2019 Project Abstract
For the Period Ending June 30, 2022

PROJECT TITLE: Citizen-aided carp management: overcoming roadblocks to lake restoration.
PROJECT MANAGER: Andrew Dickhart
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FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04q

APPROPRIATION AMOUNT: $106,000
AMOUNT SPENT: $104,185
AMOUNT REMAINING: $1,815

Sound bite of Project Outcomes and Results

This project demonstrated new innovative methods of carp management that includes local volunteer residents. The use of baited box nets and an electric guidance system produced an integrated and multi-faceted approach to long term carp management, which we know is important given the longevity of the species.

Overall Project Outcome and Results

The major objective of this project was to demonstrate new methods of managing common carp that can be implemented by residents and local governments to improve water quality and other lake response variables to carp removal. We partnered with Carp Solutions LLC and local residents to study carp management and removal using baited box-nets and an electric guidance system (EGS) in Benton Lake, a small shallow lake in Carver County that is impaired for nutrients. Although research shows that lakes can be restored by managing common carp, widespread implementation of carp management has been hindered by lack of effective removal methods. We addressed these challenges by enlisting local residents to test a simple, innovative method of removing carp via baiting and trapping, using corn and custom box-nets, and later a second method using an electric barrier. Research suggests that there is a threshold (100kg/hectare) at which common carp can be managed without negative effects to water quality and habitat. After removing 15,000 carp, the carp biomass decreased but just halfway towards the management threshold, short of our goal. We attributed our inability to reduce carp below the management threshold to a high rate of carp reproduction. Tracking technology was used to identify the main carp nursery and the EGS we tested may offer the most practical management option in this system because it can be used for many management scenarios, like blocking adult carp from accessing the nursery and block juveniles from dispersing out of the nursery. The cost efficiency of reducing nutrients was $2,100/kg of phosphorus, which put this method on the low side of the cost range for methods used to reduce nutrients. Through this work, two advances in carp management occurred. First, we showed that residents can play an important role in assisting carp removal efforts, and two, we showed how electric barriers can be used for controlling carp reproduction and migration of adults. These lessons will be of value to other carp managers in Minnesota and elsewhere.

Project Results Use and Dissemination

Project information and updates via Storymap remain on the Carver County Website. Staff has presented project updates to local resident groups, local decision makers, and do plan to present at conferences, which was a challenge due to the pandemic. Project updates, photos, and videos can be found on the "Carver County Water Management Organization" Facebook and Instagram – @carvercountywater.

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2019 ENRTF Work Plan (Final Report)

Today's Date: 2 March 2023

Final Report

Date of Work Plan Approval:

Project Completion Date: 30 June 2022

PROJECT TITLE: Citizen-aided carp management: overcoming roadblocks to lake restoration.

Project Manager: Andrew Dickhart

Organization: Carver County

College/Department/Division: Planning & Water Management

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Location: Benton Lake – Metro Region – Central Carver County – City of Cologne

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Total Project Budget: $106,000

Amount Spent: $104,185

Balance: $1,814

Legal Citation: M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04q

Appropriation Language: $106,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with the Carver County Water Management Organization to quantify water quality improvements and the cost-effectiveness of a new citizen-aided carp management method for restoring impaired lakes in Minnesota.

I. PROJECT STATEMENT:

The goal of this project is to demonstrate a new method of managing invasive common carp that can be implemented by citizen groups and LGUs to improve water quality by reducing in-lake nutrient loading. This new approach would overcome current roadblocks to successful carp management. Although research shows that lakes can be restored by managing common carp, widespread implementation of carp management has been severely hindered by lack of effective removal methods. Traditional methods such as lake drawdowns, poisoning, and commercial seining are often ineffective, harmful to native species, cost-prohibitive, and/or rely on a few specialized contractors that are difficult to secure. We propose to address these challenges by enlisting local citizens to field-test a simple, innovative method of removing carp via baiting and trapping using corn and custom "box nets". We will also use an electric barrier/guidance system to guide carp aggregations to a removal site during spawning runs. These new approaches were developed by the U of MN startup company, Carp Solutions, and is consistent with research findings that common carp can be trained to feed in specific locations of a lake using corn as bait and can be successfully guided into traps with electric guidance systems. The chief advantage of box nets, which are stationary, is that carp can be lured into them and removed even in lakes with debris or where carp do not form natural aggregations. Further, baiting is simple enough that citizens can be trained to administer it, increasing the scalability and affordability of this strategy. Carp Solutions conducted proof-of-concept experiments in 4 lakes in 2017 which showed that 20-50% of carp were removed from each lake using only 1-4 nets, with no non-target impacts. This promising method could easily be scaled up by enlisting local residents to provide volunteer labor. Field tests have also shown that up to 80% of carp migrating to spawn can be directed into traps using electric guidance systems.

We request funding for a full-scale demonstration of carp removal using baited box nets and an electric barrier/guidance system in Benton Lake, a small lake in Carver County impaired for excess nutrients, which would serve as a model for other systems.

The Carver County Water Management Organization (CCWMO) will partner with Carp Solutions and local residents to test this new method. Effectiveness will be evaluated by quantifying carp removal efficiency and associated water quality improvements. This information will be used to guide implementation of this method in carp-infested lakes impaired for excess nutrients across the state. Our findings will also fill in important gaps in the scientific understanding of the impacts of carp and carp removal on annual nutrient dynamics. Carp Solutions LLC is the chosen consultant for this project because of their extensive knowledge and proven expertise in carp management. They are local, affordable, and are currently the only contractor using this novel approach to managing carp. Carver County solicited bids for this project, receiving none other than from Carp Solutions.

Benton Lake is an ideal site for this test because there is detailed information on the existing carp population, a fish barrier at the outlet to prevent recolonization during removal efforts, an extensive water quality monitoring record, and local partners who are willing to participate in lake restoration activities by providing in- kind support. Specifically, in 2017, the CCWMO contracted Carp Solutions to conduct a carp assessment which showed that carp biomass was very high (~600 kg/ha) and typical of shallow lakes in Minnesota. Furthermore, phosphorus modeling revealed that Benton Lake requires a 97% reduction in internal phosphorus loading to meet State water quality standards and support recreation. The proposed project will make much-needed progress towards improving the water quality in this severely degraded lake and its findings will be broadly applicable to restoring similarly impaired waters.

II. OVERALL PROJECT STATUS UPDATES:

First Update March 1, 2020

Three electrofishing surveys were conducted in July of 2019 to mark and release carp for future population estimates. Some of the captured fish were implanted with passive integrated transponders (PIT) tags to track carp movement from Benton lake to Muewissen lake where there is a temporary fish barrier in place. PIT data

showed that some of the carp were somehow passing through the barrier. The carp are thought to be spawning in Muewissen. Carp removal efforts in 2019 involved the placement of four baited box net systems. Volunteers were trained how to bait the nets. Updates on baiting and corn consumption were provided by volunteers and County staff. Nine removal attempts were made, removing 4,438 carp (2,807 kg). Carp population prior to removal was estimated at 22,304 - approximately 20% were removed in 2019. Trap net surveys were also conducted to assess native fish community. Eight species were sampled in relatively low abundance. Due to relatively low carp per removal attempt numbers, a new removal technique using electric guidance systems is being explored. This technique used in addition to box-netting could significantly raise the number of carp removed per year, getting us closer to our goal of a 50% reduction in carp population. *See Amendment Request

Amendment Request as of 03/11/2020

Because the box-net removal technique did not remove the desired number of carp to meet our goal of a 50% population reduction in year 1, a new removal technique will be explored using electric barriers to guide and "corral" carp for removal. A modified box-net and conveyer system will boost removal numbers by exploiting carp spawn runs. There are data that suggests a large portion of the carp population migrate to a channel connecting Benton and Meuwissen lakes. This system will guide a large aggregation of carp to an area where they can be easily removed without baiting. Baited box nets will continue being utilized in the main lake basin.

Additionally, because the contracted lab no longer performs analysis of cyanobacteria and cyanotoxin abundance, and these measurements were not critical to our ability to assess lake response to carp removal, these tests are being removed from the project.

Funding shifts:

1. $10,000 of the budgeted $70,000 for box-netting (Carp Solutions) shifted to rental of electric guidance system.
2. $6,100 budgeted for cyanotoxin monitoring (RMB Labs) shifted to construction of power line to provide long-term electricity for guidance system.

Amendment Approved by LCCMR 4/8/2020

Second Update September 1, 2020

Limited work done in 2020 due to Covid 19. Two carp removal attempts were conducted in the summer months with very limited success. A total of 179 fish were removed. We have been working with Carp Solutions to arrange the installation of the electric barrier for Spring 2021 if possible. Plans are still tentative due to Covid 19.

Third Update March 1, 2021

A total of 14 carp removals have been attempted since the start of this project with about 5,000 carp removed. The initial carp population assessment from 2019 estimated 22,304 carp (656 kg/ha). The most recent population estimate after the 2019 removals, was 17,534 (525 kg/ha). Despite population control efforts, such as fish barriers, predator fish stocking, and lake aeration, carp recruitment remains high. A temporary fish barrier intended to block the movement of carp failed and allowed spawning to occur in Muewissen lake, a nearby nursery. To reach our goal of decreasing the carp population to a management threshold of 100 kg/ha, a more effective barrier is needed to slow carp recruitment as well as higher removal rates in 2021. Work is planned for Spring of 2021 to install an electric guidance system to stop carp from moving to the nursery to spawn and to "corral" them in a custom enclosure for removal. This will be in addition to new box net technology that will allow us to monitor carp feeding activity and trip nets remotely to maximize catch.

Fourth Update September 1, 2021

An electric guidance system (EGS) was installed in between Benton and Muewissen Lakes in the Spring of 2021. This EGS acts as a barrier between lakes to keep carp populations from travelling to shallow Muewissen lake, where carp are thought to be spawning. The EGS also acts as a removal method, guiding and enclosing carp to an

area where they can easily be removed. Because of Covid-19 international travel restrictions, we were unable to get our contractor to the US until late Spring, which delayed the installation and subsequently missed the large carp migration, however, 637 carp were captured with the EGS during 6 days of removals in late May and early June. Other challenges were experienced during the early stages of the EGS operation such as carp pushing through the barrier due to power and technology issues that have since been addressed, and a drought that decreased the water flow in the channel between lakes.

Our contractor improved their baited box-net design with the addition of PIT antennas that can track the timing of when carp visit the nets, and the addition of a device for tripping/setting the nets remotely. A total of 9,998 carp were removed via box-nets in 2021, which is the best year yet in terms of removals. The carp have also increased significantly in size. Total carp captured in 2021 was 10,635. We don't yet have an updated population estimate at the time of this update.

Some preliminary data show that there may be an increase in water quality, but we will need more data to report any significant trends.

Fifth Update March 1, 2022

In the spring of 2021, before the carp spawning run occurred, Carp Solutions assisted in the installation of an Electric Guidance System (EGS) and a physical trap between Benton and Meuwissen Lakes for blocking and removing common carp during spawning migrations. Staff is researching funding opportunities to purchase the EGS system if found to be effective for long term management.

In the summer of 2021, we continued to test a different management strategy, the removal of carp from Benton Lake using updated box nets. Three nets were installed in August, one of which was equipped with an antenna for detecting PIT tagged carp at the bait. This antenna was critical in monitoring carp activity at the bait online, which allowed us to spring the nets when carp activity was highest. 66% of the PIT tags detected at the bait were removed, suggesting relatively high efficacy of our approach. Volunteers were not utilized in 2020, due to Covid regulations, however, the volunteers returned in 2021 and plan to return once again in 2022.

Carp biomass in the lake was reduced from 505 kg/ha to 305 kg/ha. However, a high abundance of juvenile carp was detected through 2021 which complicated mark-recapture estimates. Curbing juvenile carp production/dispersal in combination with aggressive removal activities for juveniles and adults will be needed to achieve management goals in the future. To get below the critical threshold of 100 kg/ha, an additional 10,905 carp need to be removed. Again, this number may be conservative as the exact number of small carp in the lake, and especially those < 200 mm (cutoff for the box nets we used) is difficult to estimate.
The EGS system will be utilized again this Spring (2022) and box nets will be used again in the Fall, however, the Fall box netting will be outside of this project's timeline, so the final 2022 carp population estimate will not be reported in the final report.

Amendment Request 4/18/2022

Because we were able to pay for the 2022 year-round water quality analyses with our internal department budget, we request that $3,000 be re-allocated from the "Subcontract RMB Labs" budget line to the "Subcontract Carp Solutions" line to conduct additional carp removal.

- RMB budget would be reduced by $3,000 to a revised budget of $710
- Carp Solutions budget would increase by $3,000 to a revised budget of $8,000

This re-allocation will help ensure that both tasks are carried out cost effectively by shifting available resources to the more costly task of coordinating the efforts involved with the electric barrier system and population assessments.

Amendment Approved by LCCMR 6/01/2022

Final Report between project end (June 30) and August 15, 2022

The major objective of this project was to demonstrate new methods of managing common carp that can be implemented by residents and local governments to improve water quality and other lake response variables to carp removal. We partnered with Carp Solutions LLC and local residents to study carp management and removal using baited box-nets and an electric guidance system (EGS) in Benton Lake, a small shallow lake in Carver County that is impaired for nutrients.

Although research shows that lakes can be restored by managing common carp, widespread implementation of carp management has been hindered by lack of effective removal methods. We addressed these challenges by enlisting local residents to test a simple, innovative method of removing carp via baiting and trapping, using corn and custom box-nets, and later a second method using an electric barrier. Research suggests that there is a threshold (100kg/hectare) at which common carp can be managed without negative effects to water quality and habitat. After removing 15,000 carp, the carp biomass decreased but just halfway towards the management threshold, short of our goal. We attributed our inability to reduce carp below the management threshold to a high rate of carp reproduction. Tracking technology was used to identify the main carp nursery and the EGS we tested may offer the most practical management option in this system because it can be used for many management scenarios, like blocking adult carp from accessing the nursery and block juveniles from dispersing out of the nursery.

The cost efficiency of reducing nutrients was $2,100/kg of phosphorus, which put this method on the low side of the cost range for methods used to reduce nutrients. Through this work, two advances in carp management occurred. First, we showed that residents can play an important role in assisting carp removal efforts, and two, we showed how electric barriers can be used for controlling carp reproduction and migration of adults. These lessons will be of value to other carp managers in Minnesota and elsewhere.

III. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Demonstration of the new baited box net method

We will use multiple (≥5) baited box nets and an electric guidance system to aggressively remove carp from Benton Lake. The guidance system will be installed in a channel near a temporary fish barrier between Benton and Meuwissen lakes and used to direct carp into a trap whenever they are observed migrating through the channel. The nets will be placed along the shoreline in mid-summer and baited using corn to condition the carp to aggregate at the bait site at night. Baiting will be conducted by citizens/partners who will be trained to administer the appropriate amount of bait and monitor its consumption by carp. The carp will be conditioned for 5-10 days and then the sides of the nets will be lifted to enclose the carp for counting and removal. The proportion of the carp population removed will be calculated by examining previously marked fish. This effort will be repeated at least four times per year. The goal is to achieve at least a 50% reduction in abundance in year 1. This effort will be conducted for two years in an attempt to reduce carp biomass from approximately 600 kg/ha to below 100 kg/ha (management threshold) and examine how quickly the goal can be achieved and whether effectiveness decreases as carp abundance declines. Overall removal efficiency (% population removed) will be calculated and plotted against time (number of net lifts and carp abundance). Labor and costs will also be calculated, including in-kind contributions, to enable calculations of cost per lb phosphorus (See Activity 3).

ENRTF BUDGET: $ 87,176 ($26,780 of additional in-kind support)

Outcomes	Completion Date
1. Capture, marking, & release of ≥ 200 carp to enable tracking of removal progress	*July 31, 2019*
2. Nets installed, citizens/partners trained	*Aug 31, 2019*
3. Reduction of carp abundance by ≥ 50%; Season 1	*Dec 31, 2019*
4.Electric guidance system installed	*May 31, 2020*
5. Nets re-installed after winter, citizen/partner refresher workshop	*June 30, 2020*
6. Reduction of carp abundance ≥ 75%; Season 2	*Dec 31, 2020*

First Update March 1, 2020

(TASK 1.) Three electrofishing surveys were conducted on July 1, July 8, and July 11. During these surveys, 196 carp were marked with a fin clip. Fifty-nine of these fish were also implanted with PIT tags to track carp movement at the physical barrier between Benton and Muewissen lakes. Each carp tagged was also measured.

(Task 2.) Four baited box-net tripping systems were installed in July. Each system consisted of 2 box-nets side-by-side. A training session was provided to volunteers on July 22 to go over instructions on baiting the nets and providing updates on corn consumption. Updates on consumption are critical to planning timing of each removal event.

Task 3.) Nine removal attempts were made with the box-net systems. The first removal occurred on July 24 and only involved three net-systems. The remaining eight removals used all four net-systems. A total of 4,438 (2,806 kg) carp were removed with the nets. Based on the mark-recapture estimate, 22,304 carp were estimated to be inhabiting Benton lake prior to 2019 removal efforts. After removal, that number should be down about 20% to 17,866, short of our goal of 50% reduction. Next year, to increase the number of carp removed, PIT antennas will be placed around several box-nets to study at what times carp are visiting the nets, and a new removal technique using electric guidance systems is being explored.

Second Update September 1, 2020

Only two carp removal attempts were made this season with very limited success – a total of 179 fish were removed. Because of Covid 19, we are holding off until 2021 to continue with any more work. We are hopeful that we can get an electric barrier installed in 2021.

Third Update March 1, 2021

A total of 14 carp removals have been attempted since the start of this project with about 5,000 carp removed. The initial carp population assessment from 2019 estimated 22,304 carp (656 kg/ha). The most recent population

estimate from after the 2019 removals was 17,534 (525 kg/ha). We did not meet our 50% and 75% carp abundance reduction goals for 2019 and 2020 respectively, likely due to the failure of a temporary carp barrier and pandemic setback. The electric guidance system was delayed due to Covid-19 and is planned for a Spring 2021 installation. More box netting will occur in 2021 with improved technology that should increase carp removal numbers.

Local volunteers were once again trained and utilized to bait the box-nets, however wildlife observations from the volunteers were very low.

Note: earlier project updates indicated incorrect values for the total of carp removed and initial population estimate due to a mathematical error. Actual values are reported in this final update.

Fourth Update September 1, 2021

Four baited box-net removals were conducted in September of 2021 with the updated box-nets – 9,998 carp were removed. The EGS system was once again delayed but was installed in May and was used to remove 637 carp. Approximately 15,000 carp have been removed since the beginning of this project. However, a recent population estimate report has not yet been received at the time of this update. Young carp are still being observed, indicating new recruitment. An updated population assessment will give some insight on new recruitment numbers and an idea of carp biomass remaining in the lake.

Fifth Update March 1, 2022

An electro-shock survey will be conducted once again this Spring along with the introduction of new PIT tags to enable carp removal tracking and population estimates. The newly modified box nets with smaller mesh size will be installed in August and removals will take place in September. The EGS system is being installed this Spring with potential removals starting as early as May, when the carp began their spawn run last year.

Local resident volunteers have been an integral part of this project; however, we did not utilize the volunteers in 2020 due to Covid concerns and policies. The volunteers have consisted mostly of residents living on or near the lake. The Benton Lake Watershed Conservancy, a local lake association has members that volunteer and that help with recruiting. There have also been multiple college students that volunteer to gain field experience. Their main task is to monitor the bait (cracked corn) that is placed inside the box nets, re-fill, and record data on quantities of corn being used and when. This is a very helpful task because it allows us to monitor bait remotely, and trip nets remotely, if needed. Volunteers also record wildlife sightings, check equipment for vandalism or other issues, and occasionally assist in carp removals. Problems with the nets or gear are often caught early and sorted out quickly because the residents care deeply about the project and are always on the lookout for issues. Without the help of the residents, the cost if this project would be considerably higher due to the additional staff time and/or contracted duties that would be required. The volunteers were utilized in 2019, 2021, and will be again in 2022.

Final Report between project end (June 30) and August 15, 2022

The goal of this Carp Management Project was to demonstrate and study new methods of managing invasive common carp that can be used by local residents and governments to improve water quality by reducing in-lake nutrients, such as Phosphorous. The ultimate goal is to study if these management methods will help restore this highly degraded waterbody. The first project activity was the demonstration of new baited box-net removals and to test the efficacy of an electric guidance system as a carp barrier and removal tool.

This project activity began in July of 2019, with 3 electro-fishing surveys on separate days to mark and release carp for future population estimates, and the installation of four box-net systems. About 250 carp were marked with a fin clip, implanted with passive integrated transponders (PIT) tags, or both. The PIT tags helped us to track movement between Benton Lake and Meuwissen Lake where a temporary physical barrier exists (Figure 1 and 2). Antennae that can detect the tags were installed on both sides of the physical barrier. PIT data through the 2019 season indicated that some carp were able to pass through the barrier from Benton to Meuwissen. Carp assessment work completed before this project also suggested that a significant portion of carp in Benton migrated to Muewissen. At this point, we began exploring the use of an Electric Guidance System (EGS) in

addition to the physical barrier. Trap net surveys in Meuwissen the same year found a high abundance of young-of- year carp, further confirming Meuwissen as a carp nursery for Benton, and emphasizing the importance of

Figure 2. Physical temporary barrier

Figure 1. Temporary carp barrier location

managing the connection between lakes. Of the carp tagged in July of 2019, about 1/5 of them were detected at the barrier. The box-nets were installed in early July, and volunteers were trained to bait the nets.

The volunteer component of this project was phenomenal. There were many people from the local community who volunteered immediately and there were also folks from quite a distance away that were willing to volunteer when available. In the beginning, the interest in the project was almost overwhelming. The volunteer component was also critical to the project because the volunteers were very often the ones checking the bait, checking the nets for snags and other issues, and performing wildlife counts. Overall, we learned that a volunteer component included in a carp management project can bring labor and contractor costs down significantly, especially if the local community has a stake in the project and is excited about it. Keeping some of the labor and contractor costs down can open-up some funds to be utilized elsewhere in the project.

There were 9 removal attempts made with the box nets the first year (2019), resulting in the removal of 4,438 carp. Based on the data from the electro-fishing surveys, 22,304 carp were estimated to be inhabiting Benton Lake prior to the 2019 removals and about 18,000 after the removals. We did not achieve our goal, which was to remove 50% of the carp the first year.

In early 2020, we planned to move forward with the EGS install to reinforce the physical barrier and to test another removal method since we were unable to remove 50% in 2019. The EGS was planned to be installed at a culvert downstream of the physical barrier. However, the Covid 19 pandemic delayed this effort until 2021. We also planned to ramp up box-netting. But, because of low success that year with the initial removal efforts and the observation that many juvenile carp fell through the mesh nets, we also postponed any more box-netting until 2021, while the contractor worked on developing technology to capture small carp and understand the timing of the carp feeding.

The operation of the PIT antenna placed between Benton and Meuwissen was continued in 2020. The configuration, upstream and downstream of the barrier to examine its effectiveness, was not changed in 2020. Carp were detected by this antenna from 3/29 until 11/9, with a peak in late May which suggests that late Spring is when the carp are migrating to spawn. Most of the carp were detected between March and July. The small number of unique PIT tags (27) detected in 2020 compared to 2019 (90) and 2018 (162) suggests that mortality of carp in the Benton system is high. As in 2019, the same unique PIT tagged carp were detected on both sides of the barrier in 2020, again suggesting that carp are passing through the temporary physical barrier. In fact, most (22 of the 27, 81%) of the carp that were detected at the barrier were detected on both sides at some point (Figure 3). In our experience, a temporary physical barrier was not adequate to block the migration of carp and would not

recommend unless using as a back-up barrier.

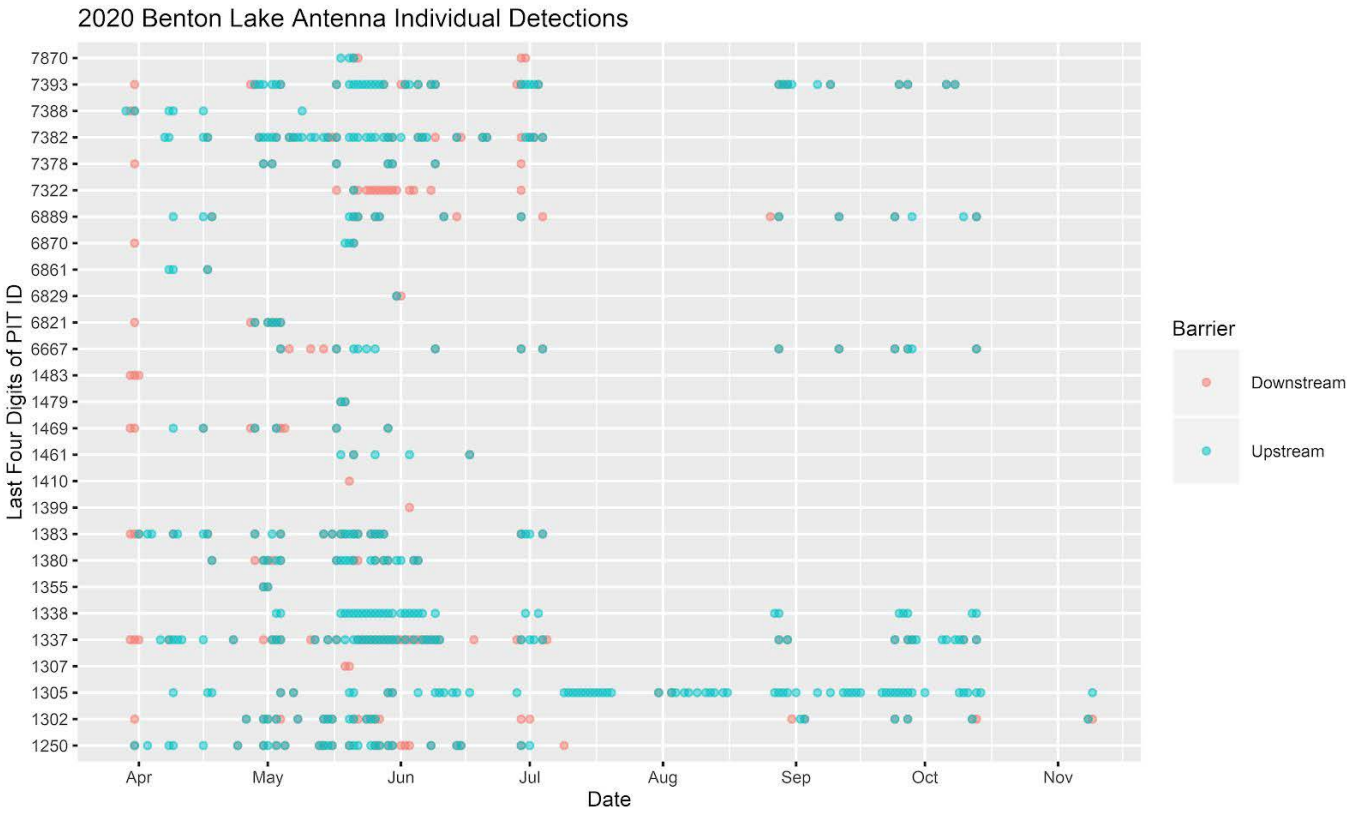

Figure 3. Dates on which each of the 27 tags were detected at physical barrier. Each dot represents a date on which an individual tag was detected. Red dots represent detections coming from Benton and blue represents detections on the nursery side.

In the Spring of 2021, the EGS (Figure 4) was installed concurrent to the carp migration to Meuwissen Lake and another electro-fishing survey was conducted to tag more fish so we could determine when and how many carp attempted to cross the barrier, similar to the process for the temporary physical barrier. Most carp were observed trying to cross in the month of May, with the peak in late May once again. About half of the tagged carp were detected at the EGS, indicating that a significant portion of the carp in Benton were trying to migrate from Benton to Meuwissen. The physical barrier remained in place, but we opened a space for the carp to pass through to detect any that were trying to go back into Benton, especially juveniles attempting to disperse out of the nursery area.

Figure 4. Electric guidance system.

During the early stages of the migration, several challenges arose. Some technical issues with the EGS allowed some carp to pass through into Meuwissen, but carp were still able to be removed on their way back to Benton later in the migrating season. The 2021 spring migration was also limited due to low water levels. The EGS was run on generators early season, while a main power line was being run from a municipal building nearby. The generators worked nicely most of the time but required monitoring almost every day, and did have nights where they stopped operating, usually because the fuel ran out. Once the main power line was run to the site, it interfered with the PIT antenna that was placed near the EGS, so the antenna was moved further away from the power source and functioned well for the remainder of the season. A total of 637 carp were removed using the EGS. We learned that having reliable power was critical and important for managers to consider before the use of an EGS system.

In the summer of 2021, the new and improved smaller mesh box-nets were installed. Three nets were installed in August, one of which was equipped with a PIT antenna for detecting carp at the bait. The antenna allowed us to spring the nets when carp activity was at its highest. It was monitored on-line so the nets could be tripped quickly and from a distance. The antenna also allowed us to determine what time of day the carp were visiting the bait and the data indicated the most carp visited in evening hours. The bottoms of the nets were noticed floating at the surface, attributed to an algae bloom occurring at the time. The nets were removed for a few weeks and work then continued. About 10,000 (43% of the population) carp were removed with the box-nets in 2021. However, a high abundance of juveniles was detected, which complicated population estimates (Figure 5). Overall, carp management efforts were greatly advanced with the addition of the EGS and new box-net components. Over twice the number of carp were removed with fewer removal attempts compared to 2019.

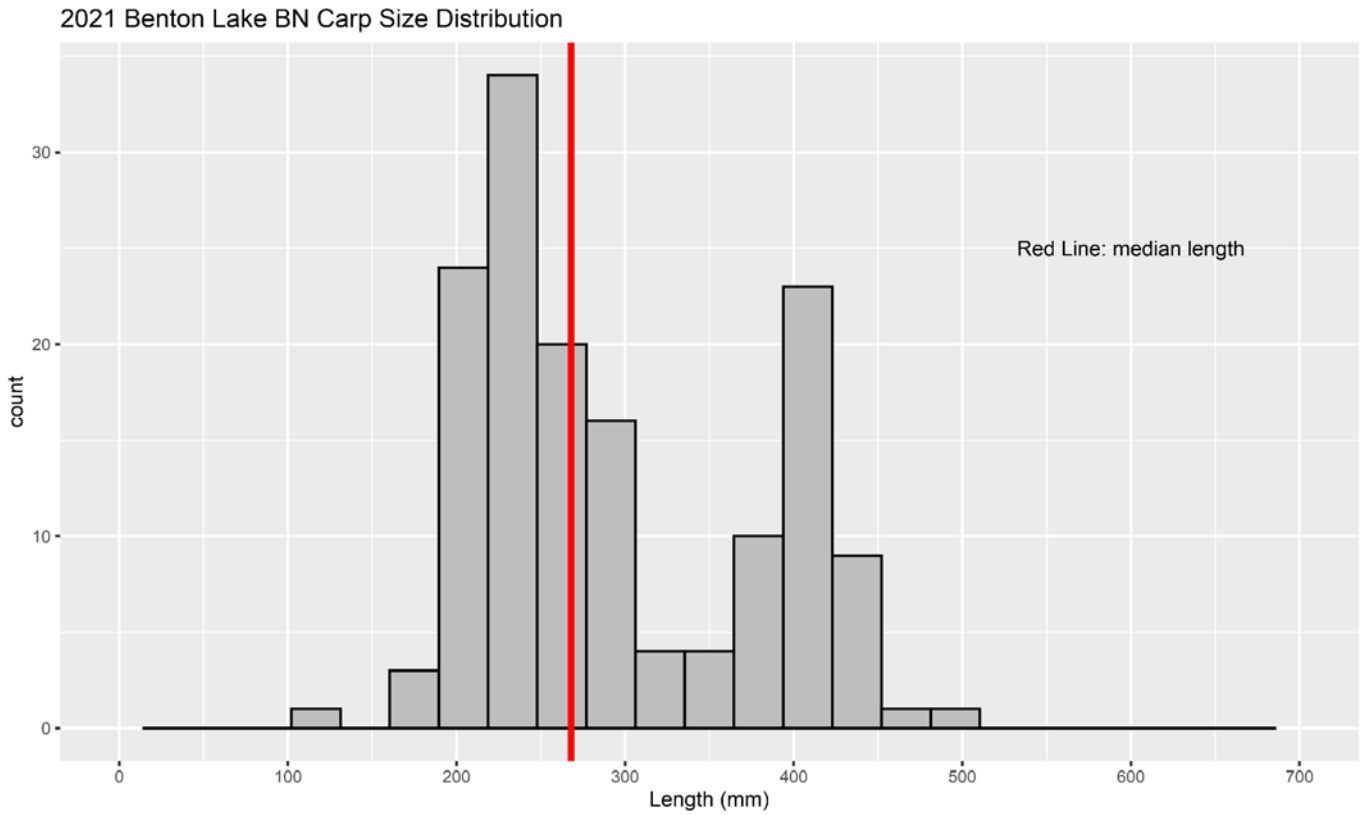

Figure 5. Size distribution of carp captured in box-nets in 2021

It was confirmed in 2021 that high rates of juvenile carp production were hindering the achievement of our management goals. We also determined that curbing juvenile carp production and dispersal with aggressive removal methods will be necessary to achieve management goals in the future. Technology described in this report can facilitate these management actions. However, we found that the EGS did not trap nearly as many young carp as were detected in the electro-fishing surveys. This is consistent with other systems with larger populations of carp, where the average size caught in stream migration traps is often 100 mm larger than those caught in electro surveys and box nets (Figure 6).

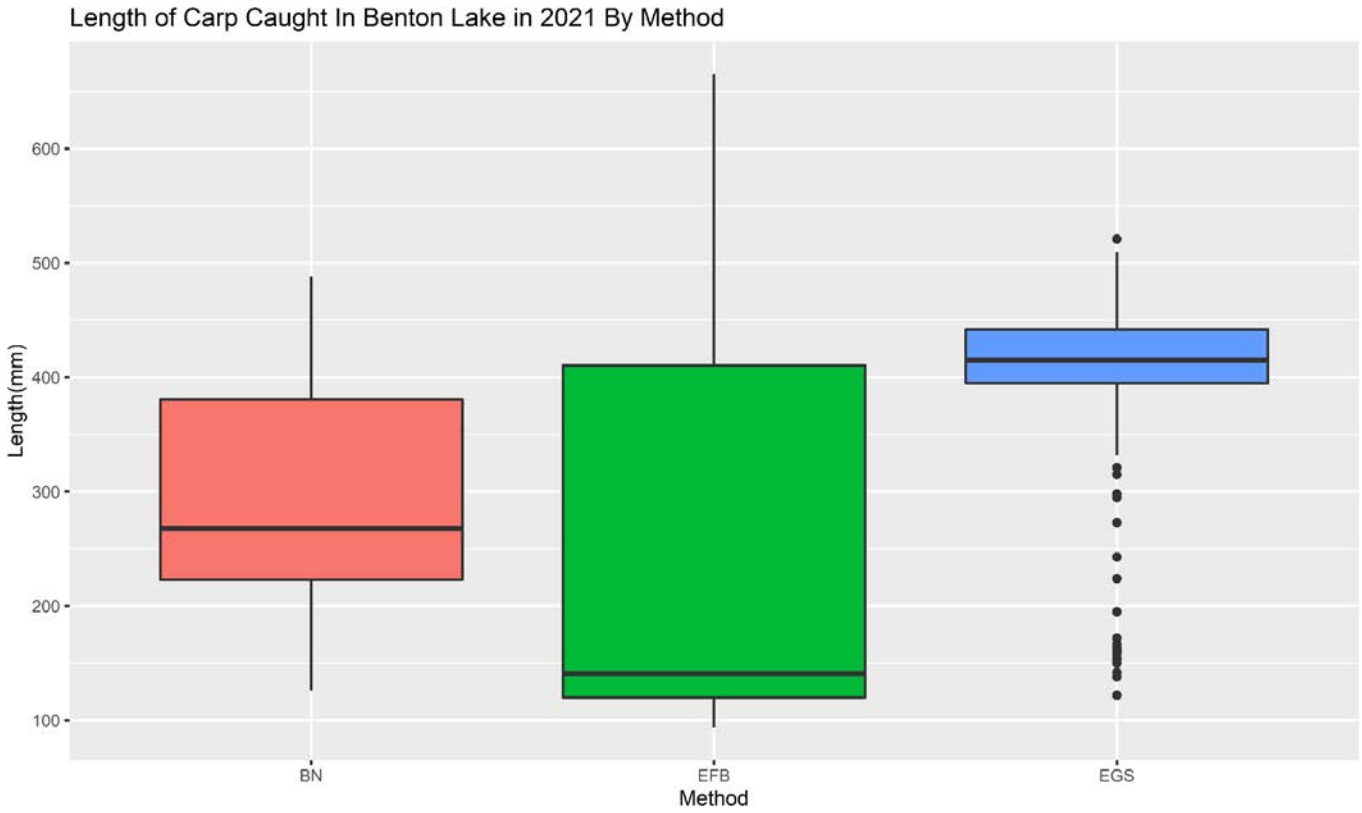

Figure 6. Carp size comparisons between box-nets, electro-fishing surveys, and EGS.

In the Spring of 2022, very few carp were detected in the electro survey and only about 1/3 of tagged carp were detected at the EGS, with a peak in early to mid – May, a little earlier than previous years. This indicates the migration was relatively small in 2022 compared to 2021. It seems that the EGS was 95% effective at preventing migration with just 1 of 20 tagged carp making it past the EGS – likely during a power outage. Leaving the generators on site might have remedied this issue. With such a small number of carp detected by the electro-fishing surveys, the adult carp population seems to be much lower than we would have predicted based on previous population estimates. The reason for this is currently unknown. There could been a winter kill that went unnoticed, or perhaps the carp have found new nursery areas after being blocked from accessing Meuwissen. Future work is being planned to document ALL potential migration routes for young and adult carp, including small inlets and accessible surrounding wetlands, using PIT technology. The EGS will also be utilized as a barrier to study the effectiveness of blocking juveniles and as a long-term barrier and removal method (10 years minimum).

ACTIVITY 2: Monitoring of lake response to carp removal activities

We will collect detailed data to monitor improvements in Benton Lake resulting from carp removal to fill in key data gaps in the scientific literature. Specifically, lake restoration efforts via carp management typically focus

only on total phosphorus (TP) and only during the growing season (May-September). We will measure in-lake concentrations of TP and total Kjeldahl nitrogen (TKN) year-round as well as select response variables including Secchi transparency, total suspended solids, chlorophyll-a.. We will also measure aquatic vegetation richness and cover, native fish community structure, waterfowl use, and recreational use. Furthermore, we will measure stream flow and nutrients at the outlet to calculate changes in nutrient export to downstream waters. All monitoring will be conducted annually for two years.

ENRTF BUDGET: $22,600 ($19,400 of additional in-kind support)

Outcome	Completion Date
1. Water quality, vegetation, fish, and waterfowl surveys – year 1 summer and fall	*Dec 31, 2019*
2. Water quality monitoring– year 1 winter and spring	*June 30, 2020*
3. Water quality, vegetation, fish and waterfowl surveys – year 2 summer and fall	*Dec 31, 2020*
4. Water quality monitoring– year 2 winter and spring	*June 30, 2021*

First Update March 1, 2020

In lake concentrations of nutrients and other response variables including Secchi transparency, suspended solids, and chlorophyll were sampled year-round beginning July 2019. Cyanobacteria abundance and cyanotoxins were not analyzed because the contracted lab no longer performs those analyses. This water quality data is still being reviewed. Two vegetation surveys were conducted in August and September 2019 and very few aquatic plants were observed. Trap-net surveys were completed to assess the native fish community in the Benton/Meuwissen system. Eight species were observed with relatively low abundance. Bullhead and Crappie had the highest catch rate. Waterfowl counts were recorded by volunteers and County staff – data still being reviewed. Water quality sampling is continuing over winter months.

Second Update September 1, 2020

In lake concentrations of nutrients and other response variables including Secchi transparency, suspended solids, and chlorophyll are being sampled year-round. Water quality data is not showing significant trends currently. One vegetation survey was conducted in 2020 with just one species of floating vegetation observed. Trap net surveys have not been completed yet this year. We may wait until 2021.

Third Update March 1, 2021

In lake concentrations of nutrients and other response variables including Secchi transparency, suspended solids, and chlorophyll are being sampled year-round. Water quality data is not showing significant trends currently. One vegetation survey was conducted in 2020 with just one species of floating vegetation observed. A vegetation survey and trap net survey for native fish are planned for 2021. Wildlife counts were not recorded in 2020 due to Covid-19, however, they will resume in Spring 2021.

Fourth Update September 1, 2021

In lake concentrations of nutrients and other response variables including Secchi transparency, suspended solids, and chlorophyll are being sampled year-round. A native fish survey and vegetation survey were conducted in the summer of 2021. The fish survey results showed the top 1-3 most abundant fish being bullhead, common carp, and black crappie, respectively. Eight of the 150 fish surveyed were bluegill sunfish, revealing that the bluegill population may still be low, despite stocking and aeration efforts. Just one species of aquatic vegetation was observed from the 32 areas surveyed.

Fifth Update March 1, 2022

In lake concentrations of nutrients and other response variables including Secchi transparency, suspended solids, and chlorophyll are being sampled year-round. Water quality data is not showing significant trends currently, however, the data does indicate a slight improvement in water quality metrics, unlike the previous two years. More data will be needed to report any statistically significant changes in the water quality. Wildlife counts

reported by volunteers seem to be increasing slightly, but again, not significantly. It's important to note that wildlife counts are reported anecdotally and are not controlled for statistically. A native fish survey and vegetation survey is scheduled for this Spring and Summer, respectively.

Final Report between project end (June 30) and August 15, 2022

To monitor the lake's response to carp removal activities, in-lake nutrients and other response variables were sampled year-round to fill in data gaps in scientific literature. Cyanobacteria and cyanotoxins (blue-green algae) were not analyzed because the contracted lab no longer performed those analyses. This allowed some dollars to be shifted toward running electricity to the site. We also performed several aquatic vegetation surveys to measure any improvements in the plant community, trap net surveys to measure native fish communities, and casual observations of waterfowl and recreation use.

This data collection began at the very beginning of the project in July of 2019. Eight fish species were observed in trap nets with relatively low abundance, mostly bullhead and crappie. Fish surveys in other years were similar, except that one did include large numbers of juvenile carp in Meuwissen Lake. Benton lake is stocked with blue-gill sunfish on occasion by the local lake association, so higher blue-gill numbers were expected. A portion of the lake gets aerated to provide a refuge for native fish (outside of grant funding), especially blue-gill sunfish, which are known to consume carp eggs. The hope was that the bluegill would help lower recruitment numbers. In this particular system of lakes, this strategy was challenging because of frequent oxygen deficits in the winter months that are likely to reduce blue-gill abundance. We did not include a method to monitor or examine whether bluegill had a positive impact on recruitment. This could be something for managers to keep in mind, if feasible. Another item to keep in mind is the timing of the fish stocking and surveys – one would want to perform the survey before the fish are stocked. Good communication with program partners will be helpful in this regard – we learned the hard way. Vegetation surveys did not show an improvement in vegetative richness or percent cover, in fact, almost no vegetation other than cattails and a patch of water lilies were found over the period of the project.

Figure 7. Winter lake aeration on Benton Lake

Volunteers took casual observations of waterfowl and other wildlife. The observations varied year-to-year. In 2019, and a couple years leading up to, it was common to witness pelicans on the lake, which was a new observation for the community. It is thought that perhaps the stocking of panfish, and addition of an aerator and water fountain may have attracted the pelicans. The pan fish may have looked tasty, and the structures provided some roosts in the water that were a distance from the shore. Few pelicans were witnessed after 2019. Another factor attracting the pelicans could be the smell of the carp when being removed or surveyed. Other waterfowl species were observed (mallards, Canada geese, and occasional visits by flights of cormorants) but only a relatively small and unverifiable increase in numbers. The hope was that with an increase in water quality and fish community structure, more waterfowl would visit the system. Because our goal of reducing carp biomass below 100kg/ha was not met, there is no evidence yet to claim that carp removal will increase waterfowl numbers at Benton Lake. Other common wildlife was observed such as, muskrats and turtles, who would sometimes get caught in the box nets. There were a few muskrat and turtle casualties from box-netting over the period of the

project. Recreational use was low. Very few kayaks and canoes were observed going through the canoe launch. Most recreators were children and families fishing from the pier at a small local park. Although our carp biomass removal goals were not met over the period of this project, the local community has been very grateful of the work being done and we have established some very meaningful relationships with some of them. We are also grateful for the many volunteer hours and positive energy that the community has contributed to this project and look forward to more collaboration on the restoration of Benton Lake.

ACTIVITY 3: Summarizing results and reporting findings

This task involves analyzing the carp removal and water quality data to quantify removal efficiency and lake response. The cost efficiency of reducing nutrients ($ per lb of P and N) via carp management will be calculated for TP and TKN based on the mass of carp removed, measured in-lake nutrient concentrations, and annual discharge. Before and after comparisons of clarity, chlorophyll-a, plants, fish, waterfowl, and recreation will be also reported. Findings will be formally presented at the annual MN Water Resources Conference which brings together natural resource managers from across the state. CCWMO will also conduct educational outreach at pop-up stations onsite during carp removal efforts and at their annual city-wide festival.

ENRTF BUDGET: $ 2,775($6,900 of additional in-kind support)

Outcome	Completion Date
2. Cost effectiveness and lake response report – year 1	*June 30, 2020*
4. Final report on cost effectiveness and lake response	*June 30, 2021*

First Update March 1, 2020

Cost effectiveness report coming July 2020.

Second Update September 1, 2020

We have not yet summarized any data on cost effectiveness due to limited work performed in 2020 – not enough data.

Third Update March 1, 2021

We have not yet summarized any data on cost effectiveness due to limited work performed in 2020 – not enough data.

Fourth Update September 1, 2021

Cost effectiveness data will be included the final report. No analysis completed currently.

Fifth Update March 1, 2022

Cost effectiveness data will be included the final report. No analysis completed currently.

Final Report between project end (June 30) and August 15, 2022

During this project, 15,302 carp (7,614 kg) were removed from Benton Lake. This equates to 38.1 kg of phosphorus with carp biomass, as phosphorus accounts for 0.5% of carp's mass.

Given that about $80,000 were allocated to carp removal, one kg of phosphorus removed has a cost of about $2,100, which is in the range of values associated with phosphorus removal via other watershed best-management-practices where costs per 1 kg often range between $2,000 and $10,000. We were hoping for higher amounts of phosphorus per dollar spent through an improvement in water quality. This, however, did not occur because carp biomass could not be suppressed enough (below 100 kg/ha) to allow the lake to flip into a clearer state. In-lake nutrient concentrations (Phosphorus and Nitrogen) showed considerable year-to-year variability, and did improve over the period of this project, however, fell just short of showing a statistically significant trend. A larger sample size and more advanced statistical analysis taking seasonality into account, may have shown a different result, but we chose not to include this nutrient reduction in our efficiency calculations, especially because of the goal of reducing carp biomass to below 100kg/ha was not met. Water clarity remained

unchanged (Figure 8).

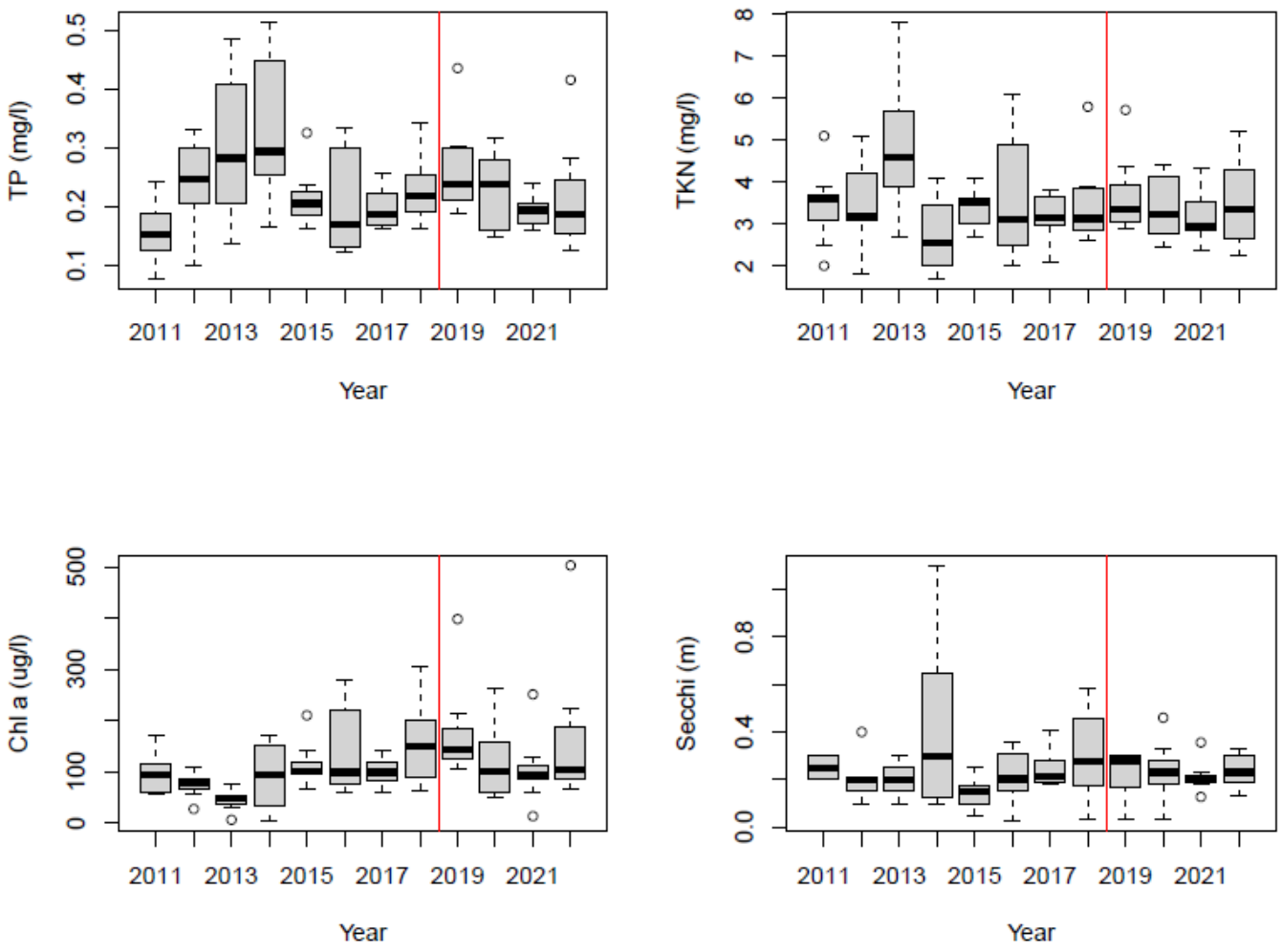

Figure 8. Benton Lake water quality trends. Red line indicates beginning of this project.

IV. DISSEMINATION:

Description: Project results will be formerly presented at the annual MN Water Resources Conference and possibly the Upper Midwest Invasive Species conference. Project information and updates will be made available on the Carver County Website in story map form.

The Minnesota Environment and Natural Resources Trust Fund (ENRTF) will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the ENRTF Acknowledgement Guidelines.

First Update March 1, 2020
Project information can be obtained in story map form on the Carver County Website.

Second Update September 1, 2020
Project information can be obtained in story map form on the Carver County Website.
www.co.carver.mn.us/water

Third Update March 1, 2021

Project information can be obtained in story map form on the Carver County Website.

Fourth Update September 1, 2021
Project information can be obtained in story map form on the Carver County Website.

Fifth Update March 1, 2022
Project information can be obtained in story map form on the Carver County Website.

Final Report between project end (June 30) and August 15, 2022
Project information and updates have been and remain on the Carver County Website. Staff has presented project updates to local resident groups, local decision makers, and do plan to present at conferences, which was a challenge due to the pandemic. Project updates, photos, and videos can be found on the "Carver County Water Management Organization" Facebook and Instagram – @carvercountywater.

V. ADDITIONAL BUDGET INFORMATION:

A. Personnel and Capital Expenditures

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

Explanation of Use of Classified Staff: N/A

Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 0

Enter Total Estimated Personnel Hours for entire duration of project: 0

Divide total personnel hours by 2,080 hours in 1 yr= TOTAL FTE: 0

Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:
Enter Total Estimated Contract Personnel Hours for entire duration of project:

Divide total contract hours by 2,080 hours in 1 yr = TOTAL FTE:

VI. PROJECT PARTNERS:

A. Partners outside of project manager's organization receiving ENRTF funding

Name	Affiliation	Role
Carp Solutions, LLC	Consultant	Provides technical expertise and equipment for carp removal and fish surveys

B. Partners outside of project manager's organization NOT receiving ENRTF funding

Name	Affiliation	Role
Benton LakeWatershed Conservancy	Citizen Group	Provides volunteer labor and monitoring

VII. LONG-TERM- IMPLEMENTATION AND FUNDING:

In addition to providing in-kind support for this project, CCWMO has invested in assessments and infrastructure to plan for long-term carp management in this system. In 2013, CCWMO installed a carp barrier at the outlet of Benton Lake, to protect this system from downstream sources of carp. In 2017, CCWMO contracted Carp Solutions to estimate carp abundance which showed that carp biomass was very high (661 kg/ha) and that carp

were most likely responsible for poor water quality. In 2017, CCWMO also conducted a preliminary assessment of the box net technology, which showed that 21% of the population (5,105 carp) were removed with just 2 nets. In 2018, CCWMO is committed to investing in studies of carp recruitment, seasonal migrations, and overwintering sites. CCWMO is also examining the need for a winter aeration system to strengthen native fishes (bluegills) to reduce future carp reproductive success. Implementation of these activities is funded by local dollars through annual budgetary processes including the Carver County Capital Improvement Plan. Overall, the vision of CCWMO is to implement an integrated pest management strategy for carp in a shallow lake system that could be used as a model for other locations across Minnesota.

VIII. REPORTING REQUIREMENTS:

- Project status update reports will be submitted March 1 and September 1 each year of the project
- A final report and associated products will be submitted between June 30 and August 15, 2022.

IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

A. Budget Spreadsheet
B. Visual Component or Map
C. Parcel List Spreadsheet
D. Acquisition, Easements, and Restoration Requirements
E. Research Addendum

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2019 Budget Spreadsheet - Final
Legal Citation: M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04q
Project Manager: Andrew Dickhart
Project Title: Citizen-aided carp management: overcoming roadblocks to lake restoration
Organization: Carver County
Project Budget: $106,000
Project Length and Completion Date: 3 years, June 30, 2022
Today's Date: 18 December 2023

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget 6/01/2022	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)			
All Carver County staff time will be listed as in-kind contribution.			
Professional/Technical/Service Contracts			
Subcontract Carp Solutions LLC, to provide technical expertise and specialty equipment for: electrofishing to catch, mark, and release carp for progress tracking ($6,840). Training Citizens & local partners to bait/monitor nets, oversight ($3,600). Seasonal deployment and management of box nets, removal, and disposal of carp ($60,336). Electric guidance system rental ($10,000). Native fish community surveys following DNR protocols ($4,000). Data analyisis and reporting ($2,400). Carp Solutions LLC is the chosen consultant for this project because of their extensive knowledge and proven expertise in carp management. They are local, affordable, and are currently the only contractor using this novel approach to managing carp. Carver County solicited for bids for this project, receiving none other than from Carp Solutions.	$ 87,176	$ 87,176	$ -
Subcontract RMB Labs for water quality analyses: In-lake monitoring for TP,TKN, TSS, Chl-a, biweekly; year-round, 2 years ($3,250). Outlet monitoring for TP, TKN; year round; 2 years ($2,950). Courier for sample pick up, 2 years ($1,400). Our organization recently started condtracting with RMB Labs for all of our water quality analyses. We recieved 4 bids and chose RMB based on affordable cost, proven track record, and local offices.	$ 7,600	$ 7,010	$ 590
Contruction cost for Electricity: a power line will be run from a wastewater treatment facility to an area along the channel bewteen Benton and Meuwissen lakes to provide long term electricity to the electric guidance system ($6,100).	$ 6,100	$ 6,100	$ -
Equipment/Tools/Supplies			
Continuous water level logger for outlet stream	$ 1,400	$ 1,231	$ 169
Trail cameras for wildlife monitoring	$ 349	$ 290	$ 59
Corn for baiting 6 nets, 4 attempts per year; 2 years	$ 3,000	$ 2,379	$ 621
Capital Expenditures Over $5,000			
Fee Title Acquisition			
Easement Acquisition			
Professional Services for Acquisition			
Printing			
Travel expenses in Minnesota (will be reported as in-kind)			
Other: Registration fee for Water Resources Conference	$ 375	$ -	$ 375
COLUMN TOTAL	$ 106,000	$ 104,186	$ 1,815

OTHER FUNDS CONTRIBUTED TO THE PROJECT	Budget 6/01/2022	Spent	Balance
Non-State:			
State:			
In kind:			
Carver County Staff time for water quality monitoring, community outreach, & data analysis.	$ 30,800	$ 10,000	$ 20,800
Citizen baiting and monitoring of box nets	$ 22,280	$ 10,000.00	$ 12,280
PAST AND CURRENT ENRTF APPROPRIATIONS		**Spent**	**Balance**
Current appropriation:			
Past appropriations:			

PLANNING & WATER MANAGEMENT WEB MAP

Date: 2/23/2023

This map was created using Carver County's Geographic Information Systems (GIS), it is a compilation of information and data from various City, County, State, and Federal offices. This map is not a surveyed or legally recorded map and is intended to be used as a reference. Carver County is not responsible for any inaccuracies contained herein.

0 0.0375 0.075 0.15 0.225 0.3 mi