

[Insert Appropriation Year of Legal Citation] Project Abstract

For the Period Ending June 30, 2019

PROJECT TITLE: Invasive Carp Management Research in Lake Nokomis Subwatershed

PROJECT MANAGER: Adam Arvidson

AFFILIATION: Minneapolis Park and Recreation Board

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FUNDING SOURCE: Environment and Natural Resources Trust Fund

LEGAL CITATION: M.L. 2016, Chp. 186, Sec. 2, Subd. 06g

APPROPRIATION AMOUNT: \$189,000

AMOUNT SPENT: \$189,000

AMOUNT REMAINING: \$0

Sound bite of Project Outcomes and Results

This project resulted in the quantification of the carp population within the subwatershed and fundamental understanding of how carp move throughout the subwatershed and individual waterbodies. This led to the removal of carp biomass and the development of a long-range plan to sustainably control carp to improve water quality.

Overall Project Outcome and Results

Survey data and anecdotal information suggested that invasive common carp were abundant in the project area and were negatively impacting water quality and ecological integrity. Objectives of this project were to quantify the carp population; study movement patterns to identify carp nurseries, migration routes, and aggregation areas; and removal of carp.

The general approach was to use standardized methodology to develop a carp population estimate for all waterbodies within the subwatershed while simultaneously tracking movement of carp within and between waterbodies using high frequency radio tags surgically implanted in adult carp. Results show that the biomass of carp (>260 pounds/acre) is roughly three times the identified threshold of 89 pounds/acre. This may be leading to increased internal phosphorous loading and significant reduction in submergent aquatic vegetation.

During the course of the project, it was determined that carp are using a small wetland between Lake Nokomis and Taft Lake as a nursery site, and carp aggregate most densely during late fall/early winter during open water in the southeast portion of Lake Nokomis. This data provided project partners the ability to target migrating and aggregating carp for removal. Through the use of electrofishing, gill nets, and baited box nets, 6,508 pounds of carp biomass (32 pounds/acre) were removed from the system. While the total carp biomass removed to date is only 10% of the population, a long-term Carp Integrated Pest Management Plan, was developed to guide future management within the system, using foundational carp population data and "lessons learned" from successful and unsuccessful carp removal events.

By following the plan to sustainably reduce the carp population within the system, dramatic reductions in internal phosphorous loading should be achieved, resulting in improved water quality, an increase in aquatic vegetation abundance, and an improved fishery.

Project Results Use and Dissemination

The project team (Minneapolis Park and Recreation Board, MN DNR-West Metro Fisheries, Minnehaha Creek Watershed District, Blue Water Science, and WSB) met 1-2 times per year to discuss results and data and plan for upcoming objectives. A workplan and Powerpoints were developed for each of these meetings.

Aquatic Plant Survey Reports were developed for Lake Nokomis in 2016 and 2017 and Taft Lake in 2017. Fishery survey reports were drafted and sent to the group for Lake Nokomis (2016, 2017, and 2019), and Solomon Wetland and Legion Lake in 2019.

The project concluded with the development of a Carp Integrated Pest Management Plan that utilized both pre-project data and data collected during the course of the project. This Plan was a collaborative effort between project partners and is intended to guide carp management within the subwatershed.

The Minneapolis Park and Recreation Board has also developed a dedicated webpage for this project to inform members of the public as results became available and management activities were implemented.



Environment and Natural Resources Trust Fund (ENRTF)

M.L. 2016 Work Plan

Date of Report: December 31, 2019

Date of Next Status Update Report: NA

Date of Work Plan Approval: June 7, 2016

Project Completion Date: December 31, 2019

Does this submission include an amendment request? NO

PROJECT TITLE: Invasive Carp Management Research in Lake Nokomis Subwatershed

Project Manager: Adam Arvidson

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Location: Lake Nokomis Subwatershed, Hennepin County, Minneapolis and Richfield, MN

Total ENRTF Project Budget:

ENRTF Appropriation: \$189,000

Amount Spent: \$189,000

Balance: \$0

Legal Citation: M.L. 2016, Chp. 186, Sec. 2, Subd. 06g

Appropriation Language:

\$189,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with the Minneapolis Park and Recreation Board to apply current invasive carp management research to the entire Lake Nokomis subwatershed and provide demonstration guidance for large-scale carp management. This appropriation is available until June 30, 2020, by which time the project must be completed and final products delivered.

I. PROJECT TITLE: Invasive Carp Management Research in Lake Nokomis Subwatershed

II. PROJECT STATEMENT:

Using the same methods pioneered by Dr. Peter Sorensen (judas fish technique, telemetry monitoring, biomass estimates) of the University of Minnesota's Sorensen Lab and successful projects implemented on Clam Lake (Burnet County, WI) and Silver Lake (Ramsey County, MN), this project will track, assess, and manage common carp in the Lake Nokomis subwatershed. Applying the latest research to an entire subwatershed will increase statewide understanding of common carp in interconnected lake and wetland systems. It will also improve water quality in Lake Nokomis, Taft Lake, Mother Lake, Legion Lake, and several wetlands within the subwatershed. Significantly reducing carp biomass can increase aquatic vegetation, reduce re-suspension of phosphorous-laden sediments, and decrease turbidity, all of which improve water quality and clarity.

The Invasive Carp Applied Research and Management project includes the entire Lake Nokomis subwatershed, which is 6,004 acres in size and includes portions of the cities of Minneapolis and Richfield and lands belonging to the Metropolitan Airports Commission. The subwatershed includes four lakes (Nokomis in Minneapolis, Taft and Legion in Richfield, and Mother within the International Airport) and several associated wetlands. The lakes constitute a total of 235 acres of open water and nearly five miles of shoreline.

It is important to consider the entire subwatershed because carp are most likely migrating through storm sewers from Lake Nokomis to other lakes and wetlands that experience winter kill, so they can spawn without competition. With this comprehensive approach comes greater opportunity for success in water quality improvement, aquatic vegetation increase, and carp management, as well as valuable additional research that can help managers of other interconnected lake and wetland systems statewide. Water quality and invasive species management goals will be accomplished through radio tracking of carp to discover migration routes and patterns, ongoing assessment of carp and aquatic vegetation, strategic and targeted carp removal, and creation of a long-term carp management plan based on previous research and this new research in the subwatershed.

III. OVERALL PROJECT STATUS UPDATES:

Project Status as of February 1, 2017:

The project was initiated in September 2016 with the acquisition of a MN DNR Fisheries research permit. Electrofishing and netting surveys were completed to develop initial population estimates for Taft and Lake Nokomis. Netting was also completed on Mother Lake however; Legion Lake was not accessible in fall 2016.

Aging structures are currently being examined to determine length-age frequency data and the amount and frequency of recruitment events.

Telemetry data has allowed us to identify one winter aggregation in Nokomis and shown that radio tagged carp have stayed in the basin they were originally implanted in through the 3-month monitoring period thus far. No migration was observed.

Data collected during this first period is summarized in the individual task sections below.

Project Status as of August 1, 2017:

In January of 2017, WSB acquired an updated MN DNR Fisheries research permit to cover work to be completed in the Nokomis Subwatershed in the 2017 field season. Electrofishing surveys were completed to further develop population estimates for Lake Nokomis, Taft Lake, and Mother Lake. A netting attempt was also

completed for Legion Lake on June 22, 2017. Though no carp were captured here, there were observations that confirm the presence of carp in this waterbody. Netting was also conducted in Solomon Wetland to capture carp in order to implant them with radio tags.

Additional aging structures were collected in this reporting period to determine length-age frequency data and to suggest the amount and frequency of recruitment events. Aging structures collected included both carp ear bones called otoliths and left pectoral fin rays. Preliminary readings of fin ray sections suggest that it is likely that a number of carp in the Nokomis Subwatershed exceed the age of 12-13, a range scientists agree fin rays are not a reliable estimator of. Because of this phenomenon, otoliths are being collected to better estimate ages of carp within the subwatershed. It should be noted that carp must be exterminated in order to collect otolith samples, and fish collected for this purpose are considered biomass removed from the system and is being tracked throughout the project period.

Telemetry data and the implantation of additional radio tags into both Lake Nokomis and a smaller basin called the Solomon Wetland that connects Nokomis to Taft Lake. This addition of radio tags has given us a better understanding of the movements within the watershed and plans to implant up to six (6) more radio tags during the next reporting period have been initiated.

Data collected during this second period is summarized in the individual task sections below.

Project Status as of February 1, 2018:

By examining the age structure of carp in the subwatershed, recruitment patterns may be identified. Fin rays were collected from a subsample of 28 carp from Nokomis and 5 carp from Taft Lake in 2016. These samples were viewed through a light microscope and it was determined that they were not clear enough to determine if the fish was older than approximately 13 years old. As specified in the project plan, otoliths were collected to better age the fish. In 2017, otoliths were collected from 78 carp and several them were thin sectioned and viewed by one (1) reader. It was determined that these structures were clear enough to determine age and at least one (1) other reader will examine them before ages are reported. We plan to collect up to an additional 22 otoliths from carp in Nokomis for analysis in 2018 during electrofishing or taking a sub-sample from commercial seine netting catch.

Project Status as of August 1, 2018:

Most of the data collection objectives have been completed to date. These include water quality measurements, vegetation surveys, carp population estimates and ageing analysis, and telemetry surveys for most basins. The remaining tasks to complete include carp and bluegill young of the year trap netting in Mother, Taft, Legion, and Nokomis, a mark-recapture population estimate for Taft and Nokomis, carp ageing analysis for Taft, and an adult carp sample from Legion. Telemetry surveys will be completed throughout the remainder of the project period to identify aggregations for removal and movement between waterbodies.

The remainder of the project will focus primarily on carp biomass removal from Lake Nokomis and drafting of the Lake Nokomis Subwatershed Integrated Pest Management (IPM) Plan for carp. Data from the electrofishing efforts in 2016 and 2017, show elevated carp biomass in Lake Nokomis. Estimates range from 153 kg/ha-460 kg/ha with an average estimate of 266 kg/ha. Literature suggests that carp are ecologically damaging at 100 kg/ha. Carp populations should be managed well below this density ($\sim \leq 60$ kg/ha) to prevent degradation to water quality and lake ecology.

Project Status as of February 1, 2019:

Attempts were made between August 2018- January 2019 to remove carp biomass from Lake Nokomis. Commercial netting crews visited the lake on October 11 and November 8, 2018 to sonar the lake to confirm aggregations and deploy seine nets. No carp were captured in these netting events since substrate conditions are unfavorable due to historic dredging operations. A baited box net was deployed in late summer 2018 and baited for several days to attract and trap carp feeding at the site. In three box-net pulls a total of 14.5 kg/ha was removed from Lake Nokomis.

An attempt was made to update the population and biomass estimate using mark-recapture methodology and one timed electrofishing survey in the fall of 2018. The results of the electrofishing survey completed on October 9th confirm that an elevated carp biomass remains in Lake Nokomis. Trap-net sampling was completed by Bluewater Science in Solomon Wetland, Taft Lake, and Mother Lakes. Young of year common carp were found in Solomon Wetland, but not in Mother or Taft Lakes during young of the year carp surveys. This data will be used in the next project period to recommend barriers to carp movement.

Barrier designs will be explored in this next project period to alleviate the technical teams concerns about impact to water levels and telemetry surveys will continue to track radio-tags with remaining battery life. The focus through the end of December 2019, will be primarily on carp biomass removal from Lake Nokomis and drafting of the Lake Nokomis Subwatershed Integrated Pest Management (IPM) Plan for carp.

Project status as of December 31, 2019:

Most work that has progressed since February 1 was in the removal activities. Gill nets were set in Solomon Wetland in May which captured 13 carp presumably moving from Nokomis to the wetland to spawn. Simultaneously, spawning carp were captured via boat electrofishing in Nokomis. 211 carp were captured in one day which reduced the biomass in Nokomis by 9.8 kg/ha. Box netting removed 493 individuals which reduced the biomass of carp in Nokomis by approximately 25.8 kg/ha. Electrofishing CPUE catch rates from surveys conducted in 2019 were quite variable (46 at the highest, and 2.4 at lowest). Even with the lowest catch rate and the average sized carp captured, it estimates a carp biomass only marginally below the management threshold (estimated 83.8 kg/ha with a threshold of 100 kg/ha). The average CPUE biomass estimate was 372.2 kg/ha, more than three times the management threshold.

Bluewater Science conducted vegetation surveys as well as fall young of year trap net surveys in order to track change over time and to monitor for carp recruitment. Mini trap netting completed by Bluewater Science during the course of the project period showed no young of year carp captured in Lake Nokomis in 2016, 2018, nor 2019. No young of year carp were captured in Solomon Wetland in 2019 but were captured in 2018 by WSB. Many young of year carp were captured in Legion Lake in 2019, but none in Mother. Results of fisheries assessments show diverse assemblages of fish species in Taft, Solomon, and Nokomis Lakes, while Legion and Mother Lakes support low diversity, tolerant fish species assemblages. These assessments indicate that Legion Lake and Solomon wetland act as carp nurseries.

Vegetation surveys (point-intercept) completed for Taft Lake and Lake Nokomis show the presence of aquatic invasive species in both lakes with Lake Nokomis supporting growth of Eurasian water milfoil and curly leaf pondweed and Taft lake supporting curly leaf pondweed. In Lake Nokomis, submergent aquatic vegetation abundance is limited, ranging from 11% to 29% frequency of occurrence between 2011 and 2017. Species diversity is quite low with a maximum of 10 different species surveyed in 2014 and eight (8) species found in 2017. Submergent aquatic vegetation abundance and diversity may be limited by low secchi depth, lack of adequate littoral areas, and an abundance of carp. No major shifts in aquatic vegetation abundance were documented since carp biomass was not significantly reduced during the project period in Lake Nokomis.

Six new radiotags were implanted in October and their locations were tracked in November. Side scan sonar and telemetry surveys done in early November did not indicate an appropriate aggregation to initiate

commercial open water netting before ice covered the lake. These radio tags were monitored in November and early December in preparation for a carp removal, but high water levels and thin ice prevented commercial crews from competing carp removal activities.

AMENDMENT REQUEST February 4, 2020

We are requesting funds be shifted between several categories, to reflect the realities of project expenditures on the ground. The total funding amount is not requested to change, nor are the outcomes of the project. Essentially, we are requesting to allocate the budget line called “unallocated at this time” into several existing budget line items, primarily to provide additional funding to carp netting and removal, which was more challenging than expected. The specific modifications requested are:

- The Unallocated budget would be reduced by \$21,221 to a revised budget of \$0.
- The Personnel budget would be increased by \$2,094 to a revised budget of \$3,900
- The Professional Contracts: WSB Engineers budget would be reduced by \$1,523 to a revised budget of \$102,500
- The Professional Contracts: Blue Water Science budget would be increased by \$400 to a revised budget of \$26,400
- The Professional Contracts: Carp Netting budget would be increased by \$17,350 to a revised budget of \$48,350
- The Equipment/Tools/Supplies budget would be increased by \$2,900 to a revised budget of \$7850

Adjustment of these budget line items necessitates adjustments in the budgets for activities 2 and 3, as follows:

- Activity 2 would be reduced by \$10,000 to a revised budget of \$73,000
- Activity 3 would be increased by \$10,000 to a revised budget of \$64,000

In order to be properly reimbursed, we must request that this amendment be made retroactive to the initiation of the project. The reason for this request is one of practicality. It would have been difficult to predict exactly the cost of carp removal and associated administrative and equipment costs until that work was underway—at which time it would have been impossible to stop work and request an amendment. Carp removal was far more challenging than expected and staff and consultants needed to remain nimble and work as needed. We appreciate your consideration of this amendment so that we can be reimbursed the full amount of the grant.

Amendment Approved by LCCMR 2/5/2020

Overall Project Outcomes and Results:

Survey data and anecdotal information suggested that invasive common carp were abundant in the project area and were negatively impacting water quality and ecological integrity. Objectives of this project were to quantify the carp population; study movement patterns to identify carp nurseries, migration routes, and aggregation areas; and removal of carp.

The general approach was to use standardized methodology to develop a carp population estimate for all waterbodies within the subwatershed while simultaneously tracking movement of carp within and between waterbodies using high frequency radio tags surgically implanted in adult carp. Results show that the biomass of carp (>260 pounds/acre) is roughly three times the identified threshold of 89 pounds/acre. This may be leading to increased internal phosphorous loading and significant reduction in submergent aquatic vegetation.

During the course of the project, it was determined that carp are using a small wetland between Lake Nokomis and Taft Lake as a nursery site, and carp aggregate most densely during late fall/early winter during open water in the southeast portion of Lake Nokomis. This data provided project partners the ability to target migrating and aggregating carp for removal. Through the use of electrofishing, gill nets, and baited box nets, 6,508 pounds of carp biomass (32 pounds/acre) were removed from the system. While the total carp biomass removed to date is

only 10% of the population, a long-term Carp Integrated Pest Management Plan, was developed to guide future management within the system, using foundational carp population data and “lessons learned” from successful and unsuccessful carp removal events.

By following the plan to sustainably reduce the carp population within the system, dramatic reductions in internal phosphorous loading should be achieved, resulting in improved water quality, an increase in aquatic vegetation abundance, and an improved fishery.

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Ecological Data Collection and Assessment

Description:

Ongoing quantification of carp biomass and aquatic vegetation extents and diversity will be performed. Carp will be assessed through mark and recapture activities, as well as fin ray or otolith study to determine age structure of carp fishery. Annual point intercept vegetation surveys and ongoing water quality and clarity monitoring will determine response to management activities.

Summary Budget Information for Activity 1:

ENRTF Budget: \$ 52,000
Amount Spent: \$ 52,000
Balance: \$ 0

Outcome	Completion Date
1. Determine carp population, age structure, recruitment	7/1/2017
2. Document reduction in carp population and provide guidance for changes in methodology	3/31/2019
3. Document response of aquatic vegetation and water quality to carp management	8/1/2019

Activity Status as of February 1, 2017:

In preparation for data collection on carp migration and population estimates, a MN DNR fisheries research permit was secured on October 4, 2016. The permit allows project participants to capture carp to implant high frequency radio tags and complete electrofishing and netting surveys to collect population data.

In addition to data collection on the carp population, project partners completed a fisheries assessment, point-intercept aquatic vegetation survey, and collected data on water quality metrics. This data will be considered a baseline for comparison to the same metrics post carp biomass removal.

The first electrofishing survey was completed on October 19, 2016. Survey time was 126 minutes. A total of 28 carp were captured resulting in a catch per effort of 13.3 carp/hour. Using the boat electrofishing catch per unit effort (CPUE) model, we calculated a density of 65.7 carp per hectare or 238 kg/ha for the first Nokomis survey. Age structures (pectoral fin ray) were removed for analysis and are being examined with results expected for the next LCCMR activity status report. The left pectoral fin ray was completely removed as a mark to be used as part of a mark/recapture population estimate. All fish captured in 2017 will be marked with this same mark and released to be recaptured during removal operations.

A second electrofishing survey was completed on November 3, 2016. This survey resulted in the capture of 9 carp over a 66-minute period. Aging structures (pectoral fin ray) were removed and a mark (left pectoral fin clip) was applied like the first survey. This data revealed a CPUE of 8.4 carp/hour, 42 carp/ha, and 154.7 kg/ha carp biomass. The average biomass calculation for these two surveys was 196.5 kg/ha or double the 100 kg/ha threshold value identified by Bajer 2009. Previous surveys completed by the University of Minnesota in 2014

and 2015 show the carp biomass estimate to be 298 kg/ha and 373 kg/ha respectively. These surveys were completed in September and July during warm water periods which may have influenced the CPUE values.

One electrofishing survey was completed for Taft Lake on October 25, 2016. Water temperature was 54°F and electrofishing time was 62 minutes. A total of five (5) carp were captured or a CPUE of 4.84 carp/hour. This resulted in an estimate of 25.8 fish/ha or 81 kg/ha. No previous survey data is available for comparison, but this sampling event results in a whole lake carp biomass close to the 100 kg/ha threshold identified in the literature. All five carp were given a right pectora fin clip for completing a mark/recapture population estimate. These structures were retained for aging analysis.

Mother Lake was sampled on November 16 and 17, 2016 using gill nets. Nets were 150’ in length, 6’ deep and had 7” stretch. One net was set on the west side of the lake and the other on the east. No fish (carp or gamefish) were captured in the net or observed while on the water.

Project participants were not able to gain access to Legion Lake in 2016 but plan to set gill nets in 2017 if access is allowed.

Lake Nokomis was sampled with trap nets on October 25-27, 2016. Nets were set for 2 nights with six net sets for a total of 12 net nights. Large fyke nets (6 x 4’ frame, 3/8” mesh size) were used for sampling. Eleven species were captured. Bluegill, yellow perch, and black crappies dominated the catch accounting for 91% of the total catch (bluegill made up 42% alone). No carp were captured during the trap net survey period.

A point-intercept plant survey was completed for Nokomis Lake on August 5, 2016. A total of six (6) different species were documented in this survey. Of the 173 points sampled, 14% were vegetated. This results in 24 acres of Nokomis Lake supporting aquatic vegetation or roughly 25% of the littoral area.

Water quality sampling was completed on numerous sites around Nokomis Lake and within Taft, Mother, and Legion Lakes. Specific assessment metrics include total phosphorous (TP), soluble reactive phosphorous (SRP), chlorophyll-a, and secchi depth. We plan to develop baselines for each metric based on historical data and compare those to post carp biomass removal data to determine the effect of biomass removal on those metrics.

The table below shows the long-term averages for each of the metrics compared to the 2016 average growing season concentrations (Table 1).

Lake	Total Phosphorous (ug/l)		Soluble Reactive Phosphorous (ug/l)		Chlorophyll-a (ug/l)		Secchi Depth (m)	
	LT	2016	LT	2016	LT	2016	LT	2016
Taft	98	84	26	6	41	13	1.24	1.52
Legion	180	115	50	25	NA	NA	NA	NA
Mother	62	34	5.3	7	19.9	5.46	NA	NA
Nokomis	NA	NA	NA	NA	NA	NA	NA	NA

Table 1: LT- Long term average. Mother 2011-2016 (provided by MCWD), Taft 2009-2016 (provided by City of Richfield), Legion 2009-2016 (provided by City of Richfield) ,

The full data set for Lake Nokomis was not available at the time this report was drafted but will be included in future LCCMR activity reports.

Activity Status as of August 1, 2017:

Three (3) electrofishing surveys were conducted in 2017 January through July. The main objective to capture carp for the purpose of radio-tagging and collecting aging samples and secondarily, time and catch was recorded to calculate catch per unit effort (CPUE) estimate of population. On April 12, 2017 an electrofishing survey was done in Lake Nokomis and one transect lasting .5 hours was traversed and a total of 14 carp were captured. Using an electrofishing CPUE model developed for estimating carp abundance, a value of 511.35 kg/ha is being

reported for this date. Eleven (11) carp captured on this date were removed from the system so that aging structures could be processed and the remaining three (3) carp were implanted with radio-tags and released in Lake Nokomis.

The second survey was conducted on April 25, 2017 in Lake Nokomis. One transect lasting 0.98 hours was traversed and a total of 26 carp were captured. The CPUE model returns a value of 433.14 kg/ha on this date. Changes in catch rates is expected to occur through April – June are months where carp are known to migrate. Therefore, data points collected through this time period will not be used for final population estimate reporting but can monitored and compared to Nokomis Lake surveys that will be conducted on or near this date in the future.

The third survey was conducted on July 11, 2017 for the purpose of collecting carp for aging structures (otoliths) and to collect data so that a CPUE estimate could be calculated. The timing of this survey occurred after projected migration of carp into or out of Lake Nokomis had concluded and data can be used in the final CPUE estimate of population. The first transect lasted 0.43 hours and a total of nine (9) carp at an average weight of 3.07 kg were captured which calculates to 309.2 kg/ha. The second transect lasted 1.07 hours and a total of 39 fish were captured, using the same average weight used for the first transect, an estimate of 612.7 kg/ha has been developed. The CPUE estimate for this survey date is 461.0 kg/ha. 36/39 carp captured on this date were removed from the system so that aging structures could be collected. Biomass removed is reported under Activity 3.

To date, a total of 52 carp remain in the system marked with a left-pectoral fin clip so that they can be used to calculate a mark-recapture estimate of the population of carp in the subwatershed. Fish have not been recaptured to the extent to which eliminates likely statistical error, so these numbers are not being reported at this time. Catch rates and ratios of marked to unmarked fish will be continually monitored.

Point-intercept plant surveys and fishery trap net surveys will be conducted by Bluewater Science in the Fall of 2017 and will be reported on in the next reporting period ending on February 1, 2018.

Water quality sampling was completed on numerous sites around Nokomis Lake and within Taft, Mother, and Legion Lakes. Sampling was completed by Minnehaha Creek Watershed District, Minneapolis Park and Rec Board, and WSB staff under separate programs and not as part of this LCCMR project. However, this water quality data will be incorporated into our overall baseline assessment of the basins within the Nokomis Subwatershed and reviewed post carp removal to detect any initial shifts in water quality due to the removal of carp biomass which we anticipate will reduce internal loading.

Activity Status as of February 1, 2018:

We are using two methods to estimate carp abundance in the Nokomis subwatershed. One method will be to employ a multiple mark and recapture estimate. Fish captured in Nokomis and Taft Lakes will be marked with a unique fin clip. In 2016 Nokomis carp received a left pectoral fin clip and carp from Taft received a right pectoral fin clip. This mark that was employed late in 2016 was used for recapture estimates in 2017. Throughout the field season of 2017, marks were employed in the sub-watershed that included left pectoral fin clips in Nokomis and will be used to estimate population in the case of recapture in the 2018 field season. During the 2018 field season, we anticipate marking carp captured in Lake Nokomis with a left pelvic fin clip and marking carp captured in Taft Lake with a right pelvic fin clip, and marking fish captured in Legion Lake with a top caudal fin clip. These marks will be used to estimate a mark-recapture estimate in 2018 and 2019 in the event of recapture.

The second method will be to fit fall electrofishing catch per unit effort (CPUE) data to a model developed by researchers at the University of Minnesota. This model uses CPUE (# of carp/hour) to estimate density (kg of

carp/hectare). Data collection will be standardized for this project by electrofishing known index stations previously completed by U of MN researchers on Lake Nokomis and surveying the entire shoreline of Taft Lake and Mother Lake. We do not anticipate using this method for Legion Lake as there is no boat access.

Biomass is calculated by establishing an average carp weight, multiplying by the PE, and dividing by lake acreage. Lake Nokomis Carp Catch Per Unit (CPUE) Electrofishing Survey data collected to date:

Date	Transect	Total Time (min.)	# Carp	Carp/hour	Biomass Est. (kg/ha)
10/19/2016	1	126	28	13.3	238.4
11/3/2016	1	30	5	10.0	182.0
	2	36	4	6.7	125.6
	Average				153.8
4/12/2017	1	30	14	28.0	511.4
4/25/2017	1	58	26	25.48	433.1
7/11/2017	1	26	9	20.79	309.2
	2	64	39	41.73	612.7
	Average				460.9
8/30/2017	1	21	11	31.4	463.4
	2	24	8	20	298.5
	3	31	15	28.8	425.8
	Average				395.9
9/27/2017	1	34	2	5.4	87.4
	2	15	3	20	298.5
	3	15	7	28	414.2
	Average				266.7

Taft Lake Carp Catch Per Unit Effort (CPUE) Electrofishing Survey data collected to date:

Date	Transect	Total Time (min.)	# Carp	Carp/hour	Biomass Est. (kg/ha)
10/25/2016	1	24	2	5	94.1
	2	19	1	3.13	63.0
	3	19	2	6.3	115.8
	Average				91.0

Mother Lake Carp Catch Per Unit Effort (CPUE) Electrofishing Survey data collected to date:

Date	Transect	Total Time (min.)	# Carp	Carp/hour	Biomass Est. (kg/ha)
5/17/2017	1	28	0	0	-
10/24/2017	1	54	0	0	-

To guide management decisions and report biomass estimates based on CPUE estimates, survey dates that have parameters (i.e. date, water temperature) that fall outside of the model specifications, are excluded and are reported below. These estimates will be refined throughout the remainder of the study. Similar surveys are scheduled for the 2018 field season.

Reporting Date	Lake	Biomass Estimate (kg/ha)
12/31/2017	Nokomis	340.5
	Taft	91.0
	Mother	No carp detected

Activity Status as of August 1, 2018:

Bluewater Science has completed meander surveys for curly leaf pondweed in Taft and Nokomis to develop bed maps as part of the baseline data collection. Point-intercept surveys will be completed in August 2018.

Activity Status as of February 1, 2019:

A mark-recapture method of estimation was attempted using capture data from box net removal efforts in October 2018 and one electrofishing survey was completed on October 9, 2018.

In the box net removal, a total of 211 carp were captured over three events, one (1) fish was marked with a right pelvic fin clip and five (5) fish were marked with a left pelvic fin clip. At the time of this removal effort, 70 carp remained marked in the system with a left pelvic fin clip. Using this data, it is estimated that 167.9 ± 125.2 kg/ha resides in Lake Nokomis. The variability of the estimate is large since a small number of recaptured carp was achieved and this estimate will not be used in reporting final biomass estimate for lake Nokomis. These metrics will be continually tracked through the end of this project period in case a more reliable estimate can be made using mark-recapture.

Following box net removal on October 9, 2018, an electrofishing CPUE survey was conducted. Two transects were traversed capturing a total of 30 carp (Table 2). The average weight of all carp captured in 2018 was used to calculate carp biomass in kg/ha. Using an average weight of 5.6 kilograms (12.3 lbs), the 2018 CPUE estimate resulting from this survey is 776.3 ± 94.1 kg/ha. This survey is not reported in the final summary of CPUE estimates because it was targeting carp for removal, violating an assumption of the model. Carp have increased in average weight from 3.1 kg in 2017 to 5.6 kg in 2018 and in part can explain the increase in total biomass (kg/ha). In 2019, a more robust survey is planned for late summer thru early fall when water temperatures are between 59-77 °F to strengthen the CPUE estimates.

Date	Transect	Total Time (min.)	# Carp	Carp/hour	Biomass Est. (kg/ha)
10/9/2018	1	35	19	32.6	776.3 ± 94.1
	2	26	11	25.4	

Table 2: Catch per unit effort population survey estimate on Lake Nokomis in 2018.

Activity Status as of December 31, 2019:

Carp biomass estimates were again updated in the late summer- fall of 2019 with three visits to the lake on July 17, July 23, and August 13. In 2019, there is a large variability between survey dates that could be explained by removal activities that were being completed on Lake Nokomis. These surveys were completed amongst carp removal activities via baiting and box netting in three locations on Lake Nokomis (Activity 3) and it is unknown how this activity changes carp dynamics in the whole lake. The resulting CPUE estimate in 2019 is 372 ± 321 (Table 3).

On June 5, 2019, Mother Lake was sampled via boat electrofishing to complete a CPUE estimate and confirm a presence/absence of carp in this basin. In the Fall of 2018, a connection to Taft Lake had been restored with culvert maintenance under Cedar Ave/Hwy 77. Zero (0) carp were captured in this sampling event and no carp were observed in the basin (Table 3). It was confirmed that no adult carp reside in Mother Lake but the possibility does exist that movement between Taft Lake and Mother could occur.

Lake	Date	Transect	Total Time (min.)	# Carp	Carp/hour	Biomass Est. (kg/ha)/Transect	Biomass Est. (kg/ha)/Year
Nokomis	7/17/2019	1	19.6	15	45.9	965.0	372 ± 321
		2	18.75	10	32.0	676.5	
	7/23/2019	1	23.25	4	10.3	227.3	
		2	23.5	5	12.8	277.9	
		3	31.25	3	5.8	132.8	
	8/13/2019	1	25	1	2.4	63.1	
		2	20	1	3.0	75.6	
		3	12.5	1	4.8	112.9	
	Mother	6/5/2019	1	52.8	0	0	

Table 3: 2019 electrofishing CPUE survey data by date and transect on Lake Nokomis and Mother Lake.

In the springtime of 2019, during a telemetry survey to locate radio-tagged carp within the sub-watershed, it was discovered that a winterkill had occurred on Taft Lake, leaving behind many carp carcasses. This event was reported to the MN DNR Conservation Officer, UMN Minnesota Aquatic Invasive Species Research Center and project partners in April 2019 and the MN DNR reported to MPRB that this winterkill was likely caused by winter-time hypoxia and laboratory results are still pending from the research center.

Blue Water Science sampled Lake Nokomis, Legion Lake, and Solomon Wetland in the fall of 2019 using trap-nets. These surveys were completed to assess the fishery as a whole and to confirm the presence or absence of young of the year common carp. In Legion Lake, 60 young of the year carp/trap-net were sampled on October 31, 2019 ranging from 3-5.5 inches. Zero (0) young of the year carp were sampled in Nokomis or Solomon in 2019, however, it should be noted that young pike were sampled in Solomon, indicating this basin may serve as a nursery for more than just young common carp that were sampled here in 2018.

In the Springtime of 2019, gill nets were set in the inlet and outlet area of Solomon wetland to capture the movement of carp through these connections. In total, 13 adult common carp were captured and removed from this Solomon Wetland, eleven (11) at the outlet to Nokomis moving upstream into the basin and two at the inlet from Taft Lake, direction of movement is unknown. This confirms that there is some immigration into Solomon Wetland in 2019 during known spawning migration.

Final Report Summary:

Common carp population estimates in Nokomis Sub-watershed

Population estimates have been developed for Nokomis, Taft and Mother Lake. Only presence/absence has been determined for Legion Lake and Solomon Wetland due to accessibility to these lakes with sampling equipment. Population estimates have been developed by using two methods: a boat electrofishing catch per unit effort (CPUE) model of estimation and a mark-recapture model of estimation.

Lake	Method	Biomass Estimate (kg/ha)	Presence/absence
Nokomis	CPUE	318 ± 67	Present
Nokomis	Mark-recapture	144 (+ 250 – 79)	Present
Taft	CPUE	91 ± 22	Present
Mother	CPUE	0	Absent

Legion	n/a	n/a	Present
Solomon	n/a	n/a	Present

Table X: Summary table of carp biomass estimates and presence absence on Nokomis sub-watershed lakes.

CPUE model of estimation:

The CPUE model for estimating common carp biomass in a basin was developed at the University of Minnesota in 2009 (Bajer, 2009). This model uses the number of carp captured standardized by time spent electrofishing to estimate density of carp per hectare in a waterbody (Equation 1).

$$\text{Density/hectare} = 4.71 * \text{carp captured per hour} + 3.04$$

Equation 1: Electrofishing catch per unit effort (CPUE) equation of estimating density of carp within a basin.

This model gives researchers a chance to get a snapshot of carp relative abundance in a basin at the time of the survey. Multiple surveys are completed in one season between August and October when water temperatures are between 59-77 °F. Multiple surveys are completed to reduce the bias due to environmental conditions and the density is averaged and multiplied by average weight of fish to report a biomass estimate in kilograms per hectare in that year. The standard deviation from the mean value represents the variation in catch rates between survey dates in a given year.

Lake Nokomis:

The most robust electrofishing sampling was completed in Lake Nokomis in 2016, 2017, and 2019. In this report, we are including data collected prior to the start of this project by University of Minnesota researchers who completed CPUE surveys in 2014, and 2015 on Lake Nokomis to show a trend over time (Figure 2). It should be noted that UMN researchers reported catching one young of the year carp in their 2014 survey.

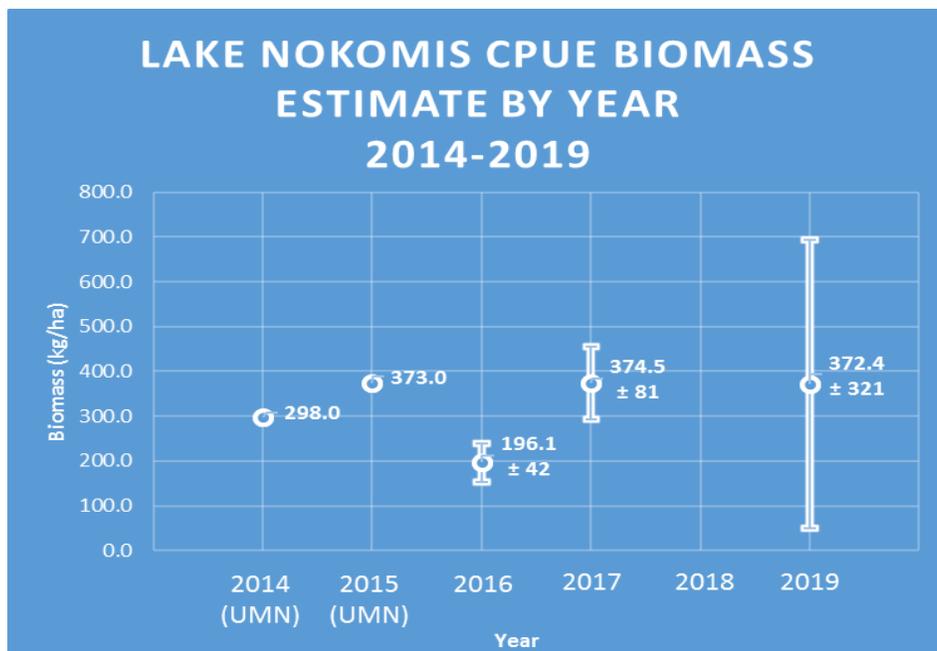


Figure 2. Lake Nokomis Carp Electrofishing CPUE Annual Biomass Estimates (kg/ha).

Electrofishing surveys in 2014 and 2015 were completed by researchers at the University of Minnesota (UMN) on Lake Nokomis; A data set describing transect data was not available to develop a standard deviation in 2014/15. A CPUE survey was not completed in 2018.

In 2019, electrofishing CPUE surveys were completed on July 17, July 23, and August 13 and resulted in variable daily estimates (Table 4). This variation in the catch rate per day may be attributed to the transects surveyed and the distribution of fish throughout the survey period. It should also be noted that carp removal was ongoing throughout the survey period that may have changed the distribution of carp in Lake Nokomis (Table 5). It is unknown how baiting and box netting change the distribution of fish in a whole lake, but it is possible that this activity, along with other environmental conditions, may have changed the dynamics of fish within the Nokomis basin during the survey period.

Lake	Date	Transect/ Time (hr)	# Carp Captured	CPUE estimate (kg/ha) by transect	CPUE Estimate (kg/ha) by date	2019 CPUE estimate
Nokomis	7/17/2019	T1/.33	15	964.9	820.8 ± 144.2	372.4 ± 321.4
		T2/.31	10	676.5		
	7/23/2019	T1/.39	4	227.3	212.7 ± 60.2	
		T2/.39	5	277.9		
		T3/.52	3	132.8		
	8/13/2019	T1/.42	1	63.1	83.8 ± 21.1	
		T2/.33	1	75.6		
		T3/.21	1	112.9		

Table 4. 2019 Carp Electrofishing CPUE

Date	Method	# Carp Removed	Total Wt (kg) removed	Total Wt (kg/ha) removed
5/30/2019	Electrofishing - Spawning fish capture	211	798.30	9.802
May-19	Solomon Gill Netting @ Inlet/outlet	13	54.83	0.673
7/19/2019	Box Net Pull #1	310	1220.12	14.982
7/25/2019	Box Net Pull #2	4	15.45	0.190
7/26/2019	Box Net Pull #3	38	183.54	2.254
8/14/2019	Box Net Pull #4	73	358.75	4.405
8/23/2019	Box Net Pull #5	52	244.18	2.998
9/13/2019	Box Net Pull #6	16	76.96	0.945
2019 Totals	All	717	2952.1	36.2

Table 5: 2019 Carp Removal Summary

Carp removal was ongoing throughout the 2019 CPUE survey period and may have changed the dynamics of fish within the Nokomis basin, affecting the survey data by date.

Taft:

Taft lake was sampled on October, 25 2016 to complete a CPUE survey and to capture carp to implant with radio-tags. This is the only survey that was completed on Taft Lake in this project period and resulted in an estimate of 91 ± 22 kg/ha (Table 6). Carp ranged from 21.6 to 25 inches in length and no young of the year were

observed or sampled. Multiple surveys were not pursued on Taft Lake because of the difficult access conditions, however multiple trap net surveys were conducted by Blue Water Science that found no young of the year carp. This indicates that Taft Lake is not likely a nursery site for young carp.

Lake	Date	Transect/Time (hr)	# Carp Captured	CPUE estimate (kg/ha) by Transect	CPUE estimate (kg/ha)
Taft	10/25/2016	T1/.40	2	94.1	91.0 ± 22
		T2/.32	1	63.0	
		T3/.32	2	115.8	

Table 6: Taft Lake Electrofishing CPUE Biomass Estimate (kg/ha)

Mother:

Mother Lake was sampled in 2017 and 2019 to complete a round of presence absence in the springtime (2017) and conduct CPUE surveys (2017, 2019). Over the course of two (2) CPUE surveys, zero (0) carp were captured or observed resulting in an estimate of 0 kg/ha (Table 7).

Lake	Date	Transect/Time (hr)	# Carp Captured	CPUE estimate (kg/ha) by Transect	CPUE estimate (kg/ha)
Mother	5/15/2017	Presence/Absence	0	NA	NA
	10/24/2017	T1/.90	0	0	0
	6/5/2019	T1/.88	0	0	0

Table 7: Mother Lake CPUE and presence/absence surveys completed via boat electrofishing.

Legion and Solomon (presence/absence):

Legion Lake was not sampled with an electrofishing boat because access to this basin is limited. However, the shallow basin was visited on a number of occasions to check for radio-tags that may have moved into the basin from either Lake Nokomis or Taft Lake and WSB water quality checks as part of a project ongoing with the City of Richfield. In one of these visits in the spring of 2016, WSB scientists observed a number of adult carp in the outlet stream where it enters a culvert near HWY 62 in the northeast corner of Veteran’s Park. Although anecdotal, this suggests that some migration into or out of this basin may exist. Additionally, Blue Water Science set trap-nets as a part of this project in the basin in 2019 and sampled young of the year common carp. This implies that Legion Lake may act as a source of carp for the greater sub-watershed.

Solomon Wetland was not sampled with an electrofishing boat because access to this basin is limited. It was sampled via gill nets in 2017 and 2019 and occasionally checked for the presence of radio-tags by WSB and sampled by Bluewater Science with trap-nets in 2018. Radio-tags from Taft Lake were found to have moved into Solomon in the spring of some years while radio-tags that were implanted into adult carp captured via gill nets in spring of 2017 moved back to Nokomis. Subsequent trap-net sampling in the fall of 2018 found the presence of young of the year carp in Solomon. This data suggests that Solomon Wetland likely acts as a source of carp for the greater sub-watershed.

Mark-recapture model of estimation:

This method uses a ratio of marked to un-marked fish to estimate the number of individuals in a waterbody. Accuracy of this method rests on the following assumptions being met: 1) no individuals immigrate or emigrate

during the sampling period, 2) each individual has an equal chance of being captured, 3) sufficient time between initial marking period and recapture is allowed for individuals to disperse throughout the population, and 4) marks remain distinguishable throughout the sampling period (Chapman, 1951). To avoid violating these assumptions, carp were marked with a unique fin clip by year and the final calculation uses only fish marked and recaptured in the 2019 sampling period.

Lake Nokomis:

Throughout the project period, a total of 95 carp were marked with a left pectoral fin clip (2016 & 2017), left pelvic fin clip (2019) or radio-tag (2016 & 2017) in Lake Nokomis. In 2019, multiple marking and recapture events occurred (Table 8). To account for the fact that marks were added, and some marks were removed during removal operations, a Schnabel formula was used to calculate the mark-recapture estimate of population. This equation sums each event total number of marked fish at the time of sampling multiplied by the number of fish examined in that event and divides by the total number of recaptured in the sampling period, in this case 2019 sampling period (Equation 2). The returned value is the number of individuals estimated to be in the basin, then, the average weight (kg) of carp captured in the sampling period and lake size in hectares is used to calculate biomass in kg/ha (Table 9).

$$\text{Schnabel} = (\text{SUM}(\text{Marked} * \text{Examined})) / \text{Total Recaptured}$$

Equation 2: Schnabel equation

This equation takes into account multiple events where an animal is marked and released over a sampling period specified sampling period, in this case, the 2019 sampling period.

A Poisson distribution table is used to calculate the variation in the estimate. In this case, six (6) carp were recaptured in the 2019 sampling period and used in the Schnabel formula to calculate the population estimate. Using a Poisson distribution table, 13.1 was used as the upper limit and 2.2 was used for the lower limit. This type of distribution was used because of the low number of marked and recaptured fish in this sampling period. A Poisson distribution helps to define the variability in the data with the consideration that the number cannot be zero.

2019 Capture Event	# of carp captured	# of Recaptures	# new/unmarked carp captured	Total number of carp tagged
1	25	0	25	0
2	310	3	307	25
3	12	0	12	22
4	42	1	41	34
5	3	0	3	34
6	141	2	139	37
Total		6		

Table 8: 2019 Mark-Recapture Data

Total number of carp tagged in Lake Nokomis; takes into account the marked fish that were removed in removal events.

	Schnabel	Poisson Upper (13.1)	Poisson Lower (2.2)
N (est. # individuals)	2460.2	1126.8	6709.5
2019 Avg wt (kg)	4.79	4.79	4.79

Total wt (kg)	11784.2	5397.3	32138.7
Total ha	81.3	81.3	81.3
kg/ha	144.9	66.4	395.3

Table 9: Schnabel Estimate using a Poisson Distribution to Show Variability

Summary of Lake Nokomis population estimate - methods and results:

A mark-recapture estimate and the 2019 electrofishing CPUE estimate are plotted together to see how they relate to one another (Figure 3). Both have a large range of variability. The electrofishing CPUE estimate in 2019 has a large range due to the variability in catch rate between survey dates. The mark-recapture estimate has a large range due to the low number of fish marked and recaptured in the survey period. Using this data, researchers are not able to predict the exact number of fish in Lake Nokomis, however, it is clear using this data and taking into account survey data from 2014-2017 (Figure 2) the trend suggests that biomass is elevated well above the threshold of 100 kg/ha.

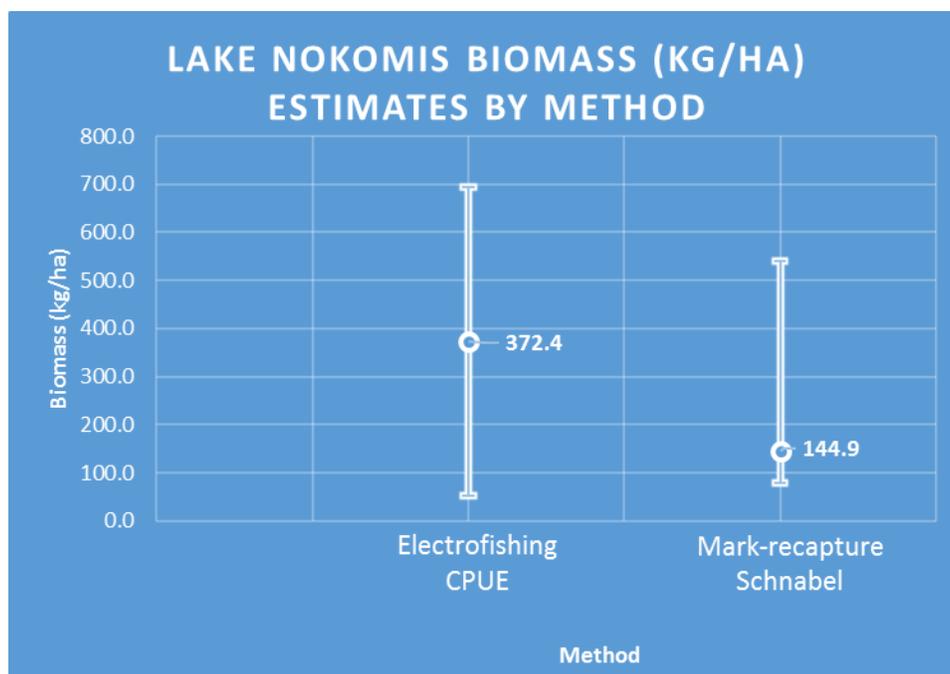


Figure 3: 2019 Electrofishing CPUE Estimate and 2019 Mark-Recapture Estimate of Population (kg/ha) in Lake Nokomis

Initially the mark-recapture estimate was planned to be completed as a way to validate the CPUE estimate and provide a more accurate estimate of carp abundance. The recapture event was planned to be completed with a large-scale removal. Since this did not happen, recaptured carp were collected during electrofishing and box netting, but in small numbers. This method of mark-recapture resulted in the large variability in the estimate. Additional marking and large-scale removals in a future phase of carp management may provide the ability to refine this mark-recapture estimate.

Movement data collected throughout this project period suggests that carp do leave the Lake Nokomis main basin in the springtime but return to the basin for the remainder of the year. Using this data, we assume that fish do not emigrate from the system and the rate at which they immigrate, or recruit to the system, is currently unknown. Relying on the assumption that fish do not emigrate or immigrate to the system, we can look at the trend over the 2016-2019 project period and pre-project data collected by the University of Minnesota

researchers to predict a rough estimate of population. The average of all CPUE survey data through 2014-2019 is 318 ± 67 kg/ha. For the purpose of recommending future management actions, we will assume the carp population estimate in Lake Nokomis is >300 kg/ha.

Aging carp in the Nokomis Sub-watershed

A subset of carp fin-rays and otoliths were collected as aging structures. In 2016, an attempt was made to read fin-rays as a method of estimating the age structure of carp within Lake Nokomis. It was quickly determined that carp ages were hard to discern after age 13 and it was decided that a subset of otoliths (ear-bones) would be collected, thin sectioned, and read under a 10x microscope. Using this data, it is suggested that carp were recruiting to Lake Nokomis in almost all years between 1999 – 2011 (Figure 4).

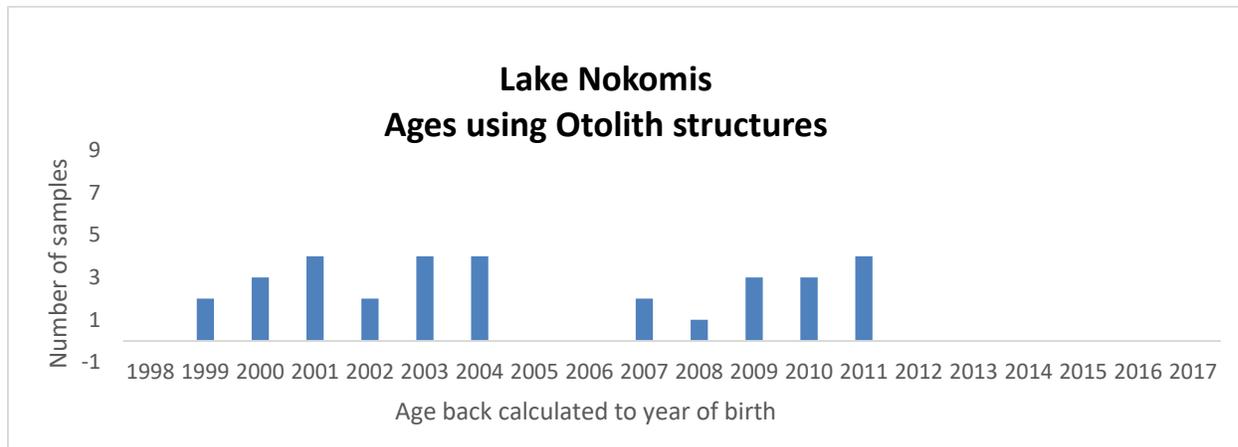


Figure 4. Carp Ageing Analysis using Otoliths as the Ageing Structure

To begin attributing carp recruitment years to environmental conditions, the aging data was charted against water levels reported on Lake Nokomis (Figure 5). Although some variation exists, it appears that carp recruitment follows high water years in Lake Nokomis but does not follow all high-water years. As data is collected as carp management continues, this aging data may help to strengthen hypothesis on what factors effect carp recruitment to occur in Lake Nokomis. More data collected on aging data within the Nokomis basin would help to further define age classes present in Lake Nokomis. Under this study, only 32 carp were aged using the otolith structure.

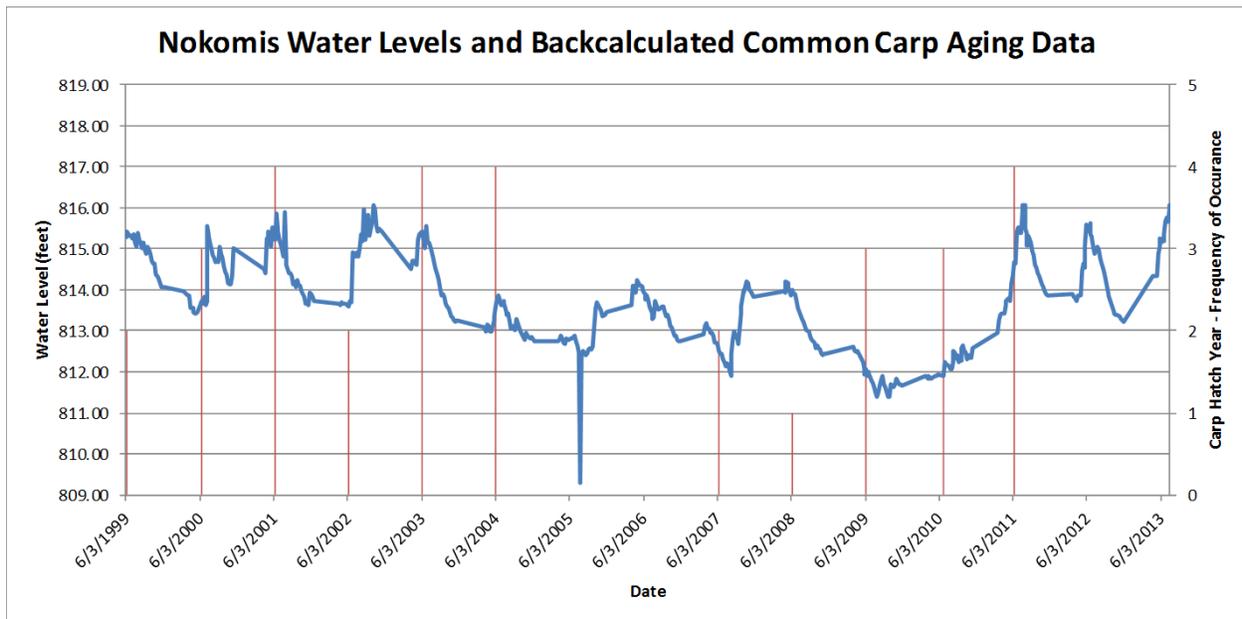


Figure 5. Nokomis Historical Water Level Elevations (Line) and Carp Ages (Bars)
Carp ages are back-calculated to year of hatch.

Point-intercept vegetation surveys and water quality monitoring in Lake Nokomis

Vegetation:

Point-intercept vegetation surveys have been ongoing since 2010 by Blue Water Science in Lake Nokomis. Data shows that the Lake Nokomis vegetative community exhibits relatively low diversity and quality and dominated by invasive Eurasian watermilfoil. Eurasian watermilfoil has dominated the community for 6 out of 8 years (Table 10) and coontail, an unrooted submergent aquatic plant, is a co-dominant (McComas, Appendix C). The ability of submergent and emergent aquatic vegetation is limited by a variety of factors including a limited littoral area and the presence of rough fish (common carp).

Year	Survey month	# of Species	Plant Coverage (ac)	Most abundant species
2010	September	2	13	Eurasian watermilfoil
2011	July	3	12	Eurasian watermilfoil
2012	August	3	15	Eurasian watermilfoil
2013	July	8	22	Eurasian watermilfoil
2014	August	10	32	Eurasian watermilfoil
2015	August	8	29	Eurasian watermilfoil
2016	August	6	24	Coontail
2017	August	8	22	Coontail
2018	August	6	22	Coontail
2019	July	6	8	Coontail

Table 10. Lake Nokomis Vegetation Survey Metrics – Data Provided by Blue Water Science

Water Quality:

Lake Nokomis was listed as impaired in 2002 due to excess nutrients (phosphorous). Site specific water quality standards apply to lake Nokomis due to natural background conditions. These are identified as a total phosphorous concentration of 50 µg/l (0.05 mg/l), 20 µg/l chlorophyll-a, and a secchi depth of > 1.4 meters. Water quality sampling is ongoing and collected by the Minneapolis Park and Recreation Board. Water quality standards for total phosphorous have been met between 2014 and 2019, the chlorophyll-a standard has been exceeded in 2018 and 2019, and the secchi depth standard has only been met once in the last five (5) years (2014) (Table 11).

Year	Secchi (m)	Chl-a (ug/l)	Total P (mg/l)	TP TSI	Secchi TSI	Chl-a TSI
State Standard	>1.4	20 ug/l	0.05 mg/l			
2014	1.76	10.2	0.034	54.76	52.07	51.95
2015	1.34	11.1	0.038	56	55	54
2016	1.1	16.8	0.043	57.91	57.22	57.5
2017	1.08	19.2	0.049	59.01	55.66	58.28
2018	1.04	30.2	0.043	57.9	57.02	62.49
2019	1.17	25.9	0.044	59.26	57.9	61.53

Table 11. Lake Nokomis Cumulative Water Quality Data (2014-2019, May-September) – Data Provided by MPRB

The TMDL identifies a number of sources (internal and external) of phosphorous that limit the lake’s ability to meet established site-specific standards. To meet the standard a 35% reduction in phosphorous will be required, with the largest load reduction coming from internal loading, a portion of which is most likely contributed by carp bioturbation and secondary impacts.

Because carp biomass has remained elevated in Lake Nokomis throughout the project period, an attempt to correlate changes in vegetative (species diversity and abundance) and water quality has not been made.

ACTIVITY 2: Spatial Monitoring of Common Carp

Description:

Carp will be captured and surgically implanted with radio transmitters. Carp movement will be tracked for several years to determine seasonal movement throughout the subwatershed and spawning activities. The project area includes 4 separate lake basins (Lake Nokomis, Taft Lake, Mother Lake, Legion Lake) and one major stream (Minnehaha Creek).

Summary Budget Information for Activity 2:

ENRTF Budget: \$ 73,000
Amount Spent: \$ 73,000
Balance: \$ 0

Outcome	Completion Date
1. Determine whether carp populations within the four basins are distinct or one interconnected population.	6/1/2018
2. Identify winter aggregation sites within each of the four basins.	2/28/2019
3. Evaluate the necessity and viability of carp barrier installations between the major basins and Minnehaha Creek, should telemetry show migration between these water bodies.	6/1/2019

Activity Status as of February 1, 2017:

Eight (8) adult carp were captured on November 3, 2016 and surgically implanted with high frequency radio tags. Carp ranged in length from 21.6 to 35 inches in length. Carp were released immediately after tags were implanted. Subsequent telemetry surveys showed 100% survival.

Three (3) adult carp were captured and implanted with high frequency radio tags on October 25, 2016 in Taft Lake. Sizes ranged from 21.6 to 25 inches in length. Carp were released immediately after tags were implanted. Subsequent telemetry surveys appear to show little movement in the radio tagged carp. This may not be a good indicator of survival since Taft Lake is relatively small and the fish appear to be relating to a deep water area that contains aerators.

A total of two (2) telemetry surveys were completed for Nokomis Lake. The first on December 5, 2016 showed the radio tagged carp were slightly aggregated in the south central portion of the lake in 15-20 feet of water. The second survey on January 10, 2017, showed that three (3) radio tagged carp remained in the area identified in the December survey, two (2) had moved slightly north, and two (2) radio tagged carp were found along the north shore of Nokomis. The eighth radio tagged was located during this survey.

A total of four (4) telemetry surveys were completed on Taft between November 15, 2016 and January 10, 2017. All three tags remained in the Taft basin, and moved slightly between surveys, but stayed concentrated in deep water (30-40') near a set of aerators operated by the City of Richfield.

Activity Status as of August 1, 2017:

Of the fish captured on April 12, 2017, three (3) were radio tagged and two (2) fish captured on April 25, 2017 were radio tagged and released. This brought the total number of carp tagged in Lake Nokomis to 13 individuals. Three carp remain tagged in Taft, zero (0) in Mother, and zero (0) in Legion Lake. Additionally, gill netting was conducted in the Solomon Wetland and three (3) radio tags were implanted on June 7, 2017. Spatial monitoring of these carp showed movement into the Nokomis main basin by June 20, 2017.

Spatial monitoring of the 13 carp radio tagged in Nokomis, three (3) fish tagged in Solomon Wetland, and three (3) fish radio tagged in Taft continued throughout this reporting period and a total of 10 telemetry surveys were completed. Throughout this time, no carp that were originally tagged in Lake Nokomis were tracked outside of this main basin. On May 24, 2017 one (1) radio tag that was originally implanted in Taft Lake was detected north of Highway 62 in the Solomon Wetland. In response to this observation, carp in this basin were targeted for the purpose of implanting radio tags and on June 7, 2017 carp were captured in the gill net and three (3) radio tags were implanted in carp caught in the Solomon Wetland and released to this basin. These newly implanted carp along with the remaining 16 carp tagged in the subwatershed were tracked again on June 20, 2017 and spatial data collected on this date revealed the movement of 3/3 carp tagged in the Solomon Wetland to the Lake Nokomis basin.

In early June 2017, WSB employees observed common carp in the outlet stream of Legion Lake and entering the culvert that connects Taft Lake. In response to this observation a gill netting attempt was made at this location to capture carp to implant with a radio tag so that potential movement to a neighboring basin could be recorded. On June 22, no carp were present in the outlet stream of Legion Lake and a gill net was stretched in the main basin of Legion Lake where carp were observed nearshore. No carp were captured during this netting attempt, however, the confirmation of the presence of carp in Legion Lake makes it a priority to radio tag a number of fish in this basin when conditions allow to observe their potential movement throughout the subwatershed.

On May 15, 2017 an electrofishing boat was launched in Mother Lake and an electrofishing survey lasting 0.48 hours. Zero (0) carp were captured in this survey event. No carp have been observed in Mother Lake during this project period.

Spatial monitoring of carp will continue throughout Fall 2017 and a commercial seining event will be attempted if a tight aggregation of carp is observed in either open water or under ice cover. Fisherman were contacted in July 2017 to confirm their general availability for the coming Fall.

Activity Status as of February 1, 2018:

By using radio-telemetry data and tracking unique marks in the event carp are recaptured, it can be determined if carp are moving freely throughout the system and can be considered one population or if fish stay partitioned into separate basins and are distinct populations. Movement into the Solomon Wetland by carp radio-tagged in both Taft and Nokomis indicates that the populations do mix. Since these fish moved back to the lake they were originally tagged in, we suspect that these populations are distinct and mixing is only temporary. Additionally, no radio-tagged fish have left the sub watershed via Minnehaha Creek that intersects Lake Nokomis to the North.

Anecdotal information suggests that fish from Legion Lake move towards Taft Lake in the springtime. We aim to collect data that confirms this and radio tags, up to three (3), will be implanted in 2018 in the event carp are captured there. Since Legion Lake has no boat access, these fish will be targeted using gill nets that are monitored during the net set. Additional tags will be implanted into Taft Lake and Mother Lake, up to three (3), in the event carp are captured there. If no carp are captured in Taft Lake or Mother Lake or Legion, these tags will be employed in Lake Nokomis.

To date, sixteen (16) carp that are radio-tagged reside in Lake Nokomis and three (3) carp reside in Taft Lake. The project holds six (6) additional tags that will be implanted in sub-watershed basins. An attempt to capture fish in Legion Lake will be made in 2018 and carp that are large enough to tag, up to three (3) carp will be implanted with radio tags and released into the basin.

Locations of each radio tagged carp along with water temperature, ice conditions, and other observations, are entered into an internal geodatabase and maps are delivered to Minneapolis Park and Recreation Board Staff.

Activity Status as of August 1, 2018:

Six (6) telemetry surveys have been completed during the project period. Three of the surveys were completed during ice cover, and three (3) were completed in open water during and post-spawn. The ice cover surveys were completed to determine if there were additional aggregation areas in Lake Nokomis that could be targeted for removal. Two (2) surveys were completed in March and one (1) was completed in February.

The March 2nd survey, showed a slight aggregation of carp in the norther 1/3 of Lake Nokomis, but this was not a tight aggregation and gear for removal would most likely only be able to capture four (4) of the tags in this area. Radio tagged carp remained well distributed in the other two surveys.

The June and July surveys were completed to determine movement between the basins. Most of the radio tags remained in the basin they were originally implanted (Taft or Nokomis). However, one of the radio tagged carp from Taft was located in the Solomon wetland on June 5, 2018 during peak carp spawning. The three carp radio tagged in the Solomon wetland complex in 2017, remain in Lake Nokomis.

Staff from MPRB and WSB surveyed the waterway that connects Taft, Solomon Wetland, and Lake Nokomis for potential barrier sites. Three (3) sites were recommended for barriers. These took advantage of existing

infrastructure (culverts). Barrier design included using existing grating on an 81" culvert between Solomon and Nokomis to attach small mesh (4" x 4" square metal fencing to. The third design would be installed at the culvert inlet to Solomon to prevent carp from Taft from entering Solomon. This design included a set of steel T-posts and fencing anchored to the bottom.

MPRB and WSB coordinated with the Lake Nokomis watershed technical team to discuss barrier placement, timing, duration, and design. In addition, WSB secured a temporary permit for installation of the barriers from MN DNR fisheries (West Metro). The technical team was concerned that the barriers may have the potential to increase the water levels in the subwatershed. WSB and MPRB staff will continue to work with the technical team to develop consensus to install barriers in 2019 to prevent carp migration to and spawning in Solomon Wetland.

Activity Status as of February 1, 2019:

Telemetry surveys continued through fall open water season to document potential aggregations of carp that could be targeted for removal. Small aggregations tracked on November 8 in the south-east portion of Lake Nokomis were targeted but substrate conditions limited success. Since November, telemetry surveys have been limited and coordination with the MN DNR has been ongoing to permit for alternative methods for removal.

Barrier designs will be explored in this next project period to alleviate the technical teams concerns about impact to water levels. Barriers are being recommended since movement between Lake Nokomis and Solomon Wetland should be limited to lower young carp recruitment potential from this neighboring basin. Trap net results from summer-fall trap netting by Bluewater Science show that young-of-year carp are present in Solomon Wetland and telemetry data has confirmed movement of adult carp from both Taft and Nokomis into this basin in some years.

Activity update as of November 14, 2019:

A telemetry survey was completed in Lake Nokomis on March 15, 2019 and the whole sub-watershed was monitored on May 2nd, 2019. No radio-signals were heard in the March Survey and batteries were expected to have expired. The survey in May was designed to determine that the fish had not moved to other lakes and in fact the tags had expired. Again, no radio-signals were heard in Nokomis, Taft, Mother, or Legion Lake. It has been determined that battery life expired in Radiotags that were implanted in 2016.

To monitor movement without the presence of radio-tags in the Springtime of 2019, gill nets were used in the connecting channel of Nokomis to Solomon Wetland and from Taft into Solomon. These connections have been confirmed migration routes in the springtime and in 2019 carp captured would be removed from the system. In addition to capturing movement, this activity was designed to assess the feasibility of carp barriers and potential for removal using in-stream trapping techniques. In total, thirteen (13) adult carp were captured throughout the four rounds of gill net sets, two (2) carp in the connection from Taft to Solomon and the remaining eleven (11) carp in the outlet of Solomon to Nokomis.

One hundred feet of gill net material was used in the inlet from Taft and the outlet to Nokomis. Nets were stretched in a zig-zag fashion across the stream and net section where carp were captured was used to determine direction of movement. At the outlet of Solomon carp were captured in the first and second section that were furthest downstream or Nokomis side of outlet and none were captured in the upstream most sections. This indicates that these fish were moving into Solomon from Nokomis. Direction was harder to determine at the inlet from Taft since fish here were tangled between the net sections.

On October 29, 2019 six (6) new radio-tags were implanted into carp in Lake Nokomis. These fish were captured from the northern portion of the lake and southern portion of the lake to capture potential mixing and

aggregations of carp throughout the basin in subsequent telemetry surveys. In the case carp aggregate before the end of the project period, removal may be attempted using a modified seine net and gill nets. One telemetry survey was completed on November 5, 2019 and tags were found to be distributed loosely around the basin.

Final Report Summary:

Carp were captured and surgically implanted with high frequency radio transmitters throughout the project period. Implant dates include October 25, 2016, November 3, 2016, April 12, 2017, June 7, 2017, and October 29, 2019. Carp movement was tracked for several years to determine seasonal movement throughout the sub-watershed. The project area includes four (4) separate lake basins (Lake Nokomis, Taft Lake, Mother Lake, Legion Lake) and one major stream (Minnehaha Creek). Lake Hiawatha was also surveyed infrequently to assess whether carp were utilizing this waterbody outside of the Nokomis Subwatershed, but hydrologically connected. No radio tagged carp were documented in Hiawatha or anywhere outside the Nokomis subwatershed during the project period.

Radio-tags and radio-telemetry were used this project period to monitor the movement of carp throughout the sub-watershed (Appendix D). In 2016, a total of eleven (11) carp were implanted with uniquely numbered high frequency radio-tags, eight (8) in Lake Nokomis and three (3) in Taft Lake. These fish were captured via boat electrofishing, anesthetized in a mixture of clove oil and water, and surgically implanted with high frequency radio-tags manufactured by Advanced Telemetry Systems (ATS), Isanti, MN. Radio-tags were model F1850B with a programmed 12-hour duty cycle to remain on during the day and turn off overnight, extending battery life. This same method of implantation and radio-tag model used throughout this project period.

A number of tags were set aside in case the opportunity arose to tag carp in Legion or Mother Lakes, however, carp were not captured in these basins throughout the remainder of this project period. It should be noted however, that juvenile carp were observed in Legion Lake and the potential for movement out of the basin does exist, but the extent remains unknown. Gill nets were set in Solomon Wetland on June 7, 2017 to target carp that were observed in the basin. Three (3) carp were captured and implanted with a radio-tag on this date. In the summer of 2018, zero (0) tags were found to be transmitting in the Lake Nokomis Subwatershed and it was determined that battery life had expired. The remaining six (6) radio-tags were implanted in Lake Nokomis carp on October 29, 2019. These tags were used to track potential aggregations of carp that could be targeted for removal.

Telemetry data has confirmed the movement of fish between Taft Lake, Solomon Wetland and Lake Nokomis (Figure 6). This movement occurred in the spring of 2017 and 2018 and has been denoted a spawning migration since spawning activity was observed in Solomon Wetland in those years. In one year of study, one of three tagged fish from Taft Lake moved into Solomon and back to Taft Lake for the remainder of the season. In the next year, the same tagged fish moved into Solomon from Taft Lake and continued to move downstream into Lake Nokomis. Additionally, the three (3) fish that were tagged in Solomon Wetland moved into Lake Nokomis in the summer of 2017, just after they were implanted. This suggests that these carp were originally from Lake Nokomis and had migrated there early in the springtime of 2017 and returned to Nokomis for the remainder of the season. These fish were not observed to move back into Solomon in subsequent years.



Figure 6. Nokomis Subwatershed Telemetry – All Locations (2016-2019)

Winter-time telemetry surveys did not show a propensity for fish to aggregate in Taft Lake, however in Lake Nokomis, an early aggregation of all radio-tags was documented in all years. This aggregation typically formed during open water in early November in the southeast portion of the Lake Nokomis main basin (Figure 7).

The aggregation of carp dispersed in every year after safe ice conditions existed and human activity on the lake increased. This may be due to the high level of winter activities that occur on Lake Nokomis such as pond hockey, ice fishing, cross-country skiing, and hiking. We also theorize that airline traffic over the lake may have an effect on carp within the lake as the noise from the aircraft may be amplified under the ice, but no data exists to support or refute that theory. Smaller aggregations do exist throughout the remainder of the winter, but they are infrequent, random, and continually shifting, making it difficult to target these aggregations.

No tags were employed in Mother Lake because of the absence of carp in all trap net, beach seine, and electrofishing surveys. No tags were employed in Legion Lake because it was not possible to capture carp here due to access limitations. Carp were observed in the outlet stream of Legion Lake where it enters into a culvert towards Taft Lake. This observation suggests that carp attempt to move through this connection, but the extent of movement is unknown.

In the springtime of 2017, carp were implanted with radio-tags in Solomon Wetland to attempt to track movement following the spawning season. These fish moved from Solomon into Lake Nokomis and remained there for the remainder of the project period.

The feasibility of barrier implementation within the subwatershed has been explored, especially between Taft Lake, Solomon Wetland, and Lake Nokomis. Movement of adult carp into Solomon wetland was documented with radio-tag movement between Taft, Solomon, and Nokomis in 2017 and 2018 and young of the year carp were sampled in Solomon Wetland in 2018. This basin serves as springtime spawning grounds and recruitment of young carp to adulthood is likely. Although, it is unknown to what extent these carp recruit to Taft Lake or Nokomis, it is recommended that adult carp movement in the springtime should be limited to reduce this risk.

In 2018, a reconnaissance of the stream reach between Solomon Wetland and Nokomis and Solomon and Taft was completed (Appendix E). A number of suggestions were made for barrier types at a number of locations; however, physical barriers come with a concern that debris may cause blockage at these locations resulting in flood conditions. The sub-watershed is a highly urbanized business and residential area and it is a priority to limit this type of risk. To fully commit to a barrier in this system, a more in-depth study on the potential for flooding in response to any type of barrier being put in place will be pursued.

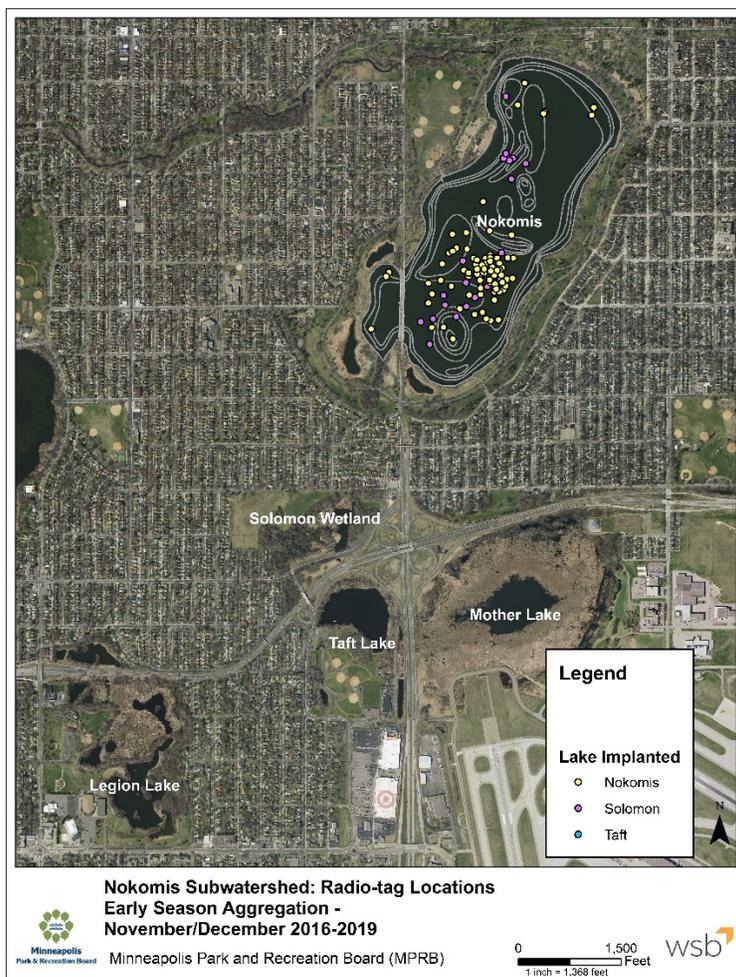


Figure 7. Late Fall/Early Winter Carp Aggregation

ACTIVITY 3: Carp Removal and Management Planning

Description:

Carp will be removed from Lake Nokomis and other basin lakes during the winter using telemetry implemented in Activity 2. This “judas-fish” technique ensures efficiency of removal by helping commercial anglers exactly locate winter aggregations of carp. Carp biomass in each lake will be reduced using a combination of open water and under ice netting in each lake to achieve a biomass level well under 88 lbs./acre. This biomass threshold will

also be based on observed ecological responses of water quality, aquatic vegetation, and each lake’s respective fishery, as assessed in Activity 1.

An adaptive management plan will be developed using data collected under Activity 1. This plan will also rely on existing literature and published articles to develop a dynamic plan that is responsive to data collected during the project period and beyond.

Summary Budget Information for Activity 3:

ENRTF Budget: \$ 64,000
Amount Spent: \$ 64,000
Balance: \$ 0

Outcome	Completion Date
<i>1. Remove carp from subwatershed lakes, using telemetry to locate winter aggregations of fish.</i>	3/31/2019
<i>2. Complete long-term management plan to improve water quality through ongoing carp management</i>	6/1/2019

Activity Status as of February 1, 2017:

No activity has been completed to date.

Activity Status as of August 1, 2017:

Carp collected for the purpose of retrieving aging samples were removed from the system and resulted in a total biomass reduction of 3.32 kg/ha. On April 12, 11 carp were removed at an average weight of 3.79 kg, on April 25, twenty-six carp were removed at an average weight of 3.52 kg, and on July 11, forty-five carp were removed at an average weight of 3.07 kg. This does not contribute to a substantial reduction in biomass, however, it will be used in final reporting of total biomass removed from the system at the end of the project period.

Activity Status as of February 1, 2018:

In November 2017, radio telemetry surveys indicated an aggregation of carp in the southeast portion of the Nokomis main basin (Figure 8). A series of telemetry surveys were completed frequently to confirm this aggregation.



Figure 8: Aggregation of carp in the south-east portion of Lake Nokomis in November, 2017.

WSB staff attempted to coordinate an open water removal with a commercial fishing crew shortly after confirming the location and size of the aggregation. Since Nokomis is identified as infested with zebra mussels, the commercial fishing crew indicated that they could not net the lake. WSB and MPRB staff coordinated with MN DNR central office staff and the commercial fishing crew to develop a method for tagging equipment as infested and decontaminating to allow the commercial fishing crew to net other waterbodies after completing Nokomis.

Unfortunately, after finalizing this process, the carp aggregation shifted and the commercial fishing crew indicated that the seine net they would use would not wrap around the western extent of the aggregation and efforts to complete an open water removal in 2017 was abandoned.

Once ice was safe for foot travel, WSB staff completed telemetry surveys to determine if another aggregation would form under the ice. A smaller aggregation of carp was identified in roughly the same location as the one that was identified in November 2017. MPRB staff indicated they would prefer to wait until after Superbowl LI due to an increase in lake use which may have conflicted with removal operations.

Subsequent telemetry surveys indicate that the aggregation is still present. WSB and MPRB staff are currently coordinating a carp removal for early March 2018.

Activity Status as of August 1, 2018:

Traditional carp removal methods include using commercial fishing crews and large seine nets to remove large quantities of carp when they are aggregated. This requires a relatively flat lake bottom that is free from obstructions.

Lake Nokomis has been extensively dredged around the entire shoreline. This creates a drop off where water depths range from 5-15' deep in a relatively short horizontal distance. This reduces the efficacy of seining since the lead line of the seine cannot hold to the bottom and may allow carp to swim out of the net under the lead line.

To mitigate this, the project team is pursuing two alternatives; one is to use baited box netting to remove smaller amount of biomass over a longer period and the other is to build a seine that is much deeper than the water column that will remain slack over the drop offs and force carp to become entangled in the net.

Baiting (cracked corn in a mesh bag) was initiated in early July. Carp began consuming the bait on the first evening. Baiting has continued through July to "train" carp to come to the same location. A box net will be installed in the bait location in August and tested throughout August and September. Carp appear to only be at the bait site during the overnight period, as confirmed by radio telemetry surveys during the day. These surveys show carp distributed away from the bait during daylight hours after the bait has been consumed.

One primary aggregation site has been identified in Lake Nokomis, just north of the bridge along the eastern shoreline. Carp begin to aggregate here in November, but the aggregation breaks up once ice forms and does not reform until the following November. The project team will work on building a seine that is deeper and provides slack that will be utilized in an open water removal attempt in November 2018.

Activity Status as of February 1, 2019:

The installation of a box-net style trap was finalized on October 1, 2018. The location of the box net was in the southwest bay of Lake Nokomis where a stream inlets from Solomon Wetland. This area was chosen because the bathymetry in the area allowed access to the site from shore. Eight (8) posts with pullies attached were pounded into the substrate and ropes through pullies were tied to sides of the net that extended 10 feet on the shore side to 25 feet on lake side (Figure 9). These net sides are attached to a 40 foot by 50-foot net bottom to form a box when sides are pulled upwards. Ropes were then stretched to shore where they could be pulled when carp were determined to be attracted to the site to trap them inside for removal.



Figure 9. Baited Box Net With Sides Up

Since baiting had been ongoing since early July and the box net had been introduced to the lake about one week prior to finalization, a pull was attempted on October 2, 2018. On this date, the box net was pulled, meaning net sides were pulled by ropes and pullies to the surface by WSB scientists between 3-4 am. A total of 139 carp were captured in this netting event and removed via boat electrofishing and net corralling. A second box netting attempt was made on October 9 where similar protocol for pulling sides and removing fish was made. A total of 29 carp were removed from Nokomis on that date. The third and final attempt at box net removal was made on October 11, 2018 when twelve (12) carp were captured and removed. Efficacy of the box net may have been reduced due to lower water temperatures which resulted in reduced feeding behavior by carp. Lower water temperatures may also have driven carp to deeper water habitats, rather than shallow water which experienced dramatic cooling by the end of the box net period. Additional box netting should be attempted in summer 2019, when water temperatures are warmer and carp feeding behavior is elevated.

On October 11, 2018, JR Commercial fishing test-netted in the south west bay near the location of the box net to determine efficacy of seining there. A large seine net was deployed and preparations to pull the net in on the south-east shoreline of that bay was made. The net became hung-up a number of times and it was determined that the ridges created from historic dredging operations were causing this. With consultation with WSB staff it was determined that netting in this area via seine net would not be possible with the current net steep (weight and depth) and the net was pulled from the lake. One (1) carp was captured by getting tangled in the net sides and is included in the total removed from the lake.

A boat electrofishing survey followed the box net pull on October 9, 2018. This survey was designed to complete a catch per unit effort survey for carp abundance and all carp captured were removed from the lake and disposed of with box net catch. A total of 30 carp were captured and removed via boat electrofishing on October 9, 2018.

On November 8, 2018 JR Commercial Fishing LLC visited Lake Nokomis to conduct another test-netting operation using a net designed to account for steep drop off along shoreline. Telemetry and sonar was employed to locate aggregations of carp and a 3,000 foot seine net was deployed in the south east quadrant of Lake Nokomis. When fishing crews began pulling net towards shore, the net would snag on the uneven lake bottom. The net was lifted over obstructions multiple times before it was again determined that the

dredged bottom contours were preventing the net pull from being completed and the net was lifted from the lake.

No other aggregations were detected on November 8 so another test-net was not attempted and zero carp were captured. In 2018, the total number of carp removed from Lake Nokomis was 211 equating to 14.4 kg/ha removed.

Out of all attempts for removal that has been made in this project period, box netting remains to be the most effective means for removal. However, the low percentage of the total carp population removed per box netting event and intensive personnel requirements, prompts project partners to continue searching for a more efficient removal mechanism. In 2019, we will work with MN DNR to develop alternatives to seine and box net efforts that include but are not limited to gill netting and in-stream removal operations.

Activity status as of December 31, 2019:

Activity covered under activity two designed to monitor movement between Nokomis and Solomon and Taft and Solomon also served as a removal activity under Activity 3. Gill netting in two locations in Solomon Wetland captured a total of thirteen (13) carp at an average weight of 4.2 kg (9.3 lbs) that were subsequently removed from the system and composted. This effort equated to an overall biomass reduction of .7 kg/ha between May 21 and May 30, 2019.

On May 30, 2019, WSB scientists walked along sections of the creek between Solomon and Nokomis and the shoreline of Lake Nokomis to monitor for carp movement and spawning behavior. On this date, water levels in Lake Nokomis were elevated and portions of the lawn surrounding the basin were under-water and carp were observed spawning in these areas as well as shoreline of the lake itself. To accelerate carp removal efforts, it was decided that spawning groups would be targeted for removal using boat electrofishing on this date. In total, 211 adults averaging 3.8 kg (8.3 lbs) were captured using this method equating to approximately 798 kg (1,760 lbs) or 9.8 kg/ha of carp biomass removed from Lake Nokomis.

In summer – early fall 2019 carp removal was attempted with the use of the baited box trap that was first used in the early fall of 2018. Over the course of three months, the trap was installed in three different locations (lagoon on west side of Cedar Ave bridge, southwest area of main lake, and the northeast area near the cement wall). The trap was triggered on six (6) occasions throughout this period to remove fish that were lured to the area. In total, 493 carp were removed from Lake Nokomis at an average weight of 4.92 kg (10.8 lbs) equating to a total biomass reduction of 25.8 kg/ha.

Newly implanted tags were tracked in early November to check if an aggregation of carp might exist to pursue open water seining with commercial fishermen. Although traditional seining methods proved to be unsuccessful, a technique using multiple nets and net types was discussed with commercial fishermen, MN DNR, and project partners that seemed feasible to attempt. This method was not pursued after it was found that fish were spread throughout the basin and no strong aggregation was thought to exist based on radio-tag locations. One week later, ice covered over 80% of the lake surface, canceling any attempt at open water seining in late fall 2019. Safe ice conditions were not present for the remainder of 2019 and no additional attempts to remove carp biomass were able to be made.

Box net removal results are summarized in the table below:

Location	Date	# of carp removed	Ave length	Average weight (pounds)	kg/ha removed
Nokomis-West of Cedar Bridge	19-Jul	310	25.8	8.67	15.0
Nokomis-West of Cedar Bridge	25-Jul	4	--	8.67	0.2
Nokomis-West of Cedar Bridge	26-Jul	38	27.1	11	2.3
Southwest Nokomis Lake	14-Aug	73	27.6	10.8	4.4
Southwest Nokomis Lake	23-Aug	52	26.9	10.1	2.9
Northeast Nokomis Lake	13-Sep	16	26.6	10.2	0.9
Total					25.8

Table 12: Removal summary in the spring-fall of 2019.

Final Report Summary:

The third and final planned activity under the LCCMR grant was to remove carp biomass if necessary, as dictated by the carp population estimates. The amount of carp biomass to be removed would be enough to lower the level of biomass well below the ecological tipping point of 100 kg/ha (89 lbs/acre). The first year of the project (fall 2016-fall 2017) was used to collect data and develop the carp population and biomass estimates. Data indicated between 15,876 and 30,294 kg (34,927 to 66,646 lbs) of carp biomass in Nokomis. This would require roughly 7,776 to 18,387 kg (15,552 to 40,451 lbs) of carp to be removed just to meet the ecological threshold.

The “judas technique,” using radio telemetry to identify aggregations of carp, was planned to be used to locate the aggregations and guide large scale seine netting as the primary removal technique (Bajer, 2011).

Lake Nokomis does not have a history of supporting a large amount of carp removal, but in 2001 Geyer Commercial Fishing crew (Don Geyer, Waterville, MN) completed a seine netting event on Lake Nokomis. This was completed under a recommendation as part of the Blue Water Partnership project to address water quality. In this attempt, they used stationary sonar units to locate an aggregation in the north-west portion of the lake (personal correspondence). A seine net was pulled through this location capturing a large number of crappie and approximately 20,000 pounds of adult carp. In personal communication with Don Geyer, he stated that he thought he had a much larger number of carp in the net initially than what he landed or removed, but he hit a “trench” which ultimately reduced the number of carp he was able to capture and remove. No other large-scale netting was attempted after this event.

A variety of tools were used to reduce carp biomass within Lake Nokomis (Table 13). These include large scale seine netting, baited box nets, electrofishing, and small-scale gill netting. Each of these removal techniques and subsequent results are discussed below.

Year	Date	Method for Removal	Number Carp Removed	Average Weight (kg)	Total Wt Removed (kg)	Total Wt Removed (kg/ha)
2017	4/25/2017	Boat Electrofishing for aging samples	26	3.52	91.52	1.124
2017	7/11/2017	Boat Electrofishing for aging samples	45	3.07	138.15	1.696
2017	9/27/2017	Boat Electrofishing for aging samples	12	3.07	36.84	0.452
2018	10/2/2018	Box Net	139	5.29	734.82	9.023
2018	10/9/2018	Box Net	29	6.41	185.97	2.284
2018	10/9/2018	Electrofishing CPUE survey	30	6.20	185.97	2.284
2018	10/11/2018	Box Net	12	5.08	60.96	0.749
2018	10/11/2018	Commercial Seine Event	1	5.08	5.08	0.062
2018	11/8/2018	Commercial Seine Event	0	n/a	0	0.000
2019	5/30/2019	Electrofishing - Spawning fish capture	211	3.78	798.30	9.802
2019	5/19/2019	Solomon Gill Netting @ Inlet/outlet	13	4.22	54.83	0.673
2019	7/19/2019	Box Net Pull #1	310	3.94	1220.12	14.982
2019	7/25/2019	Box Net Pull #2	4	3.94	15.45	0.190
2019	7/26/2019	Box Net Pull #3	38	4.83	183.54	2.254
2019	8/14/2019	Box Net Pull #4	73	4.91	358.75	4.405
2019	8/23/2019	Box Net Pull #5	52	4.70	244.18	2.998
2019	9/13/2019	Box Net Pull #6	16	4.81	76.96	0.945
TOTAL	ALL	ALL	1011	4.3	4391.5	53.9

Table 13. Carp removal activities and removal amounts throughout the 2016-2019 project period

Large-Scale Seine Netting

In 2016-2019 a number of carp were implanted with high frequency radio-tags to monitor movement throughout the season. It was observed through this study that carp in Lake Nokomis aggregated in late fall to early winter in open water and under thin ice conditions near the center of the lake as discussed in section 4.2. These aggregations were identified as ones that could be targeted for large scale removal via commercial seine netting and occurred each year. However, safe ice conditions did not occur before the large aggregation began to split into smaller groups (Figure 10). It is likely that an increase in human activity on Lake Nokomis was partly responsible for this dissemination of the carp aggregation.



Figure 10. Map showing dispersal of aggregation January-March 2016-2019

Any large-scale removal operations were delayed until the carp population was able to be assessed to reduce variability and bias in the estimates during the initial year of the project fall 2016- to fall of 2017. The late fall open water aggregation was identified initially in the fall of 2017, but no removal was attempted as we assumed that the aggregation would become tighter and more easily targeted as ice formed over the lake, and the commercial crews preferred to net on the ice since removal operations on ice are easier and more rapid to complete. As discussed in section 4.2, winter telemetry showed that the aggregation actually dispersed which did not provide an opportunity for removal in winter 2017/2018. Winter rain events and an influx of stormwater near this area most likely influenced carp aggregation behavior and limited the ability of safe ice to form and crews to access the lake.

For planning purposes, commercial fishing crews visited the lake in January of 2018 to scout the lake to pursue a future seine location. With safe ice conditions, it was decided that smaller groups could be targeted for removal. However, the fishermen could not identify a location that would be suitable to land the net along the shoreline. This was due to the narrow littoral zone followed by a steep drop into the lake. Carp aggregate near the drop-offs and are able to escape the seine net as they are able to swim under the lead line of the net since it is not in contact with the irregular bottom due to the furrows. As the net was brought towards shore, the bottom line would be stretched straight along the steep drop, allowing a space for carp to escape the net.

The change in lake bathymetry after dredging (steep drop-offs and remnant furrows) poses a challenge to commercial netting, as well other obstructions in the lake that include the remnants of the old Cedar Avenue Bridge on the bottom of the lake, anchors and piling near the beach, and large trees tipped waterward along the shoreline that make it difficult for the seine to be pulled along the shoreline.

A modified seine net was built specifically for Lake Nokomis to accommodate water depths and the undulating lake bottom. The amount of leads and weights were reduced to allow the net to move over and through the sediments more easily. This needed to be balanced with having enough weight on the lead line to keep the net on the bottom to disallow carp from swimming under the net and escaping the removal operations. Jeff Reidemann (Jeff Reidemann Commercial Fishing) completed the net construction in August 2018.

A small aggregation was found in Lake Nokomis in the bay west of the Cedar Avenue Bridge and commercial fishing was attempted on October 11, 2018. This location proved to be a flocculant and muddy bottom that caused the bottom of the net to get stuck, hindering the chance at a successful seine attempt. The net was pulled out backwards on this date and only one carp was captured and removed.

A second large-scale seine was attempted on November 8, 2018. Commercial Fishermen visited the lake to test pull the net through the are in the south-east quadrant of the lake where the one known large aggregation had been identified in fall 2017. The net was pulled through open water in the main basin and it was discovered that ridges on the lake bottom caught the bottom of the net, making it impossible to pull the weighted lead line through the area. These ridges were the result of dredging activities in Lake Nokomis in the early 1900's discussed in section 2.2. Again, the net was pulled out backwards and no carp were captured in this attempt. Figure 11 shows the location of the two (2) seine hauls that were attempted.



Figure 11. 2018 Carp Seining Areas

No seining was attempted during the winter of 2018-2019 as previous attempts in open water had proven unsuccessful and commercial crews were reluctant to attempt seining under the ice due to the lack of an area to land the net (due to unprecedented high water) and previous attempts showed the net would not come through the haul due to the dredged lake bottom. Also, no large aggregations formed to facilitate netting had the net been able to come through the haul.

Even though the attempted seine events were unsuccessful, MPRB, MN DNR, WSB, and the commercial crews coordinated to develop a modified plan to remove carp from Lake Nokomis using large scale seining. A plan was developed that involved the use of multiple seine nets and incorporation of gill nets into the design (Figure 12). A large seine net would be used where weights had been removed from the bottom. This net would be used to guide aggregation of carp into a smaller area where a traditional seine net would be used to capture carp. Gill nets would be used on both flanks of the area being targeted to capture fish trying to escape the guide net. WSB coordinated with the MN DNR West Metro Fisheries on permitting to allow for this technique. After initial coordination, MN DNR determined that the gill nets would not be able to be allowed under the commercial permit, but rather large seine type nets. These nets were not readily available to commercial crews and early ice restricted the ability to implement any seining on Lake Nokomis. Based on this, no attempt was made to remove carp via seine netting in 2019, but WSB and MN DNR are still discussing the use of gill nets to facilitate this plan in the future. The gill nets are proposed to be issued under the scientific permit that WSB currently holds and completed with strict oversight and special conditions such as frequent lifts and large mesh size to reduce the amount of bycatch and fish mortality.



Figure 12. 2019 Removal Plan Diagram

Baited Box Netting

The feasibility of removing carp from the sub-watershed using baiting and trapping method known as baited box trapping was implemented as another tool for carp removal. This method employs a trap that is designed with bottom webbing and four side walls that remain collapsed on the lake bottom until bait is consistently consumed and a time is chosen to spring the trap.

This method was first deployed in fall 2018 after purchasing the net from Duluth Nets. Small mesh fabric bags filled with cracked corn were placed in two (2) locations in the southern portion (south of Cedar Avenue Bridge) of Lake Nokomis in late August 2018. This was done to habituate carp to feeding on the bait. Carp were consuming 50-100 pounds of cracked corn per night regularly. Once carp were habituated, the box net was installed and baited. The box net was pulled the first time on October 2, 2018. A total of 139 carp (1,620 pounds) were removed. The net was lifted two (2) additional times, but catch rates dropped off precipitously (most likely due to reduced feeding rates triggered by colder water temperatures) and the net was removed on October 11, 2018 concurrent with the first seine attempt after only catching 41 additional carp.

The baited box net was deployed in 2019 starting in July 2019. The net was lifted six (6) times between July and September 2019. Similar to 2018, the initial catch rate was very high; 310 individuals captured in the first lift on July 19, 2019 (2,690 pounds). However, the next lift on July 25 only resulted in four (4) carp being captured and removed. The net was moved from the initial location (same as 2018) in the southern portion of the lake, to the eastern shoreline. The net was lifted four (4) times and the average catch was 44 carp (16-73 individual range).

Between 2018 and 2019 baited box trapping was pulled or sprung on aggregating fish on nine (9) occasions capturing 673 carp that were subsequently removed from the system. In total a biomass of 37.8 kg/ha was removed from the Lake Nokomis sub-watershed using the baited box trap. Figure 13 below shows the location of the box net sets.



Figure 13. Box Net Locations

Removal Using Boat Electrofishing

Boat electrofishing was primarily used to capture carp for data collection; specifically, to measure carp biomass using a CPUE model, collect samples for aging purposes, gather length and weight data, and apply unique fin clips for a mark-recapture population estimate. In some cases, fish captured through boat electrofishing were removed from the system opportunistically.

Between 2017 and 2019, fish were removed from the system using this method on five (5) occasions equating to 323 individual carp. In total a biomass of 15.42 kg/ha was removed using a boat electrofisher. The greatest number of carp (211) were captured in the springtime of 2019 when groups of spawning carp were targeted along the shoreline and in inundated areas above the WPA wall. Initially this was not a scheduled removal operation, but the number of carp observed in these inundated areas provided a unique opportunity for targeted removal. The boat electrofisher would enter isolated flooded areas above the weir wall and “trap” carp in these areas. The booms would extend over the area and stun any carp that were trapped. Most of these areas were quite large and all of the carp could not be captured. However, this technique was considered quite successful for the amount of effort that was applied (roughly 4 hours).

Removal Using Gill Nets

Gill nets are a permitted gear under the existing MN DNR scientific permit that WSB holds for this project. The permit specifies relatively small amounts of gill net can be used (300 ft.) for capturing carp within the Nokomis Subwatershed. Gill nets were set in both the inlet and outlet of the Solomon Wetland in May 2019

to act as a temporary barrier to carp migration into the wetland from Nokomis and Taft, and to gather additional data on carp.

The nets were initially deployed on May 22, 2019 and set and checked daily between May 22-24 and again between May 29-31, resulting in two, three-day periods. A total of 13 carp were captured during these periods. Only two carp were captured near the inlet from Taft, while the remainder were captured as they tried to enter Solomon from Lake Nokomis. As discussed earlier, gill nets may be most effective deployed in the Lake Nokomis as part of integrated approach used in conjunction with seining as discussed in section 4.3.1.

As shown multiple carp removal strategies were explored and implemented with varying degrees of success throughout the project period. While seining has not been successful to date, this technique holds the greatest potential for large scale removal but should be supported by complimentary removal techniques.

V. DISSEMINATION:

Description:

Project data, status, and general public information will be shared on the websites of the Minneapolis Park and Recreation Board (www.minneapolisparcs.org) and the Minnehaha Creek Watershed District (www.minnehahacreek.org). In addition, information will be disseminated at the Lake Nokomis boat inspection booth. MPRB and MCWD will work with other project partners to post information on those organizations' websites. Final research data will be made available to the public and researchers upon request.

Status as of February 1, 2017:

No activity.

Status as of August 1, 2017:

No activity.

Status as of February 1, 2018:

Locations of each radio tagged carp along with water temperature, ice conditions, and other observations, are entered into an internal geodatabase and maps are delivered to Minneapolis Park and Recreation Board Staff. Bi-yearly updates on all activities are delivered to MPRB and information is disseminated to the general public through updates to the project webpage and presentations at local public informational meetings.

Status as of August 1, 2018:

Data collected as part of this project period has been disseminated to all members of the project team (MPRB, MCWD) as well the MN DNR and Nokomis watershed technical team. Project updates are also included on MPRB's website.

Perhaps one of the more useful findings will be the efficacy of the box netting, carp response to baiting, and the efficacy of the seine. These techniques, if successful, will be shared with project managers who are working on similar biomanipulation projects.

Status as of February 1, 2019:

Data collected as part of this project period has been disseminated to all members of the project team (MPRB, MCWD) as well the MN DNR and Nokomis watershed technical team. Project updates are also included on MPRB’s website.

A common carp integrated pest management plan for the Nokomis sub-watershed is being drafted in 2019 and will be delivered to project partners by the end of December of 2019. This plan will outline recommendations for carp management based on findings of this study. This document will be adaptive to future data collection and findings.

Final Report Summary:

A final draft of a common carp integrated pest management plan (IPM) was delivered to the MPRB on December 31, 2019. This plan highlights data collected throughout this project period and uses it to recommend a strategy for moving forward with carp management activities. Throughout the project period, project updates have been provided to project partners in annual to bi-annual meetings. This information has then been shared on MPRB and/or MCWD website to keep the general public informed. Additionally, many outreach opportunities presented themselves at the boat launch on Lake Nokomis or while scientists were conducting work in the parks surrounding the sub-watershed lakes and streams.

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget Overview:

Budget Category	\$ Amount	Overview Explanation
Personnel:	\$ 3,900	MPRB Director of Strategic Planning: one full time salaried position throughout 36-month duration of project; 0.5% total project period salary = \$1,308; 0.5% total project period benefits = \$498
Professional/Technical/Service Contracts:	\$ 177,250	Tony Havranek, WSB Engineers (Telemetry, population estimates, aging, coordination of removals, management planning) = \$89,023 Steve McComas, Blue Water Science (Fisheries assessment, plant surveys) = \$26,000 Targeted carp netting and removal (contractor to be determined) = \$31,000
Equipment/Tools/Supplies:	\$ 7,850	Radio tags, surgical supplies, radio receiver
Other	\$ 0	Unallocated at this Time. Likely to be used for unforeseen expenses and additional consulting needs driven by project realities.
TOTAL ENRTF BUDGET:	\$ 189,000	

Explanation of Use of Classified Staff: The MPRB Director of Strategic Planning is funded through project-specific expenses, all of which are tracked hourly and can be justified. Other MPRB and MCWD staff are salaried and do not appear here as budgeted expenditures in this request. See “Other Funds” below for use of salaried position costs as matching funds.

Explanation of Capital Expenditures Greater Than \$5,000: N/A

Number of Full-time Equivalent (FTE) Directly Funded with this ENRTF Appropriation: 0.05

**Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF
Appropriation: 0.3**

B. Other Funds:

Source of Funds	\$ Amount Proposed	\$ Amount Spent	Use of Other Funds
Non-state			
Minneapolis Park and Recreation Board	\$ 25,408	\$	Water resources specialist time: 5% salary and benefits through 36-month project duration; Technical water resources staff for sampling and analysis: 5% salary and benefits through 36-month project duration
Minnehaha Creek Watershed District	\$ 10,813	\$	Water quality manager time: 5% salary and benefits through 36-month duration of project
State			
Clean Water, Land, and Legacy Amendment via Lessard-Sams Outdoor Heritage Council	\$ 444,000	\$	Restoration of more than 4,000 linear feet of lake Nokomis shoreline for aquatic and terrestrial habitat enhancement
TOTAL OTHER FUNDS:	\$ 480,221	\$	

VII. PROJECT STRATEGY:

A. Project Partners:

The project will be led by the Minneapolis Park and Recreation Board (MPRB), the primary ENRTF funding recipient, and will involve the Minnehaha Creek Watershed District (MCWD), other public agencies, and two project consultants.

Project Partners Receiving Funds:

- Minneapolis Park and Recreation Board [\$1,806]: project management, planning, and oversight
- WSB Engineers (Tony Havranek) [\$89,959]: project execution
- Blue Water Science (Steve McComas) [26,000]: project execution
- Contract anglers to be determined [\$31,000]: targeted carp removal

Project Partners Not Receiving Funds: Minnehaha Creek Watershed District, City of Richfield, City of Minneapolis, Metropolitan Airports Commission

B. Project Impact and Long-term Strategy:

This project is a critical piece of an overall water quality improvement strategy that has been in progress for more than a decade, led by MCWD, MPRB, and the City of Minneapolis. Previous and ongoing activities include the installation of stormwater treatment wetlands within the watershed, construction of a weir to prevent flow of Minnehaha Creek into Lake Nokomis, regular stocking of predatory fish to manage panfish and bullhead populations, and shoreline restoration. These complementary activities have been funded directly by the agencies involved. A major restoration project (one-half of the shoreline of Lake Nokomis) received funding approval from the Lessard-Sams Outdoor Heritage Council and was approved by the State Legislature. This

project will begin in 2016. MPRB and MCWD provide funds for Lake Nokomis annually through staff time, aquatic invasive species inspections, water sampling and analysis, and invasive vegetation removal.

LCCMR funding would allow for three years of the Invasive Carp Applied Research and Management project, after which, management activities would continue and would most likely be funded by MPRB and MCWD. Findings from this watershed-scale research would be made available to other lake and watershed managers throughout the state. This project will demonstrate how current University of Minnesota research can be applied to entire interconnected watersheds (even those connected through storm sewer rather than overland flows). It will also demonstrate how that research can be applied to ongoing management of carp.

C. Funding History:

Funding Source and Use of Funds	Funding Timeframe	\$ Amount
Minnehaha Creek Watershed District / City of Minneapolis: implementation of stormwater pre-treatment basins to improve lake water quality	2000	\$ 300,000
Minnehaha Creek Watershed District: lake biomanipulation project	2010 – 2016	\$ 41,800
Minnehaha Creek Watershed District: Lake Nokomis / Minnehaha Creek barrier weir to prevent invasive species introduction to Lake Nokomis and reduce nutrients via creek inflow	2012-2013	\$ 72,598
Minnehaha Creek Watershed District: stocking of predatory fish to reduce panfish populations	2012 - 2016	\$ 9,200
Minneapolis Park and Recreation Board: ongoing lake management and monitoring, including full-time staffed aquatic invasive species inspections checkpoint at boat launch, aquatic vegetation removal, water quality sampling and analysis	Pre-2000 – 2016	Approx. \$30,000 annually

VIII. FEE TITLE ACQUISITION/CONSERVATION EASEMENT/RESTORATION REQUIREMENTS:

A. Parcel List:

B. Acquisition/Restoration Information: N/A

IX. VISUAL COMPONENT or MAP(S): See Attached Subwatershed Map

X. RESEARCH ADDENDUM: N/A

XI. REPORTING REQUIREMENTS:

Periodic work plan status update reports will be submitted no later than February 1, 2017, August 1, 2017, February 1, 2018, August 1, 2018, and February 1, 2019. A final report and associated products will be submitted between June 30 and December 31, 2019.

**Environment and Natural Resources Trust Fund
Final M.L. 2016 Project Budget**



Project Title: *Invasive Carp Management Research in Lake Nokomis Subwatershed*

Legal Citation: *M.L. 2016, Chp. 186, Sec. 2, Subd. 06g*

Project Manager: *Adam Arvidson*

Organization: *Minneapolis Park and Recreation Board*

M.L. 2016 ENRTF Appropriation: \$ 189,000

Project Length and Completion Date: *3 Years, June 30, 2019*

Date of Report: *February 7, 2020*

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Activity 1 Balance	Activity 2 Budget	Amount Spent	Activity 2 Balance	Activity 3 Budget	Amount Spent	Activity 3 Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM											
Personnel (Wages and Benefits)											
MPRB Director of Strategic Planning: one full time salaried position throughout 36-month duration of project; 0.5% FTE total project period salary = \$1,308; 26.2% benefits = \$498	\$2,600	\$2,600	\$0	\$650	\$650	\$0	\$650	\$650	\$0	\$3,900	\$0
Professional/Technical/Service Contracts											
Tony Havranek, WSB Engineers (Telemetry, population estimates, aging, coordination of removals, management planning) = \$104,023	\$28,000	\$28,000.0	\$0	\$65,000	\$65,000	\$0	\$9,500	\$9,500	\$0	\$102,500	\$0
Steve McComas, Blue Water Science (Fisheries assessment, plant surveys) = \$26,000	\$21,400	\$21,400	\$0	\$0	\$0	\$0	\$5,000	\$5,000	\$0	\$26,400	\$0
Targeted carp netting and removal (contractor to be determined) = \$31,000	\$0	\$0	\$0	\$0	\$0	\$0	\$48,350	\$48,350	\$0	\$48,350	\$0
Equipment/Tools/Supplies											
Radio tags, surgical supplies, radio receiver				\$7,350	\$7,350	\$0	\$500	\$500	\$0	\$7,850	\$0
Capital Expenditures Over \$5,000											
<i>List specific items - one row per item. Add rows as needed.</i>											
Printing											
<i>List types of printing costs anticipated.</i>											
Travel expenses in Minnesota											
<i>Specify purpose for and types of travel expenses and indicate estimated allocations toward each type of expense, e.g., mileage, lodging, meals. Per diems are not allowed.</i>											
Other											
Unallocated at this time											
COLUMN TOTAL	\$52,000	\$52,000	\$0	\$73,000	\$73,000	\$0	\$64,000	\$64,000	\$0	\$189,000	\$0