency, minimal aesthetic disturbance (the piping and other aeration equipment should not be visible to lake users), and this system is not anticipated to affect usage of the lake by residents (i.e., winter ice thickness should not be measurably impacted). Figure 7-2 shows the essential components of the side stream saturation system.

To aerate both North and South Cornelia, two separate aeration systems will be required. Installation of an aeration system in South Cornelia only is recommended at this time for several reasons:

- Installation of the system in South Cornelia allows the system to be tested and refined prior to installation of a system in North Cornelia. There is no impediment to installing an aeration system in North Cornelia several years after installation in South Cornelia.
- There is potential for North Cornelia to freeze to the bottom due to its shallow nature, thereby rendering the aeration system less effective; and
- If North Lake Cornelia freezes to the bottom and kills all the native fish, it is possible that the North Cornelia fish population may be repopulated by the fish in South Cornelia. The possibility

of fish passage between South and North Cornelia will be better understood after completion of the carp and goldfish tracking study (see Section 7.6).

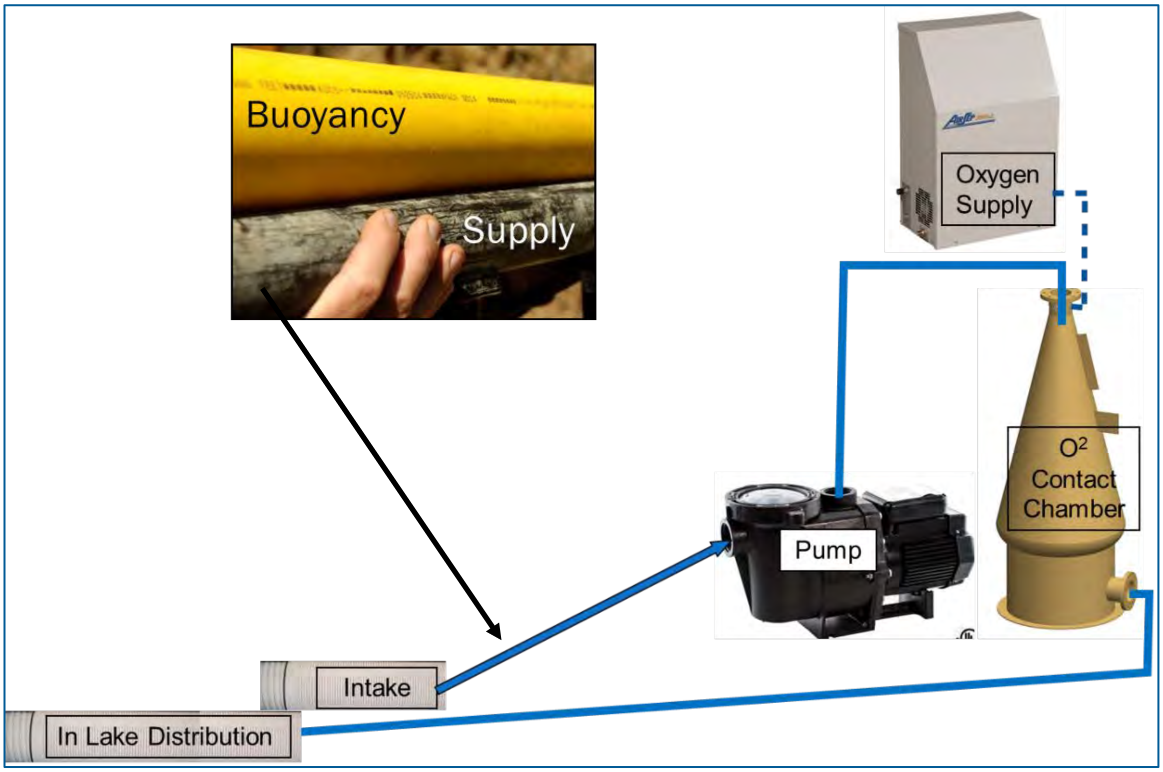
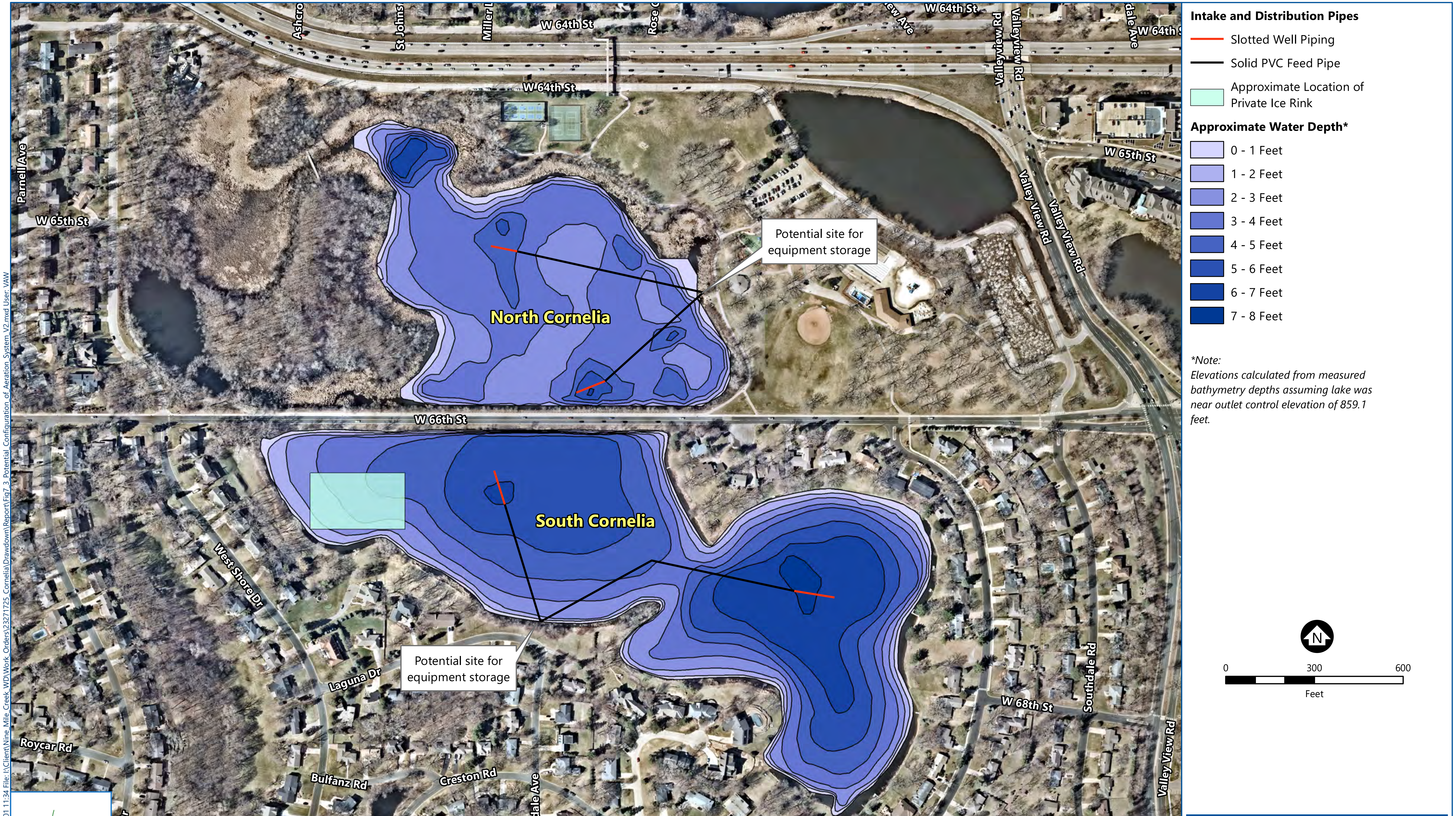


Figure 7-2 Main Components of the Side-stream Aeration System for Lake Cornelia

Figure 7-3 shows the potential configuration of a side stream aeration system in South Cornelia. The system includes an intake located in one bay of South Cornelia and an outlet in the other bay. The intake is located to minimize short circuiting and to pull water in a circular pattern in the west part of South Cornelia. Between the inlet and outlet, a pump and the oxygen injection system components would be housed in an approximately 8-foot by 8-foot building. The outlet consists of PVC pipe with slots designed to slowly feed water into the bottom of the lake at very low velocities. The intake and outlet pipes will be positioned approximately 4 inches above the lake bottom. This system will operate from January until about mid-March and will be able to deliver 17 kilograms/day of oxygen. Additional design details are provided in Appendix E.

7.4.3 Permitting

A MnDNR Aeration Permit would be required for installation of the aeration system. The permitting process is straightforward and requires minimal information such as the purpose of aeration (prevention of winter fish kill is one option), the permittee, period of operation, and a description of the system.



Potential Configuration of Aeration System
Lake Cornelia and Lake Edina
Water Quality Improvement Project
Edina, Minnesota

FIGURE 7-3

7.4.4 Opinion of Probable Cost

A planning-level opinion of probable cost has been developed for designing and installing a side stream aeration system in South Cornelia.

Costs were not developed for an aeration system in North Cornelia at this time due to the recommended staged approach. However, it is anticipated that design and installation of a side stream aeration system in North Cornelia would be similar to that of South Cornelia. The planning-level opinion of probable cost for designing and installing a side stream aeration system in South Cornelia is $202,000, with a range of $172,000 to $243,000 (-15 percent to +20 percent) (Table 7-1). The opinion of probable cost is based on engineering judgement, and experience with similar projects. The opinion of cost includes costs for specialty design services and technical support from Gantzer Water during project installation and system start-up including follow-up site visits, as needed. A detailed opinion of probable cost is included in Appendix D.

Table 7-1 Summary of Estimated Costs for Winter Aeration

Items	Estimated Cost
Mobilization/Demobilization	$9,700
Safety, erosion control, and site prep	$15,900
Aeration system	$76,400
Site restoration	$4,300
Construction subtotal:	$106,300
Construction contingency (30%)	$31,900
Estimated construction cost	**$138,200**
Gantzer Water design and commissioning support[1]	$22,000
Planning, engineering, and design (30%)	$41,500
Total	**$201,700**
Low range (-15%)	$171,500
High range (+20%)	$242,000

[1] Gantzer Water design and commissioning support includes engineering and design support, startup testing, operations and maintenance manual and training, and 2 years of startup support.

7.5 Stocking

Stocking of native fish such as bluegill, largemouth bass and/or pike is recommended to reduce success of goldfish following initial removal of a large biomass of the existing goldfish population and mitigation of winterkill (aeration) to allow for native fish populations to survive for more than just a few seasons.

North and South Cornelia have been sporadically stocked by the MnDNR West Metro Area Fisheries and via the MnDNR Fishing in the Neighborhood (FIN) programs since 1961 (Reference (45)). Stockings in the last 10 years have been comprised primarily of bluegill with some black crappie, along with hybrid and pumpkinseed sunfish. All fish stocked in the last 10 years are shown as adults (2+ year of age) on Lakefinder. The last noted stocking was in 2016 with 300 adult bluegills stocked. Lake Cornelia is managed as a highly disturbed winterkill lake under the FIN program. Ongoing stocking is influenced by availability of fish due to the area-wide presence of viral hemorrhagic septicemia (VHS) an infectious viral disease. VHS has precluded MnDNR from accessing fish for trap and transfer of adults from previously used sources (Reference (46)).

Stocking rates of adult bluegill by MnDNR have been variable based on the availability of fish; however, during several of the years from 2010 through 2016, adult bluegills were stocked at the rate of approximately 6 adults/surface acre (total stocking of approximately 300 fish). This rate is below rates recorded by Dauwalter and Jackson (Reference (47)) where the rate of stocking 3- to 5-inch bluegills in adjacent states such as South Dakota was approximately 100/surface acre (in combination with largemouth bass in a planned stocking management option). Spring stocking of sexually mature fish requires fewer fish; as few as 2 pair of sexually mature fish per ½ acre of surface water can provide an adequate initial stocking (Reference (48)). Using this guideline for stocking of sexually mature fish, Lake Cornelia would require approximately 420 sexually mature adults equally split between male and female for an initial stocking. Under some conditions as few as 10 pair of gravid brood stock bluegills per one hundred surface acres are suggested to be capable of establishing a population (Reference (49)).

Due to regularly occurring winterkill and/or frequent winter occurrences of very low oxygen levels in Lake Cornelia, carry-over of any bluegills stocked the previous year is highly variable. This factor combined with likely removal of some stocked bluegill via sport fishing results in low numbers of bluegills likely present each spring. Sampling in 2018 with fyke nets showed low numbers of bluegill in South Cornelia (1/net) with higher numbers in North Cornelia (10/net). The Minnesota statewide normal range for bluegill catch per unit effort in trap nets is 3.7- 42.9/net.

Future successful stocking of bluegill or other potential fishes to prey on various life stages of goldfish will be influenced by the availability of fish (Reference (44)) from VHS disease-free sources and prior mitigation of regularly recurring winterkill.

Future stocking schedules, species and rates should be determined in conjunction with MnDNR fisheries West Metro management and could include approaches such as:

a) Stocking 3–5” size disease free bluegills at a rate of 100/surface acre. This should be conducted in combination with largemouth bass in a planned management option.

b) Alternatively, initially stock up to 420 sexually mature bluegill adults from disease free sources equally split between male and female

c) Stock at rates similar to the past history of MnDNR management from disease free sources that include bluegill, largemouth bass and northern pike

7.5.1 Permitting

Since Lake Cornelia is a public water, all future potential stocking must be coordinated with MnDNR.

7.5.2 Costs

The approximate cost range for private hatchery, certified disease-free adult bluegills is $1–$3/fish plus transportation. Other species such as northern pike or largemouth bass have a higher cost/fish.

7.6 Additional Monitoring

A combination of physical removal and biological control (predation) is the recommended approach to manage goldfish at this time, as removal efforts can be selective/targeted to goldfish to reduce impacts to other fish and wildlife. As mentioned in Section 7.3, additional information is needed to assess the potential effectiveness of removal efforts, including monitoring of the goldfish population in the Lake Cornelia system to understand their movements (assess feasibility of targeted removals) and assessment of the efficacy of baited box nets for removal of goldfish.

Barr staff worked with staff from NMCWD and WSB to develop a monitoring program to gather additional information on goldfish and carp in the Lake Cornelia system. The monitoring program will help confirm goldfish and carp populations and will include analysis of age structure of a goldfish sample to better understand the environmental conditions that drive goldfish movements to connected water bodies. The monitoring program will also track movement of goldfish and carp, which is important in better understanding their mobility, spawning patterns and likelihood to travel/spread within a system. Finally, a possible goldfish removal method (baited box net trapping) will be tested to determine effectiveness with goldfish (this method has shown to be successful with carp. The goldfish and carp monitoring program will begin in summer 2020. A copy of the scope of work is included as Appendix F.

8 Lake Management Conclusions and Recommendations

In 2019, the NMCWD completed a water quality study for Lake Cornelia and downstream Lake Edina; the study recommended further consideration of several watershed and in-lake management activities to improve water quality in both lakes. This report summarizes a feasibility analysis and/or evaluation of options for several potential management activities, including the following:

- Feasibility analysis and preliminary design of a stormwater treatment filtration system in Rosland Park;
- Review of other potential watershed BMPs, including conceptual design of retrofit stormwater BMPs in the Lake Edina watershed and consideration of treatment opportunities in ponds upstream of Lake Cornelia;
- Evaluation of curly-leaf pondweed management options, including herbicide treatment and lake drawdown; and
- Evaluation of fishery management options to control goldfish and carp populations, including winter aeration to prevent winterkill of predator species, fish removal, and fish stocking

8.1 Stormwater Treatment in Rosland Park

The 2019 water quality study concluded that stormwater runoff is a major contributor of phosphorus to Lake Cornelia and recommended implementation of a stormwater best management practice (BMP) located in Rosland Park to remove phosphorus from water flowing from the Swimming Pool Pond to North Lake Cornelia. As part of this feasibility study, Barr staff worked closely with NMCWD and City of Edina staff from the Engineering, Public Works, and Parks and Recreation departments to identify a conceptual BMP design and location within Rosland Park. The proposed stormwater BMP is an above-ground filtration vault that will treat a significant portion of the water that flows from Swimming Pool Pond to Lake Cornelia. The above-ground filtration vault design allows for more design flexibility, increased treatment capacity, simplified operation and maintenance, and fewer concerns about functionality as compared with an underground system. The proposed location minimizes parkland impacts and provides an opportunity to incorporate plantings, park signage, public art or education into the feature design to make the system not only a functional means of reducing phosphorus to Lake Cornelia, but an attractive element of the park as well.

Under the proposed pumping scenario, the pump will operate approximately 12 hours per day mid-April through mid-November when water levels are higher than or within 3.6 inches of the existing control elevation. Based on this scenario, approximately 52% of the flow between Swimming Pool Pond and North Cornelia between mid-April and mid-November will be treated, on average. A three-chamber filtration vault is proposed to test three different filtration media types, with a goal of assessing and ultimately using the filtration media that most effectively removes phosphorus. The estimated total phosphorus removal efficiency for the proposed filtration vault is approximately 63%, based on the anticipated removal efficiencies of the proposed filtration media. Based on this and the estimated volume of water filtered, the filtration vault is anticipated to remove 22 pounds of phosphorus on an average annual basis, with a range of 12 – 28 pounds for evaluated years, dependent on climatic conditions.

A feasibility-level design cost estimate was developed for the Rosland Park filtration vault and is shown in Table 8-1. The opinion of probable cost provided generally corresponds to standards established by the Association for the Advancement of Cost Engineering (AACE). A class 3 feasibility-level opinion of cost was used based on the level of project definition (between 10% and 40%), wide-scale use of parametric models to calculate estimated costs (i.e., making extensive use of order-of-magnitude costs from similar projects), and uncertainty with an acceptable range of between -15% and +20% of the estimated project cost. The estimated annualized cost per pound of total phosphorus removed is also summarized in Table 4-7.

Table 8-1 Rosland Park Treatment Vault Feasibility-Level Cost Estimate

BMP	Feasibility-Level Cost Estimate[1]	Feasibility-Level Cost Range (-15% - +20%)	Estimated Life of Project	Estimated Annualized Cost per Pound TP Removed[2]
Rosland Park Treatment Vault	$744,000	$632,000–$892,000	30 years	$2,200

[1] Feasibility-level cost estimate does not include annual costs for operations and maintenance. Cost does include engineering and design estimate

[2] Feasibility-level estimated annualized cost per pound total phosphorus removed assumes an annual maintenance cost of approximately $11,000 and an inflation rate of 3%.

Based on preliminary discussions with staff from the MnDNR, the proposed pumping from Swimming Pool Pond will require a water appropriations permit. A Work in Public Waters permit will likely not be necessary since the proposed pumping draw down depth is less than one half foot. Notification of impacted riparian landowners and an accounting of support will be required as part of the permitting process. While it is not anticipated that a permit will be necessary from MPCA for the proposed filtration vault, discussions with MPCA staff regarding the proposed BMP and proposed filtration media is recommended prior to or early in the design process to confirm.

NMCWD will need to obtain the necessary rights to construct the proposed filtration vault on property owned by the City of Edina. It is anticipated that NMCWD and the City of Edina will enter into a cooperative agreement upon ordering of the project. A permit for construction of the proposed filtration vault will also be required from NMCWD.

Prior to design and construction, it is recommended that testing of the proposed filtration media be considered, including evaluating the hydraulic conductivity of the CC17 and iron-enhanced CC17 media and conducting bench scale testing of the media for phosphorus removal effectiveness.

8.2 Other Watershed BMP Opportunities

As part of the 2019 UAA study, several watershed best management practices (BMPs) were evaluated to assess their effectiveness in reducing phosphorus loading to Lake Cornelia and Lake Edina, including watershed-wide infiltration, a BMP in Rosland Park, and street sweeping. This feasibility study expanded on previous analyses to include a high-level evaluation of other potential BMP opportunities in the Lake Cornelia and Lake Edina watersheds, including consideration of retrofit stormwater BMPs on publicly-owned land in the Lake Edina watershed and treatment opportunities in ponds upstream of Lake Cornelia (Point of France Pond, Lake Otto, Lake Nancy).

8.2.1 Stormwater BMP Retrofit Opportunities in Lake Edina Watershed

Watershed runoff comprises a significant portion of the external phosphorus loading to Lake Edina, ranging from 35% to 45% of annual phosphorus sources in modeled years (Reference (1)). A high-level watershed analysis was conducted as part of this study to identify potential opportunities to implement stormwater BMPs in the Lake Edina watershed, with a focus on partnership projects on publicly-owned lands. Two properties were identified for the potential to incorporate infiltration-based BMPs: Cornelia Elementary School, owned by Edina Public Schools, and the open green space area between Lynmar Lane and Bristol Boulevard owned by the City of Edina (from this point forward referred to as Lynmar basin). Three rain gardens proposed at Cornelia Elementary School would collect and infiltrate stormwater runoff from approximately 2.6 acres of primarily school parking lot. A stormwater infiltration feature within the Lynmar Basin would collect and infiltration runoff from an 18-acre residential watershed.

Concept-level opinions of probable cost were developed for the two potential BMP projects and are shown in Table 8-2. The opinions of probable cost are generally correspond to standards established by the AACE. Class 5 opinions of cost were used based on the limited project definition, wide-scale use of parametric models to calculate estimated costs (i.e., making extensive use of order-of-magnitude costs from similar projects), and uncertainty with an acceptable range of between -30% and +50% of the estimated project cost.

The estimated annual total phosphorus removals are approximately 3.6 and 20.5 pounds from the Cornelia Elementary School basins and the Lynmar Basin, respectively. The estimated annualized cost per pound of total phosphorus removed is also summarized in Table 8-2.

Table 8-2 Lake Edina Watershed Infiltration-BMP Concept-Level Cost Estimates

Location	Concept-Level Cost Estimate[1]	Concept Level Cost Range (-30% – +50%)	Estimated Life of Project	Estimated Annualized Cost per Pound TP Removed[2]
Cornelia Elementary School (3 Infiltration BMPS)	$332,000	$233,000–$498,000	30 years	$5,500
Lynmar Basin (1 Infiltration BMP)	$512,000	$359,000–$768,000	30 years	$1,500

[1] Concept-level cost estimates do not include annual costs for operations and maintenance. Costs do include engineering and design estimates.

[2] Concept-level estimated annualized cost per pound total phosphorus removed assumes an annual maintenance cost of approximately 10% of estimated construction costs and an inflation rate of 3%.

If the NMCWD is interested in pursuing implementation of stormwater BMPs on these sites, the next step would be to contact the property owners to discuss partnership opportunities. The City of Edina has indicated potential interest in preliminary discussions. Edina Public Schools has not been contacted yet. It is recommended that the NMCWD consider preparing some sketches/renderings of the proposed rain gardens and infiltration basin prior to meeting with Edina Public Schools and City of Edina.

8.2.2 Opportunities for Treatment of Ponds Upstream of Lake Cornelia

Internal P loading in stormwater ponds has been increasingly identified as an issue in the Twin Cities area. There are generally two causes of internal P loading in ponds: (1) high phosphorus in pond bottom sediment resulting from years of sediment accumulation and the occurrence of low oxygen during the summer months, and (2) an abundant population of fish such as carp, bullheads, and other fish such as goldfish which disturb bottom sediments and cause phosphorus to release into the water column. In many cases ponds are afflicted by both problems, they have high phosphorus in bottom sediments as well as an abundant population of bottom foraging fish such as carp and goldfish.

Given the root cause of internal loading in ponds, there are three viable approaches to reducing internal phosphorus loading in ponds: (1) remove and eliminate the bottom feed fish such as goldfish and carp, (2) bind the phosphorus in the pond bottom sediment by adding aluminum (alum), iron (e.g., iron filings per the studies conducted by the University of Minnesota, or calcium (e.g., spent lime (calcium carbonate) is currently being studied), and (3) aerate to improve oxygen concentrations. Removing fish such as carp has been shown to be successful in the in the Ramsey Washington Metro Watershed District with carp removal leading to reduced phosphorus concentrations within the pond water column at the pond outlet. Lower turbidity, but also increased aquatic plant abundance, occurs in conjunction with carp removal. The use of alum (aluminum is the main component) is a well-established method for reducing internal phosphorus loading and this approach is being used for Lake Cornelia. The use of iron and spent lime are also potentially viable approaches but are more experimental. Spent lime is a waste material and repurposing of that material to treat phosphorus is attractive. However, there are potential challenges in identifying an approach to apply spent lime as spent lime is a solid material that is largely insoluble in water and would have to be ground and spread in some manner. Iron has potentially similar application challenges. The short- and long-term benefits of treatment using spent lime and iron in a waterbody are still unknown. Aeration may also help by increasing oxygen in the water column and reduce the rate of phosphorus release from bottom sediments. The appropriate aeration approach such as a fountain or forced air bubbler would need to be evaluated on a pond-by-pond basis.

The first step before committing to a management action is to determine if a pond is exporting phosphorus as a consequence of internal P loading by monitoring at the ponds' inlet and outlet (or within the water column). Once it is established that a pond or series of ponds are releasing phosphorus, then appropriate mitigation approaches can be identified and applied if the magnitude of phosphorus export justifies the action. A 2018 monitoring analysis conducted by the University of Minnesota concluded that minimal internal phosphorus release was occurring in Swimming Pool Pond and Point of France Pond upstream of Lake Cornelia. Water quality data has not been collected from Lake Nancy or Lake Otto, but should be considered in the future to better understand whether internal loading from sediment phosphorus release is occurring.

It is expected that carp and goldfish management efforts at Lake Cornelia will also benefit upstream ponds if there is a connection (e.g., active fish passage) between Lake Cornelia and these ponds. If there is a connection then it will be necessary to reduce or eliminate carp and goldfish populations in those ponds as well as in Lake Cornelia. The 2018 fishery survey noted an abundant goldfish population in Lake Nancy, which is connected to North Cornelia via a storm sewer under Highway 62. Before other management activities are considered in Lake Nancy, it is recommended that we wait to realize the benefits of carp and goldfish control at Lake Cornelia. No fisheries information is currently available for Lake Otto.

8.3 Curly-leaf Pondweed Management

The presence of curly-leaf pondweed and its mid-summer die-off negatively impacts the water quality of Lake Cornelia. Accordingly, management of curly-leaf pondweed is an important component of a long-term management plan for Lake Cornelia. Effective control of aquatic invasive species can require long-term management. While a long-term curly-leaf pondweed management goal of reducing presence of the invasive plant until neither curly-leaf pondweed nor turions are observed in the lake would be most protective of Lake Cornelia and downstream lake ecosystems, it would require intensive treatment that may not be sustainable for the duration needed to be successful. As such, a more immediate curly-leaf management goal is to reduce the extent and density of the invasive plant throughout Lake Cornelia so it doesn't significantly hinder growth of native plants and so mid-summer die off of curly-leaf pondweed does not cause reduced water quality.

Two alternatives for curly-leaf pondweed management were evaluated as part of this study: annual herbicide treatment (current approach) and a lake drawdown.

8.3.1 Annual Herbicide Treatments

The City of Edina has been conducting annual herbicide treatments in Lake Cornelia since 2017 to reduce the impact of curly-leaf pondweed die-back on water quality in Lake Cornelia and downstream Lake Edina and to help promote a healthy native aquatic plant population. Spring pre-treatment plant surveys since 2017 indicate annual treatments are having some level of effectiveness in reducing the presence and density of curly-leaf pondweed throughout the lake. While annual herbicide treatments can reduce the extent and density of curly-leaf pondweed, this approach may necessitate long-term annual herbicide treatments.

The planning-level opinion of probable cost for herbicide treatment of the curly-leaf pondweed in Lake Cornelia is approximately $28,000 per year of treatment, with a range of $26,000 to $34,000 (-10% to +20%). This estimate includes preparation of contract documents, permitting, and herbicide application. The cost estimate also includes potential costs related to monitoring that may be deemed appropriate or required by the MnDNR as part of permitting, including temperature measurements, herbicide residue monitoring, and aquatic plant monitoring.

The City of Edina anticipated conducting an herbicide treatment of Lake Edina in 2020 to manage curly-leaf pondweed. However, a pre-treatment survey in spring of 2020 found little or no curly-leaf pondweed in the lake.

8.3.2 Lake Drawdown

Another potential method to control curly-leaf pondweed is to draw down water levels in a lake to allow the lake bed to freeze over the winter. Curly-leaf pondweed primarily propagates through production of dormant vegetative propagules called turions. Turions are produced in late spring, remain dormant in sediment through the summer, and germinate under cooler water conditions in the fall. A winter freeze can kill the turions, thus disrupting curly-leaf pondweed's reproductive cycle.

A high-level evaluation of a drawdown in Lake Cornelia to control curly-leaf pondweed was included as part of this feasibility study due to the success of this approach in other lakes, including several in the NMCWD, and the desire to avoid recurring management activities. Results of the analysis indicate that while it would be feasible to draw the lake down, the project is cost prohibitive. The drawdown would require a pumping capacity of 3,000 gallons per minute (gpm) to have a reasonable likelihood of drawing down lake levels within the timeframe required by MnDNR and keeping lake levels drawn down throughout the winter months. In addition, three separate 3,000 gpm pumps would be necessary to pump water from the several deeper holes throughout North and South Cornelia.

Conducting a lake drawdown would require approval from the MnDNR through a Work in Public Waters Permit. Under Minnesota Statute Section 103G.408, 75 percent of the riparian landowners must authorize a drawdown. The City of Edina owns all of the property adjacent to North Lake Cornelia and approximately half of the shoreline property around South Lake Cornelia. South Lake Cornelia has 31 private, riparian landowners.

8.3.3 Curly-Leaf Management Recommendation

Given that the annual herbicide treatments are having some level of effectiveness in reducing the presence and density of curly-leaf pondweed throughout Lake Cornelia, it is recommended that this management approach be continued. Additional monitoring to compare year-to-year effectiveness in reducing the presence and density of curly-leaf pondweed is recommended. Because of the high cost, intensive permitting requirements, and uncertainty regarding the likelihood of maintaining a drawn down condition throughout the winter months, a lake draw down is not recommended at this time.

8.4 Fishery Management

A 2018 fish survey identified a large population of goldfish in Lake Cornelia and upstream Lake Nancy. Similar to carp, goldfish have the potential to negatively impact water quality by increasing in-lake turbidity due to benthic feeding habits and increase in-lake nutrient levels from nutrient cycling through the fish gut. With the high numbers of goldfish in the Lake Cornelia system and their potential to reduce water quality, management options to reduce the goldfish population were considered as part of this feasibility study. While carp were found in lesser numbers in Lake Cornelia, they were more abundant in Point of France Pond and are being included in consideration of management options.

While a relatively large amount of research has been conducted on common carp and their impact on water quality in Minnesota, limited research is available regarding goldfish and goldfish/carp hybrids. A literature review was conducted as part of this feasibility study to better understand the characteristics of goldfish and goldfish/carp hybrids, their role and movements within lake systems, and potential goldfish control methods.

8.4.1 Fish Management Recommendations

Based on the literature review of goldfish in lake systems and currently-available information regarding the fishery in Lake Cornelia, an integrated approach to goldfish and carp management using a combination of management actions is anticipated to be the most successful option. The following management approach is recommended:

1) **Conduct removal of goldfish and carp in combination with mitigation of recurrent winterkill through the use of winter aeration**
   As identified in the literature review, there are several potential methods for goldfish and carp removal, including biological control, lake drawdown, physical removal and chemical control. A combination of physical removal and biological control (predation) is the preferred approach at this time (versus lake drawdown and/or chemical treatment), as removal efforts can be selective/targeted to goldfish to reduce impacts to other fish and wildlife. However, additional information is needed to assess the potential effectiveness of removal efforts, including monitoring of the goldfish and carp populations in the Lake Cornelia system to understand their movements (assess feasibility of targeted removals) and assess the efficacy of baited box nets for removal of goldfish.

2) **Stock native fish following removal of large numbers of goldfish and winterkill mitigation.** Stocking of native fish such as bluegill, largemouth bass and/or pike is likely to reduce success of goldfish following initial removal of a large biomass of the existing goldfish and carp populations and mitigation of winterkill to allow for native fish populations to survive for more than just a few seasons. Stocking of native fish may be affected by availability of disease free fish stocks in the region.

8.4.2 Winter Aeration

A comprehensive evaluation was conducted by Barr's subconsultant, Gantzer Water, to evaluate the feasibility of installing a winter aeration system that could be used in either North or South Cornelia, or both basins, to prevent periodic winter fish kill, promote the establishment of a self-sustaining native fish population, and reduce the carp and goldfish population in Lake Cornelia. Several different types of aeration systems were considered and evaluated according to effectiveness, aesthetic effects, potential impacts on winter ice thickness (safety consideration), and ease of maintenance.

A side stream saturation system was identified as the preferred approach as it will be most capable of meeting the criteria identified for this project, which include efficiency, minimal aesthetic disturbance (the piping and other aeration equipment should not be visible to lake users), and this system is not anticipated to affect usage of the lake by residents (i.e., winter ice thickness should not be measurably impacted).

Two separate systems would be required to aerate both North and South Cornelia. It is recommended that an aeration system be installed only in South Cornelia at this time. Installation of the system in South Cornelia will allow the system to be tested and refined prior to potential future installation of a system in North Cornelia. It is expected that the aeration system in South Cornelia may be more effective than North Cornelia, as there is greater potential for North Cornelia to freeze to the bottom due to its shallow nature.

The side stream saturation aeration system in South Cornelia will include an intake located in one bay of and an outlet in the other bay, pulling water in a circular pattern in the west part of South Cornelia. A pump and the oxygen injection system components would be housed in an approximately 8-foot by 8-foot equipment storage building on the City-owned property on the south side of South Cornelia. The proposed system would operate from January until about mid-March.

The planning-level opinion of probable cost for designing and installing a side stream aeration system in South Cornelia is $202,000, with a range of $172,000 to $243,000 (-15% to +20%). The opinion of probable cost is based on engineering judgement, and experience with similar projects. The opinion of cost includes costs for specialty design services and technical support from Gantzer Water during project installation and system start-up including follow-up site visits, as needed.

8.4.3 Goldfish and Carp Removal

A combination of physical removal and biological control (predation) is the preferred approach to remove goldfish and carp from the Lake Cornelia system. While information is limited regarding effective goldfish removal techniques, there is hope that the baited box net approach that has been successful with carp will also be effective in catching and removing goldfish. NMCWD intends to test the baited box net approach in 2020 and 2021 as part of their goldfish monitoring project.

8.4.4 Stocking

Stocking of native fish such as bluegill, largemouth bass and/or pike is recommended to reduce success of goldfish following initial removal of a large biomass of the existing goldfish population and mitigation of winterkill (aeration) to allow for native fish populations to survive for more than just a few seasons. Future stocking schedules, species and rates should be determined in conjunction with MnDNR fisheries West Metro management and could include approaches such as:

a) Stocking 3-5" size disease free bluegills at a rate of 100/surface acre. This should be conducted in combination with largemouth bass in a planned management option.

b) Alternatively, initially stocking up to 420 sexually mature bluegill adults from disease-free sources equally split between male and female.

c) Stocking at rates similar to the past history of MNDNR management from disease-free sources that include bluegill, largemouth bass and northern pike.

8.4.5 Additional Monitoring

As compared with carp, limited research is available regarding goldfish and goldfish/carp hybrids. As such, it is important to gather additional information on goldfish in the Lake Cornelia system. The proposed monitoring program, beginning in summer of 2020, will help confirm goldfish and carp populations and will include analysis of age structure of a goldfish sample to better understand the environmental conditions that drive goldfish movements to connected water bodies. The monitoring program will also track movement of goldfish and carp, which is important in better understanding their mobility, spawning patterns and likelihood to travel/spread within a system. Finally, a possible goldfish removal method (baited box net trapping) will be tested to determine effectiveness with goldfish (this method has shown to be successful with carp).

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Appendices

(in Separate PDF)